Timber Durability & Preservation

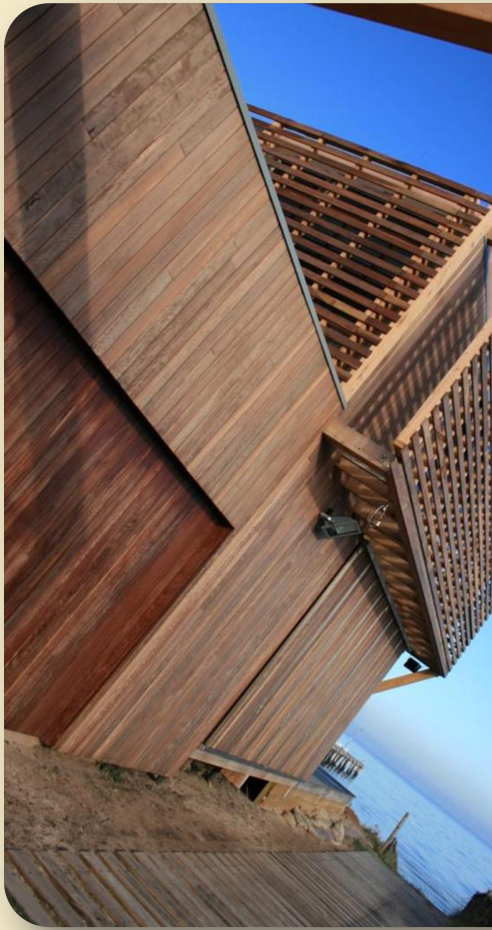
Building Designers Association Victoria

Wood Solutions

This Presentation

Designing for Durability

- Design Process
- Design for Decay (Fungal Attack)
- Weathering
- Finishing
- Good Design Practice
- Design for Insect Attack
- Design for Corrosion



Seaford SLSC
Photo Tait Timbers

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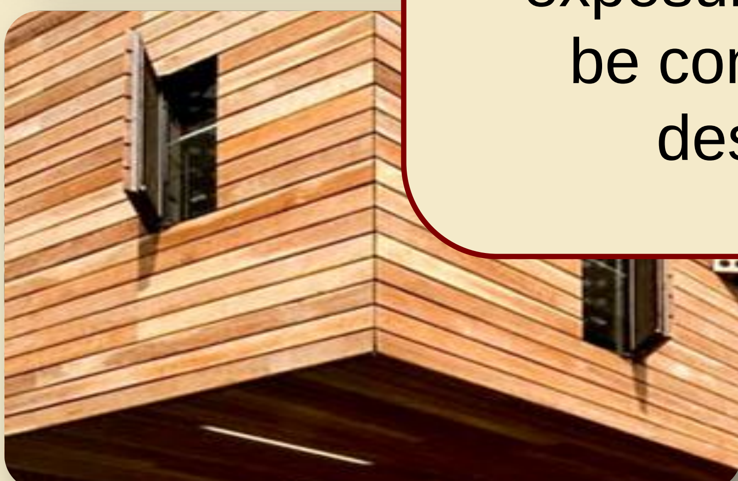
Construction Framing

Fit-out & Finishes

Different applications have different levels of exposure that need to be considered and designed for



External Cladding

Public Infrastructure

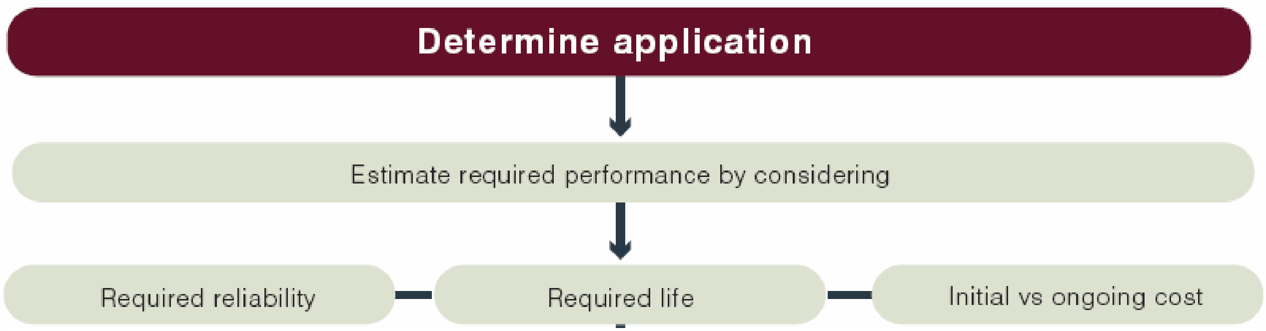
Design Guide for Durability

By carefully considering the key factors affecting timber's durability, timber structures can be designed that meet or exceed their needs and expectations.

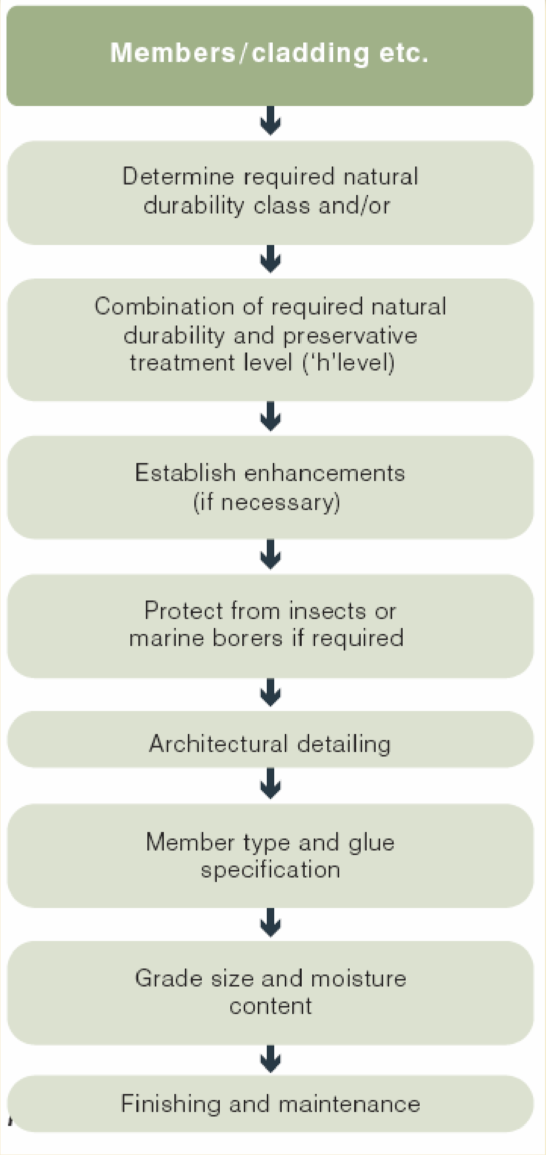
Technical Design Guide based on:

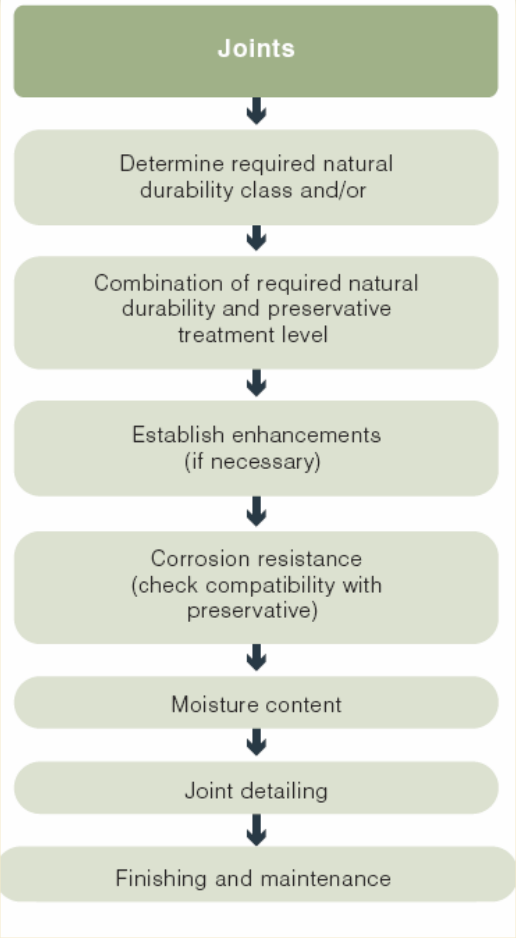
- 12 Years of research (1995 - 2007)
- $ 4.0+ million (cash plus in-kind)
- 12 Researchers including:-
  - engineers
  - micro biologists
  - entomologists
  - pathologists
  - metallurgists

Design Process

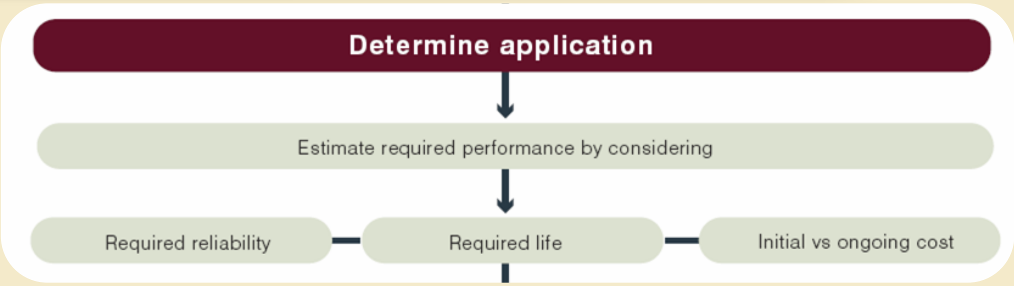


Design Process (cont.)





Design Process



- **Performance** requirements you need to consider:
  - **Required level of reliability** (life safety, cost or consequence of failure)
  - **Target life expectancy** (minimum regulatory, standards or contractual requirements)
  - **Costs** (initial vs. ongoing maintenance, repair or replacement costs)
- In the context of building regulations, the Building Code of Australia (BCA) does have implicit durability performance expectations
  - (see "Durability in Buildings – Handbook, 2006" at www.abcb.gov.au)

Design Process: BCA Design Life Guideline

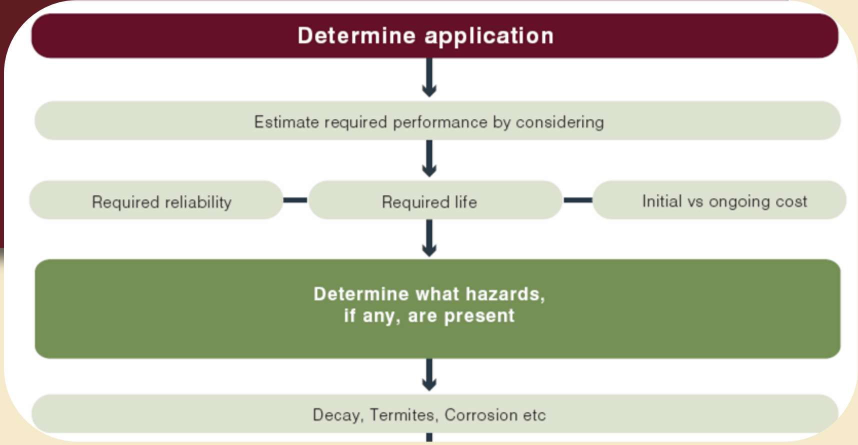
Table 2.1: BCA Durability Design Life Guideline.

Design life of building (dl) (years)		Design life of components or sub-systems (years)		
		Category		
Category	No. of years	Readily accessible and economical to replace/repair	Moderate ease of access but difficult or costly to replace or repair	Not accessible or not economical to replace or repair
Short	$1<dl<15$	5 or dl (if $dl<5$)	dl	dl
Normal	50	5	15	50
Long	100 or more	10	25	100

Note: Houses are considered normal, with respective design life requirements of 5, 15 and 50 years.

As can be seen from the above table, for normal buildings, the design life for most structural timber members would be 50 years and for moderately accessible members 15 years.

Timber Hazards



From a durability perspective,
the main hazards that need to be considered are:-

- Decay (fungal attack): in-ground and above ground
- Weathering
- Insect attack (incl. termites)
- Corrosion (of fasteners)
- Marine borers
- Chemical degradation (not usually an issue)

Above ground durability trials, Beerburrum QLD

Decay (Fungal Attack)

Decay: Causes

For fungi to thrive they need:

- Moisture: > 20% MC in wood; and
- Oxygen ;
- Temperature >25^{o}C to <40^{o}C (ideal); and
- Food (sapwood of timber high in sugars & carbohydrates)

Removal of any of these four conditions will prevent fungal attack, however in practice **'removal of moisture'** requires greatest consideration

In-ground durability trials 'Wedding Bells', Nth NSW

Decay: Absence of Causes Example

- Wood in an anaerobic condition (no oxygen) last forever
  - Example: Kauri dug out from the ground. Age of Kauri from 10,000 to 50,000 years old

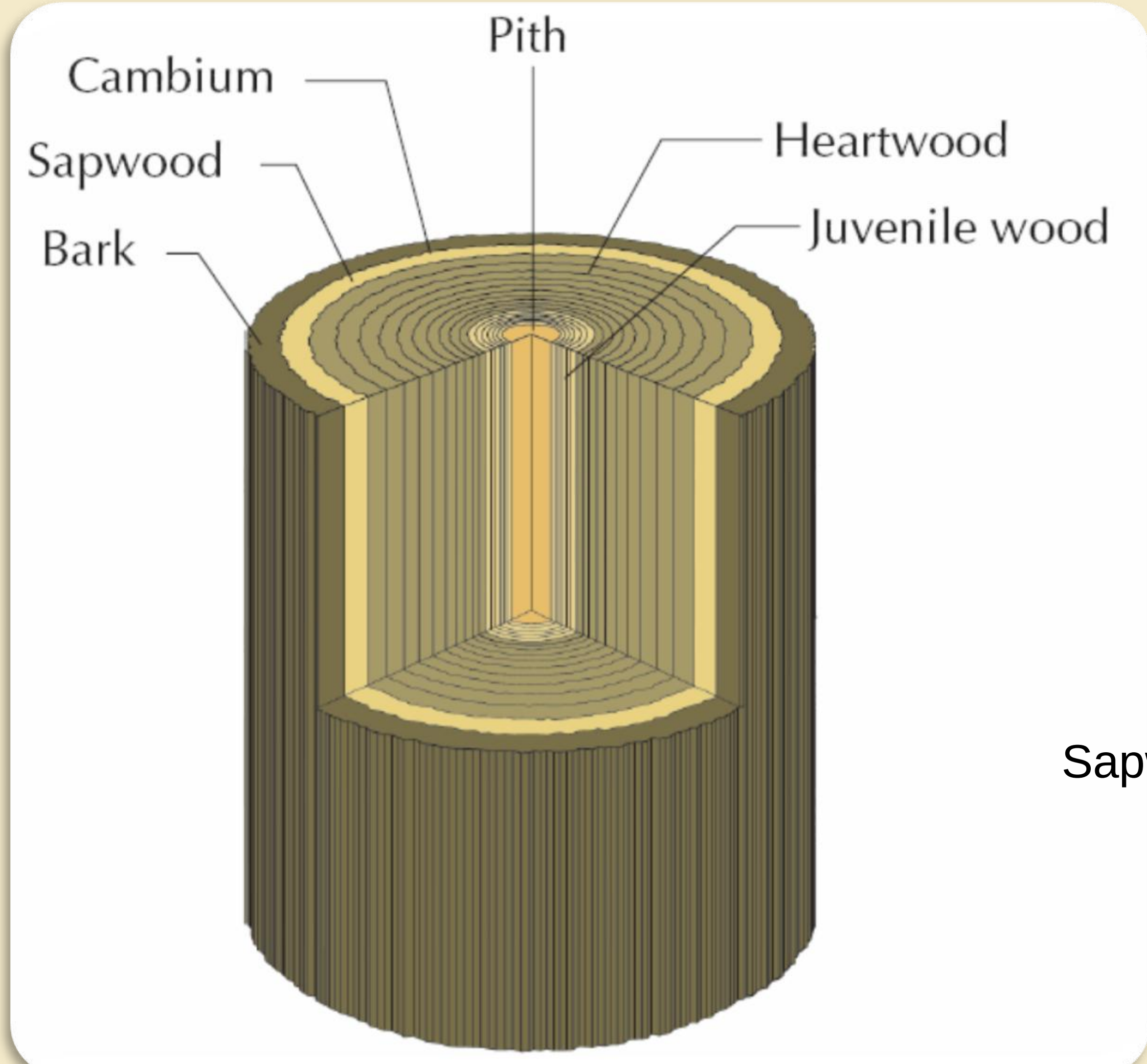
45,000 year old surf board

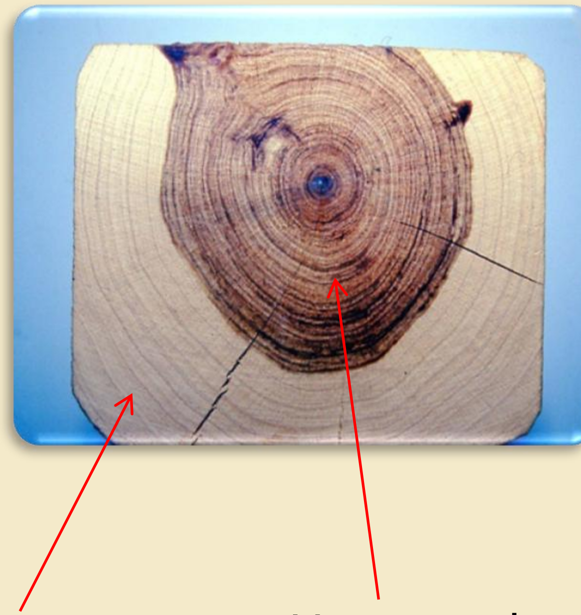
Decay: Protection

Timber is best protected from fungal action by:

- eliminating contact with moisture (coating); or
- using species with a 'natural durability' appropriate to the application; or
- by using timber that has been preservative treated to a level appropriate to the hazard *(i.e. the nutritional source for the fungi is negated by insertion of a preservative) .*

Natural Durability – relates only to heartwood





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Natural Durability Classes

Natural durability (Relates to heartwood only)

Natural durability Class	Probable heartwood life expectancy (years) AS 5604		
	Inside above ground (Fully protected from weather and termites)	Outside above ground	In-ground contact
Class 1 Highly durable	50+	40+	25+
Class 2 Durable	50+	15 to 40	15 to 25
Class 3 Moderately durable	50+	7 to 15	5 to 15
Class 4 Non-durable	50+	0 to 7	0 to 5

AS 5604 Timber – Natural Durability Ratings

Natural Durability: In-ground

In-ground

Natural durability class	Species
Class 1	Ironbarks, Tallowwood, Turpentine, Coast Grey Box
Class 2	Spotted Gum, Blackbutts, Cypress, River Red Gum, Jarrah
Class 3	Brush Box, Sydney Blue Gum, Rose/Flooded Gum, Western Red Cedar, Keruing, Messmate, Karri, Stringybarks, Silvertop Ash
Class 4	Radiata Pine, Hoop Pine, Slash Pine Douglas Fir (Oregon), Tasmanian Oak, Mountain & Alpine Ash / Vic ash, Meranti, Baltic Pine, Unidentified timbers, Sapwood of any species

In-ground durability trials 'Wedding Bells', Nth NSW

Natural Durability: Outside above-ground

Outside above-ground

Natural durability class	Species
Class 1	Ironbarks, Tallowwood, Turpentine, Coast Grey Box, Cypress, River Red Gum, Spotted Gum, Blackbutt, Kwila (Merbau)
Class 2	Rose Gum, Jarrah, Silvertop Ash, Western Red Cedar, Sydney Blue Gum, Stringybarks, New England Blackbutt
Class 3	Brush Box, Rose/Flooded Gum, Keruing, Messmate, Karri, Silver-topped Stringybark, Mountain & Alpine Ash / Vic ash, Tasmanian Oak, Kempas, American White Oak
Class 4	Radiata Pine, Hoop Pine, Slash Pine Douglas Fir (Oregon), Meranti, Baltic Pine, Unidentified timbers, Sapwood of any species

Photo Tait Timbers

Why treat with preservatives?

- Extends the life of timber against borers, termites and decay
- Sapwood has less natural resistance to insect attack and fungal decay than the heartwood of the same species
- Only the sapwood can effectively be treated
- Treating timber improves reliability and provides a calculable service life

CCA treated sapwood outperforming durability Class 2 heartwood

Preservative treatment

Hazard Levels

- Select the level of treatment (H level) required to cope with the environment in which the timber will be used
- H level corresponds to the biological hazard and exposure to the environment

Treated pine framing

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Preservative treatment

AS 1604.1 Hazard Levels

HAZARD LEVEL	EXPOSURE	BIOLOGICAL HAZARD	TYPICAL APPLICATIONS
H1	**Inside, above ground, protected from wetting**	Borers only	Framing, furniture, flooring
H2	**Inside, above ground, protected from wetting**	Borers and termites	Framing, roof trusses, beams, interior battens, flooring
H3	**Outside, above ground, subject to moderate wetting**	Moderate fungal decay and termites	Weatherboard, fascia, pergolas (above ground), window joinery, decking boards, decking bearers & joists
H4	**Outside, in-ground subject to severe wetting**	Severe fungal decay, borers and termites	Fence posts, greenhouses, pergolas (in ground) and landscaping timbers e.g. garden walls, beds and edging
H5	**Outside, in-ground and contact with or in fresh water, subject to extreme wetting**	Very severe decay, borers and termites	Structural retaining walls, piling, house stumps, building poles
H6	**Marine waters, immersed in sea water**	Marine borers and decay	Boat hulls, marine piles, jetty cross-bracing, landing steps

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Preservative treatment

Types of preservatives

- Water-borne (CCA, ACQ - Alkaline Copper Quaternary)
  - Landscape, fencing, decking, framing, outdoor timber
  - In-ground and above ground applications

- LOSP (light organic solvent preservatives)
  - Joinery, handrails, framing
  - Above ground applications only

- Envelope treatments (blue-pine framing - synthetic pyrethroid)
  - H2F framing south of tropic only

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Preservative treatment

Types of preservatives

Creosote treated poles

- Oil-borne (Creosote)
  - Power poles, marine, vineyard sticks
  - In-ground or in water use
- Supplementary brush/spray/dip (e.g. copper naphthenate)
- Glue-line
  - LVL, plywood, particleboard flooring
  - Hazard level H2S (south of Tropic of Capricorn only)

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Decay- Estimating Structural Life

Timber products use ‘In-Ground’ contact

To estimate the service life a timber species has, use the following procedure:

1. Determine the **natural durability** class in-ground from Table 4.1.
2. Determine the **structure location zone** from Figure 4.1.
3. Determine the **typical service life** for **various applications** and combinations of timber, cross sections, treatments and natural durability from Tables 4.2 to 4.13
   - *Round poles (Tables 4.2 – 4.5)*
   - *Square posts (Tables 4.6 – 4.9)*
   - *Rectangular posts (Tables 4.10 – 4.13)*

Decay- Estimating Structural Life

Timber products use ‘In-Ground’ contact

1. Determine the natural durability class in-ground from Table 4.1.

Table 4.1: Timber natural durability classification for in-ground decay.

Trade name	Botanical name	In-ground durability class
Ash, alpine	*Eucalyptus delegatensis*	4
Ash, Crow’s	*Flindersia australis*	1
Ash, mountain	*Eucalyptus regnans*	4
Ash, silvertop	*Eucalyptus sieberi*	3
Balau (selangan batu)	*Shorea* spp.	2
Bangkirai	*Shorea laevis*	2
Beech, myrtle	*Nothofagus cunninghamii*	4
Belian (ulin)	*Eusideroxylon zwageri*	1
Blackbutt	*Eucalyptus pilularis*	2
Blackbutt, New England	*Eucalyptus andrewsii*	2

Decay- Estimating Structural Life

Timber products use ‘In-Ground’ contact

2. Determine the structure location zone from Figure 4.1.

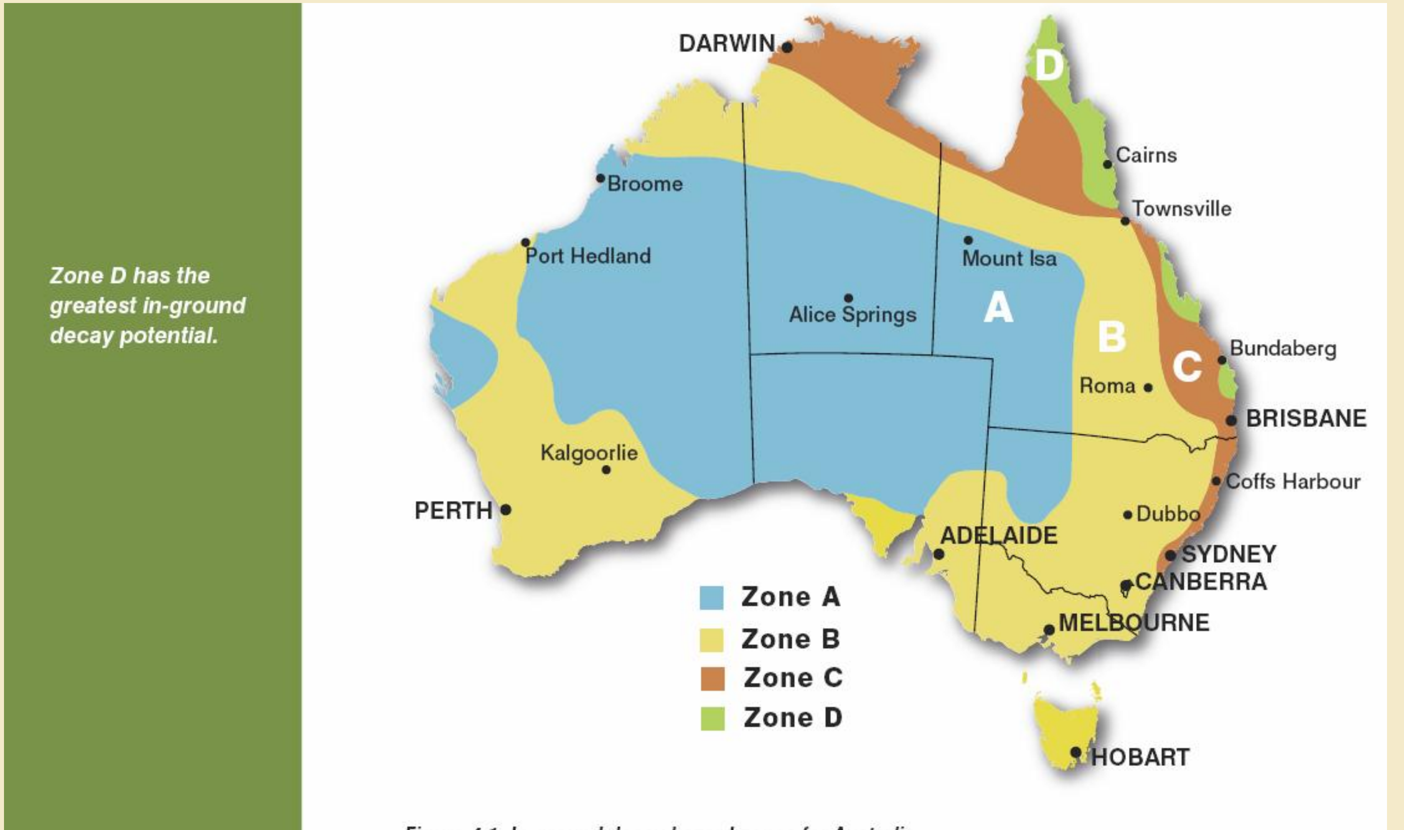

Figure 4.1: In-ground decay hazard zones for Australia.

Melbourne

Zone B

Decay- Estimating Structural Life

Timber products use ‘In-Ground’ contact

3. Determine the typical service life for various applications and combinations of timber, cross sections, treatments and natural durability from Tables 4.2 to 4.13.

Melbourne

Zone B

Table 4.7: Typical service life of square posts against in-ground decay in Zone B.

Timber type	In-ground durability class[1]	Treatment[2]	Typical service life (years)			
			100 x 100 (mm)	150 x 150 (mm)	200 x 200 (mm)	250 x 250 (mm)
Treated softwood full penetration[3]	4	H4	50	60	70	80
		H5	80	90	>100	>100
Treated softwood 80% penetration[4]	3 and 4	H4	15	20	30	30
		H5	15	20	30	35
Untreated hard-wood[3]	1	—	30	40	45	50
	2	—	15	20	20	25

Notes:

1. See Table 4.1.

2. As per AS 1604.1 for CCA and creosote.

3. It is assumed that preservative treatment penetrates full cross-section.

4. It is assumed that 20% of cross-section is not penetrated by preservative treatment.

Decay- Estimating Structural Life

Timber products used ‘Above-Ground’ exposed to the weather

To estimate the service life a timber species has, use the following procedure:

- Determine the **natural durability** class for the species ‘above ground’ from Table 5.1.
- Determine the **decay hazard zone** for the application from Figure 5.2.
- Determine the **service life for various applications** (Figures 5.3 to 5.7) and combinations of timber, cross sections, treatments and natural durability from Tables 5.2 to 5.11.
  - *Fencing (5.1.1)*
  - *Domestic Decking (5.1.2)*
  - *Commercial Decking (5.1.3)*
  - *Pergolas & similar applications (5.1.4)*

Decay- Estimating Structural Life

Timber products used 'Above-Ground' exposed to the weather

1. Determine the natural durability class in-ground from Table 5.1.

Table 5.1: Timber classification for above-ground decay.

Trade name	Botanical name	Above-ground durability class
Ash, alpine	*Eucalyptus delegatensis*	3
Ash, Crow's	*Flindersia australis*	1
Ash, mountain	*Eucalyptus regnans*	3
Ash, silvertop	*Eucalyptus sieberi*	2
Balau (selangan batu)	*Shorea* spp.	1
Bangkirai	*Shorea laevis*	1
Beech, myrtle	*Nothofagus cunninghamii*	3
Belian (ulin)	*Eusideroxylon zwageri*	1
Blackbutt	*Eucalyptus pilularis*	1
Blackbutt, New England	*Eucalyptus andrewsii*	2

Decay- Estimating Structural Life

Timber products used ‘Above-Ground’ exposed to the weather

2. Determine the structure location zone from Figure 5.2.

Zone D has the greatest decay hazard potential.

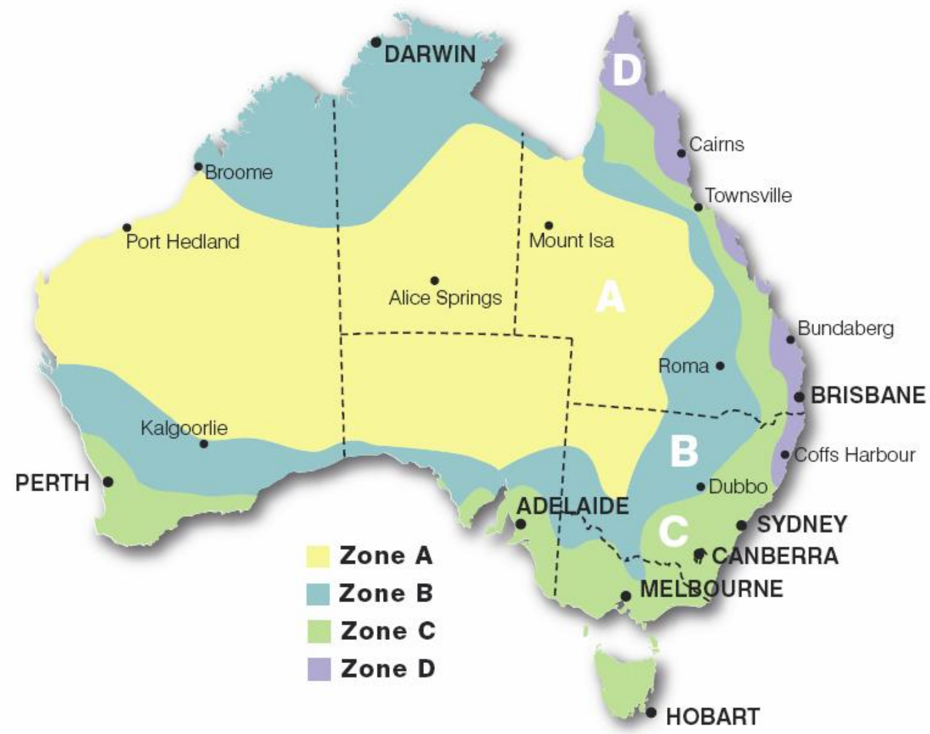

Figure 5.2: Above ground decay hazard zones for Australia.

Melbourne

Zone C

Decay- Estimating Structural Life

Timber products used 'Above-Ground' exposed to the weather

3. Determine the typical service life for various applications and combinations of timber, cross sections, treatments and natural durability from Tables 5.2 to 5.11.

    - *Fencing (5.1.1)*
    - *Domestic Decking (5.1.2)*
    - *Commercial Decking (5.1.3)*
    - *Pergolas & similar applications (5.1.4)*

Decay- Estimating Structural Life

Timber products used **‘Above-Ground’** – Domestic Decking

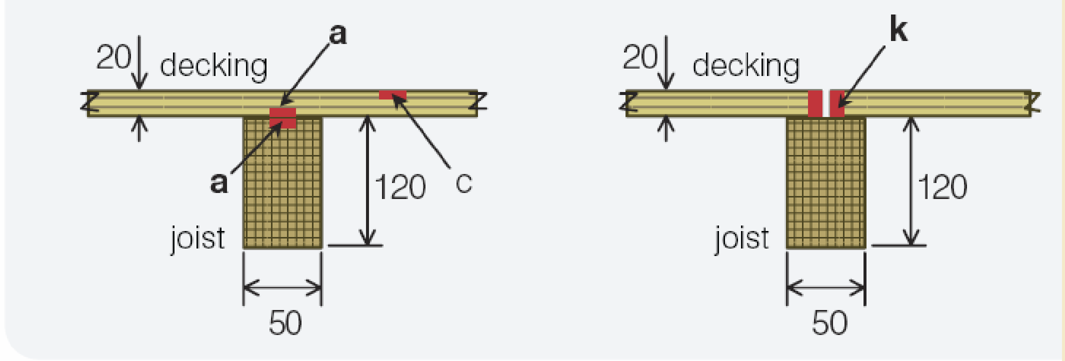

Figure 5.4: Typical dimensions of decking and locations of interest for service lives.

Decay in untreated sapwood

Table 5.4: Typical service life for onset of decay in decking. *(See Fig. 5.4 for location in the assembly.)*

Climate zone	Timber type	Above-ground durability class[1]	Treatment[2]	Typical service life (years)		
				a	c	k
C	Treated sapwood	all	H3	40	50	40
	Untreated heartwood	1	—	20	25	20
		2	—	15	20	15
		3	—	9	10	9
		4	—	5	7	5
	Untreated sapwood	all	—	2	3	2

Decay- Estimating Structural Life

Timber products used

‘Above-Ground’

– Pergolas

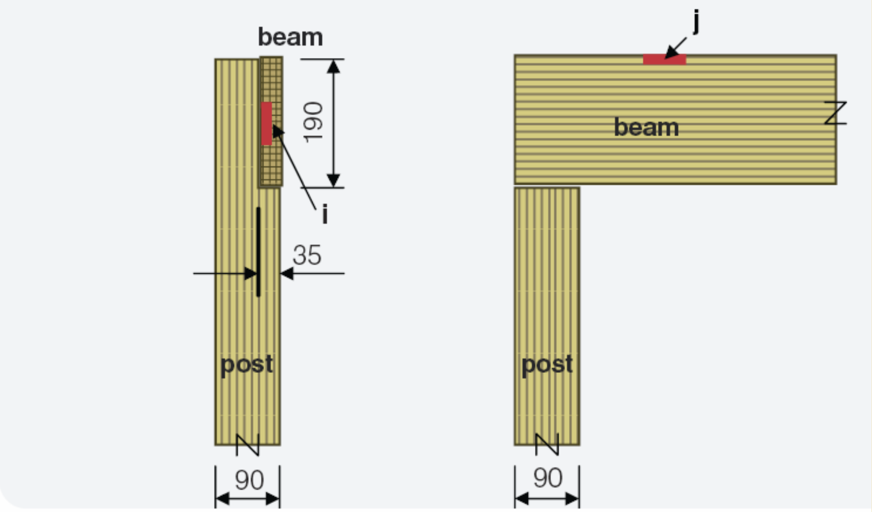

Figure 5.6: Typical dimensions of pergola and locations of interest for service lives.

Table 5.8: Typical service life for onset of decay in pergolas. *(See Fig. 5.6 for location in the assembly.)*

Climate zone	Timber type	Above-ground durability class(1)	Treatment(2)	Typical service life (years)	
				i	j
C	Treated sapwood	all	H3	30	50
	Untreated heartwood	1	—	15	25
		2	—	15	20
		3	—	8	10
		4	—	4	7
	Untreated sapwood	all	—	2	3

Insect Attack

Insects

The main insects that are of commercial significance to timber's durability performance are:-

- Lyctus beetles, and
- Termites

Lyctus beetles only attack the sapwood of some susceptible hardwood species.

Termites can attack any cellulose based materials.

Termite damage to a timber stump

Insects: Termites

- Termites can also damage plasterboard, carpets, plastics, books, artwork, clothing and fitout timbers.
- A CSIRO study found that steel and masonry houses had virtually the same chances of attack as timber houses.
- The key priority is to provide a 'system that addresses the whole of the house', not just the structural elements.
- This usually consists of a barrier system built into the construction that is designed to assist termite inspections once the house is occupied.

Insects: Termites

There are two types of termites that can cause commercial damage to timber

- Drywood termites
  - Do not require contact with the ground. They are present from Cooktown (QLD) to further north. The use of naturally termite resistant or preservative treated timber should be used where drywood termites are prevalent.
- Subterranean termites
  - Are by far the most significant insect pest for timber. They require contact with the ground (for moisture), therefore a range of termite management options are available including isolation from the ground.

Insects: Termite Protection

- The Building Code (BCA) requires termite protection for buildings in designated termite prone areas.
- Where termite prone is designated, the BCA provides two options, either:
  - Use of termite resistant materials for all ‘primary structural elements’ or
  - Provision of ‘barriers’ in accordance with *AS 3660.1 Termite Management* which provides options and combinations of options including *isolation, termite shields, physical and chemical soil barriers*

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Insects

- Effectively all States/Territories except Tasmania and some Victorian local government authorities, are designated termite prone areas
- Termites are more active and prevalent in northern regions of Australia.
- The potential risk of attack varies according to the location of the house in Australia and site specific features of the local environment.

Insects: Termite Hazard Zones

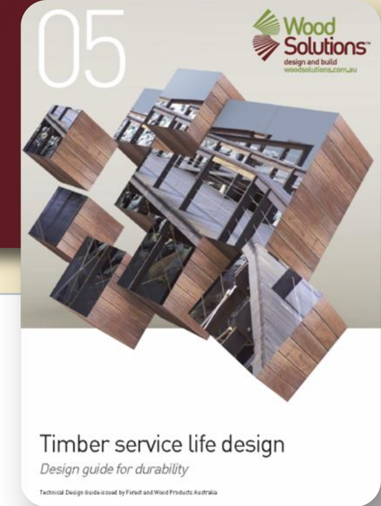


Figure 7.1 Termite hazard zones for Australia (Zone D has the greatest termite hazard)

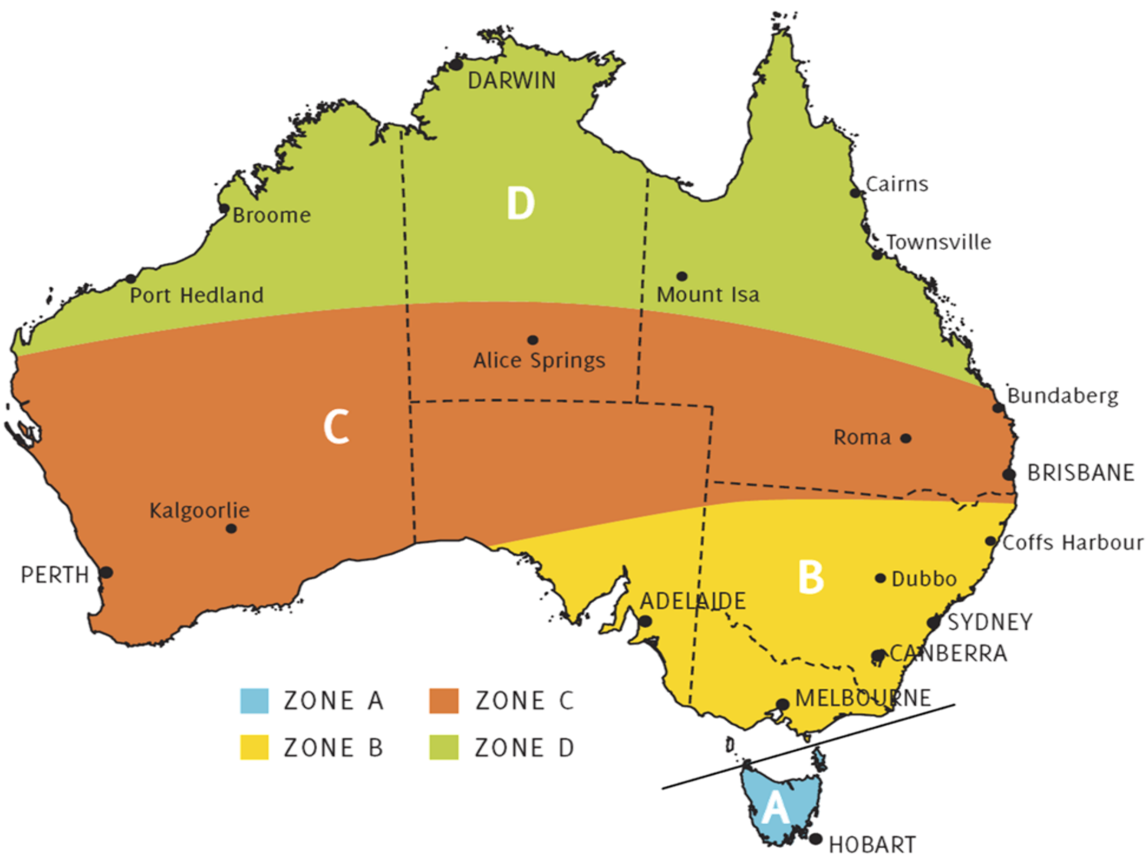


Table 7.1: Hazard score for location zone.

Location Zone	Hazard score
B	0
C	2
D	4

Currently, Tasmania does not have subterranean termites which damage houses, and accordingly termite management measures are not warranted there.

Insects: Evaluating Hazard Score

Table 7.8: Evaluation of hazard score total.

Hazard factor	Hazard score
Location zone	**0**
Age of suburb	**2.0**
Distance to built-up suburbs	**0.5**
Food sources	**0.5**
Ground contact	**0**
Construction material	**1.0**
Environmental conditions	**0**
Hazard score total = 4.0	

For the example given above (highlighted in yellow), a Total Hazard Score of 4 was obtained. The highlighted areas of Table 7.9 show the termite strategies that, if adopted, will provide at least the apparent risk of attack than is currently considered acceptable in Australia.

Insects: Evaluating Hazard Score

For the example a Total Hazard Score of 4 was obtained.

The highlighted areas (in yellow), of Table 7.9 show the termite strategies that, if adopted, will provide **a significantly lower apparent risk of attack** than is currently considered acceptable in Australia.

Note – all systems rely on some level of regular inspection

Table 7.9: Specification of termite management requirements.

Barrier type(1)	Period between inspections (yrs)(2)	Period between treatments (yrs)(3)	Maximum acceptable hazard score total
Graded crushed stone	<1	-	9.5
	1-5	-	7.5
	>5	-	3.5
Stainless steel mesh	<1	-	10.0
	1-5	-	8.0
	>5	-	4.0
Toxic chemical	<1	T_m	no limit
		$2T_m$	no limit
		$>8T_m$	10.5
	1-5	T_m	13.5
		$2T_m$	10.5
		$>8T_m$	7.5
	>5	T_m	6.5
		$2T_m$	5.0
		$>8T_m$	4.0
Repellant chemical	<1	T_m	14.0
		$2T_m$	11.0
		$>8T_m$	8.5
	1-5	T_m	9.5
		$2T_m$	8.0
		$>8T_m$	6.5
	>5	T_m	5.0
		$2T_m$	4.0
		$>8T_m$	3.5
No barrier(4)	<1	-	5.5
	1-5	-	4.0
	>5	-	2.5

Notes:

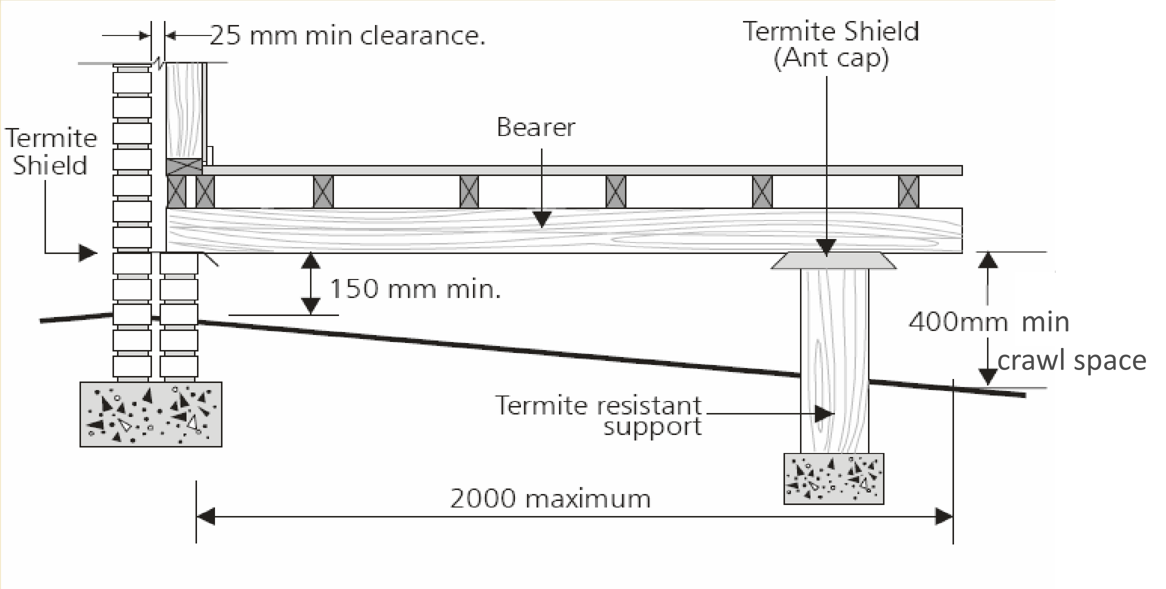
1. For barriers placed and maintained according to AS 3660.1.

2. For inspections carried out in according to AS 3660.2.

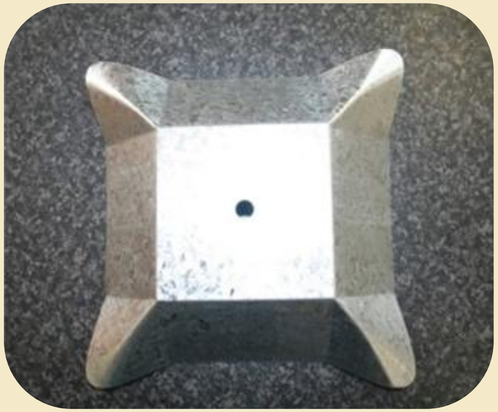
3. Tm denotes the period between re-treatments as recommended by the chemical manufacturer.

4. The term 'no barrier' denotes the absence of a house perimeter barrier, such as that provided by graded crushed stone, stainless mesh or chemicals.

Termite Protection: Metal Shields



(a) Metal shields



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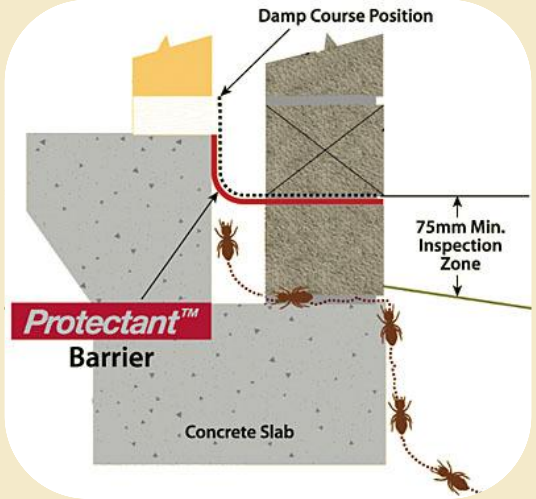
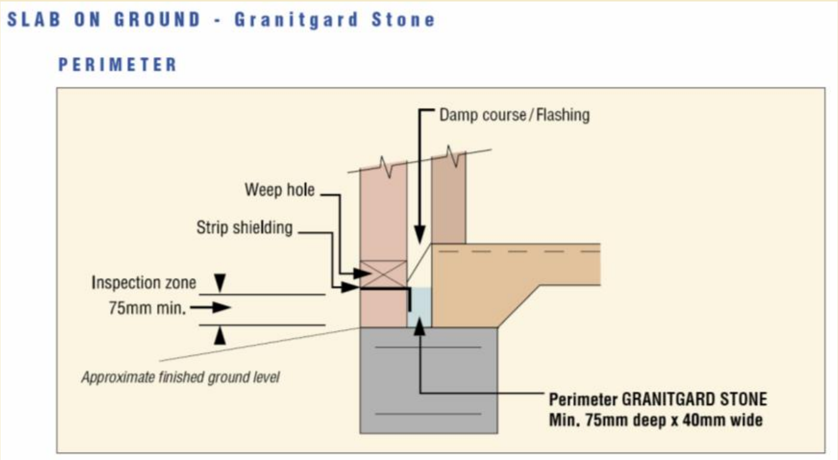
Termite Protection: Physical Barrier

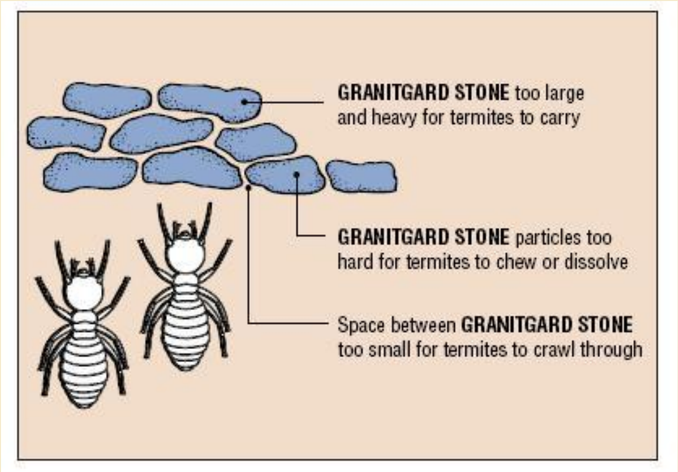


Impregnated polyester fabric

Stainless steel mesh

Termite Protection: Graded Stone





Corrosion of Fasteners

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Corrosion: Fasteners

Corrosion of fasteners needs to be considered for the following reasons:

- Breakdown of wood
- Integrity of fasteners and connections
- Aesthetics (rusting and stains etc)

40 year old hot dipped galv. bolts in cross-arms

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Corrosion: Fasteners

Breakdown of Wood

The interaction of moisture and chemicals on metals can cause a breakdown of the fibres around the metal fasteners.

Where moisture is present, this breakdown can lead to additional moisture traps and loosening of joints with a propensity for decay.

To avoid this problem, metal fasteners should be detailed and specified using material with the required resistance to corrosion, appropriate to the life of the structure.

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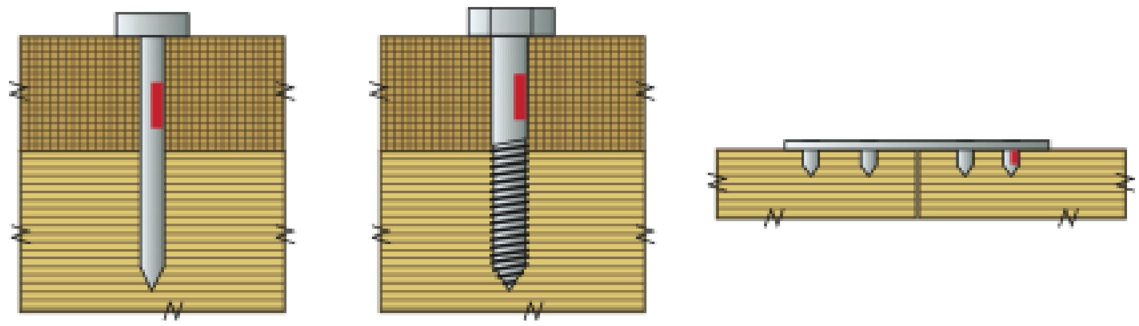
Corrosion: Fasteners

Two types of corrosion:

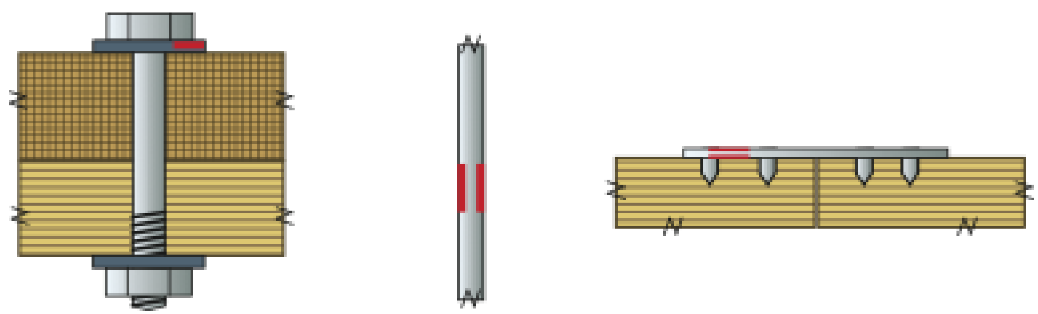
Embedded

Figure 8.1
Typical installation of fasteners embedded in wood subjected to corrosion



Atmospheric

Figure 8.2
Typical fastener installation subjected to atmospheric corrosion



Note: red marks denote where corrosion is considered

Corrosion: Fasteners

Most metal fasteners for timber have a part that is embedded in the timber as well as a part exposed to the atmosphere.

Embedded portion

Corrosion of the embedded portion will be dictated by

- moisture content in the timber,
- the natural pH of the timber, and
- any electrolytic action that may occur due to the presence of preservatives such as copper in CCA or ACQ treated timber.

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Corrosion: Fasteners

Exposed portion

Corrosion of the exposed portion of the fasteners will be influenced

- by all of the embedded factors,
- air-borne contaminants such as salt or other chemicals.

The macro climatic hazard influences on corrosion therefore need to differentiate between embedded and atmospheric corrosion with separate hazard maps applying.

The sapwood in this pole has been treated with CCA and is causing accelerated corrosion of the galvanized plate

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Corrosion: Hazard Zones – Embedded Corrosion

Figure 8.2 Hazard zones for embedded corrosion

(Zone C is the most hazardous)

Corrosion: Hazard Zones – Atmospheric Corrosion

Figure 8.4 Coastal Zones Related to corrosion due to airborne salt

(Zone E has the greatest hazard)

Corrosion: Resistance

Resistance to corrosion is best provided by selecting and using material with the required resistance to corrosion, appropriate to the intended life of the structure – refer to the following table.

Cross-arm King bolt (hot dipped galvanized) after 35 years exposure in power pole.

Corrosion: Resistance

SELECTING CORROSIVE RESISTANT FASTENERS

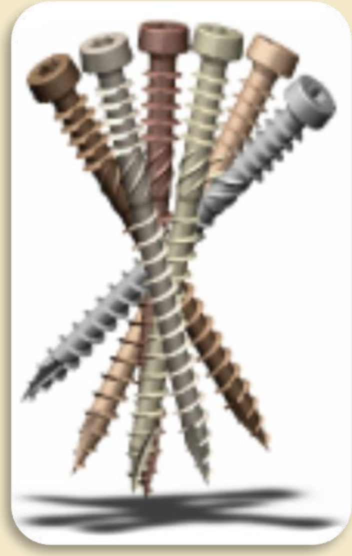
Material	Applications	Remarks
Stainless Steel 304	Chemical, Industrial & Marine	Grade 316 is preferred for marine environments. Additional protection via coatings should be applied to grade 304.
Monel	Marine	Usually used in boat building, nails/ screws available.
Silicon Bronze, Copper, Brass	Marine	Usually used in boat building, nails and screws available. Do not bring in contact with aluminum. Nails also available for acidic species, i.e. western red cedar cladding.
Hot Dipped Galvanised & Mechanically Plated	External exposed to weather and low corrosivity. Industrial and marine environments.	Where in contact with moist CCA treated timber, additional protection using plastic sheaths or bituminous or epoxy coatings are suggested for bolts. Other protective coatings can be applied to other types of connectors.
Plated (Zinc, Cadmium) and Gold Passified.	Internal exposed to view or protected from the weather and corrosive environments.	Care required with handling and installation to avoid damage of the protective coating.
Mild Steel	Fully protected from the weather, moisture or corrosive gases.	Use zinc dust paint systems to provide a base for conventional paints.

NOTE: Life expectancy of zinc coatings is determined primarily by the weight or thickness of the zinc. As a minimum, hot dipped galvanized fasteners should have a coating thickness of 42 microns.

Corrosion: Resistance

To help reduce deterioration of timber around metal fasteners where moisture is present, consider:-

- Avoiding joint details that trap moisture
- Use non-corrosive or protected metals (galvanized, coated, stainless steel or monel metals)
- Avoid use of dissimilar metals in contact with each other (i.e. copper as in CCA or ACQ treatments with zinc as in galvanized coatings)
- Grease, coat or sheath fasteners in contact with CCA or ACQ treated timber using shrink wrap plastic or bituminous or epoxy paints
- Countersink and plug or 'stop' fasteners



Polymer coat screws.

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Design Detailing

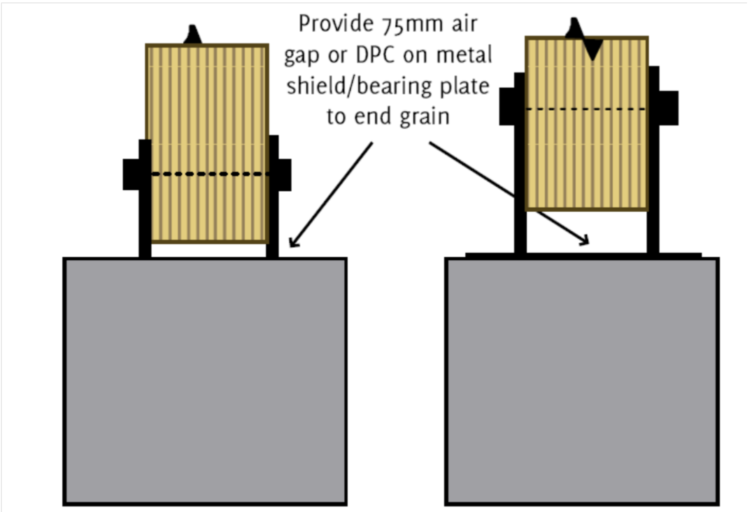
Design Detailing

- Utilise capping to protect top and end grain of protected beams

Design Detailing

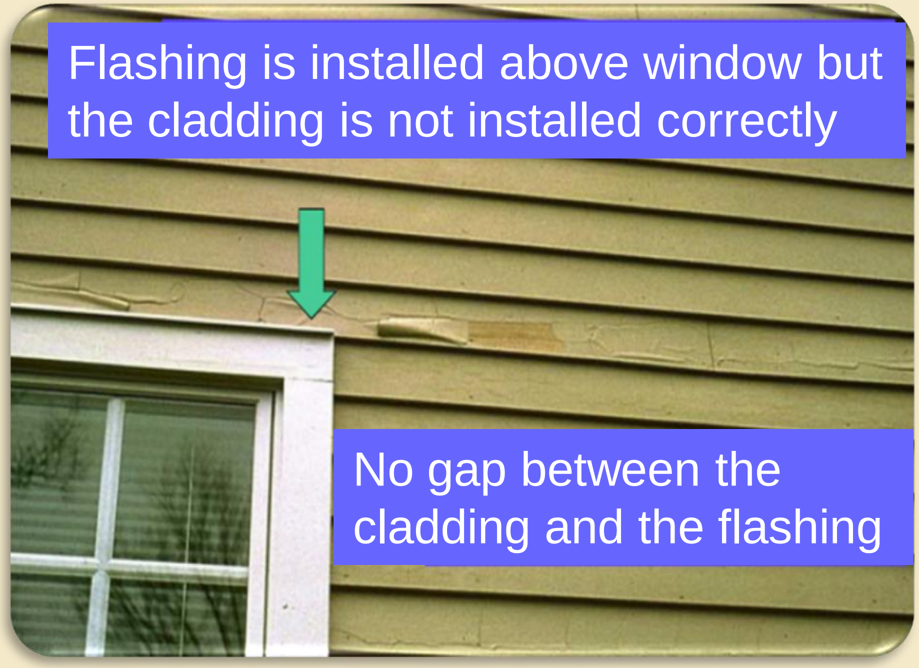
- Avoid moisture traps, and
- Provide well ventilated, free draining supports to posts

A well-ventilated, free-draining post support.



Design Detailing

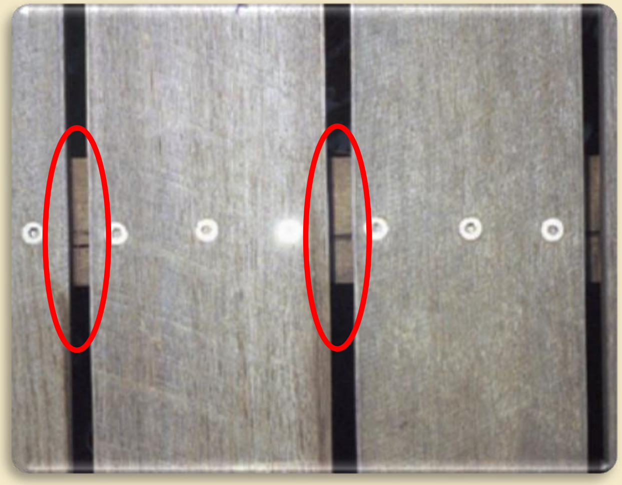
- Fit flashings correctly over, beams doors and windows

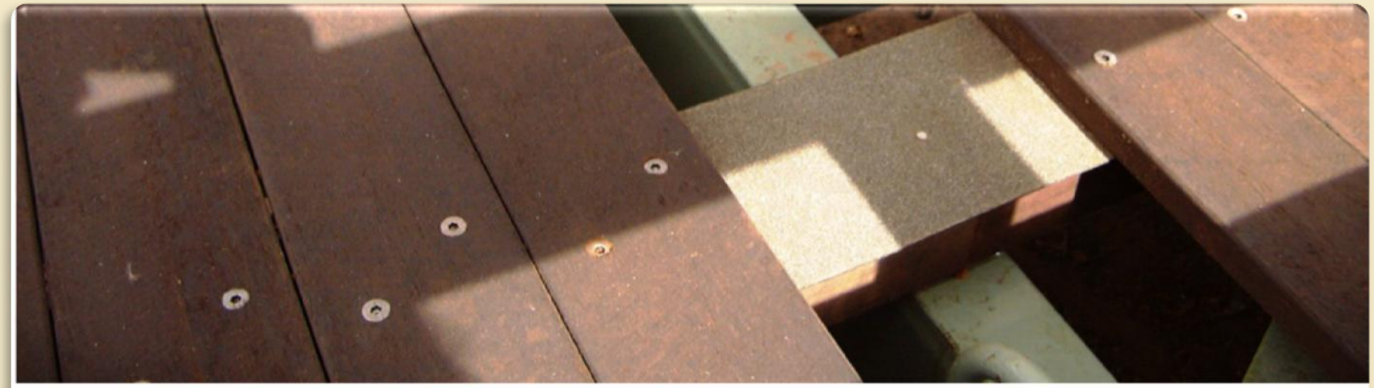


No capillary gap left between cladding & flashing

Design Detailing

- Stagger deck screws to prevent splitting of joists
- Isolate timber using a damp proof course (DPC)





Good detailing (staggered screws and DPC over joists) used for this prefabricated bridge.

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Conclusion

- There are a significant number of agents that need to be considered to enable appropriate design, specifications and detailing of timber structures to ensure satisfactory durability performance.
- They are well known and understood
- A probabilistic durability design method is now available

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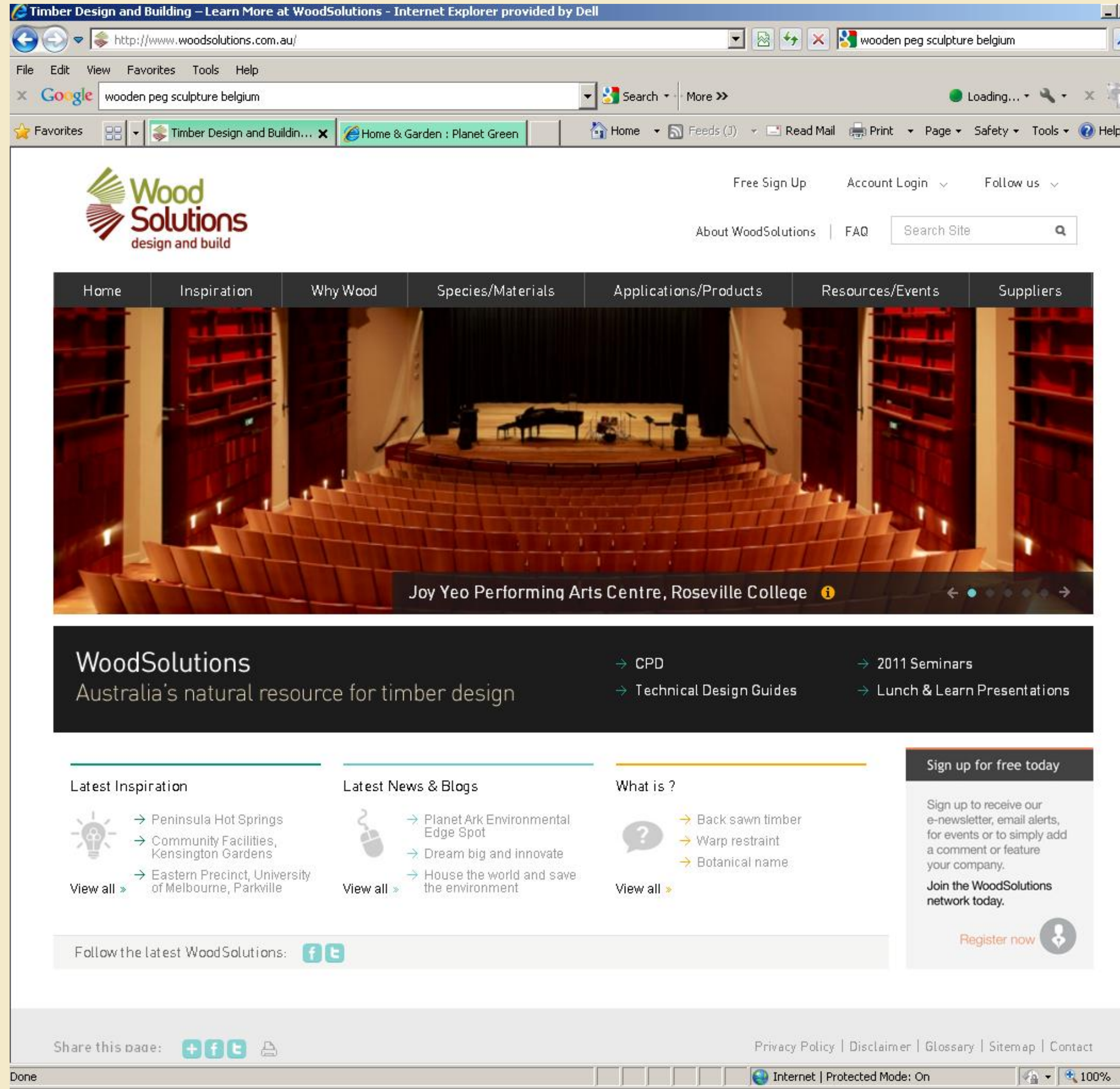
More Information – www.woodsolutions.com.au



Designing for Durability

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WoodSolutions is an industry initiative designed to provide information on timber and wood products to professionals and companies involved in building design and construction

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