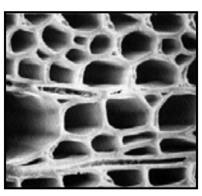
Characteristics of timber - Relationship to properties

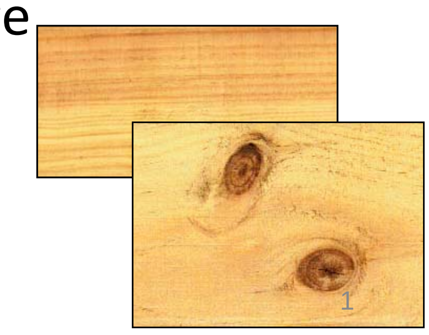
Maximise performance of timber

Intuitive understanding of timber behaviour

Knowledge of Properties and Performance



- Physiology of timber fibres, cells, grain, growth rings
- Moisture content *emc* and shrinkage
- Creep and duration of load effects
- Natural growth characteristics
- Structural properties of timber



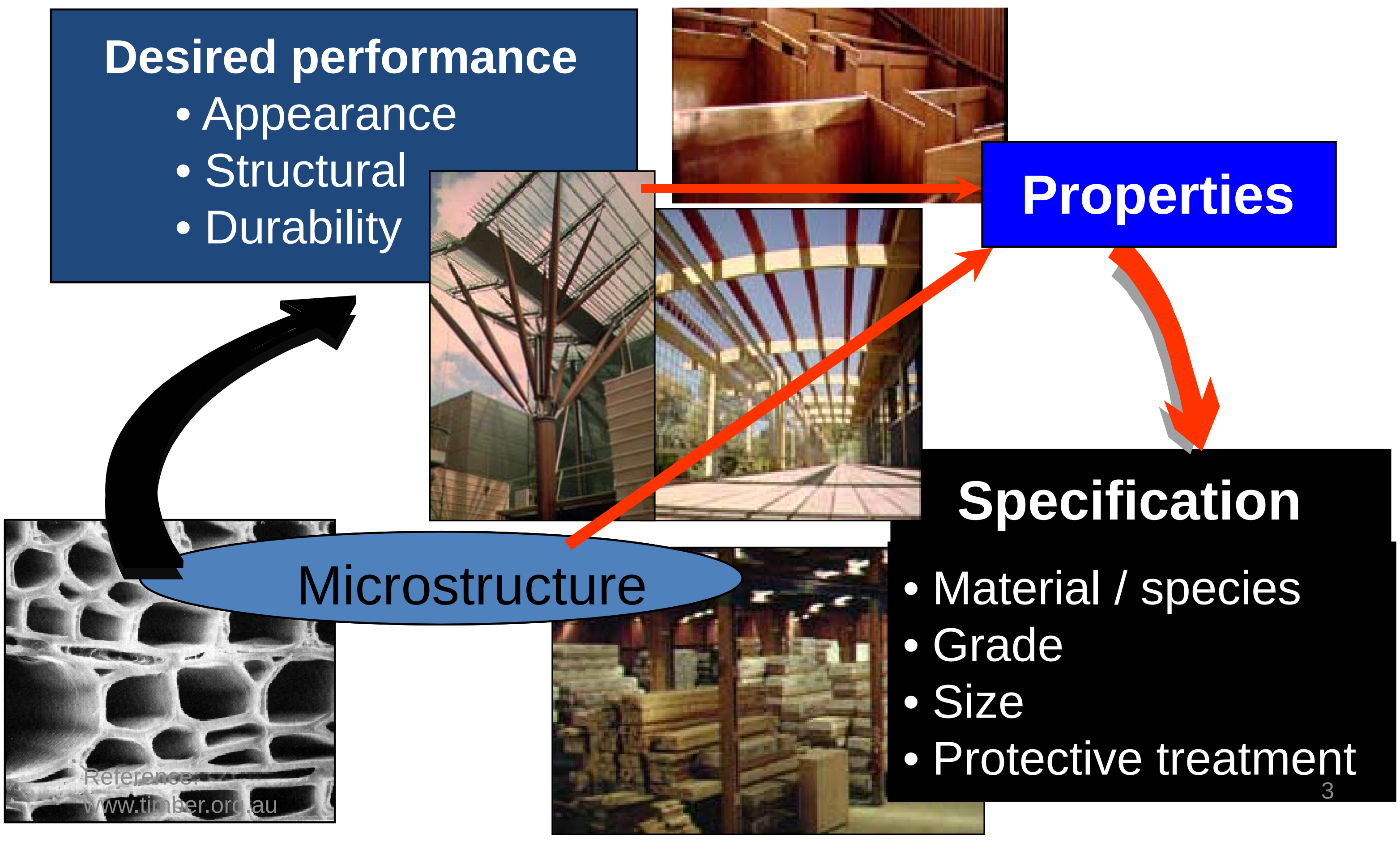
Reference:
www.timber.org.au

An elementary understanding of wood science can develop an intuitive understanding of wood properties to maximise the performance of the timber and minimise the impact of limitations.

This slide points out that the properties and behaviour of timber can all be understood in terms of the wood microstructure and the way it interacts with its environment.

If we want to maximise the performance of timber, we MUST understand the way it behaves. We also need to know about its physical properties. To effectively understand behaviour and know its properties, we need to understand a little about wood science.

Performance of Timber



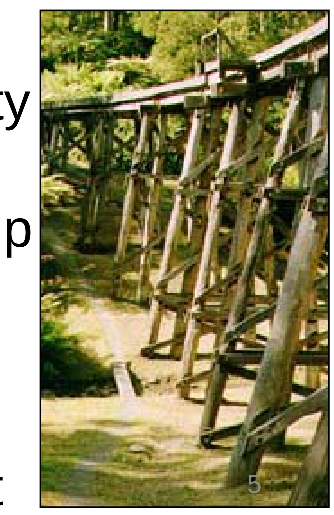
For any given use, we have an expectation of the performance we require from the timber.

This presentation explores the micro-structure that underpins the behaviour we are interested in. We will be focussing principally on the structure of the wood as it affects durability and strength.

An appreciation of the microstructure assists in understanding timber properties, and eventually leads to an intuitive feel for the way timber responds to both load and the environment.

Performance of Timber
Appearance/Structural/Durability

- **Appearance**
  - Grain and colour
  - Feature
  - Dimensional stability & *emc*%
- **Structural**
  - Essential e.g. strength and stiffness
  - Utility e.g. dimensional stability
    - shrinkage/*emc*
  - Straightness - bow, spring, cup and twist
- **Durability**
  - Biological hazards
  - Natural resistance / treatment



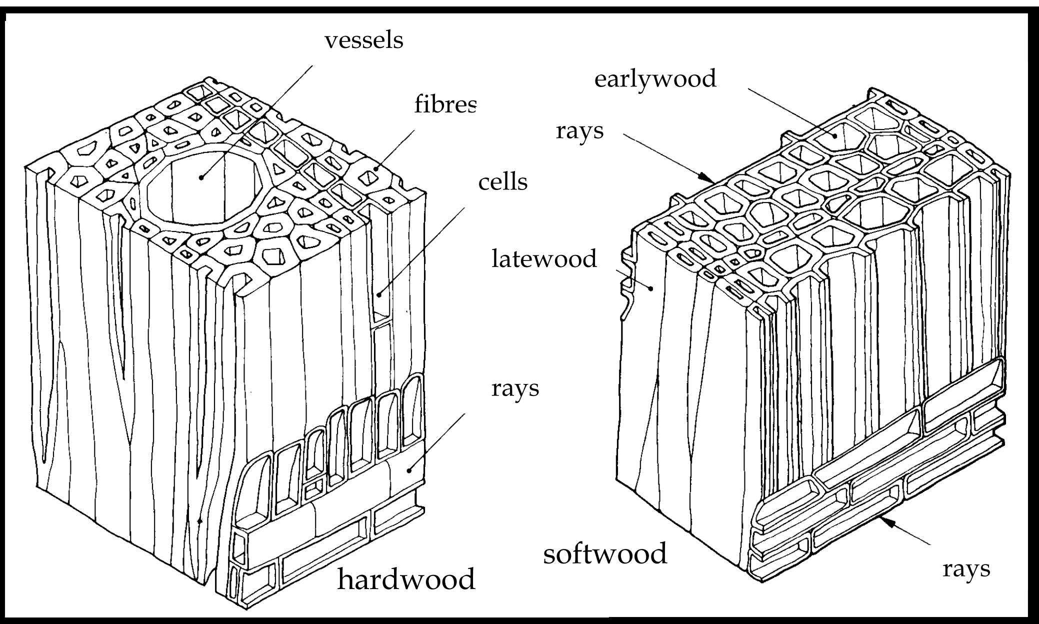
Reference:
www.timber.org.au

Principally, builders are interested in an appropriate level of **performance**. The type and level of performance varies for the applications of timber in a building. It is important that a builder understands what performance is required for each and every material to be used in the structure.

Performance requirements will lead to properties that are important for inclusion in the specification. Generally for timber, this can be accomplished by selecting an appropriate grade, species and treatment for the timber

Reference:
www.timber.org.au

Microstructure of Timber



Grain direction

- Cells - fibres - mainly longitudinal orientation
- Bound together with rays
- Higher strength and stiffness parallel to grain

Reference:
www.timber.org.au

Cell structure of both softwood and hardwood timber.

The essential difference between hardwoods and softwoods is the presence of vessels in hardwoods. These are continuous pipes running the length of the tree and serve as conduits for water and nutrients in the outer layers of wood in a growing tree. The actual cells in the softwood species have the same function as the vessels in hardwoods.

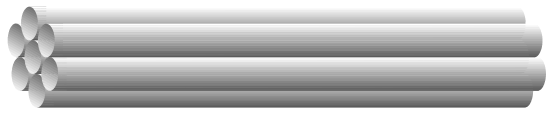
The diagrams show a number of important features of wood.

The cells constitute fibres and have the main direction of orientation in the longitudinal direction (parallel to the trunk of the tree).

The individual cells are stuck together rather weakly but parcels of longitudinal cells are bound together with a few cells that run transverse to the longitudinal axis of the wood. These are called rays.

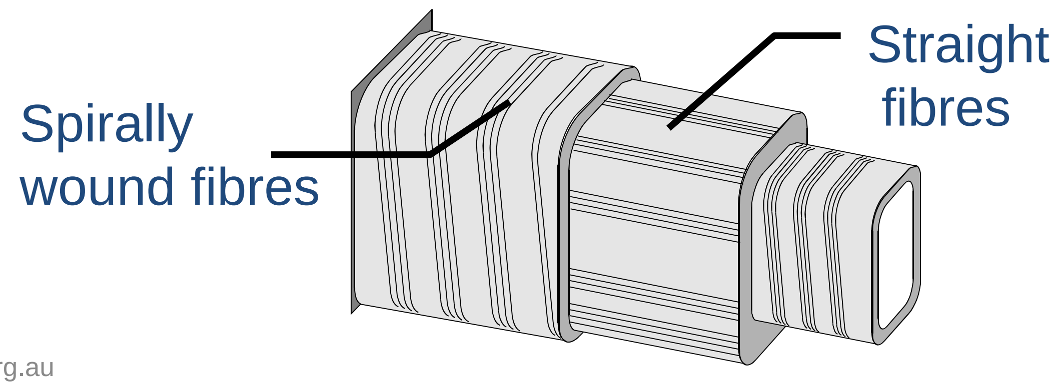
Reference:
www.timber.org.au

Cells



Chemical components of wood - products of photosynthesis

- *Cellulose* - network of molecules
  cell walls - microfibrils - fibrous
- *Lignin* - ‘gel’ - acts as bonding agent which ‘glues’ cells together
- *Hemicellulose* - cross linking - binds cellulose into the cell



Cells are composed of three main chemicals;

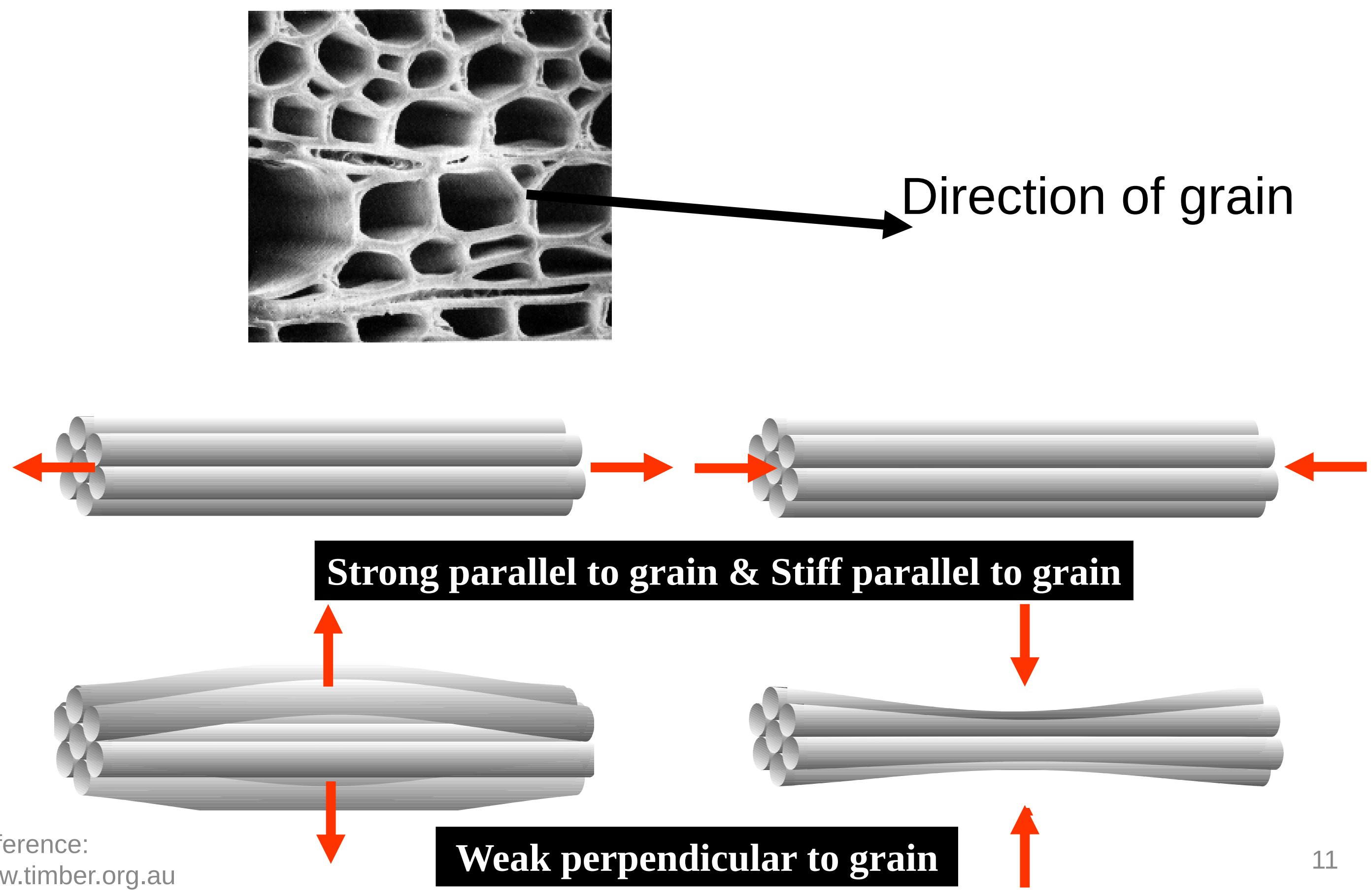
cellulose - a long chain polymer with the chains principally aligned with the long axis of the cell. In some parts of the cell wall, the cellulose is spirally wound.

lignin - glass-like substance that serves as the filler - like the resin in fibreglass. It is a brown colour.

hemicellulose is a cellulose-type molecule, but not as long as the main cellulose. It is a more mat-like molecule that is used to wrap up the cell.

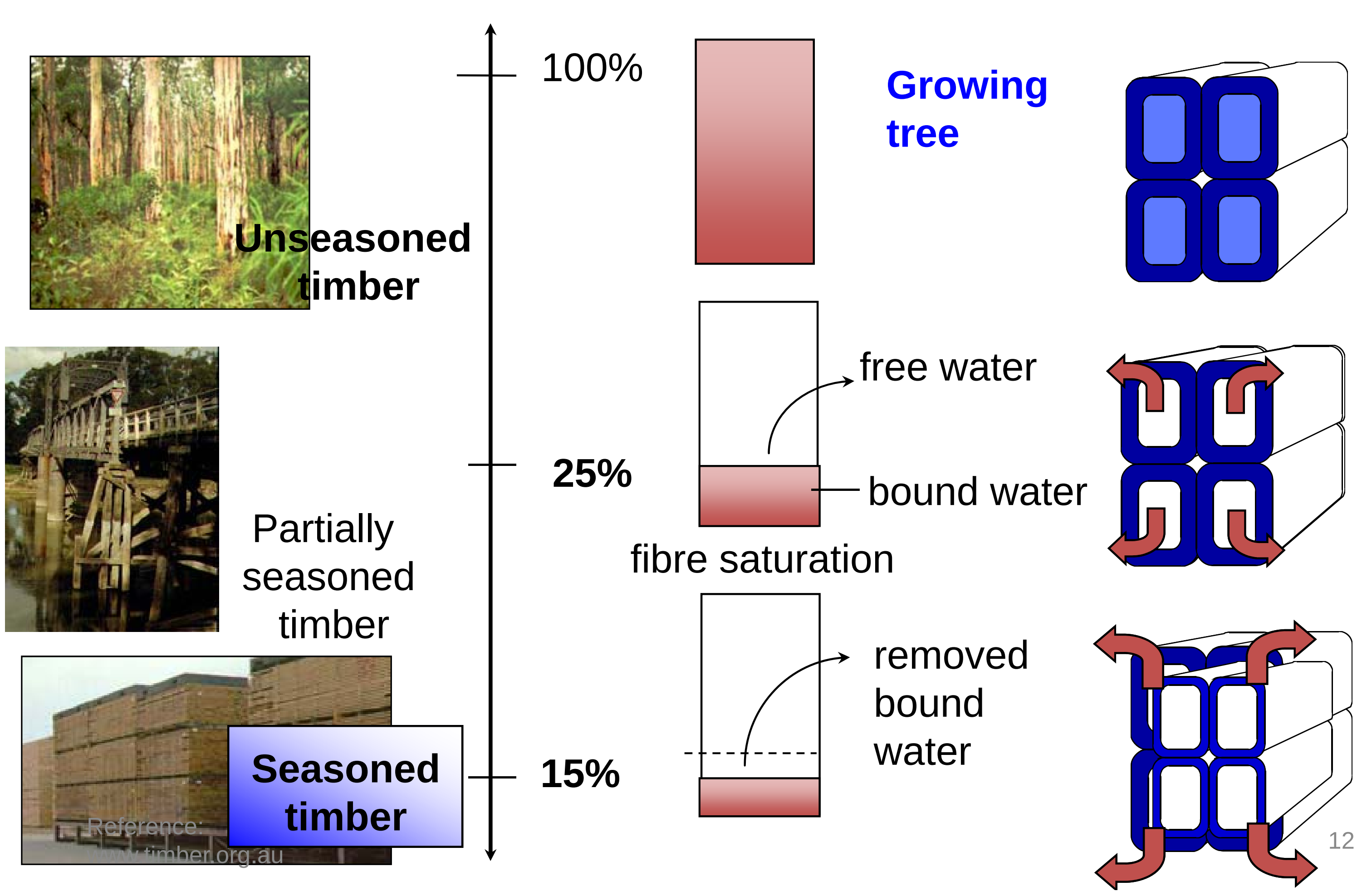
The main structural element is the cellulose which is very effective in transmitting tension or compression. The spiral winding of the cell gives buckling resistance to the cellulose that is parallel to the cell axis.
Cells are hollow tubes, so liquids can be taken into the wood along the cells much more easily than across the cells.

Direction of Strength and Stiffness



Reference:
www.timber.org.au

Moisture in Wood Cells



Reference:
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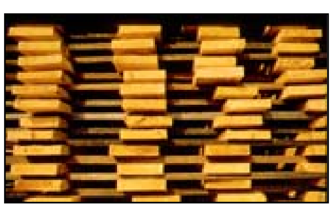
Moisture in Timber

- **Moisture content** (*mc*) = $\frac{\text{weight water}}{\text{weight wood}}$

  – in growing tree - *mc* = 50% to > 100%
  – felled tree - *mc* begins to decrease

- **Seasoning** - process of removing moisture from timber



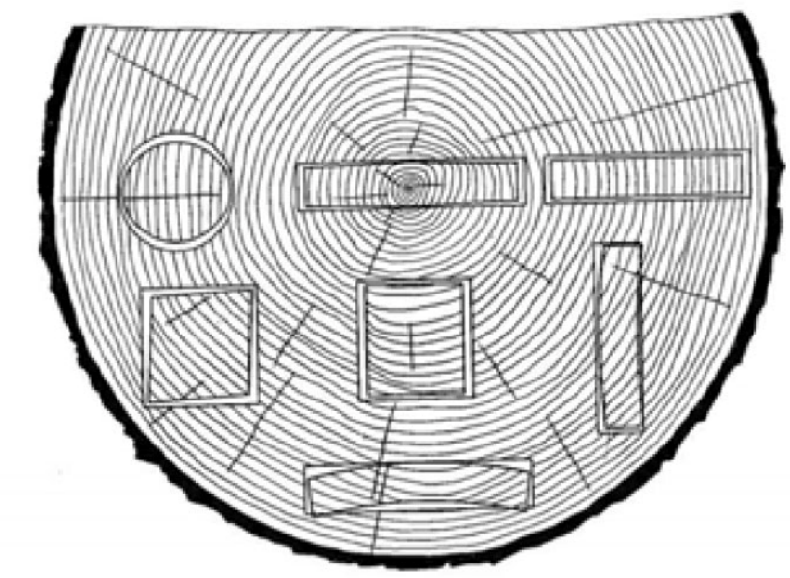
  - Kiln drying (steam, LPG gas, solar)
  - Air drying
  - Other - chemical, microwave.

Moisture in timber: When timber is growing in trees, the cells are all full of sap, water and extractives. Once the tree is felled, the moisture will start to move out of the wood. The first moisture to go is the free water - this is the water that is held in the voids of the cells. Once the moisture content is at **fibre saturation point**, (around 25%) all of the free water has gone and the remainder is bound water that is held in the structure of the cell walls.

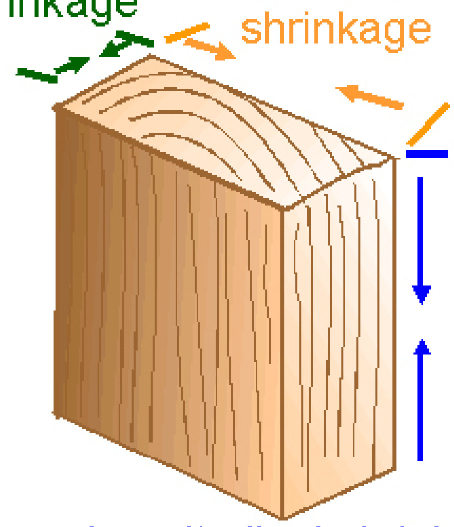
Seasoning is the process of removing moisture from timber. The aim is to remove the moisture at a uniform rate through the piece, so that there is a minimal moisture content differential within the piece. Where a large moisture content differential exists, then degradation of the timber can occur, causing twisting, cupping, checking, splitting, collapse, etc.

The most appropriate method of seasoning to use varies with species. However, the moisture content of the timber delivered is of importance in many applications.

Shrinkage



As wood dries below its fibre saturation point, it shrinks. Shrinkage is the reduction in dimensions of timber due to the movement of moisture out of cell walls of the wood.



- There is little change in the longitudinal dimension. There is virtually no shrinkage parallel to the length of a piece of timber
- Radial shrinkage is perpendicular to the growth rings
- Tangential shrinkage is in the direction parallel to the growth rings. It is always a little larger than the shrinkage in the radial direction.

Reference:
www.timber.org.au

Shrinkage

Shrinkage is a defect, and generally a natural defect, occurring during the seasoning process.

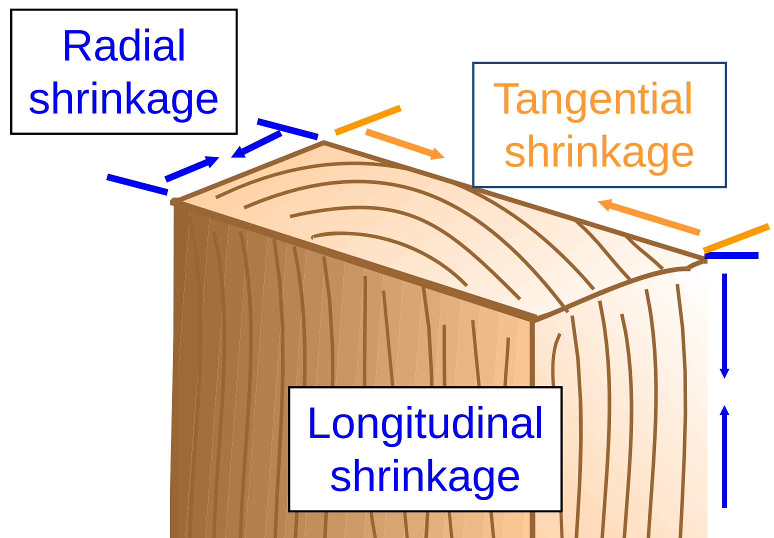
When timber is seasoning and it's moisture content (MC) is reduced below the Fibre Saturated Point (FSP) continued drying will cause dramatic change such as increase in strength but also distortion and shrinkage.

Shrinkage is the greatest tangentially over the radial direction with little loss along the length of the grains, etc.

Reference:
www.timber.org.au

Shrinkage

- Loss of moisture in range mc <25%
- Reduction in cell wall thickness
- Reduction in cross-sectional dimensions



Shrinkage from 25% to 12%

Softwood	Radiata Pine	Rad 3.5%	Tang 4%
	Hoop Pine	Rad 2.5%	Tang 3.5%
	Cypress	Rad 3.5%	Tang 4%
Hardwood	Spotted Gum	Rad 4.5%	Tang 6%
	Karri	Rad 4.5%	Tang 10%
	Sydney Blue Gum	Rad 5%	Tang 9%
	Grey Iron Bark	Rad 5.5%	Tang 7.5%
	Mountain Ash	Rad 6.5%	Tang 13%

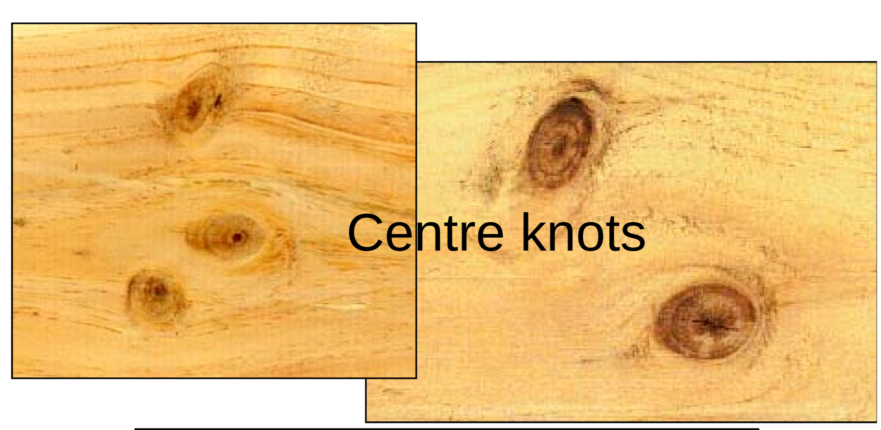
Reference:
www.timber.org.au

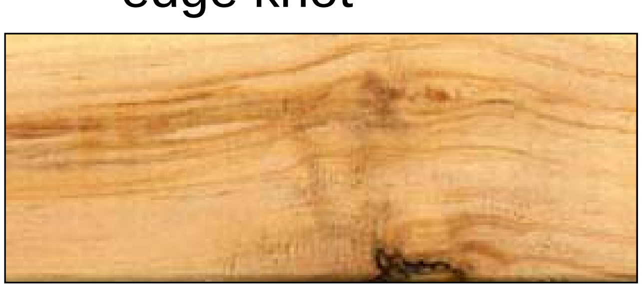
Natural features in Sawn Timber

Knots

contain weak juvenile wood,
cause slope of grain @ edge

edge knot





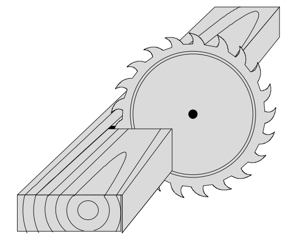
Arris knot

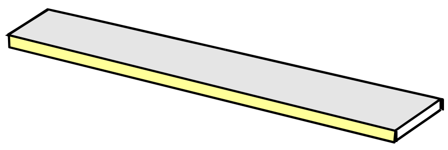
Slope of grain

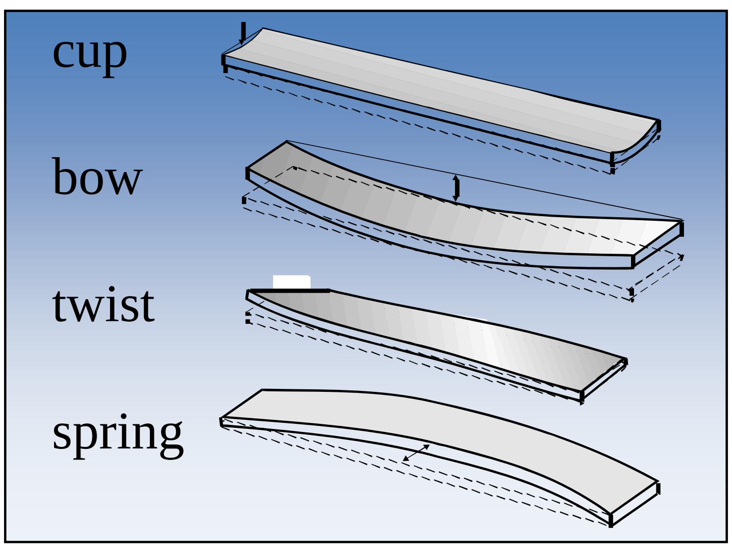
Especially at edges - low strength
perpendicular to grain decreases strength at angle to grain

Reference:
www.timber.org.au

Utility of Sawn Timber







- **Trees are prestressed**
- **Cutting boards from trunks causes stress relief & slow change in shape of boards**
- **Bent trees can cause slope of grain in products**
- **Spring is a problem for all timber**

Producers minimise problems by
- **good cutting practice**
- **quality control - grading**

Reference:
www.timber.org.au

Processing of timber can produce some problems for both structural performance and appearance. Modern sawing techniques can minimise the problems.

Cutting a board from part of a pre-stressed tree can cause residual stresses across the board. On drying these stresses are relieved by movement of the initially straight board which produces cup, bow, spring or twist.

> In general, **bow and cup** are not severe problems for structural timber as they can be removed by use of appropriate construction techniques and building layouts.
>
> **Spring** is difficult to remove in most applications. In most appearance
> uses, significant deviation from straightness is unacceptable.
> Most hidden structural timber really has little cause for restrictions on cup, bow or twist. Reasonably generous amounts of spring may be tolerated in some circumstances.

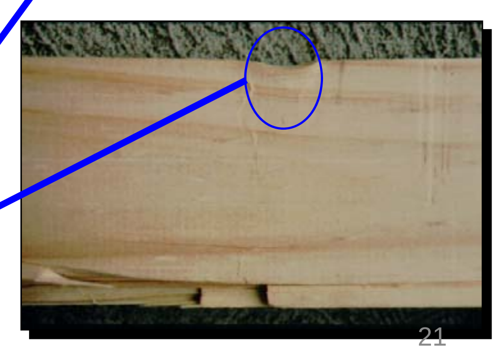
Many appearance applications require tight control over all of the utility limitations on timber.

Reference:
www.timber.org.au

Evaluation of Structural Properties

- **Small clear specimens** - data only reflects wood fibre strength
- For timber beams, we must reduce small clear strengths significantly to allow for strength reducing natural features

- **In-grade testing** - commercial sized timber under realistic loading conditions
- **Commercial timber**
  - tensile strength < compression strength
  - tensile failures - splintery, brittle, sudden, loud
  - compression failures - wrinkles, ductile, slow, quiet



Reference:
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Summary - Properties of Timber

- **Appearance:**
  - Colour, grain, features, smoothness of surface
  - Reflect species, growth patterns, history of tree
  - Specification: species, durability, appearance graded
- **Utility:**
  - Dimensional stability (shrinkage, twist, bow, cup, spring), surface hardness
  - Reflect stress changes with moisture loss, creep
  - Specification: moisture content (best close to equilibrium moisture content)
- **Structural:**
  - Strength (tension, compression, bending, shear, bearing) - stronger parallel to grain
  - Stiffness (MoE) - stiffer parallel to grain
  - Reflect grain structure, slope of grain, features in timber
  - Specification: structural grade and species

Reference:
www.timber.org.au

End

Properties Presentation