Wood Properties

Technology

Practical Lesson

Activity information

Level:	Junior secondary school Years 7 – 10
Duration:	Approximately 2 lessons
Preparation:	Collect two samples of timber
Summary:	Students will examine and compare the wood properties of different types of trees. They will learn how to measure the oven dried moisture content of wood in the laboratory, and be able to apply this knowledge when selecting appropriate uses for the timber.

Background information

According the Australian Bureau of Statistics, 66 000 people are currently employed in the forest, logging and wood manufacturing industry in Australia, where the annual monetary turnover of $22.3 billion accounts for 0.6% of Australia's Gross Domestic Product (DAFF, 2012). Most wood products are used in home building and construction, and are popular because they are a natural and renewable resource with good thermal and mechanical properties.

The major wood products we export are paper and paperboard, woodchips, sawn wood and panels. The major wood products produced in Australia include sawn timber, veneers, plywood, particle board and fibre board. Australian wood is harvested from both plantations (mainly exotic conifers and native eucalypts), and naturally occurring native forests (total annual harvest is 26.5 million m^3/yr).

Wood property measurements help to characterise the nature of the wood for determining how it is best used and what further processing may be necessary, and can include density, moisture, and mechanical, thermal, electrical and acoustic properties.

Density

Density is the mass of wood per unit of volume. It is important to note that the density of different types of wood is often below 1.0 g/cm^3 because the volume of a given sample of wood includes the cell walls as well as the air spaces in between.

Density g/cm^3 = [mass of wood] / [volume of wood]

Density and compressive strength of some common Australian woods

Common name	Type	Scientific name	Density (g/cm^3)	Compressive strength - seasoned (MPa)
Narrow Leaved Red Ironbark	Hardwood	*Eucalyptus crebra*	1.090	70
Lemon Scented Gum/ Spotted Gum	Hardwood	*Corymbia Maculata/ Corymbia Citriodora subsp. variegata*	1.010	75
Southern Blue Gum	Hardwood	*Eucalyptus globulus*	0.980	83
Karri	Hardwood	*Eucalyptus diversicolour*	0.829	72
Jarrah	Hardwood	*Eucalyptus marginata*	0.835	61
Silvertop Stringybark	Hardwood	*Eucalyptus laevopinea*	0.860	73
Qld Maple	Hardwood	*Flindersia brayleyana*	0.575	44
Tasmanian Oak/Victorian Ash (commonly referred to as Mountain Ash)	Hardwood	*Eucalyptus regnans*	0.700	70
White Cypress Pine	Softwood	*Callitris glaucophylla*	0.675	53
Monterey Pine	Softwood	*Pinus radiata*	0.545	42
Western Red Cedar NB species which is not grown in Australia. Instead its timber is imported.	Softwood	*Thuja plicata*	0.380	34

(Sources: Qld Qld Dept Agriculture, Forestry and Fisheries; WoodSolutions™; and *Forest Trees of Australia* by Boland et al, CSIRO Publishing)

Moisture

Water is present in wood in bound form to cellulose in cell walls, and as free water both inside cells and between cell cavities. Free water moves along the grain of the wood due to capillary action, while bound water moves as vapour due to changes in temperature, humidity and water content. When wood is dried, it is the free water that is removed, while the cell walls are still saturated and in balance with the surrounding atmosphere. Air dried wood tends to have around 12% moisture at 65% relative humidity and 21˚C.

Moisture content % = [(mass of water in wood) / (mass of oven dried wood)] x 100

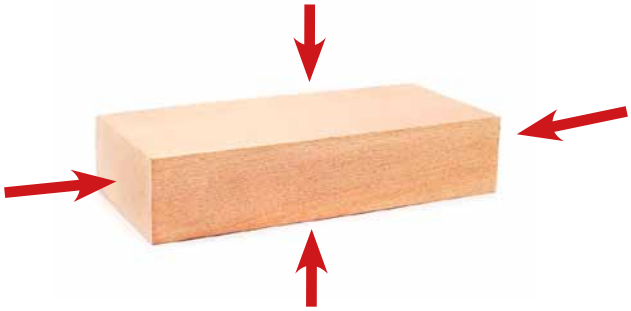
Shrinkage

After trees are felled, the wood begins to dry. Free water is the first to be lost until Fibre Saturation Point (FSP) is reached. Then bound water is lost from the cell walls until a condition known as Equilibrium Moisture Content (EMC) is reached, and depends on the relative humidity and temperature of the surroundings. Most shrinking in size occurs as the wood dries between FSP and EMC. When shrinking is uneven throughout the wood, problems such as warping, splitting and open joints can occur (see the following picture).

Shrinking problems can be minimised if drying is done slowly under controlled conditions such as ensuring constant relative humidity and temperature with even air circulation. Wood is seasoned to EMC levels appropriate for location and use of timber. This may be down to 6-8% in dry conditions such as western NSW, or as high as 15-18% in subtropical climates in coastal Qld; the Australian Standard requires timber to be seasoned within 10 -15% moisture range where conditions are ideal for resale to consumers.

Strength

This is a mechanical property measured by tension, bending and compression. Compression is defined as two forces or loads acting along the same axis, while either shortening a dimension or reducing the volume of the wood. It can be applied either parallel to the wood grain or perpendicular. Compressive strength is greater parallel to the wood grain. It is measured by the load a piece of wood can withstand at the end grain in Mega Pascals (MPa).



Compression

Tension

Tension is the action of two forces or loads along the same axis trying to lengthen a dimension or increase the volume of the wood. Tension is the strongest in parallel to the grain due to the longitudinal orientation of wood fibers.

Tension

Bending strength

This is the degree of deflection in wood under a given force or load without breaking. Stiffness on the other hand is the ability to regain shape after bending forces applied.

FACT

Wood is very resilient against bending compared to other building materials and is therefore very useful for making beams and joists, even for use in bridges that carry large trucks. Wood can take enormous compression against its grain, and this is why furniture legs for chairs are made along the grain to maximise strength.

Activity 1

Measure and compare the moisture level in green and seasoned wood samples

Preparation:

Watch the podcast on using the Oven Dry method for calculating wood moisture content to industry standard AS1080.1, presented by the University of Tasmania School of Architecture & Design at:

www.youtube.com/watch?v=_fW_IDwZLHE&feature=BFa&list=PL7757534EF9E14929

(a) Select two boards for sampling; one green wood (i.e. recently cut) and one seasoned (i.e. dried and ready for use in construction)

(b) Cut a sample from each board using a drop saw at least 400mm from the end. If the boards are less than 800mm, then cut samples from the centre. Sample sizes need to be 15 – 30 mm in size (Note: Use safety precautions such as safety glasses, eye and ear protection). Remove any loose shavings from the samples

(c) Weigh sample blocks and record

(d) Place samples in oven set at 101 - 105°C for 24hrs

(e) Weigh samples blocks after drying and record

(f) Calculate the moisture content for each type of wood using the formula.

$$\text{Moisture content \%} = \frac{\text{initial mass of wood (g)} - \text{dry mass of wood (g)}}{\text{mass of oven dried wood (g)}} \times 100$$

Results table

Sample	1	2
Initial mass of sample block (g)		
Oven dry mass of sample block		
Difference (initial minus oven dry mass)		
Moisture content (%)		

FACT

Green wood can have an oven-dried moisture content greater than 100%, particularly in low density softwoods such as pines, meaning that there is more water than mass of solid wood in the sample. Green wood is not used for construction, as it shrinks while it dries and alters its dimensions. Cutting and drying timber before use also helps to protect the wood against decay.

Questions

1. Explain what reasons there could be for the variation in moisture content between the two samples?

2. Explain why some timbers warp when they are dried?

3. How can warping be minimised when kiln drying timber?

4. Using information provided in the Table on page 2, discuss which type of timber, either hardwoods or softwoods, would withstand compression loads the best?

5. Draw a basic 3D design of a wood product. Include the direction of the wood grain to maximise compressive and tensile strength where it may be needed. Can you suggest a tree species that may be appropriate for making your product, giving reasons? (you may like to use one from the list in the Table on page 2)

 Written by Andrea Jane Leys PhD for Forest Learning