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Timber service life design

Design guide for durability

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Prepared by:
Colin MacKenzie - *Timber Queensland Limited*
C H Wang, R H Leicester, G C Foliente, M N Nguyen - *CSIRO Sustainable Ecosystems*

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Preface

By carefully considering the key factors affecting timber's durability, industry, specifiers and timber users can achieve timber structures that meet or exceed their needs and expectations. This document is based on currently available information. It is anticipated that future research will considerably improve reliability in timber design life predictions.

This guide provides information to assist timber industry employees, timber users and specifiers of timber to select members and structures with respect to their service life requirements. The information provided has been derived from historical performance and field and laboratory research and experience. The outcomes from a 10-year, multi-million dollar 'world first' research project to develop a probabilistic durability design method for timber have also been incorporated in this publication where appropriate.

The guide addresses specific hazards with respect to the service life of timber construction:

- In-ground decay
- Above-ground decay
- Weathering
- Termites
- Corrosion
- Marine borers.

More detailed information associated with timber performance for other hazards, including fire resistance and chemical degradation, should be obtained from other sources.

Better or more cost-effective performance is achieved with better knowledge. This guide will be updated to reflect contemporary knowledge and research outcomes. This may include coverage of alternative preservative treatment processes such as ACQ, Copper Azole, and others, which are now referenced in Australian Standards and State legislation.

Other timber durability design resources that are outcomes from the Forest and Wood Products Australia Durability Design Project completed in 2007 are:

1. A draft proposal for AS1720.5 – Durability of Structural Timber Members

This report provides detailed calculation procedures to enable structural engineers to determine net residual sections of timber that have been subjected to a range of hazards over time. The remaining structural adequacy of the sections can then be assessed. It can be accessed and downloaded from woodsolutions.com.au

2. TimberLife Educational Software

This software is intended to be used as an educational tool. It provides detailed estimates of service-life performance with time for an extensive range of hazards. It can be accessed and downloaded from woodsolutions.com.au.

In addition to these resources, seven detailed technical reports have been prepared that document the durability and service life prediction models that have been used as a basis for some of the information contained in this guide. These reports which can be accessed at www.fwpa.com.au are:

1. Wang, C-H., Leicester, R.H. and Nguyen, M.N. "Manual No. 3: Decay in ground contact."
2. Wang, C-H., Leicester, R.H. and Nguyen, M.N. "Manual No. 4: Decay above ground."
3. Nguyen, M.N., Leicester, R.H. and Wang, C-H. "Manual No. 5: Atmospheric corrosion of fasteners in timber structures."
4. Nguyen, M.N., Leicester, R.H. and Wang, C-H. "Manual No. 6: Embedded corrosion of fasteners in timber structures."
5. Nguyen, M.N., Leicester, R.H. and Wang, C-H. "Manual No. 7: Marine borer attack."
6. Leicester, R.H., Wang, C-H. and Nguyen, M.N. "Manual No. 8: Termite attack."
7. Nguyen, M.N., Leicester, R.H. and Wang, C-H. "Manual No. 9: Service Life Models for timber structures protected by a building envelope."

The computations for the service lives stated in this design guide have been based on equations derived in the above manuals. The relevant equations have been collated into a single manual titled as follows:

8. Wang, C-H., Leicester, R.H. and Nguyen, M.N. "Manual No. 11: Equations for use in a service life design guide."

1

Introduction

Timber structures and components can be designed to perform their intended function for a known life span, with minimal or programmed maintenance and where due recognition is given to all of the important aspects that relate to the durability of wood and other components of the timber system.

As defined in the ISO 15686-1:2000(E), durability is: "(the) capability of a building or its parts to perform its required function over a specified period of time under the influence of the agents anticipated in service."

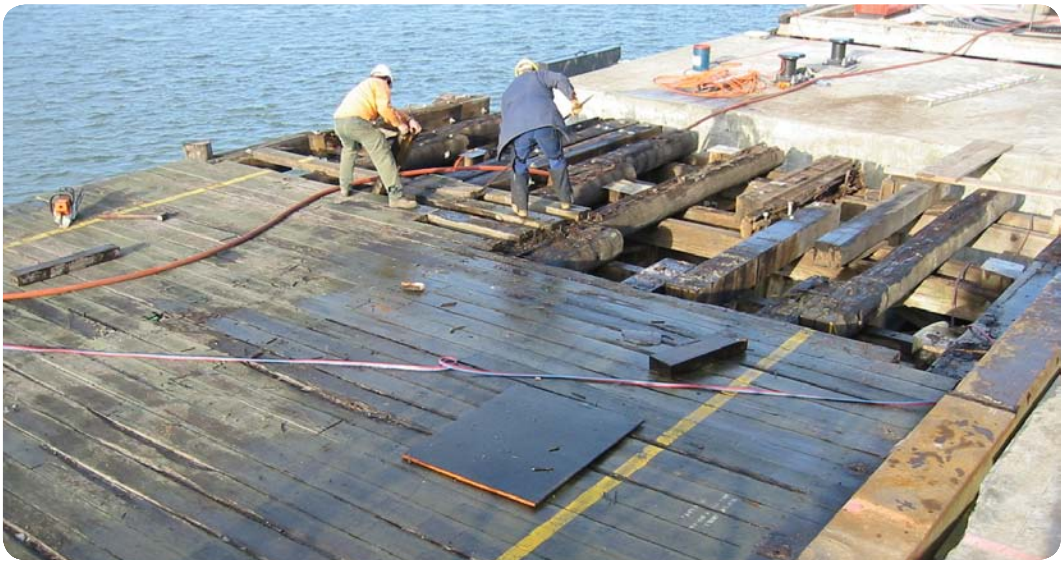
Service life is: "(The) period of time after installation during which a building or its parts meets or exceeds the performance requirements."

That function may be aesthetic, structural or for amenity.

This definition does not negate the responsibility of suppliers, designers and specifiers to consider ongoing aspects relating to maintenance or repair.

The desired outcome can be expected when the whole custody chain influencing durability (from specifier and supplier to builder and end user) is addressed. This includes:

- design
- product quality and properties (fitness for purpose)
- detailing
- specification
- workmanship
- maintenance.



Wharf timbers to be recycled and re-used after approximately 60 years in-service.

2

Standards and Codes Requirements

Increasing consumer expectations and demands are being reflected in the performance requirements specified in standards, codes and regulations. The following brief overview of some of these is provided to enable suppliers, designers and specifiers to be better informed on these matters with respect to timbers durability requirements.

2.1 Consumer Protection

The Australian Trade Practices Act 1974 sets out direction with respect to the responsibilities and requirements for product manufacturers and suppliers with respect to false or misleading representations. Requirements included in the issues addressed by Clause 53 of the Act are that corporations shall not:

“falsely represent that goods are of a particular standard, quality, value, grade, composition, style or model or have had a particular history or particular previous use”

“make a false or misleading representation concerning the existence, exclusion or effect of any condition, warranty, guarantee, right or remedy”

These requirements place clear onus on producers and manufacturers to ensure that they achieve product compliance and do not overstate any product performance levels including durability and life expectancy.

2.2 Other Regulatory Issues

There are many regulatory issues, current and pending, that will impact upon the production, sale and use of timber, including timbers durability and preservative treatment.

2.2.1 Building Regulation Framework

The building regulation framework in Australia is performance based, and specifically addresses health, safety, amenity and sustainability, as primary objectives. Whilst the Building Code of Australia (BCA) currently does not have specific durability performance requirements, it does have implicit requirements, and it contains both prescriptive deemed to comply solutions, acceptable construction practices and verification procedures.

In addition, the Australian Building Codes Board (ABCB) has published a durability guideline document that gives guidance on the implicit requirements of the BCA that should be followed by manufacturers and specifiers wishing to satisfy the BCA’s requirements.

The administration and application of the BCA is devolved by legislation to state and territory authorities and/or private certifiers who then have to interpret and apply relevant standards or acceptable solutions.

Roof overhangs provide good protection to timber walls below.

The hierarchy of building regulations in Australia for timber and durability is as follows:

- The BCA is adopted by all States and Territories under a Memorandum of Understanding (MOU) between the Federal Government and the States and Territories.
- The BCA, in turn, has primary referenced Standards and documents such as AS 1684 – Timber Framing Code and AS 1720.1 – Timber Structures Code and in some cases, individual State variations such as Construction Timbers in Queensland which is an additional State variation applicable in Queensland.
- BCA primary referenced documents do, invariably in turn, call up secondary references such as the AS 1604 series for the preservative treatment of timber and AS 5604 on natural durability classifications.

Note: BCA secondary referenced documents may have equivalent legal status as primary referenced documents.

2.2.2 ABCB – 'Durability in Buildings – Guideline Document'

This document is specifically intended to provide guidance for manufacturers, appraisers, Standards Committees and others on the implicit durability performance requirements of the BCA.

The document defines durability as – "capability to perform a function over a specified period of time" and defines the minimum design life required for a building and its components or sub-systems as given in Table 2.1.

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.

The guideline requires consideration of all environmental and specific conditions that might affect durability including the following:

- environmental agents
- temperature
- radiation
- humidity
- rainfall
- wind
- soil type
- pollutants
- biological agents
- chemical effects, etc.

Specific conditions that are stated when considering durability requirements include:

- condensation
- cyclic changes
- agents due to usage, e.g. abrasion, maintenance
- ground contact
- intended use
- performance criteria
- expected environmental conditions
- composition, properties and performance of materials
- structural system
- shape and detailing
- workmanship, QC, maintenance, etc.

2.2.3 Timber Preservation and Natural Durability Standards

The secondary BCA referenced standards relating to timber preservation and natural durability classifications are as follows:

- AS 1604.1- Specification for preservative treatment. Part 1 Sawn and round timber
- AS/NZS 1604.2 – Specification for preservative treatment. Part 2 Reconstituted wood-based products
- AS/NZS 1604.3 – Specification for preservative treatment. Part 3 Plywood
- AS/NZS 1604.4 – Specification for preservative treatment. Part 4 Laminated veneer lumber (LVL)
- AS/NZS 1604.5 – Specification for preservative treatment. Part 5 Glued laminated timber products
- AS 5604 – Timber – Natural durability ratings.

The AS 1604 series gives preservative treatment specifications for a range of decay and insect hazards, but they do not account for varying levels of hazard due to macro or micro climatic conditions, etc.

AS 5604 provides natural durability classifications for untreated timber for decay in and above ground, lyctus susceptibility, termite resistance and marine borer resistance.

2.2.4 Other Application Standards

There are an increasing number of other application standards that are being developed by civil engineering and other Standards committees where specific durability and life expectancy requirements are being included.

Some examples of these are:

- Structural Design Requirements for Utility Service Poles (Power, etc), AS/NZS 4676
- Buildings and Constructed Assets- Service Life Planning – Part 1: General Principles, ISO 15686-1
- Earth-Retaining Structures, AS 4678.

The durability performance requirements contained in some of these standards are quite explicit and detailed. For example, AS 4678 requires each component to provide satisfactory performance over the design life of the structure which in turn must consider changes with time for:

- loads
- reliability
- environmental conditions
- durability and corrosion (chemical, biological, creep, damage, etc).

AS 4678 states that the design life for earth retaining structures (retaining walls) in residential applications is 60 years. It is assumed that this design life relates to retaining walls required to provide structural support to the actual dwelling.

Engineers required to design and certify retaining walls may be expected to comply with this standard.

Use only Durability Class 1 hardwood or H5 Preservative treated timber for engineered retaining walls.

3

Selection and Specification of Durability

Designing for durability is dependent upon two key factors. These are:

- **the performance requirements of the element or structure as dictated by minimum regulatory/standards requirements or other contractual specifications; and**
- **factors affecting durability.**

For structural design, available quantitative data enables designers to reach fairly precise conclusions regarding structural performance. This is now also possible with respect to durability design although perhaps with less certainty and greater variability.

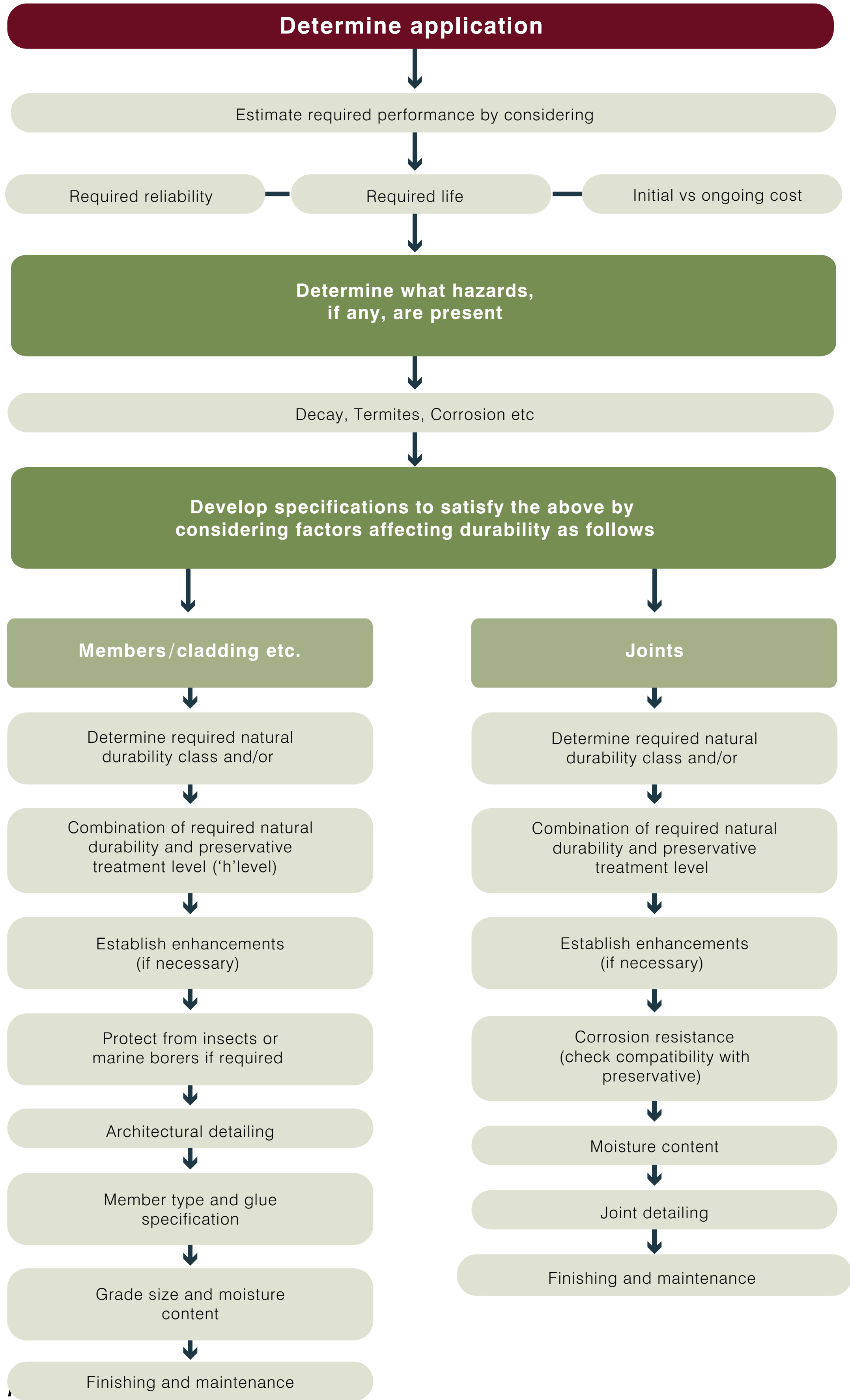
Qualitative and quantitative assessment is possible by equating required performance levels to available research and historical durability evidence, coupled with a detailed consideration of the factors affecting durability.

Figure 3.1 provides a logical sequence to enable design and specification for timbers durability.

3.1 Performance Requirements

Performance requirements for durability must be determined or considered in a manner similar to that required for structural design as is indicated in Table 2.1, that is:

- **Design Considerations**
  - – Temporary/Permanent Structure
  - – Part of Building – envelope, cladding, roofing, structural framework, etc
  - – Typical Life Expectancy
- **Reliability Considerations**
  - – Temporary/Permanent Structure
  - – Level of Safety (Loss of life or injury)
  - – Cost or Consequence of Failure
  - – Part of Building
  - – Cladding
  - – Structure
- **Cost considerations**
  - – Initial costs
  - – Maintenance costs
  - – Replacement costs
  - – Costs incurred if in-service failure occurs.


Determine application
Estimate required performance by considering
Required reliability
Required life
Initial vs ongoing cost
Determine what hazards, if any, are present
Decay, Termites, Corrosion etc
Develop specifications to satisfy the above by considering factors affecting durability as follows
Members/cladding etc.
Determine required natural durability class and/or
Combination of required natural durability and preservative treatment level ('h'level)
Establish enhancements (if necessary)
Protect from insects or marine borers if required
Architectural detailing
Member type and glue specification
Grade size and moisture content
Finishing and maintenance
Joints
Determine required natural durability class and/or
Combination of required natural durability and preservative treatment level
Establish enhancements (if necessary)
Corrosion resistance (check compatibility with preservative)
Moisture content
Joint detailing
Finishing and maintenance

3.2 Hazards and Protection

The vast majority of timber is used in applications where its permanence is unquestioned. Protected from weathering, moisture, insects and strong chemicals, timber has documented satisfactory performance for centuries. The natural and calamitous hazards that timber and timber connectors may have to contend with do require consideration. These can be summarised as:

- fungal attack
  - in-ground
  - above ground
- insect attack
  - termites and borers
- corrosion of fasteners
- weathering
- marine borers
- chemical degradation
- fire.

The following Sections give guidance on durability design and performance against these hazards.

3.3 Hazard Levels, Natural Durability and Preservation

To enable appropriate selection and specification of natural durability and preservative treatment, hazard levels have been generalised and defined by AS 1604 and State Legislation.

In Queensland and New South Wales, legislation prescribes requirements for hazard levels and preservative treatment under the *Timber Utilisation and Marketing Act* and the *Timber Marketing Act* respectively.

3.3.1 Decay Conditions

Timber will not be subjected to fungal attack unless four conditions are satisfied:

- The correct moisture: 0-20% Moisture Content – attack will not occur (too dry), 20-60% – sufficient moisture for attack to occur, >60% too wet with insufficient oxygen for attack to occur.
- Oxygen must be present. Timber completely submerged or saturated timber is rarely attacked and timber 600 mm or more below ground is rarely attacked due to lack of available oxygen.
- Temperature must be in the range of 5-40°C; 25°C to 40°C is ideal. At lower temperatures, fungal attack is retarded. At higher temperatures, the fungus will not survive.
- Food in the form of nutrients (carbohydrates, nitrogen, minerals, etc) must be present. These are usually provided by the timber itself, particularly sapwood, which is normally high in sugars and carbohydrates.

Removal of any one of these four conditions will prevent fungal attack although, in practice, it is usually the removal of moisture that requires the greatest consideration.

Consequently, timber is best protected from fungal action by:

- eliminating contact with moisture; or
- using species with a durability appropriate to the application or by using species (containing limited untreatable heartwood) that have been preservative treated (i.e. the nutritional source for the fungi is negated by insertion of a preservative) to a level appropriate to the hazard.

3.3.2 When treatment may be required

This is a difficult question that industry and users of timber face. The decision must be based on judgments that consider many factors, some of which are:

- the presence of a hazard (moisture, insect, decay, chemical, etc);
- the degree of structural reliability required (is the system loadsharing or non-loadsharing, the cost of failure and if failure occurs, the potential for death or injury);
- the desired or expected service life of the structure;

- the natural durability of the timber (resistance to decay or insect attack);
- the type or design of the building or component; and
- the presence of sapwood (only sapwood can be effectively treated unless the timber is mechanically incised or specially processed as is proposed using microwave technology).

Figure 3.2 provides guidance in flow chart form (for structures that are considered permanent) to determine if preservative treatment is required. In considering this, the following should be noted:

- Only sapwood (both hardwoods and softwoods), can consistently be effectively preservative treated (unless the timber is incised).
- The sapwood of some species, i.e. cypress and Douglas fir cannot be effectively penetrated.
- Plantation softwoods and some hardwood species have wide sapwood bands and are ideal for preservative treatment, particularly in round form.

This guide should only be used as a first approximation as other factors such as the design life of the structure and specific local hazards will also require consideration.

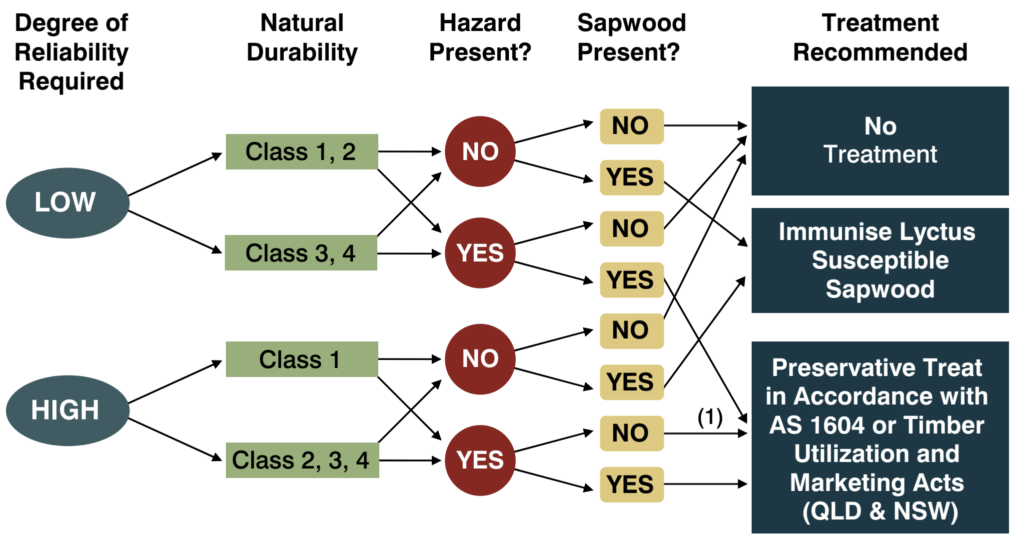


Figure 3.2: Guide to preservative treatment.

Note: Incise to enable adequate penetration.

3.3.3 Hazard Levels

Table 3.1 gives the standard levels of hazard relevant to preservative treatment for decay and insects adopted in Australian Standards and State Legislation. The degree of hazard increases with the 'H' number, with H1 representing timber fully protected from moisture and termites. The 'H' level should be used to specify a level of preservative treatment.

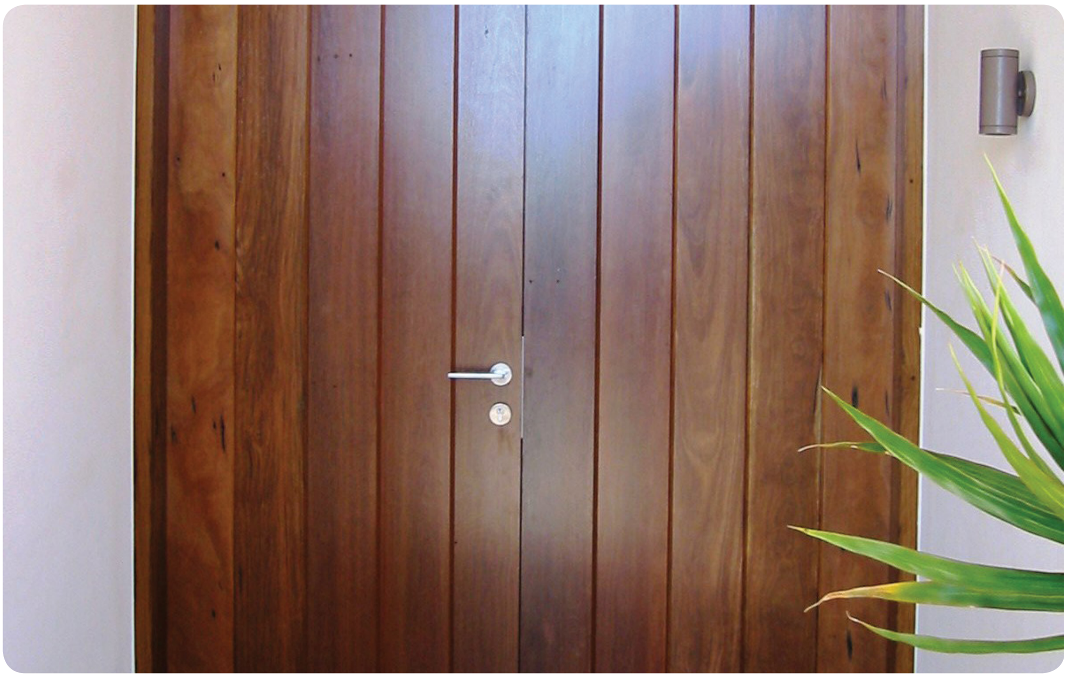
It should be noted that the Hazard Class system in AS 1604 is very general in nature and does not account for macro and micro climatic variation across Australia. Also, depending upon the application, there can be a significant difference in performance (life expectancy) even within one Hazard Class. For example, in H3, well ventilated free draining vertical surfaces are in fact a much lower hazard when compared to horizontal surfaces and where moisture can be trapped.

Sections 4 and 5 provide more detailed and accurate life expectancy predictions that reflect a number of the additional parameters and factors influencing performance including macro and micro climatic influences.

Table 3.1: Hazard levels for specification of preservative treated timber as specified in AS 1604.

Hazard Class		Exposure	Specific Service Conditions	Biological Hazard	Typical Use
H1		Inside, above ground	Protected from the weather, well ventilated and protected from termites	Insects other than termites (e.g. lyctid borer)	Framing, flooring, furniture, interior joinery or other protected applications
H2		Inside, above ground	Protected from wetting. Nil leaching,	Borers and termites	Framing, flooring, and similar uses as above
H3		Outside, above ground	Subject to periodic moderate wetting and leaching	Moderate decay, borers and termites	Weatherboards, fascia barges, pergolas, decks, window and door joinery etc
H4		Outside in-ground	Subject to severe wetting and leaching	Severe decay, borers and termites	Fence posts, greenhouses, pergola posts, and non-critical landscaping
H5		Outside in-ground contact or in fresh water	Subject to extreme wetting, leaching and/or where the critical use requires a higher degree of reliability	Very severe decay, borers and termites.	Piles, poles, structural retaining walls, cooling tower fill, or structural members in permanent ground contact or wet conditions
H6 or **H6SW**	**H6**	Marine waters, northern and southern	Subject to prolonged immersion in sea water	Marine wood borers and decay	Boat hulls, marine piles, cross bracing, steps, landings etc
	H6SW	Marine waters southern only			

Note: Refer to AS 1604 or State Timber Utilisation and Marketing Acts (QLD and NSW) for detailed information on Hazard 'H' levels.



Recycled durability class 1 hardwood used for external doors.

3.3.4 Natural Durability and Life Expectancy

Table 3.2 gives general guidance according to AS 5604 on the probable life of untreated timber used in a range of environments related to the hazard that they are exposed to. It should be noted that these are typical values and the natural variability of durability and hazard will lead to considerable variation around these values. Sections 4 and 5 give more explicit guidance.

The natural durability ratings for a wide range of timber species are published in a number of Australian Standards and these are continuously being updated with AS 5604 – Timber – Natural durability ratings, being the most recent. This publication now provides two distinct decay classes for both in-ground and above ground decay resistance of timber species. AS 5604 also provides ratings of species for termite, lyctus and marine borer resistance.

Table 3.2: General guide to probable life expectancy according to AS 5604.

	Probable heartwood life expectancy (years)		
Natural durability class	**Fully protected from the weather and termites**	**Above ground exposed to the weather but protected from termites**	**In-ground contact and exposed to termites**
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

Large overhangs provide good protection.

4 Decay of Timber In-Ground Contact

This Section provides estimates of the structural life of timber placed in ground contact. The equations used for these estimates are given in Report number 8 referred to in the Preface.

The estimates are derived from a model based initially on 35 year tests of small timber stakes embedded in-ground at various sites around Australia. It should be emphasised that there are various reasons as to why the in-ground behaviour of small stakes differs considerably from that of large members, particularly poles. These include the occurrence of splitting and in some cases, the downwards movement of preservatives. Hence, the data derived from small stakes, while extremely useful for formulating a model, requires field data of full size members to calibrate it before it can be used for predictive purposes. The model has been calibrated by data on a limited number of poles in NSW. This provides a degree of a reality check on the model, but because of the great variety of timber, treatments and climates found around Australia, a considerable amount of further field calibrations must be made before the model is considered to give reliable predictions.

Since the computational model has been made on the basis of data obtained from in-ground stake tests, the decay classes based on these tests (given in Table 4.1) have been used herein. These decay classes relate to the outer heartwood of the species listed.

For round poles, the estimated service life given in the tables relate to an estimate of the time taken for decay to reduce the bending strength of a pole to 70% of its initial value. The estimate is a typical or average value. Only attack by decay has been considered; the model does not include any allowance for attack by other biological and mechanical degradation agents. For example, it does not consider the effects of attack by termites.

For the case of rectangular sawn timber sections, two values of the design life are given for the case of treated timber. One relates to a section deemed to be 100% sapwood and therefore fully treated; the other relates to a section that contains 20% untreatable heartwood, in accordance with the specifications of AS: 1604.1. It should be noted that the predicted life is for timber sited in exposed locations such as occurs for fence posts; the predictions should be conservative when applied to timber sited in protected locations such as occurs with house stumps placed in dry ground under a house.

4.1 Application

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

- Determine the natural durability class in-ground from Table 4.1.
- Determine the structure location zone from Figure 4.1.
- 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.
- For round poles, add on the extra service life afforded by maintenance treatments given in Table 4.14.

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
Blackbutt, WA	*Eucalyptus patens*	2
Blackwood	*Acacia melanoxylon*	4
Bloodwood, red	*Corymbia gummifera*	1
Bloodwood, white	*Corymbia trachyphloia*	1
Bollywood	*Litsea reticulata*	4
Box, brush	*Lophostemon confertus*	3
Box, grey	*Eucalyptus moluccana*	1
Box, grey, coast	*Eucalyptus bosistoana*	1
Box, long leaved	*Eucalyptus goniocalyx*	3
Box, red	*Eucalyptus polyanthemos*	1
Box, steel	*Eucalyptus rummeryi*	1
Box, swamp	*Lophostemon suaveolens*	2
Box, yellow	*Eucalyptus melliodora*	1
Box,white	*Eucalyptus albens*	1
Brigalow	*Acacia harpophylla*	1
Brownbarrel	*Eucalyptus fastigata*	4
Bullich	*Eucalyptus megacarpa*	3
Calantas (kalantas)	*Toona calantas*	2
Candlebark	*Eucalyptus rubida*	4
Cedar, red, western	*Thuja plicata*	3
Cypress	*Callitris glaucophylla*	2
Fir, Douglas (Oregon)	*Pseudotsuga menziesii*	4
Gum, blue, southern	*Eucalyptus globulus*	3
Gum, blue, Sydney	*Eucalyptus saligna*	3
Gum, grey	*Eucalyptus propinqua*	1
Gum, grey, mountain	*Eucalyptus cypellocarpa*	3
Gum, maiden's	*Eucalyptus maidenii*	3
Gum, manna	*Eucalyptus viminalis*	4
Gum, mountain	*Eucalyptus dalrympleana*	4
Gum, red, forest	*Eucalyptus tereticornis*	1
Gum, red, river	*Eucalyptus camaldulensis*	2
Gum, rose	*Eucalyptus grandis*	3
Gum, salmon	*Eucalyptus salmonophloia*	2
Gum, scribbly	*Eucalyptus haemastoma*	3
Gum, shining	*Eucalyptus nitens*	4
Gum, spotted	*Corymbia maculata,* incl. *corymbia citriodora*	2
Gum, sugar	*Eucalyptus cladocalyx*	1

Table 4.1 *(continued)***: Timber natural durability classification for in-ground decay.**

Trade name	Botanical name	In-ground durability class
Gum, yellow	*Eucalyptus leucoxylon*	2
Hardwood, Johnstone River	*Backhousia bancroftii*	3
Hemlock, Western	*Tsuga heterophylla*	4
Ironbark, grey	*Eucalyptus paniculata*	1
Ironbark, red	*Eucalyptus sideroxylon*	1
Ironbark, red (broad-leaved)	*Eucalyptus fibrosa*	1
Ironbark, red (narrow-leaved)	*Eucalyptus crebra*	1
Ironwood Cooktown	*Erythrophloeum chlorostachys*	1
Jam, raspberry	*Acacia acuminata*	1
Jarrah	*Eucalyptus marginata*	2
Kapur	*Dryobalanops* spp.	3
Karri	*Eucalyptus diversicolor*	3
Keruing	*Dipterocarpus* spp.	3
Kwila (merbau)	*Intsia bijuga*	3
Mahogany, Philippine, red, dark	*Shorea* spp.	3
Mahogany, Philippine, red, light	*Shorea, Pentacme, Parashorea* spp.	4
Mahogany, red	*Eucalyptus resinifera*	2
Mahogany, white	*Eucalyptus acmenoides*	1
Mahogany, white	*Eucalyptus umbra*	1
Mahonany, southern	*Eucalyptus botryoides*	3
Mallet, brown	*Eucalyptus astringens*	2
Marri	*Corymbia calophylla*	3
Meranti, red, dark	*Shorea* spp.	4
Meranti, red, light	*Shorea* spp.	4
Mersawa	*Anisoptera* spp.	4
Messmate	*Eucalyptus obliqua*	3
Messmate, Gympie	*Eucalyptus cloeziana*	1
Oak, bull	*Allocasuarina luehmannii*	1
Oak, white, American	*Quercus alba*	4
Peppermint, black	*Eucalyptus amygdalina*	4
Peppermint, broad leaved	*Eucalyptus dives*	3
Peppermint, narrow leaved	*Eucalyptus radiata*	4
Peppermint, river	*Eucalyptus elata*	4
Pine, black	*Prumnopitys amara*	4
Pine, Caribbean	*Pinus caribaea*	4
Pine, celery-top	*Phyllocladus aspleniifolius*	4
Pine, hoop	*Araucaria cunninghamii*	4
Pine, Huon	*Lagarostrobos franklinii*	3
Pine, kauri	*Agathis robusta*	4
Pine, King William	*Athrotaxis selaginoides*	3
Pine, radiata	*Pinus radiata*	4
Pine, slash	*Pinus elliottii*	4
Ramin	*Gonystylus* spp.	4
Redwood	*Sequoia sempervirens*	2
Rosewood, New Guinea	*Pterocarpus indicus*	3
Satinay	*Syncarpia hillii*	2
Stringybark, Blackdown	*Eucalyptus sphaerocarpa*	2
Stringybark, brown	*Eucalyptus baxteri*	3

Zone D has the greatest in-ground decay potential.

Table 4.1** (continued)**: Timber natural durability classification for in-ground decay.

Trade name	Botanical name	In-ground durability class
Stringybark, red	*Eucalyptus macrorhyncha*	3
Stringybark, white	*Eucalyptus eugenioides*	3
Stringybark, yellow	*Eucalyptus muelleriana*	3
Tallowwood	*Eucalyptus microcorys*	1
Taun	*Pometia* spp.	3
Teak, Burmese	*Tectona grandis*	2
Tingle, red	*Eucalyptus jacksonii*	4
Tingle, yellow	*Eucalyptus guilfoylei*	2
Tuart	*Eucalyptus gomphocephala*	1
Turpentine	*Syncarpia glomulifera*	1
Wandoo	*Eucalyptus wandoo*	1
Woolybutt	*Eucalyptus longifolia*	1
Yate	*Eucalyptus cornuta*	2
Yertchuk	*Eucalyptus consideniana*	2

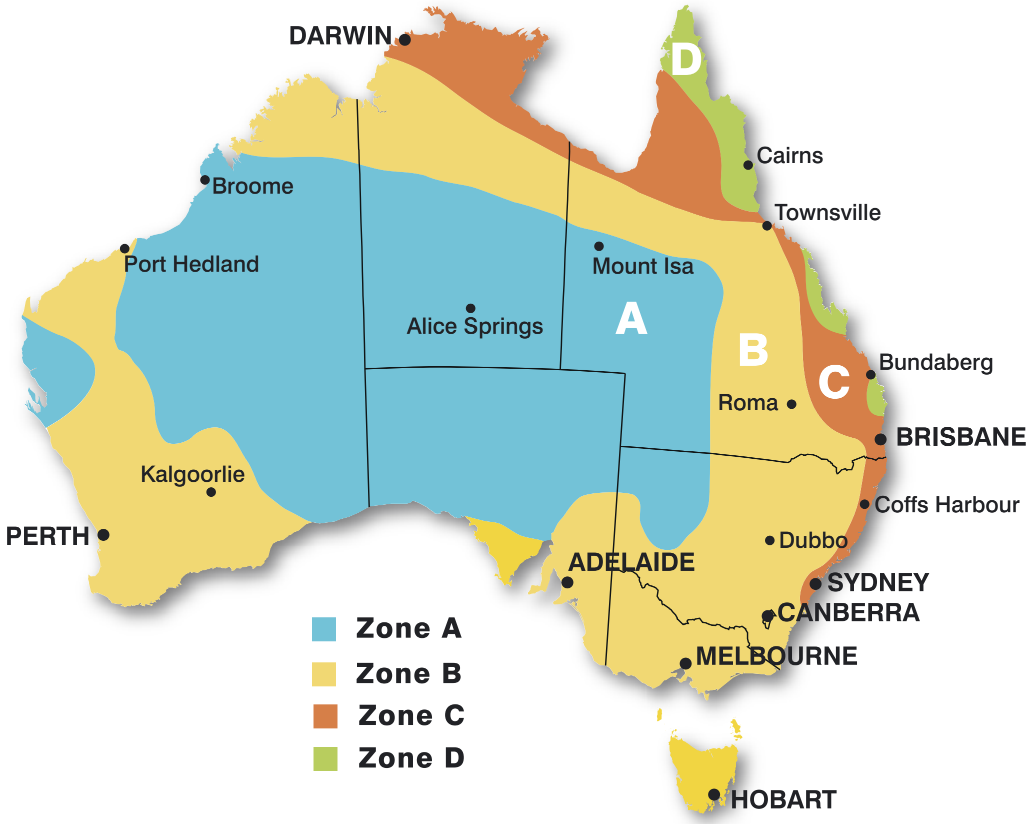


Figure 4.1: In-ground decay hazard zones for Australia.

Table 4.2: Typical service life of round poles against in-ground decay in Zone A.

Timber type	In-ground durability class(1)	Treatment(2)	Typical service life (years)		
			Pole diameter 200 mm	Pole diameter 300 mm	Pole diameter 400 mm
Treated softwood	4	H4	>100	>100	>100
		H5	>100	>100	>100
Treated hardwood	1	H4	>100	>100	>100
		H5	>100	>100	>100
	2	H4	>100	>100	>100
		H5	>100	>100	>100
	3	H4	90	>100	>100
		H5	>100	>100	>100
	4	H4	70	90	>100
		H5	80	>100	>100
Untreated hardwood(3)	1	—	>100	>100	>100
	2	—	70	90	>100

Notes:
1. See Table 4.1.
2. As per AS 1604.1. for CCA and creosote.
3. De-sapped poles.

Table 4.3: Typical service life of round poles against in-ground decay in Zone B.

Timber type	In-ground durability class(1)	Treatment(2)	Typical service life (years)		
			Pole diameter 200 mm	Pole diameter 300 mm	Pole diameter 400 mm
Treated softwood	4	H4	60	80	100
		H5	100	>100	>100
Treated hardwood	1	H4	50	80	90
		H5	80	>100	>100
	2	H4	50	70	70
		H5	80	100	>100
	3	H4	40	45	60
		H5	50	60	70
	4	H4	30	35	45
		H5	40	45	50
Untreated hardwood(3)	1	—	45	60	80
	2	—	25	30	40

Notes:
1. See Table 4.1.
2. As per AS 1604.1. for CCA and creosote.
3. De-sapped poles.

Table 4.4: Typical service life of round poles against in-ground decay in Zone C.

Timber type	In-ground durability class[1]	Treatment[2]	Typical service life (years)		
			Pole diameter 200 mm	Pole diameter 300 mm	Pole diameter 400 mm
Treated softwood	4	H4	40	50	60
		H5	60	80	100
Treated hardwood	1	H4	35	50	60
		H5	60	80	90
	2	H4	35	45	50
		H5	50	70	70
	3	H4	25	30	35
		H5	40	45	50
	4	H4	20	25	30
		H5	30	35	40
Untreated hardwood[3]	1	—	30	40	50
	2	—	15	20	25

Notes:
1. See Table 4.1.
2. As per AS 1604.1 for CCA and creosote.
3. De-sapped poles.

Table 4.5: Typical service life of round poles against in-ground decay in Zone D.

Timber type	In-ground durability class[1]	Treatment[2]	Typical service life (years)		
			Pole diameter 200 mm	Pole diameter 300 mm	Pole diameter 400 mm
Treated softwood	4	H4	35	45	50
		H5	60	70	80
Treated hardwood	1	H4	30	45	50
		H5	50	70	70
	2	H4	30	40	40
		H5	45	60	60
	3	H4	25	30	35
		H5	35	40	45
	4	H4	20	25	25
		H5	30	30	35
Untreated hardwood[3]	1	—	25	30	40
	2	—	10	15	20

Notes:
1. See Table 4.1.
2. As per AS 1604.1 for CCA and creosote.
3. De-sapped poles.

Square Posts

Table 4.6: Typical service life of square posts against in-ground decay in Zone A.

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	>100	>100	>100	>100
		H5	>100	>100	>100	>100
Treated softwood 80% penetration(4)	3 and 4	H4	50	60	70	90
		H5	50	70	90	>100
Untreated hard-wood(3)	1	—	90	>100	>100	>100
	2	—	45	60	70	80

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.

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.

Table 4.8: Typical service life of square posts against in-ground decay in Zone C.

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	35	40	45	50
		H5	50	60	70	80
Treated softwood 80% penetration(4)	3 and 4	H4	9	15	15	20
		H5	9	15	15	20
Untreated hard-wood(3)	1	—	20	25	30	35
	2	—	9	10	15	15

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.

Table 4.9 Typical service life of square posts against in-ground decay in Zone D.

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	30	35	40	45
		H5	45	50	60	70
Treated softwood 80% penetration(4)	3 and 4	H4	8	10	15	20
		H5	8	10	15	20
Untreated hard-wood(3)	1	—	15	20	25	25
	2	—	8	10	10	15

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.

Rectangular Posts

Table 4.10: Typical service life of rectangular posts against in-ground decay in Zone A.

Timber type	In-ground durability class(1)	Treatment(2)	Typical service life (years)(5)			
			200 x 75 (mm)	200 x 100 (mm)	300 x 100 (mm)	300 x150 (mm)
Treated softwood full penetration(3)	4	H4	>100	>100	>100	>100
		H5	>100	>100	>100	>100
Treated softwood 80% penetration(4)	3 and 4	H4	80	80	90	90
		H5	>100	>100	>100	>100
Untreated hard-wood(3)	1	—	90	>100	>100	>100
	2	—	45	50	50	60

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.

5. Design service life given in brackets are where the member is stressed in bending about its minor axis.

Table 4.11: Typical service life of rectangular posts against in-ground decay in Zone B.

Timber type	In-ground decay class(1)	Treatment(2)	Typical service life (years)(5)			
			200 x 75 (mm)	200 x 100 (mm)	300 x 100 (mm)	300 x150 (mm)
Treated softwood full penetration(3)	4	H4	45	50	50	60
		H5	70	80	80	>100
Treated softwood 80% penetration(4)	3 and 4	H4	35	30	35	35
		H5	40	45	50	50
Untreated hard-wood(3)	1	—	30	35	35	45
	2	—	15	15	15	20

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.

5. Design service life given in brackets are where the member is stressed in bending about its minor axis.

Table 4.12: Typical service life of rectangular posts against in-ground decay in Zone C.

Timber type	In-ground decay class(1)	Treatment(2)	Typical service life (years)(5)			
			200 x 75 (mm)	200 x 100 (mm)	300 x 100 (mm)	300 x150 (mm)
Treated softwood full penetration(3)	4	H4	30	35	35	45
		H5	50	60	60	70
Treated softwood 80% penetration(4)	3 and 4	H4	20	25	25	25
		H5	25	30	30	35
Untreated hard-wood(3)	1	—	20	20	20	25
	2	—	9	10	10	15

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.

5. Design service life given in brackets are where the member is stressed in bending about its minor axis.

Table 4.13: Typical service life of rectangular posts against in-ground decay in Zone D.

Timber type	In-ground decay class(1)	Treatment(2)	Typical service life (years)(5)			
			200 x 75 (mm)	200 x 100 (mm)	300 x 100 (mm)	300 x150 (mm)
Treated softwood full penetration(3)	4	H4	30	30	30	35
		H5	45	50	50	60
Treated softwood 80% penetration(4)	3 and 4	H4	20	20	20	20
		H5	20	25	25	35
Untreated hard-wood(3)	1	—	15	20	20	20
	2	—	8	9	9	10

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.

5. Design service life given in brackets are where the member is stressed in bending about its minor axis.

4.2 Maintenance of Timber In-ground Contact

A maintenance procedure can stop or slow down timber degradation, and thus extend service life. This is illustrated in Figure 4.2. Table 4.14 presents the extra life gained considering four types of maintenance procedures. This extra life is simply added to the value of the design life determined above.

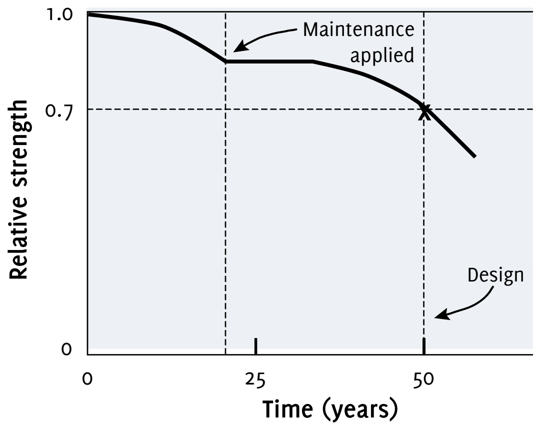


Figure 4.2: illustration of the effect of a maintenance procedure.

Table 4.14: Effect of maintenance procedures.

Maintenance procedure	Extra service life for each application of the maintenance procedure (years)
External diffusing chemical barrier	5
External non-diffusing chemical barrier	2
External physical barrier	0
Insertion of internal diffusing chemicals[(1)]	5[(2)]

Notes:

1. In addition to increasing the service life for resistance to decay, the use of internal diffusing chemicals is also useful for other reasons. First it provides a very effective deterrent to termite attack. Another benefit is that in the case of treated hardwood poles, the use of these chemicals can be used to ensure that some untreated heartwood always remains; hence, the residual structure is not totally reliant on a thin skin of treated sapwood that may fail in a brittle and catastrophic manner.

2. The potential for extra life due to the use of internal diffusing chemicals tends to vary with the type of pole, and is greater for hardwood than for softwood poles.

Degradation of basement column after 100 years in service in Brisbane.
Note: the concrete slab and part of the footing have been cut away to expose the in-ground portion.

5 Decay of Timber Above-Ground Exposed to the Weather

This Section provides estimates of the service life of timber, above ground, exposed to the weather and out of ground contact. The equations used for these estimates are given in Report number 8 referred to in the Preface.

Figures 5.1 and 6.1 give guidance on the definition of exposure to the weather.

Figure 5.2 provides a general guide to the level of decay hazard likely to be encountered in Australia. It should be noted that this map generally reflects the influence of both moisture and temperature relative to decay on a macro climatic regional basis.

The estimates are based on measurements of the decay of small pieces of timber exposed for 20 years at a number of test sites around Australia. A limited number of species were tested at each site. Most of the tests used heartwood timber, although some data on sapwood timber was also obtained. The model used for these estimates has been checked against data obtained from fencing and decking from a limited number of houses in Melbourne and Brisbane. Because of the wide range of species and climates possible in practical applications, a considerable amount of further field calibrations need to be made for the model to be considered to give reliable predictions.

The tables relate to the effects of decay only. Attacks by other biological agents such as termites or the effects of mechanical degradation are also not considered. See Sections 6 and 7 for these agents.

In the tables, the service life for the onset of decay refers to a theoretical estimate by the current version of the decay model of the mean time taken to develop decay to a depth of 2 mm; similarly, the service life for timber replacement refers to an estimate of the mean time taken to develop decay to a depth of 10 mm. These serviceability limits are defined as the times to the occurrence of decay and the need for replacement, respectively.

It should be noted that for simplicity in the presentation of data, the tables shown do not demonstrate the full scope of the decay model. The influences of many parameters have been omitted, such as the effects of timber orientation and the effects of shielding from sun and rain. In addition, no mention is made of the aesthetic degradation of the timber, one of the major design considerations in the use of timber outdoors. Examples of aesthetic degradation include discolouration, surface checking and distortion. Section 6 provides guidance in this regard.

5.1 Application

To estimate the typical service life of a timber member, 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 (or depth of decay for the case of cross-arms) 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.

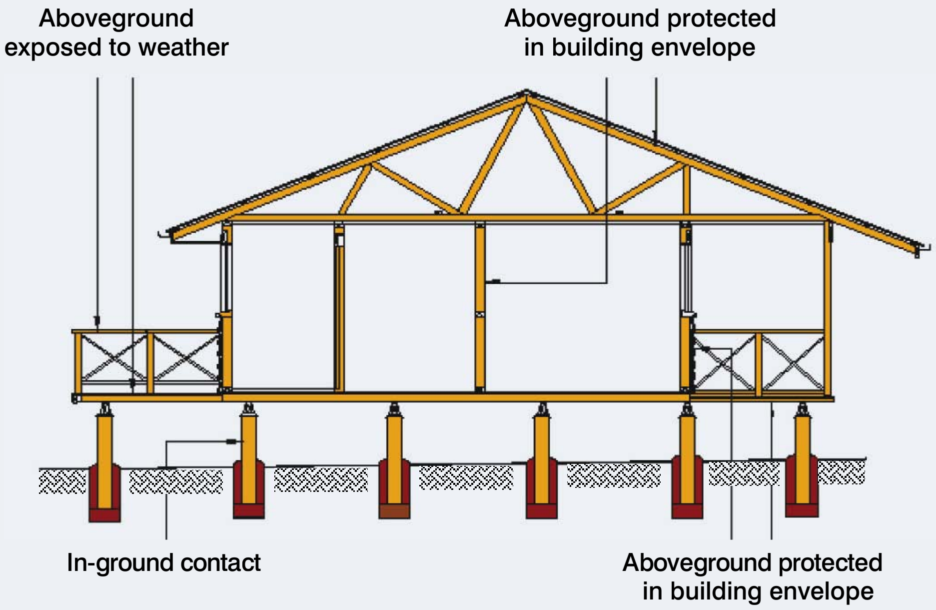


Figure 5.1: Weather exposure (see Figure 6.1 for further explanation).

Above-ground durability test site in South-East Queensland.

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
Blackbutt, WA	*Eucalyptus patens*	1
Blackwood	*Acacia melanoxylon*	3
Bloodwood, red	*Corymbia intermedia*	1
Bloodwood, white	*Corymbia trachyphloia*	1
Bollywood	*Litsea reticulata*	4
Box, brush	*Lophostemon confertus*	3
Box, grey	*Eucalyptus moluccana*	1
Box, grey, coast	*Eucalyptus bosistoana*	1
Box, long leaved	*Eucalyptus goniocalyx*	2
Box, red	*Eucalyptus polyanthemos*	1
Box, steel	*Eucalyptus rummeryi*	1
Box, swamp	*Lophostemon suaveolens*	1
Box, yellow	*Eucalyptus melliodora*	1
Box,white	*Eucalyptus albens*	1
Brigalow	*Acacia harpophylla*	1
Brownbarrel	*Eucalyptus fastigata*	3
Bullich	*Eucalyptus megacarpa*	2
Calantas (kalantas)	*Toona calantas*	1
Candlebark	*Eucalyptus rubida*	3
Cedar, red, western	*Thuja plicata*	2
Cypress	*Callitris glaucophylla*	1
Fir, Douglas (Oregon)	*Pseudotsuga menziesii*	4
Gum, blue, southern	*Eucalyptus globulus*	2
Gum, blue, Sydney	*Eucalyptus saligna*	2
Gum, grey	*Eucalyptus propinqua*	1
Gum, grey, mountain	*Eucalyptus cypellocarpa*	2
Gum, maiden's	*Eucalyptus maidenii*	2
Gum, manna	*Eucalyptus viminalis*	3
Gum, mountain	*Eucalyptus dalrympleana*	3
Gum, red, forest	*Eucalyptus tereticornis*	1
Gum, red, river	*Eucalyptus camaldulensis*	1
Gum, rose	*Eucalyptus grandis*	2
Gum, salmon	*Eucalyptus salmonophloia*	1
Gum, scribbly	*Eucalyptus haemastoma*	2
Gum, shining	*Eucalyptus nitens*	3
Gum, spotted	*Corymbia maculata,* incl. *corymbia citriodora*	1
Gum, sugar	*Eucalyptus cladocalyx*	1
Gum, yellow	*Eucalyptus leucoxylon*	2

***Table 5.1** (continued): Timber classification for above-ground decay.*

Trade name	Botanical name	Above-ground durability class
Hardwood, Johnstone River	*Backhousia bancroftii*	2
Hemlock, western	*Tsuga heterophylla*	4
Ironbark, grey	*Eucalyptus paniculata*	1
Ironbark, red	*Eucalyptus sideroxylon*	1
Ironbark, red (broad-leaved)	*Eucalyptus fibrosa*	1
Ironbark, red (narrow-leaved)	*Eucalyptus crebra*	1
Ironwood, Cooktown	*Erythrophloeum chlorostachys*	1
Jam, raspberry	*Acacia acuminata*	1
Jarrah	*Eucalyptus marginata*	2
Kapur	*Dryobalanops* spp.	2
Karri	*Eucalyptus diversicolor*	2
Keruing	*Dipterocarpus* spp.	3
Kwila	*Intsia bijuga*	1
Mahogany, Philippine, red, dark	*Shorea* spp.	2
Mahogany, Philippine, red, light	*Shorea, Pentacme, Parashorea* spp.	3
Mahogany, red	*Eucalyptus resinifera*	1
Mahogany, white	*Eucalyptus acmenoides*	1
Mahogany, white	*Eucalyptus umbra*	1
Mahogany, southern	*Eucalyptus botryoides*	2
Mallet, brown	*Eucalyptus astringens*	1
Marri	*Corymbia calophylla*	3
Meranti, red, dark	*Shorea* spp.	3
Meranti, red, light	*Shorea* spp.	4
Mersawa	*Anisoptera* spp.	3
Messmate	*Eucalyptus obliqua*	3
Messmate, Gympie	*Eucalyptus cloeziana*	1
Oak, bull	*Allocasuarina luehmannii*	1
Oak, white, American	*Quercus alba*	3
Peppermint, black	*Eucalyptus amygdalina*	3
Peppermint, broad leaved	*Eucalyptus dives*	2
Peppermint, narrow leaved	*Eucalyptus radiata*	3
Peppermint, river	*Eucalyptus elata*	3
Pine, black	*Prumnopitys amara*	4
Pine, Caribbean	*Pinus caribaea*	4
Pine, celery-top	*Phyllocladus aspleniifolius*	2
Pine, hoop	*Araucaria cunninghamii*	4
Pine, Huon	*Lagarostrobos franklinii*	3
Pine, kauri	*Agathis robusta*	4
Pine, King William	*Athrotaxis selaginoides*	2
Pine, radiata	*Pinus radiata*	4
Pine, slash	*Pinus elliottii*	4
Ramin	*Gonystylus* spp.	4
Redwood	*Sequoia sempervirens*	1
Rosewood, New Guinea	*Pterocarpus indicus*	2
Satinay	*Syncarpia hillii*	1
Stringybark, Blackdown	*Eucalyptus sphaerocarpa*	1
Stringybark, brown	*Eucalyptus baxteri*	2
Stringybark, red	*Eucalyptus macrorhyncha*	2

Zone D has the greatest decay hazard potential.

Table 5.1** (continued)**: Timber classification for above-ground decay.

Trade name	Botanical name	Above-ground durability class
Stringybark, white	*Eucalyptus eugenioides*	2
Stringybark, yellow	*Eucalyptus muelleriana*	2
Tallowwood	*Eucalyptus microcorys*	1
Taun	*Pometia* spp.	2
Teak, Burmese	*Tectona grandis*	1
Tingle, red	*Eucalyptus jacksonii*	3
Tingle, yellow	*Eucalyptus guilfoylei*	1
Tuart	*Eucalyptus gomphocephala*	1
Turpentine	*Syncarpia glomulifera*	1
Wandoo	*Eucalyptus wandoo*	1
Woolybutt	*Eucalyptus longifolia*	1
Yate	*Eucalyptus cornuta*	1
Yertchuk	*Eucalyptus consideniana*	1

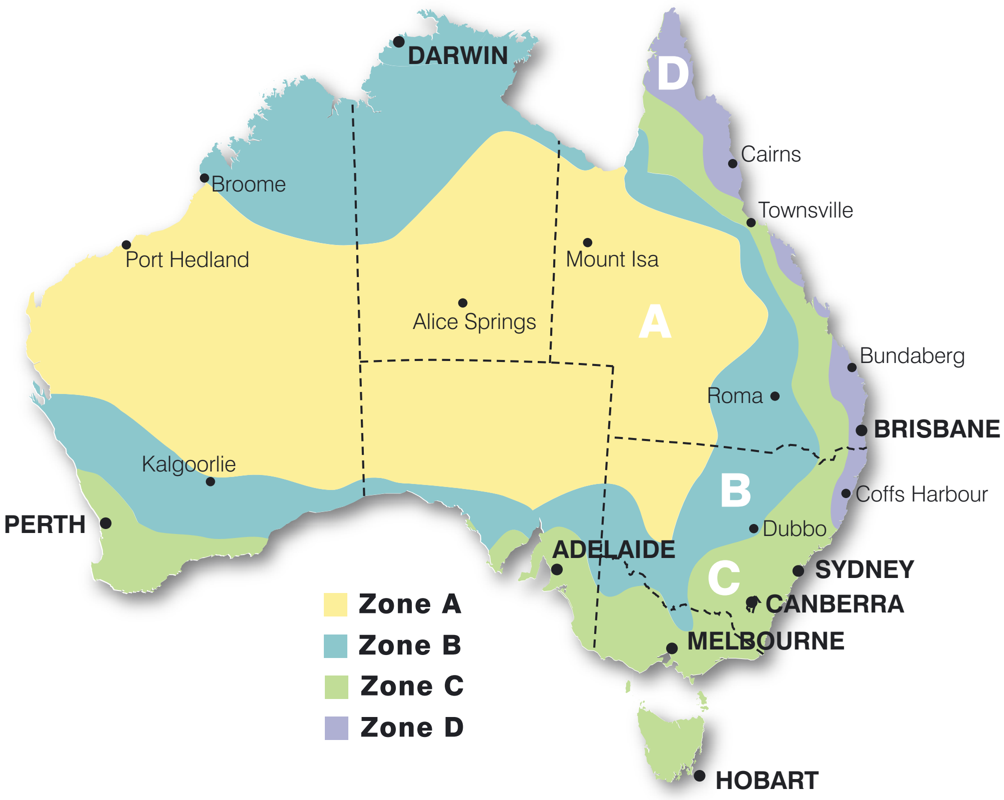


Figure 5.2: Above ground decay hazard zones for Australia.

5.1.1. Fencing and similar applications

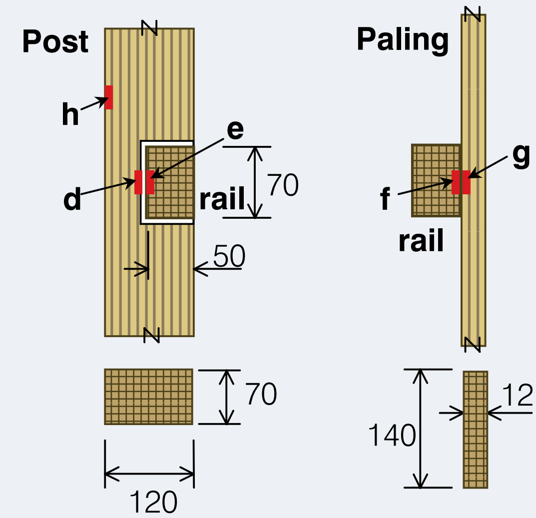


Figure 5.3: Typical dimensions of fencing and locations of interest for service lives. (For in-ground decay of post, refer to Section 4.)

Table 5.2: Typical service life for onset of decay in fencing. *(See Fig. 5.3 for location in the assembly.)*

Climate zone	Timber type	Above-ground durability class(1)	Treatment(2)	Typical service life (years)				
				d	e	f	g	h
A	Treated sapwood	all	H3	70	70	>100	>100	>100
A	Untreated heartwood	1	—	35	35	60	70	60
A	Untreated heartwood	2	—	30	30	45	60	45
A	Untreated heartwood	3	—	15	15	25	35	25
A	Untreated heartwood	4	—	9	9	15	20	15
A	Untreated sapwood	all	—	3	3	5	7	5
B	Treated sapwood	all	H3	50	50	90	>100	90
B	Untreated heartwood	1	—	30	30	45	60	45
B	Untreated heartwood	2	—	25	25	35	50	35
B	Untreated heartwood	3	—	15	15	20	30	20
B	Untreated heartwood	4	—	7	7	10	15	10
B	Untreated sapwood	all	—	3	3	4	6	4
C	Treated sapwood	all	H3	40	40	70	90	70
C	Untreated heartwood	1	—	20	20	35	45	35
C	Untreated heartwood	2	—	20	20	30	40	30
C	Untreated heartwood	3	—	10	10	15	20	15
C	Untreated heartwood	4	—	6	6	9	10	9
C	Untreated sapwood	all	—	2	2	3	5	3
D	Treated sapwood	all	H3	35	35	60	80	60
D	Untreated heartwood	1	—	20	20	30	40	30
D	Untreated heartwood	2	—	15	15	25	35	25
D	Untreated heartwood	3	—	9	9	15	20	15
D	Untreated heartwood	4	—	5	5	8	10	8
D	Untreated sapwood	all	—	2	2	3	4	3

Notes:

1. See Table 5.1.

2. As per AS 1604.1 for CCA only.

Table 5.3: Typical service life for replacement of timber in fencing. *(See Fig. 5.3 for location in the assembly.)*

Climate zone	Timber type	Above-ground durability class[1]	Treatment[2]	Typical service life (years)				
				d	e	f	g	h
A	Treated sapwood	all	H3	>100	>100	>100	>100	>100
A	Untreated heartwood	1	—	80	80	>100	>100	>100
A	Untreated heartwood	2	—	60	60	>100	>100	>100
A	Untreated heartwood	3	—	35	35	60	80	60
A	Untreated heartwood	4	—	20	20	30	40	30
A	Untreated sapwood	all	—	7	7	10	15	10
B	Treated sapwood	all	H3	>100	>100	>100	>100	>100
B	Untreated heartwood	1	—	60	60	>100	>100	>100
B	Untreated heartwood	2	—	50	50	80	>100	80
B	Untreated heartwood	3	—	30	30	45	60	45
B	Untreated heartwood	4	—	15	15	25	35	25
B	Untreated sapwood	all	—	6	6	9	10	9
C	Treated sapwood	all	H3	100	100	>100	>100	>100
C	Untreated heartwood	1	—	50	50	80	>100	80
C	Untreated heartwood	2	—	40	40	70	90	70
C	Untreated heartwood	3	—	25	25	35	50	35
C	Untreated heartwood	4	—	10	10	20	25	20
C	Untreated sapwood	all	—	5	5	7	10	7
D	Treated sapwood	all	H3	80	80	>100	>100	>100
D	Untreated heartwood	1	—	45	45	70	90	70
D	Untreated heartwood	2	—	35	35	60	80	60
D	Untreated heartwood	3	—	20	20	30	45	30
D	Untreated heartwood	4	—	10	10	20	25	20
D	Untreated sapwood	all	—	4	4	6	9	6

Notes:

1. See Table 5.1.

2. As per AS 1604.1 for CCA only.

(5.1.2 Domestic Decking

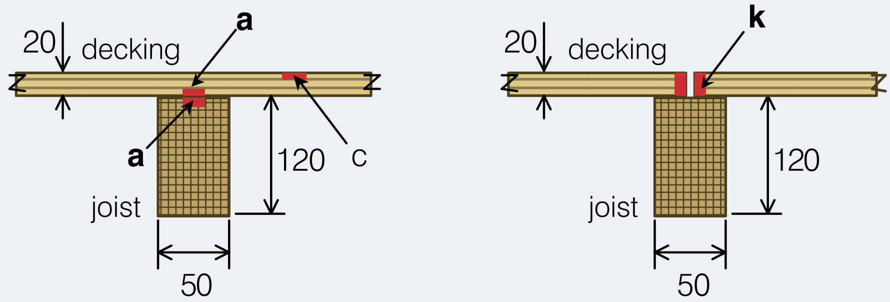


Figure 5.4: Typical dimensions of decking and locations of interest for service lives.

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
A	Treated sapwood	all	H3	60	80	60
	Untreated heartwood	1	—	30	40	30
		2	—	25	35	25
		3	—	15	20	15
		4	—	8	10	8
	Untreated sapwood	all	—	3	4	3
B	Treated sapwood	all	H3	50	60	50
	Untreated heartwood	1	—	25	35	25
		2	—	20	25	20
		3	—	10	15	10
		4	—	7	9	7
	Untreated sapwood	all	—	2	3	2
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
D	Treated sapwood	all	H3	35	45	35
	Untreated heartwood	1	—	20	25	20
		2	—	15	20	15
		3	—	8	10	8
		4	—	5	6	5
	Untreated sapwood	all	—	2	2	2

Notes:

1. See Table 5.1.

2. As per AS 1604.1 for CCA only.

Table 5.5: Typical service life for replacement of timber in decking. *(See Fig. 5.3 for location in the assembly.)*

Climate zone	Timber type	Above-ground durability class(1)	Treatment(2)	Typical service life (years)		
				a	c	k
A	Treated sapwood	all	H3	>100	>100	>100
	Untreated heartwood	1	—	70	90	70
		2	—	60	80	60
		3	—	30	40	30
		4	—	20	25	20
	Untreated sapwood	all	—	6	8	6
B	Treated sapwood	all	H3	>100	>100	>100
	Untreated heartwood	1	—	60	80	60
		2	—	45	60	45
		3	—	25	35	25
		4	—	15	20	15
	Untreated sapwood	all	—	5	7	5
C	Treated sapwood	all	H3	90	>100	90
	Untreated heartwood	1	—	45	60	45
		2	—	35	50	35
		3	—	20	25	20
		4	—	10	15	10
	Untreated sapwood	all	—	4	5	4
D	Treated sapwood	all	H3	80	100	80
	Untreated heartwood	1	—	40	50	40
		2	—	30	40	30
		3	—	20	25	20
		4	—	10	15	10
	Untreated sapwood	all	—	4	5	4

Notes:

1. See Table 5.1.

2. As per AS 1604.1 for CCA only.

5.1.3 Commercial Decking

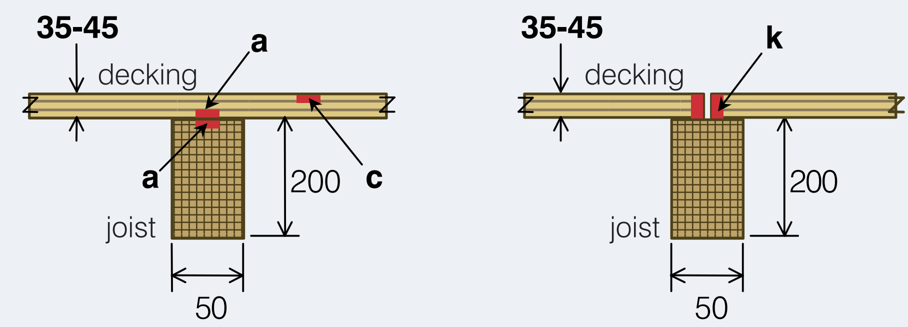


Figure 5.5: Typical dimensions of commercial decking and locations of interest for service lives.

Table 5.6: Typical service life for onset of decay in decking. *(See Fig. 5.5 for location in the assembly.)*

Climate zone	Timber type	Above-ground durability class(1)	Treatment(2)	Typical service life (years)		
				a	c	k
A	Treated sapwood	all	H3	60	80	60
	Untreated heartwood	1	—	30	40	30
		2	—	25	35	25
		3	—	15	20	15
		4	—	8	10	8
	Untreated sapwood	all	—	3	4	3
B	Treated sapwood	all	H3	50	60	50
	Untreated heartwood	1	—	25	35	25
		2	—	20	25	20
		3	—	10	15	10
		4	—	7	9	7
	Untreated sapwood	all	—	2	3	2
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
D	Treated sapwood	all	H3	35	45	35
	Untreated heartwood	1	—	20	25	20
		2	—	15	20	15
		3	—	8	10	8
		4	—	5	6	5
	Untreated sapwood	all	—	2	2	2

Notes:

1. See Table 5.1.

2. As per AS 1604.1 for CCA only.

Decay in untreated sapwood on edges of decking boards.

Table 5.7: Typical service life for replacement of timber in decking.
(See Fig. 5.5 for location in the assembly.)

Climate zone	Timber type	Above-ground durability class[1]	Treatment[2]	Typical service life (years)		
				a	c	k
A	Treated sapwood	all	H3	>100	>100	>100
	Untreated heartwood	1	—	70	90	70
		2	—	60	80	60
		3	—	30	40	30
		4	—	20	25	20
	Untreated sapwood	all	—	6	8	6
B	Treated sapwood	all	H3	>100	>100	>100
	Untreated heartwood	1	—	60	80	60
		2	—	45	60	45
		3	—	25	35	25
		4	—	15	20	15
	Untreated sapwood	all	—	5	7	5
C	Treated sapwood	all	H3	90	>100	90
	Untreated heartwood	1	—	45	60	45
		2	—	35	50	35
		3	—	20	25	20
		4	—	10	15	10
	Untreated sapwood	all	—	4	5	4
D	Treated sapwood	all	H3	80	100	80
	Untreated heartwood	1	—	40	50	40
		2	—	30	40	30
		3	—	20	25	20
		4	—	10	15	10
	Untreated sapwood	all	—	4	5	4

Notes:
1. See Table 5.1.
2. As per AS 1604.1 for CCA only.

5.1.4 Pergolas and similar applications

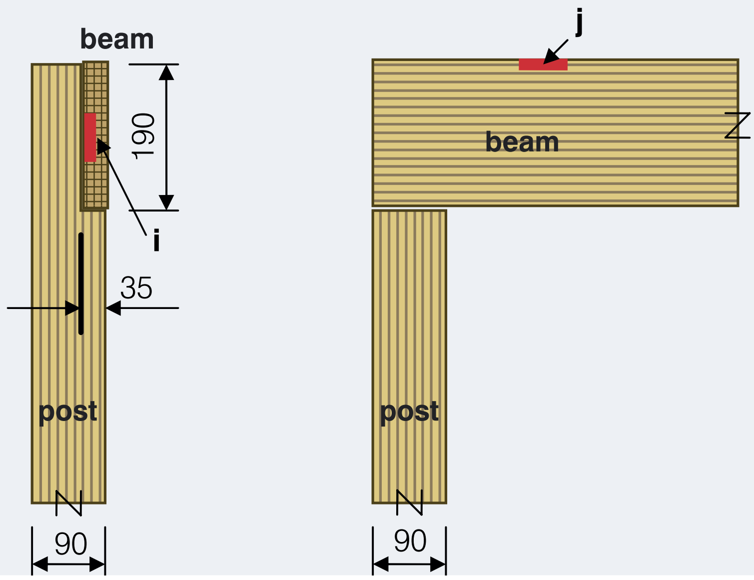


Figure 5.6: Typical dimensions of pergola and locations of interest for service lives.

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	Typical service life (years) j
A	Treated sapwood	all	H3	50	80
	Untreated heartwood	1	—	25	40
		2	—	20	35
		3	—	10	20
		4	—	7	10
	Untreated sapwood	all	—	3	4
B	Treated sapwood	all	H3	40	60
	Untreated heartwood	1	—	20	35
		2	—	15	25
		3	—	10	15
		4	—	6	9
	Untreated sapwood	all	—	2	3
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
D	Treated sapwood	all	H3	30	45
	Untreated heartwood	1	—	15	25
		2	—	10	20
		3	—	7	10
		4	—	4	6
	Untreated sapwood	all	—	1	2

Notes:

1. See Table 5.1.

2. As per AS 1604.1 for CCA only.

Table 5.9: Typical service life for replacement of timber 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
A	Treated sapwood	all	H3	>100	>100
	Untreated heartwood	1	—	60	90
		2	—	50	80
		3	—	25	40
		4	—	15	25
	Untreated sapwood	all	—	5	8
B	Treated sapwood	all	H3	90	>100
	Untreated heartwood	1	—	45	80
		2	—	40	60
		3	—	20	35
		4	—	10	20
	Untreated sapwood	all	—	4	7
C	Treated sapwood	all	H3	70	>100
	Untreated heartwood	1	—	35	60
		2	—	30	50
		3	—	15	25
		4	—	9	15
	Untreated sapwood	all	—	3	5
D	Treated sapwood	all	H3	60	100
	Untreated heartwood	1	—	30	50
		2	—	25	40
		3	—	15	25
		4	—	8	15
	Untreated sapwood	all	—	3	5

Notes:

1. See Table 5.1.

2. As per AS 1604.1 for CCA only.

5.1.5 Decay of Timber Cross-Arms and Similar

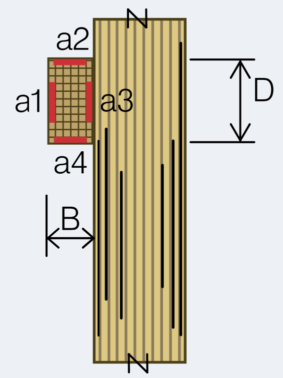


Figure 5.7: Timber cross-arms: dimensions and decay zones to be considered.

Note: The decay zones a1-a4 shown in Figure 5.7 are intended to indicate the general location of the decay and not the actual geometry of the decay attack. In particular, decay in the zones a1 and a2 would be due to water entry and retention at splits and checks. This will initiate decay below the wood surface. In fact, the surface may remain free of decay if the surface temperatures arising from solar radiation are high enough to kill fungi.

Table 5.10: Typical decay depths of cross-arms in Zones A and B.
(See Fig. 5.7 for location in the assembly.)

			Cross-arms, at 20 years						
			Dimension (mm)		Typical decay depths (mm)				
					a1				
Zone	Timber		B	D	NW[1]	SE[1]	a2	a3	a4
A	Heartwood	Class 1	100	100	0	0	1	0	0
		Class 2	100	100	0	0	1	0	0
		Class 3	100	100	1	1	3	1	0
		Class 4	100	100	5	3	10	5	1
	Sapwood	Untreated	100	100	>20	18	>20	>20	10
		H3 treated(2)	100	100	0	0	0	0	0
B	Heartwood	Class 1	100	100	0	0	1	0	0
		Class 2	100	100	1	0	1	1	0
		Class 3	100	100	2	1	4	2	1
		Class 4	100	100	7	4	14	7	2
	Sapwood	Untreated	100	100	>20	>20	>20	>20	14
		H3 treated(1)	100	100	0	0	0	0	0

Notes:

1. 'NW' and 'SE' indicate the facing direction. 'NW' is for facing north and west; 'SE' is for facing south and east.

2. Note that AS1604 permits 20% of the cross-section to be heartwood timber and not penetrated by preservatives. The decay depth for the untreated heartwood timber should be estimated as the decay depth of the corresponding class of heartwood.

CCA treated sapwood outperforming durability class 2 heartwood

Mineral wools are not all the same. Check product sheets to ensure correct fusion temperature.

Table 5.11: Typical decay depths of cross-arms in Zones C and D.
(See Fig. 5.7 for location in the assembly.)

Zone	Timber		Cross-arms, at 20 years						
			Dimension (mm)		Typical decay depths (mm)				
					a1				
			B	D	NW[1]	SE[1]	a2	a3	a4
C	Heartwood	Class 1	100	100	1	0	2	1	0
		Class 2	100	100	1	1	2	1	0
		Class 3	100	100	3	2	7	3	1
		Class 4	100	100	12	7	>20	12	3
	Sapwood	Untreated	100	100	>20	>20	>20	>20	>20
		H3 treated[2]	100	100	0	0	0	0	0
D	Heartwood	Class 1	100	100	1	1	2	1	0
		Class 2	100	100	1	1	3	1	0
		Class 3	100	100	4	3	10	4	1
		Class 4	100	100	14	9	>20	14	4
	Sapwood	Untreated	100	100	>20	>20	>20	>20	>20
		H3 treated[2]	100	100	0	0	1	0	0

Notes:

1. 'NW' and 'SE' indicate the facing direction. 'NW' is for facing north and west; 'SE' is for facing south and east.

2. Note that AS1604 permits 20% of the cross-section to be heartwood timber and not penetrated by preservatives. The decay depth for the untreated heartwood timber should be estimated as the decay depth of the corresponding class of heartwood.

6 Weathering, Finishing, Good Practice, Maintenance and Other Considerations

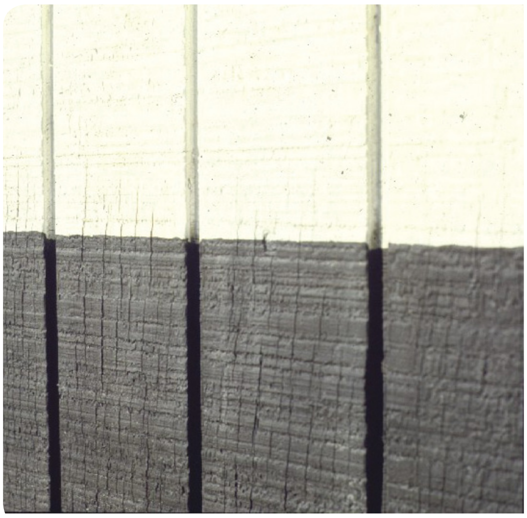
Section 5 refers to the performance of uncoated wood. This Section provides advice and general recommendations associated with finishing, detailing and good practice.

6.1 Weathering and Finishing

Protection from weathering can be afforded by the following means:

- Application and maintenance of finishes including paints, stains and water repellents
- Architectural and design detailing including overhangs, capping, verandahs, shading, etc.

6.1.1 Coatings – General



Light coloured finishes are preferred to dark colours as they are less prone to checking.

It is difficult to give useful quantitative information on the effects of coating systems in general. Paint systems have an initial beneficial effect in delaying the onset of moisture entry and hence of decay. However, once cracks occur, moisture enters the wood, and the paint systems then inhibit drying and hence may accelerate the onset and progress of decay. The rate of decay and checking of wood can also be accelerated if the coating is a dark colour, because this then encourages the wood to absorb the heat from the sun.

From in-service performance data and recent research it has been found that low quality and or poorly maintained acrylic paints, applied to low durability timber, may actually speed up the onset and progress of decay by a factor of two. This is caused by the paint system permitting moisture entry and then trapping the moisture in the timber.

Conversely, a quality acrylic paint system applied to a highly durable timber such as a Class 1 timber or CCA-treated pine, will extend the service life by delaying the effects of weathering and subsequent water entry.

It has also been found from research that the application and regular maintenance of pigmented oil based stain finishes or water repellent preservatives on low durability timber will extend service life by inhibiting the onset of decay and weathering due to the water repellency and preservative nature of these products.

Hence, while high quality coating systems should be beneficial if they are applied and maintained in accordance with manufacturers recommendations, they may also be either beneficial or detrimental to the long term performance of exposed wood, depending on a large number of parameters.

Most commercial finishes do not provide a complete moisture seal, but a suitable finish will reduce movement from moisture uptake and loss and will also reduce the effects of weathering. To obtain the full benefit of coating systems, end grain and surfaces of joints should be sealed with an oil based primer, stain or water repellent to maximise service life.

Bottom half of panel maintained with water repellant finish as indicated by 'water bucket' test.

6.1.2 Finishing

Timber absorbs and desorbs moisture in sympathy with its environment. Generally, the denser the species, the less reactive it is to rapid moisture changes. On the other hand, denser species tend to have greater overall percentage movement, therefore permanent moisture changes will lead to greater movement than occurs with less dense species.

Movement (expansion and contraction) in timber can be greatly reduced by providing protective vapour barriers. By far the most economical of these is attained by the application of suitable paints, stains or water repellents.

It should be noted that these do not confer a total seal and that given sufficient time, timber will reach a moisture content in equilibrium with its environment.

The following points should be considered when deciding upon the efficacy of finishes required to minimise moisture changes and subsequent movement:

- pale colours absorb less heat, therefore the effects of drying and accelerated decay due to raised temperatures are minimised
- oil based paint systems are generally better 'vapour' barriers than acrylic systems
- good quality primers and undercoats (oil or acrylic) are designed to seal the timber and provide a key for top coats
- stains and water repellents require more frequent re-application to maintain a water resistant finish than paints and
- sawn surfaces provide a better "key" for stains and water repellents than do dressed surfaces; particularly for denser species.

Table 6.1 provides a summary of finishes and maintenance appropriate for timber used externally.

Table 6.1: Exterior wood finishes: types, treatments and maintenance.

Finish	Initial Treatment	Appearance of Wood	Cost of Initial Treatment	Maintenance Procedure	Maintenance Period of Surface Finish	Mainten-ance Cost
Paint	Prime and two top coats	Grain and natural colour obscured	Medium to high	Clean and apply top coat or remove and repeat initial treatment if desired	7 – 10 years(1)	Medium
Clear (film forming)	Four coats (minimum)	Grain and natural colour unchanged if adequately maintained	High	Clean and stain bleached areas and apply two more coats	2 years or when breakdown begins	High
Water Repellent(3)	One or two coats of clear material, or preferably dip applied	Grain and natural colour; visibly becoming darker and rougher textured	Low	Clean and apply sufficient material	1 – 3 years or when preferred	Low to medium
Stains	One or two brush coats	Grain visible; coloured as desired	Low to Medium	Clean and apply sufficient material	3 – 6 years or when preferred	Low to Medium
Organic Solvents Preser-vatives (4)	Pressure, steeping, dipping, brushing	Grain visible; coloured as desired	Low to Medium	Brush down and reapply	2 – 3 years or when preferred	Medium
Waterborne Preservatives	Pressure	Grain visible; greenish or brownish; fading with age	Medium	Brush down to remove surface dirt	None unless stained, painted or varnished	Low to medium for stained or painted

Notes:

1. This table is a compilation of data from the observations of many researchers.

2. Using top quality acrylic latex paints.

3. With or without added preservatives. Addition of preservative helps control mildew and mould growth.

4. Pentachlorophenol, tri-n-butyltin oxide, copper naphthenate and similar materials.

6.2 Design Detailing

6.2.1 General

Architectural and structural detailing are critical considerations to ensure durable structures. The following are some key factors that should be considered:

- shielding – overhangs, pergolas, vegetation, capping, flashing, fascias, barges, etc
- isolation – damp proof course's, sarking, claddings, etc
- moisture traps – housed joints, free draining, well ventilated, end grain
- ventilation and condensation – cold climates, warm climates, sarking, foil, insulation, etc
- joint detailing.

Figures 6.1 to 6.6 provide examples of the above.

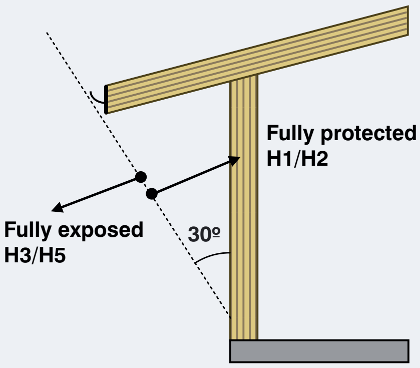


Figure 6.1: Architectural detailing – shielding.

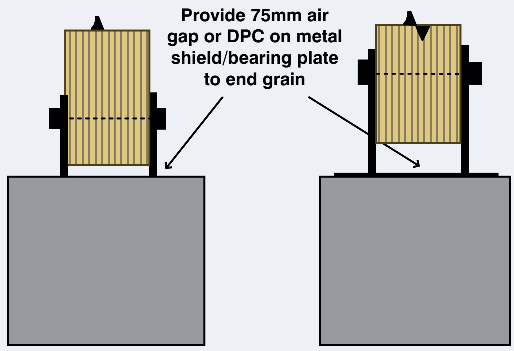
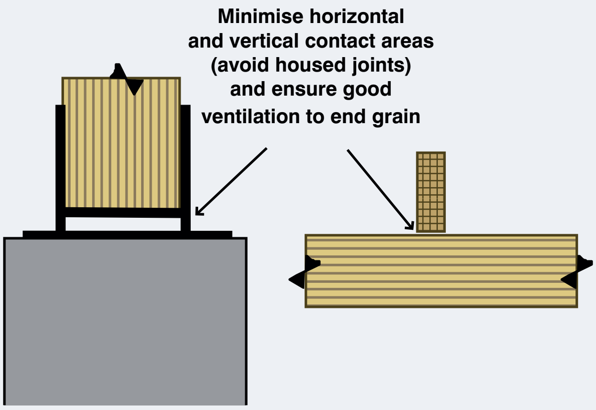
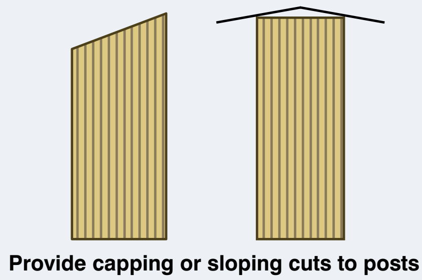


Figure 6.2: Isolation of timber from moisture traps.



A well-ventilated, free-draining post support.

Figure 6.3 Moisture traps.



Capping protects top and end grain of projected beam.

Figure 6.4 Weather protection.

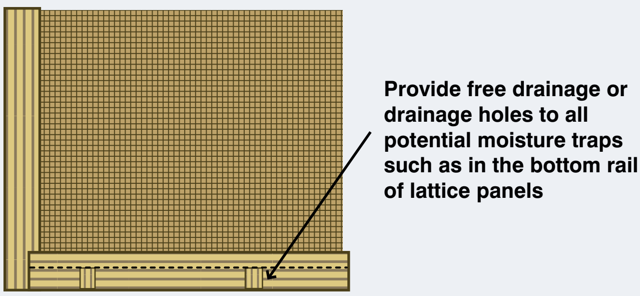


Figure 6.5 Drainage holes.

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

6.2.2 Other Considerations

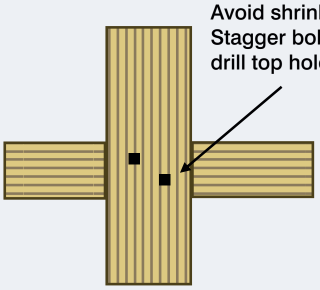
Successful structures rely heavily upon detailing. Attention to detail and simplicity will usually provide the most economical durable connections. The following factors require consideration:

- minimising moisture traps and contact areas
- avoiding restraint due to shrinkage
- allowing for shrinkage or differential movement
- using the correct fastener
- use of corrosive resistant metals.

Shrinkage Restraint

Shrinkage restraint at joints needs to be considered, particularly where unseasoned timber is used. Where shrinkage restraint occurs, stresses perpendicular to grain may be induced that can cause splitting and subsequent moisture ingress or loss of structural integrity. To avoid shrinkage restraint, the following should be considered:

- minimise moisture content changes – finishes + end grain sealant
- align fasteners along member axis
- use single fasteners
- use connections that allow some movement
- use seasoned timber
- drill holes 10% oversize in unseasoned timber.



Good handrail detail – sloped end grain and sloped bracket to take handrail that will be fixed from underside.

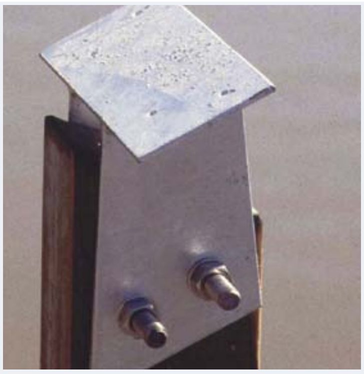


Figure 6.6: Good detailing.

Allow for Shrinkage/Movement

Allowance may also need to be made for shrinkage and differential movement at connections and in construction. Failure to do so may lead to a breakdown of the building envelope, allowing ingress of moisture. Measures than can be taken to avoid this include:

- if unseasoned timber is used (e.g. floor joists), specify species with similar shrinkage values.
- where timber is mixed with steel and/or concrete construction, (e.g. bearers or beams supporting buildings), use seasoned timber to avoid differential movement.
- allowing for vertical movement in unseasoned framing by leaving adequate clearance to the top of masonry veneer.
- allowing adequate clearance at the top of unseasoned members faced fixed to members that will not shrink.

Moisture Traps

Moisture traps should also be avoided particularly where connections and joints are exposed to the weather. In addition, in exposed situations, horizontal contact areas between members should be kept to a minimum and where possible, all joints should be free draining. If necessary, drainage holes should be included in the joint detail. Timber enclosed in sockets or "shoes" exposed to the weather should be avoided.

Fastener Selection

Fastener selection is also important when detailing joints for durability. In external applications in particular, where moisture content and temperature variations will induce timber movement, fasteners should be selected to provide restraint against shrinkage and swelling and to minimise loosening of joints due to vibration or impact loads, etc.

To highlight this, the following joints can be considered:

- cladding to framing
- heavy decking to joists.

In the cladding to framing example, if the cladding is left unprotected (i.e. not painted), cyclic moisture changes will induce constant shrinkage and swelling that will induce tension into the connector (usually a nail). The connector therefore has to be designed to resist these forces and it has been found from practical experience that:

- bullet head, plain shank nails are satisfactory for hardwood cladding where cladding is painted and nails are punched and stopped
- plain shank, flat head nails (greater resistance to "pull through") are satisfactory for paintedftwood cladding
- galvanised, deformed shank (ring or annular) flat head nails are required for unpainted preservative treated softwood cladding fixed to pine framing
- 'T' head machine driven nails are unsatisfactory (pull through and withdrawal) for use with unpainted cladding (or decking).

Plain shank decking nails in pine have 'worked out' with cyclic wetting and drying.

Incorrect use of non-galvanised 'T' head nails in decking.

In the second example of **heavy decking** (38 – 75 mm thick) to joists, movement due to seasonal moisture changes and traffic vibration, etc, can cause local crushing under decking spikes and withdrawal of spikes. To overcome this, fasteners with larger diameter heads and greater holding power provide more positive fixing, e.g. coach screws with washers, Type 17 self-drilling countersunk screws (for up to 50 mm thick decking) and where necessary, coach bolts (these can be re-tightened during programmed maintenance).

Bituminous DPC fixed to top of deck joists.

Deck screws should have been staggered to prevent splitting of joists.

No splitting of joists where deck screws were staggered.

6.3 Type of Member and Glue

The type of member selected for a particular application can also be a deciding factor in the durability of structures. For example, glued-laminated timber or sheet products exposed to the weather will, (when left unpainted or, finished with products that allow moisture ingress resulting in shrinkage/swelling), check along lines adjacent to the glue-lines. This is in sharp contrast to solid timber where seasoning checks tend to occur randomly. The consequences are that major moisture traps and lines of shear strength weakness can occur.

The successful use of glued timber products (engineered wood products) exposed to the weather is therefore dependent upon using durable timber and excluding moisture. This can best be achieved by either using architectural detailing (a roof) or by naturally durable or preservative treated glued timber products treated after gluing that are painted or finished and regularly maintained with a moisture excluding envelope.

The durability of glue must also be considered.

Beams built up by mechanical means (nail laminated and nail plated) also require consideration with regard to durability. Joins in these beams provide a potential moisture trap where used exposed to the weather. In addition, the plate joined beams may need special consideration where a corrosive environment exists.

Generally, nail plated timber products are not recommended for use in weather exposed applications as the plates work loose with cyclic wetting and drying.

6.4 Timber Grade and Size

Australian Standard grading rules usually provide a suitable range of grades that can be selected from for specific applications. For example:

- For hardwood milled products, select – medium feature, standard and high feature grades are described in AS 2796 and for softwoods, AS 4785.2 provides various grades depending upon species.
- For stress graded timber, Structural Grades No. 1 to 5 are available with additional appearance grades optional. Refer to AS 2082 and AS 2858.

With regard to weather exposed applications, the general structural grades may not provide for, or limit defects that can have a bearing on durability. Additional requirements that may need to be considered with regard to durability are untreated sapwood, sapwood orientation (i.e. it should be placed to the outside of joints or exposed to higher levels of ventilation), open defects, loose knots, voids and splits, etc. Additional considerations are required to be specified for commercial decking. For example:

- limiting open defects on the top surface
- laying decking with the 'heart side' down.

The size and proportions of the cross-section of members should be considered when detailing for durability. This is particularly so for unseasoned timber where shrinkage and movement due to moisture changes plays an important part.

Consideration should be given to the following:

- Members with breadth to depth ratios not exceeding about 3:1 are less prone to cupping, i.e. decking exposed to the weather.
- Narrower board products expand/contract less than wider boards, i.e. smaller gaps in flooring result where narrower boards are used also, less stress is induced in fixings where shrinkage occurs.
- Stockier members are usually less prone to the effects of bowing and slender members are usually less prone to the effects of spring.
- Thinner members dry out quickly.

6.5 Moisture Content

Timber properties are greatly affected by the level of moisture content in the material.

Seasoned timber kept dry (MC $< 20\%$) will not decay and similarly, fully immersed timber, where oxygen is excluded, will not decay. In addition, fewer insect pests attack seasoned timber.

Seasoned timber also offers the following advantages with respect to durability:

- more dimensionally stable
- easier to treat, paint and can be glued and
- more resistant to the transmission of heat and electricity.

6.6 Maintenance

Unless designed and specified for very specific purposes or for a short life span, all structures require maintenance. This is particularly so for a building or structure's external envelope.

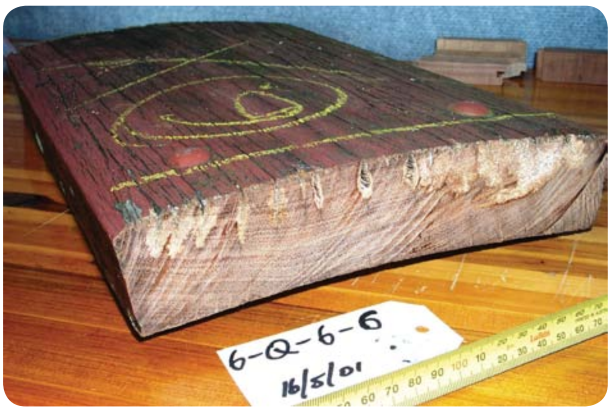
The purpose of maintenance is to ensure that the original condition of a material will remain intact so that it can continue to effectively perform its intended function be it functional or for aesthetic reasons..

Maintenance must therefore be considered at the design stage as the level and intensity of maintenance is a function of original design and materials specification. This is where initial costs must be weighed up against future maintenance or repair costs.

Table 6.2 provides general guidance on the selection and scheduling of a number of maintenance procedures for timber structures.

Public boardwalk in process of maintenance with decking oil.

Poor maintenance of stair tread.



Section of stair tread showing poor maintenance has led to premature decay.

Table 6.2: Selection and scheduling of maintenance.

Item	Suggested Maintenance and Inspection Periods	Remarks
i) Finishes **– external** **- internal**	Refer to Table 6.1 As required but approximately every 10-15 years.	
ii) Building Envelope - cladding, roofing, weatherproofing	Varies depending upon initial quality of materials, however, ten year inspections would be warranted for most products.	These can be designed for specific lives from 5 years to 100+ years.
iii) Termite Protection **- Mechanical Barriers** **- Chemical Barriers**	Approximately 10 years. Replenish at intervals in accordance with manufacturers registration labels.	Refer to AS 3660.1
iv) Ventilation - **- subfloor, wall and roof**	Ensure vents remain unblocked. Clean where necessary – 10 years.	Vents are often covered over during new work. This must be avoided or new vents installed.
v) Vapour Barriers	Check integrity of vapour barriers in roofs, under floors, approximately at 15 year intervals.	
vi) Metal Fasteners **- Corrosion**	Varies depending upon initial quality of materials and presence of hazards.	If corrosion present, repair or replace immediately to prevent further ingress of moisture/dirt.
- Integrity	If unseasoned timber is used, re-tighten bolts, screws, etc, after 6 months and 12 months. If nails become loose, re-punch or re-nail where necessary.	Use of hot-dipped galvanised fasteners overcomes many fixing problems. Use stainless steel in marine environments.
vii) Plumbing	Repair or replace leaking or defective plumbing immediately and re-establish finish (inspection cycles determined by above).	Presence of moisture increases possibility of decay and termite attack.
viii) Decay	If noticed, repair or replace defective material immediately and re-establish finish (inspection cycles determined by above).	
ix) Supplementary preservatives, end grain sealants and end grain plating	Require inspection and/or maintenance about 3-5 year intervals, depending upon type and application.	These are usually used in heavy engineering applications, such as wharves, bridges and posts in ground.
x) Cleaning	Clean surfaces as required. Use of blowers rather than hosing down is far better, particularly for decks.	Build up of dirt, etc, on timber surfaces will increase potential for decay via moisture traps, etc.

6.7 Fire

Refer to the Building Code of Australia and Australian Standard AS 1720, Part 4 and also woodsolutions.com.au

6.8 Chemical

Timber is resistant to mild acids, however, strong acids (pH less than 2) and strong alkalis (pH greater than 10) can cause degradation of the chemical components of timber. The degree of degradation is dependent upon many factors including species of timber (softwoods are more resistant to attack by acids and alkalis than hardwoods), type of chemical (oxidising acids are worse than non-oxidising) and exposure conditions.

Examples of timber applications where timber's resistance to chemical attack is of great benefit include:

- enclosed swimming pool structures
- tanneries
- chemical storage buildings such as fertiliser sheds
- wastewater treatment works
- piles in acidic soils (peaty conditions)
- water reservoir roof structures.

As many variables are involved in adverse chemical environments, industry and recognised research sources should be consulted for specific advice.

7

Insect Attack

Timber structures are best protected from damage by insects by consideration given to correct design and construction procedures and accurate specification, including species selection and where necessary, preservative treatment. The main insects that may cause damage to structures or contents are:

- **termites**
- **lyctus beetles**
- **furniture beetles (a low risk in Australia).**

7.1 Termites

Termites that attack timber can be classified into two types, subterranean and dry wood. Subterranean termites pose by far the most significant economic risk to structures in Australia, but it should be kept in mind that adoption of simple and cost effective procedures can greatly reduce the risk of termite attack and subsequent damage.

7.1.1 Subterranean Termites

The best protection in areas where subterranean termites are prevalent is to provide simple and inexpensive measures during construction, to eliminate moisture traps and to provide proper ventilation to enable drying out of timber. Adopting the following good practices will assist:

- eliminate/minimise cracks in concrete foundations. Install slabs and footings to AS 2870 with concrete vibrated or compacted.
- ensure building sites and under buildings are clear of debris, trees and organic matter.
- do not landscape (gardens, planters, etc) against building or foundations or in contact with timber.
- include ant caps (termite shields) in accordance with AS 3660.1
- minimise untreated timber in contact with the soil. Ensure crawl spaces have adequate clearance for inspection and ventilation.

In addition to proper design and construction, in areas where subterranean termites present a higher hazard, chemical treatment of the soil or installation of additional physical barriers should be applied in accordance with AS 3660.1. Additional protection for structural elements can also be achieved by the use of either naturally termite resistant or chemically treated timber or both.

7.1.2 Limiting the risk of termite damage

This following specifies the level of termite control recommended for limiting the risk of termite damage to new houses and other buildings. The equations used for these estimates are given in Report number 8 referred to in the Preface.

The specifications given have been chosen so that the theoretical risk of attack on all Australian houses is the same, for a great range of conditions of location, house type and termite management measures. The requirements have been computed by use of a model calibrated with quantitative estimates given by a very small number of experts and a termite tally of some 5000 houses. The model has been applied to determine the level of inspection required so that the theoretical risk of attack by termites within the first 50 years is 20%. This level is probably slightly better than the level of apparent risk that is currently accepted in Australia. Similar specifications can be developed for reduced levels of risk. The specifications are indicative only. For development of a model that can be used with confidence, further expert opinion and field data are necessary.

Zone D has the greatest termite. hazard.

To apply this section, it is first necessary to evaluate the hazard scores of various parameters influencing termite hazard (Figure 7.1 and Tables 7.1 to 7.7 and Appendix 2). These scores are then totalled (Table 7.8). Finally the hazard score totals are used to assess the acceptance of termite control procedures according to the rules given in Table 7.9.

To illustrate the application of this procedure, some example Hazard Scores have been highlighted in the Tables and commentary provided under Table 7.9.

In the following, the term 'risk' is used to indicate the probability that a house is attacked by termites. Factors that affect this risk are termed 'hazards'.

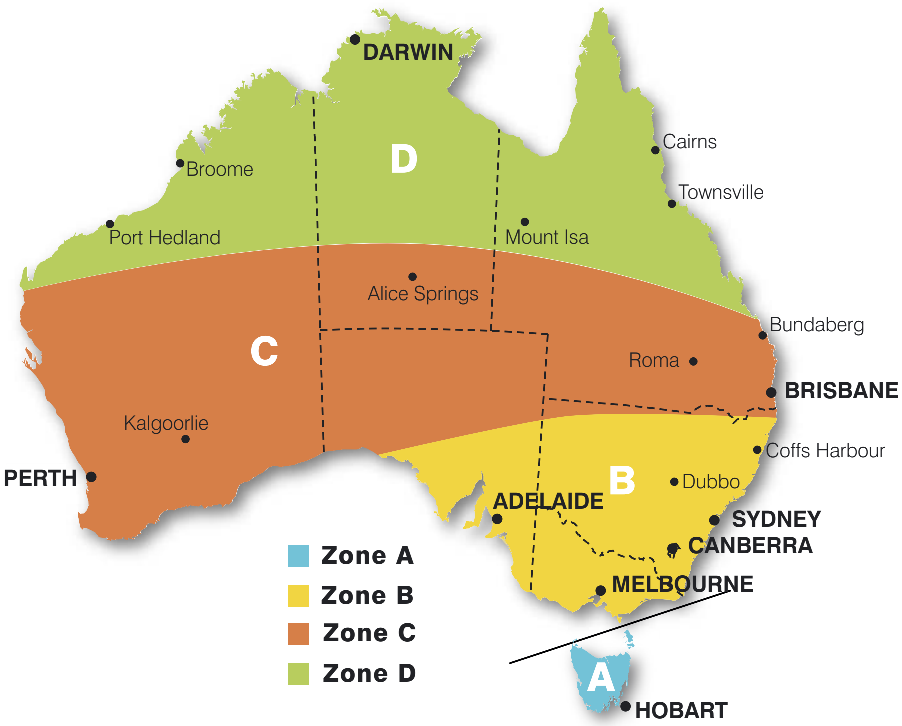


Figure 7.1: Termite hazard zones for Australia.

Table 7.1: Hazard score for location zone.

Location Zone	Hazard score
B	0
C	2
D	4

Note: See Figure 7.1. Recommendations for Zone A are given after Table 7.9.

Table 7.2: Hazard score for age of suburb.

Age of suburb	Hazard score
<10 yrs	0
10-70 yrs	2
>70 yrs	4

Note: Suburb refers to areas within which at least 20% of the land is covered by buildings.

Table 7.3: Hazard score for distance to nearest boundary fence, established housing or bush land.

Distance to nearest built-up suburb	Hazard score
>8 m	0
2—8 m	0.5
<2 m	1.0

Table 7.4: Hazard score for food sources for termites.

Hazard related to substantial food sources*	Hazard score
low	0
medium	0.5
high	1.0

Note: See Table A.2.1 in Appendix 2.

Table 7.5: Hazard score for contact of house with ground.

Hazard related to ground contact*	Hazard score
low	0
medium	1
high	2

Note: See Table A.2.2 in Appendix 2.

Table 7.6: Hazard score for type of construction material.

Hazard related to type of construction materials*	Hazard score
low	0
medium	1
high	2

Note: See Table A.2.3 in Appendix 2.

Table 7.7: Hazard score for environment favourable to termites.

Hazard related to favourable environmental conditions*	Hazard score
low	0
medium	1
high	2

Note: See Table A.2.4 in Appendix 2.

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

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.

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.

7.1.2 Drywood Termites

Drywood termites do not require contact with the ground and as there is little external evidence of infestation, they are difficult to detect. Their presence is widespread throughout the Pacific region, however, in Australia, at present, preventative measures against drywood termites is only considered warranted in the coastal lowlands north of Cooktown, QLD and tropical regions further north. For West Indian termites (a notifiable pest in QLD) found in isolated pockets in coastal Queensland, the Queensland Government conduct a 'containment' program using fumigation treatment of structures.

Protection for drywood termites is most economically provided by the use of termite resistant species (cypress, ironbark and other t species – Refer AS 5604) and/or by preservative treatment of the timber, particularly pine, to H2 level.

7.2 Powder Post Beetle (Lyctus)

In Queensland and New South Wales, State legislation (Timber Users Marketing acts), prohibits the sale of lyctus susceptible sapwood. In other states, Australian Standards grade descriptions usually limit the amount of lyctus susceptible sapwood permitted for most products. If protection from lyctus is required, then this can be achieved by using timber species that are not lyctus susceptible, by eliminating susceptible sapwood or by preservative treatment of sapwood.

7.3 Furniture Beetles

As protection is afforded by climate (cold and temperate regions not affected) and by surface films, enclosure in a structure, and by elevated temperatures (i.e. unsarked roof cavities), these insects are not of great concern. If protection is required for highly critical members, then preservative treatment should be considered for the species that are susceptible.

Termite damage to non-resistant timber.

8

Corrosion of Fasteners

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. Table 8.1 provides a general guide for the selection of appropriate levels of corrosion resistance.

Table 8.1: 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 galvanised fasteners should have a coating thickness of 42 microns.

Corrosion of metal fasteners needs to be considered in terms of the type of exposure of the fastener. Most timber connections and fasteners have an ‘exposed’ portion (exposed to atmosphere) and an ‘embedded’ portion (embedded in the timber).

Corrosion of the embedded portion of the fastener will be dictated by moisture content of the timber, the timbers natural ‘pH’, availability of oxygen and any electrolytic action that may be facilitated via other influences such as preservative treatment of the timber, such as CCA treatment, (copper vs zinc). The natural pH of many species of timbers are given in Table 8.2.

Corrosion of the ‘exposed’ portion of the fastener will be dictated by all of the above factors, but will also be influenced by air-borne contaminants such as salt deposition and in industrial areas, other chemicals.

Most timbers are slightly acidic (pH 3.5 to 5.5 with species such as western red cedar and kapur being at the low end) therefore when moisture is present and the metals in contact with the timber have a low resistance to corrosion (unprotected steel) chemical reactions are set up that cause a strength loss in the surrounding timber (dark staining around steel fasteners).

To prevent deterioration of timber around metal (particularly fasteners) where moisture is present, the following can be employed:

- Use non-corrosive or protected metals. (i.e. galvanised, coated, stainless steel or monel metals)
- Countersink and plug or 'stop' fasteners.
- Avoid the use of dissimilar metals in contact with each other (copper as in CCA and ACQ, etc, with zinc).
- Grease, coat or sheath fasteners in contact with CCA treated timber, i.e. shrink wrap with prophylatics or coat with bituminous or epoxy paints.

Information for estimating the service life of fasteners with respect to embedded corrosion is given in Sections 8.1 below. Information for estimating the service life of fasteners subjected to atmospheric corrosion is given in Section 8.2. For the case of bolts a special procedure combining embedded corrosion and enhanced atmospheric corrosion needs to be considered and this is given in Section 8.3. The enhanced atmospheric corrosion occurs due to the accumulation of rainwater and airborne chemicals within loose fitting bolt holes.

8.1 Embedded Corrosion – Nails, Screws, and Teeth of Nail Plates

8.1.1 Estimate of Service Life

The estimated service lives given in this Section are based on a corrosion model developed for the FWPA project. The equations used for these estimates are given in Report number 8 referred to in the Preface.

The model is based on relatively short-term laboratory and field experiments. The model used requires further field calibrations for two aspects. First, the extrapolation from short term to long term needs to be verified. Second, the model relies on an estimate of the moisture content of the timber, and the procedure used for this requires a check to be made on a larger number and variety of houses and other structures than has been done.

The houses examined for this study comprised a set of typical single-storey houses. Most of the houses were of brick veneer wall construction, including walls both with and without sarking. There was moderate air leakage into and out of these wall systems. Both tiled and sheet metal roofs were to be found among these houses. All metal roofs and some of the tiled roofs were sarked. Many of the houses contained sub-floors; these sub-floor areas were ventilated either by gratings or by weep holes. The above comprises quite a range of housing types, and accordingly the model used to assess the building environment is based on a composite of these various housing types. In addition, averaged values are used for features that influence the local climate such as the prevailing wind, vegetation, elevation, shielding from other buildings, etc. Hence, the model can, at best, be described as providing an example of an environment that is not unusual in Australian housing. If predictions for specific houses are required, then more elaborate models must be used, however the available field data is not adequate to calibrate such models.

Figure 8.1 shows some typical installations of fasteners embedded in wood subjected to corrosion. The typical service life, either in bending or in tension, given in Table 8.4 is taken as the mean estimate of the time taken for the embedded part of the steel fastener to lose 30% of its initial strength.

For fasteners embedded in untreated timber, the following procedure is used to derive an estimate of the design life:

- From Table 8.2 determine the acidity class of timber
- From Figure 8.2 determine the Zone of application
- From Tables 8.3 determine the Hazard Score
- From Table 8.4 determine the Hazard Rating
- Using the Hazard Rating determine the structural service life from Table 8.5 for the embedded metal fasteners.

The contribution of a zinc coating (alone) to the service life of a fastener embedded in untreated timber is given in Table 8.6.

For fasteners embedded in CCA-treated timber, the following procedure is used to derive an estimate of the design life:

- From Table 8.2 determine the acidity class of timber
- From Figure 8.2 determine the Zone of application
- From Tables 8.3 determine the Hazard Score
- From Table 8.7 determine the Hazard Rating
- Using the Hazard Rating determine the structural service life from Table 8.8 for the embedded metal fasteners.

The contribution of a zinc coating (alone) to the structural service life of a fastener embedded in CCA-treated timber is given in Table 8.9.

Note: In the following section, reference is made only to CCA treated timber. For ACQ and Copper Azole treated timber, however, the effects of these treatments on the corrosion rates of zinc coated fasteners has been found to be significantly greater than CCA, with some research indicating rates greater than twice that of CCA.

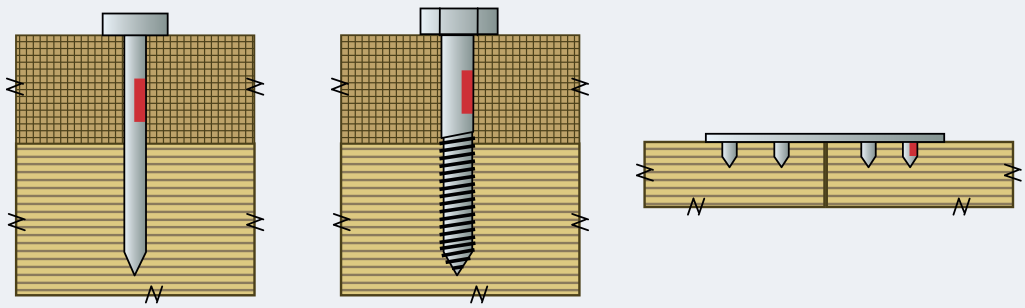


Figure 8.1: Typical installation of fasteners embedded in wood subjected to corrosion.
(Red marks denote where corrosion is considered.)

Table 8.2: Acidity pH value of commonly used timber and acidity classification.

Trade name	Botanical name	Acidity class	Measured pH(1)
Ash, alpine	*Eucalyptus delegatensis*	3	3.6
Ash, Crows	*Flindersia australis*	1	5.1
Ash, mountain	*Eucalyptus regnans*	2	4.7
Ash, silvertop	*Eucalyptus sieberi*	3	3.5
Balau (selangan batu)	*Shorea* spp.	2	-
Bangkirai	*Shorea laevis*	2	-
Beech, myrtle	*Nothofagus cunninghamii*	2	-
Belian (ulin)	*Eusideroxylon zwageri*	2	-
Blackbutt	*Eucalyptus pilularis*	3	3.6
Blackbutt, New England	*Eucalyptus andrewsii*	3	-
Blackbutt, WA	*Eucalyptus patens*	3	-
Blackwood	*Acacia melanoxylon*	2	-
Bloodwood, red	*Corymbia gummifera*	3	3.6
Bloodwood, white	*Corymbia trachyphloia*	3	-
Bollywood	*Litsea reticulata*	3	3.9
Box, brush	*Lophostemon confertus*	2	4.5
Box, grey	*Eucalyptus moluccana*	3	3.5
Box, grey, coast	*Eucalyptus bosistoana*	3	3.4
Box, long leaved	*Eucalyptus goniocalyx*	3	-
Box, red	*Eucalyptus polyanthemos*	3	-
Box, steel	*Eucalyptus rummeryi*	3	-
Box, swamp	*Lophostemon suaveolens*	2	-

***Table 8.2** (continued): Acidity pH value of commonly used timber and acidity classification.*

Trade name	Botanical name	Acidity class	Measured pH(1)
Box, yellow	*Eucalyptus melliodora*	3	-
Box,white	*Eucalyptus albens*	3	-
Brigalow	*Acacia harpophylla*	2	-
Brownbarrel	*Eucalyptus fastigata*	3	3.3
Bullich	*Eucalyptus megacarpa*	3	-
Calantas (kalantas)	*Toona calantas*	2	-
Candlebark	*Eucalyptus rubida*	3	-
Cedar, red, western	*Thuja plicata*	3	3.3
Cypress	*Callitris glaucophylla*	1	5.4
Fir, Douglas (Oregon)	*Pseudotsuga menziesii*	3	3.5
Gum, blue, southern	*Eucalyptus globulus*	3	-
Gum, blue, Sydney	*Eucalyptus saligna*	3	3.6
Gum, grey	*Eucalyptus propinqua*	3	3.8
Gum, grey, mountain	*Eucalyptus cypellocarpa*	3	3.6
Gum, maiden's	*Eucalyptus maidenii*	3	-
Gum, manna	*Eucalyptus viminalis*	3	-
Gum, mountain	*Eucalyptus dalrympleana*	3	-
Gum, red, forest	*Eucalyptus tereticornis*	2	4.2
Gum, red, river	*Eucalyptus camaldulensis*	3	-
Gum, rose	*Eucalyptus grandis*	1	5.1
Gum, salmon	*Eucalyptus salmonophloia*	3	-
Gum, scribbly	*Eucalyptus haemastoma*	3	-
Gum, shining	*Eucalyptus nitens*	3	-
Gum, spotted	*Corymbia maculata*, incl. *Corymbia citriodora*	2	4.5
Gum, sugar	*Eucalyptus cladocalyx*	3	-
Gum, yellow	*Eucalyptus leucoxylon*	3	-
Hardwood, Johnstone River	*Backhousia bancroftii*	2	-
Hemlock, western	*Tsuga heterophylla*	2	4.9
Ironbark, grey	*Eucalyptus paniculata*	3	4.0
Ironbark, red	*Eucalyptus sideroxylon*	3	-
Ironbark, red (broad-leaved)	*Eucalyptus fibrosa*	3	-
Ironbark, red (narrow-leaved)	*Eucalyptus crebra*	3	4.0
Ironwood Cooktown	*Erythrophloeum chlorostachys*	2	-
Jam, raspberry	*Acacia acuminata*	2	-
Jarrah	*Eucalyptus marginata*	3	3.3
Kapur	*Dryobalanops* spp.	3	3.3
Karri	*Eucalyptus diversicolor*	2	4.2
Keruing	*Dipterocarpus* spp.	1	5.1
Kwila (merbau)	*Intsia bijuga*	2	-
Mahogany, Philippine, red, dark	*Shorea* spp.	2	-
Mahogany, Philippine, red, light	*Shorea, Pentacme, Parashorea* spp.	2	-
Mahogany, red	*Eucalyptus resinifera*	3	3.0
Mahogany, white	*Eucalyptus acmenoides*	3	3.5
Mahogany, white	*Eucalyptus umbra*	3	-
Mahonany, southern	*Eucalyptus botryoides*	3	-
Mallet, brown	*Eucalyptus astringens*	3	-
Marri	*Eucalyptus calophylla*	3	
Meranti, red, dark	*Shorea* spp.	3	3.9

***Table 8.2** (continued): Acidity pH value of commonly used timber and acidity classification.*

Trade name	Botanical name	Acidity class	Measured pH(1)
Meranti, red, light	*Shorea* spp.	2	5.0
Mersawa	*Anisoptera* spp.	2	4.5
Messmate	*Eucalyptus obliqua*	3	3.2
Messmate, Gympie	*Eucalyptus cloeziana*	3	-
Oak, bull	*Allocasuarina luehmannii*	2	-
Oak, white, American	*Quercus alba*	2	-
Peppermint, black	*Eucalyptus amygdalina*	3	-
Peppermint, broad leaved	*Eucalyptus dives*	3	-
Peppermint, narrow leaved	*Eucalyptus radiata*	3	3.2
Peppermint, river	*Eucalyptus elata*	3	-
Pine, black	*Prumnopitys amara*	2	-
Pine, caribbean	*Pinus caribaea*	3	3.9
Pine, celery-top	*Phyllocladus aspleniifolius*	2	-
Pine, hoop	*Araucaria cunninghamii*	1	5.2
Pine, Huon	*Lagarostrobos franklinii*	2	4.6
Pine, kauri	*Agathis robusta*	2	-
Pine, King William	*Athrotaxis selaginoides*	2	-
Pine, radiata	*Pinus radiata*	2	4.8
Pine, slash	*Pinus elliotii*	2	-
Ramin	*Gonystylus* spp.	1	5.2
Redwood	*Sequoia sempervirens*	2	-
Rosewood, New Guinea	*Pterocarpus indicus*	2	-
Satinay	*Syncarpia hillii*	2	-
Stringybark, Blackdown	*Eucalyptus sphaerocarpa*	3	-
Stringybark, brown	*Eucalyptus capitellata*	3	-
Stringybark, red	*Eucalyptus macrorhyncha*	3	-
Stringybark, white	*Eucalyptus eugenioides*	3	-
Stringybark, yellow	*Eucalyptus muelleriana*	3	4
Tallowwood	*Eucalyptus microcorys*	3	3.5
Taun	*Pometia* spp.	2	-
Teak, Burmese	*Tectona grandis*	2	4.5
Tingle, red	*Eucalyptus jacksonii*	3	-
Tingle, yellow	*Eucalyptus guilfoylei*	3	-
Tuart	*Eucalyptus gomphocephala*	3	-
Turpentine	*Syncarpia glomulifera*	3	3.5
Wandoo	*Eucalyptus wandoo*	3	-
Woolybutt	*Eucalyptus longifolia*	3	-
Yate	*Eucalyptus cornuta*	3	-
Yertchuk	*Eucalyptus consideniana*	3	-

Note:
1. The natural pH for additional species can be found in "Manual No. 6: Embedded corrosion of fasteners in exposed timber structures" by Nguyen, M.N., Leicester, R.H. and Wang, C-H.

Zone C is the most hazardous.

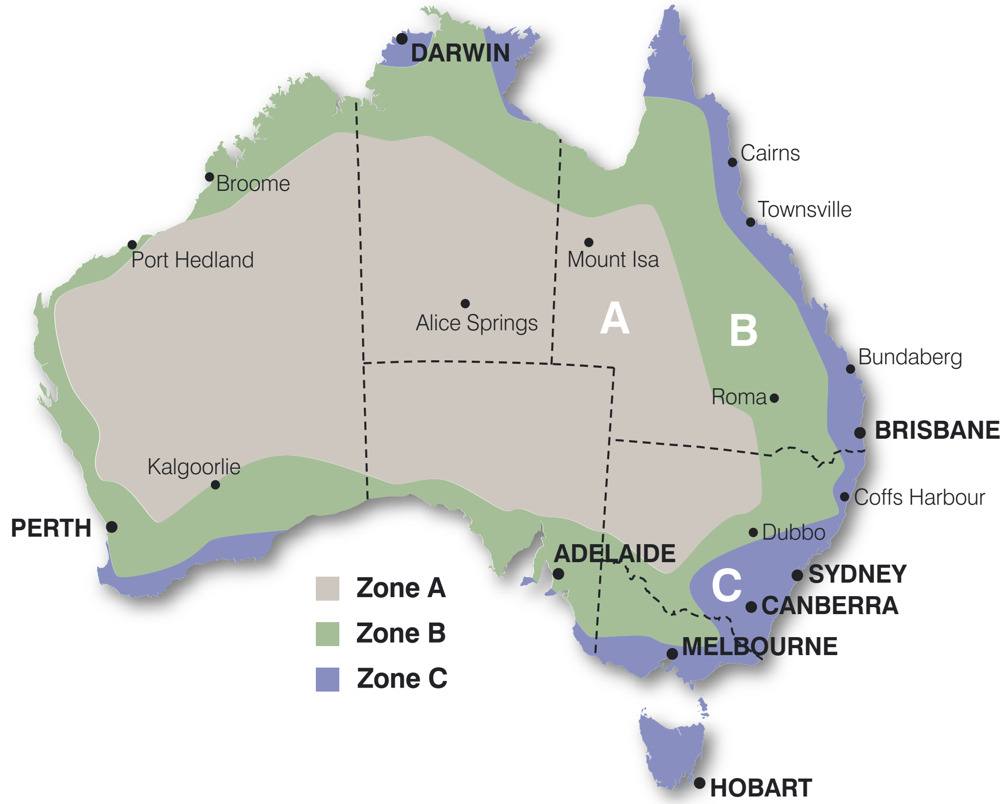


Figure 8.2: Hazard zone for embedded corrosion.

Table 8.3: Hazard scores for untreated and CCA-treated timber.

Microclimates[1]	Hazard scores for various microclimates					
	Zone A(2)		Zone B(2)		Zone C(2)	
	Marine(3)	Other	Marine	Other	Marine	Other
Subfloor(7)	14	12	16	14	18	16
Wall cavity(7)	12	12	14	14	16	16
Roof space(7)	11	9	13	11	15	13
Outdoor						
Sheltered/partly sheltered(4)	19	12	23	16	26	19
Exposed vertical surface(5)	21	14	27	20	35	28
Exposed horizontal surface(6)	24	17	35	28	49	42

Notes:
1. Enclosed sub-floor spaces have the minimum BCA ventilation requirements. Ventilated wall cavities are those typical of brick veneer and suspended timber floors. Sealed roof spaces are those with a sheet metal roof or sarked tile roof with no or little eaves or roof cavity ventilation.
2. See hazard zone map in Figure 8.2.
3. Climate zone is 'Marine' when distance to coast <1 km.
4. For example: house cladding.
5. For example: fencing.
6. For example: decking.
7. Typical ventilation conditions are assumed for the building envelope.

Table 8.4: Definition of hazard ratings for fasteners embedded in untreated timber.

Hazard score		Hazard rating
Hardwoods	Softwoods	
<12	<14	$HR_{un}1$
12~19	14~22	$HR_{un}2$
>19	>22	$HR_{un}3$

Note: The Hazard score is defined in Table 8.3.

Table 8.5: Typical service life for fasteners embedded in untreated timber.

Fasteners			Hazard rating	Typical service life (yrs)		
Commercial name	**Thickness or diameter of steel (mm)**	**Thickness of zinc coating (μm)**		**Class 1**	**Class 2**	**Class 3**
Nail plate Metal web	0.95	20	$HR_{un}1$ $HR_{un}2$ $HR_{un}3$	>100 >100 >100	>100 >100 80	>100 60 35
Nail plate Metal web	2.0	20	$HR_{un}1$ $HR_{un}2$ $HR_{un}3$	>100 >100 >100	>100 >100 >100	>100 >100 85
Plain steel nail	2.8	0	$HR_{un}1$ $HR_{un}2$ $HR_{un}3$	>100 >100 >100	>100 >100 >100	>100 >100 >100
Galvanised nail	2.8	50	$HR_{un}1$ $HR_{un}2$ $HR_{un}3$	>100 >100 >100	>100 >100 >100	>100 >100 >100
Plain steel nail	3.75	0	$HR_{un}1$ $HR_{un}2$ $HR_{un}3$	>100 >100 >100	>100 >100 >100	>100 >100 >100
Galvanised nail	3.75	50	$HR_{un}1$ $HR_{un}2$ $HR_{un}3$	>100 >100 >100	>100 >100 >100	>100 >100 >100
No. 10 steel screw	3.2	0	$HR_{un}1$ $HR_{un}2$ $HR_{un}3$	>100 >100 >100	>100 >100 >100	>100 >100 >100
No. 10 galva-nised screw	3.2	40	$HR_{un}1$ $HR_{un}2$ $HR_{un}3$	>100 >100 >100	>100 >100 >100	>100 >100 >100
No. 14 steel screw	4.5	0	$HR_{un}1$ $HR_{un}2$ $HR_{un}3$	>100 >100 >100	>100 >100 >100	>100 >100 >100
No. 14 galva-nised screw	4.5	40	$HR_{un}1$ $HR_{un}2$ $HR_{un}3$	>100 >100 >100	>100 >100 >100	>100 >100 >100

Note: The hazard rating is defined in Table 8.4.

Table 8.6: Typical protection due to zinc coating for fasteners embedded in untreated timber.

Thickness of zinc coating (μm)	Hazard Rating	Typical protection in untreated timber (yrs)		
		Acidity Class 1	Acidity Class 2	Acidity Class 3
10	$HR_{un}1$ $HR_{un}2$ $HR_{un}3$	>100 100 25	>100 16 5	>100 5 1
20	$HR_{un}1$ $HR_{un}2$ $HR_{un}3$	>100 >100 100	>100 65 20	100 20 7
40	$HR_{un}1$ $HR_{un}2$ $HR_{un}3$	>100 >100 >100	>100 >100 80	>100 80 25
50	$HR_{un}1$ $HR_{un}2$ $HR_{un}3$	>100 >100 >100	>100 >100 >100	>100 >100 40

Note: The hazard rating is defined in Table 8.4.

Table 8.7: Definition of hazard ratings for fasteners embedded in CCA-treated timber.

Hazard score	Hazard rating
<12	$HR_{tr}1$
12~17	$HR_{tr}2$
18~23	$HR_{tr}3$
24~30	$HR_{tr}4$
>30	$HR_{tr}5$

Note: The hazard score is defined in Table 8.3.

Table 8.8: Typical service life for fasteners embedded in CCA-treated timber.

Fasteners			Hazard rating	Typical service life (yrs)
Commercial name	**Thickness or diameter of steel (mm)**	**Thickness of zinc coating (μm)**		
Nail plate Metal web	0.95	20	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 25 8 4 3
Nail plate Metal web	2.0	20	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 35 12 6 5
Plain steel nail	2.8	0	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 25 11 7 5
Galvanised nail	2.8	50	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 95 25 15 10
Plain steel nail	3.75	0	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 30 15 10 7
Galvanised nail	3.75	50	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 100 30 17 12
No. 10 steel screw	3.2	0	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 25 12 8 6
No. 10 galva-nised screw	3.2	40	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 70 20 12 8
No. 14 steel screw	4.5	0	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 35 16 10 8
No. 14 galva-nised screw	4.5	40	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 80 25 15 10

Note: The hazard rating is defined in Table 8.7.

Table 8.9: Protection due to zinc coating for fasteners embedded in CCA-treated timber.

Thickness of zinc coating (μm)	Hazard rating	Typical protection (yrs)
10	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 5 0 0 0
20	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 15 3 0 0
40	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 45 10 4 2
50	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 70 15 8 5

Note: The hazard rating is defined in Table 8.7.

8.1.2 Other Coatings

No model has yet been developed for the effect of coating systems other than zinc on the performance of embedded fasteners. However a rough estimate could probably be made on the basis of the information in the standard AS/NZS 2312 (2002) Guide to the Protection of Iron and Steel against Exterior Atmospheric Corrosion.

8.2 Atmospheric Corrosion – Plates, Webs, Washers

8.2.1 Typical Service Life

The estimated service lives given in this Section are based on a corrosion model developed for the FWPA project. The equations used for these estimates are given in Report 08 referred to in the Preface.

The model is based on short-term laboratory and field experiments. The model used requires further field calibrations for two aspects. First, the extrapolation from short term to long term needs to be verified. Second the model relies on an estimate of airborne salt and moisture within a building envelope and exposed elements; to obtain reliable results the procedure used for this requires a check to be made on a larger number and variety of houses and environments than has been done.

The houses examined for this study comprised a set of typical single-storey houses. Most of the houses were of brick veneer wall construction, including walls both with and without sarking. There was moderate air leakage into and out of these wall systems. Both tiled and sheet metal roofs were to be found among these houses. All metal roofs and some of the tiled roofs were sarked. Many of the houses contained sub-floors; these sub-floor areas were ventilated either by gratings or by weep holes. The above comprises quite a range of housing types, and accordingly the model used to assess the building environment is based on a composite of these various housing types. In addition, averaged values are used for features that influence the local climate such as the prevailing wind, vegetation, elevation, shielding from other buildings, etc. Hence, the model can at best be described as providing an example of an environment that is not unusual in Australian housing. If predictions for specific houses are required, then more elaborate models must be used, and the available field data is not adequate to calibrate such models.

Typical installations of fasteners subjected to atmospheric corrosion are shown in Figure 8.3. The typical service life estimates are taken as the estimate of the mean time taken for metal fasteners to lose 30% of their initial tension strength and for washers 30% of their initial bending strength. A special aspect of the tables is that in computing the design life for connectors nominally located at the coastline, allowance is made for the possibility of airborne salt spray, a very severe hazard situation.

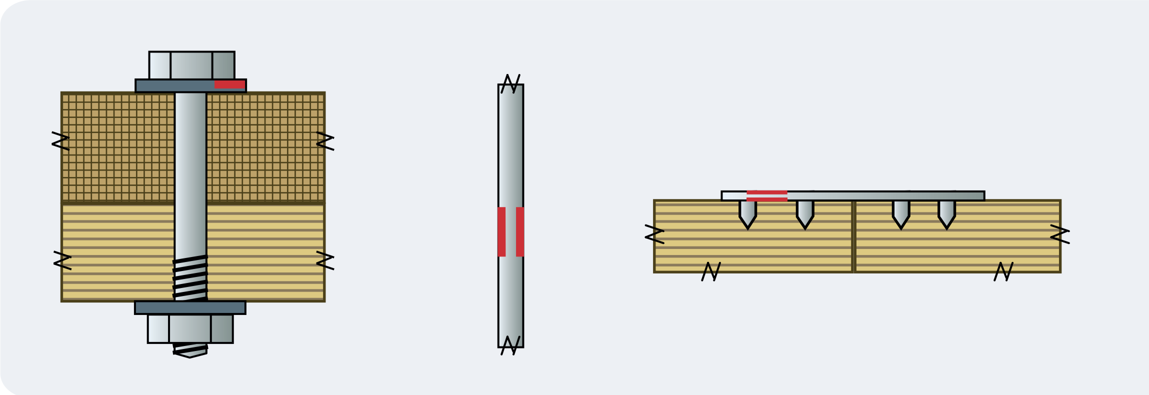


Figure 8.3: Typical fastener installation subjected to atmospheric corrosion.
(Red marks denote where corrosion is considered.)

The case of fasteners that are in contact with exposed wood is considered herein. Particularly for the case of CCA treated wood, these represent a particularly corrosive environment as the contact surface is usually subjected to high levels of moisture, salt and oxygen. An example of how the performance of these connectors may be assessed is given for the case of bolted joints in Section 8.3.
The following procedure is used to determine an estimate of the typical service life:

Determine the coastal zone from Figure 8.4

Determine the hazard scores according to the criteria given in Tables 8.10 to 8.14

Once this is done, the scores are added to produce a total hazard score as in Table 8.15.
NOTE: An example is highlighted in yellow in Tables 8.11 to 8.15.

A hazard rating can then be derived as defined in Table 8.16

Using these hazard ratings, the structural design life for exposed metal fasteners can be read from Table 8.17.

The contribution of a hot-dipped zinc coating (alone) to the design life of a fastener is given in Table 8.18.

Zone E is the most hazardous.

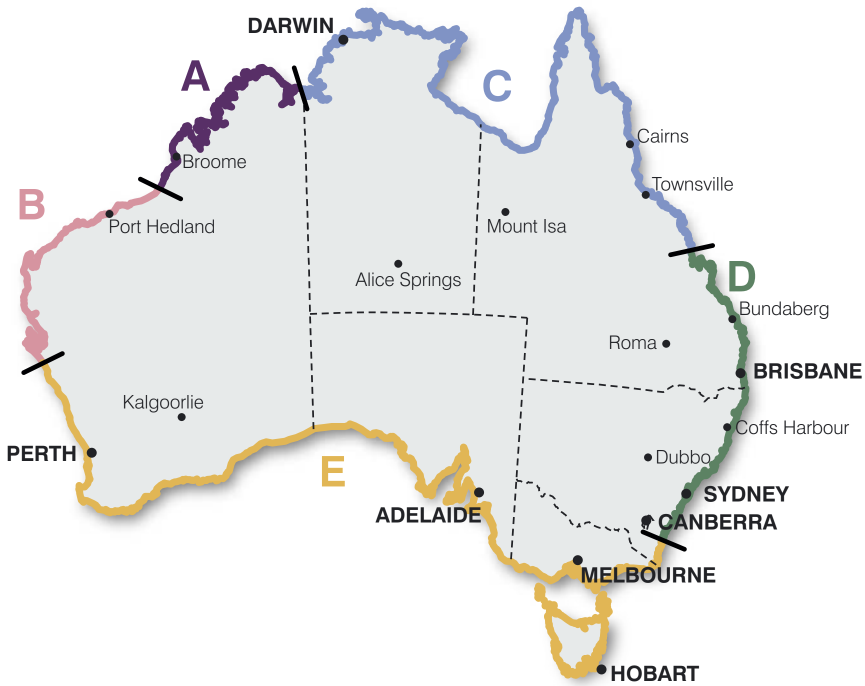


Figure 8.4: Coastal zones related to corrosion due to airborne salt.

Table 8.10: Hazard score for coastal zone.

Hazard zone	Hazard score
A	3.2
B	3.3
C	3.5
D	4.3
E	4.9

Corrosion of nail plates on deck joists after 6 years exposure near surf beach.

Table 8.11: Hazard score for coastal exposure.

Coastal exposure	Hazard score
Sheltered bay	1.1
Partially closed bay	1.3
Very open bay	1.8
Open surf	2.3

Note: For definition of coastal exposure see Appendix 1.

Corrosion of HDG nails close to pool edge.

Table 8.12: Hazard score for site classification.

Site classification	Hazard score
Open to sea	1.0
Urban (suburb)	0.3
Urban (city centre)	0.0
Other site	0.7

Table 8.13: Hazard score for microclimate.

Microclimate(1)		Hazard score
Wall cavity(2)		0.3
Roof space(2)		0.2
Sub-floor(2)		0.4
Out-door	Sheltered from rain	1.0
	Exposed to rain	0.7

Notes:
1. For information on the building envelope refer to Note 1 in Table 8.2.
2. Typical ventilation conditions are assumed for the building envelope.

Table 8.14: Hazard score for pollution.

Industry type	Hazard score			
	L = 1	L = 5	L = 10	L ≥ 20
Heavy industry (steel works, petrochemical)	3	1	0.5	0.0
Moderate industry (paper mills, large manufacturing)	1	0.5	0	0
Light industry (assembly plants)	0.5	0	0	0
No industry	0.0	0.0	0.0	0.0

Note: L is the distance to the industry (km).

Table 8.15: The total hazard score.

Item	Hazard score
Coastal zone	4.9
Coastal exposure	2.3
Site classification	0.3
Microclimate	1.0
Pollution	0.5
Total hazard score	9.0

Table 8.16: Definition of hazard rating.

Total hazard score	Hazard rating
<6	$HR_{atm}1$
$\leq 6 < 7$	$HR_{atm}2$
$\leq 7 < 8$	$HR_{atm}3$
≥ 8	$HR_{atm}4$

Note: The hazard score is defined in Table 8.15.

Table 8.17: Typical service life.

Fastener			Hazard rating[(1)]	Typical service life (years)[(2)]			
Type	Thickness of steel (mm)	Thickness of zinc (μm)		L = 0 (km)	L = 1 (km)	L = 10 (km)	L = 50 (km)
Plates and webs	1.0	0	$HR_{atm}1$	20	35	40	50
			$HR_{atm}2$	8	20	20	30
			$HR_{atm}3$	nr*	8	10	15
			$HR_{atm}4$	nr*	nr*	5	8
	1.0	20	$HR_{atm}1$	>100	>100	>100	>100
			$HR_{atm}2$	>100	>100	>100	>100
			$HR_{atm}3$	70	>100	>100	>100
			$HR_{atm}4$	15	90	>100	>100
	2.0	0	$HR_{atm}1$	50	80	90	>100
			$HR_{atm}2$	20	45	50	80
			$HR_{atm}3$	7	20	25	40
			$HR_{atm}4$	nr*	8	10	20
	2.0	20	$HR_{atm}1$	>100	>100	>100	>100
			$HR_{atm}2$	>100	>100	>100	>100
			$HR_{atm}3$	70	>100	>100	>100
			$HR_{atm}4$	20	100	>100	>100
	6.0	0	$HR_{atm}1$	>100	>100	>100	>100
			$HR_{atm}2$	80	>100	>100	>100
			$HR_{atm}3$	30	80	>100	>100
			$HR_{atm}4$	9	35	50	80
	6.0	20	$HR_{atm}1$	>100	>100	>100	>100
			$HR_{atm}2$	>100	>100	>100	>100
			$HR_{atm}3$	100	>100	>100	>100
			$HR_{atm}4$	25	>100	>100	>100
Washers	1.6	0	$HR_{atm}1$	40	70	80	>100
			$HR_{atm}2$	15	35	45	70
			$HR_{atm}3$	6	15	20	35
			$HR_{atm}4$	nr*	7	10	15
	1.6	20	$HR_{atm}1$	>100	>100	>100	>100
			$HR_{atm}2$	>100	>100	>100	>100
			$HR_{atm}3$	70	>100	>100	>100
			$HR_{atm}4$	15	100	>100	>100
	2.5	0	$HR_{atm}1$	70	>100	>100	>100
			$HR_{atm}2$	30	60	80	>100
			$HR_{atm}3$	10	30	40	60
			$HR_{atm}4$	nr*	10	20	30
	2.5	20	$HR_{atm}1$	>100	>100	>100	>100
			$HR_{atm}2$	>100	>100	>100	>100
			$HR_{atm}3$	80	>100	>100	>100
			$HR_{atm}4$	20	>100	>100	>100

Notes:
** nr = Not Recommended because service life <5 years.*
1. The hazard rating is defined in Table 8.16.
2. L is the distance to the coast (km).

Table 8.18: Typical protection due to zinc coatings.

Thickness of zinc coating (μm)	Hazard rating(1)	Typical protection (years)(2)			
		L = 0 (km)	L = 1 (km)	L = 10 (km)	L = 50 (km)
10	$HR_{atm}1$	>100	>100	>100	>100
	$HR_{atm}2$	70	>100	>100	>100
	$HR_{atm}3$	20	80	>100	>100
	$HR_{atm}4$	4	30	45	90
20	$HR_{atm}1$	>100	>100	>100	>100
	$HR_{atm}2$	>100	>100	>100	>100
	$HR_{atm}3$	70	>100	>100	>100
	$HR_{atm}4$	15	90	>100	>100
50	$HR_{atm}1$	>100	>100	>100	>100
	$HR_{atm}2$	>100	>100	>100	>100
	$HR_{atm}3$	>100	>100	>100	>100
	$HR_{atm}4$	70	>100	>100	>100

Notes:
1.The hazard rating is defined in Table 8.16.
2. L is the distance to the coast (km).

8.3.2 Other Coatings

The effect of coatings, other than zinc, can be estimated from the recommendations in the standard AS/NZS 2312 (2002) Guide to the Protection of Iron and Steel Against Exterior Atmospheric Corrosion.

8.3 Bolts

The information here is tentative. There has been no corrosion research directed specifically on bolted timber joints, and the field data is either anecdotal or meagre. It is known that bolted joints can form a very special case of embedded fastener, because they are often placed in oversized holes pre-drilled into the timber. The holes allow moisture, salt and oxygen to enter, a situation that does not occur with other embedded fasteners. To provide some sort of indication of the long duration strength of bolted joints, the assumption is made that the worst corrosion occurs near the neck of the bolt and this is either due to the usual embedded corrosion mechanism or due to atmospheric corrosion that is enhanced if the connector is near a beach. Other limitations on the accuracy of the model used here are the same as those given in Sections 8.1 and 8.2. The definition of typical service life, either in bending or in tension, is the mean estimate of the time taken for the embedded part of the bolt fastener to lose 30% of its initial strength.

A typical bolt embedded in wood is shown in Figure 8.5.

The service life controlled by atmospheric corrosion for fasteners in both CCA treated and untreated timber is determined by first evaluating the hazard rating HRatm as indicated in Section 8.2; then the design life is taken from Table 8.19 for bolts in bending, and Table 8.20 for bolts in tension. The contribution of a hot-dipped zinc coating (alone) to the service life of a fastener is given in Table 8.21.

For bolts embedded in CCA-treated timber, an additional check for the effects of embedded corrosion is needed and can be undertaken as follows:

- From Figure 8.2 determine the hazard Zone of application
- From Tables 8.3 determine the Hazard Score
- From Table 8.7 determine the Hazard Rating
- Using the Hazard Rating, determine the typical structural service life of a bolt in bending from Table 8.22 and in tension from Table 8.23.

The contribution of a zinc coating (alone) to the design life of a fastener embedded in CCA-treated timber is given by Table 8.24.

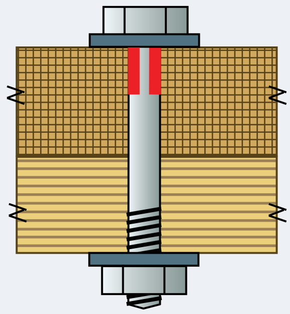


Figure 8.5: A typical bolt embedded in wood. *(Red marks denote where corrosion is considered.)*

Table 8.19: Typical service life due to atmospheric corrosion for bolts embedded in untreated and CCA treated timber subjected to bending.

Fastener			Hazard rating(1)	Typical service life (years)(2)			
Type	**Diameter of steel (mm)**	**Thickness of zinc (μm)**		***L* = 0 (km)**	***L* = 1 (km)**	***L* = 10 (km)**	***L* = 50 (km)**
M6 Steel Bolt	5.2	0	$HR_{atm}1$	10	30	90	>100
			$HR_{atm}2$	nr*	15	50	70
			$HR_{atm}3$	nr*	7	25	40
			$HR_{atm}4$	nr*	nr*	10	20
M6 Galvanised Bolt	5.2	30	$HR_{atm}1$	>100	>100	>100	>100
			$HR_{atm}2$	80	>100	>100	>100
			$HR_{atm}3$	25	>100	>100	>100
			$HR_{atm}4$	5	50	>100	>100
M10 Steel Bolt	8.8	0	$HR_{atm}1$	25	60	>100	>100
			$HR_{atm}2$	9	30	100	>100
			$HR_{atm}3$	nr*	15	45	80
			$HR_{atm}4$	nr*	5	25	40
M10 Galvanised Bolt	8.8	50	$HR_{atm}1$	>100	>100	>100	>100
			$HR_{atm}2$	>100	>100	>100	>100
			$HR_{atm}3$	50	>100	>100	>100
			$HR_{atm}4$	10	>100	>100	>100
M16 Steel Bolt	14.5	0	$HR_{atm}1$	45	>100	>100	>100
			$HR_{atm}2$	15	60	>100	>100
			$HR_{atm}3$	6	25	90	>100
			$HR_{atm}4$	nr*	10	45	70
M16 Galvanised Bolt	14.5	50	$HR_{atm}1$	>100	>100	>100	>100
			$HR_{atm}2$	>100	>100	>100	>100
			$HR_{atm}3$	60	>100	>100	>100
			$HR_{atm}4$	15	>100	>100	>100

Notes:

** nr = Not Recommended because service life <5 years.*

1. The hazard rating is defined in Table 8.16.

2. L is the distance to the coast (km).

Table 8.20: Typical service due to atmospheric corrosion for bolts embedded in untreated and CCA treated timber subjected to tension.

Fastener			Hazard rating[1]	Typical service life (years)[2]			
Type	Diameter of steel (mm)	Thickness of zinc (μm)		*L* = 0 (km)	*L* = 1 (km)	*L* = 10 (km)	*L* = 50 (km)
M6 Steel Bolt	5.2	0	$HR_{atm}1$	20	45	>100	>100
			$HR_{atm}2$	7	25	80	>100
			$HR_{atm}3$	nr*	10	40	60
			$HR_{atm}4$	nr*	nr*	20	30
M6 Galvanised Bolt	5.2	30	$HR_{atm}1$	>100	>100	>100	>100
			$HR_{atm}2$	80	>100	>100	>100
			$HR_{atm}3$	25	>100	>100	>100
			$HR_{atm}4$	5	50	>100	>100
M10 Steel Bolt	8.8	0	$HR_{atm}1$	40	90	>100	>100
			$HR_{atm}2$	15	45	>100	>100
			$HR_{atm}3$	5	20	80	>100
			$HR_{atm}4$	nr*	9	35	60
M10 Galvanised Bolt	8.8	50	$HR_{atm}1$	>100	>100	>100	>100
			$HR_{atm}2$	>100	>100	>100	>100
			$HR_{atm}3$	60	>100	>100	>100
			$HR_{atm}4$	15	>100	>100	>100
M16 Steel Bolt	14.5	0	$HR_{atm}1$	70	>100	>100	>100
			$HR_{atm}2$	25	90	>100	>100
			$HR_{atm}3$	10	40	>100	>100
			$HR_{atm}4$	nr*	15	70	>100
M16 Galvanised Bolt	14.5	50	$HR_{atm}1$	>100	>100	>100	>100
			$HR_{atm}2$	>100	>100	>100	>100
			$HR_{atm}3$	60	>100	>100	>100
			$HR_{atm}4$	15	>100	>100	>100

Notes:

** nr = Not Recommended because service life <5 years.*

1. The hazard rating is defined in Table 8.16.

2. L is the distance to the coast (km).

Table 8.21: Typical service life related to atmospheric corrosion due to zinc coatings on bolts embedded in untreated and cca treated timber.

Thickness of zinc coating (μm)	Hazard rating[1]	Typical service life protection (years)[2]			
		L = 0 (km)	*L* = 1 (km)	*L* = 10 (km)	*L* = 50 (km)
30	$HR_{atm}1$	>100	>100	>100	>100
	$HR_{atm}2$	70	>100	>100	>100
	$HR_{atm}3$	20	>100	>100	>100
	$HR_{atm}4$	4	45	>100	>100
50	$HR_{atm}1$	>100	>100	>100	>100
	$HR_{atm}2$	>100	>100	>100	>100
	$HR_{atm}3$	50	>100	>100	>100
	$HR_{atm}4$	10	>100	>100	>100

Notes:

1. The hazard rating is defined in Table 8.16.

2. L is the distance to the coast (km).

Table 8.22: Typical service life due to embedded corrosion for bolts embedded in CCA-treated timber subject to bending.

Fasteners			Hazard rating	Design service life (yrs)
Commercial name	**Thickness or diameter of steel (mm)**	**Thickness of zinc coating (μm)**		
M6 Steel Bolt	5.2	0	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 40 20 12 9
M6 Galvanised Bolt	5.2	30	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 70 25 15 10
M10 Steel Bolt	8.8	0	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 70 35 20 15
M10 Galvanised Bolt	8.8	50	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 >100 50 30 20
M16 Steel Bolt	14.5	0	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 >100 55 35 25
M16 Galvanised Bolt	14.5	50	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 >100 70 40 30

Note: The hazard rating is defined in Table 8.16.

Table 8.23: Typical service life related to embedded corrosion for bolts embedded in CCA-treated timber subject to tension.

Fasteners			Hazard rating	Typical service life (yrs)
Commercial name	Thickness or diameter of steel (mm)	Thickness of zinc coating (μm)		
M6 Steel Bolt	5.2	0	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 60 30 17 13
M6 Galvanised Bolt	5.2	30	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 90 35 20 15
M10 Steel Bolt	8.8	0	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 >100 50 30 25
M10 Galvanised Bolt	8.8	50	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 >100 65 40 30
M16 Steel Bolt	14.5	0	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 >100 80 50 40
M16 Galvanised Bolt	14.5	50	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 >100 95 60 45

Note: The hazard rating defined in Table 8.16.

Table 8.24: Typical protection from embedded corrosion due to zinc coatings on bolts embedded in CCA-treated timber.

Thickness of zinc coating (μm)	Hazard rating	Protection (yrs)
30	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 30 7 4 2
50	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 70 15 8 5

Note: The hazard rating is defined in Table 8.16.

9 Marine Borers

Protection for marine piles or timber in marine contact is best afforded by:

- **using species with high natural resistance such as turpentine, or in cooler southern waters, swamp box, river red gum and white mahogany;**
- **using timbers impregnated with chemical preservatives (requires a wide sapwood band) including plantation softwoods and spotted gum;**
- **using mechanical barriers and floating collars.**

For a few species which are naturally resistant (either because of high silica content or naturally toxic extractives), the bark if left intact may provide up to 2-5 years additional protection in southern zones.

Species with wide sapwood bands can be effectively treated with preservatives to provide resistance to marine borers. CCA is effective against Limnoria while creosote type preservatives are effective against teredinids although exceptions can occur. Double treatment (CCA followed by creosote) provides service life extended by as much as 45% to 3 times that of single treatments. CCA eucalypts in northern Queensland might last 8 years, creosote treated eucalypts perhaps 20 years while double treatment should last 25-30 years or more. Accordingly a double treatment should be considered when a high marine hazard exists as in tropical waters.

Mechanical barriers also offer excellent protection to marine piles. Mechanical barriers include metallic sheathing, plastic barriers or for more permanent work concrete encasement such as poured concrete collars or piles driven through concrete or fibre cement pipes (high water to mud line). Where piles are encased in pipes, sand is usually placed between the timber and the pipe to provide mechanical support to the pipe and act as an indicator if a hole occurs in the pipe. In zones where Sphaeroma is active, even barriers restricted to the tidal zone can greatly extend the service life.

Care should be taken with all marine piles to ensure that any damaged sapwood, splits, knots or other imperfections are given additional mechanical protection so as to impede attack by borers.

Regular scheduling of inspection and maintenance procedures for all waterfront structures (piles in particular) is imperative to ensure a long serviceable life.

The typical service life for marine piles given in the following tables relate to an estimate of the time taken for borer attack to reduce the cross section of a pile to 200 mm in diameter. This corresponds with the requirements currently used for pile replacement by many authorities.

9.1 Scope and Application

This following provides estimates of the typical service life for timber sections attacked by marine borers. The attack patterns are depicted in Figure 9.2. The design life estimates are based on the assumption that the net pile diameter will be 200 mm at the end of the service life. The estimated service lives given in this Section are based on a model developed for the FWPA project. The equations used for these estimates are given in Report number 8 referred to in the Preface.

It is assumed that:

- Untreated hardwood piles of marine borer resistance classes 1 and 2 have heartwood diameters of 300 or 400 mm as given in Tables 9.4 to 9.10 (marine piles are not de sapped, and where possible they are installed with bark on), or marine durability classes 1 to 4 of hardwood piles with sapwood treated to H6 level in accordance with AS 1604.1.
- Treated piles, both hardwood and softwood, have the original sapwood retained and the diameters of 300 or 400 mm include both treated sapwood and heartwood timber.
- The minimum thickness of sapwood that is fully treated for treated hardwood piles of marine borer resistance classes 1 to 4 is 20 mm.
- The minimum thickness of sapwood that is fully treated for treated softwood piles of marine borer resistance class 4 is 50 mm.

- AS 1604.1 – 2005 specifies that H6 treatment level with CCA alone or with creosote alone is appropriate only to southern waters, which correspond approximately to the marine hazard zones A to D in Figure 9.1, whereas double-treatment is applicable to all zones.

The following procedure should be used to estimate the typical service life of a marine pile:

- Determine the timber marine borer resistance class from Table 9.1
- Determine the location zone from Figure 9.1
- Determine the salinity class of the seawater from Table 9.2.
- Determine whether the water surrounding piles is calm or surf from Table 9.3.
- The estimated design service lives are given in Tables 9.4 to 9.10 for round piles.

Table 9.1: Timber marine borer resistance classification.

Trade name	Botanical name	Marine borer resistance class
Alder, blush	*Sloanea australis*	4
Alder, brown	*Caldcluvia paniculosa*	4
Alder, pink	*Gillbeea adenopetala*	4
Alder, rose	*Caldcluvia australiensis*	4
Amberoi	*Pterocymbium* spp.	4
Apple, rough-barked	*Angophora floribunda*	4
Apple, smooth-barked	*Angophora costata*	4
Ash, alpine	*Eucalyptus delegatensis*	4
Ash, Blue Mountains	*Eucalyptus oreades*	4
Ash, Crow's	*Flindersia australis*	4
Ash, mountain	*Eucalyptus regnans*	4
Ash, pink	*Alphitonia petriei*	4
Ash, silver	*Flindersia bourjotiana, Flindersia schottiana*	4
Ash, silvertop	*Eucalyptus sieberi*	4
Ash, white	*Eucalyptus fraxinoides*	4
Baltic, red (pine, Scots)	*Pinus sylvestris*	4
Baltic, white (spruce, Norway)	*Picea abies*	4
Beech, myrtle	*Nothofagus cunninghamii*	4
Beech, negrohead	*Nothofagus moorei*	4
Beech, silver	*Nothofagus menziesii*	4
Belian	*Eusideroxylon zwageri*	1
Birch, white, Australia	*Schizomeria ovata*	4
Blackbutt	*Eucalyptus pilularis*	3
Blackbutt, New England	*Eucalyptus andrewsii, Eucalyptus campanulata*	2
Blackbutt, Western Australian	*Eucalyptus patens*	3
Blackwood	*Acacia melanoxylon*	4
Bloodwood, red	*Corymbia gummifera*	3
Bollywood	*Cinnamomum baileyanum, Litsea* spp.	4
Box, brush	*Lophostemon confertus*	2
Box, grey	*Eucalyptus macrocarpa, Eucalyptus moluccana Eucalyptus woollsiana*	2
Box, grey, coast	*Eucalyptus bosistoana*	3
Box, ironwood	*Choricarpia leptopetala Choricarpia subargentea*	4
Box, kanuka	*Tristania exiliflora, Tristania laurina*	4
Box, long-leaved	*Eucalyptus goniocalyx*	4
Box, swamp	*Lophostemon suaveolens*	2
Brownbarrel	*Eucalyptus fastigata*	4
Bullich	*Eucalyptus megacarpa*	4

Table 9.1** (continued): **Timber marine borer resistance classification.

Trade name	Botanical name	Marine borer resistance class
Calophyllum	*Calophyllum* spp.	4
Candlebark	*Eucalyptus rubida*	4
Carabeen, yellow	*Sloanea woolsii*	4
Cedar, red	*Toona australis*	4
Cedar, western red	*Thuja plicata*	4
Cheesewood, white	*Alstonia scholaris*	4
Coachwood	*Ceratopetalum apetalum*	4
Cypress, black	*Callitris endlicheri*	3
Cypress	*Callitris glaucophylla*	2
Fir, amabilis	*Abies amabilis*	4
Fir, Douglas (Oregon)	*Pseudotsuga menziesii*	4
Geronggang	*Cratoxylon arborescens*	4
Gum, blue, southern	*Eucalyptus globulus*	4
Gum, blue, Sydney	*Eucalyptus saligna*	3
Gum, grey	*Eucalyptus canaliculata, Eucalyptus major, Eucalyptus propinqua, Eucalyptus punctata*	2
Gum, grey, mountain	*Eucalyptus cypellocarpa*	4
Gum, Maiden's	*Eucalyptus maidenii*	4
Gum, manna	*Eucalyptus viminalis*	4
Gum, mountain	*Eucalyptus dalrympleana*	4
Gum, pink	*Eucalyptus fasciculosa*	4
Gum, poplar	*Eucalyptus alba*	4
Gum, red, forest	*Eucalyptus blakelyi, Eucalyptus tereticornis*	2
Gum, red, river	*Eucalyptus camaldulensis*	2
Gum, rose	*Eucalyptus grandis*	4
Gum, round-leaved	*Eucalyptus deanei*	4
Gum, shining	*Eucalyptus nitens*	4
Gum, spotted	*Corymbia maculata,* incl. *Corymbia citriodora*	4
Gum, swamp	*Eucalyptus camphora*	4
Gum, white, Dunn's	*Eucalyptus dunnii*	4
Gum, yellow	*Eucalyptus leucoxylon*	4
Hardwood, Johnston River	*Backhousia bancroftii*	4
Hemlock, western	*Tsuga heterophylla*	4
Iroko	*Chlorophora excelsa*	1
Ironbark, grey	*Eucalyptus drepanophylla, Eucalyptus paniculata, Eucalyptus siderophloia*	3
Ironbark, red	*Eucalyptus sideroxylon*	2
Jam, raspberry	*Acacia acuminata*	2
Jarrah	*Eucalyptus marginata*	3
Jelutong	*Dyera costulata*	4
Kamarere	*Eucalyptus deglupta*	4
Kapur	*Dryobalanops* spp.	4
Karri	*Eucalyptus diversicolor*	4
Kauri, New Zealand	*Agathis australis*	4
Kauri, Queensland	*Agathis atropurpurea, Agathis microstachya Agathis robusta*	4
Kempas	*Koompassia malaccensis*	4
Keruing	*Dipterocarpus* spp.	4

Table 9.1 (continued)**: Timber marine borer resistance classification.**

Trade name	Botanical name	Marine borer resistance class
Kwila (merbau)	*Intsia bijuga*	3
Lumbayau (mengkulang)	*Heritiera* spp.	4
Mahogany, African	*Khaya* spp.	4
Mahogany, American	*Swietenia mahogani*	4
Mahogany, brush	*Geissois benthamii*	4
Mahogany, red	*Eucalyptus pellita, Eucalyptus resinifera*	2
Mahogany, red, Philippine,	*Shorea* spp.	4
Mahogany, southern	*Eucalyptus botryoides*	4
Mahogany, white	*Eucalyptus acmenoides, Eucalyptus tenuipes* *Eucalyptus umbra* subsp. *carnea*	2
Malas	*Homalium foetidum*	4
Mallet, brown	*Eucalyptus astringens*	4
Malletwood	*Rhodamnia argentea, Rhodamnia costata*	4
Malletwood, brown	*Rhodamnia rubescens*	4
Malletwood, silver	*Rhodamnia acuminata*	4
Mangrove, grey	*Avicennia marina*	4
Maple, Queensland	*Flindersia brayleyana*	4
Maple, rose	*Cryptocarya erythroxylon*	4
Maple, scented	*Flindersia laevicarpa*	4
Maple, sugar (rock)	*Acer saccharum*	4
Marri	*Corymbia calophylla*	4
Meranti, bakau	*Shorea* spp.	4
Meranti, dark-red	*Shorea* spp.	4
Meranti, light-red	*Shorea* spp.	4
Meranti, white	*Shorea* spp.	4
Meranti, yellow	*Shorea* spp.	4
Mersawa	*Anisoptera* spp.	4
Messmate	*Eucalyptus obliqua*	4
Nyatoh	*Palaquium* and *Payena* spp.	4
Oak, silky, northern	*Cardwellia sublimis*	4
Oak, tulip, blush	*Argyrodendron actinophyllum*	4
Oak, tulip, brown	*Argyrodendron polyandrum* *Argyrodendron trifoliolatum*	4
Oak, tulip, red	*Argyrodendron peralatum*	4
Oak, white, American	*Quercus alba*	4
Paulownia	*Paulownia* spp.	4
Penda, brown	*Xanthostemon chrysanthus*	2
Penda, red	*Xanthostemon whitei*	2
Penda, southern	*Xanthostemon, oppositifolius*	2
Penda, yellow	*Ristantia pachysperma*	2
Peppermint, black	*Eucalyptus amygdalina*	4
Peppermint, broad-leaved	*Eucalyptus dives*	4
Peppermint, narrow-leaved	*Eucalyptus radiata,* incl. *Eucalyptus australiana*	4
Peppermint, river	*Eucalyptus elata*	4
Peppermint, white	*Eucalyptus pulchella*	4
Pine, brown	*Podocarpus elatus*	3
Pine, bunya	*Araucaria bidwillii*	4
Pine, Canary Island	*Pinus canariensis*	4

Table 9.1** (continued)**: Timber marine borer resistance classification.

Trade name	Botanical name	Marine borer resistance class
Pine, Caribbean	*Pinus caribaea*	4
Pine, celery-top	*Phyllocladus aspleniifolius*	4
Pine, Corsican	*Pinus nigra*	4
Pine, hoop	*Araucaria cunninghamii*	4
Pine, Huon	*Lagarostrobos franklinii*	4
Pine, King William	*Athrotaxis selaginoides*	4
Pine, klinki	*Araucaria hunsteinii*	4
Pine, loblolly	*Pinus taeda*	4
Pine, longleaf	*Pinus palustris*	4
Pine, maritime	*Pinus pinaster*	4
Pine, NZ white (kahikatea)	*Dacrycarpus dacrydioides*	4
Pine, patula	*Pinus patula*	4
Pine, ponderosa	*Pinus ponderosa*	4
Pine, radiata	*Pinus radiata*	4
Pine, Scots	*Pinus sylvestris*	4
Pine, slash	*Pinus elliottii*	4
Pine, white, western	*Pinus monticola*	4
Planchonella	*Planchonella chartacea*	4
Poplar, balsam	*Populus* spp.	4
Poplar, pink	*Euroschinus falcata*	4
Quandong, silver	*Elaeocarpus angustifolius, Elaeocarpus grandis*	4
Ramin	*Gonystylus* spp.	4
Redwood	*Sequoia sempervirens*	4
Rimu	*Dacrydium cupressinum*	4
Rosewood, New Guinea	*Pterocarpus indicus*	4
Sassafras	*Daphnandra dielsii, Daphnandra micrantha Daphnandra repandula, Doryphora aromatica Doryphora sassafras*	4
Satinash, grey	*Syzygium claviflorum, Syzygium gustavioides*	4
Satinash, rose	*Syzygium crebrinerve, Eugenia francisii*	4
Satinay	*Syncarpia hillii*	1
Sepetir	*Copaifera* spp., *Pseudosindora* spp., *Sindora* spp.	4
Sheoak, beach	*Allocasuarina equisetifolia*	4
Sheoak, black	*Allocasuarina littoralis*	4
Silkwood, maple	*Flindersia pimenteliana*	4
Spruce, Norway	*Picea abies*	4
Spruce, Sitka	*Picea sitchensis*	4
Stringybark, blue-leaved	*Eucalyptus agglomerata*	4
Stringybark, brown	*Eucalyptus baxteri, Eucalyptus blaxlandii Eucalyptus capitellata*	4
Stringybark, diehard	*Eucalyptus cameronii*	4
Stringybark, red	*Eucalyptus macrorhyncha*	3
Stringybark, silvertop	*Eucalyptus laevopinea*	4
Stringybark, white	*Eucalyptus eugenioides, Eucalyptus globoidea Eucalyptus phaeotricha*	3
Stringybark, yellow	*Eucalyptus muelleriana*	3
Sycamore, silver	*Cryptocarya glaucescens*	4
Tallowwood	*Eucalyptus microcorys*	3

Zone G is the most hazardous.

Table 9.1** (continued)**: Timber marine borer resistance classification.

Trade name	Botanical name	Marine borer resistance class
Taun	*Pometia* spp.	4
Tea-tree, broad-leaved	*Melaleuca leucadendron, Melaleuca quinquenervia, Melaleuca viridiflora*	3
Tea-tree, river	*Melaleuca bracteata*	4
Tingle, red	*Eucalyptus jacksonii*	4
Touriga, red	*Calophyllum costatum*	4
Tuart	*Eucalyptus gomphocephala*	4
Turpentine	*Syncarpia glomulifera*	1
Walnut, New South Wales	*Endiandra virens*	4
Walnut, Queensland	*Endiandra palmerstonii*	4
Walnut, yellow	*Beilschmiedia bancroftii*	4
Wandoo	*Eucalyptus wandoo*	3
Yate, swamp	*Eucalyptus occidentalis*	4

Figure 9.1: Marine borer hazard zones.

Table 9.2: Salinity classification.

Salinity class	Sea water salinity (parts per thousand)
1	1-10
2	11-25
3	26-35

Note: Sea water salinity can be measured with a hydrometer. Typically, salinity class 1 is water in rivers with a tidal influence, salinity class 2 is water in river mouth areas, and salinity class 3 is water in bays or open sea areas.

Table 9.3: Sheltering of piles.

Shelter	Shelter classification
Sheltered from strong current or surf (eg. Directly behind breakwaters)	Calm
Exposed to current and/or surf	Surf

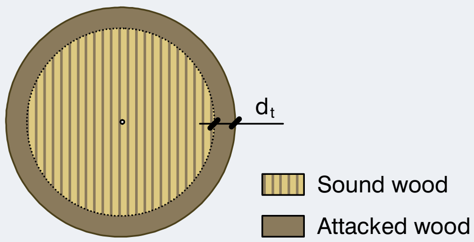


Figure 9.2: Assumed attack patterns for round piles.

Double treated marine piles at Couran Cove, Queensland.

Table 9.4: Typical service life of round piles in Hazard Zone A.

Hazard zone[1]	Salinity class[2]	Shelter class[3]	Timber	Marine borer resistance class[4]	Treatment[5]	Typical service life (years)							
						Construction type A*		Construction type B*		Construction type C*		Construction type D*	
						300mm dia	400mm dia	300mm dia	400mm dia	300mm dia	400mm dia	300mm dia	400mm dia
A	1	Calm	Untreated Hardwood	1	none	100	>100	>100	>100	50	100	100	>100
				2	none	60	>100	>100	>100	30	60	60	>100
			Treated Hardwood	1	H6 (CCA)	100	>100	>100	>100	50	100	100	>100
					H6 (creosote)	>100	>100	>100	>100	70	>100	>100	>100
					H6 (DBT)	>100	>100	>100	>100	70	>100	>100	>100
				2	H6 (CCA)	80	>100	>100	>100	40	70	80	>100
					H6 (creosote)	>100	>100	>100	>100	60	90	>100	>100
					H6 (DBT)	>100	>100	>100	>100	60	90	>100	>100
				3	H6 (CCA)	60	90	>100	>100	30	45	60	90
					H6 (creosote)	90	>100	>100	>100	45	60	90	>100
					H6 (DBT)	>100	>100	>100	>100	50	70	>100	>100
				4	H6 (CCA)	45	50	90	100	25	25	45	50
					H6 (creosote)	70	80	>100	>100	40	40	70	80
					H6 (DBT)	90	90	>100	>100	45	50	90	90
			Treated Softwood	4	H6 (CCA)	60	60	>100	>100	30	30	60	60
					H6 (creosote)	>100	>100	>100	>100	50	60	>100	>100
					H6 (DBT)	>100	>100	>100	>100	60	60	>100	>100
		Surf	Untreated Hardwood	1	none	>100	>100	>100	>100	80	>100	>100	>100
				2	none	>100	>100	>100	>100	50	>100	>100	>100
			Treated Hardwood	1	H6 (CCA)	>100	>100	>100	>100	80	>100	>100	>100
					H6 (creosote)	>100	>100	>100	>100	>100	>100	>100	>100
					H6 (DBT)	>100	>100	>100	>100	>100	>100	>100	>100
				2	H6 (CCA)	>100	>100	>100	>100	70	>100	>100	>100
					H6 (creosote)	>100	>100	>100	>100	90	>100	>100	>100
					H6 (DBT)	>100	>100	>100	>100	>100	>100	>100	>100
				3	H6 (CCA)	100	>100	>100	>100	50	80	100	>100
					H6 (creosote)	>100	>100	>100	>100	80	100	>100	>100
					H6 (DBT)	>100	>100	>100	>100	90	>100	>100	>100
				4	H6 (CCA)	70	80	>100	>100	35	40	70	80
					H6 (creosote)	>100	>100	>100	>100	60	70	>100	>100
					H6 (DBT)	>100	>100	>100	>100	70	80	>100	>100
			Treated Softwood	4	H6 (CCA)	90	>100	>100	>100	50	50	90	>100
					H6 (creosote)	>100	>100	>100	>100	90	90	>100	>100
					H6 (DBT)	>100	>100	>100	>100	100	>100	>100	>100
	2	Calm	Untreated Hardwood	1	none	80	>100	>100	>100	40	80	80	>100
				2	none	60	>100	>100	>100	30	50	60	>100
			Treated Hardwood	1	H6 (CCA)	90	>100	>100	>100	45	90	90	>100
					H6 (creosote)	>100	>100	>100	>100	60	100	>100	>100
					H6 (DBT)	>100	>100	>100	>100	60	>100	>100	>100
				2	H6 (CCA)	70	>100	>100	>100	35	60	70	>100
					H6 (creosote)	100	>100	>100	>100	50	80	100	>100
					H6 (DBT)	>100	>100	>100	>100	60	80	>100	>100
				3	H6 (CCA)	50	80	>100	>100	30	40	50	80
					H6 (creosote)	80	>100	>100	>100	40	50	80	>100
					H6 (DBT)	90	>100	>100	>100	45	60	90	>100
				4	H6 (CCA)	40	45	80	90	20	25	40	45
					H6 (creosote)	70	70	>100	>100	35	35	70	70
					H6 (DBT)	80	80	>100	>100	40	40	80	80
			Treated Softwood	4	H6 (CCA)	50	60	100	>100	25	30	50	60
					H6 (creosote)	90	100	>100	>100	45	50	90	100
					H6 (DBT)	>100	>100	>100	>100	50	50	>100	>100

Table 9.4 *(continued)*: ***Typical service life of round piles in Hazard Zone A.***

Hazard zone(1)	Salinity class(2)	Shelter class(3)	Timber	Marine borer resistance class(4)	Treatment(5)	Typical service life (years)							
						Construction type A*		Construction type B*		Construction type C*		Construction type D*	
						300mm dia	400mm dia	300mm dia	400mm dia	300mm dia	400mm dia	300mm dia	400mm dia
A	2	Surf	Untreated Hardwood	1	none	>100	>100	>100	>100	70	>100	>100	>100
				2	none	90	>100	>100	>100	45	90	90	>100
			Treated Hardwood	1	H6 (CCA)	>100	>100	>100	>100	70	>100	>100	>100
					H6 (creosote)	>100	>100	>100	>100	90	>100	>100	>100
					H6 (DBT)	>100	>100	>100	>100	>100	>100	>100	>100
				2	H6 (CCA)	>100	>100	>100	>100	60	>100	>100	>100
					H6 (creosote)	>100	>100	>100	>100	80	>100	>100	>100
					H6 (DBT)	>100	>100	>100	>100	90	>100	>100	>100
				3	H6 (CCA)	90	>100	>100	>100	45	70	90	>100
					H6 (creosote)	>100	>100	>100	>100	70	90	>100	>100
					H6 (DBT)	>100	>100	>100	>100	80	100	>100	>100
				4	H6 (CCA)	60	70	>100	>100	35	35	60	70
					H6 (creosote)	>100	>100	>100	>100	60	60	>100	>100
					H6 (DBT)	>100	>100	>100	>100	70	70	>100	>100
			Treated Softwood	4	H6 (CCA)	80	90	>100	>100	40	45	80	90
					H6 (creosote)	>100	>100	>100	>100	80	80	>100	>100
					H6 (DBT)	>100	>100	>100	>100	90	90	>100	>100
	3	Calm	Untreated Hardwood	1	none	70	>100	>100	>100	35	70	70	>100
				2	none	45	90	90	>100	25	45	45	90
			Treated Hardwood	1	H6 (CCA)	70	>100	>100	>100	35	70	70	>100
					H6 (creosote)	90	>100	>100	>100	45	80	90	>100
					H6 (DBT)	100	>100	>100	>100	50	80	100	>100
				2	H6 (CCA)	60	100	>100	>100	30	50	60	100
					H6 (creosote)	80	>100	>100	>100	40	60	80	>100
					H6 (DBT)	90	>100	>100	>100	45	70	90	>100
				3	H6 (CCA)	45	60	80	>100	25	35	45	60
					H6 (creosote)	60	90	>100	>100	35	45	60	90
					H6 (DBT)	70	90	>100	>100	40	50	70	90
				4	H6 (CCA)	30	35	60	70	15	20	30	35
					H6 (creosote)	50	60	>100	>100	25	30	50	60
					H6 (DBT)	60	70	>100	>100	30	35	60	70
			Treated Softwood	4	H6 (CCA)	40	45	80	90	20	25	40	45
					H6 (creosote)	80	80	>100	>100	40	40	80	80
					H6 (DBT)	80	90	>100	>100	40	45	80	90
		Surf	Untreated Hardwood	1	none	>100	>100	>100	>100	60	>100	>100	>100
				2	none	70	>100	>100	>100	35	70	70	>100
			Treated Hardwood	1	H6 (CCA)	>100	>100	>100	>100	60	>100	>100	>100
					H6 (creosote)	>100	>100	>100	>100	80	>100	>100	>100
					H6 (DBT)	>100	>100	>100	>100	80	>100	>100	>100
				2	H6 (CCA)	90	>100	>100	>100	45	80	90	>100
					H6 (creosote)	>100	>100	>100	>100	60	100	>100	>100
					H6 (DBT)	>100	>100	>100	>100	70	>100	>100	>100
				3	H6 (CCA)	70	>100	>100	>100	35	50	70	>100
					H6 (creosote)	>100	>100	>100	>100	50	70	>100	>100
					H6 (DBT)	>100	>100	>100	>100	60	80	>100	>100
				4	H6 (CCA)	50	60	100	>100	25	30	50	60
					H6 (creosote)	90	90	>100	>100	45	50	90	90
					H6 (DBT)	>100	>100	>100	>100	50	60	>100	>100
			Treated Softwood	4	H6 (CCA)	70	70	>100	>100	35	40	70	70
					H6 (creosote)	>100	>100	>100	>100	60	70	>100	>100
					H6 (DBT)	>100	>100	>100	>100	70	70	>100	>100

** Construction types A, B, C, and D indicate the construction features of the piles, defined as follows:*
A refers to piles stand-alone without contact with other structure element, having no maintenance measure applied.
B refers to piles stand-alone, having plastic wrap or floating collar as maintenance measure applied.
C refers to piles in contact with other element (e.g. X-brace), having no maintenance measure applied.
D refers to piles in contact with other element (e.g. X-brace) , having plastic wrap or floating collar as maintenance measure applied.
1. Hazard zone is defined in Figure 9.1.
2. Salinity class is defined in Table 9.2.
3. Shelter class is defined in Table 9.3.
4. Durability class is defined in Table 9.1.
5. H6 treatment levels are in accordance with AS 1604.1 – 2005. DBT stands for double-treatment.

Table 9.5: Typical service life of round piles in Hazard Zone B.

Hazard zone[1]	Salinity class[2]	Shelter class[3]	Timber	Marine borer resistance class[4]	Treatment[5]	Typical service life (years)							
						Construction type A*		Construction type B*		Construction type C*		Construction type D*	
						300mm dia	400mm dia	300mm dia	400mm dia	300mm dia	400mm dia	300mm dia	400mm dia
B	1	Calm	Untreated Hardwood	1	none	80	>100	>100	>100	40	70	80	>100
				2	none	50	100	100	>100	25	50	50	100
			Treated Hardwood	1	H6 (CCA)	80	>100	>100	>100	40	80	80	>100
					H6 (creosote)	100	>100	>100	>100	50	90	100	>100
					H6 (DBT)	>100	>100	>100	>100	60	90	>100	>100
				2	H6 (CCA)	60	>100	>100	>100	30	60	60	>100
					H6 (creosote)	90	>100	>100	>100	45	70	90	>100
					H6 (DBT)	100	>100	>100	>100	50	70	100	>100
				3	H6 (CCA)	45	70	90	>100	25	35	45	70
					H6 (creosote)	70	90	>100	>100	35	50	70	90
					H6 (DBT)	80	>100	>100	>100	40	50	80	>100
				4	H6 (CCA)	35	40	70	80	20	20	35	40
					H6 (creosote)	60	60	>100	>100	30	30	60	60
					H6 (DBT)	70	70	>100	>100	35	35	70	70
			Treated Softwood	4	H6 (CCA)	45	50	90	100	25	25	45	50
					H6 (creosote)	80	90	>100	>100	40	45	80	90
					H6 (DBT)	90	100	>100	>100	45	50	90	100
		Surf	Untreated Hardwood	1	none	>100	>100	>100	>100	60	>100	>100	>100
				2	none	80	>100	>100	>100	40	80	80	>100
			Treated Hardwood	1	H6 (CCA)	>100	>100	>100	>100	60	>100	>100	>100
					H6 (creosote)	>100	>100	>100	>100	80	>100	>100	>100
					H6 (DBT)	>100	>100	>100	>100	90	>100	>100	>100
				2	H6 (CCA)	100	>100	>100	>100	50	90	100	>100
					H6 (creosote)	>100	>100	>100	>100	70	>100	>100	>100
					H6 (DBT)	>100	>100	>100	>100	80	>100	>100	>100
				3	H6 (CCA)	80	>100	>100	>100	40	60	80	>100
					H6 (creosote)	>100	>100	>100	>100	60	80	>100	>100
					H6 (DBT)	>100	>100	>100	>100	70	90	>100	>100
				4	H6 (CCA)	60	70	>100	>100	30	35	60	70
					H6 (creosote)	100	>100	>100	>100	50	50	100	>100
					H6 (DBT)	>100	>100	>100	>100	60	60	>100	>100
			Treated Softwood	4	H6 (CCA)	70	80	>100	>100	40	40	70	80
					H6 (creosote)	>100	>100	>100	>100	70	70	>100	>100
					H6 (DBT)	>100	>100	>100	>100	80	80	>100	>100
	2	Calm	Untreated Hardwood	1	none	70	>100	>100	>100	35	70	70	>100
				2	none	45	80	90	>100	20	45	45	80
			Treated Hardwood	1	H6 (CCA)	70	>100	>100	>100	35	70	70	>100
					H6 (creosote)	90	>100	>100	>100	45	80	90	>100
					H6 (DBT)	100	>100	>100	>100	50	80	100	>100
				2	H6 (CCA)	50	100	>100	>100	30	50	50	100
					H6 (creosote)	70	>100	>100	>100	40	60	70	>100
					H6 (DBT)	80	>100	>100	>100	45	60	80	>100
				3	H6 (CCA)	40	60	80	>100	20	35	40	60
					H6 (creosote)	60	80	>100	>100	35	45	60	80
					H6 (DBT)	70	90	>100	>100	35	50	70	90
				4	H6 (CCA)	30	35	60	70	15	20	30	35
					H6 (creosote)	50	60	100	>100	25	30	50	60
					H6 (DBT)	60	70	>100	>100	30	35	60	70
			Treated Softwood	4	H6 (CCA)	40	45	80	90	20	20	40	45
					H6 (creosote)	70	80	>100	>100	35	40	70	80
					H6 (DBT)	80	80	>100	>100	40	40	80	80

Table 9.5** (continued): **Typical service life of round piles in Hazard Zone B.

Hazard zone(1)	Salinity class(2)	Shelter class(3)	Timber	Marine borer resistance class(4)	Treatment(5)	Typical service life (years) Construction type A* 300mm dia	Construction type A* 400mm dia	Construction type B* 300mm dia	Construction type B* 400mm dia	Construction type C* 300mm dia	Construction type C* 400mm dia	Construction type D* 300mm dia	Construction type D* 400mm dia
B	2	Surf	Untreated Hardwood	1	none	>100	>100	>100	>100	60	>100	>100	>100
				2	none	70	>100	>100	>100	35	70	70	>100
			Treated Hardwood	1	H6 (CCA)	>100	>100	>100	>100	60	>100	>100	>100
					H6 (creosote)	>100	>100	>100	>100	70	>100	>100	>100
					H6 (DBT)	>100	>100	>100	>100	80	>100	>100	>100
				2	H6 (CCA)	90	>100	>100	>100	45	80	90	>100
					H6 (creosote)	>100	>100	>100	>100	60	100	>100	>100
					H6 (DBT)	>100	>100	>100	>100	70	>100	>100	>100
				3	H6 (CCA)	70	>100	>100	>100	35	50	70	>100
					H6 (creosote)	>100	>100	>100	>100	50	70	>100	>100
					H6 (DBT)	>100	>100	>100	>100	60	80	>100	>100
				4	H6 (CCA)	50	60	100	>100	25	30	50	60
					H6 (creosote)	80	90	>100	>100	45	45	80	90
					H6 (DBT)	100	>100	>100	>100	50	50	100	>100
			Treated Softwood	4	H6 (CCA)	70	70	>100	>100	35	35	70	70
					H6 (creosote)	>100	>100	>100	>100	60	60	>100	>100
					H6 (DBT)	>100	>100	>100	>100	70	70	>100	>100
	3	Calm	Untreated Hardwood	1	none	50	>100	>100	>100	25	50	50	>100
				2	none	35	70	70	>100	20	35	35	70
			Treated Hardwood	1	H6 (CCA)	60	>100	>100	>100	30	50	60	>100
					H6 (creosote)	70	>100	>100	>100	35	60	70	>100
					H6 (DBT)	80	>100	>100	>100	40	70	80	>100
				2	H6 (CCA)	45	80	80	>100	25	40	45	80
					H6 (creosote)	60	90	>100	>100	30	50	60	90
					H6 (DBT)	70	>100	>100	>100	35	50	70	>100
				3	H6 (CCA)	35	50	60	100	20	25	35	50
					H6 (creosote)	50	70	100	>100	25	35	50	70
					H6 (DBT)	60	70	>100	>100	30	40	60	70
				4	H6 (CCA)	25	30	50	60	15	15	25	30
					H6 (creosote)	40	45	80	90	20	25	40	45
					H6 (DBT)	50	50	100	>100	25	25	50	50
			Treated Softwood	4	H6 (CCA)	30	35	60	70	15	20	30	35
					H6 (creosote)	60	60	>100	>100	30	30	60	60
					H6 (DBT)	60	70	>100	>100	35	35	60	70
		Surf	Untreated Hardwood	1	none	90	>100	>100	>100	45	90	90	>100
				2	none	60	>100	>100	>100	30	60	60	>100
			Treated Hardwood	1	H6 (CCA)	90	>100	>100	>100	45	90	90	>100
					H6 (creosote)	>100	>100	>100	>100	60	>100	>100	>100
					H6 (DBT)	>100	>100	>100	>100	70	>100	>100	>100
				2	H6 (CCA)	70	>100	>100	>100	35	60	70	>100
					H6 (creosote)	100	>100	>100	>100	50	80	100	>100
					H6 (DBT)	>100	>100	>100	>100	60	80	>100	>100
				3	H6 (CCA)	50	80	>100	>100	30	40	50	80
					H6 (creosote)	80	>100	>100	>100	40	60	80	>100
					H6 (DBT)	90	>100	>100	>100	50	60	90	>100
				4	H6 (CCA)	40	45	80	90	20	25	40	45
					H6 (creosote)	70	70	>100	>100	35	35	70	70
					H6 (DBT)	80	90	>100	>100	40	45	80	90
			Treated Softwood	4	H6 (CCA)	50	60	>100	>100	25	30	50	60
					H6 (creosote)	100	>100	>100	>100	50	50	100	>100
					H6 (DBT)	>100	>100	>100	>100	50	60	>100	>100

** Construction types A, B, C, and D indicate the construction features of the piles, defined as follows:*
A refers to piles stand-alone without contact with other structure element, having no maintenance measure applied.
B refers to piles stand-alone, having plastic wrap or floating collar as maintenance measure applied.
C refers to piles in contact with other element (e.g. X-brace), having no maintenance measure applied.
D refers to piles in contact with other element (e.g. X-brace) , having plastic wrap or floating collar as maintenance measure applied.
1. Hazard zone is defined in Figure 9.1.
2. Salinity class is defined in Table 9.2.
3. Shelter class is defined in Table 9.3.
4. Durability class is defined in Table 9.1.
5. H6 treatment levels are in accordance with AS 1604.1 – 2005. DBT stands for double-treatment.

Table 9.6: Typical service life of round piles in Hazard Zone C.

Hazard zone(1)	Salinity class(2)	Shelter class(3)	Timber	Marine borer resistance class(4)	Treatment(5)	Typical service life (years) Construction type A* 300mm dia	Construction type A* 400mm dia	Construction type B* 300mm dia	Construction type B* 400mm dia	Construction type C* 300mm dia	Construction type C* 400mm dia	Construction type D* 300mm dia	Construction type D* 400mm dia
C	1	Calm	Untreated Hardwood	1	none	60	>100	>100	>100	30	60	60	>100
				2	none	35	70	70	>100	20	35	35	70
			Treated Hardwood	1	H6 (CCA)	60	>100	>100	>100	30	60	60	>100
					H6 (creosote)	80	>100	>100	>100	40	70	80	>100
					H6 (DBT)	80	>100	>100	>100	45	70	80	>100
				2	H6 (CCA)	45	80	90	>100	25	45	45	80
					H6 (creosote)	60	100	>100	>100	35	50	60	100
					H6 (DBT)	70	>100	>100	>100	40	60	70	>100
				3	H6 (CCA)	35	50	70	>100	20	30	35	50
					H6 (creosote)	50	70	>100	>100	30	35	50	70
					H6 (DBT)	60	80	>100	>100	30	40	60	80
				4	H6 (CCA)	25	30	50	60	15	15	25	30
					H6 (creosote)	45	50	90	90	25	25	45	50
					H6 (DBT)	50	60	>100	>100	25	30	50	60
			Treated Softwood	4	H6 (CCA)	35	40	70	70	15	20	35	40
					H6 (creosote)	60	70	>100	>100	30	35	60	70
					H6 (DBT)	70	70	>100	>100	35	35	70	70
		Surf	Untreated Hardwood	1	none	90	>100	>100	>100	45	90	90	>100
				2	none	60	>100	>100	>100	30	60	60	>100
			Treated Hardwood	1	H6 (CCA)	100	>100	>100	>100	50	90	100	>100
					H6 (creosote)	>100	>100	>100	>100	60	>100	>100	>100
					H6 (DBT)	>100	>100	>100	>100	70	>100	>100	>100
				2	H6 (CCA)	80	>100	>100	>100	40	70	80	>100
					H6 (creosote)	>100	>100	>100	>100	50	80	>100	>100
					H6 (DBT)	>100	>100	>100	>100	60	90	>100	>100
				3	H6 (CCA)	60	90	>100	>100	30	45	60	90
					H6 (creosote)	90	>100	>100	>100	45	60	90	>100
					H6 (DBT)	>100	>100	>100	>100	50	70	>100	>100
				4	H6 (CCA)	45	50	80	100	20	25	45	50
					H6 (creosote)	70	80	>100	>100	35	40	70	80
					H6 (DBT)	90	90	>100	>100	45	45	90	90
			Treated Softwood	4	H6 (CCA)	60	60	>100	>100	30	30	60	60
					H6 (creosote)	>100	>100	>100	>100	50	60	>100	>100
					H6 (DBT)	>100	>100	>100	>100	60	60	>100	>100
	2	Calm	Untreated Hardwood	1	none	50	100	100	>100	25	50	50	100
				2	none	30	60	60	>100	15	30	30	60
			Treated Hardwood	1	H6 (CCA)	50	100	100	>100	25	50	50	100
					H6 (creosote)	70	>100	>100	>100	35	60	70	>100
					H6 (DBT)	70	>100	>100	>100	40	60	70	>100
				2	H6 (CCA)	40	70	80	>100	20	40	40	70
					H6 (creosote)	60	90	>100	>100	30	45	60	90
					H6 (DBT)	60	90	>100	>100	35	50	60	90
				3	H6 (CCA)	30	45	60	90	15	25	30	45
					H6 (creosote)	45	60	90	>100	25	35	45	60
					H6 (DBT)	50	70	>100	>100	30	35	50	70
				4	H6 (CCA)	25	25	45	50	10	15	25	25
					H6 (creosote)	40	40	80	80	20	20	40	40
					H6 (DBT)	45	50	90	100	25	25	45	50
			Treated Softwood	4	H6 (CCA)	30	35	60	70	15	15	30	35
					H6 (creosote)	60	60	>100	>100	30	30	60	60
					H6 (DBT)	60	60	>100	>100	30	30	60	60

Table 9.6** (continued)**: Typical service life of round piles in Hazard Zone C.

Hazard zone[1]	Salinity class[2]	Shelter class[3]	Timber	Marine borer resistance class[4]	Treatment[5]	Typical service life (years)							
						Construction type A*		Construction type B*		Construction type C*		Construction type D*	
						300mm dia	400mm dia	300mm dia	400mm dia	300mm dia	400mm dia	300mm dia	400mm dia
C	2	Surf	Untreated Hardwood	1	none	80	>100	>100	>100	40	80	80	>100
				2	none	50	>100	>100	>100	25	50	50	>100
			Treated Hardwood	1	H6 (CCA)	80	>100	>100	>100	45	80	80	>100
					H6 (creosote)	>100	>100	>100	>100	60	100	>100	>100
					H6 (DBT)	>100	>100	>100	>100	60	>100	>100	>100
				2	H6 (CCA)	70	>100	>100	>100	35	60	70	>100
					H6 (creosote)	90	>100	>100	>100	50	70	90	>100
					H6 (DBT)	>100	>100	>100	>100	50	80	>100	>100
				3	H6 (CCA)	50	80	100	>100	25	40	50	80
					H6 (creosote)	80	>100	>100	>100	40	50	80	>100
					H6 (DBT)	90	>100	>100	>100	45	60	90	>100
				4	H6 (CCA)	40	45	70	80	20	20	40	45
					H6 (creosote)	60	70	>100	>100	30	35	60	70
					H6 (DBT)	80	80	>100	>100	40	40	80	80
			Treated Softwood	4	H6 (CCA)	50	50	100	>100	25	25	50	50
					H6 (creosote)	90	100	>100	>100	45	50	90	100
					H6 (DBT)	100	>100	>100	>100	50	50	100	>100
	3	Calm	Untreated Hardwood	1	none	40	80	80	>100	20	40	40	80
				2	none	25	50	50	100	15	25	25	50
			Treated Hardwood	1	H6 (CCA)	40	80	80	>100	25	40	40	80
					H6 (creosote)	50	90	>100	>100	30	50	50	90
					H6 (DBT)	60	100	>100	>100	30	50	60	100
				2	H6 (CCA)	35	60	60	>100	20	30	35	60
					H6 (creosote)	45	70	90	>100	25	35	45	70
					H6 (DBT)	50	80	100	>100	25	40	50	80
				3	H6 (CCA)	25	40	50	70	15	20	25	40
					H6 (creosote)	40	50	70	100	20	25	40	50
					H6 (DBT)	45	60	90	>100	25	30	45	60
				4	H6 (CCA)	20	20	35	40	10	10	20	20
					H6 (creosote)	30	35	60	70	15	20	30	35
					H6 (DBT)	35	40	70	80	20	20	35	40
			Treated Softwood	4	H6 (CCA)	25	25	45	50	15	15	25	25
					H6 (creosote)	45	45	90	90	25	25	45	45
					H6 (DBT)	50	50	100	100	25	25	50	50
		Surf	Untreated Hardwood	1	none	70	>100	>100	>100	35	70	70	>100
				2	none	45	80	90	>100	20	45	45	80
			Treated Hardwood	1	H6 (CCA)	70	>100	>100	>100	35	70	70	>100
					H6 (creosote)	90	>100	>100	>100	45	80	90	>100
					H6 (DBT)	100	>100	>100	>100	50	80	100	>100
				2	H6 (CCA)	50	100	>100	>100	30	50	50	100
					H6 (creosote)	70	>100	>100	>100	40	60	70	>100
					H6 (DBT)	80	>100	>100	>100	45	60	80	>100
				3	H6 (CCA)	40	60	80	>100	20	35	40	60
					H6 (creosote)	60	80	>100	>100	35	45	60	80
					H6 (DBT)	70	90	>100	>100	35	50	70	90
				4	H6 (CCA)	30	35	60	70	15	20	30	35
					H6 (creosote)	50	60	100	>100	25	30	50	60
					H6 (DBT)	60	70	>100	>100	30	35	60	70
			Treated Softwood	4	H6 (CCA)	40	45	80	90	20	20	40	45
					H6 (creosote)	70	80	>100	>100	35	40	70	80
					H6 (DBT)	80	80	>100	>100	40	40	80	80

** Construction types A, B, C, and D indicate the construction features of the piles, defined as follows:*
A refers to piles stand-alone without contact with other structure element, having no maintenance measure applied.
B refers to piles stand-alone, having plastic wrap or floating collar as maintenance measure applied.
C refers to piles in contact with other element (e.g. X-brace), having no maintenance measure applied.
D refers to piles in contact with other element (e.g. X-brace) , having plastic wrap or floating collar as maintenance measure applied.
1. Hazard zone is defined in Figure 9.1.
2. Salinity class is defined in Table 9.2.
3. Shelter class is defined in Table 9.3.
4. Durability class is defined in Table 9.1.
5. H6 treatment levels are in accordance with AS 1604.1 – 2005. DBT stands for double-treatment.

Table 9.7: Typical service life of round piles in Hazard Zone D.

Hazard zone[1]	Salinity class[2]	Shelter class[3]	Timber	Marine borer resistance class[4]	Treatment[5]	Typical service life (years) – Construction type A* 300mm dia	Construction type A* 400mm dia	Construction type B* 300mm dia	Construction type B* 400mm dia	Construction type C* 300mm dia	Construction type C* 400mm dia	Construction type D* 300mm dia	Construction type D* 400mm dia
D	1	Calm	Untreated Hardwood	1	none	35	70	70	>100	20	35	35	70
				2	none	10	20	20	35	5	9	10	20
			Treated Hardwood	1	H6 (CCA)	40	80	80	>100	20	40	40	80
					H6 (creosote)	50	90	>100	>100	30	45	50	90
					H6 (DBT)	60	90	>100	>100	30	50	60	90
				2	H6 (CCA)	25	35	45	60	15	20	25	35
					H6 (creosote)	40	45	70	90	20	25	40	45
					H6 (DBT)	45	50	90	>100	25	25	45	50
				3	H6 (CCA)	20	25	45	50	10	15	20	25
					H6 (creosote)	35	40	70	80	20	20	35	40
					H6 (DBT)	40	45	80	90	20	25	40	45
				4	H6 (CCA)	20	20	40	40	10	10	20	20
					H6 (creosote)	35	35	60	70	15	20	35	35
					H6 (DBT)	40	40	80	80	20	20	40	40
			Treated Softwood	4	H6 (CCA)	25	25	50	50	15	15	25	25
					H6 (creosote)	45	50	90	100	25	25	45	50
					H6 (DBT)	50	50	>100	>100	25	25	50	50
		Surf	Untreated Hardwood	1	none	60	>100	>100	>100	30	60	60	>100
				2	none	15	30	30	60	8	15	15	30
			Treated Hardwood	1	H6 (CCA)	70	>100	>100	>100	35	60	70	>100
					H6 (creosote)	90	>100	>100	>100	45	70	90	>100
					H6 (DBT)	100	>100	>100	>100	50	80	100	>100
				2	H6 (CCA)	40	50	80	>100	20	30	40	50
					H6 (creosote)	60	80	>100	>100	30	40	60	80
					H6 (DBT)	70	90	>100	>100	35	45	70	90
				3	H6 (CCA)	35	45	70	90	20	25	35	45
					H6 (creosote)	60	70	>100	>100	30	35	60	70
					H6 (DBT)	70	80	>100	>100	35	40	70	80
				4	H6 (CCA)	30	35	60	70	15	20	30	35
					H6 (creosote)	50	60	>100	>100	25	30	50	60
					H6 (DBT)	60	70	>100	>100	35	35	60	70
			Treated Softwood	4	H6 (CCA)	40	45	80	90	20	25	40	45
					H6 (creosote)	80	80	>100	>100	40	40	80	80
					H6 (DBT)	90	90	>100	>100	45	45	90	90
	2	Calm	Untreated Hardwood	1	none	30	60	60	>100	15	30	30	60
				2	none	9	15	15	30	4	8	9	15
			Treated Hardwood	1	H6 (CCA)	35	70	70	>100	20	35	35	70
					H6 (creosote)	50	80	90	>100	25	40	50	80
					H6 (DBT)	50	80	>100	>100	30	45	50	80
				2	H6 (CCA)	20	30	40	60	10	15	20	30
					H6 (creosote)	35	40	60	80	20	20	35	40
					H6 (DBT)	40	45	80	90	20	25	40	45
				3	H6 (CCA)	20	25	40	45	10	10	20	25
					H6 (creosote)	30	35	60	70	15	20	30	35
					H6 (DBT)	35	40	70	80	20	20	35	40
				4	H6 (CCA)	15	20	35	35	9	10	15	20
					H6 (creosote)	30	30	60	60	15	15	30	30
					H6 (DBT)	35	35	70	70	20	20	35	35
			Treated Softwood	4	H6 (CCA)	25	25	45	45	10	15	25	25
					H6 (creosote)	40	45	80	80	20	20	40	45
					H6 (DBT)	45	45	90	90	25	25	45	45

Table 9.7 *(continued)*: ***Typical service life of round piles in Hazard Zone D.***

Hazard zone[1]	Salinity class[2]	Shelter class[3]	Timber	Marine borer resistance class[4]	Treatment[5]	Typical service life (years)							
						Construction type A*		Construction type B*		Construction type C*		Construction type D*	
						300mm dia	400mm dia	300mm dia	400mm dia	300mm dia	400mm dia	300mm dia	400mm dia
D	2	Surf	Untreated Hardwood	1	none	50	>100	>100	>100	25	50	50	>100
				2	none	15	25	30	50	7	15	15	25
			Treated Hardwood	1	H6 (CCA)	60	>100	>100	>100	30	60	60	>100
					H6 (creosote)	80	>100	>100	>100	40	70	80	>100
					H6 (DBT)	90	>100	>100	>100	45	70	90	>100
				2	H6 (CCA)	35	50	70	90	20	25	35	50
					H6 (creosote)	50	70	>100	>100	30	35	50	70
					H6 (DBT)	60	80	>100	>100	35	40	60	80
				3	H6 (CCA)	30	40	60	80	15	20	30	40
					H6 (creosote)	50	60	100	>100	25	30	50	60
					H6 (DBT)	60	70	>100	>100	30	35	60	70
				4	H6 (CCA)	30	30	50	60	15	15	30	30
					H6 (creosote)	45	50	90	100	25	25	45	50
					H6 (DBT)	60	60	>100	>100	30	30	60	60
			Treated Softwood	4	H6 (CCA)	35	40	70	80	20	20	35	40
					H6 (creosote)	70	70	>100	>100	35	35	70	70
					H6 (DBT)	70	80	>100	>100	40	40	70	80
	3	Calm	Untreated Hardwood	1	none	25	50	50	100	15	25	25	50
				2	none	7	15	15	25	3	6	7	15
			Treated Hardwood	1	H6 (CCA)	30	50	60	>100	15	30	30	50
					H6 (creosote)	40	60	70	>100	20	35	40	60
					H6 (DBT)	45	70	80	>100	25	35	45	70
				2	H6 (CCA)	20	25	35	45	10	15	20	25
					H6 (creosote)	25	35	50	60	15	15	25	35
					H6 (DBT)	30	40	60	70	15	20	30	40
				3	H6 (CCA)	15	20	30	40	8	10	15	20
					H6 (creosote)	25	30	50	60	15	15	25	30
					H6 (DBT)	30	35	60	70	15	15	30	35
				4	H6 (CCA)	15	15	25	30	8	8	15	15
					H6 (creosote)	25	25	45	45	15	15	25	25
					H6 (DBT)	30	30	50	60	15	15	30	30
			Treated Softwood	4	H6 (CCA)	20	20	35	40	10	10	20	20
					H6 (creosote)	35	35	70	70	15	20	35	35
					H6 (DBT)	35	40	70	70	20	20	35	40
		Surf	Untreated Hardwood	1	none	40	80	80	>100	20	40	40	80
				2	none	10	20	25	45	6	10	10	20
			Treated Hardwood	1	H6 (CCA)	45	90	90	>100	25	45	45	90
					H6 (creosote)	60	>100	>100	>100	35	50	60	>100
					H6 (DBT)	70	>100	>100	>100	35	60	70	>100
				2	H6 (CCA)	30	40	50	70	15	20	30	40
					H6 (creosote)	45	50	90	>100	25	30	45	50
					H6 (DBT)	50	60	100	>100	25	30	50	60
				3	H6 (CCA)	25	30	50	60	15	15	25	30
					H6 (creosote)	40	45	80	90	20	25	40	45
					H6 (DBT)	50	50	90	>100	25	30	50	50
				4	H6 (CCA)	20	25	45	50	10	15	20	25
					H6 (creosote)	40	40	70	80	20	20	40	40
					H6 (DBT)	45	45	90	90	25	25	45	45
			Treated Softwood	4	H6 (CCA)	30	30	60	60	15	15	30	30
					H6 (creosote)	50	60	>100	>100	30	30	50	60
					H6 (DBT)	60	60	>100	>100	30	30	60	60

** Construction types A, B, C, and D indicate the construction features of the piles, defined as follows:*
A refers to piles stand-alone without contact with other structure element, having no maintenance measure applied.
B refers to piles stand-alone, having plastic wrap or floating collar as maintenance measure applied.
C refers to piles in contact with other element (e.g. X-brace), having no maintenance measure applied.
D refers to piles in contact with other element (e.g. X-brace) , having plastic wrap or floating collar as maintenance measure applied.
1. Hazard zone is defined in Figure 9.1.
2. Salinity class is defined in Table 9.2.
3. Shelter class is defined in Table 9.3.
4. Durability class is defined in Table 9.1.
5. H6 treatment levels are in accordance with AS 1604.1 – 2005. DBT stands for double-treatment.

Table 9.8: Typical service life of round piles in Hazard Zone E.

Hazard zone(1)	Salinity class(2)	Shelter class(3)	Timber	Marine borer resistance class(4)	Treatment(5)	Typical service life (years)							
						Construction type A*		Construction type B*		Construction type C*		Construction type D*	
						300mm dia	400mm dia	300mm dia	400mm dia	300mm dia	400mm dia	300mm dia	400mm dia
E	1	Calm	Untreated Hardwood	1	none	20	40	40	80	10	20	20	40
				2	none	6	10	10	20	2	5	6	10
			Treated Hardwood	1	H6 (CCA)	25	45	45	80	15	25	25	45
					H6 (creosote)	30	50	60	100	15	25	30	50
					H6 (DBT)	35	50	70	>100	20	30	35	50
				2	H6 (CCA)	15	20	30	35	8	10	15	20
					H6 (creosote)	20	25	40	50	10	15	20	25
					H6 (DBT)	25	30	50	60	15	15	25	30
				3	H6 (CCA)	15	15	25	30	7	8	15	15
					H6 (creosote)	20	25	40	45	10	10	20	25
					H6 (DBT)	25	25	45	50	15	15	25	25
				4	H6 (CCA)	10	15	20	25	6	7	10	15
					H6 (creosote)	20	20	35	40	10	10	20	20
					H6 (DBT)	20	25	45	45	10	15	20	25
			Treated Softwood	4	H6 (CCA)	15	15	30	30	8	8	15	15
					H6 (creosote)	25	30	50	50	15	15	25	30
					H6 (DBT)	30	30	60	60	15	15	30	30
		Surf	Untreated Hardwood	1	none	35	70	70	>100	20	35	35	70
				2	none	9	15	20	35	5	9	9	15
			Treated Hardwood	1	H6 (CCA)	40	70	70	>100	20	35	40	70
					H6 (creosote)	50	80	100	>100	25	45	50	80
					H6 (DBT)	60	90	>100	>100	30	45	60	90
				2	H6 (CCA)	25	30	45	60	15	15	25	30
					H6 (creosote)	35	45	70	90	20	25	35	45
					H6 (DBT)	40	50	80	100	20	25	40	50
				3	H6 (CCA)	20	25	40	50	10	15	20	25
					H6 (creosote)	35	40	60	70	15	20	35	40
					H6 (DBT)	40	45	80	90	20	20	40	45
				4	H6 (CCA)	20	20	35	40	10	10	20	20
					H6 (creosote)	30	30	60	60	15	15	30	30
					H6 (DBT)	35	40	70	70	20	20	35	40
			Treated Softwood	4	H6 (CCA)	25	25	45	50	15	15	25	25
					H6 (creosote)	45	45	90	90	25	25	45	45
					H6 (DBT)	50	50	100	100	25	25	50	50
	2	Calm	Untreated Hardwood	1	none	20	40	40	80	10	20	20	40
				2	none	6	10	10	20	2	5	6	10
			Treated Hardwood	1	H6 (CCA)	25	45	45	80	15	25	25	45
					H6 (creosote)	30	50	60	100	15	25	30	50
					H6 (DBT)	35	50	70	>100	20	30	35	50
				2	H6 (CCA)	15	20	30	35	8	10	15	20
					H6 (creosote)	20	25	40	50	10	15	20	25
					H6 (DBT)	25	30	50	60	15	15	25	30
				3	H6 (CCA)	15	15	25	30	7	8	15	15
					H6 (creosote)	20	25	40	45	10	10	20	25
					H6 (DBT)	25	25	45	50	15	15	25	25
				4	H6 (CCA)	10	15	20	25	6	7	10	15
					H6 (creosote)	20	20	35	40	10	10	20	20
					H6 (DBT)	20	25	45	45	10	15	20	25
			Treated Softwood	4	H6 (CCA)	15	15	30	30	8	8	15	15
					H6 (creosote)	25	30	50	50	15	15	25	30
					H6 (DBT)	30	30	60	60	15	15	30	30

Table 9.8: Typical service life of round piles in Hazard Zone E.

Hazard zone[1]	Salinity class[2]	Shelter class[3]	Timber	Marine borer resistance class[4]	Treatment[5]	Typical service life (years)							
						Construction type A*		Construction type B*		Construction type C*		Construction type D*	
						300mm dia	400mm dia	300mm dia	400mm dia	300mm dia	400mm dia	300mm dia	400mm dia
E	2	Surf	Untreated Hardwood	1	none	35	70	70	>100	20	35	35	70
				2	none	9	15	20	35	5	9	9	15
			Treated Hardwood	1	H6 (CCA)	40	70	70	>100	20	35	40	70
					H6 (creosote)	50	80	100	>100	25	45	50	80
					H6 (DBT)	60	90	>100	>100	30	45	60	90
				2	H6 (CCA)	25	30	45	60	15	15	25	30
					H6 (creosote)	35	45	70	90	20	25	35	45
					H6 (DBT)	40	50	80	100	20	25	40	50
				3	H6 (CCA)	20	25	40	50	10	15	20	25
					H6 (creosote)	35	40	60	70	15	20	35	40
					H6 (DBT)	40	45	80	90	20	20	40	45
				4	H6 (CCA)	20	20	35	40	10	10	20	20
					H6 (creosote)	30	30	60	60	15	15	30	30
					H6 (DBT)	35	40	70	70	20	20	35	40
			Treated Softwood	4	H6 (CCA)	25	25	45	50	15	15	25	25
					H6 (creosote)	45	45	90	90	25	25	45	45
					H6 (DBT)	50	50	100	100	25	25	50	50
	3	Calm	Untreated Hardwood	1	none	20	40	40	80	10	20	20	40
				2	none	6	10	10	20	2	5	6	10
			Treated Hardwood	1	H6 (CCA)	25	45	45	80	15	25	25	45
					H6 (creosote)	30	50	60	100	15	25	30	50
					H6 (DBT)	35	50	70	>100	20	30	35	50
				2	H6 (CCA)	15	20	30	35	8	10	15	20
					H6 (creosote)	20	25	40	50	10	15	20	25
					H6 (DBT)	25	30	50	60	15	15	25	30
				3	H6 (CCA)	15	15	25	30	7	8	15	15
					H6 (creosote)	20	25	40	45	10	10	20	25
					H6 (DBT)	25	25	45	50	15	15	25	25
				4	H6 (CCA)	10	15	20	25	6	7	10	15
					H6 (creosote)	20	20	35	40	10	10	20	20
					H6 (DBT)	20	25	45	45	10	15	20	25
			Treated Softwood	4	H6 (CCA)	15	15	30	30	8	8	15	15
					H6 (creosote)	25	30	50	50	15	15	25	30
					H6 (DBT)	30	30	60	60	15	15	30	30
		Surf	Untreated Hardwood	1	none	35	70	70	>100	20	35	35	70
				2	none	9	15	20	35	5	9	9	15
			Treated Hardwood	1	H6 (CCA)	40	70	70	>100	20	35	40	70
					H6 (creosote)	50	80	100	>100	25	45	50	80
					H6 (DBT)	60	90	>100	>100	30	45	60	90
				2	H6 (CCA)	25	30	45	60	15	15	25	30
					H6 (creosote)	35	45	70	90	20	25	35	45
					H6 (DBT)	40	50	80	100	20	25	40	50
				3	H6 (CCA)	20	25	40	50	10	15	20	25
					H6 (creosote)	35	40	60	70	15	20	35	40
					H6 (DBT)	40	45	80	90	20	20	40	45
				4	H6 (CCA)	20	20	35	40	10	10	20	20
					H6 (creosote)	30	30	60	60	15	15	30	30
					H6 (DBT)	35	40	70	70	20	20	35	40
			Treated Softwood	4	H6 (CCA)	25	25	45	50	15	15	25	25
					H6 (creosote)	45	45	90	90	25	25	45	45
					H6 (DBT)	50	50	100	100	25	25	50	50

** Construction types A, B, C, and D indicate the construction features of the piles, defined as follows:*
A refers to piles stand-alone without contact with other structure element, having no maintenance measure applied.
B refers to piles stand-alone, having plastic wrap or floating collar as maintenance measure applied.
C refers to piles in contact with other element (e.g. X-brace), having no maintenance measure applied.
D refers to piles in contact with other element (e.g. X-brace) , having plastic wrap or floating collar as maintenance measure applied.
1. Hazard zone is defined in Figure 9.1.
2. Salinity class is defined in Table 9.2.
3. Shelter class is defined in Table 9.3.
4. Durability class is defined in Table 9.1.
5. H6 treatment levels are in accordance with AS 1604.1 – 2005. DBT stands for double-treatment.

Table 9.9: Typical service life of round piles in Hazard Zone F.

Hazard zone(1)	Salinity class(2)	Shelter class(3)	Timber	Marine borer resistance class(4)	Treatment(5)	Typical service life (years)							
						Construction type A*		Construction type B*		Construction type C*		Construction type D*	
						300mm dia	400mm dia	300mm dia	400mm dia	300mm dia	400mm dia	300mm dia	400mm dia
F	1	Calm	Untreated Hardwood	1	none	15	25	25	50	8	15	15	25
				2	none	4	7	8	15	2	3	4	7
			Treated Hardwood	1	H6 (CCA)	15	30	30	60	9	15	15	30
					H6 (creosote)	20	35	40	70	10	20	20	35
					H6 (DBT)	25	35	45	70	15	20	25	35
				2	H6 (CCA)	10	15	20	25	5	7	10	15
					H6 (creosote)	15	20	30	35	8	10	15	20
					H6 (DBT)	20	20	35	40	9	10	20	20
				3	H6 (CCA)	9	10	15	20	5	6	9	10
					H6 (creosote)	15	15	25	30	8	9	15	15
					H6 (DBT)	15	20	30	35	9	10	15	20
				4	H6 (CCA)	8	9	15	15	5	5	8	9
					H6 (creosote)	15	15	25	25	7	8	15	15
					H6 (DBT)	15	15	30	30	9	9	15	15
			Treated Soft-wood	4	H6 (CCA)	10	10	20	20	5	6	10	10
					H6 (creosote)	20	20	35	35	10	10	20	20
					H6 (DBT)	20	20	40	40	10	10	20	20
		Surf	Untreated Hardwood	1	none	25	45	45	90	10	25	25	45
				2	none	6	10	10	25	3	5	6	10
			Treated Hardwood	1	H6 (CCA)	25	50	50	90	15	25	25	50
					H6 (creosote)	35	60	70	>100	20	30	35	60
					H6 (DBT)	40	60	70	>100	20	30	40	60
				2	H6 (CCA)	15	20	30	40	8	10	15	20
					H6 (creosote)	25	30	45	60	15	15	25	30
					H6 (DBT)	30	35	50	70	15	15	30	35
				3	H6 (CCA)	15	20	25	35	8	9	15	20
					H6 (creosote)	25	25	45	50	10	15	25	25
					H6 (DBT)	25	30	50	60	15	15	25	30
				4	H6 (CCA)	15	15	25	25	7	8	15	15
					H6 (creosote)	20	20	40	40	10	10	20	20
					H6 (DBT)	25	25	50	50	15	15	25	25
			Treated Soft-wood	4	H6 (CCA)	15	20	30	35	9	9	15	20
					H6 (creosote)	30	30	60	60	15	15	30	30
					H6 (DBT)	35	35	60	70	15	20	35	35
	2	Calm	Untreated Hardwood	1	none	15	25	25	50	8	15	15	25
				2	none	4	7	8	15	2	3	4	7
			Treated Hardwood	1	H6 (CCA)	15	30	30	60	9	15	15	30
					H6 (creosote)	20	35	40	70	10	20	20	35
					H6 (DBT)	25	35	45	70	15	20	25	35
				2	H6 (CCA)	10	15	20	25	5	7	10	15
					H6 (creosote)	15	20	30	35	8	10	15	20
					H6 (DBT)	20	20	35	40	9	10	20	20
				3	H6 (CCA)	9	10	15	20	5	6	9	10
					H6 (creosote)	15	15	25	30	8	9	15	15
					H6 (DBT)	15	20	30	35	9	10	15	20
				4	H6 (CCA)	8	9	15	15	5	5	8	9
					H6 (creosote)	15	15	25	25	7	8	15	15
					H6 (DBT)	15	15	30	30	9	9	15	15
			Treated Soft-wood	4	H6 (CCA)	10	10	20	20	5	6	10	10
					H6 (creosote)	20	20	35	35	10	10	20	20
					H6 (DBT)	20	20	40	40	10	10	20	20

Table 9.9 *(continued)****: Typical service life of round piles in Hazard Zone F.***

Hazard zone(1)	Salinity class(2)	Shelter class(3)	Timber	Marine borer resistance class(4)	Treatment(5)	Typical service life (years) Construction type A* 300mm dia	Construction type A* 400mm dia	Construction type B* 300mm dia	Construction type B* 400mm dia	Construction type C* 300mm dia	Construction type C* 400mm dia	Construction type D* 300mm dia	Construction type D* 400mm dia
F	2	Surf	Untreated Hardwood	1	none	25	45	45	90	10	25	25	45
				2	none	6	10	10	25	3	5	6	10
			Treated Hardwood	1	H6 (CCA)	25	50	50	90	15	25	25	50
					H6 (creosote)	35	60	70	>100	20	30	35	60
					H6 (DBT)	40	60	70	>100	20	30	40	60
				2	H6 (CCA)	15	20	30	40	8	10	15	20
					H6 (creosote)	25	30	45	60	15	15	25	30
					H6 (DBT)	30	35	50	70	15	15	30	35
				3	H6 (CCA)	15	20	25	35	8	9	15	20
					H6 (creosote)	25	25	45	50	10	15	25	25
					H6 (DBT)	25	30	50	60	15	15	25	30
				4	H6 (CCA)	15	15	25	25	7	8	15	15
					H6 (creosote)	20	20	40	40	10	10	20	20
					H6 (DBT)	25	25	50	50	15	15	25	25
			Treated Softwood	4	H6 (CCA)	15	20	30	35	9	9	15	20
					H6 (creosote)	30	30	60	60	15	15	30	30
					H6 (DBT)	35	35	60	70	15	20	35	35
	3	Calm	Untreated Hardwood	1	none	15	25	25	50	8	15	15	25
				2	none	4	7	8	15	2	3	4	7
			Treated Hardwood	1	H6 (CCA)	15	30	30	60	9	15	15	30
					H6 (creosote)	20	35	40	70	10	20	20	35
					H6 (DBT)	25	35	45	70	15	20	25	35
				2	H6 (CCA)	10	15	20	25	5	7	10	15
					H6 (creosote)	15	20	30	35	8	10	15	20
					H6 (DBT)	20	20	35	40	9	10	20	20
				3	H6 (CCA)	9	10	15	20	5	6	9	10
					H6 (creosote)	15	15	25	30	8	9	15	15
					H6 (DBT)	15	20	30	35	9	10	15	20
				4	H6 (CCA)	8	9	15	15	5	5	8	9
					H6 (creosote)	15	15	25	25	7	8	15	15
					H6 (DBT)	15	15	30	30	9	9	15	15
			Treated Softwood	4	H6 (CCA)	10	10	20	20	5	6	10	10
					H6 (creosote)	20	20	35	35	10	10	20	20
					H6 (DBT)	20	20	40	40	10	10	20	20
		Surf	Untreated Hardwood	1	none	25	45	45	90	10	25	25	45
				2	none	6	10	10	25	3	5	6	10
			Treated Hardwood	1	H6 (CCA)	25	50	50	90	15	25	25	50
					H6 (creosote)	35	60	70	>100	20	30	35	60
					H6 (DBT)	40	60	70	>100	20	30	40	60
				2	H6 (CCA)	15	20	30	40	8	10	15	20
					H6 (creosote)	25	30	45	60	15	15	25	30
					H6 (DBT)	30	35	50	70	15	15	30	35
				3	H6 (CCA)	15	20	25	35	8	9	15	20
					H6 (creosote)	25	25	45	50	10	15	25	25
					H6 (DBT)	25	30	50	60	15	15	25	30
				4	H6 (CCA)	15	15	25	25	7	8	15	15
					H6 (creosote)	20	20	40	40	10	10	20	20
					H6 (DBT)	25	25	50	50	15	15	25	25
			Treated Softwood	4	H6 (CCA)	15	20	30	35	9	9	15	20
					H6 (creosote)	30	30	60	60	15	15	30	30
					H6 (DBT)	35	35	60	70	15	20	35	35

** Construction types A, B, C, and D indicate the construction features of the piles, defined as follows:*
A refers to piles stand-alone without contact with other structure element, having no maintenance measure applied.
B refers to piles stand-alone, having plastic wrap or floating collar as maintenance measure applied.
C refers to piles in contact with other element (e.g. X-brace), having no maintenance measure applied.
D refers to piles in contact with other element (e.g. X-brace) , having plastic wrap or floating collar as maintenance measure applied.
1. Hazard zone is defined in Figure 9.1.
2. Salinity class is defined in Table 9.2.
3. Shelter class is defined in Table 9.3.
4. Durability class is defined in Table 9.1.
5. H6 treatment levels are in accordance with AS 1604.1 – 2005. DBT stands for double-treatment.

Table 9.10: Typical service life of round piles in Hazard Zone G.

Hazard zone(1)	Salinity class(2)	Shelter class(3)	Timber	Marine borer resistance class(4)	Treatment(5)	Typical service life (years)							
						Construction type A*		Construction type B*		Construction type C*		Construction type D*	
						300mm dia	400mm dia	300mm dia	400mm dia	300mm dia	400mm dia	300mm dia	400mm dia
G	1	Calm	Untreated Hardwood	1	none	15	25	25	50	8	15	15	25
				2	none	4	7	8	15	2	3	4	7
			Treated Hardwood	1	H6 (CCA)	15	30	30	60	9	15	15	30
					H6 (creosote)	20	35	40	70	10	20	20	35
					H6 (DBT)	25	35	45	70	15	20	25	35
				2	H6 (CCA)	10	15	20	25	5	7	10	15
					H6 (creosote)	15	20	30	35	8	10	15	20
					H6 (DBT)	20	20	35	40	9	10	20	20
				3	H6 (CCA)	9	10	15	20	5	6	9	10
					H6 (creosote)	15	15	25	30	8	9	15	15
					H6 (DBT)	15	20	30	35	9	10	15	20
				4	H6 (CCA)	8	9	15	15	5	5	8	9
					H6 (creosote)	15	15	25	25	7	8	15	15
					H6 (DBT)	15	15	30	30	9	9	15	15
			Treated Soft-wood	4	H6 (CCA)	10	10	20	20	5	6	10	10
					H6 (creosote)	20	20	35	35	10	10	20	20
					H6 (DBT)	20	20	40	40	10	10	20	20
		Surf	Untreated Hardwood	1	none	25	45	45	90	10	25	25	45
				2	none	6	10	10	25	3	5	6	10
			Treated Hardwood	1	H6 (CCA)	25	50	50	90	15	25	25	50
					H6 (creosote)	35	60	70	>100	20	30	35	60
					H6 (DBT)	40	60	70	>100	20	30	40	60
				2	H6 (CCA)	15	20	30	40	8	10	15	20
					H6 (creosote)	25	30	45	60	15	15	25	30
					H6 (DBT)	30	35	50	70	15	15	30	35
				3	H6 (CCA)	15	20	25	35	8	9	15	20
					H6 (creosote)	25	25	45	50	10	15	25	25
					H6 (DBT)	25	30	50	60	15	15	25	30
				4	H6 (CCA)	15	15	25	25	7	8	15	15
					H6 (creosote)	20	20	40	40	10	10	20	20
					H6 (DBT)	25	25	50	50	15	15	25	25
			Treated Soft-wood	4	H6 (CCA)	15	20	30	35	9	9	15	20
					H6 (creosote)	30	30	60	60	15	15	30	30
					H6 (DBT)	35	35	60	70	15	20	35	35
	2	Calm	Untreated Hardwood	1	none	15	25	25	50	8	15	15	25
				2	none	4	7	8	15	2	3	4	7
			Treated Hardwood	1	H6 (CCA)	15	30	30	60	9	15	15	30
					H6 (creosote)	20	35	40	70	10	20	20	35
					H6 (DBT)	25	35	45	70	15	20	25	35
				2	H6 (CCA)	10	15	20	25	5	7	10	15
					H6 (creosote)	15	20	30	35	8	10	15	20
					H6 (DBT)	20	20	35	40	9	10	20	20
				3	H6 (CCA)	9	10	15	20	5	6	9	10
					H6 (creosote)	15	15	25	30	8	9	15	15
					H6 (DBT)	15	20	30	35	9	10	15	20
				4	H6 (CCA)	8	9	15	15	5	5	8	9
					H6 (creosote)	15	15	25	25	7	8	15	15
					H6 (DBT)	15	15	30	30	9	9	15	15
			Treated Soft-wood	4	H6 (CCA)	10	10	20	20	5	6	10	10
					H6 (creosote)	20	20	35	35	10	10	20	20
					H6 (DBT)	20	20	40	40	10	10	20	20

Table 9.10 *(continued)****: Typical service life of round piles in Hazard Zone G.***

Hazard zone(1)	Salinity class(2)	Shelter class(3)	Timber	Marine borer resistance class(4)	Treatment(5)	Typical service life (years) Construction type A*		Construction type B*		Construction type C*		Construction type D*	
						300mm dia	400mm dia	300mm dia	400mm dia	300mm dia	400mm dia	300mm dia	400mm dia
G	2	Surf	Untreated Hardwood	1	none	25	45	45	90	10	25	25	45
				2	none	6	10	10	25	3	5	6	10
			Treated Hardwood	1	H6 (CCA)	25	50	50	90	15	25	25	50
					H6 (creosote)	35	60	70	>100	20	30	35	60
					H6 (DBT)	40	60	70	>100	20	30	40	60
				2	H6 (CCA)	15	20	30	40	8	10	15	20
					H6 (creosote)	25	30	45	60	15	15	25	30
					H6 (DBT)	30	35	50	70	15	15	30	35
				3	H6 (CCA)	15	20	25	35	8	9	15	20
					H6 (creosote)	25	25	45	50	10	15	25	25
					H6 (DBT)	25	30	50	60	15	15	25	30
				4	H6 (CCA)	15	15	25	25	7	8	15	15
					H6 (creosote)	20	20	40	40	10	10	20	20
					H6 (DBT)	25	25	50	50	15	15	25	25
			Treated Soft-wood	4	H6 (CCA)	15	20	30	35	9	9	15	20
					H6 (creosote)	30	30	60	60	15	15	30	30
					H6 (DBT)	35	35	60	70	15	20	35	35
	3	Calm	Untreated Hardwood	1	none	15	25	25	50	8	15	15	25
				2	none	4	7	8	15	2	3	4	7
			Treated Hardwood	1	H6 (CCA)	15	30	30	60	9	15	15	30
					H6 (creosote)	20	35	40	70	10	20	20	35
					H6 (DBT)	25	35	45	70	15	20	25	35
				2	H6 (CCA)	10	15	20	25	5	7	10	15
					H6 (creosote)	15	20	30	35	8	10	15	20
					H6 (DBT)	20	20	35	40	9	10	20	20
				3	H6 (CCA)	9	10	15	20	5	6	9	10
					H6 (creosote)	15	15	25	30	8	9	15	15
					H6 (DBT)	15	20	30	35	9	10	15	20
				4	H6 (CCA)	8	9	15	15	5	5	8	9
					H6 (creosote)	15	15	25	25	7	8	15	15
					H6 (DBT)	15	15	30	30	9	9	15	15
			Treated Soft-wood	4	H6 (CCA)	10	10	20	20	5	6	10	10
					H6 (creosote)	20	20	35	35	10	10	20	20
					H6 (DBT)	20	20	40	40	10	10	20	20
		Surf	Untreated Hardwood	1	none	25	45	45	90	10	25	25	45
				2	none	6	10	10	25	3	5	6	10
			Treated Hardwood	1	H6 (CCA)	25	50	50	90	15	25	25	50
					H6 (creosote)	35	60	70	>100	20	30	35	60
					H6 (DBT)	40	60	70	>100	20	30	40	60
				2	H6 (CCA)	15	20	30	40	8	10	15	20
					H6 (creosote)	25	30	45	60	15	15	25	30
					H6 (DBT)	30	35	50	70	15	15	30	35
				3	H6 (CCA)	15	20	25	35	8	9	15	20
					H6 (creosote)	25	25	45	50	10	15	25	25
					H6 (DBT)	25	30	50	60	15	15	25	30
				4	H6 (CCA)	15	15	25	25	7	8	15	15
					H6 (creosote)	20	20	40	40	10	10	20	20
					H6 (DBT)	25	25	50	50	15	15	25	25
			Treated Soft-wood	4	H6 (CCA)	15	20	30	35	9	9	15	20
					H6 (creosote)	30	30	60	60	15	15	30	30
					H6 (DBT)	35	35	60	70	15	20	35	35

** Construction types A, B, C, and D indicate the construction features of the piles, defined as follows:*
A refers to piles stand-alone without contact with other structure element, having no maintenance measure applied.
B refers to piles stand-alone, having plastic wrap or floating collar as maintenance measure applied.
C refers to piles in contact with other element (e.g. X-brace), having no maintenance measure applied.
D refers to piles in contact with other element (e.g. X-brace) , having plastic wrap or floating collar as maintenance measure applied.
1. Hazard zone is defined in Figure 9.1.
2. Salinity class is defined in Table 9.2.
3. Shelter class is defined in Table 9.3.
4. Durability class is defined in Table 9.1.
5. H6 treatment levels are in accordance with AS 1604.1 – 2005. DBT stands for double-treatment.

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- Dr John French and Mr Jim Creffield – termite studies
- Mr Craig Seath – field calibration, laboratory studies and logistics
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Images:

Images provided by Outdoor Structures Australia and Kennedy's Classic Aged Timbers included in this publication are also greatly appreciated.

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Appendix 1
Definitions – Exposed Corrosion

The coastal exposure condition is defined by the opening angle, θ(degrees), and radius, R (km), of a bay as shown in Figure A.1.1. The exposure factor for the idealised bay, abay , is calculated as follows:

$$\alpha_{bay}^{2} = \left(\frac{\theta}{85}\right)^{2} + \left(\frac{R}{20}\right)^{2}$$

The coastal exposure condition is then defined as follows:

For $\alpha_{bay} < 1$	CLOSED BAY
For $1 < \alpha_{bay} < 1.5$	PARTIALLY CLOSED BAY
For $1.5 < \alpha_{bay} < 2.5$	OPEN BAY
For $\alpha_{bay} > 2.5$	OPEN SURF

These coastal exposure factors, and associated exposure conditions are shown plotted in Figure A.1.1.

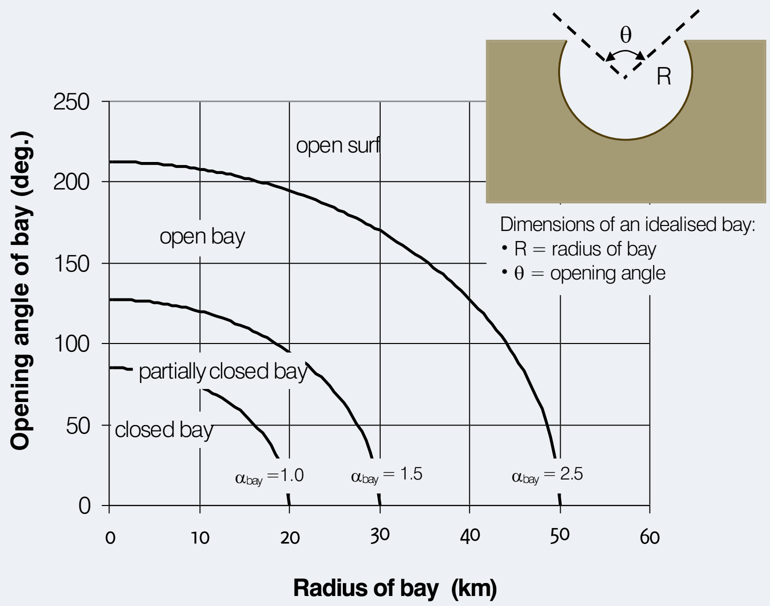

Figure A.1.1: Coastal exposure condition.

Appendix 2
Termites

Description of hazard parameters

Table A.2.1 shows in quantitative terms some typical distributions of wood corresponding to low, medium and high hazard levels of termite attack. For other distributions of wood, suitable estimates may be made through interpolation of these values.

Table A.2.1: Definition of hazard assessment due to occurrence of wood in the garden and under the house.

Hazard class	Number of potential nesting sites(1)	Typical distance between substantial food source (m)(2)
Low	<2	>20
Medium	2-5	5-20
High	>5	<5

(1) Examples of potential nesting sites

The following refers to potential nest sites for harbouring mature colonies which are not more than 50 m from the building.

- Tree (diameter larger than 300 mm)
- Tree stump or untreated pole (diameter larger than 200 mm)
- Untreated landscape timber (e.g., sleepers, retaining walls, length > 1.0 m, height > 0.5 m)
- Woodheap (height >0.5 m, ground contact area 0.5 x 0.5 m, length of periods that bottom layer woodheap is untouched > 1 year)
- Compost heap
- Wood "stepping stones"
- Subfloor storage (height >0.5 m, ground contact area >0.5 x 0.5 m, length of period which it is untouched >1 year).
- Solid infill under a verandah
- Any part of a building with water leaking under it

(2) Example of a substantial food source

A typical example of a substantial food source would be a piece of timber non termite resistant timber equal to or greater than 200 × 50 mm lying in ground contact.

Table A.2.2 gives examples of building construction that leads to high, medium and low hazard of termite attack related to ground contact characteristics.

Table A.2.2: Examples of hazard assessment due to the nature of the ground contact of a house.

Hazard class	Ground contact elements
Low	• House supported by exposed concrete piers or steel stumps more than 2 m high
Medium	• Intact concrete slab on ground with slab edge exposure for visual inspection; • House on stumps less than 600 mm high with ant caps and made of concrete or treated timber(1) or heartwood of termite and decay resistant timber(2)
High	• Construction does not comply with AS 3660.1 • Building not inspective according to AS 3660.2 • Concealed entry zones of any type • Floor connected to ground by stair cases of untreated softwood, untreated non-durable timber(3), untreated sapwood of durable timber; • Attached patio with solid infill • Concrete slab-on-ground with large cracks and/or unprotected pipe penetrations • Floors connected to ground by elements containing hidden cavities (e.g. masonry construction, deeply grooved elements, members in imperfect contact). • Brick veneer house with non slab edge exposure • Leakage of moisture to ground • Suspended floor less than 600 mm off the ground and no chemical or physical barriers installed under floor.

Notes:

1. Treated timber refers to timber treated according to AS 1604.1-2005 [7].

2. For a listing of timber durability classes 1 and 2, see AS 5604-2005 [9].

3. For a listing of non-durable timber of classes 3 and 4 see AS 5604-2005 [9].

Table A.2.3 gives examples of high, medium and low hazard of termite attack related to the type of material used for construction.

Table A.2.3: Examples of hazard assessment related to the type of construction material used.

Hazard class	Type of construction material attacked
Low	• Treated timber(1) • Untreated heartwood of Termite Resistant timber(2)
Medium	• Untreated heartwood of other timber with in-ground durability class 1 or 2(2)
High	• Untreated timber of durability classes 3 and 4(2) • Untreated sapwood of all species • Composite wood boards

Notes:

1. Treated timber refers to timber treated in accordance AS 1604.1-2005 to H2 level or higher [7].
2. For durability classes, see AS 5604-2005 [9].

Table A.2.4 gives a method for assessing the hazard due to the nature of exposure of timber.

Table A.2.4: Examples of hazard related to environment favourable to termites.

Hazard class	Environment favourable to termites
Low	• High human activity • High up a building • Humidity <30%
Medium	• Exposed to rain
High	• No disturbance and dark (e.g. wall stud, double leaf masonry wall, roof member.) • Exposed to sources of moisture so as to be periodically wet • Abandoned houses or mostly vacant holiday houses • Humidity >90%

TimberLife Educational Software

Following 10 years of intensive industry and government supported R&D, this leading edge, world first, multi million dollar project has delivered an extensive range of the necessary 'tools' that will give building and construction industry professionals the confidence to specify and detail timber in a wide range of applications, from sole plates to suspension bridges.

Timber has mistakenly been viewed as a less reliable construction material to steel or concrete from a durability perspective. This has arisen mainly due to the huge range of species and natural durability and treatments available, coupled with the diverse macro and micro climatic environmental considerations facing specifiers across Australia.

One of the developed tools is the TimberLife Educational Software package that provides a means of predicting timber's service life performance, with confidence, using the following predictive models:

- In-ground decay
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- Decay and corrosion within the building envelope
- Corrosion of fasteners exposed to the weather
- Marine borers
- Cost effective termite management and options.

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