Department for Environment and Heritage

Maintenance and Repair of Older Buildings in South Australia

Technical Note 3.1

ADELAIDE CITY COUNCIL

Government of South Australia
Department for Environment and Heritage

www.environment.sa.gov.au

Contents

Maintenance and Repair of Older Buildings in South Australia

1. Introduction

The importance of maintenance

1.1 The aims of this guide

This publication provides basic advice to owners and managers/custodians of older buildings. It covers essential maintenance issues and provides a guide to problem solving. It is intended as a starting point and does not replace expert professional advice. It aims to:

- help you develop a basic program of routine, seasonal maintenance tasks
- encourage you to be observant - to notice a developing or potential problem early and not ignore it in the hope it will go away
- let you know what to look for and alert you to the tell-tale signs of an impending problem
- guide you in what you can do yourself, and when you should seek professional advice
- help you better understand the advice you receive from professionals and contractors, as a basis for assessing the merits and pitfalls of various approaches and making sound decisions about the care of your property
- encourage you to consider how any work done to the place might impact on its cultural significance, and how the conservation of its cultural value can best be achieved.

The Heritage Branch of the Department for Environment and Heritage provides a free professional advisory service on all matters – including conservation and maintenance – relating to State Heritage Places, or to places located within a State Heritage Area.
A number of councils employ Heritage Advisers who can give professional advice in relation to State or Local heritage places. Alternatively, a professional consultant specialising in heritage conservation can be engaged. Contact your local Council or the Heritage Branch for further information.

1.2 What is maintenance?

Maintenance is one process which helps to ***conserve*** a place, in conjunction with other processes such as:

- preservation
- restoration
- reconstruction
- adaptation

The generally accepted approach in Australia to conserving the cultural significance of historic places is guided by the 'Burra Charter'[1], which adopts the following definition:

Maintenance means the continuous protective care of the ***fabric*** and ***setting*** of a ***place***, and is to be distinguished from repair. Repair involves ***restoration*** or ***reconstruction.***

These words have particular meanings within the Burra Charter and the conservation industry generally - see Conserving cultural significance (Section 1.5). A distinction is made between maintenance to prolong the life of individual elements and components, and repair to prolong the life of the place as a whole through fixing or replacing damaged or unserviceable components.

For example:

- ***maintenance*** would involve regular cleaning to prolong a gutter's life and function
- ***restoration*** would be re-fixing a gutter that had pulled away or fallen (ie repair without introducing new materials)
- ***reconstruction*** would be replacing the gutter with a matching new one (ie repair using new materials)

These definitions are useful in understanding the effect that different types of maintenance and repair may have on the historic fabric of a place. However, in dealing with the actual process of organising and carrying out work, it is useful to categorise them in another way:

- ***Preventative maintenance*** - anticipating what needs to be done to keep deterioration at bay. This is a pro-active process of planning ahead to carry out basic tasks in order to prevent predictable problems developing, such as

[1] Australia ICOMOS 1999 *The Australia ICOMOS Charter for Places of Cultural Significance (the 'Burra Charter')*

blocked gutters or paint breakdown. The terms routine maintenance, cyclical maintenance, programmed maintenance and housekeeping maintenance could also be applied. Work in this category is often carried out by the building owner or manager.

- ***Corrective maintenance*** - work necessary to bring a building back from a deteriorated state to an acceptable standard (eg treating rising damp, repairing or replacing a gutter). This is a reactive process to remedy faults which have developed, usually as a result of lack of preventative maintenance. The description minor or major repairs might also be used, and reference is sometimes made to deferred maintenance when the corrective work arises from a lack of timely action. Work in this category will sometimes be performed by the building owner/manager, but will often require the attention of specialist tradespeople.
- ***Emergency corrective maintenance*** - work necessary to safeguard the health, safety or security of a building and/or its occupants and requiring immediate response (such as a roof blown off in a storm, graffiti, or a broken window). Again a reactive process, and by its nature usually carried out by specialist tradespeople.

It should be noted that some works that fall into 'Preventative' or 'Corrective' categories in the context of this document would be classified as restoration or reconstruction under the Burra Charter definitions. The purpose of this document is to encourage the maintenance of older buildings, ranging from simple housekeeping matters that can be undertaken by the property owner, to tasks requiring highly specialised expertise in restoration and reconstruction. Engaging contractors with the right skills, experience and attitude will minimise the risk of serious and permanent damage to the building, and perhaps the extra expense of having to re-do inappropriate work.

Common myths

It is a common belief that older buildings are maintenance-intensive, however, the more onerous and expensive repairs are usually corrective maintenance - the result of neglected or inadequate preventative maintenance. This is work that should have been done sooner, but, through ignorance or inaction, has compounded into more serious damage.

The condition of older buildings is best managed by frequent preventative maintenance. This generally comprises simple and relatively inexpensive measures, such as cleaning and touching up paintwork. The frequency required is invariably greater than for a modern building, but all buildings will benefit from appropriate routine and preventative maintenance. Given timely regular attention, an old building can return much pleasure with relatively little pain.

Another common belief is that a newly-restored building should need no attention for many years to come. Again, this illustrates a failure to differentiate between preventative actions and repairs that arise from a lack of timely attention. A brand new gutter needs the leaves cleaned out of it as regularly as does a 50 year old gutter - all buildings need preventative maintenance to prevent unnecessary future corrective maintenance.

1.3 Why maintain a building?

A building is a major asset. Its value, both in financial terms and in the satisfaction it brings to its users, is affected by its condition.

Suffering in silence

Sometimes a building sustains sudden and immediate damage - a storm tears away a section of the roof or a falling tree branch demolishes a verandah - and repairs are carried out promptly to return the building to a serviceable condition and to minimise any secondary damage, such as that caused by further rainfall.

Most buildings escape such dramatic events in their lives. They suffer instead from the sort of damage that goes unnoticed for years, each small fault triggering a whole chain of consequences. The changes are so gradual that they do not attract attention until they become quite advanced.

Some owners will take notice at this stage; others will turn a blind eye because they are unsure what to do, and only become concerned enough to seek help once major damage reveals itself.

By this stage, what may have started, for instance, as a build-up of leaves in a gutter has progressed to overflowing and small rust holes. This leads to dampness in the fascia boards and wetting of the walls, and results eventually in the bottom falling out of the gutter, a rotten fascia board, cracks appearing in the wall, fretting of the internal plaster and a termite infestation in the sub-floor timbers.

An exaggeration perhaps (or perhaps not ....), but a good illustration of how the lack of simple, cheap, regular maintenance such as gutter cleaning can potentially lead to far more serious problems, both in the extent of damage and the cost of repairs. And in the case of historic buildings, there is the added risk of a permanent loss of integrity in the historic fabric of the place.

A number of observations should be kept in mind when reading this guide:

- Deterioration is a gradual process, a silent and furtive destroyer of the materials of which buildings are made
- It is easy to overlook small problems until they become more serious - and more expensive
- The regular expenditure of moderate amounts of time and money on routine preventative maintenance is better for the building, and more cost-effective, than large injections of capital for major repairs every 10 or 20 years
- When maintenance of buildings is neglected or postponed, major and expensive repairs can result. Regular maintenance can greatly reduce the expense associated with these unnecessary repairs, and in many cases eliminate them completely.

The single most destructive element at work against the fabric of older and historic buildings is water, and the majority of maintenance and repair work required on these buildings is related to the effects of dampness and moisture. An analysis of the topics covered in this publication will reveal that, with very few exceptions, the problems encountered in caring for an old building are influenced, either directly or indirectly, by moisture. These include rusting, wood rot, staining, mould, rising damp, salt attack, roof leaks, termite activity and cracking. We need to maintain and 'service' our historic buildings to ensure the best possible 'performance' and lifespan.

The historic value of a building is enhanced by ensuring that new components are sympathetic to the old, and that work is also carried out by tradespeople having the appropriate skills, experience and attitude.

1.4 A maintenance strategy

A sensible and effective approach to maintenance is based on developing a strategy tailored to the needs of the building, and to the abilities and experience of the building owner or manager. The building should be considered both as a whole and in terms of the durability of its individual parts.

At the core of such a strategy is the regular monitoring of the building's condition. This involves periodic inspection to detect potential or developing problems. In the intervening periods, keep a watchful eye on the visible areas of the property during normal day-to-day use, and be aware of any changes. These might include paintwork starting to chalk or crack, mortar beginning to fret, stains or bulges appearing in ceilings, doors binding or jamming, walls looking patchy, and so on.

This is the first step, but attempting to deal with the visible symptoms is generally futile if the root cause of any change is not first identified and corrected. If the cause is left unattended, the symptoms will reappear and the work will need to be done again.

A structured course of action should be to:

- observe and note any visible symptoms (for example, a stain on the ceiling)
- identify the underlying problem (in this case, a roof leak due to a slipped slate)
- rectify the cause of the problem (refix the slate)
- rectify the visible symptom (seal and repaint the ceiling).

Vigilance and prompt action will save money, limit the extent of damage and protect the historic value of the place.

Eliminating unnecessary maintenance

One aspect of developing a maintenance strategy is to identify ways in which maintenance requirements can be reduced. For example, stonework which has been painted over at some time in the past, for reasons of fashion and personal preference, is likely to require repainting every 5-10 years - even if it has been done well and there are no signs of any physical problems such as moisture entrapment and rising damp. The cost and effort of doing this should be weighed against the one-off cost of having the paint removed to reveal the original stonework.

Eliminating the on-going cost of regular repainting will save money in the long term, particularly if secondary effects such as rising damp are also controlled in the process. There will also be a gain to the aesthetic integrity of the building.

This example involves eliminating non-original change. In other cases, it might be justified to make changes to original fabric, particularly where the gain to the long-term wellbeing of the place outweighs the loss of historic integrity. For example, rebuilding a box gutter to a larger size and more efficient configuration could resolve an ongoing overflow problem, without significantly affecting the physical integrity of the roof.

The inspection process

The key to looking after an older building is vigilance. By keeping your eyes open for anything untoward, you will be able to deal with problems in a timely and cost-effective manner. This may mean a simple repair, such as a leaking pipe, carried out straight away, or a forewarning of a future major outlay, such as re-roofing, giving you plenty of time to budget ahead for the work.

How much, how often?

The ideal frequency of inspection and preventative maintenance depends primarily on the recurrence pattern of events such as gutter blockage, and on the life expectancy of the least durable components of the building. These frequencies will vary enormously - gutters might need cleaning four times a year; repainting of exterior woodwork could be on a four to five-year cycle; at the other extreme, stonework, under favourable conditions, might remain in good condition for 100 years or more before it needs repointing.

General awareness will save time at periodic formal inspections. Rather than having to laboriously inspect the building from top to bottom, you need only concentrate on the areas that cannot be monitored during normal use, such as the roof, the roof space and the sub-floor. It is suggested that the repeat period for each item requiring inspection or preventative action be set on the conservative side at first. Over time, it will become clear whether a particular item can perhaps be left for a longer period between inspections.

As a general rule, an overall inspection of older buildings should be carried out annually to check for problems such as potential roof leaks, failing paintwork, blocked gutters or downpipes, termite activity and the like. Certain maintenance tasks, such as gutter cleaning, usually need doing at least twice a year - more often where large trees are nearby.

Safety

It is important to take care and be aware of personal safety when inspecting and maintaining your place. It is strongly recommended that a suitably qualified, experienced and equipped person be consulted from the outset in situations involving risks to personal safety (such as inspection of the roof).

If any task is likely to place you or others at risk, don't do it. Satisfy yourself that anyone working on your behalf carries a current license and appropriate insurance.

Great care is needed in unfamiliar situations, which might also require attention to the following safety issues:

Ladders

- ensure a firm footing, safe angle, and a secure purchase at the top
- wear footwear with heels to help prevent feet slipping off the rungs
- keep well clear of power cables
- avoid over-stretching to either side or backwards.

Roofs

- avoid fragile areas of roof covering
- take care not to bend galvanised iron or crack slate/tiles when walking on them
- use non-slip footwear
- use caution with steeper roof pitches and potentially slippery surfaces - consider the use of crawl boards or similar
- use a rope or harness on 'open' roof slopes that have no parapet or similar to catch you at the bottom.

Roof space

- ensure a firm footing and avoiding potentially weak ceiling joists
- keep good balance to avoid stepping on the ceiling surface
- wear protective clothing and a face mask where dust or insulation fibres are a problem
- wear gloves to avoid splinters from roof timbers
- take care with old electrical wiring (see Section 4.5 for precautions concerning old rubber-insulated cables).

Hazardous materials

Be aware that an older building might expose you to hazardous materials, both in your day-to-day use of the place and when carrying out inspection, maintenance and repair tasks.

- **Asbestos**
  Fibrous cement sheeting (or 'fibro' as it is more commonly known) has for many decades been a widely used and versatile building material. Today's product is safe, clean and 'green', but many older buildings constructed or renovated prior to the early 1970s contain asbestos fibres for reinforcement.

  The fibres are microscopically fine and readily inhaled. Their role in causing serious lung disease and cancer is now well documented. The material is considered to be of low risk while it remains undisturbed and in good condition, but if the surface deteriorates or is drilled, disturbed or damaged, hazardous fibres are released.

Asbestos cement sheets may be present as a lining for walls or eaves, or as a ceiling material. Corrugated sheeting may have been used as the roof covering. If in doubt, have the material professionally inspected and identified. Its removal and disposal is a task for an accredited contractor.

Asbestos may also have been used as lagging around water pipes for insulation, or as a sprayed fire retardant.

- **Arsenic**
  Arsenic trioxide and other highly toxic hazardous chemicals may have been used to treat termite infestation (see Section 6.2 for further information).
- **Lead**
  Various lead compounds were common constituents of early paints, and their use continued until the 1970s. A painted surface that is chalking, flaking, peeling or chipped constitutes an exposure risk to lead poisoning, as does preparation of the surface by scraping, sanding or using a heat gun.

  The dust encountered in the roof space may also contain harmful concentrations of lead, particularly in locations near main roads. For further information on lead in paints, refer to Technical Note 3.7; Painting of Older Buildings in South Australia, in the Heritage Conservation series. A good introduction to the health risks of lead and how to deal with them can be found in the Commonwealth Government publication Lead Alert - facts: lead in house paint (see Section 7; Further Reading).

1.5 Conserving cultural significance

Cultural significance means the aesthetic, historic, scientific or social significance of a place.

Levels of heritage listing

Heritage lists identify places of cultural significance. There are different levels of heritage protection as well as various types of heritage lists. Some lists provide protection for places, while others acknowledge significance but provide no statutory protection.

The following levels of heritage protection apply in South Australia:

- **World Heritage Places** are places of outstanding universal value. Protection of Australian places is provided for under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).
- **National Heritage Places** are exceptional natural and cultural places which help give Australia its national identity. Their cultural significance is protected under the EPBC Act.
- **Commonwealth Heritage Places** are natural, indigenous and historic heritage places on Commonwealth lands and waters or under Australian Government control which are identified as having Commonwealth heritage significance. Protection is provided for under the EPBC Act.
- **State Heritage Places** and **State Heritage Areas** are places considered of heritage significance to the state. Protection is provided for under the *Heritage Places Act 1993* and the *Development Act 1993*.
- **Local Heritage Places** and **Local Heritage Areas**
  The listing of local heritage places and areas is managed by Local Councils and Planning SA under the provisions of the *Development Act 1993*.

Heritage lists that do not provide protection include:

- Register of the National Estate –The national register of Australian historic, indigenous and natural heritage places from 1976 to 2003. The National and Commonwealth Heritage Lists have since taken over this role. Inclusion in the RNE is a mark of recognition of the cultural or natural qualities of a place, and does not carry any obligations for reporting, referral or approval for private owners
- National Trust Register of Historic Buildings (Information on 'recorded', 'classified' and uncategorised places. The Register was closed for new entries in 1989)
- The Australian Historic Engineering Plaquing Program of Engineers Australia
- The Royal Australian Institute of Architects (SA) Register of Notable 20th Century South Australian Architecture

The Burra Charter

The Burra Charter defines the basic principles and procedures to be followed to conserve places of cultural heritage significance in Australia.

The guiding principles are:

- do as much as necessary to care for the place and make it useable; but otherwise
- change as little as possible so that its cultural significance is retained.

A careful approach, based on a knowledge and understanding of the place, is at the core of good heritage conservation practice.

For more information about the Burra Charter see the Australia ICOMOS (International Council on Monuments and Sites) website *http://www.icomos.org/australia/burra.html*

Planning to conserve cultural significance

The cultural significance of a place is expressed in a tangible way through its physical material – or *fabric*. Changes to this material as a result of inappropriate repairs and maintenance, or other alterations, can affect the cultural significance of a place.

This is why it is important that a detailed understanding of its cultural significance is required before planning work on a heritage place. Conservation (Management) Plans set out a methodical process for investigating, identifying and conserving the cultural significance of a place. A crucial step in planning major change to significant places, even the simplest work on an unlisted place can benefit from consideration of these basic steps:

Analysis

- Gathering information - this might include locating drawings or documentary references, tracing an oral history of the place, and conducting a physical investigation to determine how it was originally built and how it has changed over time.
- Assessing the information to identify what makes the place significant, and how and to what degree this is represented in the fabric (including individual sections of the place and separate stages of construction).
- Preparing a Statement of Cultural Significance - a summary of the aspects of significance.

Policy

- Using the Statement of Cultural Significance as a basis, develop policies that will best conserve, enrich and present the cultural significance of a place. This might mean deciding to demolish later stages of building where they detract from the significance of the place or reversing unsympathetic alterations.

Implementation

- Devising priorities, strategies and timelines to achieve the outcomes identified by the policies - the 'action' stage.

1.6 Development approval

The *Development Act 1993* defines development in relation to a State Heritage Place as:

- *the demolition, removal, conversion, alteration or painting of, or addition to, the place, or any other work that could materially affect the heritage value of the place.*

The definition for a local heritage place excludes painting but is otherwise the same.

When is approval necessary?

The categories of ***demolition***, ***removal***, ***conversion***, ***alteration*** and ***addition*** are fairly self-evident, but most repairs and maintenance tasks are likely to fall into the ***painting*** and ***other work*** categories.

Painting

The Act does not differentiate between external and internal painting. In practice, however, a certain amount of discretion is usually applied to internal painting. Carrying out internal painting without Development Approval is generally tolerated, except in the case of original unpainted surfaces, or where early finishes or decorative schemes remain (this includes wall papers and grained or polished woodwork). It is recommended that you seek advice from your local Heritage Adviser or from The Heritage Branch when planning internal repainting, to determine whether approval will be required, and how to carry out the work.

It is important that preparation techniques do not damage significant underlying finishes, that the products used are compatible with each other and also with existing finishes, and that they do not exacerbate problems such as rising damp.

The painting of a building's exterior has a greater potential to influence heritage significance (and its perception), not least because of its greater visibility to the public. Matters to be considered are colours, textures and finishes, materials and preparation techniques. Detailed guidance is given in Technical Note 3.7 *Painting of Older Buildings in South Australia*.

Approval will not normally be granted for painting of previously unpainted surfaces such as stonework and brickwork. The removal of later paint finishes from surfaces which were originally unpainted is generally encouraged.

Other work

This could include anything from a minor repair on a heritage-listed place through to a major development some distance away affecting the visual setting of a heritage place. In both cases the heritage significance of the place may be affected.

However, some types of work will generally not threaten heritage significance, for example:

- repainting a worn or deteriorating exterior finish in the same colour and type of paint
- reroofing with appropriate materials
- internal redecoration where no significant early finishes remain, and where the applied finishes won't have any adverse affects, such as aggravating rising damp
- general garden maintenance and landscaping works, where the setting itself does not possess individual heritage significance and the overall character of the setting is maintained in harmony with the place's heritage qualities
- maintenance items which do not involve any change to significant fabric, or where the work can be demonstrated to have no adverse affect on heritage value.

This is a guide only. Council interpretations of what constitutes development under the Act may vary. You are advised to consult the Heritage Branch or your local Heritage Adviser for advice when considering any work, however minor. This also provides an opportunity for details of the work to be discussed informally and for agreement to be reached before plans become too advanced.

Why is Development Approval necessary?

In the context of repairs and maintenance, the Development Approval process allows careful consideration of how a particular item of work is likely to affect the cultural significance of an historic place.

It also allows the opportunity to manage the process of change. A heritage listing does not mean that a place becomes frozen in time. Other than in exceptional circumstances, where a place is highly significant as a 'museum piece', making considered changes to a heritage place to allow new or continued use is actively encouraged.

When assessing the impact of repair and maintenance work on the heritage value of a place, the following aspects are considered:

- the extent to which the significance of the place is embodied in the fabric being repaired or replaced
- whether the work affects the physical or historic integrity of the component or of the place as a whole
- the extent of replacement versus repair – for example, whether the rotted end of a barge board is patched or the whole board replaced
- the accuracy of reproduction in replacement components and detailing – how well the new matches the old in size, profile, physical properties, colour, finish, texture and so on
- the suitability of modern alternatives to traditional materials, products and methods – for instance, how the physical and aesthetic properties of modern roofing materials and trade practices compare against their early counterparts; or how modern mortars based on cement and hydrated lime shape up against traditional mixes using slaked lime
- the degree of intervention to significant fabric – whether the injection of a chemical damp-course preserves the integrity of the wall better than partial rebuilding for a physical damp proof course.

The Development Approval process

The approval process set out in the *Development Act 1993* is based on a system of provisional consents. When the necessary consents have been obtained Development Approval is granted.

For repair and maintenance works, the consents required vary according to the heritage status of the place.

Provisional Development Plan Consent – (planning consent) is required for repairs and maintenance on heritage places under the control of the Development Act – that is, State Heritage Places including properties within a State Heritage Area, or local heritage places identified in a Council's Development Plan.

Repair and maintenance work on a non-listed place does not require Provisional Development Plan Consent if it does not constitute new construction under the Act.

Provisional Building Rules Consent (Building Consent) is required in addition to the planning consent if the repairs and maintenance constitute 'work', subject to the provisions of the Building Code of Australia. Examples include load-bearing structural work or work on wet areas.

For a place not protected by heritage listing building consent is usually the only one required. Various regulated trades such as plumbing and electrical work must also be carried out and certified to Code requirements by licensed contractors.

Obtaining Development Approval for a heritage-listed place

The following steps are typical:

1. ***Consultation –*** Approach your Heritage Adviser or the Heritage Branch to determine the details of the work, such as the necessary and desirable extent of repair, how this is to be

carried out, what materials and methods should be used, any specialised skills required, and possible pitfalls to avoid.

2. ***Documentation –*** This is useful both to lodge with your development application and to obtain quotations. Depending on the work, the documentation might comprise drawings and sketches, a written schedule of works, a written specification and annotated photographs.
3. ***Lodgement –*** After a final check with your Heritage Adviser or the Heritage Branch, complete and lodge a development application form and required documentation with your local Council. The Council will advise which consents are needed and the applicable fees .
4. ***Referral –***the Development Act requires that an application affecting a heritage place is referred by Council to the local Heritage Adviser or to the Heritage Branch for a report on the heritage issues. Depending on how well-conceived the proposal is and to what extent any issues have been resolved before lodgement, the response might be unconditional support, acceptance subject to conditions, or a recommendation that the application be amended before being considered further.
5. ***Planning Consent –*** the Council considers the heritage response and other applicable Development Plan issues before making a decision about the application. If Council decide not to fully adopt the heritage recommendation, the matter is referred to the Development Assessment Commission, who then direct Council on how to structure the Planning Consent.
6. ***Building Consent –*** If required, the assessment can be carried out by Council's building department or by a registered private certifier. In some cases, a heritage condition in the Planning Consent might require further information to be provided and approved.
7. ***Approval –*** Once the necessary consents have been obtained, Council issues a Development Approval for the work, and the project can proceed.

Further information on the planning process in relation to heritage places can be found in the *Planning Bulletin – Heritage* (see Section 7; *Further Reading).*

1.7 Financial assistance and incentives

The listing of places of cultural significance implies their value to the community as well as to the owner. Financial incentives and grants to owners recognise this shared interest, as well as encouraging good conservation practice.

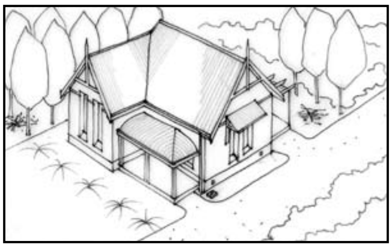
For information about financial assistance refer to the Heritage website *http://www.heritage.sa.gov.au* or contact the Heritage Branch.

2. Routine Maintenance

A program of basic tasks through the seasons

As the seasons change, there are various tasks that you can undertake to keep your property in good condition. They include cleaning the gutters, clearing downpipes and drainage systems, checking and repairing the roof and repainting outside woodwork. Use the following as a guide to developing your own program.

2.1 Summer



Fire safety

Remove debris and flammable materials, check condition of door and window screens. Ensure eaves are screened against entry of air borne sparks and embers.

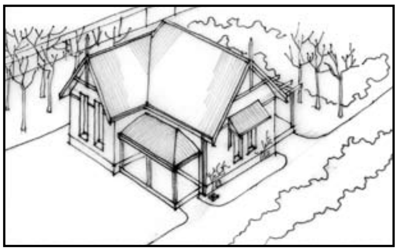
Roof

Ensure roof is watertight and that flashings and cappings are secured and in good repair.

Watering

Periodic deep watering of lawns, garden beds and trees can help stabilise soil moisture where cracking on clay soils is a problem.

2.2 Autumn



Roof

Inspect with binoculars from ground level

Leaves

Clear fallen debris and leaves from gutters, downpipes, roofs and gullies

Painting

Repair and touch up external woodwork through dry weather

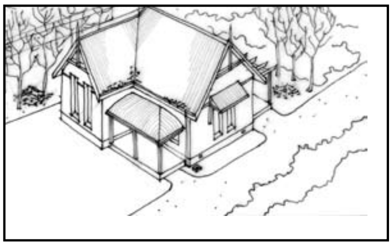
Subfloor vents

Maintain sub-floor ventilation keeping vents clear of debris and wind blown rubbish

Drains

Rod out stormwater drains and test to ensure water drains away easily and quickly

2.3 Winter



Gutters and downpipes

Monitor to see they are free of leaves and debris. Check operation during a heavy downpour

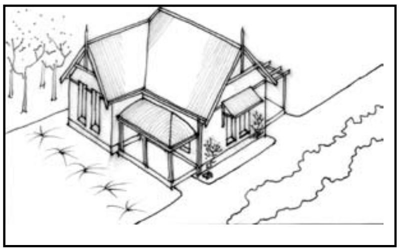
Drains

Ensure sumps and drains remain clear. Check that stormwater does not accumulate against the building

Pruning

Cut back shrubs and creepers over winter

2.4 Spring



Gutters and downpipes

Clean gutters and downpipes

Creepers

Cut back creepers and ivy. Allow tendrils to dry before removing from walls

Subfloor vents

Check to ensure debris is cleaned and air is free to flow through sub-floor space

Watering

Check operation of sprinklers – ensure they do not wet the walls

Weeds

Remove emerging weeds around building

3. The Building's Exterior

What to look for on the outside

3.1 Roof and gutters

The roof covering

Types of roof covering

The range of roofing materials used in South Australia includes:

- ***Metal tiles*** - sometimes referred to as 'pan' tiles because they comprise a flat tray with the long edges formed into a raised half-round profile. These side laps are spaced 450mm or 600mm apart, giving the roof a characteristic broad-ribbed appearance. Materials include zinc and galvanised iron.

  The pan tile was briefly re-introduced to the market in the late 1970s for conservation work. Although again no longer commercially available, its fabrication to order is straightforward.
- ***Lead*** - similar to a flat metal tile roof, but requiring special attention to fixings and junction details, because of its softness.

  Lead is also commonly used for flashings at joints and at junctions with other structures such as parapets and chimneys, and for capping the top surface of masonry parapets and large projecting mouldings to prevent moisture soaking in.
- ***Copper*** - not commonly used in South Australia, but sometimes encountered on prominent public buildings, either as pan tiles or profiled sheets.
- ***Pressed metal*** - decorative architectural elements such as turrets, cupolas, gable infills and awnings were frequently clad with pressed metal tiles or sheets. Diamond and fishscale patterns are the most common. Usually fabricated from galvanised sheet metal, but zinc was also used.
- ***Corrugated sheet metal*** - a popular roofing material in South Australia for over 130 years, 'galvo' has become a quintessentially Australian icon. The early iron sheet is thicker, heavier and more malleable than today's product, made from zinc/coated steel ('zincalume') or zinc/aluminium alloy. The closest equivalent today is a double-smelted curving grade.

  The continuous lengths now available have the advantage of eliminating the end laps which are the most vulnerable part of the roof covering. Sometimes, however, it may be appropriate to retain the traditional pattern of 6 ft sheets when renewing an historic roof.

  This material was sometimes used with particular expediency in the remote regions of the State where building timbers were scarce, by forming semi-circular vaulted roofs requiring little or no intermediate support. Individual sheets were curved and soldered, and rivetted together into a single structural membrane which was able to span from one side wall across to the other, with little or no supporting timber frame.

  Before the introduction of the ubiquitous self-drilling Tek screw, corrugated roofing was fixed with either twisted-shank nails or slot-headed screws. The nails tend to lose their bite as the timber battens dry out over time, and will quickly loosen again if re-nailed. Suitable screws are no longer readily available for conservation work, but Tek screws are generally considered visually acceptable in most circumstances. Exceptions might be where a building has a particularly low and visible roofline, or where the degree of authenticity is important.
- ***Slate*** - shingles are produced by splitting the slate into thin sheets along its natural cleavage planes. Slate deposits found at Willunga were exploited at an early date. Slates were also imported from Wales. They were widely used from the 1840s to 1870s, particularly the more prominent buildings.

  With age, slate shingles become increasingly brittle and are easily damaged. The action of water penetration and evaporation also leads to delamination (splitting into thin flakes) and powdering of the underside.

  The shingles are fixed to wooden battens with copper or galvanised nails through one or two holes in their upper edge, depending on size. The most common problems are broken shingles, and slipping due to corrosion of the nails or failure around the fixing holes.

  Even the best Welsh slates have a finite life, and cannot be expected to last indefinitely. This might range from 80-120 years depending on local conditions, compared to the less durable Willunga slates which tend to become unservicable after 50-80 years.

  Supplies of suitable slates for re-roofing are becoming harder to obtain. The blue

Willunga slate is still available, but the purple Welsh slate required to match old shingles on many South Australian buildings is in growing demand worldwide. Much of the slate now imported into Australia is Indian or Spanish, and generally unsuitable in colour and durability for conservation work. Supplies from Canada have been successfully used in recent years, but are no longer available.

- ***Imitation slates*** - imitation slate tiles or 'shingles' have been available since the early twentieth century as an imported product, such as 'Eternit' tiles from Belgium. These were made from fibrous cement, the same material later popularised as 'fibro' and 'asbestos cement'. Refer to 'Hazardous materials' part of Section 1.4 under Asbestos for a maintenance strategy. A similar product (eg James Hardies' shingle) is still available today.
- ***Terracotta tiles*** - the Arts and Crafts movement at the end of the nineteenth century introduced the terracotta tile to South Australia, initially as an import from Marseilles. Its popularity surged with the Federation style in the early twentieth century, and a local version was introduced by Wunderlich in the early 1920s.

  The Marseilles tile was unglazed and orange-red in colour, but quickly picked up a darkened patina of moss and lichens. It was formed to interlock with adjoining tiles. Fixings to the closely-spaced timber battens are by means of twisted wire ties, which are readily visible from the underside.

  Problems generally occur through cracked tiles, or through slippage when the wire ties have corroded.

  The half round 'Spanish' tile enjoyed a brief popularity in the 1930s and again in the 1970s residential market.
- ***Timber*** - before the ready availability of corrugated sheet metal, shingles split from hardwoods such as stringy bark were a common roofing material. Strictly speaking, these are 'shakes'; the term 'shingle' applies to sawn planks. Both types were laid like tiles to form several layers.

  Their durability was limited to 10-15 years, and they are often found preserved under a later covering of corrugated sheet metal. They should generally be retained for historic and interpretive reasons.
  Expediency arising from the need to employ local materials also saw bark as a popular early roofing material, laid in overlapping sheets.
- ***Thatch*** - widely used in the early years of the colony, utilising locally found materials such as straw, reeds, grasses or brush. Thatch fell out of favour as the price and availability of superior materials improved, particularly as it presented a high fire hazard, encouraged vermin and required frequent maintenance. Examples of early thatched roofs can still be found on rural outbuildings.

Later twentieth century historic buildings may have more modern roofing materials not normally associated with 'heritage' buildings. These might include:

- ***Fibrous cement*** - this material was available from the mid-1930s in the familiar corrugated profile similar to its metal equivalent. The larger 'Deep Six' profile was introduced by James Hardie in the 1940s.
- ***Sheet membranes*** - bitumen-impregnated felts, and later rubber-based membranes, mainly used on commercial buildings with flat concrete roofs concealed behind a parapet.
- ***Concrete tiles*** - the popularity of the Marseilles-type interlocking roof tile continued with the emergence of a cheaper concrete version after World War II, in response to the very restricted availability of building materials. Local production by Monier commenced in the early 1950s. Performance is generally on par with terracotta tiles, but the unglazed type becomes increasingly porous with age and can absorb a considerable weight of water.

Compatability

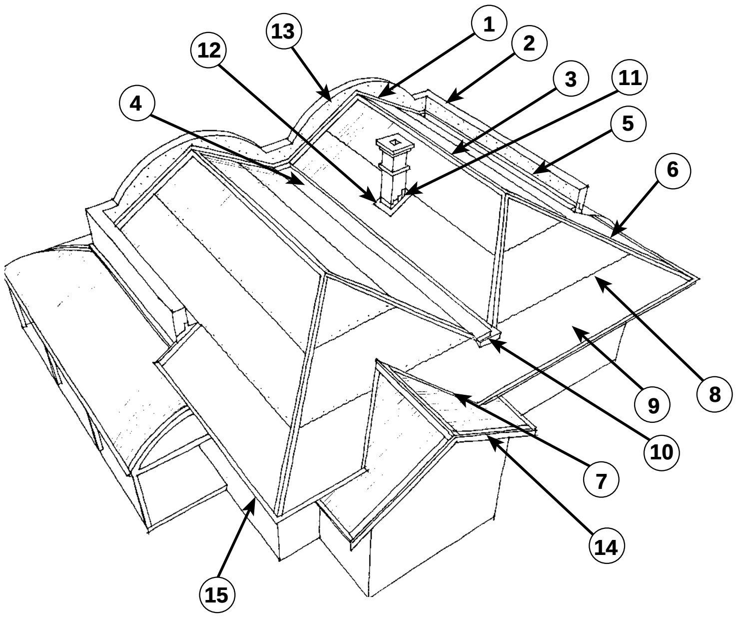
It is important to note that some roofing materials are not compatible with others, for example, a zincalume clad roof running into a galvanised gutter will result in accelerated corrosion of the gutters. Other metals like copper will also react in contact with zinc, aluminium, galvanised and zincalume roofing materials, and lead flashings can be problematic on zincalume roofs without an appropriate barrier between the two materials. When in doubt, check with a Heritage Adviser or contact the Heritage Branch for further information.

Inspecting the roof

Carry out a visual inspection of the roof from ground level (binoculars are useful). This may be sufficient if there are no problems evident from inside the building or the roof space. Many problems however, can only be identified by getting up onto the roof. Use the ground level inspection to keep a general eye on things, but undertake a more comprehensive inspection at least every two years. Safety should be the primary

Typical Roof Anatomy

1. Parapet Flashing
2. Parapet Coping
3. Ridge Cap
4. Box Gutter
5. Flashing
6. Hip Capping
7. Valley Gutter
8. Sheet Laps
9. Corrugated sheet metal Roof Sheets
10. Rainwater Head
11. Stepped Chimney Flashing
12. Chimney Soaker Tray
13. Rendered Coping
14. Barge Capping
15. Eaves Gutter



concern in deciding whether to do this yourself or engage someone else.

When inspecting from the ground, look for:

- faulty or slipped roof tiles and shingles
- damaged or lifting cappings over ridges and hips at the apex of the roof (see diagram)
- damaged or lifting flashings around chimneys or at parapet walls (flashings are the overlapping metal sections that seal the gap where the roof covering is penetrated or abuts some other part of the building)
- signs of corrosion at the joints between sheets of galvanised iron — this occurs mainly at the end laps (the joint between the lower edge of one sheet and the top edge of the next), and can be detected more easily from within the roof space (refer to Section 5).

The roof-top inspection should include a closer look at the above items, as well as the following:

- check that the flashings are securely fixed and well-fitting
- fixings (particularly nails) may have worked loose, and replacement with screws is often necessary because they cannot be successfully tightened
- inspection of box gutters, chimneys and parapets.

Gutters and downpipes

Blocked gutters and downpipes can overflow and cause saturation of the walls, which may result in mould or lichen growth, or in harmful salts being deposited within the wall. These problems can seriously affect the wall's structural integrity.

Gutter falls

Check that gutters are draining freely towards downpipes or outlets and that they do not hold water when it is not raining, which will accelerate rusting of steel or iron gutters and considerably shorten their life.

Cleaning

Using a safe and stable ladder, clean sludge and decaying leaf matter from the gutters. A build up of muck in the gutters not only blocks the flow of water and leads to overflow - it also retains highly-oxygenated moisture for long periods, resulting in rapid corrosion.

Purpose-made scrapers are available from hardware shops, but an old washing-up brush does a very good job without scratching the finish on the gutter. Wear heavy- duty PVC gloves to avoid cuts from sharp edges.

Box gutters

Box gutters can potentially overflow into the roof space, so it is doubly important to keep them clear. They are often very shallow and therefore highly susceptible to overflowing. If you have a persistent problem, consider replacing them with new gutters which extend up under the roof covering to increase their depth.

A blocked gutter and rainwater head have overflowed and saturated the surrounding brickwork, encouraging the growth of an unsightly fungal stain. Overflow such as this can also deposit harmful salts, resulting in salt attack of the masonry.

Outlets

Whether it feeds into a downpipe or discharges directly into another gutter or onto another part of the roof, the outlet from a box gutter must allow the free flow of water.

Valley gutters

In areas with overhanging trees, check the valley gutters, especially at the lower ends where they meet a horizontal gutter. Leaves can build up here and obstruct the water flow both in the valley gutter and the main gutter.

Secondary roofs

Check that balcony roofs, awnings and bay window roofs drain effectively. These often have small gutters and outlets which block easily.

Downpipes

To avoid gutter overflow, it is not enough to have the gutters clean. The downpipes must also be able to carry the water away quickly without backing up. A garden hose with the end fitting removed makes an effective probe, using moderate water pressure. Work from the top or bottom depending where the blockage is. You may need to pre-mould the hose into a bend to get around the corners.

Downpipe capacity

From the time of their initial construction, some buildings have an insufficient number of downpipes for the size of the roof. It is also common practice when renewing gutters and downpipes to change the number and position of outlets for ease of installation and to reduce cost. The result in both cases can be inadequate drainage capacity and an increased tendency for overflow.

Particularly common is the practice of discharging large quantities of water from the main roof gutter onto a verandah roof, which is often fitted with a smaller gutter and a single downpipe. The size of guttering to the smaller verandah area will usually be hopelessly inadequate to cope with the concentration of water collected from a large area onto a single point. Work out which areas of roof drain to which downpipes, and decide whether you should reconfigure the drainage system. In doing so, be mindful of the historic locations of downpipes if they have been changed, and choose new locations with care to achieve efficient drainage, good gutter falls and a solution that is aesthetically appropriate and unobtrusive.

Rainwater heads

Check that rainwater heads are clear and in good order. These are the often decorative reservoirs at the tops of downpipes and their purpose is to funnel the water efficiently and quickly into the downpipe. This arrangement has much better flow characteristics than the standard gutter/downpipe connection, and avoids a bottleneck at this point.

Old rainwater heads are often removed when guttering and downpipes are replaced. Look for evidence such as fixings into the walls or a faint outline, and consider replacing them if they have been removed.

Another form of rainwater head is a shallow tray concealed within the eaves, connecting the back of the gutter to a downpipe that runs straight down the wall without the usual offset bends at the top. This arrangement may also be used to connect to a downpipe concealed within the wall.

Replacement of this system with the standard offset downpipe may be preferable to improve drainage efficiency, but consider carefully how this might affect the historic integrity of the place, its aesthetics and detailing.

Chimneys

Chimneys are a notoriously neglected element of a building, particularly if they are not visible from below. Even highly visible chimneys will often be allowed to deteriorate despite other parts of the building being maintained. It is common to see once highly-decorative chimneys reduced to a plain rendered stump because the original mouldings have fallen off through lack of timely maintenance.

The condition of chimneys needs careful attention, because it is common for deterioration to occur at a much greater rate from inside the flue than on the outside. A chimney that appears sound from below can conceal serious erosion from within. This occurs typically when the fireplace is disused but

Check the condition of chimneys while on the roof. The erosion of these mortar joints will lead to eventual collapse of the brickwork. This chimney should be repointed using a traditional lime mortar mix.

there is still unrestricted airflow up the flue.

The combination of airflow and moisture soaking down into the masonry from the top surface leads to a form of salt attack ('salt damp'). In the presence of this falling damp, the natural upward airflow results in a high evaporation rate of salt-laden moisture from the inside surface, which is exaggerated further if the external surface is rendered, impeding evaporation from the outside and concentrating it on the inside. The consequent growth of salt crystals causes erosion of the mortar lining (or parging) of the flue, and eventually of the mortar joints and even of the bricks or stones themselves.

Chimney flues remaining in use need to be swept periodically to remove the build-up of soot and tarry deposits. Failure to do so carries the risk of chimney fires.

High rate of airflow up chimney has caused severe salt attack inside the flue, which is not visible from the outside.

Mortar joints

Inspect the mortar between the bricks or stones, as repointing may be necessary.

Airflow

Consider unobtrusively capping disused chimneys to control airflow. This is commonly done with a slab of slate or a piece of galvanised sheet metal. Ensure that any such capping is securely fixed.

Horizontal surfaces

Inspect the very top surface of the chimney, and the tops of any ledges or decorative profiles to ensure the render is not cracked. Moisture that leaches into the chimney through these surfaces will accelerate its erosion.

Parging

Check that the inside of the chimney flue has sufficient parging (render) to adequately cover the brickwork. A chimney that looks in good repair from the outside may be eroding from the inside.

Typical chimney flashings.

Flashings

Flashings around the base of the chimney should be checked for water tightness. The bottom part of the flashing needs to be securely fixed to the roof covering and to extend far enough over the roof covering to get the water well away. The upper edge of the flashing beneath the chimney should be free of cracks or tears, and be securely embedded into the chimney with mortar.

On the sides of the chimney, the down-turned flashing is typically in several overlapping sections set into the horizontal mortar joints and stepping downwards to follow the slope of the roof.

On the upper side of the chimney, the up-turned flashing is of a special type called a soaker, which forms a gutter to catch the water running down the roof from above and discharge it out past the sides of the chimney. Check the soaker for soundness and secure fixing.

Ensure that debris does not collect under flashings as this may promote leaking into the roof.

Parapets

Parapets are walls that extend up past the roof line, with the roof finishing against them. The junctions are sealed with flashings - at the lower end of the roof the flashing will turn down into a box gutter. Parapets suffer many of the same problems as chimneys, including an apparently intact external surface concealing advanced deterioration of the rear face. As with chimneys, the prevention of moisture entry through horizontal surfaces is crucial to their maintenance.

Mortar joints

Make sure the mortar between the bricks or stones is intact on both the front and rear faces of the parapet.

Render

If the parapet is rendered, check that the render is sound, and is not letting water in through cracks or where it may have lifted away from the masonry.

Horizontal surfaces

As with chimneys, inspect the top surface of the wall, and the tops of any ledge or decorative cornice to ensure the render is not cracked. These surfaces should have a clearly discernible slope to shed water away quickly. If these are sealed with lead sheet, check for any cracks, loose fixings or signs of stress.

Flashings

Junctions between the roof covering and parapet walls are sealed with two-piece metal flashings in a similar way to chimneys. Where the high edge of a roof or the sloping side edges meet a parapet, the upturned part of the flashing is fixed to the roof covering. The down-turned part of the flashing is embedded into a horizontal mortar joint at the high end. At the low edge, the roof discharges into a box gutter, and sloping junctions are sealed with stepped overlapping sections of flashing as for the side of a chimney.

Check all the flashings for holes, tears or corrosion, and make sure they fit snugly and are securely fixed.

3.2 Stormwater disposal

Drainage

Getting water away from the base of the walls is very important with old buildings. They generally have shallow footings, which are susceptible to soil movement (resulting in cracking) if too much roof water or surface water is allowed to soak in close to the building. Poorly located discharge of water can also contribute to the severity of rising damp. All stormwater and surface water should be directed away from the building walls.

Stormwater drains

Make sure that downpipes discharge into an effective drain. This can be either open (for example a shallow brick gutter) or a closed pipeline of earthenware or PVC. Downpipes should not discharge at the base of the walls or near the foundations. Check that the drains are clear and that the water drains away without backing up. Try to find where the drain discharges to - it may need relocating or extending to take the water further away.

Old sumps and drains

Old buildings with sub-surface pipelines for the discharge of stormwater typically have downpipes which empty into sumps, with earthenware drains carrying the water to a soakage pit or open discharge. These sumps are usually wet sumps (the drain pipe is above the bottom of the sump to allow sediment to collect without blocking the pipe). Because they hold water, they can be a source of excess moisture soakage into the soil if they are not watertight - which they rarely are.

Leakage is also common from earthenware pipelines, which are susceptible to damage from soil movement and tree roots. Old soakage pits may have become ineffective through sedimentation over time, or may be located too close to the building.

If you suspect that leakage from the drainage system is contributing to problems with cracking (soil movement) or rising damp, it may be advisable to install a new PVC system. The old system could also be left in place for its historic value.

Air conditioner condensate lines

The condensate from refrigerated air conditioning units should discharge into a stormwater pipe or be directed away from the base of the building.

Rainwater tanks

A slow leak from a rainwater tank can soak a large quantity of water into a small area, resulting in localised cracking or rising damp. Check above-ground tanks for leaks, including the tap, and pay attention also to the overflow pipe - as with a downpipe, this must be effectively connected to a suitable drain.

Underground tanks are usually of brick construction and lined with render for waterproofing. Cracking and leaking is common, and can affect the building's footings. Look for any developing problems, and consider having the tank re-lined for environmental as well as preventative reasons. Vinyl liners are an alternative to re-rendering.

Surface water

After heavy rain make sure there are no pools of water or soft ground within four metres of the base of the walls. Water retaining for some hours after rain, is a sign of poor soil drainage.

Extremely water-logged soil may result in permanent ground subsidence, causing the walls to crack. Wetting during the winter months can have the opposite effect with clay soils, causing them to heave upwards as they expand.

Damp soil conditions can also contribute to rising damp, cause sub-floor problems with sagging or arching of floor joists and cupping of floor boards, and attract termites.

Refer also to Section 3.6 Paving and landscaping

Extensions or additions

If the original building has been extended, the pattern of water drainage may have been altered. It is important to identify whether this is the case, and whether you need to take appropriate steps to remedy any problems.

3.3 Walls

This section covers identifying wall problems commonly found when inspecting a building from the outside. Section 4 covers those typically encountered internally.

Types of wall construction

The range of wall construction methods found in South Australian buildings includes:

Earth walls

This broad category encompasses a number of distinct but fundamentally related construction types, often found in various hybrid forms. The terms used to describe the different techniques also tend to be applied fairly loosely, causing further confusion.

- ***Adobe*** - also referred to as ***mud brick*** and ***sun-dried brick***. Clay-bearing soil is mixed with water, with chopped straw added for reinforcement. The mixture is pressed into a rectangular mould, then turned out and stacked to dry. The bricks are larger, but are laid in much the same fashion, as clay bricks.

  Adobe is usually concealed by a layer of render to protect it from the elements, but underneath will have the characteristic appearance of brickwork laid in a regular pattern. A roughcast finish (also known as pebbledash) is sometimes used, comprising a slurry of fine gravel, lime and water thrown onto the wet render.
- ***Cob*** - a basic but effective form of earth construction, brought to Australia from Britain. The raw materials of clay-bearing soil and straw are similar to adobe, but the wall is built by tossing clods of it onto the stone base, where it is compacted by treading. Progress is slow as each layer must be allowed to dry sufficiently before the next is applied. As the wall proceeds, the faces are pared back to an even alignment. Traditional practice for cob walls is to round off the corners because of the difficulty in forming squared edges in such a material.

  The application of a render refines the finished appearance and protects the cob from the elements. Identifying a cob building, even where the underlying material is visible, can be difficult but the presence of straw and discernible layers are clues.
- ***Pisé*** - also known as ***rammed earth***, from its full name of pisé de terre. This is the most sophisticated of the earth wall techniques, and can produce a construction of great durability and strength. A good friable loam was considered best, not too sandy nor with too much clay. The wall is built up in layers between wooden forms, compacted by ramming with a long-handled pounder. Straw reinforcement is unnecessary, and the mix is stiffer than for adobe or cob.

  As each layer is laid and compacted, the formwork is moved up for the next layer. The timber cross-pieces or 'putlocks' that tie the two sides of the form together leave a characteristic pattern of voids through the thickness of the wall. This together with the horizontal and vertical jointing makes identifying pisé straightforward.

  If good soil was used and the ramming was done well, pisé does not have the same need for a protective render, but it was generally given a decorative finish anyway for aesthetic reasons.

These are ancient techniques, widely used in many parts of the world for centuries. Their presence in South Australia is limited, owing no doubt to the general availability of building stone, particularly of ‘calcrete’ - a form of limestone occurring as irregular lumps close to the surface, and therefore readily and cheaply procured. The presence of surviving examples, in the light of their general scarcity, is testimony to their durability when well built and maintained.

The common characteristic of these techniques is that the base material is unfired - meaning that it has not been vitrified at high temperature in the way that clay bricks are. This makes the material more than usually susceptible to water damage.

Good building practice was for walls of these types to be built on a stone base finishing above ground level, but this is not always the case. Where an earth wall is built directly onto the ground with no damp course, it must be protected from rising damp by good surface and sub-surface drainage. The problem is not so much salt attack over an extended period, but a more immediate softening of the material as it becomes moist.

Earth walls are also damaged by erosion through the direct action of water running down the face or rain beating against it. Wide eaves and verandahs were often used to protect the walls from such erosion. If the eaves are narrow and there is a gutter set close to the wall, it is particularly important to keep it clear and to avoid overflow.

Where the wall is finished with a protective render or limewash, it must be kept in good condition to do its job effectively. Fortunately, limewash is readily maintained by regular re-application, provided the base underneath remains sound.

The main problem to watch for with render is its shearing away from the wall, allowing moisture to infiltrate into the core of the wall. Repairing small areas of defective render is relatively straightforward with due attention given to matching the mix to the original. Large areas of damage are more problematic, and may require completely stripping the wall and starting again with a new render.

Seek professional advice from a heritage consultant before proceeding with major work such as this, and choose only a contractor who has experience in working with traditional materials.

The greatest problems with earth construction are experienced with major erosion of the walling material itself. The success of large-scale patching and repair depends greatly on the condition of the surrounding material, and on the experience and skills of the contractor. Creating a good bond between old and new is difficult because of the variation in moisture content of the repair mix relative to the old material. Slow and thorough wetting down without over-saturation is essential, but if the old material is too friable, it will need to be pared back to sound material.

The selection and proportioning of materials for the repair mix is also crucial, but bear in mind that any loose old material can be collected and re-used. Once it is re-hydrated and pugged to the right consistency, it will regain its original qualities on re-curing.

With any repair work, controlling cracking as the material dries requires the utmost care. One method is the frequent application of a thin slurry to the finished surface, combined with regular misting.

Masonry

Stone and brick are the most common walling materials found in South Australia’s surviving stock of historic buildings. Good building timbers were scarce so the early settlers used readily available local materials to provide durability for their dwellings. Information of a general nature can be found in DEH Technical Notes 3.3 *Early Bricks & Brickwork in South Australia* and 3.6 *Stone Masonry in South Australia*.

Masonry walls in historic buildings will generally be of solid construction, although the brick cavity wall made its first appearance as early as the 1890s. The brick bond (that is, the pattern visible on the finished face) can be used to identify the construction - the English bond with its rows of headers (the ends of the bricks) indicates a solid double-thickness wall; the stretcher bond (long side of the brick) shows a single-leaf wall or cavity construction.

Bulging of the face of a stone or brick wall can result from separation of the two sides of the construction. In stonework, the outer layer of masonry can shear away from the soft core, and with brick cavity construction the corrosion failure of the internal wire ties can have a similar effect. The consequences for the structural stability of the wall are serious.

The identification and management of problems in masonry wall construction are given greater emphasis than for other types throughout this publication.

Concrete

This material has been used in a number of ways since the colonisation of South Australia and its use continues today in highly engineered, framed structures and ‘tilt-up’ construction. Common historic applications include:

- ***mass concrete*** - A mixture of slaked lime, sand and an aggregate of stones or gravel, packed into timber formwork which was progressively raised as the wall was built up layer by layer.

These walls are typically 500mm or more thick, with an external render sometimes lined in imitation of large ashlar blocks.

In this form, concrete shares many physical characteristics with stonework, and suffers similar problems including those arising from dampness.

Examples of mid-nineteenth century mass concrete buildings are not uncommon, disguised under a layer of render.

Poured mass concrete walls also had a brief resurgence as a result of the shortage of building materials after the Second World War.

- ***reinforced concrete*** - The use of reinforcement to improve the performance of concrete was pioneered by the Romans, but the technology was lost until the early twentieth century.

  In South Australia, builders such as Walter Torode began experimenting with the use of steel rods and wire mesh to create concrete footing systems that would cope with the movement of Adelaide's reactive clay soils. He also developed a cavity wall construction comprising two 50mm thick precast concrete panels separated by a precast concrete stud.

  The general term for lightly reinforced construction such as this is ***ferro-concrete*** - ie concrete with ferrous (iron or steel) reinforcement.

  Increasing sophistication in reinforced concrete design saw the emergence of the concrete-framed building, in which the structure comprised a three-dimensional grid of reinforced concrete columns and beams with non-structural infill panels.

  The most serious problem with reinforced concrete of any description is corrosion of the reinforcing. This occurs when moisture penetrates through to the metal as a result of cracks or imperfections. It is exacerbated by carbonation of the concrete, which reduces its protective alkalinity. When the metal corrodes, it expands to five times its original volume. This action, known as concrete cancer, exerts huge internal pressures and literally breaks the concrete apart.

  Repair is costly and labour-intensive, and you should seek appropriate professional advice if faced with this problem. Many early concrete structures suffer from it because the reinforcement is too close to the surface and therefore has insufficient protection from moisture.

- ***concrete block*** - The concrete block is not normally thought of as an historic building material, but it will sometimes be encountered in buildings from the World War II era and the Austerity Period that followed. These blocks were made on site in simple moulds, and the finished wall rendered to give it a satisfactory appearance.

Iron

Iron came to prominence as a structural material in the latter half of the nineteenth century. Two predominant types were used:

- ***cast iron*** - so named because the molten metal is poured into moulds or casts. It cools to a granular, brittle texture, which makes it unsuitable for tensile or bending stresses.

  Cast iron is used structurally in applications involving mainly compressive loads, such as columns and arched spans.

- ***wrought iron*** - the iron is worked or 'puddled' in a semi-molten state, and cools to a malleable, ductile form with a distinctly directional grain. It is readily worked into different shapes and is used in applications requiring good tensile performance such as beams and tie rods.

Nineteenth century iron tends to be relatively pure, which gives it a good resistance to corrosion compared to more modern steels with higher carbon contents. The highest quality iron components can survive years of neglect with little adverse effect other than a light surface oxidation, but regular repainting is warranted in most circumstances. Refer to DEH Technical Note 3.7 *Painting of Older Buildings in South Australia.*

Timber frame

This category encompasses many variants, with the following examples being the principal ones:

Lightweight construction

A term describing any construction comprising a light timber frame of regularly-spaced vertical 'studs' and horizontal 'noggings', sheeted with various cladding materials. The protection of the frame from damage by moisture and termites is common to any type of lightweight construction.

Types of cladding which might be encountered, and particular problems to be aware of, include:

- ***weatherboards*** - overlapping horizontal timber boards, ranging from plain rough-sawn planks to tapered profiles with moulded beadings at the lower edge and rebated joints. Regular repainting is important in ensuring the maximum life of weatherboards. More rudimentary examples may be unpainted and naturally-weathered, and advice should be sought on the appropriate use of timber preservatives or lime washes to protect them.

- ***corrugated iron/sheet metal*** - well-known as a roofing material but popular also in rural areas for walling because of its ease of transport and low cost. Used horizontally or vertically, inside or outside, and in the standard profile as well as the smaller ripple iron or mini orb.

  Problems with rust damage are generally kept at bay by the protective zinc coating, but any prolonged moisture presence should be dealt with, as much for the sake of the timber frame as the metal cladding.

  The appearance of corrugated sheet metal cladding can suffer from dings and dents over the years, but sheets that are otherwise intact can be removed and re-rolled, or replaced with salvaged sheets if necessary. However, it is worth checking the width and depth of the corrugations to ensure a match to adjacent sheets.

  Full replacement with new corrugated steel sheeting might be justified in more extreme cases.

  Note that it is important to ensure material is compatible – re-roofing in zincalume can result in the accelerated corrosion of galvanised gutters and rainwater goods, and flashings need to be considered carefully for the same reason. Generally, replacement of roof sheeting and associated products in galvanised sheet metal is the most appropriate for heritage buildings.

  It is important to note that some roofing materials are not compatible with others, for example, a zincalume clad roof running into a galvanised gutter will result in accelerated corrosion of the gutters. Other metals like copper will also react in contact with zinc, aluminium, galvanised and zincalume roofing materials, and lead flashings can be problematic on zincalume roofs without an appropriate barrier between the two materials. When in doubt, check with a Heritage Adviser or contact the Heritage Branch for further information.

- ***pressed metal*** - any cladding material formed from sheet metal. Designs used for external walls include imitations of brickwork, rough-faced stonework and weatherboards.

  As with corrugated sheet metal, these panels are relatively maintenance free. Sheets which have lost most of their protective zinc coating can be removed and re-galvanised. Damaged panels cannot be reformed as readily as corrugated sheet metal, but automotive panel beating techniques can be applied.

- ***roughcast*** - infill panels of roughcast or pebbledash are more often found in timber gable frames, but were sometimes used as a form of lightweight construction for service buildings and outbuildings. Application of the base render is usually onto a galvanised wire mesh for reinforcement. See the comments above on ferro-concrete.

Slab construction

This technique derives its name from the large slabs or planks forming the wall panels. They are generally split from River Red Gum *(Eucalyptus camaldulensis).* There are several variants, with the slabs sometimes set vertically into the ground, or held clear of the ground on timber cross-rails, or sometimes slotted horizontally into channels cut into the main uprights.

Slab buildings usually have a substantial timber frame comprising large posts set into the ground, each with a fork at the top to support the main roof timbers.

The main problem with age is the gradual rotting of the timber posts at and below ground level. This not only causes localised settlement, but because the lateral stability of the whole structure relies on their embedment within the ground, also results in progressive leaning and collapse. If the slabs are set into the ground, they will also be susceptible to rot.

Good drainage is crucial to the long-term maintenance of this form of construction. Dampness in the soil encourages termite attack in addition to wood rot, and measures to divert moisture away from the structure must be considered. Look for signs of subsidence or distortion in the frame as a warning signal of wood rot.

Buildings of such rudimentary construction often have no gutters to collect roof run-off, or the gutters are only partially effective. Ensure that the ground surface around the building is well graded away from the structure. In some cases it may be necessary to install surface drains to divert run-off, or agricultural drains to intercept sub-surface water.

To get some idea of the condition of the timber below ground level, you can dig down beside a post and check for softness in the outer layers, and for ‘waisting’ or narrowing of the post.

A technique which avoids disturbance is to drill down into the post at an angle to check for softness or sponginess. If done professionally, core samples can be taken for analysis, and the holes used for treating against wood rot with boron-based capsules or rods.

Stabilising structures which are suffering advanced damage is a specialised undertaking, and expert advice should be sought. In some cases, cross-bracing can be inconspicuously incorporated.

There are also techniques for repairing the main posts, such as splicing in new sections of timber and introducing timber outrigger stumps or purpose-designed concealed steel stirrups set in concrete pads.

Fachwerk

This building technique is also known as half-timbered construction where vertical, horizontal and diagonal members are infilled with wattle and daub panels or brick. These buildings are normally set on a substantial stone base to protect the timber frame and brickwork from rising damp. Where dampness is a problem, look for evidence that the ground level might have been raised over time (refer to Ground level build-up under Section 3.6).

The bottom rails of the frame may need to be replaced with new facsimiles if too far gone.

Wattle and daub

Traditionally, wattling consists of a row of vertical stakes fixed to a top and bottom rail, leaving space within which another pliable material (usually straw in South Australia) is then interwoven. Both sides are plastered or 'daubed' with a plastic mixture of chopped straw and mud. Internal surfaces were generally trowelled smooth, and sometimes even covered with sail cloth or calico. A limewashed finish internally and externally aided both appearance and protection.

A variation on this technique is ***pug and pine***. The ‘pug’ is another term for daub, and the ‘pine’ refers to the uprights of *callytris* or native pine. These are closely spaced without the inter-laced wattling and the pug applied directly to them. This technique can be found in rudimentary outbuildings, and sometimes in place of brick nogging in timber-framed buildings of German derivation.

Problems to look out for include those described for fachwerk. Depending on the particular construction, the vertical staves may either be set directly in the ground or supported in a grooved timber base rail set on the ground. In either case, wood rot will result in the panels dropping and sagging. Look for gaps developing at the top edge of the infill panel where it meets the top rail.

New or old bottom rails and staves can be protected from damp by digging a trench underneath and packing it with coarse gravel. This will avoid direct contact with damp soil and allow moisture to drain away from the timber.

Composite masonry construction

Structural problems will arise if the frame is damaged by rot or termites, as loads are then transferred to the masonry. Cracking or buckling of the wall can result if it is unable to support these loads.

Pay particular attention to keeping the timbers dry below ground level, and check regularly for any signs of termite activity. The techniques described above for testing, protecting and conserving timber frames can be applied here.

Look also for signs of distress in the masonry which may indicate a developing problem, either with the footings that support the walls or with load transfer from the timber frame. Seek professional advice if unsure.

Dampness in masonry walls

Problems with dampness in external walls arise generally from two causes - rising damp or falling damp.

Rising damp

One of the two most common sources of dampness in old buildings is rising damp - moisture that rises up from the ground into the base of masonry walls. When this moisture contains high levels of dissolved salts, the problems of rising damp are compounded by salt attack. The action of the two together is commonly known in South Australia as *salt damp*.

This is perhaps the single most destructive force at work against old buildings in South Australia. Further information is given in Section 6, and the subject is covered in detail in the DEH Technical Note 3.8 *Rising Damp & Salt Attack*.

Damage in external walls from rising damp and salt attack is typified by the ongoing breakdown of the mortar joints between individual bricks or stones. Decay of the bricks or stones occurs if the wall has been repointed with a mortar that is harder and less porous than they are.

The presence of rising damp, with or without salt attack, indicates a dampcourse problem. This is discussed in more detail in Section 6.5.

Falling damp

Moisture that enters the wall from above is known as falling damp. It is generally the result of overflow in the roof drainage system, a leaking roof or ineffective flashings. These problems are discussed in Section 3.1.

Common causes of overflow are blocked downpipes or gutters (particularly box gutters), because of lack of cleaning or poor design. If gutters are under-sized and are overloaded by too much water, the problem may be traced back to the original design, or from later changes to the location and number of downpipes or outlets.

Also look out for downpipes leaking from an intermediate joint because of a blockage low down in the pipe.

Identify the source

Having found signs of dampness in the external walls, it is important to correctly determine the source of the moisture. An accurate diagnosis will avoid wasting time and money on inappropriate treatments.

Stone and brickwork

Mortar joints

Inspect the condition of mortar in stone and brickwork joints. Where the mortar has fretted or is missing this may be a result of wind and rain slowly eroding mortar, or of rising damp or structural movement.

Cracking

Structural movement declares itself in masonry walls by the appearance of cracks. The building owner can help to identify the cause by keeping a note of any changes in the extent or pattern of cracking, but should seek professional advice before proceeding with any repairs.

Cracks can be less obvious from the outside because the texture of the wall will tend to mask them, particularly with rough surfaces such as random rubble stonework or rock-faced work. Movement that is readily apparent from inside on a smooth plaster finish may not show up to the untrained eye on the outside surface until it is quite advanced.

This would suggest that there is little to be learnt from investigating the exterior for signs of cracking, but often the reverse applies. For aesthetic reasons, internal cracking is usually repaired promptly, but this is rarely the case externally - because it is less apparent, has less effect on the owner's enjoyment of the place and specialised skills are required to repair it, it will often be left alone.

These fine cracks are sufficient to allow in water and eventually lead to the structural failure of this decorative cornice.

Lack of maintenance on top surface of cornice has allowed water to seep in and damage the moulding.

This can provide useful information in determining the history of cracking, and yield clues which have been erased internally. Reading the two together will give a more complete picture and enable a more accurate identification of the cause.

Look for stepped cracking that runs horizontally and vertically through the mortar joints, and take a note of its extent and the width of the crack at different positions. If there are signs of previous patching or repointing, this will generally indicate that the problem was at some stage relatively severe. Evidence of repeated patching suggests a long-standing problem which has never been satisfactorily dealt with.

For further information on cracking, refer to Section 6.6.

Repointing

Wear and tear are a normal part of a building's aging process, and may include the deterioration of mortar joints. These can be regarded to some extent as an expendable component that wears out in the course of doing its job. The lime-based mortars used in traditional construction have a resilience and self-healing quality that enables them to absorb some of the movement and stresses within the wall in a way that cement-rich mortars cannot.

In addition, traditional mortar mixes are designed to be softer and more porous than the stone or brick from which the wall is built. The joints then form the path of least resistance to rising damp and salt attack, so that they sacrifice themselves over time and thereby protect the masonry itself from decay. Repointing is cheaper and simpler than replacing decayed bricks or stones, and loss of the original stone or brick will also have a far greater impact on the historic integrity of the building.

Repairing mortar joints is critical; like the roof, they are a first line of defence in preserving the building.

When repointing a wall the mortar joints should always be weaker than the strength of the stone or brickwork. Repairs to mortar joints must match the colour, finish and mix (the cement: lime: sand ratio) of the original mortar joints in order to maintain the integrity, appearance and physical properties of the wall.

This is specialised work and should be undertaken only by someone with appropriate knowledge and experience. Always have small samples done for approval before allowing the work to proceed.

Ledges and projections

Decorative stone mouldings, such as cornices or parapets, should be closely inspected to ensure

Mortar has been eroded from the joints in this stone cornice by the penetration of moisture through the top surface. Failure to repoint the joints has caused considerable damage to the stone either side of the joints. The damage is a form of salt attack due to air movement through the open joints in the presence of salts (from bird droppings for instance)

that the mortar between individual pieces of stone, particularly the vertical mortar joints, is intact. Even minor cracking or a small loss of mortar between the stones can result in rainwater penetrating into the masonry and causing delamination (deterioration of successive layers) of the stonework and structural weakening of the wall.

Repair techniques

Damaged stonework can be repaired by resurfacing individual stones if the depth of erosion is moderate. This technique is sometimes referred to as 'synthetic stone' and involves using a carefully chosen mortar mix to approximate the colouring and texture of the original stone. It is more successful with stonework that has a noticeable colour variegation. Brickwork and evenly coloured stonework are not as successfully repaired by this method because the repairs are too readily apparent.

In cases of more severe damage, it may be necessary to dig out and replace individual stones or bricks with matching ones. If the condition of the stone or brick has deteriorated to such an extent that it crumbles like powder, then clearly it should be replaced with new stone or brick to match. Again, it is critical that the cause of the problem is identified and rectified prior to repairing damaged stonework.

3.4 Woodwork

Timber in buildings is highly susceptible to decay if it is not properly maintained. Termites, borers, other insects and fungal rot can attack the structural and decorative timber of a building, resulting in its eventual destruction.

There are three things that the building owner can do to preserve the timber in the building. These are:

- ***Inspect the building*** at least every 12 months for signs of termites or borers. If evidence of activity is found, a qualified pest exterminator should be engaged.
- ***Keep the timber dry***. Wet timber promotes fungal attack or rot as well as creating an ideal environment for termites. Prolonged dampness of the timber must be avoided.
- ***Repaint timber surfaces*** regularly to protect them from the entry of water.

Inspect external joinery such as timber windows and doors for breakdown of the painted surface. Pay particular attention to the joints between individual pieces of timber, checking whether looseness in the joint is allowing the entry of water, or if rot is evident. Check paintwork for peeling, flaking, blistering or mould growth.

Repairing timber may simply involve cutting out the damaged or rot-affected wood and using an appropriate timber filler, or may require fitting in a new section of timber. New timber should match the size and profile of the original. Ensure also that joints between old and new timber are thoroughly prime painted to seal the timber.

Check the ends of timber beams, fascias and barge boards. The end grain is highly water-absorbent, and premature damage here is common.

Timber should not be in contact with the ground unless treated with suitable preservatives (eg CCA treatment used for PermaPine). Where this is unavoidable, check regularly for signs of termites.

Painting

Detailed advice on repainting can be found in DEH Technical Note 3.7 *Painting of Older Buildings in South Australia*. This publication covers an historical perspective, the performance of various traditional and modern paint coatings, the requirements for effective surface preparation and the approach to defining a suitable colour scheme.

Check the condition of exterior paintwork at least every two years. This is particularly important for painted timber as paint protects timber from moisture absorption and therefore from rot. Deteriorated paint must be removed and the surface primed before repainting.

When painting window sashes and doors, open and close them daily for the first few days to prevent them becoming stuck. Acrylic paints are not recommended for any moving parts like doors and windows, because they are prone to sticking even when fully cured. Enamel paints should be used instead.

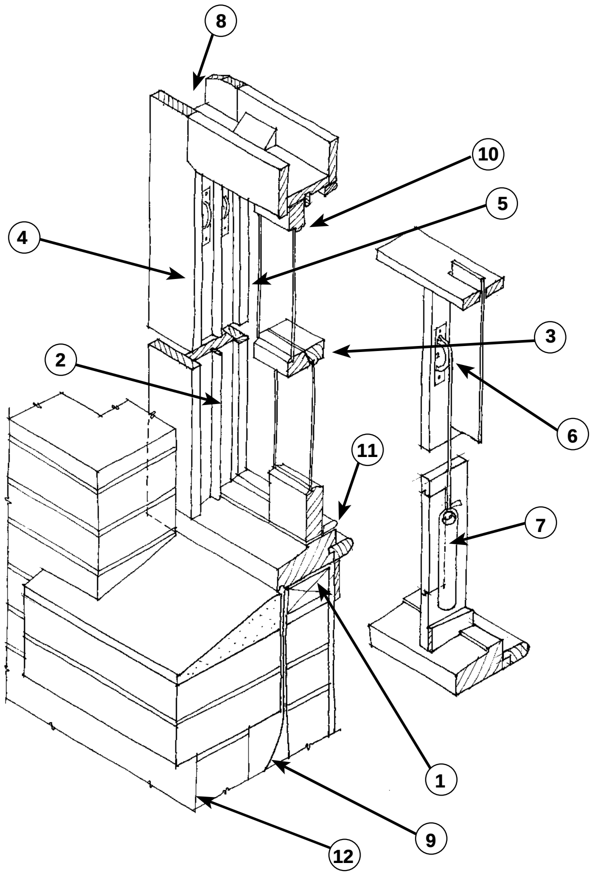
Avoid build-up of numerous coats of paint on moving surfaces; rather let the top surface wear away before re-coating.

Windows

Timber windows

The majority of historic buildings have timber windows. The most common types are the casement (side-hinged) and the double-hung window (vertically-sliding sashes with concealed counterweights). Properly maintained, timber windows have an indefinite life, but are susceptible to rapid decay if not adequately protected from moisture.

Peeling of paintwork is allowing rapid moisture damage to the window frame.



Typical timber double hung sash window - Portion of frame cutaway view

1. Cill & Drip	7. Counterweight
2. Parting Bead	8. Pocket for Weights
3. Meeting Rails	9. Flashing
4. Outside Lining	10. Top Sash
5. Inside Lining	11. Bottom Sash
6. Pulley	12. Cavity Brick Wall

The Australian Carpenter - C Lloyd Macmillan and Co, Melbourne 1951

The maintenance of timber windows requires attention to the following:

Hardware

Check that window hardware (such as locks and latches, hinges on casement windows and pulleys on double hung windows) works effectively and is sufficiently lubricated. Use machine oil or grease on pulley spindles and locks, and oil on hinges and latches. 'Dry' lubricating sticks are good for surfaces such as lock striker plates where contact with clothing might be a problem.

Remove hardware from doors and windows when re-painting - this makes the painting job easier, and it avoids paint build-up on these components which affects their operation and is detrimental to the appearance of the room as a whole.

Window sills

The external sills on timber windows are particularly vulnerable to weathering, and paint usually cracks or flakes here first. Sills should have a sufficient outward slope to shed rainwater. There should always be a 'drip' - a small groove underneath the front edge of the sill - running the full width of the window to prevent water running back underneath the sill and causing wood rot or masonry dampness.

Sash operation

Check that double-hung windows slide easily - care is required in repainting to prevent build-up of paint thickness where the sashes slide in their channels. Rubbing soap on the moving surfaces will help.

Try moving double-hung sashes back and forth to see if they rattle excessively - this can be remedied for the bottom sash by adjusting the position of the bead forming the inner edge of the vertical channel.

If the fit and operation of the sashes cannot be readily fixed, it is advisable to approach a joiner experienced with double-hung windows. Their construction is quite complex and it is easy to cause inadvertent damage.

Parting beads

Inspect the fine timber beads separating the upper and lower sashes in double-hung windows to ensure they are intact and not split.

Putty

The putty holding the glass in the timber window frame must be intact and provide a good seal. Linseed oil putty is subject to rapid oxidation from exposure, and must be painted to prolong its life. When painting the putty line, carry the paint over onto the glass by a few millimetres to properly seal it.

Sash cords (not on diagram)

These hold the counter-weights on double-hung windows, and their condition should be checked periodically - look for thinning of the diameter of the cord, which indicates that it is stretching and approaching the end of its life. Replacement is a specialised job requiring a detailed knowledge of the construction of this sort of window - unnecessary damage can be caused if this work is undertaken without suitable experience. Avoid getting paint onto sash cords when repainting, as this stiffens and weakens them.

Structural integrity

Push and pull on the frame to ensure that it is soundly fixed within the wall. Seek advice from someone experienced in this sort of work if there is any looseness or movement.

Repainting

For the best result, remove sashes from their frame when windows need repainting. Carry out any repair work and glazing before painting. As mentioned earlier, oil-based (enamel) paints should be used on windows, as acrylics have a tendency to stick moving components together even when fully cured.

Metal windows

Metal-framed window assemblies in historic buildings are usually associated with twentieth century commercial and industrial premises. On rare occasions however, examples of nineteenth century cast iron windows are found.

Metal windows are generally of casement design (hinged outwards on pivots at the top and bottom corners of the sash) but hopper types (hinged along the bottom edge to open inwards) and awning types (opening out from the top edge) are also encountered.

Steel was used generally for industrial and residential applications, while more expensive metals such as bronze were the norm for prominent commercial and public buildings. Bronze windows are normally unpainted, and care should be taken to avoid damage to the original patina, or the temptation to polish them to a bright finish.

General maintenance requirements are similar for all metal windows, but protection from corrosion is particularly important with steel. Cast iron is inherently more corrosion-resistant than steel, and although intended for a protective and decorative paint finish, can survive relatively intact over long periods of neglect.

Pay attention to the following points:

- keep pivots and stays well lubricated to avoid rusting and binding - if moving parts are seized, try repeated applications of a penetrating oil (eg 'Penetrol' or 'WD40')
- prevent rusting of steel frames and sashes with regular repainting - good preparation and the use of suitable primers and anti-corrosion products is important
- check the condition of the putty and replace when it loses its flexibility and begins to crack - paint protects putty from oxidation, so the putty on unpainted windows will consequently have a shorter life.

If rust damage has occurred through inadequate maintenance, prompt action is required. Once corrosion has started to swell and flake the steel apart, repair becomes more difficult. In severe cases it may be necessary to cut out the damaged section of the sash or frame and weld in a new piece.

3.5 Verandahs and balconies

Verandahs and balconies are important elements of historic buildings. They help define architectural style and aesthetic qualities. They also have a physical role in moderating environmental conditions between outside and inside as well as adding to the amenity of use that the building affords its inhabitants.

Yet they are perhaps the most neglected component of many buildings, often being allowed to fall into disrepair. Paradoxically, they are also one of the most maintenance-intensive parts of a building. If ever there was a case for early intervention to prevent a relatively simple problem developing into something major, it is the verandah or balcony.

We have again begun to appreciate their merits, but many verandahs and balconies were lost altogether in less enlightened times between the 1950s and the 1980s.

Structure

Posts

These will typically be either of timber or cast iron. Other less common types are reinforced concrete or wrought iron.

Timber posts are most at risk from rotting at the base, but if adequately protected they are remarkably durable. Where posts are set directly into the verandah floor, or paving has been built up around them, the usual result is gradual subsidence as the ends of the posts rot away. It also exposes them to the risk of termite attack.

Good protection is afforded by the decorative metal shoes that raise the post ends clear of the ground, but where these were not originally used, it may not be historically or visually appropriate to fit them. Instead seek advice on having a concealed bracket fitted to solve the problem unobtrusively.

The routine maintenance requirements of timber posts vary according to their design. Simple styles such as the square chamfered type or turned posts will generally need only regular painting to keep them in good order. Complex designs with decorative collars or capitals and moulded skirtings will require more frequent and intensive attention to ensure that the joints do not begin to open up and admit moisture. These elements will deteriorate rapidly once this happens, and timely repairs will avoid the expense and loss of historic integrity of having to reconstruct them.

Metal posts can be of several types, the most common being cast iron. The suitability of this material for highly ornamental designs was well exploited in Victorian and Italianate architecture, but simpler examples can be mistaken for timber at first glance. The durability of cast iron posts is generally good, and maintenance of the paint finish is normally sufficient to keep them in good condition, but there are a few points to watch out for:

- Decorative capitals are often moulded from a softer material such as zinc or lead, and fixed as four separate pieces around the cast iron shaft. Because the capital tapers outwards, the V-shaped cavity remains filled with mortar. The top surface of the mortar filling is sloped to shed water away from the shaft, but if it is not kept sealed and water penetrates, the gradual corrosion of the iron will push the assembly apart.
- Some post designs have collars at the base that fit down over a bolted base plate. If moisture is able to penetrate into the cavity, a problem similar to the above will result. Again make sure that gaps and joints remain sealed, and that surface water does not collect around the base of the post.
- One of the technological sophistications incorporated into some designs was to make use of the hollow core of the post as a downpipe. These are easily recognised by the spiggot that projects at an upward angle near the top of the post to which the gutter discharge is connected. A second spiggot at the base of the post directs the water onto the ground.

  The downfall of this system is the small diameter of the spiggots. Blockage is inevitable, and the resultant conditions of extended dampness give rise to fairly rapid corrosion of what is otherwise a relatively rust-resistant material.

  The usual solution to this problem is to bypass the built-in system with external downpipes. These however are often a visual compromise, and great care is needed to locate them unobtrusively.

There are occasional examples of very slender posts forged from wrought iron. These are solid in cross-section, and the natural resistance of the pure iron to corrosion means that anything more than surface rust is rarely a problem. As with other types of metal posts, keep the paint finish in sound condition for maximum protection.

Another variation is a patent metal post with an iron pipe constituting the structural core, sheathed in a moulded decorative casing formed from zinc or sheet metal.

Roof structure

Many verandah roofs in South Australia have no roof framing, as the corrugated metal sheets span directly from the wall plate out to the fascia without intermediate support. Wider verandahs, or those with other roofing materials, will have some minimal timber framing, but its maintenance is essentially the same as for the framing of the main roof (refer to Section 5.2).

Flooring and floor structure

Common types

The floor structure of a verandah most commonly comprises a low stone retaining wall with an in-fill of compacted rubble and a thin slab of unreinforced lime concrete overlay. This may be finished smooth or used as a base for a tiled surface.

Balconies normally employ a timber-framed floor structure of beams projecting at right angles to the wall, onto which are set joists running longitudinally topped by timber floorboards set laterally. It is also not unusual with rural buildings, particularly where the floor level is set more than a couple of steps above ground level, for the verandah floor to be similarly framed.

Problems and how to deal with them

Structural problems encountered with slab-on-fill construction usually arise from the very shallow footings (or complete lack of them) under the retaining wall, and the absence of reinforcement in the slab. As long as soil moisture is kept at a relatively stable level year-round, these design aspects may not cause any problem. However, when the balance changes for any reason (paving alterations, blocked gutters or downpipes and so on), the structure is unable to resist any resulting soil movement. The end result is cracking and dislocation of the verandah floor.

In cases of mild damage, pay attention to getting the soil moisture balance back under control, and then repair the floor in accordance with good conservation practice. Where the problem is more severe, it may be necessary to reconstruct the verandah floor, using adequately reinforced concrete footings and including some light reinforcing mesh in the slab. If the work involves re-laying historic tiles, ensure they are bedded in a weak lime-based mortar - there is little to be gained (and much to be lost) by using a strong mortar. The weak mortar will absorb any minor movement in the slab and act as a buffer between it and the tiles. It will also mean they can, if necessary, be more readily lifted, cleaned and re-laid at some future date. With a strong mortar this is usually impossible.

Timber-framed floor structures tend to remain in good condition for many years, as long as the floor boards are capable of keeping water out. Eventually the outer ends of the boards begin to rot and moisture infiltrates to the ends of the main beams where they connect with the fascia beam. Once this stage is reached, deterioration can be rapid. The floor structure can also be put under considerable stress by subsidence of the posts.

At the first line of defence - the floor surface - repair of the boards usually entails cutting out the damaged ends and replacing with matching new sections of board. The most expedient method, although not the most preferred in terms of visual and historic integrity, is to cut through all the boards in a straight line at 90 degrees to their length, locating the cut at the first joist in from the edge (or the second if the rot has progressed further). Trimmers are then fixed across from the joist to the outer edge and new boards laid at 90 degrees to the original.

The preferred method is to take up all the boards and to cut them to two different lengths corresponding with two adjacent joist positions. They can then be re-laid in an alternating pattern so that the joints are staggered. This retains a good amount of original fabric for historic reasons and keeps the boards all running in the right direction, while avoiding an unsightly continuous straight joint.

Many timber balcony floors have at some stage been sealed with a membrane such as malthoid. Consider laying a new membrane to increase the life of the whole structure and to reduce maintenance requirements. Modern high-performance membrane systems can closely replicate the appearance and character of their earlier counterparts.

If installing a membrane, it may be acceptable in some cases to carry out repairs with waterproof particleboard sheet flooring without compromising historic integrity. The Heritage Branch, or your local Heritage Adviser, can offer advice on this.

Roof

Maintaining the roof of a verandah or balcony is essentially no different from the main roof of the building, and reference should be made to Section 3.1 for general advice on what to look for. In some ways they are more straightforward - for instance there is usually no ceiling lining, and problems can be more readily spotted. However, there are some peculiarities which merit special consideration.

The roof covering

Corrugated sheet metal is certainly the most prevalent roofing material for verandahs and balconies. Early materials such as thatch, shingles or bark have usually been replaced long ago with corrugated sheet metal, but slate or terracotta tiles will still be found on the verandahs of buildings where these are the main roofing materials.

A corrugated sheet metal roof on a verandah or balcony will often outlast a building's main roof. Examples of corrugated sheet metal roofs reaching the end of their life after perhaps 100 years or more in service are not uncommon, while the verandah sheeting of the same vintage remains in good sound condition.

This is principally due to the absence of end laps - verandah sheets invariably span in a single length from wall to fascia.

Gutters and downpipes

Both gutters and downpipes are often of a smaller size for aesthetic reasons, which increases their susceptibility to blockage. Balcony gutters can be difficult to reach safely, which also affects their maintenance.

However, it is still important to keep them clean to prevent blockage and overflow, which in turn will protect the timber structure from damp and rot.

Ceiling linings

It is common to find balcony floors lined underneath with materials such as timber matchboarding or fine-fluted corrugated sheet metal. Keeping this lining in good condition is dependent on the ability of the flooring above to seal out water.

Balustrading and trim

Timber

The outer edge of the verandah or balcony is the most exposed to the weather, and therefore the most vulnerable to wetting and rot. To compound the problem, timber balustrade panels and other decorative features tend to comprise numerous small pieces with many joints. The most important maintenance task is to keep them well painted so that the joints are sealed and able to keep moisture out.

Closely inspect these joints annually and touch up frequently. This is far more cost-effective than eventual replacement

Wrought iron and cast iron

As previously explained, old cast iron and wrought iron possesses a naturally low tendency to corrosion. Although a surface layer of rust forms, it does not generally penetrate deeply except under very adverse conditions. Keep it in the best possible condition with regular painting or touch-ups, but pay due attention to the timber work it is fixed to. Iron panels can become loose and at risk of falling if the timber at the fixing points deteriorates.

3.6 Paving and landscaping

The landscape elements surrounding a building can be considered from two different points of view - their direct physical impact on the fabric of the place, and their contribution to the aesthetic qualities of its setting.

For the purposes of this publication, the physical issues are given greater emphasis, but it is important to understand the aesthetic context if the cultural value of the place is to be properly respected and conserved.

Where the setting of the place contains original elements, they will invariably add to its meaning and value. Maintenance of the place will mean caring for these as much as for the building or structure itself.

Elements that are not original, or that do not directly relate to the history or significance of the place, may nevertheless make a positive contribution to understanding and interpreting it, by reinforcing and supplementing the value of the place as a whole.

A landscape, setting or garden may even have historic value in its own right, which might be recognised by a separate heritage listing.

Other elements might actually degrade the setting or work against an understanding of the significance of the place.

Consider carefully the status of different elements, and how they contribute to the cultural value of the place. Detailed information on understanding historic settings can be found in DEH Heritage Guidelines 2.4 *Gardens in South Australia 1840-1940*.

Take the time to inspect the condition of landscape elements such as plantings, paths, paving and retaining walls, and determine what influences (positive or negative) they might be having on the building or structure.

Before you consider making changes to the setting, ensure that you understand how it relates historically, aesthetically and physically to the significance and cultural value of the place

Paving

The presence of paving around a building's perimeter can help to control the wetting and drying of the soil in the footing/foundation zone, thereby reducing the incidence of structural cracking in reactive soils and perhaps rising damp as well. Refer also to Section 6.

Precautions

To identify problems which may relate to paving in close proximity to the building, or if considering laying new paving take into account the following:

Damp proof course - Paving should be kept below the level of the damp-proof course where one exists, ideally by at least 10 cm. Avoid bridging an existing damp proof course when laying new paving or planning new garden beds. Refer to Section 6.3 for assistance in identifying old damp proof courses, as they can often be masked by later work or repointing.

Ground level build-up - Over time, considerable build-up can occur as new surfaces are laid directly over old. This incremental raising of the ground level is easy to detect in buildings with suspended floors by looking for encroachment over sub-floor vents, but with other construction types you may need to look a little harder. Excavating a small area to search for earlier finishes and levels can be very revealing.

Where raised ground levels are causing damp problems, consider excavating back to the original level.

Surface water - Paving should be graded away from the wall of the building, with a positive cross-fall of at least 1 in 20. Generally speaking, it is satisfactory to allow run-off from paving to soak into the ground as long as the width of the paving is at least 1.2 m and the run-off is evenly distributed. Where a concentration of water occurs, it may be necessary to install a drain to carry away the excess.

Concrete paving - Poured concrete paving (that is, concrete laid wet) should generally be avoided around old buildings, as its impermeability prevents the evaporation of excess ground moisture from below. This can increase the moisture load on masonry walls and exacerbate rising damp and salt attack problems.

Materials - To work effectively, paving needs to have some porosity to allow moisture to permeate to the surface where it can evaporate, while still shedding the majority of the surface water. Suitable materials include low to medium-fired bricks and concrete 'cobblestone' pavers.

Slate pieces can be used, but the joints need to have good porosity to compensate for the impermeability of the slate itself. Gravel provides good upward permeability but must be laid on a firmly-compacted base having sufficient cross fall to shed surface water quickly and effectively.

The paving base - Attention must be paid to the base on which the paving is laid to ensure that the entire paving system achieves the necessary qualities of permeability. Use a bed of well-washed coarse sand screeded to the correct levels, having first made sure the underlying ground is well compacted and stable. Avoid laying a concrete base or using a plastic membrane under the paving.

Garden beds and plantings

Over-watering and under-watering of the area around a building can cause problems with cracking and rising damp (refer to Section 6). This is of particular concern for buildings on clay soils because of their pronounced shrinkage/swelling characteristics.

The aim is to maintain constant soil moisture content in the footing/foundation zone.

Automated irrigation

The growth in popularity of automatic watering systems in recent years can potentially assist in the control of soil moisture content, particularly during long dry spells, provided the watering program is carefully set according to season and rainfall.

Automatic systems should be routinely checked for optimum operation and condition. They are often set to operate at night or when no-one is likely to be around, and problems with leaks, component failures and sprinkler spray patterns can go undetected, with the potential to cause serious building damage and considerable water wastage. A watering system should not be regarded as a 'set and forget' installation, but should receive ongoing attention to its condition and the programming of watering cycles.

Sprinklers

Make sure that sprinklers close to buildings are positioned to avoid wetting the walls. This is particularly important in the design and installation of automatic watering systems.

Gypsum

The heavy clay soils prevalent on the Adelaide Plain respond well to the addition of gypsum, which breaks down the adhesion between the clay particles and improves the structure and workability of garden soil.

However, it should not be used near buildings with porous masonry footings and walls. It is readily dissolved by soil moisture, and can significantly increase the salt concentration already existing in the natural groundwater. It therefore has the potential to increase the risk or severity of salt attack in masonry.

Creepers

Creepers and other aggressive wandering or clinging plants should be kept clear of buildings. They will ultimately work their way into small cracks and gaps between different elements of the building and literally push it apart!

Trees

Damage by trees

Trees or large bushes close to buildings can cause structural distress to buildings, particularly those with shallow unreinforced footings, by two means:

- ***moisture extraction*** - Trees' peak demand for moisture typically coincides with the period of maximum soil dryness at the end of a long, hot South Australian summer. The two factors combined will magnify the problems already associated with the shrinkage of reactive clay soils, and the results can be particularly damaging.
- ***root growth*** - The physical increase in the girth of tree roots as they grow can be sufficient to heave shallow footings upwards or to push sections of a wall apart by penetrating a crack. This effect can work in combination with moisture damage as described above, when water-starved trees seek out the moister soil under buildings.

Significant trees

Before considering what action to take when a building is suffering damage from nearby trees, first establish whether there is any heritage significance attached to them. This will have a considerable bearing on the right course of action. A tree may be significant in its own right, belong to a significant garden, or contribute to the setting of a heritage place in a way that enhances or complements its significance.

In addition to a tree's potential cultural or botanical significance, the *Development Act 1993* identifies trees as significant in relation to their trunk girth and height. Development Control applies to the felling or trimming of trees over certain sizes, with different classifications for native and exotic species

Development Approval is mandatory for any work affecting or potentially affecting a protected tree, with the exception of light pruning. Check with your local Council.

Choice of trees

Select suitable trees and plants for growing near buildings. As a general rule, a tree should not be planted closer to a building than a distance equal to its mature height, or to 1.5 times this height if planted as a group.

In the case of existing plantings, identify the type of trees growing around the building in order to determine if their growth could cause damage in the future.

Tree management

If there is no sign of structural distress to walls, well-established, fully-grown trees close to buildings are best left alone. Monitor their condition to determine any changes in their health.

Seek expert advice if a large tree is to be removed, as the sudden cessation of the tree's moisture draw can cause a rebound effect and result in soil heave as the moisture balance in the soil adjusts to a new equilibrium.

Supplementary watering

One method of managing the adverse effects of a large or growing tree is to provide it with additional water to encourage its roots away from the building. Several pits can be drilled at strategic points around the root zone and backfilled with coarse gravel or rock, topped with sand. During the dry season, give these watering points a periodic deep soaking. Seek professional advice before excavating to avoid damaging the tree's root system.

Cut-off trenches

Another method of root control is the cut-off trench. A deep narrow trench is dug between the tree and the affected building, extending laterally and vertically beyond the root zone. An impermeable barrier is installed into the trench - concrete or heavy-duty plastic sheeting can be used. The barrier isolates the footing zone from the tree's root system.

These trenches are sometimes installed by local Councils where street trees are affecting building frontages close to the boundary. Again seek professional advice, both on the ability of the tree to withstand the loss of some of its root system, and on the engineering aspects of the barrier.

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4. The Building's Interior

What to look for on the inside

4.1 Floors

The most common type of floor in old buildings is the suspended timber floor - floorboards on a timber frame, supported clear of the ground. Refer to Section 5 for further information on the sub-floor space and structure.

Other floor types which may be encountered, particularly in buildings dating from the earliest days of settlement in South Australia, include:

- ***earth floors*** - rammed or compacted earth with a binder such as lime, ashes, cow dung or blood, finished to a hard, smooth surface
- ***wood block floors*** - a floor surface formed of durable timber sections. Two typical formats are short lengths of Native Pine (*Callitris*) set vertically in the ground with the top surfaces finishing level; and *Eucalyptus* cut into large rounds and laid in similar manner to paving stones
- ***wooden slab floors*** - wide slabs or boards laid on timber battens directly on the ground
- ***paved floors*** - stone flags (eg slate), stone or bricks laid directly on the ground.

Concrete floors may also be found, typically consisting of unreinforced lime concrete about 100mm thick, laid directly on the ground or on a rubble base.

Tiled floors are common on verandahs, in the entrance halls of substantial houses and in public and institutional buildings. These are generally laid on a base of building rubble topped with lime concrete.

Terrazzo became popular from the 1920s onwards - this is essentially a concrete floor, but using carefully chosen aggregates and pigments to achieve the desired colour and pattern when the surface is ground and polished. Borders, inlays and patterns of different colours were sometimes introduced, separated by brass strips.

For information on the repair and maintenance of any of the above types of floor, contact the Heritage Branch or your local Heritage Adviser.

Suspended timber floors

Problems beginning to develop in the sub-floor can, in many cases, be detected from above. Symptoms might include:

- ***cupping*** of the floorboards (curling up at the edges)
- ***squeaking*** or creaking under foot traffic
- ***weakness*** in the floorboards (excessive bending, loss of stiffness or actual failure)
- ***sagging*** or arching of the floor surface (whole floor or large sections out of level)
- ***bounce*** in the floor surface (moves up and down under foot traffic).

For advice on identifying and repairing these faults, refer also to Section 5 1.

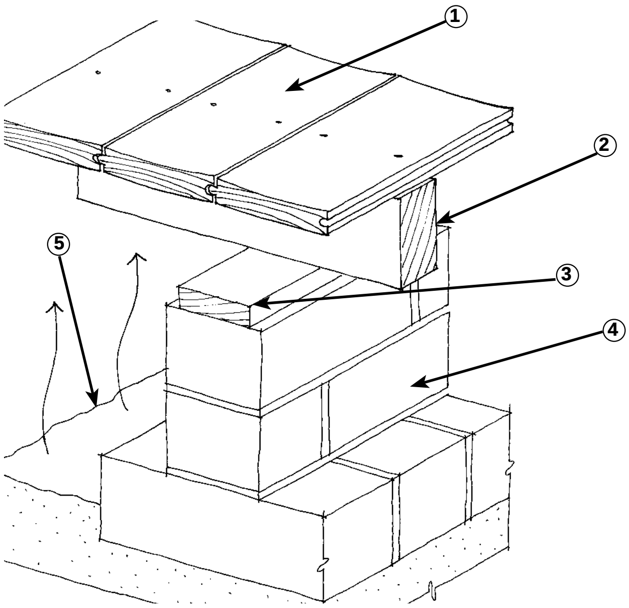
Cupping

If the surface of the floor becomes ridged because the boards have curled upwards at the tongue and groove joints, this indicates that excessive sub-floor humidity has caused the underside of the boards to expand. Because the upper surface is drier, the boards curl.

The first step is to identify and fix the cause of the sub-floor problem (refer to Section 5.1). Only then can repair of the floor surface be attempted.

The floor should not be sanded to achieve a more level surface. This will permanently damage the floor because the sanding machine will attack the raised edges of the boards and remove considerable material before it reaches the central section of the board. Once the tongue and groove joint is weakened and starts to split away, the floor is damaged beyond repair.

Cupping can be reduced quite effectively, once the boards have dried out from underneath, by



Cupped Floor Boards
1. Tongue and Grooved Boards
2. Hardwood Joist
3. Plate
4. Dwarf Wall
5. Soil Moisture Humidifies Sub-floor

wetting the surface down with kerosene and re-nailing them. The kerosene expands the top surface, thus tending to straighten the board, but evaporates readily. As the surface dries out again, the boards are held in place by the re-nailing. This method should only be undertaken by a trained professional.

After re-nailing, the floor can be prepared for refinishing as outlined in 'Alternative finishes' and 'Patina and age'. If a floor covering is to be used, first install a tempered hardboard underlay to provide a level surface. This is also an option when the cupping cannot be successfully reduced to the extent desired for a bare, polished surface.

Squeaking floorboards

Floors that squeak or creak when walked on indicate that movement is occurring at the joints between the boards. This is generally caused by long-term shrinkage of the boards, drying out after a period of being damp, or loosening of the nails.

The simplest remedy to try is puffing some talcum powder into the joint to lubricate it. If this is not enough, re-nailing that section of the floor will usually work. If the noise is caused by the boards bending because they are too thin (either from excessive sanding or sub-standard original construction), seek professional advice on the best remedy.

Traditional finishes

An important part of maintaining a timber floor is the choice of finish and the cleaning routine. Traditional floor finishes such as waxes, japans and varnishes provide a renewable wearing surface (see Section 6.1; Housekeeping) as well as sealing out dirt and moisture. Keeping the protective finish in good order and avoiding excessive wetting of the floor will greatly extend the life of the floorboards.

Polyurethane finishes

The popular practice of using modern polyurethane floor finishes to replace traditional finishes is unsuitable for floors in historic buildings where the objective is to prevent damage to the floor and extend its life as far as possible. The problem is two-fold, with long-term damage to the floor because:

- the initial sanding of the floor back to clean new wood significantly reduces the thickness and structural capacity of the floorboards (particularly if the boards are slightly cupped) and
- when the finish begins to wear through, re-coating of the floor can only be done on clean wood - this requires the whole floor to be re-sanded each time to remove the previous coating.

Even if the floorboards have sufficient thickness to survive the initial more aggressive sanding operation, the use of a polyurethane finish will eventually reduce the thickness of the floor to such an extent that strips of timber will start to split away at the joints. Once this occurs, the floor is beyond saving.

Alternative finishes

In situations where the floor is subjected to heavy use and a traditional finish is considered too labour intensive, there are modern alternatives that can be readily patched and re-coated. Increasingly popular on new and old timber floors are products based on tung oil, a natural tree resin which dries to a hard glossy surface. There are also wax/acrylic emulsions available that are far more wear-resistant than traditional waxes without requiring constant maintenance.

Patina and age

Some modern products share with traditional finishes the quality of allowing the feel and texture of the timber to be appreciated, in contrast to polyurethane finishes which give the timber the appearance of being coated with a thick layer of plastic.

In deciding which product to use, carefully consider the character and visual qualities of the floor. Usually the historic value of the floor and of the room are enhanced by allowing the floor to retain its patina and the evidence of age acquired over many years. This approach calls for the minimum preparation of the surface before re-finishing, and an acceptance of blemishes and marks as an integral part of the history of the place.

Sanding back to clean timber removes years of accumulated evidence, and markedly alters the character of the floor, inevitably leaving it somewhat sterile.

Limit preparation to light sanding with a hand-held machine, following the contours of the floor, rather than trying to achieve a perfectly level surface.

Another option is to use nylon scouring pads (eg ‘Scotchbrite’) which can be bought as discs suitable for use on a rotary floor polisher. This method also has some ability to follow the floor’s contours, and cleans up the surface with minimum removal of timber.

4.2 Walls

This section advises how to identify wall problems when inspecting the interior of a building, including the inside faces of a building's outer walls. Section 3 covers problems typical to external walls as seen from outside.

Types of wall construction

Typical materials for external wall construction in South Australia are described in Section 3.3. A number of these will also be found internally, including:

- ***masonry*** (stone and brick)
- ***fachwerk***
- ***lightweight construction***, with lining materials such as corrugated sheet metal, matchboarding, compressed fibreboard (eg Caneite) and fibrous cement ('fibro')
- ***wattle and daub***
- ***earth construction*** (adobe, pisé and rammed earth)
- ***hard plaster***

Maintenance issues are essentially as described for the equivalent external wall construction.

Fibreboard is a fragile lining material requiring special attention because of its particular susceptibility to dampness. If a moisture problem is not attended to promptly, considerable damage can be done through mould growth, swelling and softening. It is also easily damaged by physical impact.

Corrugated sheet metal cladding can suffer from dings and dents over the years, and should be repaired with matching second hand or new iron, rather than replacing it with plasterboard or some other finish.

Lath and plaster is another form of timber-framed lightweight construction, and is similar in principle to a lath and plaster ceiling. It comprises a timber frame lined each side with closely-spaced timber strips or laths, and covered with hair-reinforced plaster. The plaster is applied wet and brought to a smooth finish. In appearance, this construction is virtually indistinguishable from a plastered masonry wall, but is readily identified by its hollow sound when tapped.

It is commonly found on upper floors where the wall positions do not coincide with ground floor walls. The lath and plaster act as a structural skin over the timber frame, resulting in a wall that is practically self-supporting, despite the considerable weight of the plaster.

Lath and plaster walls are generally trouble-free. Being most commonly found on upper floors, dampness is rarely a concern unless roof or gutter problems are causing falling damp. Like its modern counterpart - the timber or steel stud plasterboard partition - lath and plaster walls are much more forgiving of minor structural movement than are masonry walls, and cracking is generally minor, readily repaired and of no structural consequence.

The problem most likely to affect this type of wall is termite attack. Detection can be almost impossible until major weakening of the timber frame has occurred, but try flexing the wall by pushing rhythmically against it if in doubt. Refer to Section 6.2 for general hints on detecting and dealing with termite activity.

Common maintenance issues

The majority of maintenance concerns with internal walls are those that affect masonry construction, of which the most common are well-known scourges in South Australia. These are:

- ***salt damp*** (the term commonly applied to the combined action of rising damp and salt attack); and
- ***cracking*** of masonry walls.

Refer to the following guidelines, and then to Section 6 for more detailed information on these particular problems.

Dampness in masonry walls

In buildings of masonry construction, internal evidence of dampness is most commonly encountered on the inside face of the external walls, but can also manifest itself on either side of the internal walls. Its presence is normally attributable to three causes - ***rising damp, falling damp*** or ***condensation***.

In addition, if damp patches are encountered in the vicinity of bathrooms, kitchens or other wet areas, there could be faults such as:

- leaking water or waste pipes within the wall
- defective tiling or grouting within shower cubicles, and poorly sealed corner joints
- leaking waste pipes or sewer pipes below floor level.

In some cases, dampness can penetrate directly through an external wall to the inside face. A common cause is leakage from a downpipe joint due to a low-level blockage within the pipe.

Where the ground level outside is higher than floor level, the moisture may be coming straight through because there is inadequate drainage away from the wall or no effective vertical moisture barrier. This is a common problem in cellars.

Etflorescent powdering on wall surface indicates active salt damp attack

Rising damp

Dampness in internal walls (including the inside face of external walls) is most commonly experienced as staining or damage of the plaster finish, due to the presence of moisture rising up from the ground into the porous masonry.

Commonly in South Australia, the rising damp will be accompanied by salt attack, which is characterised by a white powdery deposit on the wall surface and bubbling or powdering of the plaster.

The presence of rising damp, with or without salt attack, indicates a dampcourse problem. This is discussed in more detail in Section 6.3.

Falling damp

As the name implies, this is dampness due to moisture coming from above. It is identified by damp patches forming on the ceiling or upper parts of the wall and is usually the result of overflow in the roof drainage system, a leaking roof or ineffective flashings. These problems relating to the building's exterior are discussed in Section 3.1.

Condensation

There are several contributory causes to the presence of condensation on the surface of the wall, and their influence relative to each other will vary from one situation to another:

- ***humidity*** - warm, humid air is generated from sources such as a hot shower or bath, and un-flued gas room heaters. The quantity of moisture being generated can sometimes be lowered by, for instance, modifying showering habits or changing the type of heater.
- ***ventilation*** - a low rate of air change within a room allows the air humidity to rise too high. In older buildings, ventilation is usually the easiest of the three factors to modify - by opening windows or doors, unblocking sealed wall vents or installing an exhaust fan.
- ***surface temperature*** - condensation is likely when the wall surface is cold relative to the air temperature. Technically, condensation will form when the surface temperature is below the dew point of the air. The warmer the air, the more water vapour it can hold.

As the air is cooled, for instance by contact with a colder surface, it reaches a point where the quantity of water vapour (ie the gaseous form of water) within the air can no longer be held, and the excess condenses to the liquid form. The temperature at which this happens is the dew point.

The surface temperature of the wall is affected by the temperature on the other side and the insulating properties of the wall. Masonry walls have a low insulation value, and because in older buildings they are often solid, improving their insulation performance is difficult. If condensation is a problem, reverse cycle air conditioning can help because dehumidification of the air is an inherent part of the heat exchange process on both the heating and the cooling cycles.

Dealing with dampness

Before undertaking any cosmetic repairs to a damp-affected wall surface, it is important to identify the root cause - rising damp, leaking gutter etc - and to remedy this before going any further. There is little point in spending time and money on rectifying damage that can recur.

Cracking of masonry walls

Cracking of masonry walls is common in South Australia and can, in severe cases, lead to extensive and serious damage if action is not taken to stabilise the problem. Even minor cracking internally can unsettle the occupants' sense of the structural stability and integrity of the building, and mar the visual character and appeal of a room.

When to fill cracks

As with other aspects of building maintenance, it is important to identify the cause of any cracking for remedial action to be effective. Avoid the temptation to immediately fill and paint over cracks as they appear, because this will often worsen the damage over time.

Much of the cracking which occurs in South Australia is seasonal - the cracks open and close as the moisture content of the soil changes through the cycle of the seasons. Filling cracks when they are at their widest means that they are unable to close again as the cycle progresses, and the wall will be literally 'jack-knifed' out of alignment as it tries to close up again. With the next dry season, the crack will re-open and the cycle begins again. With repeated filling over time, the misalignment of the wall can become far greater than what would have occurred with simply the annual movement.

Only after the cause has been correctly identified and steps taken to manage the problem should patching and repair proceed.

The most effective way of identifying the cause of cracking is to record changes in the pattern and width of cracks over time. This is easily done in the case of plastered internal wall surfaces because any cracking can be readily observed and measured.

The subject of cracking in masonry walls is reviewed in greater detail in Section 6.6.

Plaster repairs

Masonry walls are almost without exception finished with lime render and plaster internally. Attempts to strip away the finish and re-point the wall as an exposed masonry feature will invariably result in disappointment - the lower standard of workmanship and inferior quality stones and bricks used in constructing the wall will prove quite unsuitable. Other imperfections such as chases for wiring and piping will mar the finished result even more.

This approach is also harmful to the historic and aesthetic integrity of the place, and would normally be ruled out for this reason alone.

Interior plaster may require repair due to normal wear and tear or as a result of rising damp, salt attack, falling damp or structural cracking.

Materials for repairs

Note that the lime mortars, renders and plasters used in traditional building construction have a degree of flexibility which enables the structure to tolerate and absorb small amounts of movement without cracking. The cement renders and hard plasters which are now the industry standard are stronger and more brittle - qualities which are taken into account when designing modern masonry buildings with substantial footing systems and the articulation of walls into small panels using control joints.

Their use in the repair of older buildings means an incompatibility in physical properties between the repaired sections and the original construction, and should be approached with caution, particularly if the contractor undertaking the work is inexperienced in the appropriate repair of traditional construction.

In general, repairs to old plaster finishes should be carried out using a lime-based render and set coat, to retain the integrity and performance of the original construction.

4.3 Ceilings

In many instances, old buildings have ceilings of plaster-based construction. The earliest form is the lathe and plaster ceiling, with fibrous plaster gradually taking over from the early twentieth century. Today's equivalent is the paper-faced plasterboard sheet. Other frequently encountered ceiling materials are corrugated sheet metal (commonly the small-fluted 'ripple iron'), timber matchboarding and decorative pressed metal. In the early days of the colony, buildings were often ceiled with stretched canvas or sail cloth, lime-washed for durability and appearance. Hessian or re-used wheat bags were substituted in rudimentary buildings. A lime-washed rope sometimes formed the cornice at the wall junction.

Problems encountered with ceilings may be related to:

- the structure supporting the ceiling - these are covered in Section 5.2
- the materials or construction of the ceiling itself
- indirect causes such as roof leaks or termite attack - refer to the relevant sections of this publication.

Generally

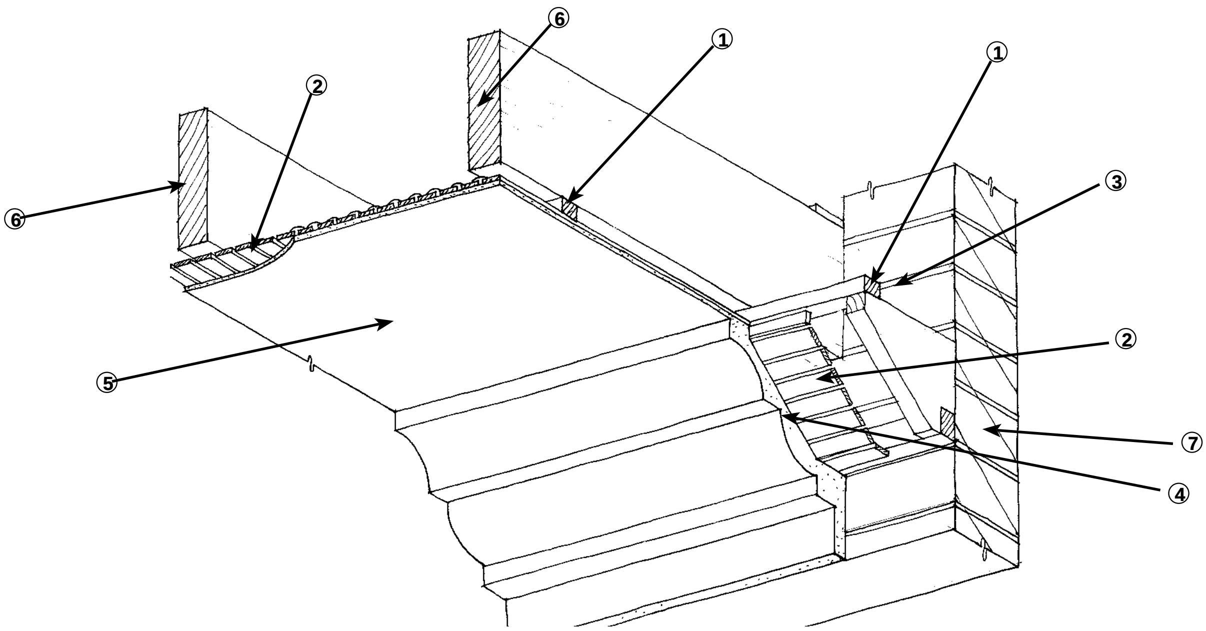
Water damage

Ceilings are highly susceptible to damage from leaking roofs, overflowing box gutters and faulty pipes or water heaters within the roof space. Areas of localised dampness resulting in unsightly staining and perhaps mould growth can be rectified without great trouble. But if damp problems are allowed to persist over a period of time, either through inaction or because they are not readily evident, more serious damage is likely.

Intact examples of early cloth ceilings are very rare, and their preservation depends on constant vigilance to protect them from moisture (which will rapidly rot them) and from damage by nesting birds, rodents and so on. Seek professional advice from a conservation consultant, your local Heritage Adviser or from the Heritage Branch.

The absorption of water by the various types of plaster ceiling will soften the material and cause localised patches to fail. More serious leaks can potentially overload the ceiling to the point of collapse. Plaster ceilings are capable of absorbing large amounts of water, which weakens the plaster.

Metal ceilings have the advantages of light weight and initial resistance to water damage, and structural problems are unlikely. They will however be progressively damaged by corrosion if persistent dampness is not rectified.



Typipcal Lath & Plaster Ceiling with Ornate Cornice

1. Hardwood Branders (Battens) 350c/c Max
2. Split Hardwood Laths
3. Rough Bracket
4. Plaster Cornice Projecting more than 150 formed with running mould
5. Plaster Ceiling
6. Joists at more than 350c/c
7. Brick wall

Lath and plaster

Description

This form of ceiling uses closely spaced timber laths - timber cut or split into narrow strips - to support the considerable weight of the plaster. The laths are nailed up to the ceiling joists, and wet plaster reinforced with animal hair or natural fibres is forced up from underneath. Plaster is squeezed through the gaps and bulges out above, forming a physical 'key' between the two materials. The unevenness and roughness of split (or 'riven') laths assists this bond. The under surface is finished off smoothly.

A central rose was usually formed in place using wet plaster and a metal template, its purpose being to ventilate the room of combustion gases from gas lighting or candles. Decorative cornices were also run in wet plaster in the more important rooms, but it was common otherwise for the wall-to-ceiling junction to be simply finished off square without any form of decoration.

Identifying problems

Old lath and plaster ceilings often show a characteristic pattern of fine surface cracking from long-term sag of the ceiling joists, but may otherwise be in good serviceable condition. When they do fail however, the results can be spectacular. To prevent the damage and disruption of a collapsed ceiling, and to avoid unnecessary loss of historic fabric, it is important to keep an eye on their condition.

Problems specific to lath and plaster ceilings include:

- failure of the plaster at the narrow neck between the laths, causing the plaster to separate from the laths
- failure of the nails fixing the laths up to the joists, resulting in both laths and plaster pulling away from the joists.

Inspection is best done from the top of a ladder, as these faults can be difficult to spot from normal eye level. Looking across the ceiling from just below its surface will clearly show up any sagging. A moderate and even curvature of the whole ceiling from the walls into the middle will often be attributable to long-term deflection of the joists - an inherent property of timber with its natural flexibility - and is of no concern if the joists are otherwise structurally adequate.

If in any doubt about the condition of the ceiling, inspect it from within the roof space to determine the nature of the problem. Refer to Section 5.2.

Fibrous plaster

Description

Fibrous plaster is the term used to describe prefabricated plaster components, as distinct from working with wet plaster on site. It derives its name from the natural fibres incorporated into the plaster for reinforcement, weight reduction and transportability. Common applications in historic buildings include moulded cornices, ceiling roses and ceiling panels (either as plain sheets or decorative moulded panels, used in conjunction with moulded ribs and bosses to cover the joints). Because of its versatility and suitability for prefabricated work it was used extensively to cheaply produce highly intricate mouldings for ceiling work and other decorative elements such as arches, columns and wall niches. In its plain form, as a flat sheet, it was the precursor to modern plasterboard.

By the mid-twentieth century its use for decorative work was declining, but the larger flat rectangular sheets remained popular for low-cost ceilings using plain timber battens over the joints. Its demise was almost total by the 1970s until a flicker of interest began to emerge from the fledging restoration industry, and its resurgence since then has been rapid.

Identifying problems

Fibrous plaster ceilings share with lath and plaster a susceptibility to softening and damage from dampness, the ability to soak up a considerable weight of water and a tendency to pull away from the ceiling joists. The approach to identifying and dealing with these problems is as outlined for lath and plaster.

It should also be noted that the relative thinness of the sheets can result in them sagging under their own weight if the supporting timbers are too widely spaced. The material, despite a relatively high initial resistance to fracture, also becomes quite fragile in its sheet form once damaged or damp.

Ceiling repairs

Lath and plaster

Several techniques are available to re-support lath and plaster ceilings:

- Brass screws with perforated washers can be used with care to re-secure the ceiling to the joists from below
- Fracturing at the neck between the laths can be repaired by removing the broken material from above, cleaning thoroughly and pouring epoxy or new plaster into the gaps to provide a new bond to the old plaster
- Where the nails securing the laths to the joists have pulled away, fibrous strapping soaked in plaster or epoxy can be draped over the joists and bonded to the cleaned top surface of the ceiling.

These are specialised techniques requiring experience for successful application. In some cases, the ceiling can be pushed back into place from below; in others, it is best stabilised in the sagged position.

Areas of localised damage (such as from a roof leak or termite attack) can be readily repaired by applying new plaster to existing laths or filling in with new laths. Expanded galvanised mesh can be used in place of timber laths where the historic integrity of the ceiling is not the primary issue.

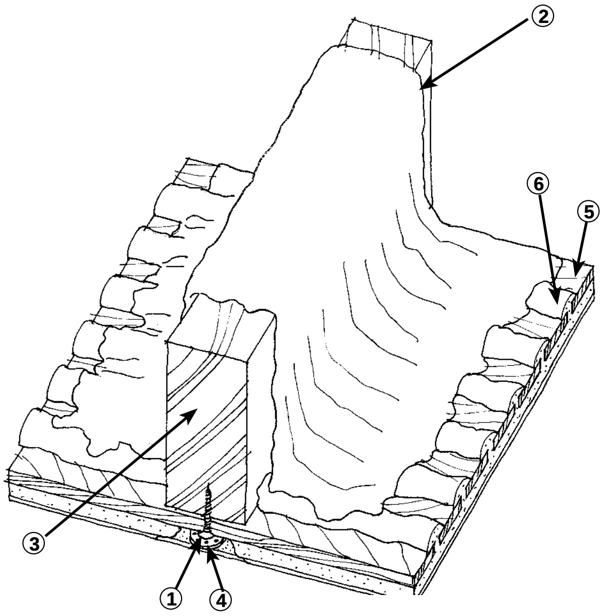
In cases of total collapse, it will normally be acceptable to install a new plasterboard ceiling, paying attention to replicating the original detailing and appearance.

The practice of fixing a new plasterboard ceiling under a damaged old ceiling should be approached with caution, as the extra weight of a second ceiling can overload the joists.

Fibrous plaster

Re-securing fibrous plaster components is generally simpler than for lath and plaster because it is easier to conceal new fixings. Strapping is again useful for re-fixing to joists.

Replacement components are readily available to match many historic patterns, often taken from original moulds. Where unavailable, a reproduction can be made by taking a new mould from an intact component.



Ceiling Stabilisation screwed and looped method

1. Screw with washer fixing from beneath
2. Fibres set in plaster or acrylic resin
3. Ceiling joists – 350 max
4. Laths resecured to ceiling joists using brass screws with peforated washers
5. 25x6 split hardwood laths fixed with galv clouts
6. guaged stuff pricking coat – 1:2:6, plaster/lime/sand and oxhair reinforcing keyed to laths

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Metal ceilings

The need to repair a metal ceiling usually arises from a persistent moisture problem causing rust damage. Having first attended to the source of the water damage, repair of the ceiling itself can be either by treating the rust or if necessary replacing the damaged section.

Consult a reputable paint manufacturer for advice on a suitable preparation, treatment and repainting specification - it is important that the process from start to finish is considered as a complete system, to ensure compatibility between each stage of preparation and each of the products used.

For replacement work, a wide range of pressed metal patterns is available off-the-shelf, or if necessary a mould can be made from an intact panel and new pressings replicated. Corrugated ceilings present no supply problems, but carefully check the exact pitch of the flutes (ie the spacing between one ridge and the next) - it may be necessary to use salvaged material to match the original ceiling.

Historic value

Even with highly decorative ceilings, the ready availability of off-the-shelf and made-to-order components makes replication in all new materials a realistic option where damage is considerable. However, consideration must first be given to the effect the loss of original fabric will have on the heritage value of the room or building. The more culturally valuable the ceiling, the greater will be the effort justifiable in saving and repairing it. Professional advice should always be sought prior to making such decisions. This will assist in the process of gaining the necessary Development Approval for undertaking work on listed heritage places.

4.4 Joinery

The design of interior joinery and its quality of workmanship and finish are important in defining the character of an historic building. Maintaining the integrity of a room's design requires an awareness of its original fittings and finishes, and careful judgment to preserve the essence of its character in the face of changing fashions in interior decoration.

The use of inappropriate mouldings in new or restoration work can easily compromise this integrity. So too can practices such as stripping woodwork back to bare timber and applying a clear finish.

Care is also needed to avoid the 'gentrification' of a plain, simple interior. Avoid the temptation to introduce, for example, more decorative skirtings or cornices, to exchange early ledged and braced doors for panelled doors, to change metal doorknobs to porcelain, or install elaborate light fittings or window furnishings.

Generally

The general approach to maintaining interior joinery and retaining its integrity is to have regard for the following:

- ***Termites*** - Regularly check for signs of termite activity. This can be difficult to spot even when an infestation is quite advanced. See Section 6.2 for advice on what to look out for, particularly with skirtings, doors, windows and architraves.
- ***Wood rot*** - Check for early signs of moisture damage from dampness, such as bubbling of paint or swelling of timber, and take prompt action. Don't forget to include built-in furniture in your inspection.
- ***Original finishes*** - Care for the original finish where this remains intact and has not been overpainted.
- ***Redecorating*** - Avoid removing earlier finishes when redecorating - the various layers are an important record of how the room has changed over time, and contribute to its cultural value.
- ***Reversibility*** - Avoid the use of any new coating which may complicate the possible future removal of non-original layers to reveal the original finish. This concept of reversibility is an important one to keep in mind when making any changes to the interior of an historic building.

Windows

For advice about the care and maintenance of internal and external windows see Section 3.4.

Doors

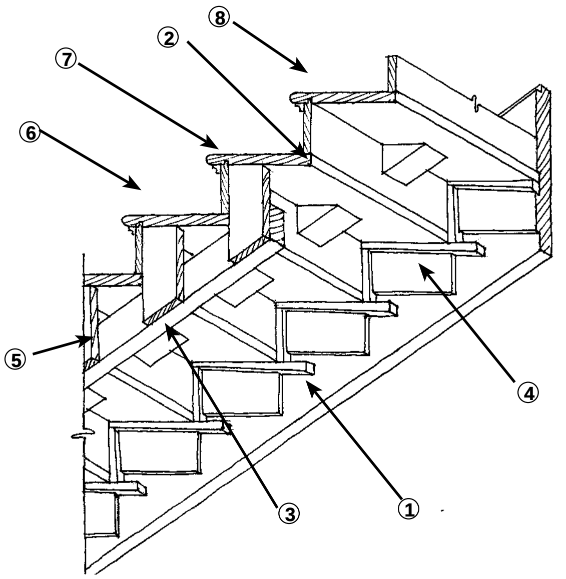
Inspect doors to check the following:

- The door opens freely, and hinges and locks are lubricated and working effectively
- The lock and the strike plate are aligned so that the door closes properly
- The doorframe is square, meaning that the jambs are vertical and the head of the frame is horizontal. An 'out of square' door frame indicates wall movement due to soil subsidence or structural failure (refer to Section 6.4)
- The door frame has not worked loose in the wall opening - to remedy this it is necessary to remove the architraves and rewedge or remake the fixings into the masonry.

Stairs

Timber stairs can range from a simple, open flight to a grand staircase of complex design. Over time, the weight and vibration of people using the staircase, in combination with long-term drying and shrinkage of the timber, can cause movement to develop between the different pieces. This causes the stairs to creak when used, and the rubbing movement in the joints promotes further wear. Re-securing the loose joints will restore the original integrity, preventing creaking and arresting wear in the staircase structure.

Arrange for another person to walk up and down the stairs while inspecting them from below. In many cases a slight movement in the staircase



Timber Stair From Beneath

1. Wedges
2. Blocks
3. String (Wall)
4. Square Blocking
5. Carriage Piece
6. Treads
7. Risers
8. T & G Joint

will be evident, enabling the loose joints to be identified and refixed. Driving a screw into the joint or fitting a blocking piece with screw fixings are normally the most effective remedies, or a purpose-cut timber wedge can be used to tighten the joint.

For anything more than simple repairs, it is wise to seek the assistance of a qualified carpenter or joiner experienced in stair construction. Some forms of staircase in particular require a good understanding of how they were built and how the various components interrelate structurally. This would include stairs with winders (ie climbing as it turns, without an intermediate landing) and cantilevered stairs (having support along one edge only).

4.5 Building Services

Plumbing

Faulty water supply and waste pipes can create enormous problems within a building, particularly as they may go undetected for lengthy periods. Regular maintenance checks are therefore critical.

As a routine measure, periodically check traps under sinks and basins for water tightness, and renew defective tap washers.

Check drain trays under water heaters to ensure that there are no leaks and that any overflow will be piped to the outside.

The materials used in old buildings for plumbing pipe work are typically:

- ***earthenware*** for below-ground sewer pipes and stormwater drains - supplied in short lengths with one end belled into a flange to receive the end of the next pipe, and relying on mortar to fill and seal the joints
- ***lead*** for above-ground waste pipes - malleable lead pipes, with formed junctions and sweated joints
- ***cast iron*** for vertical sewer stacks servicing upper floors, and sometimes as downpipes on larger buildings. Like earthenware, cast iron pipes were cast in sections with flanged joints requiring a caulking compound for sealing
- ***galvanised*** sheet metal for water supply, both underground, built into walls and exposed - in relatively long lengths, threaded at the ends to take a variety of connectors and junctions.

Common problems

Leaks which cause excessive dampness in the soil, the sub-floor or the walls of a building increase the risk of:

- ***termite activity*** - damp soil and damp timber provide ideal conditions for termites to live and feed
- ***rising damp*** - the higher the moisture content of the soil, the greater is the height to which damp will rise in the wall if not intercepted by a damp proof course
- ***salt attack*** - the nitrate salts that make their way into the soil from a leaking sewer are particularly aggressive on masonry
- ***wood rot*** - damp timber provides ideal conditions for the growth of destructive fungal organisms
- ***cracking*** - the clay-rich soils common in South Australia are particularly sensitive to moisture variations, and a localised increase from leaking plumbing will swell the soil and cause cracking in masonry walls
- ***subsidence*** - some soils lose their load-bearing capacity when saturated, resulting in permanent subsidence.

Undetected leaks in water supply pipes can also increase your water bill significantly.

Earthenware

The seasonal swelling and shrinkage characteristic of many South Australian soils in built-up areas can easily fracture earthenware sewers and drains. Being made of a rigid material with rigid joints, an earthenware pipeline has very little capacity to tolerate movement.

Even a small amount of soil movement can fracture the pipes themselves or the mortar joints, and cause seepage into the surrounding soil. The seepage attracts tree roots, which will push their way into the pipeline in search of more moisture, causing blockages and eventually extensive physical damage.

Larger degrees of movement (perhaps even promoted by the initial seepage) can actually shift adjacent sections of the drain out of alignment with each other, so that some of the flow within the pipe is diverted directly out into the soil, further exacerbating the problem.

If you suspect that an old earthenware pipeline is causing a problem, consider replacing it entirely with a new PVC drain. With its solvent-welded joints and inherent flexibility, it can be expected to give long service without trouble. In reactive soils, new drains should be bedded and backfilled in sand to protect them from the worst of the soil movement.

Galvanised sheet metal

Galvanised water pipes are largely resistant to damage from soil movement thanks to the ductility of the iron, but are prone to rusting with age. Initially the flakes of rust breaking away from the inner surface will clog filters, water heater valves and so on. As the rusting increases, its expansion within the pipe will restrict water flow - iron oxide grows to five times the volume of the original sheet metal. Eventually the pipe will start to seep as the rusting reaches the outer surface, at which stage it will be very prone to fracturing with the least physical pressure. Failure usually occurs first at the joints, because cutting the thread removes the protective zinc coating and reduces the metal thickness.

Test for sub-surface leakage by monitoring water meter readings last thing at night and first thing in the morning, having turned off toilet cisterns and the like to ensure zero usage during the test period. If a galvanised water main is found to be leaking, consider replacing it in copper, but be wary of partial replacement which mixes the two materials, as their incompatibility will cause further galvanic corrosion of the iron.

Electricity and gas

Early installations

The earliest examples of electric light and power supply in South Australia date from the late 1880s, and it was still a rarity at the turn of the century. Many buildings dating from the early twentieth century will have originally been fitted with gas lighting. By 1920, the provision of electric power and light in new buildings was commonplace, but many older buildings were not converted until some years later.

Surviving gas wall bracket lights (or at least the wooden mounting plate and gas tap) can sometimes be found in buildings pre-dating this period, but often the only visible remnant is the old gas supply piping in the roof space. Other signs of the early use of gas are the presence of ceiling vents to dispel the gas fumes. With changing fashions and the transition to electric lighting, the central 'ceiling rose' vent began to disappear.

Early domestic electric installations typically provided a central ceiling light in each room and a two-pin power socket with rotary switch in the more important rooms - power demand was minimal, with little more than reading lamps and maybe an electric fan being used. Electric bells also became popular, particularly in the larger houses which still employed staff, and it is not uncommon for the old indicator board to have survived.

Light switches were located at the ceiling outlet and operated by a cord, or brought down to a position near the door. The electricity meter and fuses (often just one power fuse and one light) were usually located on an exposed wooden board in a readily accessible position near an external door. In updating the electrical installation to meet modern demands and codes, and in carrying out renovations generally, valuable evidence of these earlier services is preserved by retaining any disused hardware - gas outlets, electric boards, switches, sockets, bell pushes, and so on.

Precautions

Exercise extreme caution if old rubber-insulated wiring is still in use. It can remain intact and serviceable for decades if undisturbed, but age turns the rubber very brittle and the least movement can cause it to disintegrate and the wiring to short circuit. This form of wiring is generally considered to be below current safety standards and should be checked by a qualified electrician who can advise on the adequacy or otherwise of the wiring, particularly if the building has been recently acquired.

Early installations may not be earthed, adding to their danger. Other potential problems that should be checked are the mechanical wear of switches, wear, arcing or corrosion of electrical contacts and any sign of abnormal deterioration.

New installations

Renewal of plumbing and electrical installations should have regard for the historic fabric of the place. Often, a little thoughtfulness in the layout of these services can avoid unnecessary damage, particularly if they are to be chased into walls. Careful planning can also avoid unsightly exposed runs of cabling or piping internally and externally.

Licensed contractors

Any work involving the reticulated water supply, waste water drainage, sewerage, septic systems and the mains electrical supply must be carried out only by a suitably qualified person. Refer all plumbing and electrical problems to a licensed contractor.

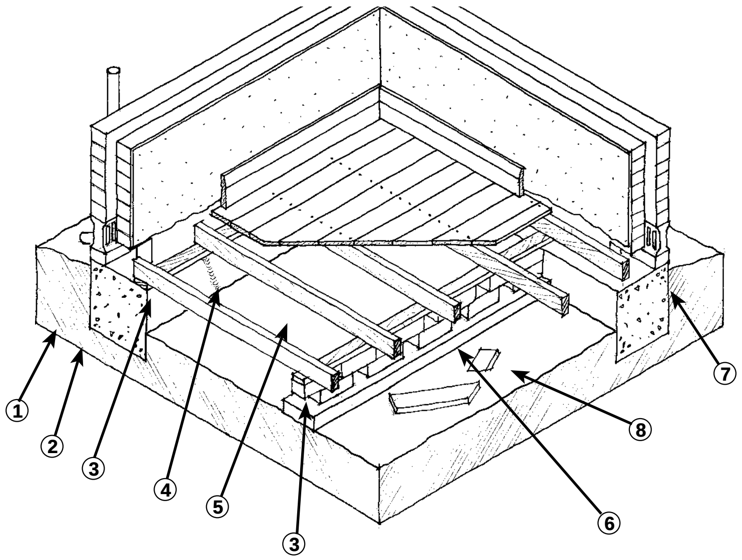
5. Out of Sight - Out of Mind?

What to look for under the floor and in the roof space

The function of a building, at the most basic level, is to provide us with interior spaces to suit our particular needs, whether it be a factory, a home or a public building. We visualise a building in terms of its external presence and its internal spaces, ignoring the hidden zones - the sub-floor and roof space - which are vital to its performance but beyond our normal day-to-day experience.

To properly maintain your building, you need to start thinking of these hidden zones as distinct parts of the building between the external environment and the interior spaces, and to become aware of how they relate to the well-being of the building as a whole. With some vigilance you can deal with developing problems in their early stages, or even prevent them altogether, rather than being taken by surprise when the trouble eventually manifests itself within the inhabited areas of the building. By this time, considerable extra damage and expense may have been incurred.

This Section provides an introduction to these zones, and guides you in identifying and dealing with the problems that can arise.



Potential Subfloor problems

1. Dampness in subfloor area from downpipes or leaking plumbing
2. Water ponding near wall, or entering through subfloor vents due to raised paving or ground levels
3. Absence of ant caps or damp proof membrane between timber floor plates and masonry dwarf walls
4. Termite tunnels giving access to timbers
5. Insufficient clearance between soil level and floor joists
6. Damaged or unstable dwarf walls
7. No damp proof course in external walls, or damp proof course damaged or bridged by repointing
8. Termites attracted by scraps of timber left on ground

5.1 The sub-floor

Section 4.1 of this Technical Note identifies various types of floor construction encountered in historic buildings, and details the care and maintenance of the most common flooring material - timber boards. In this section, the inspection and maintenance of the sub-floor space is investigated.

The term sub-floor describes the supporting structure of a suspended timber floor - that is, the system of joists, bearers and dwarf walls which supports the floor clear of the ground. The sub-floor space is the space between the ground and the floorboards. Checking conditions within the sub-floor space is critical to both the structural and aesthetic integrity of the floor.

For a suspended timber floor to remain in good condition, the most important consideration is the moisture environment - maintaining the air humidity and soil moisture content at stable and relatively dry levels. Many of the problems experienced with the sub-floor can be attributed to unsuitable moisture conditions, including:

- ***excessive air humidity*** - leading to cupping of the floor boards (curling up at the joints) as the under-surface expands
- ***excessive moisture*** in walls and dwarf walls - promoting rising damp and salt attack
- ***variations in soil moisture content*** - causing relative movement between the various dwarf walls and external walls supporting the timber floor framing, with consequent sagging or bounciness in the floor
- ***damp soil or timber*** - providing conditions conducive to termite activity or fungal rot.

Ventilation

The control of ventilation is central to the maintenance of the correct sub-floor moisture conditions. Too little ventilation encourages high moisture content in the soil and the air. Too much ventilation can increase salt attack damage to under-floor masonry, because of the accelerated evaporation rate that results.

The number and positioning of vents around the perimeter of the building is crucial to achieving an adequate quantity and distribution of fresh air. Good cross-ventilation is the aim, without dead spots. The flow of air from one side of the building to the other will be obstructed at internal wall lines unless openings have been built into the walls.

Consider the placement and number of vents around the building, particularly if alterations, additions or landscaping works have modified the original arrangement. If you suspect there may be a problem with ventilation, seek professional advice to determine the best way to proceed.

Access

Gaining access to inspect the sub-floor space is not always possible and was rarely provided for as part of the original construction of most older buildings. Fortunately, sub-floor problems can in many cases be detected by careful observation from within the room, as outlined in Section 4.1.

If the building has a cellar, access to the sub-floor is often possible, although it may be necessary to break away narrow sections of the dwarf walls to get through to adjacent compartments. Care is needed when breaking through to ensure that adequate support is maintained for bearers or joists. Keep the breaching of dwarf walls to the absolute minimum - adequate visual inspection of a compartment can usually be made from an adjacent compartment by peering over the top of the wall between the joists or bearers.

In many cases, access hatches will have been cut in the floor in the course of termite inspections - often very crudely. If the historic integrity of the floor will not be compromised, cutting new hatches can be a good option for gaining access.

Seek advice from a Heritage Branch Architect or Heritage Adviser about the best location and method before cutting floors. Take care to locate them where they will be covered by rugs or furniture, considering not just the current placement of furniture but also possible future changes in room layout. Strike a balance between the number of hatches and the necessary number of gaps in the dwarf walls.

If using a circular saw, avoid overshooting on the cut - use a jigsaw to carry the cut through to the end, and don't forget to adjust the saw to the correct depth before you start. This can be ascertained by drilling a small hole through the board clear of the joist and noting the drill depth at which it breaks through the underside. A length of timber nailed in place as a temporary guide for each cut will ensure a straight line. Avoid breaking the tongue and groove joints by using temporary screws to help spring the cut pieces up and out once the nails are removed.

Inspection

Look out for the following potential problems when inspecting the sub-floor:

- Externally, check that sub-floor vents are clear of rubbish and vegetation. Ensure that surface water is not entering through the vents
- Keep the sub-floor vermin-proofed by repairing or replacing any broken vents and sealing pipe penetrations etc through external walls
- Remove any rubbish from the sub-floor space to avoid obstruction of ventilation and for fire safety. Offcuts of wood can attract termites
- Secure any loose electrical wires and conduits
- Check water pipes for signs of leaking or sweating. Even a slow drip can raise moisture levels enough to cause water-related problems such as corrosion, cracking, rising damp and salt attack
- Check the under floor space for evidence of termites, borers or wood rot (refer to Section 6 for details of what to look for).

If abnormalities have been observed in the floor from above, look for signs to indicate the cause of the trouble. These might include:

- sagging or bounce in the floor because of settlement of dwarf walls or main walls
- lifting of a section of the floor because of heaving of dwarf walls or main walls
- weakness or flexing in a section of the floor due to termites or rot
- disintegration of dwarf walls or the supporting ledge of main walls due to salt attack, resulting in loss of support for bearers or joists
- localised wetness or dampness from a leaking water pipe, waste pipe, sewer or shower cubicle
- generalised dampness of the ground surface or timber surfaces due to poor ventilation.

5.2 The roof space

Although access to the roof space is generally easier than to the sub-floor space, it is often a neglected part of the building. The major elements within the roof space are:

- the roof framing
- the roof covering
- the ceiling framing
- chimneys
- building services

Roof framing

The timber framing that supports the roof covering is susceptible to attack from wood rot and termites, and may suffer structural problems from overloading, inadequate design or workmanship, or fatigue.

Dampness and rot

Run a strong torch along each section of the framing, looking for darker-coloured water staining or white fungal growth, particularly at joints in the roof covering, valleys, hip and ridge cappings, and at gutter lines. Refer to Section 6.4 for further information on wood rot. Before making any repairs, it is important to identify how the water is getting in, and to rectify the cause.

Termites

Check for termite shelter tubes, particularly where the framing rests on internal and external walls, and around chimney shafts. Refer to Section 6.2, and take care not to disturb the workings until professional treatment is undertaken.

Structural problems

Be on the lookout for any timbers that are out of alignment, twisted or bent - this may indicate either structural overloading or loss of strength because of termite attack.

Check for joints that may have loosened because of long-term shrinkage of unseasoned timbers, or where splitting or rot has reduced the strength of the joint. Repairs can be made by bolting a new piece of timber across the joint as a splint, or by using suitable, off-the-shelf, galvanised metal connectors.

A generalised sagging of the roof framing may be the result of re-roofing with a heavier material - for instance original corrugated sheet metal being replaced with tiles. This can be remedied by adding additional support down to the walls, usually involving the installation of purlins running at right angles under the mid-span of the rafters, with struts to take the loads from the purlins down to suitable internal wall lines. Care is needed to avoid diagonal forces onto the tops of the walls or overloading the internal walls, and professional advice should be sought.

Problems also arise when the roof framing is not adequately tied across from side to side. This is usually done with collar ties running horizontally between pairs of opposing rafters, but if these are missing or set too high up, the weight of the roof can cause the ridge to drop and the ends of the rafters to spread outwards. The solution to this problem is to introduce new collar ties, or perhaps cross-ties in the form of rods and turnbuckles at ceiling level. As before, seek professional advice to ensure that the repair method is tailored to the particular situation, particularly if the movement of the rafters has pushed the tops of the external walls out of line.

Deformed timber roof members may also result in disturbance of the roof cladding, with the potential for water leaks.

Roof covering

The relative thinness of the roof covering belies its fundamental task of protecting the main structure of the building from the potentially damaging effects of rainwater entry. To do this successfully, the entire assembly - the roofing material itself as well as the cappings, flashings and fixings - must remain intact and sound. The roofing material must be free of holes, cracks or other faults, and every other component, joint and junction must be well-executed and in sound condition.

To effectively monitor the condition of the roof covering it must be inspected both internally and externally. Refer to Section 3.1 for an introduction to the range of roofing materials used in South Australia and how to inspect the roof from the outside. The main items to look out for within the roof space are covered in this section.

For further information on roofs, refer also to DEH Technical Note 3.10 *Early Roofing and Roof Materials in South Australia*. Topics covered in detail include roof structure and geometry, roofing materials, detailing and maintenance, incorporating modern services, and advice on trade skills and workmanship.

Early detection

Often the first sign of roof problems is the appearance of damp patches in the ceilings or upper sections of the walls. But the deterioration of the roof covering is a gradual process, and the time lag between a problem developing and visible symptoms becoming apparent can be considerable.

By keeping a watchful eye on conditions within the roof space and on the outside of the roof, faults can be identified and rectified as they develop, long before the damage has spread and the effects have filtered down into the occupied spaces. By the time a damp patch has been noticed from within the room, what began as a simple and easily repaired leak has escalated into extensive water damage.

Checking the underside

Finding the exact source of roof leaks can be difficult because of the tendency of water to track downwards until it encounters some obstruction and starts to drip. The key is to be observant and thorough.

Depending on weather conditions, there are several ways to identify leaks:

- during a shower of rain, run a torch over the underside of the roof covering and look for any moist areas or drips
- on a sunny day, look for any shafts of light which might indicate a potential leak
- after rain, inspect the roof timbers for any dark moisture staining, and similarly go over the ceiling surface looking for evidence of damp patches.

The source of water entry will often not be apparent. The wind can drive water up under cappings and flashings, or between poorly fitting tiles. Capillary action can draw moisture into close fitting joints such as between tiles or roof sheets.

Corrugated sheet metal

Corrugated sheet metal invariably begins to fail where the ends of the sheets overlap. The close fit at this joint encourages capillary action which sucks water up into the joint, and once there it becomes trapped, particularly if dust has infiltrated the joint. The conditions are ideal for corrosion - initially of the protective zinc coating and eventually of the sheet metal itself.

Rusting at these joints is normally clearly evident, and once pinholes of daylight become visible the roof sheet needs repair or replacement. The most appropriate action will be guided by the historic importance of the roof. The life of the original sheet metal can be extended considerably by 'sleeving' the joints - slipping a narrow strip of iron up between the sheets to bridge the damaged section.

If replacement is necessary, new full-length sheets will avoid end laps, but heritage considerations might favour using short sheets to retain the original pattern of sheeting, or even good salvaged sheets to avoid an inappropriately new appearance.

The standard finish on the market today is a zinc/aluminium alloy known as Zincalume. It has markedly different physical and weathering properties to the traditional galvanised finish, and is generally unsuited for use on historic buildings.

Tiles

Because of the numerous joints in a slate-tiled or clay-tiled roof, there is increased potential for it to lose its integrity of cover. Look for individual cracked or broken tiles, and for slippage due to breakage at the fixing point or failure of the nail or wire fixing holding the tile in place.

A powdery appearance on the underside of a clay or slate tile is due to damage by salt attack, and indicates that the material is absorbing rather than shedding water. Its ability to continue providing an adequate waterproof barrier diminishes, and overloading of the roof structure can be a concern because of the increasing weight of water absorbed.

Seek professional advice on the most appropriate action to take, bearing in mind the historic value of the roofing material.

If renewing or re-laying the tiles becomes necessary, ensure that a layer of sarking is installed underneath. This is a reinforced moisture barrier such as Sisalation which provides a second line of defence against water entry, with the additional benefits of condensation control and reflective thermal insulation.

Ceiling framing

Problems commonly experienced with ceilings are covered in Section 4.3, as well as repair techniques where the ceiling material is pulling away. The structural adequacy of the ceiling framing is discussed here.

Joist deflection

Ceilings are normally supported by timber joists spaced at 450 mm or 600 mm centres, running across the shorter dimension of the room and supported on the walls of the longer sides. A structural problem with the framing is indicated by sagging or deflection of the joists.

In many cases this will be nothing more than long-term deformation of the joists due to the inherent flexibility of timber and the dead weight of the ceiling. In other cases the joists may be a little undersized but nevertheless quite adequate - refer to the comments on timber sizing in Section 5.3.

More serious deflection may be the result of overloading of the joists by the build-up of large amounts of debris or rubbish, or because of waterlogged insulation or ceiling material.

Deflection can be measured quite simply with a string line stretched between the ends of the joist. If in doubt, seek professional advice, particularly if there are obvious signs of structural distress or cracked timbers.

Hanging beams

The simplest remedy for excessive joist deflection is to install a hanging beam. This is a large, deep beam set at right angles to the joists and supported directly up off the tops of the walls across the middle of the room. Its size should be determined by engineering calculation or reference to beam sizing tables. The joists are fixed up to the beam with joist hangers or hoop iron straps, thereby halving their span.

The ceiling may be supported this way in its sagged position, or pushed carefully up from below to its original alignment or to some point in between, depending on its condition and the degree of deflection.

Storage

Avoid using the roof space for storage unless it is specifically designed for this purpose, or the weight is borne by the walls and not the ceiling joists. Be aware also of the potential fire hazards and of inadvertently providing nesting places for rats and other vermin.

Insulation

The use of thermal insulation in ceilings has only recently become common practice, but will be found from time to time in old buildings. Early insulation materials included seaweed and wood shavings - both highly flammable. While the use of such materials is of interest historically, their retention will rarely be justified because of the fire danger. Their performance will also fall far short of the best modern materials.

Insulation batts or granules laid directly onto the ceiling surface should not present a problem, being light in weight, but inspect the condition of your ceilings carefully beforehand because it will be the last time you will have such easy access. Look particularly for any problems in the fixing of the ceiling material to the joists.

Chimneys

The chimney shaft, as it rises through the roof space, is typically of brick construction (but sometimes stone), and is not normally prone to problems within this zone of the building. Nevertheless, a few points are worth checking while you are in the roof space:

- Look at the point where roof covering meets the chimney, keeping an eye out for signs of leaking flashings or dampness coming from above
- Make sure mortar joints are sound and that there are no signs of fretting
- Look carefully for any signs of cracking - the roof covering disguises the true height and slenderness of the chimney shaft, which relies heavily on the roof framing to brace it against earth tremors and high winds. Any signs of cracking should be followed up with professional advice.

Building services

Services which may be encountered in the roof space include:

- electrical wiring
- water pipes and water heaters
- gas piping
- air conditioning plant

Electrical

Seek the advice of a qualified electrician if in any doubt about the safety of the electrical wiring.

Take care entering the roof space until you have determined the safety of the electrical wiring. Early installations used wiring with rubber insulation which becomes brittle with age. If the electrical wiring within the roof space is contained within metal conduits or covered timber channels ('cap & casing'), great care is needed to avoid disturbing the wiring, to minimise the risk of damaging the insulation and causing shorting. Refer to Section 4.5 for more information on old electrical installations.

Note that electrical cables should be clipped into position and not loosely draped. Avoid laying insulation over cables, as it can cause them to overheat.

Water heaters

Gravity-fed hot water systems use a cold water header tank within the roof space, or an integrated water heater cylinder and header tank. The tank or cylinder should sit within an overflow tray drained usually out through the eaves. Check that the tray is dry (it is intended only as a precautionary measure), and if possible run some water into it to check that it is watertight and drains freely to the outside.

Trace the water pipes to and from the tank and look carefully for any signs of weeping or leaks.

Gas pipes

Redundant gas pipes from early gas lighting installations are frequently found in roof spaces, and pose no particular problems or risks.

Mechanical plant

The maintenance of mechanical plant such as ventilation or air conditioning equipment is beyond the scope of this publication, but pay attention to the following points:

- ***roof penetrations*** - check around any duct or pipe penetrations through the roof covering for signs of leaks
- ***drip trays*** - check drip trays (as for water heaters)

5.3 Structural adequacy

The timber framing supporting the ceilings, roof and floors of an older building may not conform to current codes of practice for timber sizes or spacings. Before the introduction of codes and standards for timber framing, the sizing of structural timbers was more often by a combination of on-site experience and guesswork rather than by calculation, and can vary from spindly to massive - often in direct proportion to the status of the building. However, if the timber is well seasoned (as would be expected in an old building) and in good condition, the structure is usually adequate.

Should any evidence of structural failure or distress arise, seek professional engineering advice. Signs to look for include:

- ***deflection*** - noticeable bending of a timber member, generally indicating excessive vertical loading or undersizing
- ***twisting*** - suggests that the timber is too slender for the loads imposed on it
- ***splitting*** - indicates serious overloading to the point of actual failure, perhaps in conjunction with a localised weakness such as a major knot or sap vein.

Look also at whole structural entities, rather than just the individual parts. For example:

- stand well back from the building and look at the general line of the roof to detect any sagging or misalignment which may not be readily detectable from within the roof space
- bounce up and down in the centre of an upstairs floor to see if it flexes excessively
- check the static deflection in the floor by stretching a string line between opposite walls and measuring the difference between the floor level at the walls and the centre.

Bear in mind that alterations or additions to a building may redistribute existing loads or impose new loads on the older parts of the building. Even though this might not be sufficient to cause the physical fracture of a timber structural member or any immediately evident distress, it can cause long-term deformation and deflection if the structure is loaded beyond its safe working strength.

6.1 Good housekeeping practice

The adverse effects of age and the day-to-day use of a building can be reduced by sensible practices that recognise the various environmental agents responsible for gradual deterioration. For most domestic situations and in buildings with limited public access, being aware of these factors and developing good housekeeping practices will usually suffice. In complex or larger buildings subject to heavier traffic, incorporate a detailed routine housekeeping schedule into a maintenance logbook, and update it regularly.

Wear and Erosion

Wear and erosion from the day-to-day use of a building can be very destructive to old surfaces over time, but can be moderated by protecting vulnerable surfaces with replaceable overlays - for example a runner over a bare floor or a valuable rug, or a timber walkway over fragile tiling. Some degree of visual intrusion is acceptable if there is a nett protective benefit.

Wax polish

Another form of renewable overlay is the wax polish used on timber finishes. The application of wax builds up a protective layer against material abrasion and wetting. As long as the thickness of the layer is maintained, the wear and erosion is taken by the wax rather than the underlying timber. Waxes that can be removed by water or turpentine should be used in preference to other types such as silicone-based compounds.

Cleaning

The abrasiveness of dirt plays a major part in the erosion of a building's fabric. Give priority to the cleaning of areas where dirt can enter the building. Tracked-in dirt is a major cause of damage to floor surfaces and can be minimised with good matting outside entry points to the building. Clean doormats regularly to maintain their effectiveness.

Historic carpets and special reproductions should be cleaned only under the direction of a specialist in this field. The Heritage Branch can provide advice if you require assistance.

Excercise care when cleaning historic surfaces, using only neutral-base cleaning agents (pH 7.0).

Humidity and temperature

To minimise stress on the interior decoration, finishes and joinery of a building, extremes of humidity should be avoided, as should excessive and rapid fluctuations in humidity. If heating or air conditioning systems are in use, monitor the humidity within the building to ensure that it is maintained at a constant and appropriate level.

Similarly, rapid changes in temperature can damage finishes such as plaster. As the temperature of the surfacing material changes, it will expand or contract relative to the base which remains at the original temperature. This action can be strong enough to shear the finish from its base.

Refrigerated air conditioning

Rapid temperature changes can be a particular problem with refrigerated air conditioning systems in old buildings. Rapid changes of surface temperature can occur on start-up when a system has been off for some time. Avoid unnecessarily high or low thermostat settings in response to extreme external conditions.

Problems can also arise with long-term drying out of building elements as a result of the dehumidifying effect of refrigerated air conditioning (this is an inherent characteristic of the process, both on heating and cooling cycles).

Components such as large plaster mouldings will shrink as their moisture content is gradually reduced, and can in some circumstances shear away from the base masonry. Timber may also begin to curl as the exposed surface dries out.

Other heating and cooling systems

Different types of heating and cooling systems vary in their effect on air humidity.

Evaporative air conditioning systems, for example, rely on raising the humidity of the air to produce the cooling effect. Provided they are used as recommended, with sufficient doors and windows open, the humidified air is quickly exhausted and an acceptable equilibrium maintained.

Electrical resistance heating of all types - radiators, convection and fan heaters, panel and column heaters, and radiant floor or ceiling heating - result in varying degrees of dehumidification of the air. Radiant systems will also tend to dry out the surface they are directly heating, but can be very useful in old buildings as they can be completely concealed. They also cope well with the large interior volumes of rooms with high ceilings.

Gas and oil-fired systems produce water vapour as part of the combustion process, but this is rarely a problem, except with unflued installations.

Painting

In order to avoid unnecessary paint build-up, rather than completely repainting, areas which have worn more quickly should be touched up from time to time (eg window sills, doors, hand rails). Keep leftover paint for touch-up work, and store it in a cool place upside down in airtight containers. This will avoid skinning on the surface when the tin is re-opened.

Touch-up work requires skill for a successful result.

Repair graffiti and vandalism promptly to discourage additional damage.

6.2 Termites

In order to understand how termites (commonly known as white ants) affect buildings, how to discourage them and how to detect their presence, it is useful to have an appreciation of their nesting and feeding habits. The information given here is intended only as a general introduction to a very complex topic, about which there are still many unknowns and some common misconceptions.

Much of the information in this publication on the subject of insect pests is sourced from *Building Out Termites* by Robert Verkerk.

The natural vs built environment

The destructive effects of natural threats (including termites, borers and fungi) to the timber incorporated into our buildings should be considered from the perspective of the natural world. These agents of destruction to the built environment are in fact the catalysts of new growth and regeneration in the natural environment, fulfilling an essential function in converting fallen and dead timber back into soil and nutrients to stimulate new growth.

Once a tree has died, the natural order is for the process of recycling to begin. The fact that we cut down trees, mill the timber to convenient sizes and season it to a suitably 'dead' state to incorporate into our built environment means nothing to a termite or a borer or a wet rot fungus. They are simply doing their job. We should also recognise that we will always be fighting nature itself in our battle to prevent incursion and damage.

Types of termite

Termites play a number of vital and beneficial roles in the natural environment. Some species go largely unnoticed within and around our built environment, while others are capable of inflicting extensive damage. The principal categories of termite are the harvester, drywood, dampwood and subterranean. Each has particular patterns of nesting and feeding.

The harvester and drywood termites are found mostly in tropical and sub-tropical regions, and are not a concern in South Australia.

The dampwood termite can cause damage to timber in direct contact with the ground, as well as to trees (they nest and feed in the damp conditions at the junction of branches with the trunk). They can be a problem where rudimentary construction or poor detailing result in timber having direct ground contact. The group of greatest concern to building owners in South Australia is the subterranean termite.

Subterranean termites

This group of termites derives its name from its tendency to build nests underground, from where they radiate to the various food sources in the vicinity. Nests may also be found as mounds or in the hollow bases of trees, but will remain sealed from the external environment, maintaining direct contact with the ground.

The characteristic of the subterranean termite which dictates its nesting and feeding habits is its sensitivity to moisture and temperature conditions - it cannot tolerate the wide environmental fluctuations associated with exposure to the open air, and relies on the protected environment within the nest. Subterranean soil conditions provide the stable temperatures and high relative humidity they require for survival.

Their staple diet is cellulose, derived chiefly from timber. Certain timbers used in old buildings, such as Australian cedar (*Toona Australis*) and native pine (*Callitris*), are naturally termite resistant, but the more common timbers such as pine (baltic, kauri, radiata) and douglas fir (oregon) are favourite termite fodder. Hardwoods are generally considered to be more immune, but not if the *Nasutitermes* species is around - they have a preference for eucalypt hardwoods, and will make a meal of jarrah while leaving adjacent softwoods alone.

To maintain the necessary temperature and moisture conditions, the subterranean termite moves between the nest and the food source within sealed tunnels and galleries. Where it becomes necessary to traverse open space, they will build shelter tubes having the appearance of mud tunnels. This is typically how they gain access to building timbers, although their route of entry can also be concealed within cracks or cavities in masonry and in concrete floors.

The distance that termites will travel to food sources varies according to the species, but a radius around the nest of up to 70 metres is not unusual.

The nest contains the queen and king, and forms the centre of a highly ordered social system. The various castes within the colony each have their particular functions and physical characteristics - the workers, the soldiers, the reproducers, and so on.

What to look for

The detection of termites requires experience, skill and a good knowledge of their behaviour. Regular inspection by a qualified contractor or consultant is recommended. An important adjunct is the building owner's or manager's vigilance, both in observing good housekeeping practices, and in keeping a watchful eye for signs of trouble.

Attention to the following points will help in early detection and enable prompt action before serious damage is done.

Nests

Subterranean termites may be present in the gardens and trees surrounding the building, whether they have gained access into the building or not. Nests within the ground which protrude slightly as a dome or mound shape are readily detected, and will often be found at a rotting tree stump.

Nests within the bases of trees are more difficult to identify without experience and knowledge, as there will usually be no external sign.

Underground nests can prove very difficult to locate, often being built under concrete slabs, verandahs or steps, where the overlying structure helps to insulate the colony from environmental fluctuations.

Although finding the nest will assist in taking appropriate action to deal with termite attack, it is not essential.

Shelter tubes

Good building practice ensures that the various timber components and structures of a building are kept clear of the ground, both to keep them dry and to protect them from termite attack. Because the subterranean termite is unable to traverse open areas away from the controlled microclimate of its nest and underground galleries, it constructs mud-like shelter tubes to get from the soil to a suitable piece of timber.

The sub-floor inspection (see Section 5.1) should include a thorough investigation of the zone between ground level and the floor framing, looking for tell-tale signs of shelter tubes running between the two. Do not break into shelter tubes as this can put the colony into 'shut down' mode and make treatment more difficult.

Cracks and crevices

Shelter tubes are not the only means by which termites will move from soil to a tempting piece of timber. The masonry sub-structure in old buildings is typically built with the stones or bricks set in soft lime mortar, and with a core of loose rubble or mud. Depending on the condition and standard of construction of the base masonry, there can be many concealed paths up through the centre of the wall without any visible signs.

Cracks caused by footing movement on reactive soils can also provide a suitable path, even in masonry which is otherwise soundly and solidly built.

Other potential points of entry are cracks in concrete floors, or where pipes and other services penetrate the floor or walls. It is not uncommon for termites to get into a roof space undetected by tracking along an old electrical conduit set into the wall.

Ant caps

Ant caps are horizontal barriers made from galvanised sheet metal inserted between the sub-floor timbers and the sub-structure (eg masonry dwarf walls) at the time of construction. They project beyond the sub-structure and have their edges folded down at an angle of 45 degrees.

Although they can certainly hinder easy entry, do not assume that their presence prevents termite access. Their value lies more in forcing the termites out into the open, where the shelter tubes around the edge of the metal cap can be readily detected during sub-floor inspection. Without the caps, it might be possible for the termites to pass directly up through the masonry into the timber with no externally visible trace.

Tell-tale signs

Termite attack frequently goes unnoticed until considerable damage has occurred within the affected timbers. Restricted sub-floor access may make effective inspection difficult, or the path of entry may be completely concealed. Often the first evidence will be when the timber surface begins to deform or break up.

Detecting the presence of termites at an earlier stage than this is not easy, and is made more uncertain by lack of experience. Nevertheless, the building owner can reduce the chance of an infestation going undetected with regular and careful observation. Using a powerful torch, look out for:

- architraves, skirtings or mouldings starting to come away from the wall, pushed out by the construction of shelter tubes
- similarly, dislocation of small trim beads around frames, built-in furniture and so on
- signs of mud tracking appearing from cracks running up plastered walls
- timber that sounds hollow when tapped with the handle of a large screwdriver
- slight rippling or buckling in the surface of painted or polished timber, including floorboards
- a feeling of 'give' in floors that previously felt firm, or in the boards themselves.

It is also possible in some cases to detect termite presence by sound. Depending on the species, the termites can be heard at work if the level of ambient noise is very low. Another test is to tap a suspect piece of timber with a screwdriver handle or mallet, and listen for any response - a stethoscope will help. Some species will react with a warning signal which can be heard as a ticking sound. Bear in mind however that although an audible noise can confirm the presence of termites, silence should not be taken to indicate their absence.

Protecting older buildings

The protection of buildings against termite attack requires the successful combination of four distinct but inter-related approaches:

Construction practice

The protection of any new structure from termite attack requires attention to building design and construction details, the choice of materials and the provision of effective termite barriers. There are certain mandatory requirements under the Building Code of Australia and applicable Standards, but it is a topic beyond the scope of this publication.

However, when undertaking any alterations or new building work affecting an older building, pay careful attention to avoid increasing the exposure risk. Replacing suspended timber floors with concrete slabs and butting new slabs up to old external walls are two common mistakes which can substantially increase the risk of termite attack in the old structure, even if all the relevant Code requirements are met.

Inspection

Have the building and grounds inspected annually by a qualified and reputable pest control contractor or consultant. Ask for potential nesting sites and the vulnerable parts of the building to be

The door frame, lining and structural timber lintel of this doorway have been completely eaten by termites. A mud gallery is clearly visible at the centre of the picture.

identified to you, and to be thoroughly inspected. Observe carefully how the inspection is conducted - ask questions and make notes afterwards to help you in keeping an eye on things between inspections.

The effectiveness and thoroughness of the inspection will depend on whether good access is available, particularly to the sub-floor zone and the building's perimeter. Consider ways in which access can be improved.

Housekeeping

The susceptibility of a building to attack by subterranean termites can be reduced by attention to good practices in managing and maintaining the building and grounds.

Damp soil

Termites are less likely to establish colonies where soil moisture content is low. Assess the area around the building for any of the following problems (refer also to Section 3.6):

- ***Roof water drainage*** - overflowing gutters, blocked downpipes, downpipes discharging at or near the base of the building, and ineffective or blocked drains
- ***Surface water drainage*** - paving fall that doesn't shed run-off well away from the building, localised concentrations of surface water due to paving design or ground levels, or areas that fail to dry out quickly after rain
- ***Garden watering*** - excessive watering, particularly with inappropriately-programmed or leaking automatic irrigation systems, or plants with high water demands planted close to the building
- ***Ground water*** - sub-surface water making its

way under the building because of ineffective or non-existent drainage to intercept and divert it - a problem associated with sloping sites.

Wood rot

Termites can be attracted to the odour of the fungi growing in or on timber that remains damp for extended periods. Dampness in the timber also helps the termites maintain humid conditions within the workings.

Keep exterior timberwork and sub-floor timbers dry by paying attention to paintwork, flashings, leaking plumbing and so on.

Gardens

Practice good housekeeping habits within the gardens and grounds, such as:

- removing tree stumps, which may provide attractive nesting conditions
- checking the health and condition of trees, particularly old specimens which may have developed hollows within the trunk conducive to termite colonisation
- keeping the grounds clear of dense undergrowth which can obscure active termite mounds
- keeping the grounds clear of timber in contact with the ground, including fallen branches and scrap building timber
- taking care with the use of landscaping materials such as untreated railway sleepers and thick bark mulches, which can provide potential artificial nesting sites.

Termite barriers

For many years, new buildings have been required to have some form of barrier to the entry of subterranean termites. This integration within the construction process means that there can be a good degree of certainty in its correct application and performance. An older building, on the other hand, may have no termite barrier at all, or may have been given a retro-active treatment during extensive alteration or addition work, or in response to a termite attack.

Chemical barriers

By far the most common form of termite barrier used during the past five decades has been the chemical barrier - the application of large quantities of poison to the ground around and under the building, to interrupt the migration of subterranean termites from the soil into the building.

Until relatively recently, the most common chemical termite barriers contained organochlorines, a group of termiticides (such as DDT) that have been banned in South Australia due to health concerns. Alternative products have been developed, including pyrethroids and organophosphates. These are considered safer alternatives, but generally have shorter effective life spans, requiring re-application at shorter intervals.

Physical barriers

Termite attack on a stump

The discontinuation of the organochlorines in South Australia has seen the appearance of environmentally sound physical alternatives on the market. The two most widely used currently are crushed granite and stainless steel mesh. Both of these materials rely on their ability to block the passage of subterranean termites, on being too hard for the termites to chew, and on their durability in contact with the soil.

Like a chemical barrier, correct placement is critical to protect every potential path of entry through the building's sub-structure. An advantage is that their presence and continuity is readily apparent.

As with the liquid termiticides, achieving a full and effective barrier in existing buildings between the soil and the below ground structure of the building is not possible. They can, however, be successfully used to protect the more accessible parts of the sub-structure.

Limitations with old buildings

Existing buildings are much more difficult to protect. Attention can only be paid to potential paths of entry which remain visible or accessible, such as around the perimeter of the building and to accessible ground surfaces within the sub-floor.

It is not practically possible to extend a barrier under or through the base walls of an existing masonry building, so the zone of contact between below ground masonry and the soil remains unprotected. The sub-floor structure can be given some protection by installing galvanised sheet metal ant caps between the dwarf walls and the bearers, but this is generally not possible at the main wall lines.

Paved areas around the building and floors, such as concrete slabs, are normally drilled close to the wall at regular intervals for the injection of termiticide. In theory, this provides a continuous barrier along the wall line, but in practice the odds of achieving this are minimal. The flow and absorption of the chemical under the solid surface is totally unpredictable, and unless grossly excessive quantities are used, there are likely to be numerous paths remaining between patches of treated soil.

Dealing with infestation

It is important that the building owner understands what is being done by the pest control contractor, and that the likely outcomes and limitations of the treatment are clearly understood. It is a common assumption that the treatment instigated in response to an outbreak of termite activity will fully protect the entire building for a given additional period, but in many cases this is not so.

If the treatment isolates the nest from the building, but does not actually destroy the colony, there is every likelihood that the problem might recur by means of another point of entry. Even destroying the colony responsible for a particular attack does not preclude the possibility of attack by another nearby colony.

No form of treatment should be taken as a reason to relax your vigilance. An alarming number of termite infestations occur within a few years of the completion of a new building, or of major preventative works to an existing building, because the owners believed they were protected. The principal approaches to treatment are listed in approximate order of prevalence. Research and development on other methods continue, both in the fields of chemical deterrents or poisons, and in natural or benign controls such as predation by other insect species, biological agents, new physical barrier materials, behavioural disruption using pheromones and the application of artificial light and heat sources.

Termiticide

When a termite infestation is discovered in a building, the response is generally to apply a chemical termiticide at the point of entry. This will immediately isolate the workings from the nest, and in most cases will successfully eliminate the activity. The termites remaining on the building side of the barrier will under most circumstances die from lack of moisture, but the colony within the nest is likely to remain unaffected. Re-entry at the site of the treatment is prevented while the poison maintains its effectiveness, but the surviving colony can re-infest the building via any other available path.

Arsenic trioxide

A highly toxic fine powder, used since the early twentieth century as a very effective means of eliminating termite activity by destroying the colony. Arsenic trioxide is used only in the case of termite presence, and has no application as a deterrent or preventative measure.

A small quantity of the powder is puffed into an opening made in a main gallery, and the opening resealed. Traces of the powder are picked up by termites returning to the nest, where their grooming habits aid its spread. The objective of the treatment is to eventually destroy the queen. With no means of reproduction, the colony cannot then survive.

Its use requires judgement and experience for the successful elimination of the queen, for without this the colony will recover and the infestation will continue.

Arsenic trioxide treatment can be carried out only by a licensed pest exterminator, and great care is required in handling and disposing of any timbers into which the powder has been puffed or carried.

Nest destruction

If the nest containing the attacking termite colony is located and accessible, it can be physically destroyed by digging it out or burning it. As above, the queen must be destroyed if the colony is to be prevented from re-establishing.

The workings within the building must be inspected again after a couple of weeks to determine whether activity has ceased, in case the wrong nest has been destroyed or more than one colony is responsible.

Termite traps

When the nest cannot be located and the workings or shelter tubes within the building are unsuitable for conventional dusting, termite traps or lures can be used to attract the termites so that arsenic trioxide can be successfully introduced into the colony.

Traps vary in design, but the principles are the same. A typical trap comprises a wooden box with slots cut into the base and a removable lid which can be sealed in place. The box contains dampened layers of cardboard which provide an attractive food source. The box is bedded into dampened ground in the vicinity of a suspected termite access route, and left undisturbed for several weeks.

Once termites have infested the box, arsenic trioxide is introduced and the lid resealed. It is possible to achieve a more effective distribution of the poison by this method, but again success relies very much on the judgement and experience of the contractor, and on their knowledge of the termites' behaviour and habits.

6.3 Borers

The term borer is loosely used to describe a number of insect species (beetles, weevils, wasps and moths) which feed on timber. Some attack only living or newly-felled wood, and can therefore be a problem with new buildings or renovations. Others prefer seasoned (dried) timbers such as those found in an older building. There are two main types responsible for the damage commonly experienced in building timbers and furniture - the furniture beetle and the powderpost beetle.

Furniture beetle

What to look for

The furniture beetle is an introduced species, and its damage is indicated by the presence of:

- ***emergence holes*** - small holes in the surface of the timber, actually the exit routes made by mature adult beetles which have recently emerged from the pupal stage; and
- ***frass*** - a fine dust deposited within the timber as a feeding by-product.

Although the emergence holes are the visible signs of attack on the timber, the majority of the damage is in fact done at the earlier larval stage of development.

Eggs laid in crevices within the timber hatch into larvae, which tunnel through the timber as they feed. The larval stage lasts about two years.

Susceptible timbers

The furniture beetle has a liking for old softwoods (including baltic pine, hoop pine, radiata pine, kauri and oregon) in cool, dark, humid situations. It very occasionally attacks well-aged hardwoods.

The damage caused by the tunnelling larvae is slow, but over the space of many years, a heavy infestation can reduce the strength of load-bearing timber to the point of collapse.

Prevention

Avoiding furniture beetle attack is often difficult because of the conditions to which built-in timbers are exposed. Nevertheless, their presence can be discouraged by reducing humidity and increasing the levels of light and ventilation.

Residual chemical treatments have been used in the past, but one of the agents - an organochlorine termiticide - is no longer permitted, and the substitute pyrethrum-based agent is not particularly effective.

Treatment

Chemical agents have also been used by spray or injection to treat active infestations. Alternative treatments include:

- ***fumigation*** - suitable only for portable items of furniture, as the treatment involves highly-toxic methyl bromide and must be carried out off-site by a licensed operator under tightly-controlled conditions. It is however very effective and leaves no toxic residue within the timber. Fumigation does not protect against re-infestation.
- ***heat*** - the larvae are readily killed by heat, which can be aplied by careful use of a hot air gun, microwaving small articles or wrapping large items in black plastic and leaving them out in the sun for a day.

Before undertaking any treatment, seek expert advice to determine whether there is any current activity. The presence of emergence holes and frass may date back to a long-ceased attack, and unnecessary treatment and expense can be avoided.

Powderpost beetle

What to look for

The symptoms of powderpost beetle attack are very similar to the furniture beetle, but the emergence holes are smaller and the frass is finer and of a flour-like texture.

Susceptible timbers

The powderpost beetle's preference is for new building timbers, and it is therefore of little concern in conserving historic fabric. It attacks mainly hardwood species and eats only the sapwood, leaving the heartwood intact. Because the sapwood comprises only a small proportion of a good quality construction timber, its destruction usually has no practical effect on structural performance.

Prevention and treatment

The powderpost larva has a much shorter lifecycle than its furniture beetle counterpart (4-6 months). As a consequence, the consumption of the sapwood by repeated infestation is usually quite rapid, and in practice there is little point in attempting to prevent it. Once the sapwood is gone, the beetle will move on, leaving the timber still well able to carry out its intended function.

6.4 Wood rot

Wood rot occurs as a result of fungal organisms penetrating and feeding on timber. The terms dry rot and wet rot are commonly used to describe fungal decay of building timbers, but the distinction between the two is often blurred.

Dry rot refers generally to fungi which are able to conduct water from a remote source such as damp earth or timber. Although requiring suitably moist conditions to establish themselves, they have the ability to spread to and feed on dry timbers. They are almost unknown in Australia.

Wet rot describes those forms of fungal decay which can sustain themselves only in damp conditions, the fungus extracting its moisture needs directly from the timber on which it is feeding. This is the form responsible for the majority of damage locally.

What to look for

Timber destroyed by dry rot has a characteristic shrunken, dried appearance and sounds hollow when tapped. The most readily identifiable feature is the deep cracking which occurs both along and across the grain, giving the surface a distinctly geometric, cubed appearance. The timber can usually be turned to a fine powder by rubbing it between the fingers.

Wet rot damage can vary in appearance according to the particular fungus responsible. Soft rot is commonly used to describe a darkening of the wood, usually confined to timbers that are more or less continuously damp such as stumps and bearers in contact with the ground.

The most common form of wet rot fungus is known as white rot, which takes its name from the characteristic white 'stringy' appearance when the surface is broken open. Probing with a small screwdriver is a good way of determining if rot is present, as the timber's impact resistance is greatly diminished.

Moisture content

Wood rot requires the presence of fungal spores, timber on which to grow and feed, a supply of air, a suitable temperature and a supply of moisture.

In the case of wet rot, the moisture is derived from the timber under attack. To sustain the fungus, the moisture content in the timber needs to be at least 25 per cent. The greatest susceptibility occurs at a moisture content of between 30 and 50 per cent. Above this level the respiration of air by the fungus is increasingly impeded, and despite the impression given by its name, wet rot is not a problem in timber that is really wet.

Prevention and treatment

The moisture content of seasoned timber in a normal stable building environment is typically in the order of 10 to 15 per cent. From this fact two observations can be made:

- timber at normal stable moisture content will not be affected by wet rot; and
- for wet rot to occur, a substantial additional amount of moisture needs to be introduced into the wood.

Therefore, the principal method of control against fungal decay is to ***keep timber dry***.

Common moisture-related problems to be avoided include:

- wood in direct contact with the ground
- leaking or overflowing gutters and downpipes
- leaking water pipes or sewer pipes
- faulty damp proof course or none at all
- inadequate sub-floor ventilation
- condensation due to poor ventilation, high humidity and temperature differences between outside and inside
- breakdown of protective paint coatings (infrequent repainting)
- paint types which impede the evaporation of moisture
- exposing the end grain of timber to excessive moisture

End grain

The cellular structure of timber is linear in nature, with fibres running lengthwise. This is analogous to a long bundle of straws, which draws up water readily through the open ends, but is resistant to moisture penetration along its length. In a similar fashion, the absorption of water into a length of timber is chiefly through its end grain. The prevention of wood rot is highly dependent upon good detailing and regular re-painting to avoid exposing the end grain to moisture.

6.5 Rising damp and salt attack

Rising damp

This is the term used to describe the dampness occurring in porous masonry walls as a result of moisture rising up from the ground by capillary action, in much the same way as oil in the wick of a lamp. It has been a widespread problem throughout the world for many centuries, affecting walls without adequate damp courses. It results in mustiness and unsightly staining, and in some cases mould growth.

The nature and extent of a rising damp problem depends on a number of factors, including:

- the porosity of the masonry
- the moisture load
- rates of air movement and evaporation;
- effective drainage of surface water and roof water
- the concentration of dissolved salts present
- the properties of the surface finish

Salt attack

In South Australia, the unusually high concentration of dissolved salts in our groundwater creates a further problem - salt attack. The two actions together - rising damp and salt attack - have become known in South Australia as salt damp.

As moisture rises up into the wall, the dissolved salts are carried up with it in solution. At the damp surface of the wall, evaporation of the saline solution takes place. As the water molecules evaporate in the form of water vapour, the dissolved salts are forced out of solution. The return of the salts to their solid form involves a large increase in volume as the crystals grow. Depending on the nature of the wall surface, this growth may be on the surface, or the crystals may actually grow within the pores just under the surface. Surface growth takes the form of a white powdery deposit known as efflorescence.

Crystallisation occurring within the surface pores literally explodes the surface structure of the masonry. This is salt attack, a process of slow erosion which over a period of time is capable of eating deep into the masonry, progressively reducing it to a fine dust.

The importance of an appropriate mortar should not be underestimated, as a soft mortar (not containing too high a proportion of cement) will act as a sacrificial element, preserving the stone by drawing the salts in the mortar joints rather than the stone itself.

Old damp course types

A damp course comprises a continuous barrier through the wall above the ground level, and serves to intercept the upward passage of moisture. Buildings from the 1870s onwards can usually be expected to have some form of damp course, but the earlier and more rudimentary the building, the greater the chance that it will not.

One of the most common types in use during the first half of the twentieth century comprised sand and tar, mixed and laid hot as a continuous layer. Earlier materials included sheets of slate or lead, hardwood blocks, and even glass. Also encountered might be perforated terracotta tiles, hard-burnt bricks and blocks of smelter slag. Chemical additives to the mortar were introduced in the 1940s, followed by bitumen-based products such as Alcor and malthoid in the 1950s and the first uses of polyethylene in the 1960s.

Bridging

Many instances of rising damp result from the original damp proof course being bridged, allowing moisture to penetrate into the wall at a higher level. Bridging can occur from the build-up of soil level in a garden bed; from new paving being laid over an earlier surface; or as a result of re-pointing of mortar joints.

Sand and tar damp courses become quite brittle and fragile where exposed to the elements, and are frequently found to be eroded back from the surface - care is needed when re-pointing to repair the dampcourse rather than bridging the joint with mortar.

Prevention and treatment

There are various approaches to the prevention and treatment of rising damp and salt attack in masonry walls. For detailed information refer to DEH Technical Note 3.8 *Rising Damp and Salt Attack.*

Generally

Decay due to salt attack occurs in the presence of four factors:

- ***porous masonry***
- ***moisture***
- ***dissolved salts***
- ***evaporation***

Theoretically, controlling any one of these factors will arrest the decay. In practice, two of the factors are beyond practical influence - the ***porosity*** of the masonry is a quality inherent to the particular material, and ***dissolved salts*** are determined by the regional groundwater salinity.

The presence of ***moisture*** can be controlled by a number of means, including:

Typical case of rising damp due to lack of damp proof course.

- introducing a damp course into the wall
- improving drainage of roof water and surface water away from the wall
- improving sub-floor ventilation
- keeping garden beds and sprinklers clear of the wall

Reducing the rate of ***evaporation*** is difficult externally, but can be useful in managing dampness internally. Panelling installed over the lower part of the wall will restrict airflow across the surface, thereby slowing or arresting the formation of salt crystals. However, it is likely that because of the lower evaporation rate, the dampness will tend to rise higher in the wall until it finds a new equilibrium.

Undersetting

The salt-affected masonry is removed to above the height of salt damage by taking out and rebuilding a short section of the wall at a time. In rebuilding, a new damp proof course (usually of heavy duty embossed polyethylene) is inserted through the full thickness of the wall.

The advantages of this method are that:

- the continuity and quality of the new damp proof course are readily apparent
- the old salt-laden masonry and plaster is replaced with 'clean' materials.

Disadvantages are that:

- historic fabric is lost
- a good match between new and old masonry is difficult to achieve
- considerable disruption and mess is involved.

Chemical damp proof courses

The wall is saturated through its full thickness at a low level using a fluid which dries to form a water-repellent lining to the pores of the masonry. This has the effect of cancelling the capillary suction within the masonry and thereby preventing the rise of moisture against gravity.

Application is by pressure or gravity feed into holes drilled at closely spaced intervals. The nature of the masonry and the thickness of the wall will influence the spacing of the holes and whether drilling is from one side or both.

Pressure injection is rarely suitable for old brick and stone walls, because the central core of the wall typically contains numerous small cavities and voids which can secretly drain large quantities of fluid away to waste, leaving sections of the wall untreated. Problems will also arise due to differing porosities between the stone or bricks and the mortar in which they are bedded - the fluid will be concentrated in the normally softer mortar at the expense of the masonry units.

Gravity feeding involves the use of cups attached to feed tubes into each hole, the cups being regularly re-filled until thorough soakage of a continuous layer right through the thickness of the wall has been achieved. The process takes considerably longer, but loss of fluid into voids is minimised and soakage into the denser parts of the masonry is encouraged.

The advantages of chemical damp proof courses are that:

- historic fabric is retained
- mess and disruption are reduced.

The main disadvantages are that:

- the continuity and effectiveness of the damp course are not visually apparent
- the quality and performance of the treatment is highly dependent on the skill, judgement, experience and integrity of the contractor
- the masonry and plaster above the level of the new damp proof course remain impregnated with salts, and can perpetuate damage by salt attack (see Rehydration)
- the common practice of using waterproofing agents when re-plastering internally (to prevent the re-emergence of salt damage by rehydration) can adversely affect the valuable external face of the masonry because the sealing of the internal surface concentrates the action on the unsealed external face
- the internal face is normally drilled just above the floor with the skirting board removed - this leaves the floor joists and bearers still prone to damage by contact with damp masonry.

Envelope damp proof courses

A third technique involves the cutting of a slot through the thickness of the wall for the insertion of a special flat tubular envelope fabricated from a similar polyethylene material to the normal damp proof course.

A short section at a time is cut using a chainsaw with an elongated blade and special masonry chain. Overlapping sections of the envelope damp proof course are inserted and injected with expanding grout to fill out the envelope and re-support the masonry. Once set, the exposed edge of the envelope is neatly trimmed. By using a waterproofing agent in the grout, the new damp proof course is effectively three layers in one.

The advantages of this method are as for the chemical damp proof course.

Disadvantages include potential problems with rehydration if separate action is not taken to draw the remaining salts out of the masonry above the level of the new damp proof course. It can also be invasive and time consuming.

The cement render cure

There are many examples of old masonry buildings which have been given a facing of grey cement render up to waist height in the belief that this would cure the rising damp problem. This misconception is grounded in a belief that relatively soft stones and mortars lack the 'strength' to resist the effects of damp, and that they are not 'waterproof'.

Such an approach is detrimental to the appearance of an historic wall, and most importantly, it does not actually work, causing even more extensive damage to the wall over time. It displays a lack of understanding of the dynamic environmental forces at work in traditional masonry construction, and the importance of keeping these in equilibrium.

Applying a cement render coating means that the path for evaporation of the moisture is blocked. Moisture then finds a new path of least resistance by rising higher in the wall to a level above the render band, or by diverting to the inner surface of the wall. This simply transfers the problem from one area to another, increasing the extent of damage to the building's fabric.

The very strength of a cement render is also its weakness. Being far more brittle and less resilient than the masonry to which it is applied, it is unable to absorb small movements. As a result it cracks and shears away from the underlying surface, becoming unstable and providing further means for water entry and retention.

If it is decided, after seeking professional advice, to repair a damp-affected wall with render, it must be designed to work in harmony with the physical properties of the underlying masonry. Careful attention is required to the mix to provide a suitably soft and porous render; one that will protect the wall by acting sacrificially (taking the brunt of the salt attack and thereby protecting the valuable masonry). The render should be regarded as expendable, to be replaced as often as necessary to protect the fabric underneath.

This approach can also be useful as a temporary measure before the later restoration of the wall. A suitably soft and compatible render will easily be removed later, having prevented deterioration of the wall in the interim. .

Rehydration

It is not unusual for the apparent signs of salt attack to persist in a wall even after the source of rising damp has been eliminated or a new damp proof course installed. This is a result of rehydration, which can occur when the remnant salts contained within the old masonry have not been extracted.

The types of salts encountered in masonry tend to be hygroscopic in nature - some highly so. This is defined as the propensity of the crystalline form of the salt to attract any available moisture and to revert to the dissolved state by rehydration. By this means, salts remaining within a treated wall can continue the destructive cycle of crystallisation and dissolving by absorbing atmospheric moisture, even when rising damp is no longer present.

Refer to DEH Technical Note 3.8 *Rising Damp and Salt Attack* for advice on removing salts from masonry.

6.6 Cracking

Cracks in masonry walls appear when the stresses within the wall exceed the wall's ability to resist them. In the majority of cases, the cause of stress will be soil movement under the building due to one or more of the following actions:

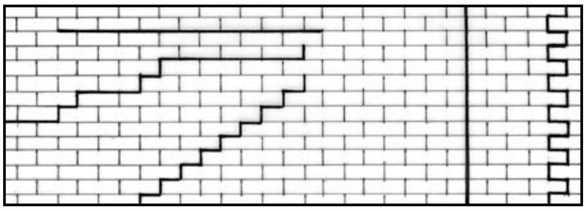
- the physical properties of the ground under the building - different soil types react in different ways to drying and wetting caused by tree root systems, evaporation, soakage of rainwater or surface water, variations in the height of the water table and so on
- initial settlement between old and new sections of the building - some compaction of the foundation zone can be expected as the new construction beds itself in, and will cause cracking at the junction with the old part if a flexible joint design is not used

- on-going movement between old and new sections - where the footing design of the new section makes it less vulnerable to fluctuations in soil conditions than the old section
- earth tremors.

Other potential causes of cracking in masonry walls are unrelated to the soil characteristics, and include:

- rusting of iron strapping built into brickwork - this appears as a long horizontal crack through a mortar joint line, and may occur at several different levels depending on the positions of the iron reinforcing straps
- lateral forces transferred from the roof framing - this may be a long-term problem of poor design, or may result from structural failure of some part of the roof structure
- overloading due to alterations and additions - where an old wall is required to provide structural support for new work, rather than the new wall being self-supporting.

Soil movement induced by changes in soil moisture content is by far the most common factor affecting older buildings in South Australia.



Types of Cracking – Cogged, Vertical, Horizantal and Stepped

Soil movement

The sub-structure of a building comprises some form of footing system, which is the part of the structure that transfers the building loads onto the foundation (defined as the ground supporting the building).

Modern buildings employ a wide variety of footing designs, including reinforced concrete strip footings, raft slabs and beams supported on deep piers. These are designed in accordance with Building Codes to protect the building from ground movements by being strong enough to resist them and by taking the building loads down to a known stable foundation stratum.

Further resistance to the effects of ground movement is achieved in modern masonry buildings by articulation - the use of flexible vertical joints to divide the walls into a series of separate panels which can move freely in relation to each other.

Older buildings, on the other hand, commonly have very rudimentary and unreinforced footings (for example, stone laid in mortar, loose rubble, lime concrete or even timber slabs), and these are typically at a shallow depth. In addition, masonry wall construction in older buildings is continuous and rigid, without any form of control jointing to absorb the movement.

The shallowness of the footings means that the foundation layer is close to the surface and therefore more susceptible to environmental conditions such as rainfall, surface drainage, temperature variations, periods of drought and moisture draw by trees. There may also be a wide variation in the structural capacity of this foundation layer due to natural geological variations, previous earthworks and landfill.

So, typically, with an older masonry building, the foundation zone is subject to variations in its behaviour - both a natural variation as an inherent characteristic of the near-surface conditions at the time of construction, and a seasonal fluctuation according to on-going environmental factors. Unreinforced footings are unable to resist the resulting movements in the foundation soils, and therefore transfer these directly to the masonry walls. These, being a continuous network of rigid and brittle construction, are similarly unable to absorb the movements transferred from the footings and therefore develop cracks at the points of stress.

Reactive clay soils

Cracking of masonry walls in older South Australian buildings is commonly due to the effect of drying and wetting on the physical properties of the soil in the foundation zone. This arises from the high concentrations of clays in the surface strata, particularly across the Adelaide Plain.

These soils are classified as reactive - meaning that they swell in volume when moistened and shrink as they dry out. By comparison, a sandy soil is quite stable under such conditions.

The degree of reactivity depends on the clay content and the thickness of the clay-rich layer, and can be graded from moderately to highly reactive.

The factors affecting soil moisture content are examined in Section 3.6, and their control is generally the key to the successful management of cracking on reactive soils. The aim is to maintain as constant a level of soil moisture as possible throughout the cycle of the seasons - the actual level, whether fairly dry or quite moist, is not of relevance; it is the changes from one extreme to the other that are the problem.

The seasonal cycles of drying and wetting of the foundation soils will typically produce cracks which open and close, reaching their widest at the end of summer and beginning to close again as the soil takes up moisture again, often returning to fully-closed by late winter. Refer to Section 4.2 for the reason why you should not repair cracks when they are at their worst, but only when the underlying cause has been identified and rectified and the wall has been allowed to stabilise.

The seriousness of this cyclical cracking will depend on the difference between the seasonal extremes and on the nature of the building's construction.

Monitoring

To accurately identify the cause of cracking, collect detailed information on:

- building construction type
- soil type
- crack width, length and location
- crack type - cracks may taper in width from top or bottom depending on the nature of the structural movement, and may be vertical, stepped or horizontal
- the history of the cracks (how they have changed over time)
- any factors potentially affecting soil moisture content.

Having collected as much information as possible, seek structural advice from an engineer or architect to ensure that the cause of serious cracking is analysed prior to any remedial work. Incorrect diagnosis of a cracking problem could result in further damage and unnecessary expense.

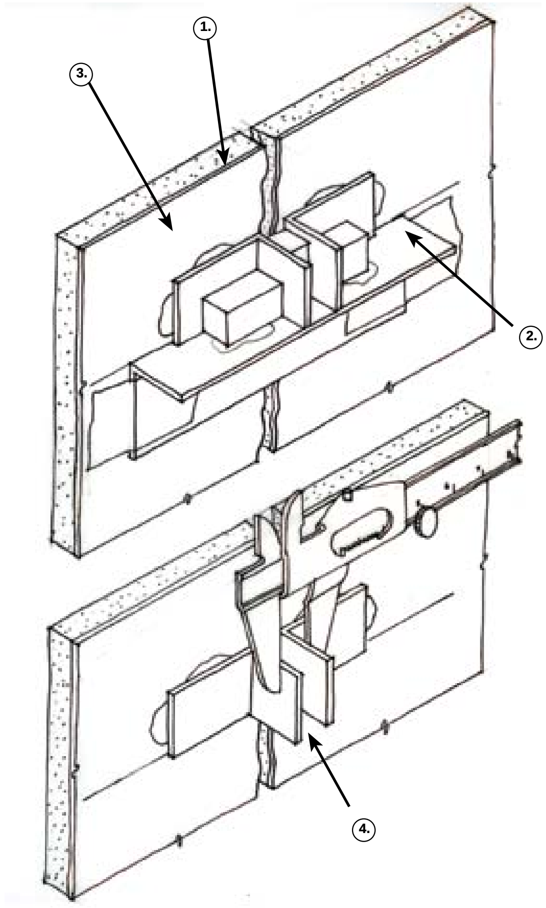
Monitor cracks to determine if they are cyclical in nature as a result of soil moisture content, or if they are caused by other factors.

Observe the location and pattern of cracking and record and note any changes over time. This can be done with a simple sketch or by marking up a photograph.

Tell-tales

A simple method of checking if a crack is moving is to mark a cross in pencil on either side of the crack in question. The crosses should be at right angles to the crack and about 100 millimetres either side. Accurately measure the distance between the crosses and record this distance. At regular intervals, say every two months, measure the distance again and record this with the previous results. If a straight line is drawn between the two crosses, any movement along the length of the crack can also be measured by noting the dislocation between the two halves of the line.

A more complete method involves the construction of a 'tell tale' as illustrated. This monitoring should be carried out for at least twelve months, and preferably two years, in order to obtain an accurate picture of the movement of the crack. General weather conditions could also be noted, for example the months during which rainfall occurred.



Tell-tale device

1. Crack tell-tale ex. – aluminium angle 20x30x2
2. Aluminium angle jig to hold tell-tales in place while epoxy glue sets.
3. Epoxy glue taped to wall surface
4. Tell-tales in place with jig removed – use vernier caliper to measure movement

Stabilising cracks

Before repairing the damage, the underlying cause of the cracking needs to be rectified. The potential causes of foundation movement are covered in Section 3.6, along with some basic remedies to help control soil moisture content. More advanced approaches are sometimes needed, and include the following:

Underpinning

This involves digging the foundation soil away from underneath a section of footing and pouring a concrete pier (or pin) underneath it. The aim is to transfer the load from the footing down to a more stable stratum (determined from a soil test). Where the reactive soil is deep the point of support should be below the zone that is affected by seasonal environmental conditions.

Seek professional engineering advice before proceeding with underpinning. There is a tendency in the building industry to regard underpinning as the universal cure-all for buildings on reactive soils, but results can be disappointing if the solution has not been determined by engineering calculations, based on a soil test to identify the nature of underlying strata. It can be an expensive mistake to approach underpinning in a hit-and-miss manner.

Even in situations where it can help, you should be aware that sections of the sub-structure which are re-supported on underpins will probably be more stable than the untreated sections, and that new problems with cracking may well develop at the interfaces.

Hydration

Various methods of controlling soil moisture content are described in Section 3.6, but in some cases may not be entirely adequate. For situations in which excessive drying out during the summer months is a problem, artificial hydration of the foundation zone under the footings may prove suitable, subject to engineering advice, and water restrictions.

A method which has been used with success in Adelaide involves laying a perforated pipe into a trench around the perimeter of the building. A dripper line made up of standard garden irrigation components is fed into the pipe. By adding a controlled amount of water into the system, the drying out of the soil during the summer months can be prevented.

The design of the system, including the positioning of the pipe in relation to the footings, and the quantity, rate and frequency of supplementary watering, should be left to a structural engineer.

A more sophisticated version of this method uses moisture sensors in the soil to automatically control the watering cycle. In either case, the aim is to add just enough water at different times of the year to maintain the moisture content of the foundation soils at a constant level.

A note of caution - adding moisture into the ground around the building increases the risk of related problems such as rising damp or termites. If soil moisture levels are already unusually high at their wet season peak, the control of cracking should look at reducing this rather than using artificial hydration to lift the dry season low up to this level.

Tie rods

Many older buildings have tie rods added at some stage during their life to control a cracking problem. They are typically set up near the ceiling level, running across the building from side to side, terminating each end in a forged or cast iron spreader plate on the external wall face.

As a general rule, their use should be restricted to situations where the sideways forces on the wall originate up at that level - for instance from spreading roof framing - rather than from the base of the wall, as in the case of footing movement. This is because that unless the footing movement is eliminated, the wall itself is subjected to opposing forces - being moved at its base but held rigid at the top. Traditional masonry construction is not well-suited to resisting this sort of loading, and it is common to see a small patch of stonework held in place around the plate while the rest of the wall has broken away from it and continues to lean outwards.

Repairing cracks

A crack that carries through the full thickness of a wall represents a loss of structural integrity; the loads and stresses are no longer distributed and absorbed by the wall as a single structural entity. The standard approach to patching cracks is to fill them with a rigid, plaster-based compound, which satisfies the aesthetic aim but does little for the structural performance of the wall.

In many cases this is not a problem, and may prove quite adequate where the movement that caused the cracking has been brought under control. However there are situations in which the stability of the wall is compromised by a major crack, and some method of re-joining the two sides is recommended. The following methods are suitable for internal wall faces where the repair is concealed by a finish such as plaster.

Metal mesh

The plaster is stripped back to a width of about 50 centimetres either side of the crack, and expanded galvanised steel mesh or a heavy aluminium mesh is fixed across the crack. The fixing method will depend on the condition and construction of the wall, but might be masonry nails or masonry anchors. The wall is then re-plastered with the mesh being fully embedded in the new plaster.

This method is useful for regaining partial continuity of the wall construction, but depends very much on the absence of any but the smallest movement between the two sections of wall, and on the ability of the wall construction itself to resist the localised forces at the fixings.

Stitching or dental repair

The term refers to the technique of bridging across the crack with new stones. At intervals along the crack, individual stones broken through by the stresses in the wall are removed and replaced with new stones, literally stitching the wall back together.

The finished result is not intended to be seen and is plastered over. The reconstruction of a cracked section of external wall can adopt the same basic principle, but of course requires the replacement of every broken stone or brick, with careful attention to the matching of colour, texture, finish and pointing.

7. Further Reading

Australia ICOMOS

The Australia ICOMOS Charter for Places of Cultural Significance (The Burra Charter), 1999.

Available online at http://www.marquis-kyle.com.au/burra99.htm

DEH Heritage Branch

Technical Information

Available online at the DEH Heritage website http://www.heritage.sa.gov.au

Heritage Victoria

Technical Information

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J. S. Kerr

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NSW Heritage Office

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Available online at the NSW Heritage Office website http://www.heritage.nsw.gov.au/03_index.htm#M-O

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Dept for Transport, Urban Planning and the Arts, Adelaide, SA, 2001

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The Illustrated Burra Charter: good practice for heritage places

Australia ICOMOS Inc., Burwood, 2004

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For further information please contact:

Department for Environment and Heritage
T: (08) 8124 4960
E: heritage@saugov.sa.gov.au

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