Design for durability

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Timber degradation

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Content

- Timber and its biodegradation
- Classification of hazards.
  - Hazard classes and hazard zones.
- Timber's natural and treated resistance to biodegradation.
- Associated materials

The nature of timber

- It is affected:
  - Weathering
  - Decay
  - Attack by insects and similar organisms.
  - Fire
- The impact of these breakdown mechanisms vary with the:
  - Exposure to hazard.
  - Nature of the wood

Weathering

- The greying and minor cracking of timber due to the *mechanical* or *chemical* breakdown of the wood surface by:
  - exposure to light, breaking down wood molecules
  - action of dust and sand, and
  - alternate shrinking and swelling due variation in moisture content.
- The effects are often limited to the surface.

A weathered fence post

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Weathering

- The rate depends on the exposure level
  - It is usually very slow
  - ~ 0.1 mm per year depending on species and board orientation.
- It affects:
  - appearance,
  - the performance of finishes; and
  - eventually, decay rate

Weathering of untreated and unfinished elements

Weathering

- Weathering can be more severe on end grain.
- Preservative treatment does not affect the weathering rate.

A weathered bridge deck element

Weathering

Decay

- Decay is the decomposition of wood by fungi.
- Fungi occur in a variety of forms, ranging from large fruiting bodies to microscopic moulds.
- To establish and sustain itself, the fungi need air, moisture and food.
- Decay can occurs if the wood
  - is available as food.
  - has access to oxygen.
  - Is above 20% MC.
  - temperature is between about 5° to 60°C.

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Decay

- Decay rates vary with:
  - The wood's character
  - Its moisture content
  - The ambient temperature.
- It occurs most readily in timber kept regularly moist,
  - Particularly in ground contact
- It can occur on any surface of a piece.
  - Decay tends to attack the moisture-permeable end-grain most vigorously.
- Decay hazard is often assessed above ground and in-ground contact.

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Decay: Absence of oxygen

- Wood in an anaerobic condition (i.e. without access to oxygen) lasts indefinitely
  - e. g. Kauri dug out from the ground after 10,000 to 50,000 years

45,000 year old surf board

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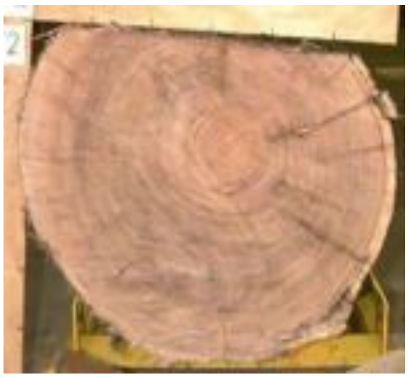
Moisture impacts



Bridge logs after ~ the same service life:
One exposed to the weather, the other protected by a water-proof deck.

Insects and other organisms

- Insects and similar organisms can consume timber.
- These include:
  - Subterranean termites;
  - Lyctid beetles; and
  - various marine organisms

Termites

Termite nest in a log

- Termites are cellulose-eating insects that occur in all parts of Australia.
  - They are rare in Tasmania and parts of Victoria
- Some species build and live in nests in the ground, in logs and in cavities in buildings and other locations, traveling to edible cellulose in moist earth galleries.

Lyctid beetles

- Lyctid moths lays their eggs in the vessels in the sapwood of susceptible hardwoods.
- Once hatched, the larvae eats the starch-rich sapwood.
- On maturity, the beetle leaves via an exit hole.
- Lyctid susceptible sapwood can be attacked at any time, even after years in service.
- Most standards limits its inclusion in timber elements.

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Lyctid beetles

Marine organisms

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Fire

- Wood burns in a fire.
- As it does, it develops an insulating carbon layer over its surface.
- Metallic fasteners can conduct heat or may fail.
- This charring layer is an insulator, reducing:
  - The temperature in unexposed wood,
  - the rate of loss of effective section.

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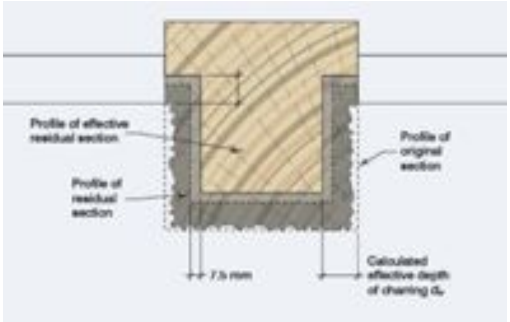
Fire



Rate of charring to AS 1720.4 is

$$C = 0.4 + (280/D)^2$$

where

C = notional charring rate in mm/min

D = timber density at 12MC in kg/m^3

Classification of hazards

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Hazards

- Hazards are defined in:
- ***Classes*** for the location in the building relative to hazards
- ***Zones*** for the intensity of the hazard relative to climatic and locational factors

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Hazard classes for timber

Hazard Class	Exposure	Service Conditions	Biological Hazard
H1	Inside above ground	Fully Protected, Well ventilated	Borers Only
H2	Inside above ground	Protected from Wetting, Nil leaching	Borers and termites
H3	Outside above ground	Moderate wetting and leaching	Decay borers& termites
H4	Outside in ground	Severe wetting & leaching	Severe decay, borers & termites
H5	Ground contact	Extreme wetting, leaching &/or critical use	Very severe decay, borers and termites
H6	Marine waters Nth & Sth	Prolonged immersion in sea water	Marine wood borers and decay

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H1: indoors, protected, ventilated

Aged Care residence, Tapping, WA
Photo: Geoff Boughton

Wall panels Hollybank Forest Centre , Tas
Photo: Greg Nolan

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H2: all internal use, poorly ventilated

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H3: above ground external use

Marina residence, SA
Photo: Greg Nolan

Queenscliffe Jetty, Vic.
Photo: Greg Nolan

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H4: in contact with dry ground

Play equipment, Geelong, Vic
Photo: Geoff Boughton

Hardwood walkway, Margaret River, WA
Photo: Geoff Boughton

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H5:in-ground, critical, subject to wetting

pole house, Townsville, Qld
Photo: Geoff Boughton

Nanga Camp, Dwellingup, WA
Photo: Geoff Boughton

Logging bridge, Pemberton, WA
Photo: Geoff Boughton

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H6: Marine use - prolonged immersion

Bussleton Jetty, WA
Photo: Geoff Boughton

Bussleton Jetty, WA
Photo: Geoff Boughton

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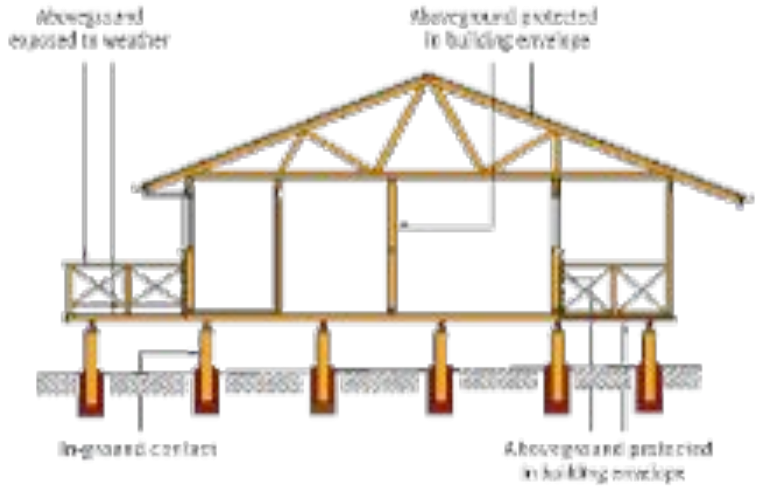
Decay zones



In-ground decay zones

Figure 4.1 IN-GROUND DECAY HAZARD ZONES FOR AUSTRALIA

FWPA 2010 Timber service life design guide

Above ground decay zones

Figure 5.2 ABOVE GROUND DECAY HAZARD ZONES FOR AUSTRALIA
(Zone D has the greatest decay hazard potential)

FWPA 2010 Timber service life design guide

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Termite hazard zones

Figure 7.1 TERMITE HAZARD ZONES FOR AUSTRALIA
(Zone D has the greatest termite hazard)

FWPA 2010 Timber service life design guide

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Resistance to degradation

Resistance to degradation

- Timber resists degradation through its natural durability and any applied treatment.
- Natural durability varies with species through:
  - The profile of extractives stored in wood. Some extractives are toxic to fungi and insects.
  - The cell structures. Some species allow certain insects to breed in the cells. Others do not.
- To simplify design, natural durability is rated in durability classes
  - in-ground contact and
  - above-ground
- With few extractives and a high starch content, all sapwood is rated as Class 4.

Life expectancy

Class	Probable in-ground life expectancy *(years)*	Probable above-ground life expectancy *(years)*	Species
1	Greater than 25	Greater than 40	Ironbark, Tallowwood
2	15 to 25	15 to 40	Spotted gum, Blackbutt, WRC
3	5 to 15	7 to 15	Brush box, Southern blue gum, Messmate
4	0 to 5	0 to 7	Vic ash, Radiata pine, Douglas fir

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.

Life expectancy – Marine

Class	Probable marine-borer-resistance life expectancy in southern waters (years)
1	Greater than 60
2	41 to 60
3	21 to 40
4	0 to 20, usually less than 5

* NOTE: Marine borer resistance is based on natural round piles containing 350 mm diameter of heartwood in southern seas reaching from Perth in the west to Batemans Bay in the east.

Only class 1 timbers can be expected to give reasonable service life (12 to 30 years) in northern waters.

Treatment

- Timber's natural durability can be improved by introducing treatment chemicals into the wood
- These protect it from fungi, insects and other biological agents.
- The level of protection is governed by the toxicity and amount of chemicals retained in the wood.
- The target retention of chemicals 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 chemical retentions in heartwood.

Major wood preservative treatments

- Insecticides and fungicides are applied by coating, dip diffusion or commercial pressure treatment:
  - for appearance timber to H2:
    - Water-borne mixtures applied to unseasoned timber.
    - Light organic solvent-borne preservatives (LOSP) applied to seasoned and finished product.
  - for structural timber to H5 – H6
    - Water borne mixtures like CCA, Tanalith E and ACQ applied to material for external applications.
    - LOSP surface insecticide treatment.

H2-S treated LVL

Treatment classes

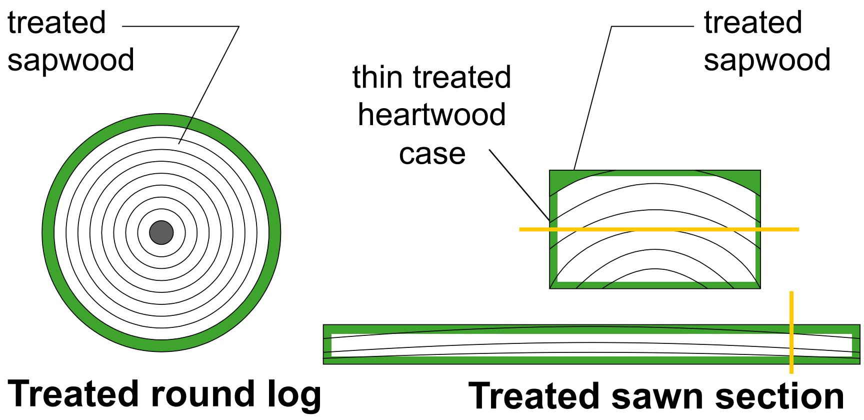
Class	Suitability	Biological hazard	
H1	suitable for H1 hazard environments – **indoors, protected**	Borers Only	
H2	suitable for H2 hazard environments – **suitable for all internal use**	Borers and termites	
H3	suitable for H3 hazard environments – up to **above ground external use**	Decay borers& termites	
H4	suitable for H4 hazard environments – up to **in contact with dry ground**	Severe decay, borers & termites	
H5	suitable for H5 hazard environments – up to **all in-ground uses**	Very severe decay, borers and termites	
H6	suitable for H6 hazard environments –up to **marine uses**	Marine wood borers and decay	

Major conventional treatment

TYPE		HAZARD LEVEL					
		H1	H2	H3	H4	H5	H6
Water	Boron	☺	☺				
	CCA	☺	☺	☺	☺	☺	☺ (1)
	Copper Azole	☺	☺	☺	☺	☺	
	ACQ	☺	☺	☺	☺	☺	
Solvent	LOSP	☺	☺	☺			
Double	CCA + Creosote						☺

(1) Southern waters only

Penetration after treatment



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Treatment really only benefits sapwood

The wood's permeability *really* does limits the treatment's effectiveness. Heartwood is very hard to treat reliably, especially in hardwood. This is due to its cell structure.

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All materials deteriorate over time

Steel: rust
Concrete: concrete cancer
Aluminium: corrode

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Steel rusts

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Steel rusts

Concrete cancer

Summary

- The major forms of timber degradation are weathering, decay, attack by insects and similar organisms and fire.
- Hazards are defined in classes (1-6) and zones (A–D).
- Timber's natural durability above and in-ground contact is defined in classes (1-4).
- Timber's treated durability is defined by chemical retention sufficient to resist hazard classes (1-6).
- Fire resistance is directly related to density.
- Associated material deteriorate to their own vulnerabilities.