TIMBER DATAFILE P4

# TIMBER - DESIGN FOR DURABILITY

National Association of Forest Industries

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# Contents



COVER PHOTO: Sea-front commercial complex utilises durable timber, quality finishes and corrosive resistance fasteners.

# Introduction

The majority of timber structures will perform their intended function for their service life with minimal maintenance. However, for this to occur, all the factors that influence the durability of the timber need to be properly considered.

Durability is defined as:
*the capacity of a timber product, component, system, building or structure to perform for a specified period of time, the function for which it was intended – be it aesthetic, structural or amenity.*

Irrespective of the durability qualities of the selected timber, it is important for the designer to consider the level of maintenance, repair or replacement that may be required within the design life of the structure.

Designing durable timber structures includes an assessment of the building material properties and preservative treatments that may be applied to those materials. It also includes an assessment of potential service hazards that may impact on the timber building elements.

This datafile provides guidance on the durability of timber in a wide range of applications. Not every application is considered, as some are not appropriate for timber use.

Where designers or specifiers require more information, they should contact the Timber Advisory Services, listed on the back page of this datafile.

Australian Government
Forest and Wood Products Research and Development Corporation

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*High traffic areas, such as the Expo '88 Boardwalk, require appropriate species selection and structural design to provide good serviceable life.*

# Designing for Durability

The qualitative data now available for a range of timber products gives designers a greater deal of certainty about the structural performance and characteristics of timber. Two key factors that designing for durability is dependent upon are :

- the performance requirements of the element or structure, and
- factors affecting durability of the element or structure.

Assessing the potential durability of timber is assisted by relating the timber's required performance standards with historical and test data. This assessment relies on the knowledge and resources of the designer to correctly analyse the specific applications and to determine the performance and durability requirements.

The flowchart in Figure 1 outlines the building specification process based on the building performance requirements and the potential hazards in a particular area.

Figures 2 and 3 outline the process for specifying the correct timber products and joint designs respectively.

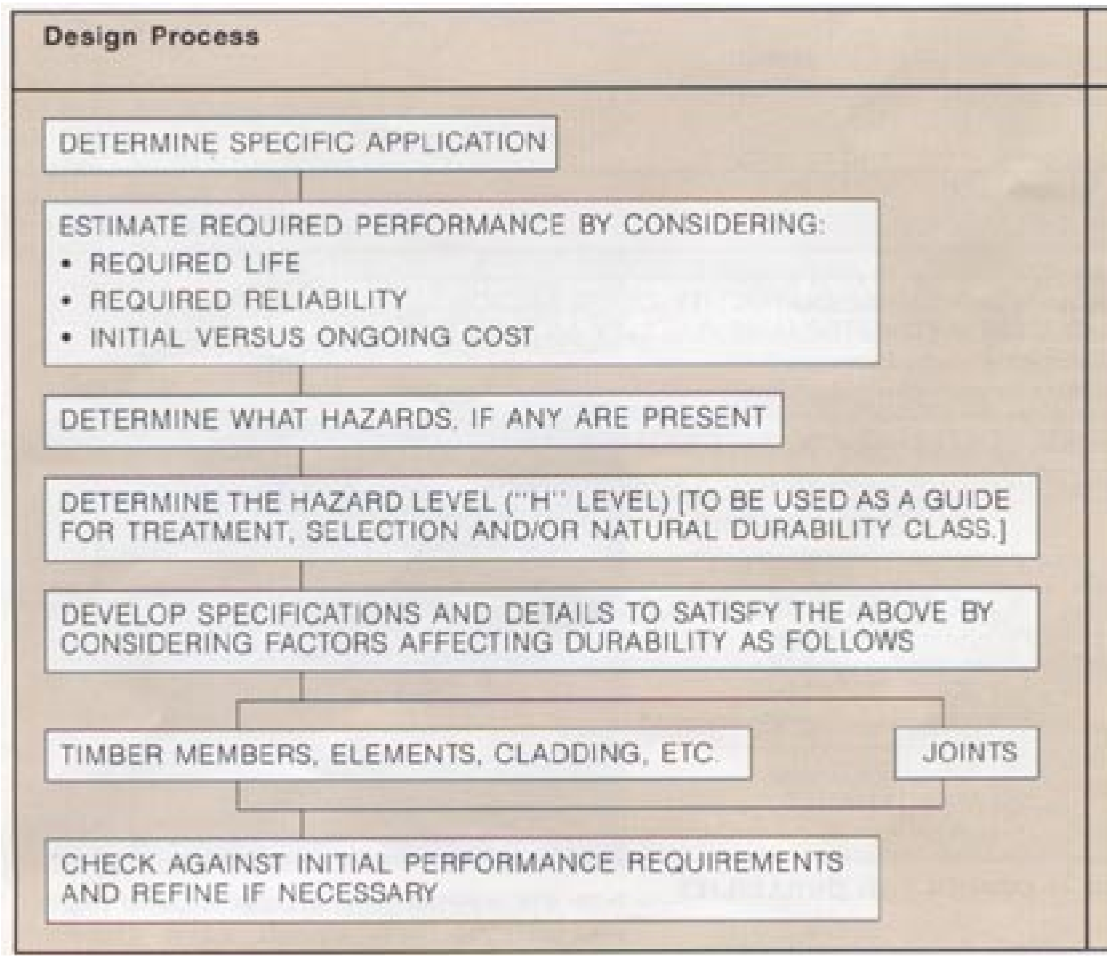



*Figure 1  The process of design for durability.*

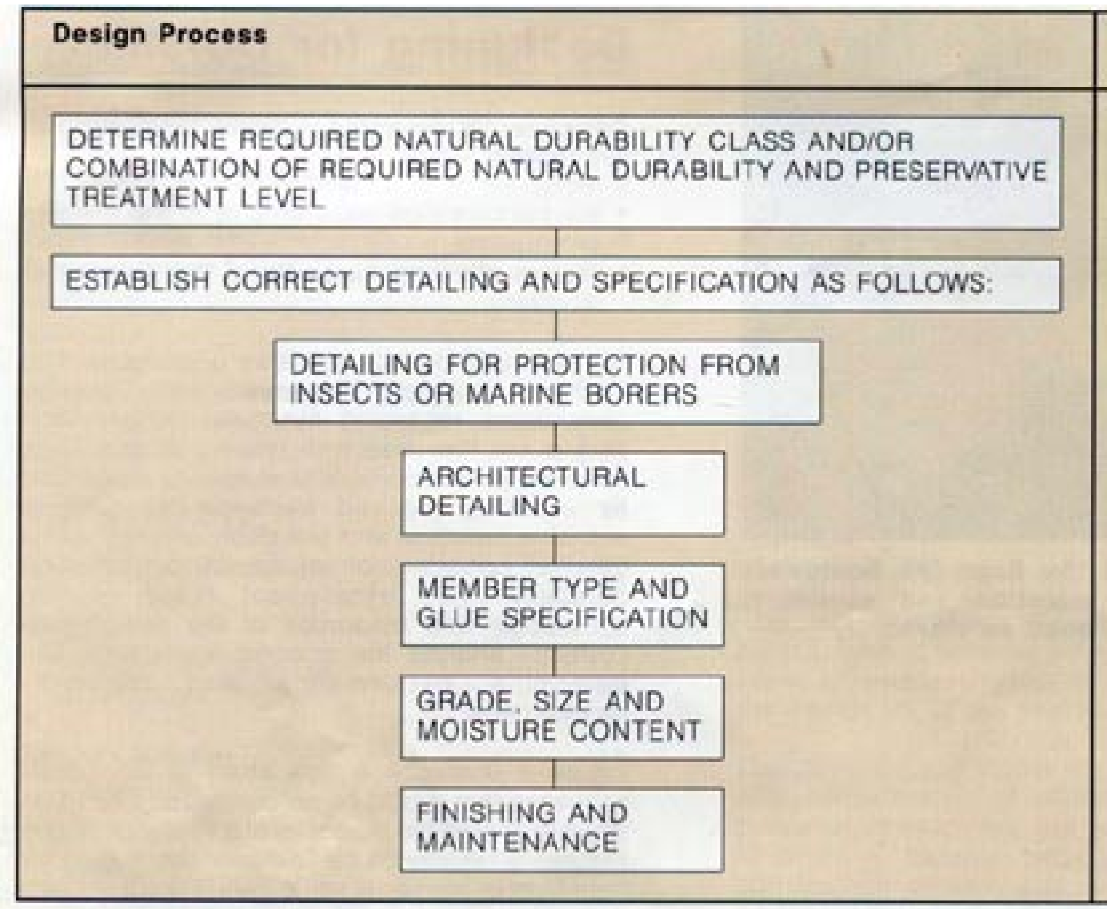



*Figure 2 Members/elements - design for durability.*

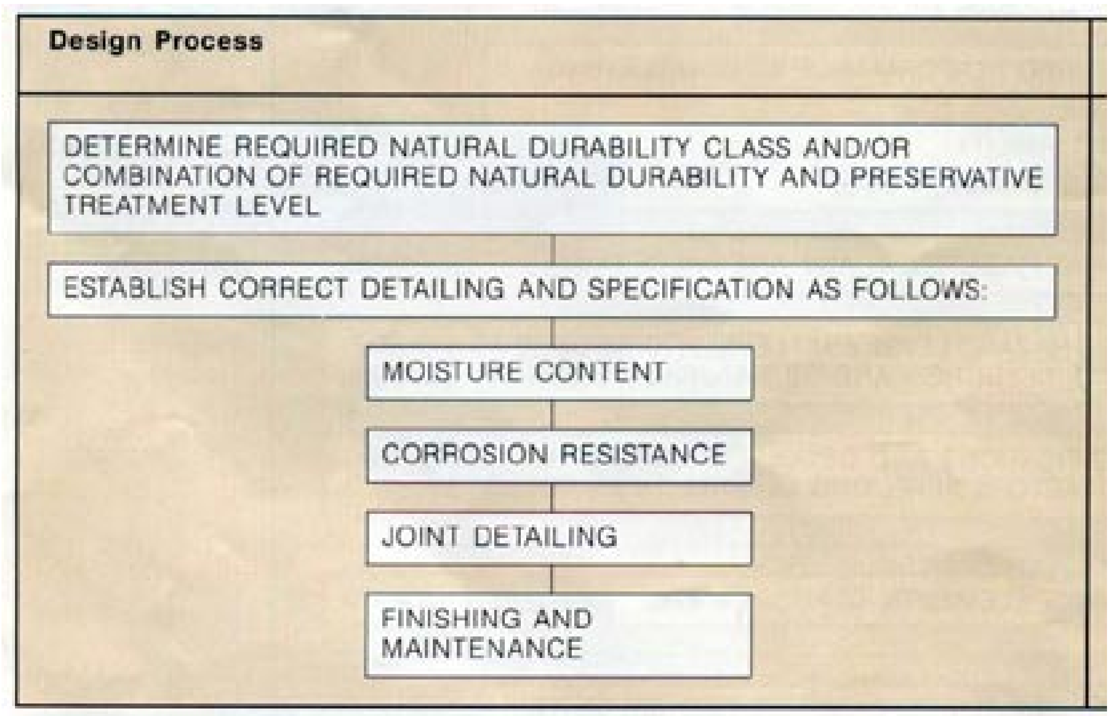



*Figure 3 Joints - design for durability.*

# Performance Requirements

When designing for durability, the performance requirements will be determined by the:

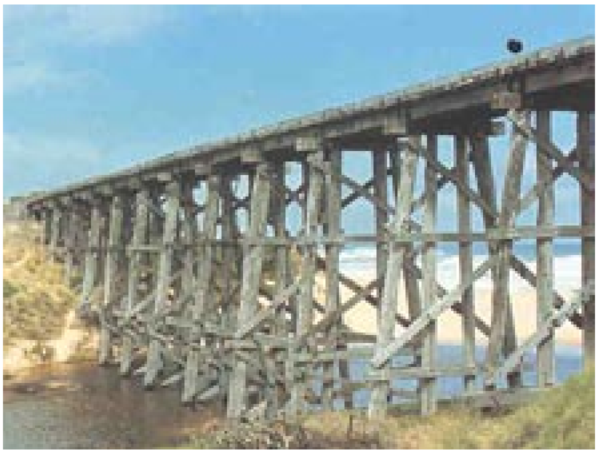
- Design life
- Reliability required from the structure or component
- Initial building costs versus the maintenance costs.

### Design Life

The design life of a structure will vary considerably, depending upon the climate, uses for the structure and the cost of replacing a building or structure. As an example, detached housing is usually (in an engineering sense), designed for a minimum life of 50 years. This does not mean that maintenance, repair or replacement of some parts of the house will not be required in less than 50 years (i.e. roofing, plumbing, painting, etc.) or that the house will not last well in excess of 50 years. The intent is, however, that the structural fabric of the house will last at least 50 years and will sustain all imposed loads for that period. Our society has come to expect this level of performance from dwellings. Other cultures may accept a lower design life, with the advantages of lower cost and portability.

Conversely, for temporary structures, such as hoardings or temporary bridges, specific design lives of a few months to a few years may be appropriate.

Table 1 (page 6) sets out the "typical" design life requirements appropriate for a number of applications. However, designers must use their judgement to assess client needs for each particular application.



*Timber bridges require long service lives, and therefore good design and construction utilising durable timber.*

### Reliability

The degree of reliability required for a particular structure or component is directly related to the minimum level of safety that needs to be achieved (that is, the potential for loss of human life or injury) and the consequences, or cost, of building product failure.

Table 1 provides broad categories of reliability for a number of applications. Designers need to use their professional judgement in connection with choices for the application they are considering.

With respect to safety, Table 1 recognises the following:

- Redundant, load sharing type structures (i.e., typical domestic house framing), have the ability to share the load without total failure, even though one or a number of members or joints may have failed.
- For major non-load sharing framing systems, (i.e., large members, wide spacing, portal frames, trusses, cross-bracing, etc.), a failure in a single member or joint may lead to collapse of the whole structure.
- Failure of building envelopes and cladding may not necessarily lead to high risk of death or injury.

### Costs

When deciding upon the durability performance requirements for buildings and structures, initial material and finishing costs must be balanced against long-term maintenance, and/or repair and replacement costs.

Long-term performance in high hazard situations will vary according to the quality of the material used. You can expect a longer service life according to the quality of the material. If the design life is short, material quality may not beas important.

Where long-term performance with minimal maintenance is important, attention should be given to:

- good detailing (which eliminates water ingress, allows for shrinkage, etc.)
- quality fastenings (that may be hot dipped galvanising or non-corroding)
- timber with high natural durability or appropriate levels of preservative treatment, and
- the quality of the finishing systems.

*Table 1 Typical life expectancy and reliability considerations.*

| Application | Part | Life Expectancy (Years) | Reliability required | | Remarks |
|---|---|---|---|---|---|
| | | | Safety | Cost of Failure | |
| **Temporary Structures** | | | | | |
| Bridges - road diversion, trench shoring, temporary construction-props and bracing | All | 0.5 - 1 | High | High | Very high degree of structural reliability required |
| Hoardings | Structural components | 2 - 3 | High | Low | Made up of 5-6 re-use applications |
| Formwork | Framework | 2 - 3 | High | Low | 5-6 re-use applications |
| | Sheeting | | Low | Low | |
| Classrooms - Transportable | Structural Framework | 10 - 20 | Low | Low | Structural reliability probably based on 25 - 50 years |
| | Cladding | 10 - 20 | Low | Low | |
| **PERMANENT STRUCTURES** | | | | | |
| Farm Buildings | All | 15 - 25 | Low | Low | |
| Bridges - Roads and Rail and Wharves | All | 20 - 50 | High | High | Require a very high degree of reliability with respect to durability and structural integrity |
| Domestic Construction | Framework | 50+ | Low | Low | |
| | Cladding | 25 - 50 | Low | Low | |
| | Add-ons Paegolas etc | 20 | Low | Low | |
| Industrial Buildings | Framework | 50 | High | High | Usually non-loadsharing |
| | Sheeting/ Cladding, etc. | 25 | Low | Low | |
| Commerical Buildings | Structural | 50 - 100 | High | High | |
| | Sheeting/ Cladding, etc. | 50 | High | High | |
| Public and Institutional Buildings - Cic Centres, Hospitals, etc. | Structural | 100+ | High | High | |
| | Sheeting/ Cladding, etc. | 50 - 100+ | High | High | |

# Hazard Conditions and Protection

With proper design, construction, use and maintenance, timber can be a permanent structural material. Certain conditions and factors do, however, affect its durability and, in turn, the maintenance costs for timber construction elements.

The vast majority of timber is used in applications where its permanence is unquestioned. Protected from weathering, moisture, insects and strong chemicals, timber has performed exceptionally well for centuries. However, the natural or calamitous hazards that timber may have to contend with, do require consideration.

These can be summarised as:

- weathering
- insect attack
- fungal attack
- chemical degradation
- corrosion
- marine organisms
- fire, and
- mechanical degradation.

*Buildings and wharf structures must be designed and protected against marine hazards.*

### Weathering

Where timber is painted, stained or protected from the weather by architectural design, degradation due to weathering should be minimal.

*Natural weathering of unprotected plinth (Photo courtesy of Dr. Harry Greaves)*

If timber is left unpainted or unfinished and exposed to the weather for an extended period, the surface will discolour, checks and cracks may form, and the surface will become quite rough.

This weathering may be the result of erosion, wetting and drying (leading to shrinkage and swelling of the timber), chemical changes (effects of light, particularly ultraviolet radiation, and oxygen) or in alpine areas, freezing and thawing. For unprotected timbers, erosion of the surface occurs slowly, at rates of between 6 –13 mm per century. The rate depends on the timber species and level of exposure.

Weathering may bleach the colour of the timber to a silver-grey. The application of a clear water-repellent finish, however, will reduce the extent of unsightly surface staining generally caused by mould growth.

Surface fibres may be loosened and eroded, particularly the early wood portions (the paler coloured components of the growth ring) for softwoods, and boards may cup or warp.

Protection from weathering can be obtained by the following means:

- Application and Maintenance of Finishes

These include paints, stains, water repellents and preservatives. Refer to Table 8 (page 36) for a summary and refer to Datafile FM1, EXTERIOR FINISHES FOR TIMBER.

- Architectural Detailing and Landscaping

These include overhangs, flashings, verandas and vegetation (but note that overgrowing vegetation, particularly if it is regularly watered, will only partially protect timber from weathering, and may lead to the development of surface discolouration).

Refer to Figure 12, (page 27), for timber protection options based on architectural design solutions.

**Insects**

Timber structures are best protected from damage by insects through proper design and construction procedures, accurate specification (including species selection) and where necessary, preservative treatment. The main insects that may cause damage to seasoned timber are:

- termites
- lyctine beetles (commonly referred to as *Lyctus* borers)
- anobiid borers (includes the furniture beetle)

**Termites**

There are about 300-350 species of termites in Australia, belonging to five families: *Mastotermitidae; Termopsidae; Kalotermitidae; Rhinotermitidae; and Termitidae.* The 40 or so genera covering these families have been described for all Australian states and territories, though it is generally accepted that termites are not commonly found in Tasmania. The insects feed on a range of materials, including live and dead trees, plant debris, grass, roots and timber. Although they derive no nutrient value from them, termites have also been known to attack buried telephone and electrical cables, as well as plastic water pipes and the like.

The termites of economic importance to the Australian forest and timber industry can be divided into three groups: dampwood, drywood, and subterranean termites.

<u>*Dampwood*</u> *termites* prefer wood that is decaying and damp. They are usually found in bathrooms, kitchens, laundries, etc. They are readily controlled by replacing the rotting timber and removing the source of moisture that gave rise to the problem in the first place.

<u>*Drywood*</u> *termites* attack relatively dry and sound timber, from which they derive their moisture. There are a number of drywood termite species indigenous to Australia, but the most destructive species known, *Cryptotermes brevis*, has been inadvertently imported with timber and can cause extensive damage where it occasionally occurs. It is a government notifiable pest found in limited distribution pockets in Queensland (and rarely as far south as Sydney). Protection in these regions is most economically provided by the use of termite resistant timber products derived from cypress, ironbark and other Durability Class 1 species and/or by preservative treated timber products.

<u>*Subterranean*</u> *termites* require contact with the ground for water. They may build above-ground nests or establish their colonies completely underground. The termite genera within this group include forest pests that attack living trees as well as building timbers, poles, posts and the like. Subterranean termites are by far the biggest of the three groups of termites. They constitute the main problem for homeowners and are the subject of most control and eradication programs.

*Subterranean termite colonies established in quite different environments*

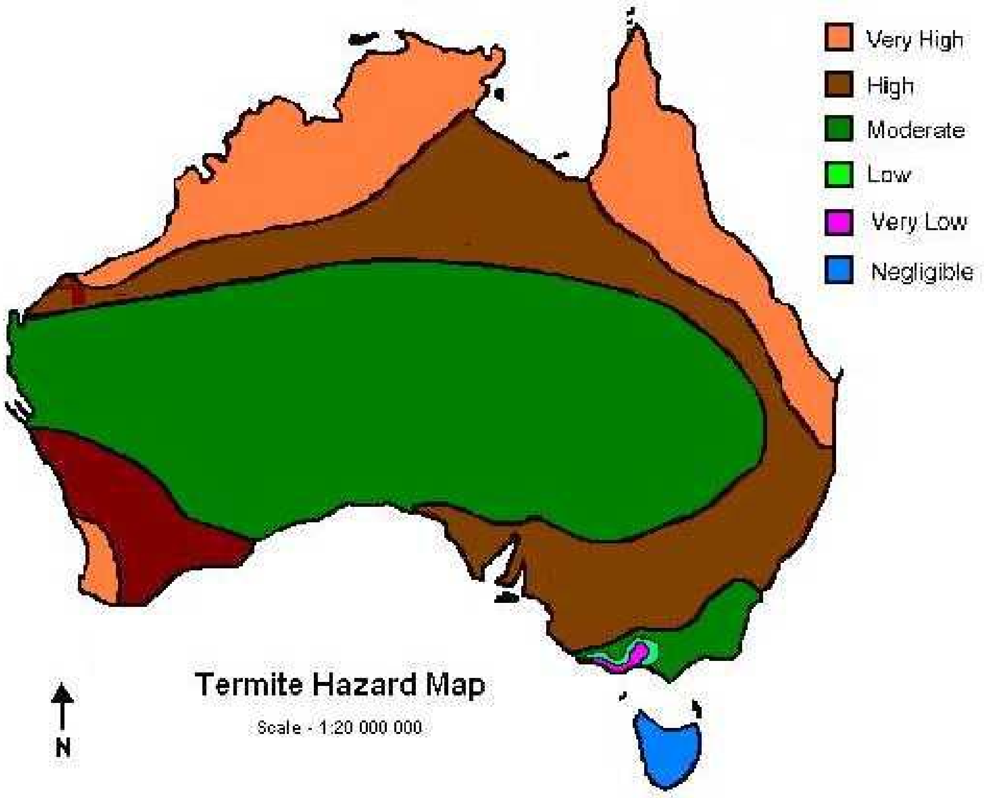



*Figure 4 Subterranean termite hazard zones.*

The following practices will assist in preventing termite attack:

- eliminate or minimise cracks in concrete foundations and slabs
- ensure the building site and the area under buildings is cleared of debris after building and landscaping have been completed
- do not build up garden beds or place planters etc. against building foundations or in contact with timber cladding or other timber elements
- ensure that building works comply with the Building Code of Australia. This Code requires some form of protection if there is a threat of termite attack
- minimise soil contact for untreated timber that may be a potential food source for termites
- ensure crawl spaces permit inspection of termite barriers and sub-floor timbers, and that they have adequate clearance and ventilation
- refer to Technical Report No. 3 (www.timber.org.au) for an outline of building products currently available for minimising the threat of termite attack.

The level of protection required will depend on the threat of termite attack, as indicated in figure 4.

Simple and inexpensive measures during construction provide the best protection in areas where subterranean termites are prevalent. These measures include eliminating the presence of or trapping moisture and to provide proper ventilation to ensure timber elements can dry out if they become wet. Regular inspection and fumigation (by licensed pest controllers only) where necessary, can also provide protection.

Where there is a threat of termite attack, the Building Code of Australia (BCA) requires that all structural elements of a new building, (the Primary Building Elements), must be protected either by providing barriers to keep the termites out (or to force them into the open where they will be seen and eradicated), or by using termite-resistant building materials, such as naturally durable or preservative-treated timber.

In Queensland, the definition of the Primary Building Elements also includes items such as door jambs, window frames and architraves. It should be noted that the BCA requirements do not include the non-structural components of a new house, such as internal joinery and the furniture.

Figure 5, (page 10), outlines some of the physical barriers for reducing the threat of termite attack.

The BCA calls up Australian Standard AS3660 *Termite Management* to define and detail appropriate systems of termite control, including barriers, and termite resistant material. This Standard sets out the design and termite management system performance requirements, guidelines for detecting and managing termite activity, and the criteria for assessing the effectiveness of termite management systems.

AS3660 covers both new (Part 1) and existing (Part 2) buildings. It refers to just subterranean termites. The distinct Parts of the Standard are closely inter-related. The deemed-to-comply management systems set down in Parts 1 and 2, have first been assessed by methods covered in Part 3 and then approved by the various authorities who control building activity under the BCA. (Refer to Datafile P5 and Technical Report Issue 3 at www.timber.org.au for more information.)

**Lyctids (Powder Post Beetles)**

Lyctine beetles, of which the powder post beetle is the most common, are widespread but only attack the sapwood of susceptible hardwoods and do not usually present concerns to designers or users of timber since:

- conifers (softwoods) are immune from attack and only the sapwood of a range of hardwood species is susceptible to infestation. Refer to Datafile P1, TIMBER SPECIES AND PROPERTIES for species susceptibility.
- State marketing Acts in Queensland and New South Wales, limit the sale of timber products with lyctid susceptible sapwood.
- Australian Standards limit the amount of lyctid susceptible sapwood that can be present in structural and other timber products.

*Lyctus borer produces a fine powdery frass when it attacks the starch-containing sapwood of hardwood roof timbers.*

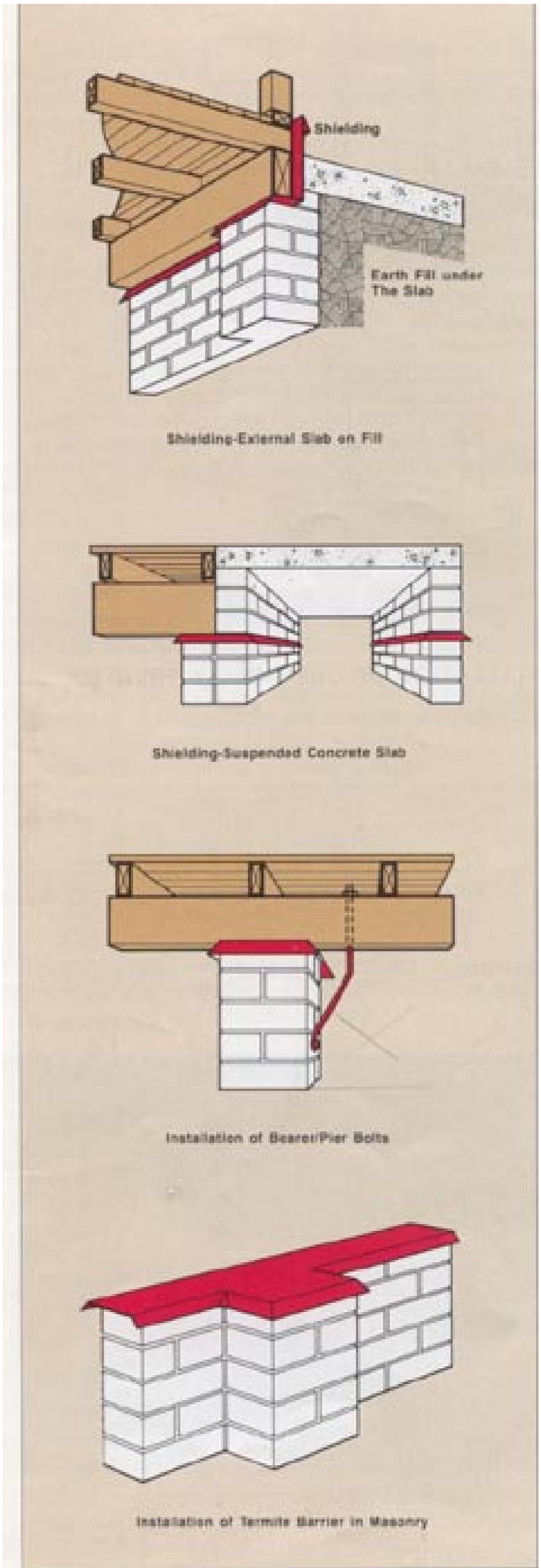



*Figure 5 Physical termite barrier*

*Severe decay in park seat supports*

*Brown rotted wood*

*(Photos courtesy of Dr. Harry Greaves)*

**Furniture Beetles**

The anobiid group of wood attacking insects, of which the *Anobium* furniture beetle is the most common, may attack all softwoods and some hardwoods. *Anobium* prefers old, well seasoned timber like Baltic pine and may also attack blackwood, and even English oak. Its relative, *Calymmaderus*, the Queensland Pine Beetle, occurs further north than *Anobium,* where it may attack hoop, kauri and similar related pines. *Anobium* occurs in southern Queensland and northern New South Wales, whereas the Queensland Pine beetles is restricted to an area east of the Great Dividing Range in South East Queensland.

Protection against the furniture beetle can be achieved by using surface films, enclosing timber within a structure, and by elevated temperatures (i.e., unsarked roof cavities). Preservative treatment should be considered if protection is required for highly critical timber members.

**Fungi**

Fungi are broadly grouped based on which components of the wood cells in the timber they attack. Moulds and stains (e.g. blue stain) usually affect the timber's appearance (severe blue stain may affect timber permeability and, to some extent, it's impact strength) whereas rot fungi (white rot, brown rot and soft rot) can significantly affect strength properties, as they penetrate and break down the cellular components of wood.

Four conditions determine the risk of fungal attack on timber:

- The wood moisture content must be above the fibre saturation point (35% or higher) for prolonged periods.
- Oxygen must be present, (i.e., completely submerged or saturated timber and timber well below ground where low oxygen conditions exist, are rarely attacked).
- Temperatures must generally be in the range of 5$^{o}$C to 40$^{o}$C to promote fungal growth. Temperatures between 25$^{o}$C to 40$^{o}$C are the ideal part of the range - at higher or lower temperatures, fungal attack will be retarded.
- Food in the form of unprotected nutrients (carbohydrates, nitrogen, essential minerals, etc.), must be present. These are usually provided by the timber itself, particularly sapwood which is normally high in sugars and carbohydrates. The sapwood can be protected by preservative treatment.

Removal of any one of these four conditions will reduce the risk of fungal attack, although in practice it is usually the exposure to high moisture levels that poses the greatest risk, as dry wood will not rot. The decay hazard zones are provided in Figure 6 (page 12).

Timber is best protected from fungal attack by:

- eliminating contact with moisture, or where this is not possible:
- using species with a durability rating appropriate for the particular application, or
- using preservative treated species or sapwood which has been preservative treated (i.e. the nutritional source is removed) to a level appropriate to minimise the risks of the fungal hazard.


*Figure 6 Decay hazard zones.*

**Chemical**

Chemicals that do not swell timber, such as petroleum oils and creosote, have no appreciable effect on timber properties. However, timber- swelling chemicals such as water, alcohol and some other organic fluids do not degrade the timber, but may diminish its mechanical properties. If these liquids are removed, swelling will be reversed and mechanical properties are restored.

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 the wood cells. The degree of degradation is dependent upon many factors including the species of timber (softwoods are more resistant to attack by acids and alkalis than hardwoods), the type of chemical (oxidising acids are worse than non-oxidising) and the conditions during exposure. In general, heartwood is more resistant to chemical attack than sapwood.

Some softwoods, such as the heartwood of cypress pine and Oregon, are highly resistant to a wide variety of chemicals at reasonable concentration and ambient temperatures, and are therefore widely used for chemical storage and processing.

Examples of timber applications where the resistance to chemical attack is of benefit include:

- waste landfill piling (usually acidic)
- tanneries
- vats
- piles or fascines in swamps
- enclosed swimming pool buildings
- chemical storage buildings, and
- water treatment works.

For special situations where chemical degradation of the timber is a concern, the natural chemical resistance of timbers can be enhanced by impregnating them with:

- Phenolic resins (improves acid resistance)
- Furfuryl alcohol (increases alkaline resistance)
- Monomeric resins followed by polymerisation (greatly improves chemical resistance).

**Corrosion**

Most timbers are slightly acidic (ph 3 to 6). Therefore, when moisture is present and metals are in contact with the timber, the metals have a low resistance to corrosion (e.g. unprotected steel). At the same time, chemical reactions are set up that cause a loss of strength in the surrounding timber (e.g. dark staining around steel fasteners).

To prevent deterioration of timber around metal objects, such as fasteners, particulary where moisture is present, the following approaches can be employed:

- use non-corrosive or protected metals (i.e. galvanised or plated)
- countersink and plug or stop fasteners (prevents moisture traps)
- avoid the use of dissimilar metals for fasteners
- grease, coat or sheath fasteners in contact with CCA treated timber (and preferably use hot-dipped galvanised fasteners)

**Marine**

Marine piles (piles in marine or tidal waters entering the ocean) are subjected to three zones of durability hazard. The bottom parts are usually embedded in mud and are free from hazard while the tops (above high water mark) have to withstand weathering and mechanical degrade (abrasion). The greatest hazard occurs in the zone between the mud line and the high water mark, where marine organisms are active.

In this zone, the greatest threats are bivalve molluscs (*Teredo*, *Nausitora*, and *Bankia* borers, better known as shipworms), and crustaceans (*Limnoria*, or gribble, *Sphaeroma* which is related to the common garden slater or wood lice, and *Martesia,* which is found in tropical and sub-tropical waters).

| Botanical classification | Preservative | Location for use | |
|---|---|---|---|
| | | Southern waters | Northern waters |
| Softwood<br>Hardwood | CCA alone | Yes<br>Yes | No<br>No |
| Softwood<br>Hardwood | Creosote alone | Yes<br>Yes | No<br>No |
| Softwood<br>Hardwood | Double treatment (CCA + Creosote) | Yes<br>Yes | Yes<br>Yes |

*Table 2 summarises the preservative treatments recommended in AS1604.1-2000 SPECIFICATION FOR PRESERVATIVE TREATMENT for protection from marine borers.*

The molluscs do not feed on wood but tunnel into the timber for shelter and their damage may go unnoticed until it becomes quite extensive. These shipworms generally prefer to live in the lower half of the tidal stream and are distributed around Australia.

Crustaceans, however, only burrow to beneath the timber surface, where they generally feed on the wood cells. *Limnoria* borers prefer cooler waters in the zone between the mud-line and the high tide mark. Their damaging effect would be negligible except for the surface breakdown caused by wave action and mechanical action. This is followed by additional burrowing until an “hour glass” shape occurs. *Sphaeroma* borers prefer warmer waters and can tolerate a wide range of salinities, so they may attack timber in estuarine situations. Unlike *Limnoria,* this crustacean borer only bores into the wood and filter feeds in the sea.

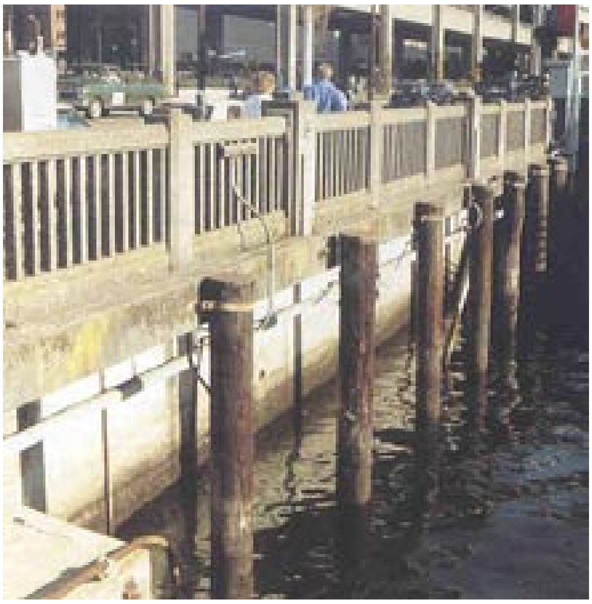
Protection for marine piles or timber in contact with water is provided by using:

- species with high natural resistance such as turpentine, satinay, cypress pine and jarrah
- timbers impregnated with chemical preservatives (requires a wide sapwood band), e.g. plantation softwoods, spotted gum etc. (See Table 2.)
- chemical and or mechanical barriers.

The few timber species that are naturally marine-borer resistant (whether because of a high silica content or the presence of naturally toxic extractives) may have up to 5 years additional protection, where the bark is left intact on the piles.

Timber species with wide sapwood bands can be effectively treated with chemicals to provide resistance to marine borers. CCA is generally effective against *Limnoria,* while creosote-type preservatives are effective against *Teredo*. Double treatment (CCA followed by creosote or PEC) should be considered for those areas where a high marine hazard exists. Refer to Figure 7 (page 14) for the general marine Hazard Classifications.

It is generally accepted that the marine-borer hazard is more severe in the warmer northern waters than it is in southern waters. The region north of Perth in the west and Batemans Bay in the east can be described as northern waters, but it should be noted that significant local variations in hazard can exist due to differences in water temperature and salt concentrations. (The options for chemically treating timber to protect it from maritime bores are outlined in Table 2.)



*Fender piles require protection against marine borers and need high wear resistance.*

*Timber and non-corrosive fasteners make an ideal combination for indoor pool structures.*

A combination of mechanical and chemical barriers may offer greater protection to marine piles. Mechanical barriers include copper sheathing or for more permanent work, concrete encasement such as poured concrete collars or timber piles driven through concrete or fibre cement pipes. Where piles are encased in pipes, sand is usually placed between the timber and the pipe to provide mechanical support to the pipe.

Care should be taken with all marine piles to ensure that any damaged sapwood, splits, knots or other imperfections are given additional chemical or mechanical protection. Regular inspections and scheduled maintenance procedures for all waterfront structures (piles in particular) is vital for ensuring the timber structures have a long, serviceable life.


*Figure 7 Marine hazard zone.*

**Fire**

The www.timber.org.au website has information covering many aspects of fire safety. It includes information about residence fit-out and building in bushfire prone areas.

**Mechanical Degradation**

Specific design considerations may be required to minimise the risk of mechanical degradation to timber applications, including:

- stair treads/door sills
- flooring
- decking
- rubbing strips/fenders
- baffles (water treatment).

Hardness and density are the best indicators of the resistance of timber species to mechanical degradation. Generally, species with densities in excess of 800 kg/$m^3$ provide satisfactory performance in the applications listed above.

For more detailed density information refer to DATAFILE P1, TIMBER SPECIES AND PROPERTIES.

## Hazard Classes

To support the appropriate selection and specification of either naturally durable or preservative-treated timber products, the hazard levels to which timber elements might be exposed in service, have been defined as Hazard Classes in the AS1604 series. Table 3 provides a summary and guidance on the determination of Hazard Classes which apply to a range of service conditions, biological hazards and uses.

| Exposure | Specific Service Conditions | Biological Hazard (Refer Figures 4, 6, 7) | Typical Uses | Hazard Class |
|---|---|---|---|---|
| Inside above ground | Completely protected from the weather and well ventilated and protected from termites | Lyctids | Lyctid-susceptible hardwood framing, flooring, furniture, interior joinery | 1 |
| Inside above ground | Protected from wetting. Nil leaching | Borers and termites | Framing, flooring and similar used in dry situations | 2 |
| Outside above ground | Subject to periodic moderate wetting and leaching | Moderate decay, borers and termites | Weatherboards, fascia, pergolas (above ground), window joinery, exterior framing and decking | 3 |
| Outside in ground | Subject to severe wetting and leaching | Severe decay, borers and termites | Fence posts, greenhouses, pergolas (in ground), and landscaping timbers | 4 |
| Outside in ground contact with or in fresh water | Subject to extreme wetting and leaching and/or where the commodity's critical use requires a higher degree of protection | Very severe decay, borers and termites | Retaining walls, piling, house stumps, building poles, cooling tower fill | 5 |
| Marine water | Subject to prolonged immersion in sea water | Marine wood borers and decay | Boat hulls, marine piles, jetty cross-branching, landing steps, etc. | 6 |

*Table 3 Hazard Class selection guide. NOTE:* Examples shown here are not exhaustive. Reference should be made to AS1604 for more complete descriptions.

| Class 1 (Highly Durable) | Class 2 (Durable) | Class 3 (Moderately Durable) | Class 4 (Non-Durable) |
|---|---|---|---|
| grey ironbark | spotted gum | rose gum | radiata pine |
| red bloodwood | blackbutt | keruing | slash pine |
| tallowwood | red cedar | messmate | Douglas fir |
| turpentine | jarrah | brush box | Tasmanian oak |
| grey gum | Sydney blue gum | taun | meranti |
| yellow cedar | kauri | kapur | Philippine red mahogany |

*Table 4 Natural in-ground durability classes*

After determining the Hazard Class facing the timber elements, it is possible to specify the appropriate timber products based on their durability class (Table 4) and expected service life (Table 5).

For example, all four durability classes of timber should have a service life of at least 40 years, if they are used in Hazard Class 1 applications (Table 5). Alternatively, the different durability classes of timber will have differing service lives in Hazard Class 3 or in Hazard Class 5 applications (Table 5).

| Durability Class | Heartwood Service Life (Years)<br><br>For Hazard Class (See Table 3) | | |
|---|---|---|---|
| | H5<br>In-Ground | H3<br>Above Ground Exposed | H1<br><br>Protected |
| 1 Highly durable | 25+ | 40+ | 40+ |
| 2 Durable | 15 - 25 | 15 - 40 | 40+ |
| 3 Moderately Durable | 5 - 15 | 7 - 15 | 40+ |
| 4 Non-Durable | < 5 | 0 - 7 | 40+ |

*Table 5 Guide to service life for each durability class*

NOTES:

1. *These life expectancies will be subject to wide variation, depending upon level of preservative treatment, finishing, maintenance, building practice, etc.*
2. *All timbers, including Class 4, will last indefinitely if kept dry and protected from termites, extreme chemical hazards and fire.*

Although these Hazard Classes have been developed specifically for preservative treated timber, they may also be used to estimate the service life of untreated timber products based on the natural durability of heartwood (see Table 5).

The Hazard Classes and condition of use for preservative-treated timber (including heartwood durability) are also included within the provisions of legislation in Queensland )through the *Timber Utilisation and Marketing Act 1987)* and in New South Wales (through the *Timber Marketing Act 1977*).

## Natural Durability

The natural durability rating system refers to the resistance of outer heartwood of each species to fungal and insect (particularly termite) attack. Note that sapwood has no natural resistance to decay or termites unless it has been preservative treated.

Durability is expressed in terms of one of four classes Table 4). The classes have been based on a combination of field trials of untreated heartwood both in the ground and above the ground, expert opinion, and experience with timber in service.

The natural durability classes reflect the in-ground service impacts on timber products in an adverse environment, (i.e., high moisture content, temperatures and subterranean termite presence). They do not necessarily provide an accurate assessment of above ground durability or resistance to certain insects such as drywood termites.

Australian Standard AS5604-2003 TIMBER NATURAL DURABILITY RATINGS also lists above-ground life expectancies and the termite resistance of timbers when used in wall frame, truss or other internal building element.

Reasonable service life means life with minimal, if any, replacement. Some examples of species in the four classes used in-ground are given in Table 4. Table 5 provides guidance on the expected satisfactory service life of many commonly used timber species.

Datafile P1, TIMBER SPECIES AND PROPERTIES provides a comprehensive list of the natural durability ratings for a range of species. It should be noted that in-ground, natural durability ratings are averages only and that differences will occur due to natural variation within species, site hazard conditions, etc. Also, the ratings do not take account of preservative treatment, variations in design installation or supplementary maintenance.

## Preservative Treatment

The preservative treatment of timber products involves the introduction of stable chemicals into the cellular wood structure, which protects the timber from wood destroying organisms, such as fungi and insects. Preservative treatments may also include chemicals with fire retardant properties.

### Chemicals and Treatment Methods

The preservative treatment of timber is primarily concerned with the protection of sapwood. Based on the current commercial treatment procedures, it is difficult to treat heartwood effectively, because heartwood cells contain resins and other extractives which limit the penetration and uptake of preservative solutions. The wide sapwood bands of the major plantation softwoods (radiata, slash, hoop pine etc.) can be effectively treated with timber preservatives.

In Australia, the major timber preservatives currently in use are:

- Boron compounds
- Light Organic Solvent Preservatives (LOSP)
- Water-borne preservatives like Copper Chrome Arsenate (CCA), ACQ, Copper Azole
- Oil-borne preservatives like Creosote and Pigment Emulsified Creosote (PEC)

### Boron Compounds

Boron compounds generally provide effective protection against attack by wood boring insects. They have been used widely throughout Australia to protect starch-containing sapwoods of *Lyctus*-susceptible hardwood timbers for the building industry. Because such timber species were predominantly grown and used in New South Wales and Queensland, these two states introduced laws to enforce the treatment of *Lyctus*-susceptible hardwoods.

The two current state Acts ensure that all *Lyctus*-susceptible hardwood offered for sale in New South Wales and Queensland is chemically treated. The Acts apply equally to *Lyctus*-susceptible timber treated anywhere in Australia and offered for sale in New South Wales and Queensland and to *Lyctus*-susceptible timber that is imported from overseas for use in New South Wales and Queensland.

*Preservative treated piles must be suitable for hazard level 5.*

*Preservative treated softwood decking delivers long-term, excellent performance in weather exposed situations.*

Boron compounds have always been the preferred treatment chemicals for insect protection in Australia. They are applied either by a diffusion process or by vacuum pressure processes that deliver borates relatively deeply into the timber.

The diffusion process treatment consists of soaking freshly sawn, unseasoned timber in solutions of boron compounds. The salts diffuse through the timber and after treatment, the timber is allowed to dry. The preservative imparts no colour to the timber, which is an advantage when timber is to be used for flooring or furniture. Boron is not fixed in the timber, regardless of whether it is applied by diffusion or by vacuum pressure impregnation. It can therefore leach out, and this restricts boron-treated timber to interior uses such as flooring and framing, where it is protected from the weather.

**Light Organic Solvent Preservatives (LOSP's)**

Light Organic Solvent Preservatives (LOSPs) are preservatives that generally contain combinations of fungicides, insecticides and water repellents in a solvent carrier such as white spirit. They are used to protect timber against insects, (including termites), and decay. **They are not intended for use in ground-contact situations.** In addition, LOSPs provide a degree of weather protection because of the water repellents they contain. LOSPs are preservatives that leave the treated timber dry, and do not cause it to swell or distort in any way.

LOSPs have traditionally been colourless, though it is now possible to obtain green and brown-coloured LOSPs. However, the colour imparted to the timber by these coloured variants remains visible only in the short-term.

Coloured LOSPs should never be mistaken for other coloured water-borne or oil-based preservatives. For example, green LOSP may look like the familiar green copper chrome arsenic (CCA). However, the LOSP will not perform in the ground, which is where CCA does best. LOSP treated products, therefore, must not be substituted for CCA-treated products simply because it may look the same colour.

LOSPs are intended to provide adequate protection to a wide range of timber products. These are generally treated in their final shape and form.

When LOSP treated-timber is used in weather exposed conditions, avoid prolonged wetting and applications where water entrapment is likely. For example, in some external above-ground applications, like pergolas and decks, LOSP-treated timber should always be given a supplementary protective coating once installed. This must be maintained throughout the structure's service life.

When treating timber in its final shape and form, LOSP's may be used because the organic solvents carrying other preservatives do not swell the timber. In comparison, water-borne preservatives like CCA tend to raise the grain of treated timber, forcing them to swell. LOSP's are therefore suitable for the treatment of joinery, cladding and finished products.

**Water-borne preservatives**

**1. Copper Chrome Arsenate (CCA)**

CCA is a well-established, water-borne preservative. It is used to protect timber in service from all major biodeteriogens, including decay fungi, wood boring insects, termites, and marine borers. The CCA concept was invented by an Indian engineer in 1933 and it is now used in most countries around the world where wood preservation plays an important part in building infrastructure applications.

CCA is the most commonly used preservative in Australia. The treatment process involves the timber being impregnated with preservative by a vacuum/pressure process in specially designed treatment plants.

When the elements copper (Cu), chromium (Cr), and arsenic (As) are introduced into the timber in combination with water, the formulation is so designed that they react with each other and with the wood structure to become fixed as insoluble compounds.

The combination of copper, chromium and arsenic offers protection of the treated timber from insect (arsenic) and fungal (copper and arsenic) degrade. The chromium component chemically locks the elements into the timber, offering resistance to leaching. Consequently, CCA-treated timber may be used safely in a variety of end uses and is suited to all in-ground and weather-exposed applications.

Where heartwood is present, it will be relatively poorly impregnated by the CCA. Accordingly, timber species with an appropriate natural durability class should be selected to match the relevant hazard level. (Refer Table 3.)

After post-treatment drying, CCA treated timber is odour-free and dry to touch.

CCA treatment does not necessarily improve the weathering characteristics of timber. Therefore supplementary finishing must be considered for weather-exposed applications.

Many tests, both in Australia and overseas, have shown that because the CCA preservatives are well fixed in the timber, the final products pose no detectable hazard to humans or livestock.

**2. Ammoniacal Copper Quaternary (ACQ)**

ACQ timber preservatives have been used around the world for almost a decade. They are specified in the AS1604 series as copper-based preservatives that provide protection against decay and insect attack. They are not applied to timber products used for purposes described under Hazard Class H6.

Copper, a naturally occurring mineral and the main ingredient in ACQ, is an effective and widely used fungicide. Such quaternary compounds are commonly used in household disinfectants and cleaners, and provide enhanced performance against copper-tolerant fungi and insects. These preservatives penetrate deeply into the timber products and remain in the wood for a long time.

**3. Copper azole**

ACQ timber preservatives have been used around the world for almost a decade. They are specified in the AS1604 series as copper-based preservatives that provide protection against decay and insect attack. They are not applied to timber products used for purposes described under Hazard Class H6.

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**Oil-borne preservatives - Creosote and Pigment Emulsified Creosote (PEC)**

Creosote and PEC are mainly used in Australia for heavy engineering applications such as piles, poles, and bridge timbers. The timber is treated by a vacuum/pressure impregnation processes employing heat. The odour and surface condition of creosote-treated timber restricts its use to commercial situations.

Pigment Emulsified Creosote (PEC) was developed as a much cleaner alternative to creosote. Vapour emissions and "bleed through" have been considerably reduced. This product is a viable alternative to conventional creosote treatment and is being increasingly used in commercial and industrial fields, including marine piles (usually double treated with CCA + PEC), poles, crossarms and marine decking.

Creosote and PEC are both used to protect timber against decay and insect and borer attack. Being oil-borne, these preservatives migrate slowly into the treated timber and may leave them with an oily surface finish. PEC is less likely to do this than normal creosote.

Not only do they provide protection against biological agents, but creosote and PEC are also strongly water repellent and therefore provide good weather protection for timber products.

Users should avoid getting the creosote or PEC on their skin. Special care should be taken when working with these treatments or treated products in bright sunshine. Creosote can cause a (reversible) skin irritation akin to sunburn. This is more likely to be prevalent in fair-skinned people.

*PEC-treated utility pole. (Photo courtesy Dr. Harry Greaves)*

*Durable hardwood (sapwood preservative treated) in a crib retaining wall.*

**Reconstituted Timber Products**

Many reconstituted timber products, including plywood, LVL, particleboard and MDF can have preservative chemicals incorporated into the products during the manufacturing process. AS1604 Parts 2, 3, 4, and 5 specify the preservative treatments for these composite products, where the preservative chemicals help address specified hazards, such as fire retardants and protection from insects.

*Preservative treatment increases the durability of softwoods for landscape applications.*

**Is Preservative Treatment Necessary?**

By far the most difficult question facing the specifier is whether to use preservative treated timber in the various building elements. The decision should be based on professional judgement that considers many factors such as:

- The presence of a hazard (moisture, insect, decay, fire, etc.).
- The degree of structural reliability required (is the system load sharing or non-load sharing, what is the cost of failure and if failure occurs, what is 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.
- The presence of non-durable sapwood (sapwood can be effectively treated but heartwood is difficult to treat and cannot be achieved as a routinely predictable and therefore reliable, commercial practice).

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Figure 8 (next page) provides some guidance on determining whether or not preservative treatment is required for the timber elements of permanent structures. In considering this, the following points should be noted:

- Only sapwood (both hardwoods and softwoods), can be predictably and consistently preservative treated (unless the timber is incised).
- The sapwood of some species, i.e., cypress pine and Douglas fir, is very difficult to effectively treat with preservatives.
- Plantation softwoods and some hardwood species have wide sapwood bands. These are ideal for preservative treatment, particularly in their round form. Good treatment of these substrates ensures they meet durability requirements and may make them equivalent to the best of our naturally durable timbers.

*Traditional veranda provides shelter and protection to timber cladding and decking.*

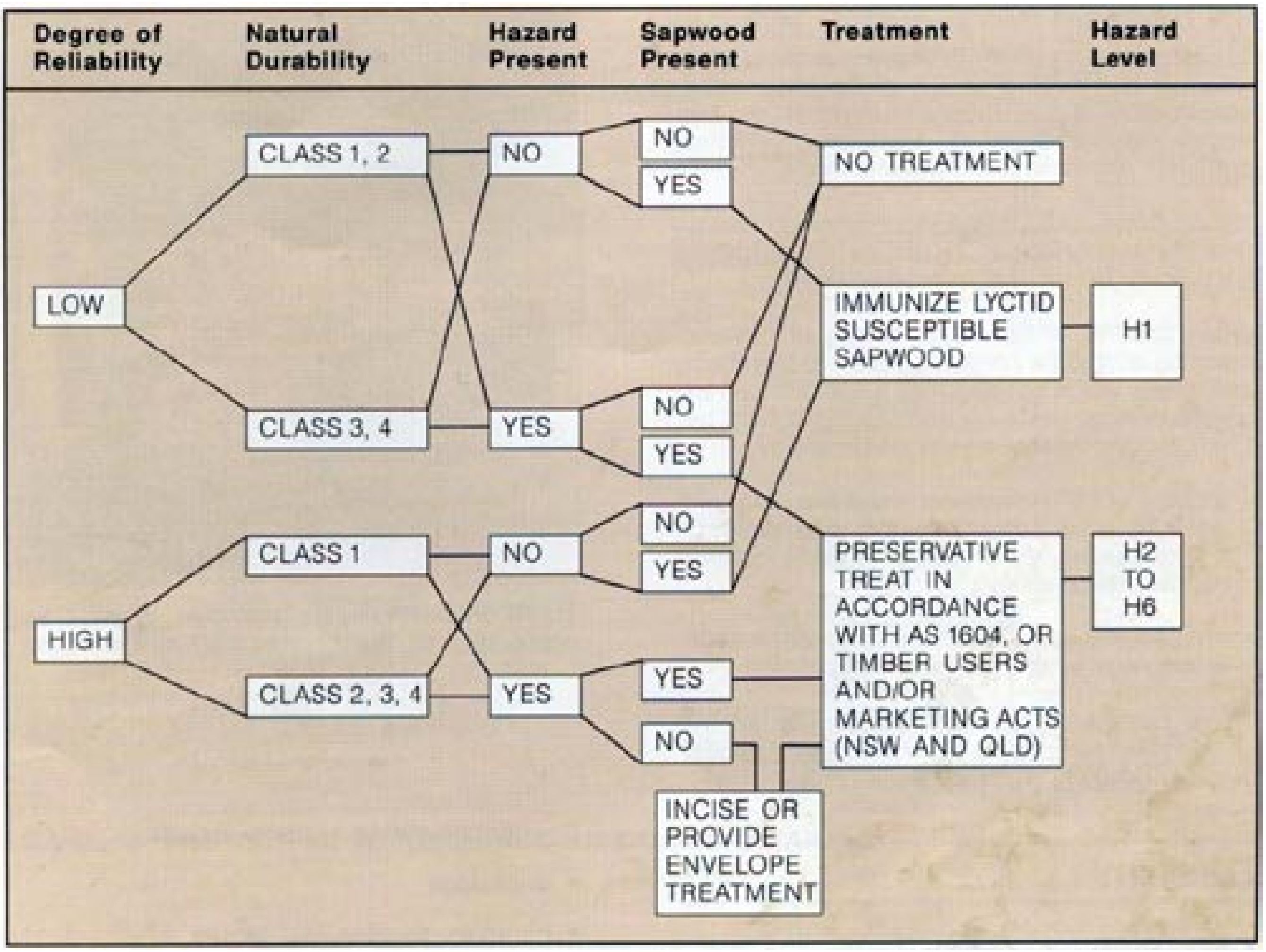


*Figure 8 Guide to preservative treatment.*

NOTE: Figure 8 should only be used as a first approximation, since other factors such as the design life of the structure and specific local hazards, must also be considered.

**Treatment Requirements**

Research and in-service trials indicate that different levels of preservation treatment are required to prevent degrade when timber products are used in various hazard conditions.

Table 3 (page 15) provides descriptive advice to support the determination of various hazard levels, expressed as Hazard Classes. When considering the level of preservative treatment required to meet identified hazard conditions, select the Hazard Class in accordance with AS1604.

In addition to AS1604, Acts of Parliament in the States of New South Wales and Queensland – *Timber Marketing Act 1977*, and *Timber Utilisation and Marketing Act 1987* respectively, regulate the sale of timber purported to be preservative treated. These Acts also specify required retention levels, durability ratings, quality control procedures and branding.

*CCA timber treatment plant (Photo courtesy of Dr. Harry Greaves)*

**Quality Assurance**

To be sure that treated timber satisfies the prescribed requirements, check sampling and analysis results that demonstrate the amounts of preservatives present and/or written certification by the supplier. AS/NZS 1605 METHODS FOR SAMPLING AND ANALYSING TIMBER PRESERVATIVES AND PRESERVATIVE-TREATED TIMBER, describes the requirements necessary for this procedure. Minimum preservative levels and required penetration patterns are contained in AS1604 and the relevant State legislation.

**Building Site Control and Timber Product Maintenance**

Adequate site control and maintenance are required to ensure that preservative-treated timber is used where it is intended, and that working with the treated timber does not weaken the effectiveness of the treatment. For example, it is essential to leave any treated envelope of the wood unbroken, and where possible, all fabrications, cutting, drilling and notching should be conducted prior to treatment. Where this is not possible, areas affected by on-site drilling, notching and cutting should be given supplementary on-site treatment.

- For CCA or LOSP treatment: flood brushing with water repellent preservatives or application of a thick coating of a preservative paste (copper napthenate) emulsion.

- For creosote/PEC: applying a flood brush application of creosote oil or PEC emulsion.

These procedures may also be considered where ongoing maintenance is necessary, e.g. where weather-exposed LOSP treated joinery has been used.

*LOSP timber treatment plant (Photo courtesy of Dr. Harry Greaves)*

# Design

### Architectural Detailing

Architectural and structural detailing are critical considerations during the design and building of durable timber structures. The following are some key factors that should be considered in association with the geographical location and building orientation:

- Shielding
- Isolation
- Moisture traps
- Ventilation and condensation
- Joint detailing

Examples of protection through architectural detailing are providedf in Figures 11 and 12 on page 27 and are illustrated in the following text.

### Shielding

Timber elements exposed on the outside of a building can be protected from high moisture and temperature variations by both vegetation and specific designations.

Where vegetation is used to limit the entry of sun, wind and rain, care should be taken to ensure there is sufficient ventilation between the vegetation and the structure. This is to avoid an excessive build-up of moisture. The careful selection and placement of trees and shrubs should be employed.

Physical shielding systems include:

- overhangs
- pergolas, screens and fences
- capping and flashing
- fascias and barges.

(Examples of shielding sytems are illustrated in Figures 11 and 12 on page 27.)

### Moisture Traps

Moisture traps should also be avoided, particularly where connections and joints are exposed to the weather. Figure 9 illustrates some suitable design options for timber building elements. 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.

Wherever possible, building components should be designed to:

- divert water away from joints and other places where it may be trapped
- allow water that does reach critical surfaces to drain away rather than soak in.

### Ventilation and Condensation

Where possible, avoid unventilated, inaccessible spaces within building construction. This is because wetting of the timber may also result in the build up of condensation. Ventilation of spaces under floors is one aspect where legislative controls are invoked to avoid such problems.

Datafile SS2, TIMBER FLOORS – COMMERCIAL AND INDUSTRIAL outlines the minimum sub-floor ventilation requirements for each Australian State.

The risk of condensation in timber-framed dwellings can be reduced by the following measures:

- In cold climates, maintain a fairly constant heating cycle for the building – intermittent heating/cooling will spread condensation on surfaces that heat up and cool down.

- Adequate room ventilation – particularly in kitchens, bathrooms, laundries and similar areas where high temperatures and humidity occur. Installation of extraction fans may be necessary for these situations.

- The use of construction detailing such as vapour barriers and sarking.

*Metal physical shield to protect against water uptake at the most vulnerable point of the structure. (Photo courtesy of Dr. Harry Greaves)*

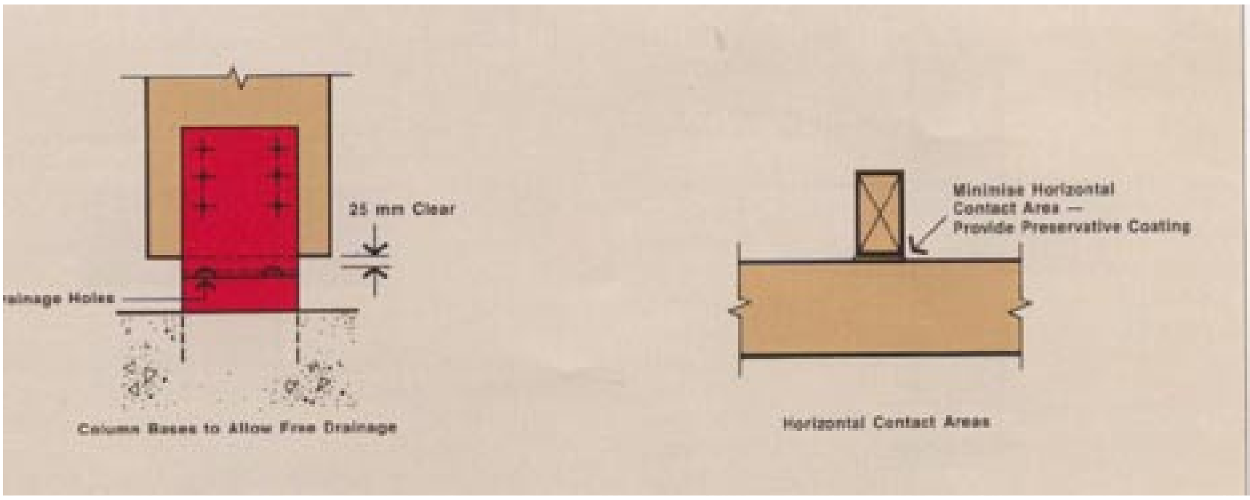


*Figure 9  Detailing to avoid moisture traps.*

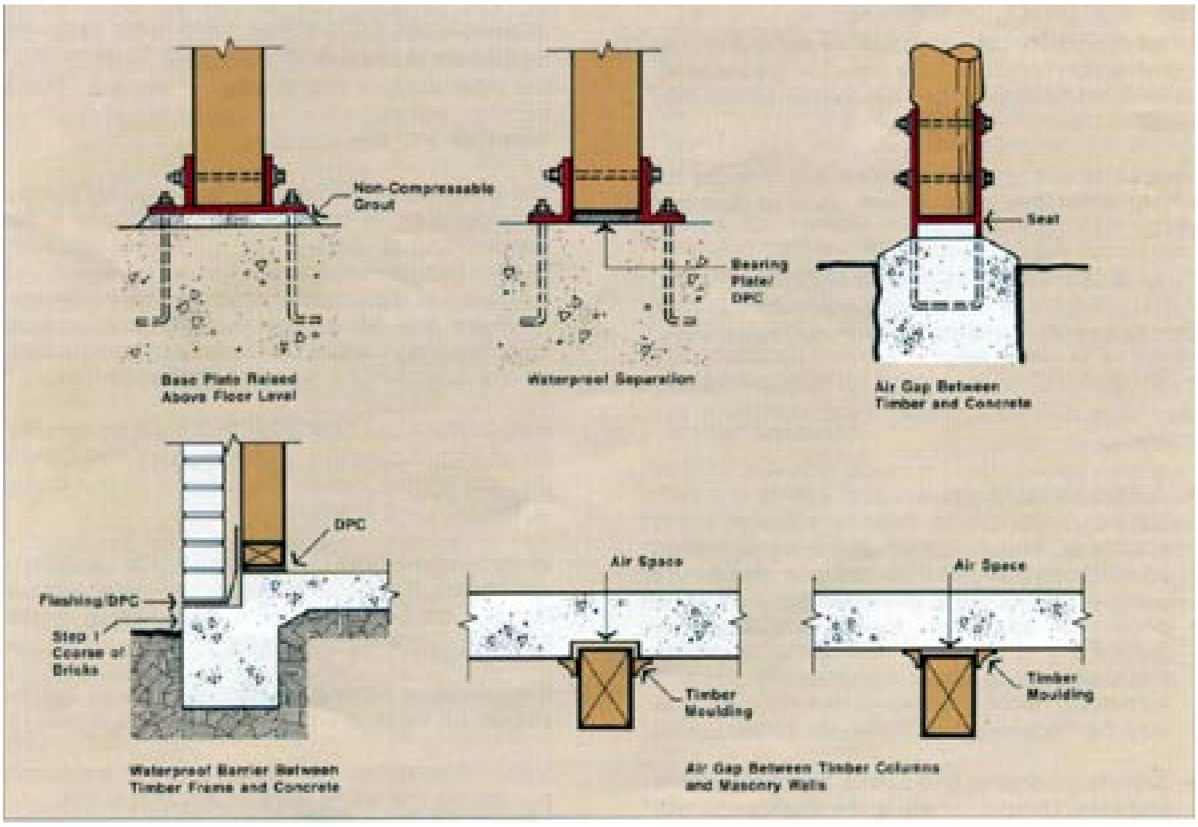


*Figure 10  Isolation of timber form masonry*

In cold climates, where internal spaces are heated and humidities are higher, vapour barriers should be installed near the inner surfaces (warm side) of the walls. These barriers will minimise the movement of moisture laden air into the spaces of the structure.

The placement of vapour barriers requires special consideration in hot climates, especially where air-conditioning is used:

- If there is prolonged use of heating during the colder months, installation of vapour barriers on the outside of a building element may be advantageous.
- If only occasional use is made of such equipment, during the colder months locating vapour barriers on the inside of the building element may be advantageous.
- In areas where both summer and winter conditions are severe, it may be necessary to install vapour barriers on both the inside and outside of the building element.
- If evaporative cooling is used, the vapour barrier may need to be located on the inside of the structure.

Remember that vapour barriers should be placed on the warm side of any insulation.

**Joint Design**

Successful structures rely upon good joint detailing. Attention to detail and simplicity will usually provide better and more durable connections. Consider the following factors:

- avoiding restraint due to shrinkage
- use of corrosive-resistant metals
- minimising moisture traps and contact areas
- allowing for shrinkage or differential movement
- using the correct fasteners and installation techniques (avoid splitting)

Joints should also be designed so that components are easily replaced should the need arise.

**Shrinkage Restraint**

Shrinkage restraint at joints can sometimes be a problem, particularly where unseasoned timber is used. Where shrinkage restraint occurs, stresses may occur perpendicular to the grain, causing splitting and subsequent moisture penetration or loss of structural integrity.

The following options will help to avoid shrinkage restraint in timber:

- Minimise moisture content changes by using finishes and end-grain sealants
- Align fasteners along member axis
- Use single fasteners iat the joints
- Use connections that allow for movement
- Use seasoned timber
- Drill holes 10% oversize in unseasoned timber.

Figure 13 (page 28) illustrates some of the options for avoiding shrinkage restraint in timber.
.

**Corrosive Resistance**

The interaction of moisture and chemicals on metals can cause a breakdown of the wood fibres around the metal fasteners. Where moisture is present, this breakdown can lead to additional moisture traps and loosening of joints, resulting in a greater chance of decay.

To avoid this problem, use metal fasteners made of material with the required resistance to corrosion and appropriate for the life of the structure. Table 6 (page 31) provides a general guide for selecting the most suitable corrosive-resistant fasteners in particular applications.

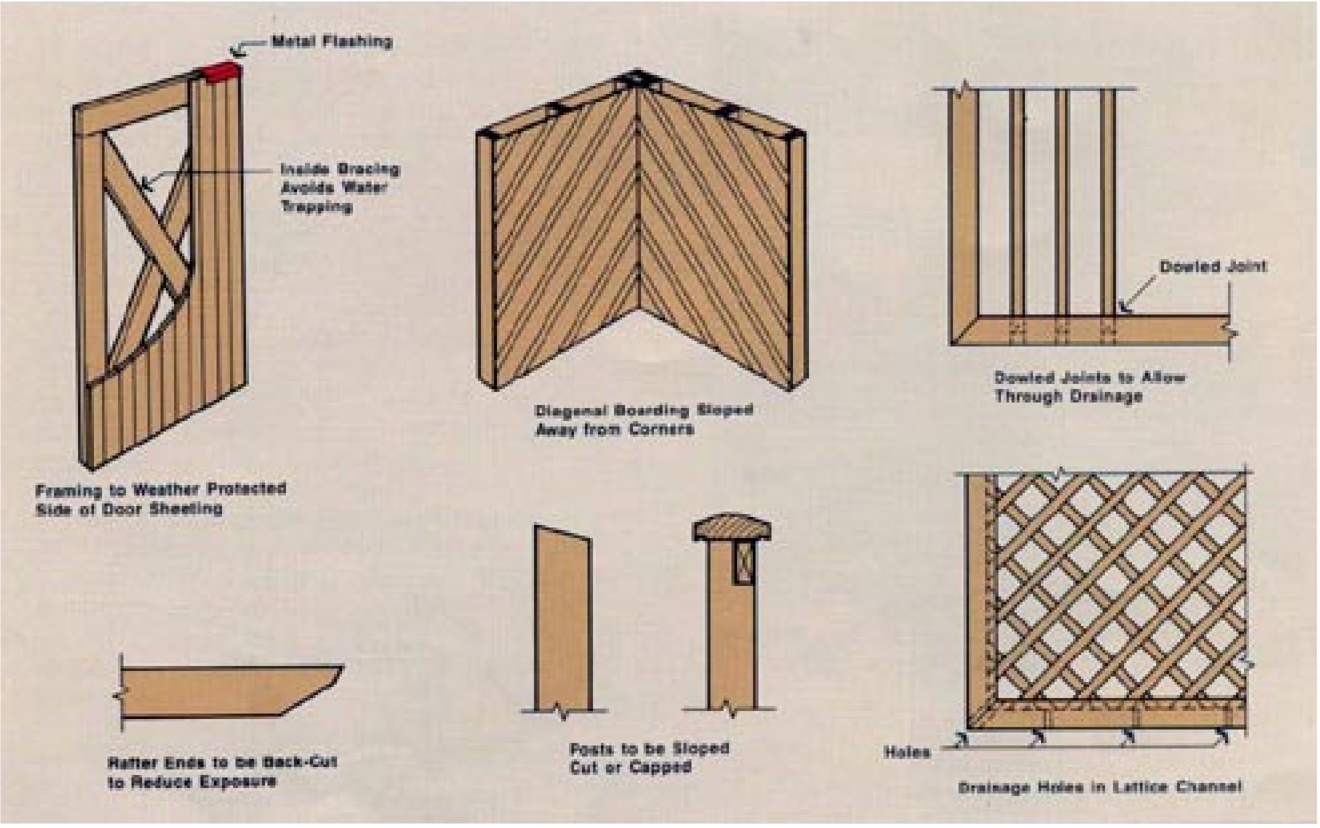


*Figure 11  Detailing to provide weather protection.*

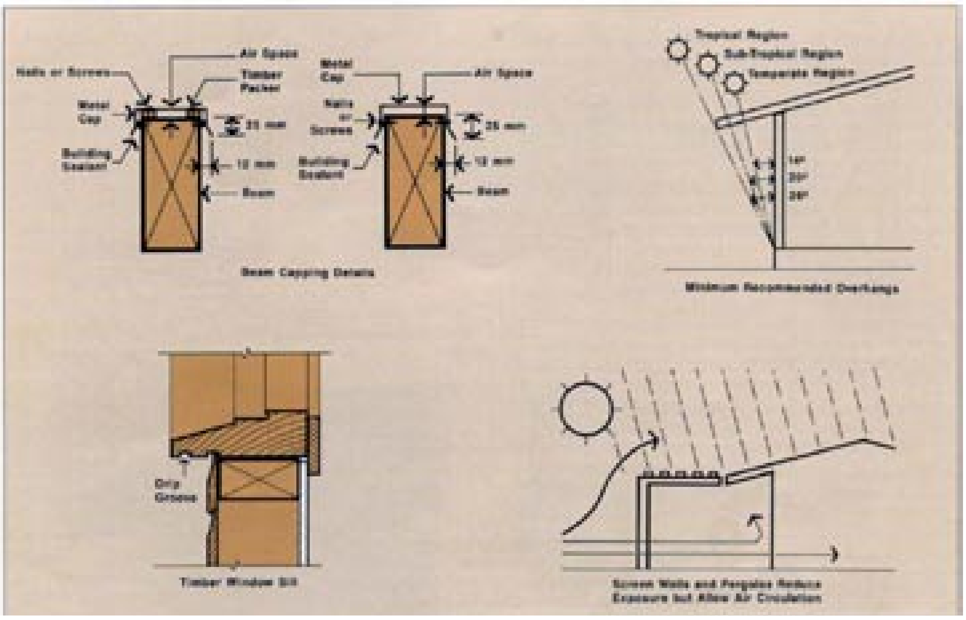


*Figure 12   Protection through architectural detailing*

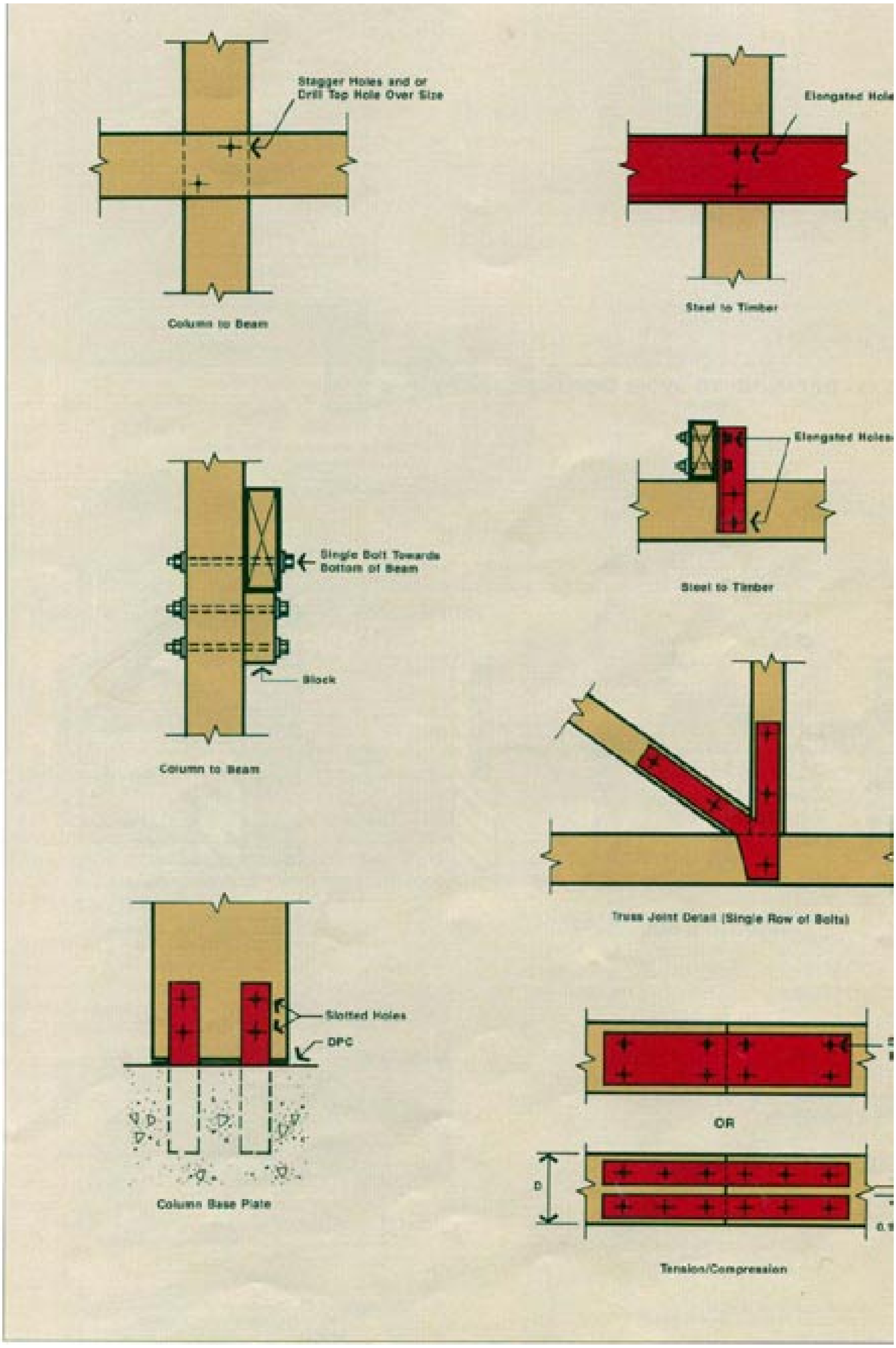


*Figure 13   Detailing to allow for shrinkage and/or moisture movement.*

### Shrinkage/Movement

Make allowance for shrinkage and differential movement at connection points in and between the timber building elements. Otherwise a breakdown of the building envelope might occur, leading to the entry of moisture. Measures that can be taken to avoid the impacts of shrinkage and movement include:

- If timber is unseasoned (e.g., floor joists), use 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 (refer to Figure 14a)
- Allow for vertical movement in unseasoned framing by leaving adequate clearance at the top of masonry veneer (refer Figure 14b)
- Allow adequate clearance at the top of unseasoned members that are face fixed to members that will not shrink (refer Figures 14c and 14d).

### Fastener Selection

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

As examples, the following joints are considered:

- Cladding to framing
- Heavy decking to joists
- Fender pile to wharf

In the cladding to framing joint, if the cladding is left unprotected (i.e., not painted), cyclic moisture changes will encourage constant shrinkage and swelling. This will add further tension into the connector (usually a nail). The connector, therefore, has to be designed to resist these forces.

It has been found from practical experience that:

- Bullet head, plain shank nails are satisfactory for hardwood cladding, provided cladding is painted and nails are punched and stopped.
- Flat head, plain shank nails (which provide greater resistance to nail head "pull through") are satisfactory for painted softwood cladding.
- Galvanised, deformed shank (ring or annular) flat head nails are required for unpainted CCA-treated softwood cladding where it is fixed to softwood framing.

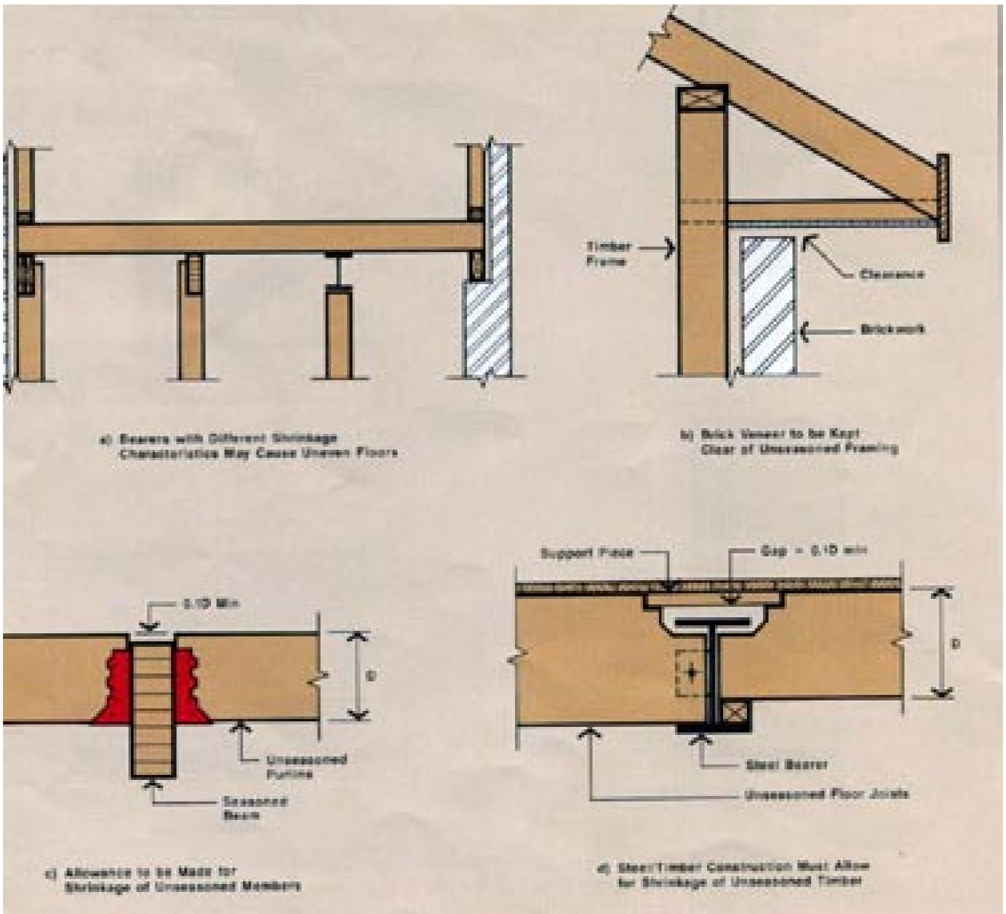


*Figure 14 Detailing to allow for shrinkage differentials.*

*Stainless stell base connection and spacing block keeps timber columns clear of wet floor area.*

Experience has shown that machine driven 'T' head nails will work loose when used in unpainted cladding/framing joints. Refer to Datafile FP1, TIMBER EXTRERNAL CLADDING.

In the case of fixing heavy decking (38-75 mm thick) to joists, movement due to seasonal moisture changes and traffic vibration can cause the localised crushing of under decking spikes and the withdrawal of spikes.

To overcome this, fasteners with large diameter heads and greater holding power provide better fixing, e.g., coach screws with washers, Type 17 self-drilling countersunk screws (for up to 50 mm thick decking) and where necessary, cuphead bolts (these can be re-tightened during programmed maintenance).

Refer also to Datafile SS4, TIMBER DECKS – COMMERCIAL, INDUSTRIAL AND MARINE.

The third example of the fender pile connection highlights where shock or impact loads need to be considered. Here, a rigid joint could lead to the localised crushing of fibres adjacent to bolts.

## Type of Member

The type of member selected for a particular application is a contributing factor to the durability of structures. For example, glue-laminated timber or sheet products exposed to the weather will shrink and swell, when left unpainted or finished with products that allow moisture penetration. This will cause checking along the lines adjacent to the glue lines.

Major moisture traps and lines of shear strength weakness can occur with glued laminated timber. This is in sharp contrast to solid timber, where seasoning checks tend to occur randomly.

### Glued Products

The success of glued products depends on choosing the correct adhesive and appropriate timber products for the application. The durability of adhesive types is outlined in Table 7 (pages 34-35). Glued products used in exposed applications must be painted or otherwise protected, and regularly maintained with a moisture-excluding envelope.

For long structural applications, the adhesive must have non-creep characteristics, permanence, and be applied under ridged control procedures.

### Built-up Beams

The question of durability also applies to beams built-up by mechanical means (nail laminated and nailplated). Joints in these beams provide a potential moisture trap when used in conditions where they will be continually exposed to the weather.

In addition, where a corrosive environment exists, the nailplate-joined beams may need special consideration.

*Good detailing of wood-based composites to eliminate water penetration as well as corrosion. (Photo courtesy of Dr. Harry Greaves)*

### Timber Grades and Size

Published Australian Standard grading rules usually provide a range of grades for timber products that can be selected to suit particular applications, e.g.

- For milled products, the clear, select, standard and utility grades are described in AS2796 TIMBER – HARDWOOD – SAWN AND MILLED PRODUCTS, AS1782 FLOORING MILLED FROM AUSTRALIAN GROWN CONIFERS (SOFTWOODS) (EXCLUDING RADIATA PINE AND CYPRESS PINE)) and AS1810 TIMBER – SEASONED CYPRESS PINE – MILLED PRODUCTSAS1492-1498 (now superseded).

| Material | Applications | Remarks |
|---|---|---|
| Stainless Steel | Chemical, Industrial and Marine | Grade 316 is preferred for marine environments. Additional protection via coatings should be applied to grade 604 |
| Monel; | Marine | Usually used in boat building, nails/scews available |
| Silicon Bonze, Copper and Brass | Marine | Usually used in boat building, nails and scews available. Do not bring in contact with aluminium. Silicon bronze nails also available for acidic species, i.e., western red cedar |
| Hot Dipped Galvanised and Mechanically Plated | External exposed to weather and medium corrosivity. Industrial and marine environments | Where in contact with moist CCA treated timber, additional protection using plastic sheaths or bituminous epoxy coatings are suggested |
| 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 system to provide a base for conventional paints |

*Table 6 Selecting corrosive resistant fasteners*

NOTES:

1. The metals/coatings described are in descending order of resistance to corrosion.
2. Life expectancy of zinc coatings is determined primarily by their weight or thickness. As a minimum, hot dipped galvanised fasteners should have a coating thickness of 42 microns. Refer to AS 1214 HOT DIPPED GALVANISED COATINGS ON THREADED FASTENERS (ISO METRIC COARSE THREAD SERIES)).

- For stress-graded timber, Structural Grades No's 1 to 5 are specified with the additional appearance grades being optional. Refer to AS2082 TIMBER – HARDWOOD – VISUALLY STRESS GRADED FOR STRUCTURAL PURPOSES), and AS 2858 TIMBER – SOFTWOODS – VISUALLY STRESS GRADED FOR STRUCTURAL PURPOSES.

The general structural grades of weather exposed applications may limit the number of defects that can have a bearing on durability.

Other factors to consider with regard to durability include the presence of 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.

Datafile SS4, TIMBER DECKS – COMMERCIAL, INDUSTRIAL AND MARINE provides an example of where additional aspects of decking installation need to be specified. For example:

- Limiting the number of open defects on the top surface
- Laying decking with the "heart side" down
- Limiting "heart in" material to the middle one third of the cross-section.

The size and relative proportions of the cross-section of members should be considered when detailing for durability. This is particularly relevant for unseasoned timber where shrinkage and movement, in response to moisture changes, can have a significant impact on the durable nature of timber building elements.

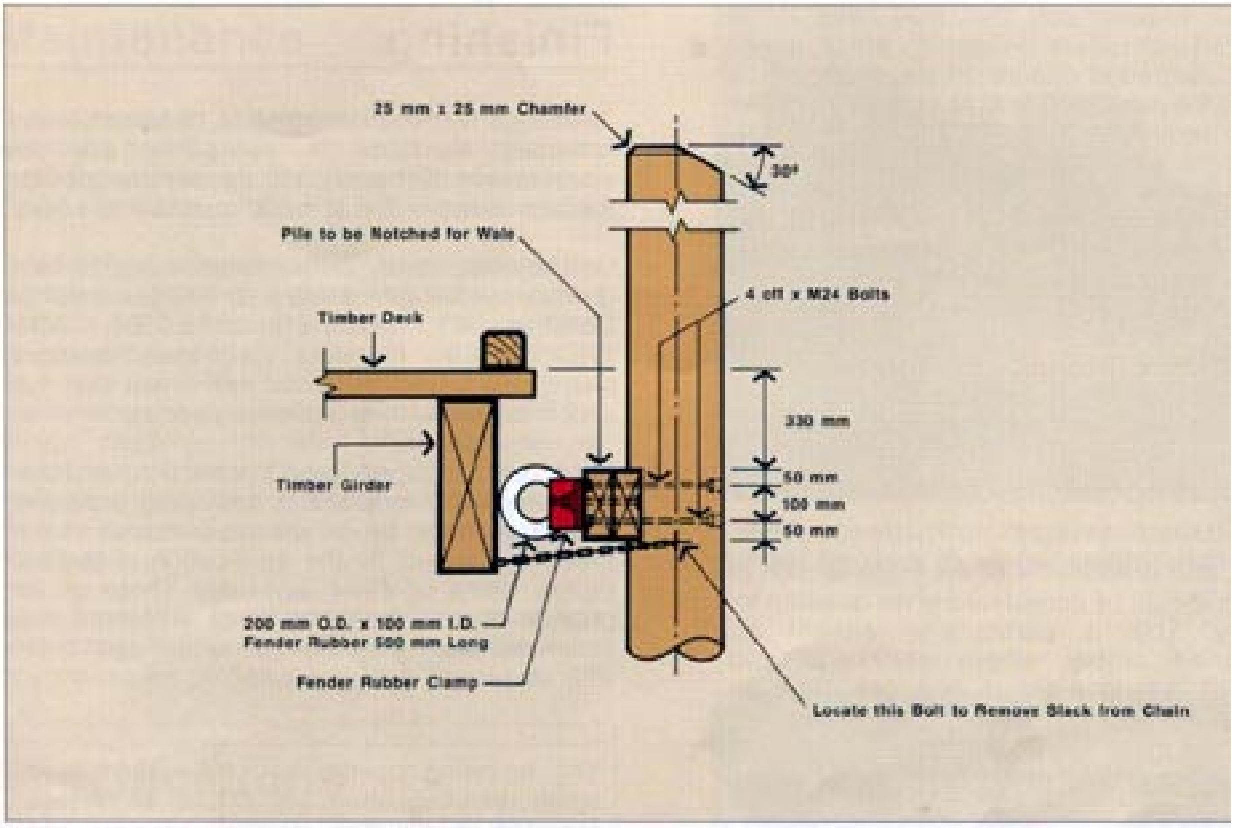


*Figure 15 Typical detail of fender pile.*

Consideration should be given to the following:

- Members with width to thickness ratios not exceeding approximately 3:1 are less prone to cupping, for example, 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 fixing where shrinkage occurs.
- Members with small width to thickness ratios are usually less prone to the effects of bowing.

**Moisture Content**

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

Seasoned timber kept dry (MC<15%), will not decay and similarly, fully immersed timber where oxygen is excluded, will not decay. Also, 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 glue
- More resistant to the transmission of heat and electricity

It may, however, be impractical to season large sections of timber and therefore provisions must be made for long-term seasoning of those timber building elements, in-service.

## Finishing

Timber is hygroscopic. That is, it absorbs and releases moisture in sympathy with its environment. Generally, however, the denser the species, the less reactive it is to rapid moisture changes.

On the other hand, denser species tend to have greater overall shrinkage percentages (refer to Datafile P1, TIMBER SPECIES AND PROPERTIES). Therefore permanent moisture changes in denser species 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. The most economical of these is attained through the application of suitable paints, stains or water repellents. These must be maintained during the service life. If they do not provide a total seal, then given sufficient time, the timber will reach a moisture content which is in equilibrium with its surrounding service environment.

The following points should be considered when deciding upon suitable finishes for minimising moisture changes and subsequent movement:

- Pale colours absorb less heat, therefore the effects of drying due to raised temperatures are minimised.
- Four coat, oil-based paint systems are generally better vapour barriers than two coat acrylic systems.
- Good quality primers and undercoats (oil or acrylic) are designed to seal the timber and provide a key for top coats.
- Exterior grade stains and water repellents require more frequent re-application to maintain a water-resistant finish.
- Sawn surfaces provide a better “key” for stains and water repellents than do dressed surfaces, particularly for denser species.
- Rounded (arrised) edges provide a better “key” for paint finishes.

Table 8 (page 36) provides a summary of the finishes and maintenance appropriate for timber used externally.
For comprehensive details on finishing timber in external application, refer to Datafile FM1, EXTERIOR FINISHES FOR TIMBER.

## Maintenance

Unless designed and specified for very specific purposes or for a short life span, all structures require on-going maintenance. This is particularly relevant for the external envelope of a building or structure.

The purpose of maintenance is to ensure that the original condition of a material will be retained intact so that it can continue to effectively perform its intended function.

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

Table 9 (page 37) provides guidance on the selection and scheduling of a number of maintenance procedures for timber structures.

## Specifications

For detailed specification clauses, reference should be made to Datafile SP1, TIMBER SPECIFICATIONS.

The following is a check list of some items which should be included in the specifications, considered at the design stage, or indicated on drawings:

- Hazard Class
- Natural durability
- Combination of natural durability and preservative treatment
- Grade – i.e., special requirements (e.g. decking)
- Moisture content
- Ventilation
- Insect and marine borer protection – chemical and/or mechanical (includes termites)
- Sarking, flashing, vapour barriers
- Joint detailing – shrinkage restraint and moisture traps
- Corrosion protection
- Workmanship
- Finishing
- Maintenance

*Timber construction requires insulation and vapour barriers in alpine environments.*

**Table 7 Adhesive types and applications.**

| Adhesive Type | Glue Line Durability | | Colour | Staining | Applications | | | | Other Comments |
|---|---|---|---|---|---|---|---|---|---|
| | Under Exposure | Under Stress | | | Interior | | Exterior | | |
| | | | | | Struct | Non-Struct | Struct | Non-Struct | |
| **THERMO SET TYPE (NON-CREEP)** | | | | | | | | | |
| (i) a) Phenolics-Synthetic i.e. Phenol Formaldehyde Resorcinol Formaldehyde Resorcinol Phenol Formaldehyde<br>b) Phenolics — Natural i.e. Tannin Formaldehyde Resorcinol/ Tannin Formaldehyde Resorcinol/ Tannin /Phenol Formaldehyde | Considered fully permanent i.e. 50 years plus | Considered fully permanent i.e. 50 years plus | Red-brown | Yes | Yes | Yes | Yes | Yes | These types of adhesives should be used in all structural wood composite or structural wood panel applications involving long-term stress or exposure, i.e. marine, laminated beams, particleboard flooring, plywood bracing, flooring and marine plywood. Structural finger jointing. Suitable timber moisture content 8-12%. |
| (ii) Amino Plastic i.e. Melamine Formaldehyde Copolymer Melamine Urea Formaldehyde | Up to 2 years fully exposed. 50 years plus, where fully protected | Up to 2 years where exposed Up to 25 years where protected | Clear to yellow | No | Yes for non-critical uses | Yes | No unless temporary i.e. form-work | Yes | These types of adhesives should be used in structural wood composites where exposure to weather will be 2 years maximum i.e. formwork or protected non-critical situations, e.g. flooring, transportable homes, caravans, 25 years maximum. Suitable timber mositure content 8-12%. |
| Amino Plastic i.e. Urea Formaldehyde | Non-durable | Non-durable | Clear to yellow | No | No | Yes | No | No | Use only in interior fully protected non-critical applications, i.e. furniture, veneers, lining, shelving etc. Suitable timber mositure content 8-12%. |
| (iii) Epoxy/Polyester Resins | Non-durable if exposed to the weather | If protected, 25 years plus | Usually clear to pale yellow | No | Yes | Yes | No unless temporary i.e. formwork | Yes | Similar to those for Amino Plastic above. Suitable timber moisture content 8-12%. |
| (iv) Casein | Non-durable | If fully protected, 25 years plus | Light brown | Yes | Yes | Yes | No | No | Uses are similar to those for melamine formaldehyde. Casein is attacked by fungal organism where MC is 25% or greater. Suitable timber moisture content 10-15%. |

**Table 7 Adhesive types and applications (continued).**

| Adhesive Type | Glue Line Durability | | Colour | Staining | Applications | | | | Other Comments |
|---|---|---|---|---|---|---|---|---|---|
| | Under Exposure | Under Stress | | | Interior | | Exterior | | |
| | | | | | Struct | Non-Struct | Struct | Non-Struct | |
| **THERMO PLASTIC TYPE (CREEP)** | | | | | | | | | |
| (i) Poly Vinyl Acetate<br>a) Highly cross-linked | Non-durable | Non-durable | Clear | No | No | Yes | No | No | Should not be used for long term structural applications. Suitable for edge jointing veneers or overlaying plywood and particleboard and furniture manufacture. Suitable timber moisture content 10-17%. |
| b) Normal PVA | Non-durable | Non-durable | Clear | No | No | Yes | No | No | |
| (ii) Animal Glue | Non-durable | Non-durable | Clear to light brown | No | No | Yes | No | No | Furniture or non-structural applications only. Suitable timber moisture content up to 15%. |
| (iii) Hot Melt Glue | Non-durable | Non-durable | Clear to light brown | No | No | Yes | No | No | Furniture or non-structural applications only. Suitable timber moisture content up to 15%. |
| (iv) Rubber Based<br>a) Wall Board | Non-durable | Non-durable | Varies | No | No | Yes | No | No | Used to glue timber/plywood lining to studs. |
| b) Contact Adhesive | Non-durable | Non-durable. | Varies | No | No | Yes | No | No | Used for gluing laminates to sheet materials. |
| c) Elastomeric | Non-durable | Non-durable | Varies | No | No | Yes | No | No | Used for sheet flooring to joists in conjunction with nails or screws. |
| d) Rubber Latex | Non-durable | Non-durable | Usually white | No | No | Yes | No | No | Parquet flooring — good gap filler. |
| e) Poly Vinyl Chloride (PVC) | Non-durable | Non-durable | Varies | No | No | Yes | No | No | For gluing PVC sheeting to timber substrates. Suitable timber moisture content-dry surface only. |

**Table 8 - Exterior timber finishes - types, treatments and maintenance.**

| Finish | Initial Treatment | Appearance of Wood | Cost of Initial Treatment | Maintenance Procedure | Maintenance Period of Surface Finish | Maintence 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 yr.[a] | Medium |
| Clear | Four coats (minimum) | Grain and natural colour unchanged if adequately maintained | High | Clean and stain bleached areas and apply two more coats | 2 yr. or when breakdown begins | High |
| Water repellent[b] | One or two coats of clear material, preferably dip applied | Grain and natural colour; visibly becoming darker and rougher textured | Low | Clean and apply sufficient material | 1-3 yr. or when preferred | Low to medium |
| Stains | One or two brush coats | Grain visible; colour as desired | Low to medium | Clean and apply sufficient material | 3-6 yr. or when preferred | Low to medium |
| Organic[c] solvents preservatives | Pressure, steeping, dipping, brushing | Grain visible; colour as desired | Low to medium | Brush down and reapply | 2-3 yr. or when preferred | Medium |
| Waterborne preservatives | Pressure | Grain visible; greenish; fading with age | Medium | Brush down to remove surface dirt | None unless stained, painted or varnished | Nil |

**Table 9 Selection and scheduling of maintenance.**

| Item | Suggested Maintenance or Inspection Periods | Remarks |
|---|---|---|
| Finishes<br>— External<br>— Internal | Refer to Table 7.<br>As required but approximately every 10-15 years. | — |
| 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. |
| Termite Protection<br>— Mechanical Barriers<br>— Chemical Barriers | Approximately 10 years.<br>Replenish approximately every 20 years or when site/grounds are disturbed. | — |
| Ventilation — Sub-floor, 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. |
| Vapour Barriers | Check integrity of vapour barriers in roofs, under floors, approximately at 15 year intervals. | — |
| 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. |
| Metal Fasteners — 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. |
| Plumbing | Repair or replace leaking or defective plumbing immediately. Inspect gutters, downpipes, etc. after 10 years then more regularly. | Presence of moisture increases the possibility of decay and termite attack. |
| Decay | If noticed, repair or replace defective material immediately and re-establish finish (inspection cycles determined by above). | — |
| 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 wharfs, bridges, and posts in ground. |
| Cleaning | Clean surfaces as required. | Build-up of dirt, mould etc. on timber surfaces will increase potential for decay via moisture traps, etc. |

*Observation deck and walkway utilises durable timber and non-corrosive fasteners.*

## Other References


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