Department of Environment and Heritage Protection

TECHNICAL NOTE

Conserving Roofs

Great state. Great opportunity.

Queensland Government

This technical note is provided as general, ‘best practice’ advice for conserving places of heritage value. It is not exhaustive and is not to be taken to legitimise works carried out without the necessary approvals.

For information about work that may be done without application, refer to General Exemption Certificate: Queensland Heritage Places, available on the EHP website at www.ehp.qld.gov.au

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Acknowledgment

This publication was produced in accordance with resource-sharing arrangements approved by the Australian Heritage Information Network. Some material and concepts have been adapted from the Heritage Information Series published by the NSW Heritage Office, online edition 2004.

Prepared March 2014

Version 1.3

#30250

Contents

INTRODUCTION—CONSERVING ROOFS

Purpose

This series of technical notes is designed to help owners and managers of heritage-listed buildings understand the characteristics of their particular building in relation to the care, and where necessary the repair, of its roof.

The word roof is used in two different senses; the supporting structure that spans the building and holds up the protective covering, and the protective covering material. These notes describe, individually, the types of roof coverings found on heritage-listed buildings in Queensland and outline conservation issues associated with them in the following sections:

1. Metal roofs—deals mainly with corrugated galvanised iron and steel but also includes copper, zinc and lead coverings.
2. Asbestos cement roofs—considers the problems posed by asbestos in the context of heritage-listed buildings.
3. Terracotta tiles, slates and shingles.

The need for a supporting structure and the means of rainwater disposal is common to all roof coverings. The individual characteristics of the coverings determine, to some extent, the detail of the rainwater goods and the type of structure required to support the roof. Conservation issues associated with disposing of rainwater and supporting various installations on the roof are discussed in the following sections:

4. Roof drainage—common to all roofs.
5. Roof structure—timber, steel or a combination of these materials make up the roof structure of most heritage-listed buildings.
6. Roof installations—aerials, satellite dishes, air conditioning units, solar panels, safety systems etc.

Context

The roof may be considered to be the most important part of the building. Even without walls, a roof can be used as a shade structure or to provide protection for produce, materials or equipment. It excludes sun, wind and rain, and protects and preserves the materials that comprise the lower parts of the structure.

In the early days of the European settlement, roofs were first covered with bark, and later with shingles split from trees such as Forest Oak (casuarina torulosa) and Ironbark (eucalyptus fibrosa). Shingles required a steep pitch. They were widely used, however their lifespan was comparatively short and few shingle roofs have survived intact today. Shingles were often simply sheeted over with corrugated iron when this material became available. The tradition of relatively steep pitched roofs was continued well into the 20th century when new materials made lower pitches more economical.

The roof of the Victorian house often drew attention to itself with varied forms, steep pitches, gables and decoration

In the Queensland climate, the need to quickly dispose of rainwater and give shade has given rise to roofs of strong visual character. The profiles of the roof ridges against the sky and spreading, lower-pitched verandah roofs are significant architectural features that must be handled with care when carrying out conservation works. These 19th and early 20th century roof forms were often celebrated with decorative elements such as cast iron cresting on ridgelines and turned finials at gable ends. Functional installations like ventilators were similarly decorated to take advantage of their location at high points of the roof.

Corrugated galvanised iron or steel sheets are the most common form of roof covering found in Queensland. It is comparatively light, easy to transport and requires only basic framing for support. It provides a good surface for collecting water, an important consideration in Queensland.

Not as common as corrugated iron, but characteristic of many suburbs in Australia, is the orange-red colour of terracotta roof tiles. The Marseilles pattern tile, introduced first in 1886, was most popular during the Federation period and is still being manufactured.

Even less common than tiles in Queensland are natural slate roofs. Slates were imported from England and Wales and, being an expensive option, were only used on prestigious buildings.

Asbestos cement first made its appearance in Australia as an imported roofing slate early in the 20th century. These slates were being produced locally by the 1920s. The greatest use of asbestos cement came in the post war years—1945 to 1970—in the form of the 'super six' roofing sheet, marketed as a low cost, fire-proof, durable material. Some heritage-listed buildings, both domestic and commercial, still have asbestos cement roofs. Although asbestos-containing products are now banned, existing roofs are not hazardous unless damaged or decaying. Removing or treating asbestos products may only be undertaken by licensed contractors.

Roofs have, over the years, become the home of a variety of installations deemed necessary for everyday life and which the structure was not designed to support. These installations range from air conditioning plant to photovoltaic panels. Apart from their likely negative affect on the appearance of the place, and hence its heritage significance, there are concerns for structural adequacy and the likelihood that the installation will be a source of leaks.

Work carried out on the roof must be done safely. On high or complex roofs, this may require installing safe access routes or at least fall arrest and restraint systems.

When it becomes necessary to replace or carry out extensive work on the roof covering it may be appropriate to consider installing insulation and sarking. Sarking adds a second line of defence against roof leaks and insulation will improve the thermal efficiency of the building. Care must be taken to ensure that problems such as condensation are not created in vulnerable spaces by the installation of insulation and sarking.

1. METAL ROOFS

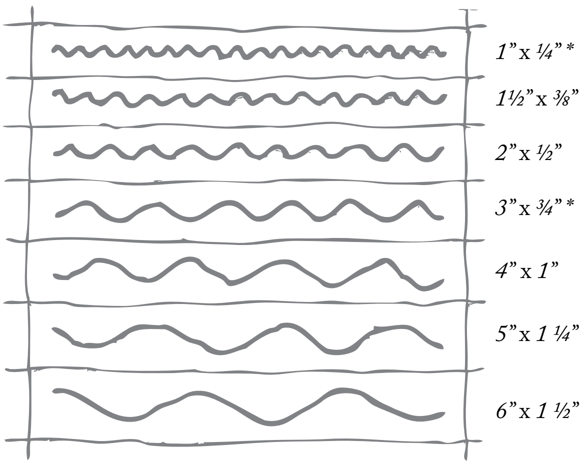
Purpose

This section describes the characteristics and conservation issues related mainly to corrugated galvanised iron and steel roof coverings. Other sheet metal coverings are dealt with, but in less detail.

Keeping the roof watertight is critical as roof failure can have serious consequences for the rest of the building. A faulty roof can lead not only to damaged ceilings and internal finishes but can also result in structural decay of elements within the building.

Prolonging the life of a metal roof

As a leaking roof is a major source of building damage, it is vital to keep it watertight. Faulty flashings, blocked valley gutters or downpipes and rusted roof sheets can all cause leaks. Water can gain entry where loose or missing fixings have allowed side laps to lift or become distorted. Faulty joints around flues, vents, skylights and chimneys can also cause problems. It is good practice to keep the roof free of debris. Frequency of cleaning will vary depending on the pitch of the roof and the amount of debris that collects. Excessive walking traffic on the roofing sheets will result in flattened corrugations, loosened fixings and general deformation. Check regularly to ensure that the roof sheeting is well nailed or screwed down.



** Correspond approximately with galvanised iron available today.*

Galvanised iron sections as illustrated in Lysaght's Referee and Storekeeper's Guide 1906

Corrugated galvanised iron

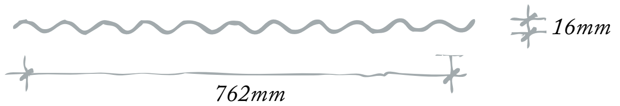
The common term 'corrugated galvanised iron' is used to describe two different materials—galvanised wrought iron and galvanised mild steel. Until the end of the 19th century, all corrugated metal sheeting was made from wrought iron. After that time, mild steel replaced the iron as steel processing techniques improved. Early production of galvanised corrugated iron relied on imported sheet iron and it was only in the 1920s that large-scale production began in Australia.

Although iron and steel are stronger than other common metals, they corrode readily in air and water, and their use as a durable building material became possible only with the protection provided by galvanising—immersion in molten zinc. A thin coating of protective zinc bonds to the iron or steel base by a series of iron-zinc alloy layers. The zinc corrodes slowly and, in the process, produces a relatively non-porous and stable protective coating to the steel.

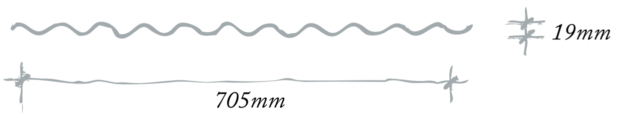
Since about 1850, corrugated galvanised iron and steel have been widely used in Australia, becoming identified with the Australian vernacular tradition. Corrugated sheeting is strong enough to span between battens without sagging. The corrugations of the sheets available ranged from 5 inches (125mm) to 1 inch (25mm) with 3 inches (76mm) and 1 inch most commonly used. Sheets were available in lengths up to 12 feet (3.6 metres). These short lengths of weathered, galvanised roofing sheets, with their prominent lead head nail fixings, provide the patina important to Queensland's cultural heritage.

Lysaght's 'Orb' branded corrugated sheets have been produced in Australia since 1921 and Custom Orb® and Custom Blue Orb® are still available. Although close to the original in appearance, the profile of the sheet has changed in the following respects: the depth of the corrugation has been reduced from 19mm to 16mm and the curve of the corrugation changed from the original circular curve to a sine curve. Custom Orb® sheets are now only available in Zincalume® and COLORBOND® finishes. Zincalume® is a coating alloy introduced in 1976 containing 55% aluminium, 43% zinc and 1.6% silicon. It has become the most common metallic roofing material available in Australia, and Zincalume® sheets are available in a pre-painted finish known as COLORBOND®.

The only zinc-galvanised corrugated steel still produced and is available as S-Rib Corrugated™ from Fielders with a Z450 (Galvanised) or Z600 (Heritage Galvanised) finish. The latter is a heavier 'double dip' zinc coating. If the sheeting is to be curved, a thicker sheet of 0.60 base metal thickness (BMT) is required. The standard thickness is 0.48 BMT.



Fielders S rib corrugated, standard corrugated sheet



Fielders Heritage barrel rolled sheets formed on a restored 75-year-old press

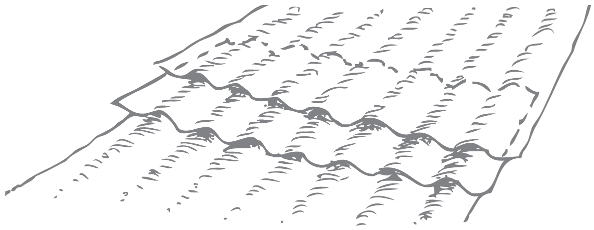
Galvanised iron roofing sheets currently available

Using a restored barrel press, Fielders also produces a Heritage Galvanised corrugated sheet with the original 19mm deep corrugation and profile in lengths up to three metres.

Lysaght also produces its thicker 0.60 BMT Custom Blue Orb® sheet with a galvanised finish, suitable for curving and for use in rainwater tanks.

Repairing corrugated galvanised roofs

- Patching small holes can extend the life of a sheet. The traditional technique is to lead solder a patch of iron over the hole.
- When lap sheets have rusted around their fixings, inserting a slip-sheet can extend the life of the roof covering. This can be a short length of matching, profiled, corrugated sheeting inserted between the sheets at the rusted lap joint. It protrudes 100mm below the lap joint and is secured on the adjacent corrugation.



A slip sheet inserted between sheets at the rusted lap joint

- Corrugations in sheets that have been damaged may be repaired by re-rolling. Some sheet metal firms may still have rollers of the correct dimensions. When replacing sheets look at the underside for brand names—this may help date any repairs or alterations made to it.
- Where a few sheets or a small section of roof sheeting need replacing, do so with material matching the profile and appearance of the existing sheeting. Second-hand sheets may be appropriate. If it is not possible to match the existing sheeting, and new sheeting is required, move the sheets around on the roof so that complete pitches or sections are of sound, older material while other pitches or sections are of the new sheeting.
- Where the patina and checkerboard pattern of corrosion on a roof is considered important as part of the cultural heritage significance, repair rather than replace sheeting.
- Complete replacement of roof sheeting may be necessary if decay or damage is extensive. Replacement roofing sheets should match the originals.

Materials—compatibility and appropriateness

Where repair or replacement is required, repair materials should match the existing. Modern alternative metal sheeting may differ in sheet length, surface finish, corrugation size, profile and dimension. Galvanised steel is still manufactured in Australia and is available in a range of profiles, thicknesses and strengths, and in several weights (thicknesses) of zinc coating.

Zincalume®, the modern-day equivalent coating to zinc galvanising for steel, has a different surface texture and retains its gloss much longer than zinc. The gloss finish is out of keeping with the matt appearance of traditional galvanising.

Zincalume® sheeting and zinc-coated materials should not be used together where rainwater runs from Zincalume® onto zinc-coated surfaces, electrolytic action causes the zinc coating to dissolve. There are similar concerns where Zincalume® is used with lead flashings. Replacing a roof in Zincalume® therefore requires removing existing guttering and flashings.

Sheet lengths

Modern production methods enable corrugated sheeting to be produced in much longer lengths than earlier sheeting. The availability of the longer sheets allows roofs to be covered in single-sheet lengths with no overlapping transverse joins, eliminating a major potential source of corrosion.

This has advantages for vulnerable roofs, but the practice needs to be weighed against the change in appearance that full-length sheets will bring. On steeply sloping roofs comprised of short sheets, the joins can be seen due to the shadow of the overlapping sheet and, less obviously, the additional nailing needed at the join. These provide a distinct horizontal element to the appearance of the roof and their loss may change the heritage significance of the roof. Where roofs are not readily visible the use of full length sheets may be appropriate.

Colour

Matching the colour of a painted roof is relatively straightforward as the new roof may be painted in that colour. Maintaining a sound paint film prolongs the life of corrugated roofing even when much of the zinc coating has been lost from the sheet. Rust converters, alkyd-based primers containing anti-corrosive pigments, and special primers for use over zinc coatings are readily available.

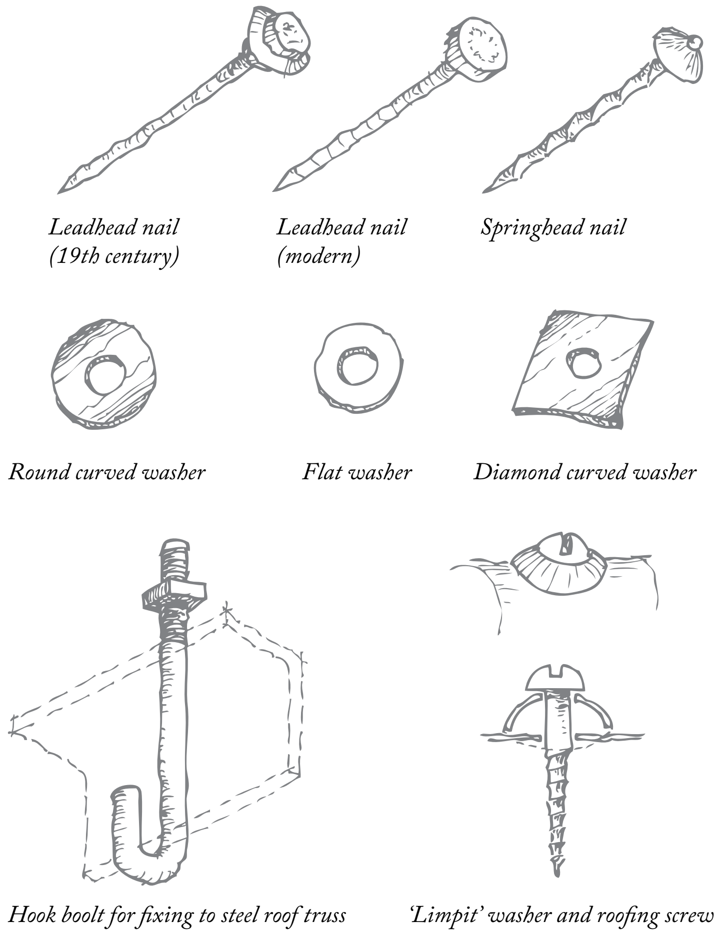
When replacing a previously painted roof, an approximation of the original colour may be found in the range of COLORBOND® finishes that are available for corrugated sheeting. The colour match is unlikely to be close and COLORBOND® weathers differently from traditional roof paints.

The colour of weathered, unpainted galvanised sheets cannot be matched by Zincalume®, which is both glossy and does not weather to the dull grey of the traditional finish. While new galvanised steel is very bright, it soon weathers to the dull grey we associate with galvanised iron buildings.

New galvanised steel has a thin coating of oil. Normally this weathers off and the sheeting may be painted after several months. If it is to be painted immediately, the roof should be washed with a detergent such as sugar soap, then rinsed with fresh water. A system based on acrylic primer and top coat may then be applied.

Fastenings

As with sheet lengths, the appearance of the roof is affected by the type of fastening. The horizontal lines of fastenings formed by traditional lead-headed nails, spring-head nails or slot-headed roofing screws and washers often contribute to the heritage significance of the building. These fasteners should be used for repairs and replacements, at least in those visible parts of the roof. Where the nail holes have become enlarged, and the nails do not hold, it may be necessary to use screw fixings.



Various fixings for corrugated sheeting

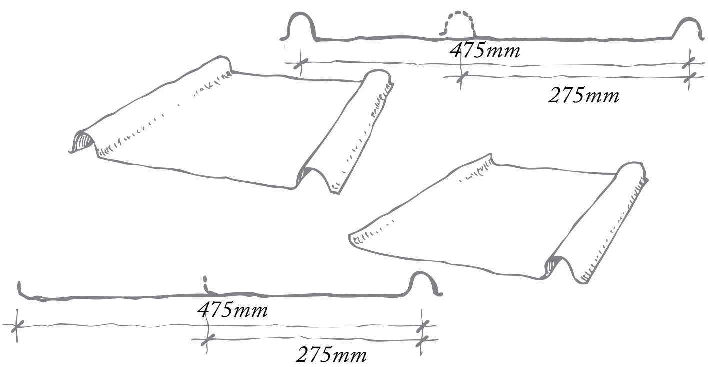
Decorative and other features

Roofs were often finished with decorative elements. Ridge lines often featured cresting of cast iron or decoratively cut galvanised sheet iron. Gable ends invariably featured finials, usually of turned timber. Acroteria formed from decoratively cut galvanised sheet iron were often located at the corners of gutters. Roof ventilators were essentially functional but, being located at the highpoint of the roof, their decorative potential was often exploited in elaborate detail.

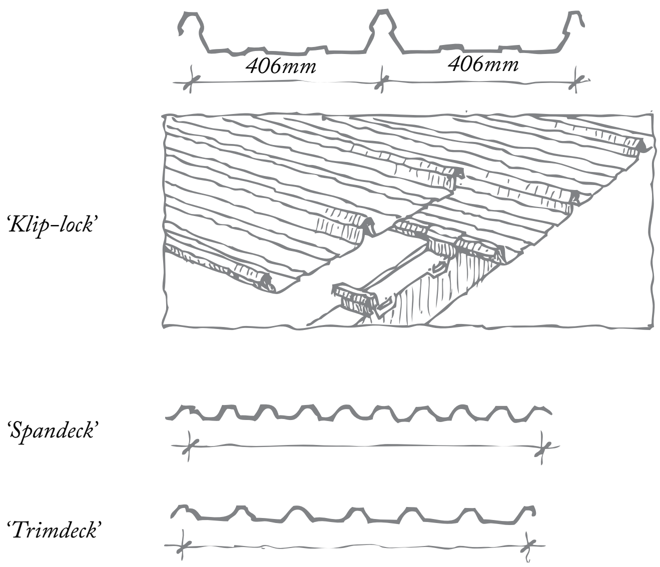
These features were an essential part of the aesthetic of the roof form and should be retained and repaired as necessary. Lost features may be readily replicated where good photographic evidence of their appearance exists. Speculative embellishments, however, should not be attempted.

Other galvanised steel profiles

- Typically corrugated iron has a rounded profile (e.g. sheets with eight 76mm corrugations and a 19mm depth), but during the late 19th century a variety of profiles were available from different manufacturers. Their corrugations varied from 76mm to 127mm and the depth varied from 16mm to 38mm. The larger profiles were stronger and had a greater spanning ability, allowing wider coverage with wider support spacing. This was useful on larger buildings where the sheeting had to be fixed with ease and speed.
- Ripple iron is a smaller profiled corrugated sheet commonly used to clad window awnings, walls, ceilings and sometimes the building exterior. It does not have the strength of traditional larger profiled corrugated iron and is not suitable for roofing or foot traffic. A modern equivalent is manufactured today as Mini Orb® but it has a flatter profile.
- Another common galvanised iron roofing profile found throughout Australia is the roll and pan (known variously as rib and pan, iron roof tiles, Queensland Government profile). This is essentially a sheet of galvanised iron (approximately 475 mm by 900 mm) with a rolled edge and an up-stand (or another roll) on the opposite edge. They were laid as tiles fixed to the battens or, less often, on boarded roofs. Roll and pan profile was widely used on government buildings in Queensland from the late 1890s where the roof was an important element in the architectural composition.
- Roll and pan roofing is susceptible to the same problems of decay as corrugated sheeting, namely corrosion at overlaps and loose fixings. Finding replacement tiles can be more problematic as sizes and profiles of the original tiles varied with manufacturer. Replacement tiles can be replicated from heavy gauge galvanised iron by a sheet metal worker. Fielders produces a Neo Roman® roll and pan profile tile based on tiles typically used in Queensland. Neo Roman® profile is made in various finishes including the Z600 Heritage Galvanised.
- During the 1960s, several new roofing sheet profiles were introduced. These were roll formed from coil strip enabling continuous sheets of up to 12m lengths to be produced. Similar in concept to the traditional corrugated sheet, these products (Spandeck® and Trimdeck®) have a trapezoidal profile quite different in appearance. A more innovative product was the Klip-Lok® 'Sixteen' that had three ribs 41mm deep. When fixed, the side ribs of adjacent sheets interlocked and did not require additional fastening making it especially suitable for near-flat roofs.



Roll and pan roofing profile produced by Fielders as 'Neo Roman'

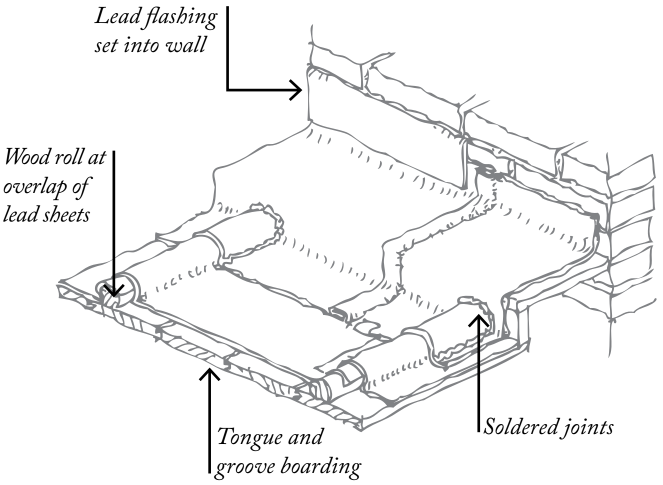


Steel roof deck profiles introduced during the 1960s and still in production (although no longer galvanised)

- These new profiles have on occasion been inappropriately used as replacements for corrugated sheets on heritage-listed buildings. The effect of the angular, trapezoidal profile is much harsher than the gentle curve of the corrugated original. Where these new profiles have been used on buildings of the 1960s through to the present day, they are quite appropriate and feature on heritage-listed buildings of the later 20th century. All are still produced but are no longer available in a galvanised finish.

Non-ferrous metal roofing

Zinc, copper and lead sheeted roofs are also found in Queensland, usually on larger, public buildings. Although comparatively expensive, these metals are durable. For this reason they were often used on prestigious buildings and to clad spires or domes as they require little maintenance. A well-laid lead, copper or zinc roof could be expected to last for 150 to 200 years.

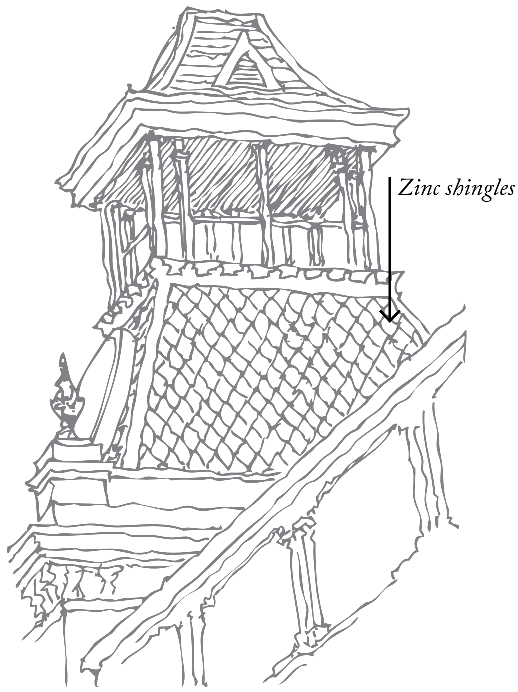


Lead roofing sheet at junction with parapet wall

The metals are laid in sheets on to a tongue and groove boarded roof. Zinc and copper sheets usually have standing seam joints while the softer lead sheets have rolled or folded joints.

Because of their durability the cause of leaks in these roofs is most likely to be a result of mechanical damage. Once the metal covering is penetrated the resulting leak may not be immediately apparent and can decay the boarding supporting the metal.

Zinc or copper shingles were sometimes used to clad steeply pitched roofs.



Zinc interlocking shingles—applied to tower as a low maintenance decorative finish

Repairing non-ferrous metal roofing materials

- Inspect roofs after rain as small holes in the lead will be more visible and areas liable to ponding will be apparent. Leaks will not necessarily be apparent directly under the damaged metal as the water may travel between the metal and the boarding for some distance before emerging.
- Repair of damaged lead roofing should only be by lead-burning (welding) carried out specialist trades people. Solder should not be used. Similarly, copper and zinc repairs should only be carried out by specialist trades people.
- Replacement tongue and groove boarding must be secret nailed (plywood is used more frequently today to support sheet metal roofs).
- Due to galvanic action, copper is affected by water running off aluminium. Aluminium, steel and galvanised fasteners must not be used on copper sheet—only copper nails should be used. Run-off from copper sheet will corrode aluminium and steel guttering. Lead and steel in association are unaffected.
- Zinc sheet may be repaired by solder, but as it is thin, piecemeal repair is not advisable. Fixings must be galvanised.

2. ASBESTOS CEMENT ROOFS

Purpose

This section provides owners of heritage-listed buildings with an overview of asbestos cement roofs. Asbestos materials may be found in heritage-listed buildings and can represent a serious health risk if they are not handled safely. This technical note includes references on where to find information on legal requirements and safe work practices, a brief history of the introduction of the material into Australia, how to identify asbestos cement roof products, and notes on maintenance, repair and painting.

Context

Asbestos is a naturally occurring mineral which has excellent durability, fire resistance and insulating properties. Asbestos cement roof products, made from asbestos fibres bonded in cement, were introduced into Australia as early as 1903 and, though they are less common after 1980, they may be found in buildings constructed up to 1990. They are especially common in houses built during and after World War II when a materials shortage led to a boom in the use of the material. Asbestos cement roof products included roof cladding, rainwater goods and other roof accessories. Asbestos cement roofing is commonly referred to as 'fibro', 'asbestos cement', 'AC sheeting' or 'Super Six'.

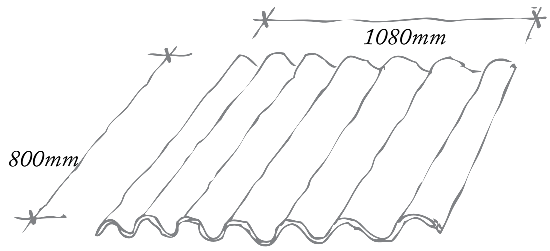
Inhaled asbestos fibres are a proven cause of life threatening illnesses including Asbestosis, lung cancer, and Mesothelioma. However, current scientific and medical evidence indicates that asbestos cement roofing in good condition does not represent a health risk while the fibres remain bound within the material. A health risk arises if fibres are released as a result of severe weathering, damage or unsafe work practices.

Due to the associated health risks, the department recommends that owners use tradespeople who are licensed to carry out work on asbestos cement. If owners remove asbestos cement illegally or unsafely they may be subject to legal action including 'on the spot' fines. See the Queensland Government websites on asbestos listed in the references.

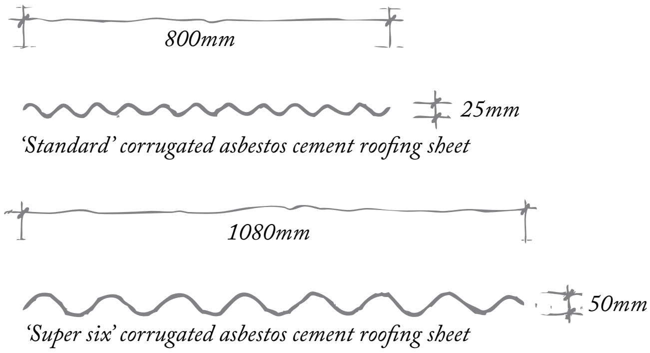
Historical introduction of asbestos cement roofing

Corrugated asbestos

Imported corrugated asbestos cement sheeting was available in Australia by 1914. Australian manufacture began in 1917 with James Hardie and Co's 'Fibrolite' corrugated sheeting and, by 1926, Wunderlich were manufacturing 'Durasbestos' corrugated sheets. Both companies subsequently introduced additional profiles: Hardie's 'Super Six' profile with deeper corrugations than their standard sheets (1926), Wunderlich's deep corrugated Durasbestos (1935), and Hardie's 'New Contour' (mid-1950s).



'Tuskan' tile—'Super six' sheets in short lengths and produced in various colours, laid as tiles

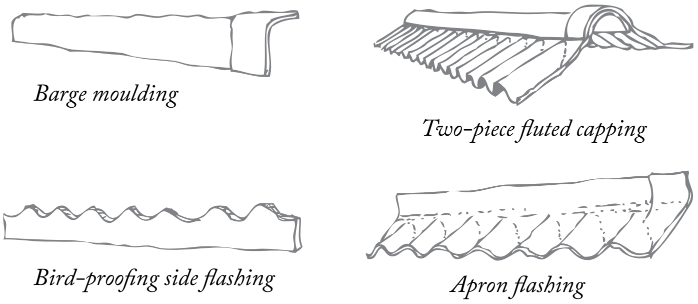


Most common asbestos cement roofing sheets

In 1969, CSR took control of Wunderlich and gradually phased out their interests. Finally, in 1977, James Hardie acquired the Durasbestos factories giving them a virtual monopoly on fibre cement manufacture in Australia.

Asbestos slates and tiles

Asbestos cement slates were first imported by James Hardie in 1903. By 1907 their range included slates in purple, blue, red and grey in various sizes and thicknesses. The earliest known examples of asbestos cement slates in Queensland date to 1908. Hardie began manufacturing slates in Australia in 1917.



Some typical asbestos cement roofing accessories

Wunderlich introduced asbestos cement 'Tropical' Roofing Tiles in about 1938. These were deeply corrugated sheets, 2 feet 6 inches (0.75m) long and reddish brown in colour.

Identifying asbestos cement roofing

Roof products containing asbestos include the following:

- corrugated sheets
- roof slates and tiles
- ridge capping
- ventilating ridges and other kinds of roof ventilators
- skylights and manholes
- flashing
- mouldings
- gutters and accessories
- downpipes
- vent pipes
- flue pipes
- soffit sheeting
- water proofing membrane
- spray on vermiculite insulation material.

Unpainted asbestos cement roofs are usually dark grey in colour and the material thickness is 5mm or more. If in doubt, have the product tested. Contact the National Association of Testing Authorities at www.nata.asn.au to obtain information about laboratories that test building materials for asbestos.

Maintaining an asbestos cement roof

Do not disturb asbestos cement roofs in good condition. Restrict maintenance to:

- regular inspections to monitor the condition of the roof
- checking and refastening fixings as required.

Use binoculars in preference to walking on the roof to carry out inspections. Asbestos cement sheets become very brittle with age and may crack, leading to leakage and possible release of asbestos fibres.

Do not clean asbestos cement roofs. Owners should note that it is illegal to use high pressure water as it can destroy the surface of the material releasing asbestos fibres. Consider applying a fungicide followed by a sealant as an alternative to cleaning.

Repairing and replacing asbestos cement roofs

Do not carry out work on asbestos cement roofing material unless it is no longer water-tight, or a health risk because it has become friable and may release asbestos fibres.

When fitting new roof elements or an entirely new roof, match the appearance and profile of the original material as closely as possible with materials that do not contain asbestos. For example:

- asbestos cement tiles may be replaced by concrete tiles of a similar appearance
- corrugated asbestos cement sheeting may be replaced by corrugated steel or fibreglass of a similar profile
- asbestos cement slates may be replaced with fibre cement slating.

Asbestos free fibre cement sheeting in a variety of forms is also available.

Painting

Only paint asbestos cement roofs that are in good condition. Damaged or badly weathered asbestos cement should be safely removed by a licenced tradesperson in compliance with legal requirements as described previously. If you decide to paint a roof, replicate the existing paint colour or reinstate the original colour.

Do not paint an unpainted roof. Unpainted asbestos cement roofs are safe if they are in good condition. The roof can be protected by applying a clear sealant that does not alter its appearance. Choose a sealant specifically designed for asbestos cement products that has a life of 10 years or more and can be applied over existing finishes.

When preparing and painting the roof, follow the safe working procedures recommended by the Queensland Government. It is illegal to use dry sanding or power tools on asbestos cement. Where possible, retain the existing paint and apply the fresh coat over the top.

3. TERRACOTTA TILES, SLATE AND SHINGLE ROOFING

Purpose

This section deals with roofing made up of small units, as distinct from sheeting, which is covered under the metal roofs technical note. While metal roofs are most common in Queensland, slate and terracotta tiles are also found on earlier buildings. Timber shingles were widely used but few have survived intact. This technical note reviews the most common damage found on these roofs and identifies appropriate repairs.

Keeping the roof watertight is the first duty of the owner or maintenance manager, as roof failure can have serious consequences for the rest of the building. A poorly performing roof can damage ceilings, discharge water over walls and at the base of the building, leading to rising damp and settlement cracking. Watertightness is achieved by overlapping the small units, the overlap needing to be sufficient to cope with water being driven up the roof by wind. The steeper the roof the smaller the overlap needed to keep the water out.

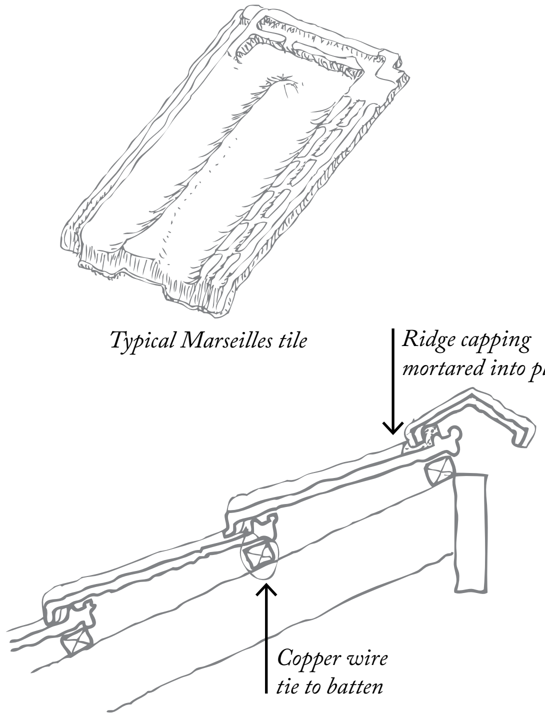
Where roof slopes meet other slopes at hips or valleys, or vertical elements such as parapets and chimneys, gutters, cappings and flashings are required. These meeting places will concentrate water and must be well protected.

Terracotta roof tiles

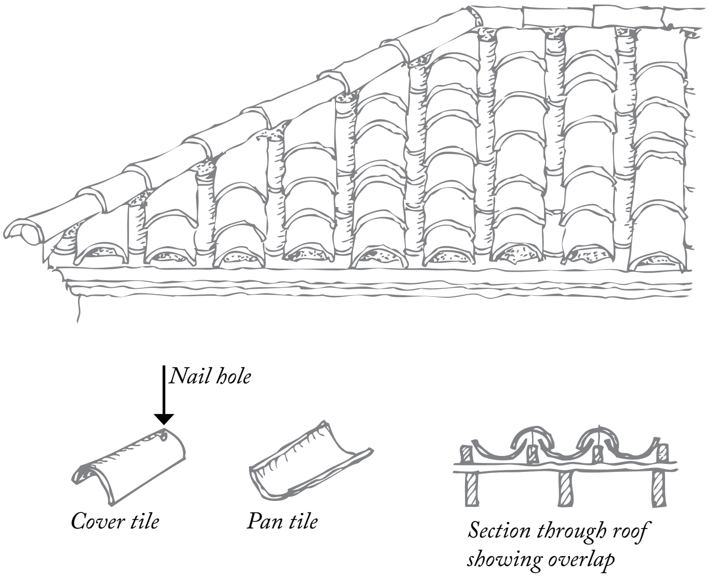
Various terracotta tile profiles can be found on Queensland roofs, mainly in the state's south-east. The most common is the Marseilles patterned tile. Originating in France, they were first imported to Australia in 1886. They were popular in the early 20th century throughout Australia, becoming a feature of Federation-style buildings. Along with other profiles such as the Spanish Mission and Cordova tiles, they were produced locally after the First World War. The orange-red colour of terracotta tiles has given many Australian suburbs their distinctive appearance.

Terracotta tiles were made in stack kilns, in a similar way to bricks. The process resulted in different degrees of firing, varying from overburnt to underburnt. Glazed tiles had the salt glaze applied by hand, resulting in variations in thickness of the glaze. The manufacturing process thus resulted in natural variations in the tiles' colour. As processes improved, these variations have been progressively eliminated and modern tiles are very uniform in colour—this may make them less suitable for re-roofing on an old building.

There are two types of terracotta roofing tiles: interlocking and overlapping. Interlocking tiles (such as the Marseilles tile) hook over a lip on the lower tile, securing the two together. They are shaped to hook over the battens, but also have holes that allow them to be fixed to the batten with copper wire. Overlapping tiles (such as the Spanish tile) generally do not have a lip and are nailed in place. The Spanish tile, where one half-cylinder overlaps another to form a cover and pan, requires vertical battens to which the cover tile is nailed.



Interlocking roof tile—'Marseilles' tile



Overlapping roof tile—'Spanish' tile

Ridge tiles were made to match the roofing tiles and were secured with mortar. More elaborate Federation-era buildings featured decorative terracotta finials and ridge tiles.

Prolonging the life of terracotta roof tiles

As with other roofs, regular and consistent maintenance is the most effective way of extending the life of a building's roof and helps conserve significant fabric. Avoid walking on tiled roofs—where access is required, make use of a 'cat ladder' to spread the load.

Inspect the roof regularly and look for any tiles that appear to have slipped or broken. Under-fired tiles are more porous and prone to decay. Decay usually occurs below the laps and will be most noticeable from inside the roof space. Inspect flashings and valley gutters for deterioration and keep them free of water-trapping debris.

Terracotta tiles benefit from maintenance washes to prevent surface dirt deposits and mould. The least harmful method is to spray with hot water before gently scrubbing the surfaces with hot water and a neutral pH soap. Scrub with a compact bristle-headed brush. Abrasive powders and powder-based detergents should not be used.

Repairing a tiled roof

Always repair rather than replace. The life of an early terracotta tiled roof can be extended by thoughtful repair, and by replacing only what is needed.

Only a roof tiler experienced in conservation work should carry out repairs on the tiled roof of a heritage-listed building.

Inspection of the roof will have revealed defective, damaged or broken tiles and any problems with cappings, flashings and gutters.

- Terracotta tiles frequently outlast their fastening systems. Where the fastening system has failed, it may be necessary to strip the roof and re-lay the tiles with new corrosion-resistant fastenings and battens.
- Pointing to ridge cappings may dislodge or crumble. Cappings should be re-pointed, taking care to match existing mortar.
- Galvanised iron flashings in the roof valleys may rust and lead flashings may deteriorate or split. Patch where possible and replace only those sections that are damaged. It will be necessary to remove adjacent tiles when repairing the flashing.
- Tiles can crack, break or decay. Damaged tiles should be replaced, matching the original exactly. It may be possible to source good quality, salvaged tiles that match. Incorrectly-sized replacement tiles can cause surrounding tiles to lift and the roof to be no longer watertight.
- Terracotta ridging, finials and decorative gargoyles are important details and should be retained. If these are damaged beyond patching, replacements may be sourced second-hand. It may be possible to reconstruct from photographic evidence, and matching reproductions may be available.

Tiled roof renewal

The life of the tiled roof should be prolonged as long as possible with regular maintenance. The most likely reason for renewing a tiled roof may be extensive mechanical damage caused by hail or other extreme weather events.

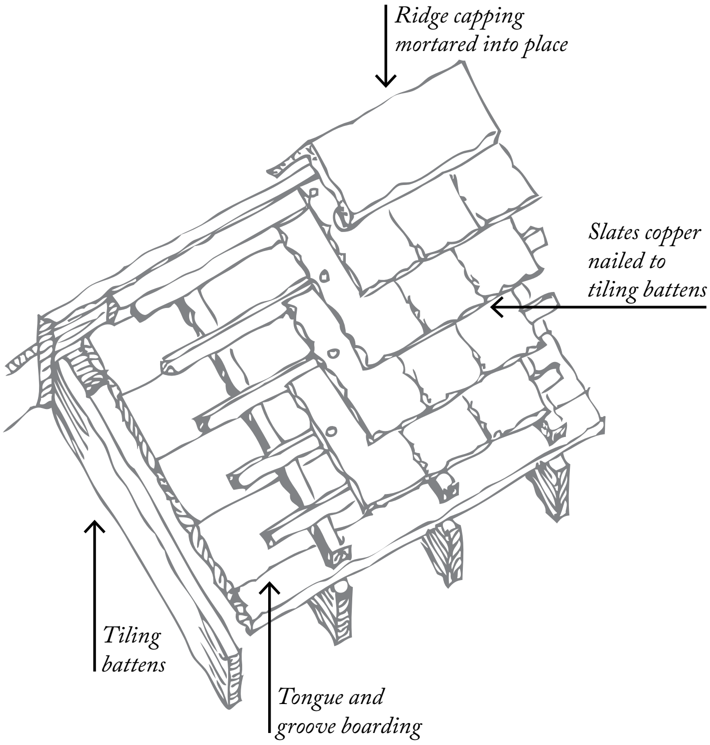
- Marseille tiles are still manufactured, as are other patterns. However, colour, size and pattern may not be an exact match and salvaged tiles are preferable. If unable to source matching tiles, it may be possible to cover the important visible planes of the roof with tiles from the rear of the building, replacing those at the rear with new tiles.
- Tiles are secured to the roof at intervals by nails or wire to prevent wind movement. Replacement wire should be copper.

Slate roofing

Slate has been used in Australia since the 1830s and was popular as a roofing material in the nineteenth and early twentieth centuries. Slates were usually imported from England and Wales, their colour ranging from blue through to grey, depending upon the quarry.

Slate is a durable and long-life roofing material, unlike other claddings such as iron or steel, which can be subject to corrosion. The slate's source determines its colour and its degree of durability. Decorative patterns can be produced using slates of different colours and shapes.

Slate tiles were fixed to timber roof battens with copper nails or clouts. The battens were usually laid over tongue and groove boarding. Ridging was made from lead (rolled and dressed over a timber dowel), galvanised iron, cast iron and, after about 1885, terracotta.



Typical slate roof structure

Prolonging the life of a slate roof

Regular and consistent maintenance is the most effective way of extending the life of the roof of a building and helps conserve significant fabric. Avoid walking on slate tiled roofs. Where access is required over a slate roof by maintenance personnel, they should use a 'cat ladder' hooked over the ridge.

Inspect the roof regularly and look for any slates that appear to have slipped or are slipping. If the bottom edges of the slates are uneven across the roof, the slate could be slipping from the battens due to breakage or faulty nails. Look for noticeable cracks or breaks. Inspect flashings and valley gutters for deterioration and keep them free of debris that may trap water.

Repairing a slate roof

Inspecting the roof will have revealed defective, damaged or slipped slates and any problems with flashings and gutters.

The ability to lay and repair slate properly requires training, practice and the right tools. Only a roof slater with experience in conservation work should be entrusted with repairs on the slate roof of a heritage-listed building.

- Determine the source of the leak. The cause may be due to a sagging roof structure or, more often, a faulty gutter, valley or flashing rather than the slates. The water's exit point may be some distance from the actual leak.
- Failure of a slate roof is caused most often by corrosion of the nail fixing or a breakdown of the slate around the nailing holes. This will cause slippage as the corroded nail no longer fixes the slate securely to the timber battens. Where the slates are sound, the existing slates should be re-nailed.
- The pointing to ridge cappings may have become dislodged or have weathered away. Cappings should be re-pointed with mortar that matches the existing mortar.
- Metal flashings may have corroded or become dislodged. Patch where possible and replace only those sections that are damaged. It may be necessary to re-point brick or stonework around the flashings.
- Slate can crack, break or delaminate; it is particularly vulnerable to breakage as a result of foot traffic and hail. Damaged slate should be replaced with matching slates. It may be possible to source good quality, salvaged slates that match. Incorrectly-sized replacement slates can cause surrounding slates to lift and the roof to no longer be watertight.

Slate roof renewal

The life of the slate roof should be prolonged as long as possible through regular maintenance. Where the slate fixings have deteriorated, stripping and refixing the roofing will be necessary.

- When slate renewal becomes necessary it is an opportune time for the roof structure to be inspected and necessary repairs carried out.
- The old slates should be carefully removed, ensuring that those in good condition are stacked vertically for re-use, preferably on the roof, to minimise breakages in handling. Lead flashings should be carefully retained for re-use.
- Slates were commonly laid on tongue and groove timber boarding. This acted as a secondary defence against leaks and cross-bracing for the roof.
- Slate is a durable material and most slates stripped from a roof are likely to be reusable. It is however common for at least 10% of the slates to require replacement. To maintain the appearance of the roof, the salvaged roof slates should be used on the most visible roof slopes, with the new slates confined as far as possible to the less visible slopes.
- Well-built slate roofs often had mitred hips with lead flashing in place of a capping. If not, mitred hips were capped with terracotta tiles bedded in mortar or with metal rolls. Ridge cappings were formed with a metal roll (usually lead) or a terracotta tile bedded in mortar. These details must be repeated when the roof is renewed.
- Imported Welsh slate is most commonly found on historic buildings. Welsh slate is still being produced and is available in a range of sizes and thicknesses. Canadian and Spanish slates are also available, but the colours are less likely to match the original. As with most natural stone, performance of slate, even if sourced from the same quarry, may vary over time and test data should be checked before making a final selection.

Shingle roofs

Discussion regarding timber shingle roofs begins with distinguishing between shingles and shakes. Shingles are timber roofing units with a sawn finish, roughly 450mm long by widths of 75 to 175mm and 13mm thick. Shakes are units of similar dimensions but are split from the log, are thicker, and have a rougher appearance. Early Queensland buildings are most likely to have been roofed with shakes.

The life of a shingle/shake roof is limited and, although their use was widespread until the late 1800s, few have survived to the present day. The practice of covering a leaking shingle roof with corrugated galvanised steel has preserved a number of shingle roofs, often without any indication of their presence.

Shingle/shake renewal

Should it be desired to renew a roof covering with the original finish it should be established if shingles or shakes were the original roof covering. Remnants of the original roof or early photographs will provide evidence.

Western red cedar is a commonly marketed and available shingle, it has a different colour and texture to the Queensland hardwoods and is not an appropriate material for use on a heritage-listed building. It has a life expectancy of no more than 15 years. Local hardwoods such as Forest Oak (casuarina torulosa), Ironbark (eucalyptus fibrosa) and Red Mahogany (eucalyptus resinfera) have a life expectancy in excess of 50 years and are available as shingles and shakes.

The Australian hardwoods are generally available as green timber and must therefore be butted together when laid to allow for shrinkage. This leaves an acceptable gap of about 10mm between them. Shingles and shakes are nailed to 50mm x 38mm battens forming a triple overlap in the same manner as roofing slates. Each shingle is twice nailed, 20mm to 25mm from the edge and 40mm to 50mm above the butt line of the next course.

Hip, ridge and valley details

Hips and ridges must be capped. This is traditionally done with a site made assembly of shingles and shakes. Galvanised steel or lead sheet were also used to form capping.

Valley gutters are formed from galvanised steel sheet and should extend at least 200mm from the centreline under the shingles or shakes.

Maintenance and repair

As with other roofs, regular and consistent maintenance is the most effective way of extending the life of a shingle or shake roof and helps conserve significant fabric. Avoid walking on these roofs—where access is required, make use of a ‘cat ladder’ to spread the load.

- Inspect the roof regularly and look for any shingles or shakes that appear to be loose or split. Drill a hole for a new nail to prevent splitting. Splits and holes can be fixed with a piece of galvanised sheet slid under the shingle and nailed in place through the shingle.
- Badly split, missing shingles or shakes should be replaced. Loosen the shingle or shake above, remove the shingle, cut off the nails and slide the new shingle into place and fix with galvanised nails.

4. ROOF DRAINAGE

Purpose

This section deals with the means by which rainwater is directed via gutters and downpipes to the ground and away from the building. This note identifies the types of guttering present on heritage-listed buildings in Queensland, common causes of their failure and appropriate measures to maintain and repair them. A fault in the roof drainage system can cause damage to the fabric of the building as the rainwater is concentrated in a small area.

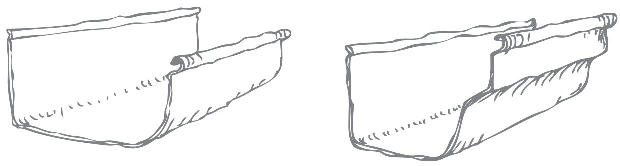
Context

The gutters and downpipes of most heritage-listed buildings are formed from galvanised iron and are often an important architectural feature. The corners of Victorian and Federation buildings were often emphasised by decorative sheet-iron acroteria on the Ogee gutters. The ogee profile itself came about as an imitation of earlier timber gutters, which were moulded to match the barge boards of gable ends. Ornate rainwater heads and downpipes with elaborate saddle straps also formed part of the decorative scheme.

The typical Queenslander house later in the 20th Century had plain Quadrant (quad) guttering. Although plain, the line of the quad gutter remained a strong architectural feature of the roof.

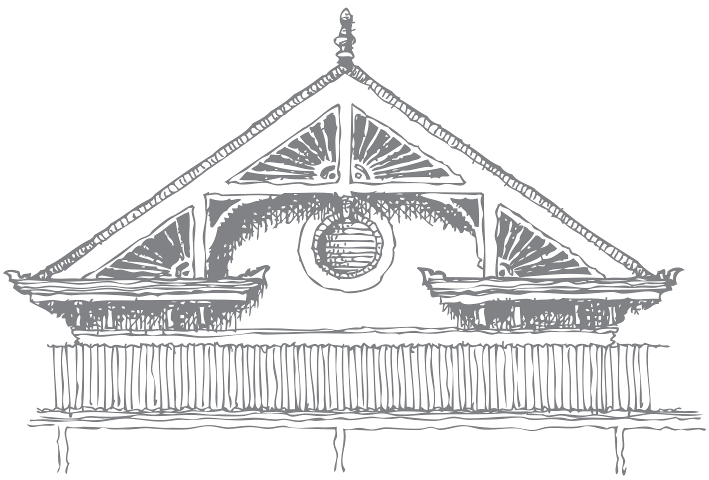
Commercial and public buildings with formal street frontages usually hid their pitched roofs behind an ornate parapet wall. This created a need for box gutters located at the junction between roof and parapet wall or between parallel roofs. Inter-war, modernist buildings seeking to achieve clean horizontal lines, without resorting to a flat roof, also hid a pitched roof behind a parapet wall. This was often only done on the main elevations, with other elevations continuing to use the quad gutter.

Commercial and industrial buildings covering a large area were usually roofed by a complex series of parallel roofs requiring box gutters between them, and which often required internal downpipes.



'Quad' gutter *'Ogee' gutter*

Common Queensland gutter profiles

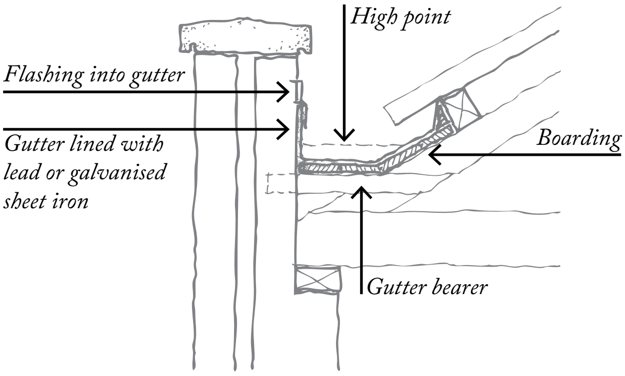


Decorative use of guttering—Victorian

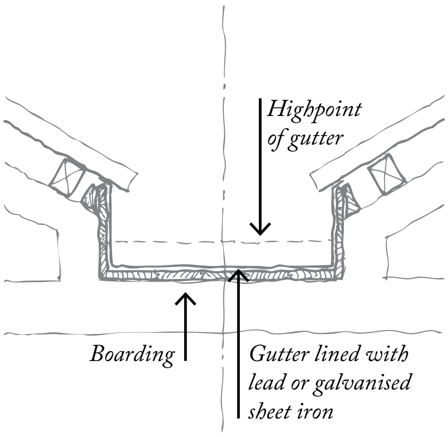
The Ogee gutter is returned around the gable and corners are emphasised with acroteria

Decorative use of guttering—1930s

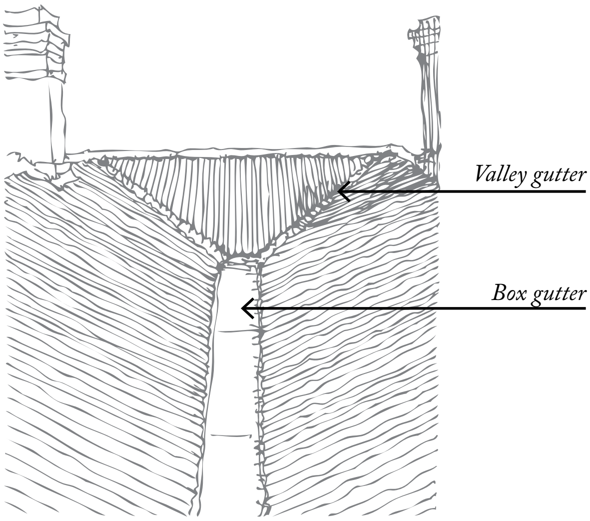
A plain building with a quad gutter taken all around the building, in front of the gable and following the pitch of the roof.



Section through box gutter at parapet wall



Sections through box gutter between parallel roofs

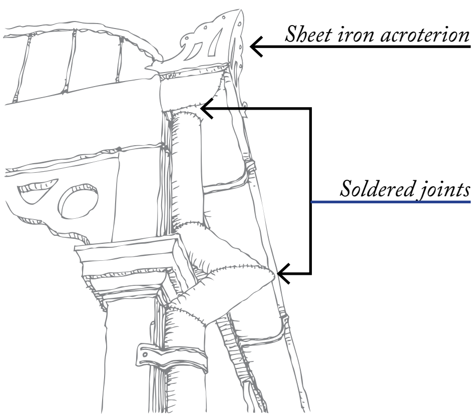


Typical box gutter between parallel roofs

Materials, profiles and size

As already noted, the majority of gutters and downpipes on heritage-listed buildings are of galvanised steel. Copper, asbestos and lead are also found. Copper gutters and downpipes are less common and are mainly found on public buildings. Asbestos gutters were widely available, but are not always found on buildings with asbestos roofs as they were comparatively brittle. Lead was used to line box gutters, but galvanised steel sheet is more common.

- When replacing gutters and downpipes, the original profiles and shapes should be reinstated. Evidence from early photographs or original specifications or from remnants such as brackets should enable the correct profile to be determined. The ogee and quad gutters are the most commonly found profiles on heritage-listed buildings. They are still popular and, while mainly produced in Zincalume® and COLORBOND®, are available in galvanised steel.
- Gutters and downpipes of some roof drainage systems on heritage-listed buildings are too small to carry the volume of water commonly shed in heavy rain. The judicious insertion of additional downpipes and rainwater heads can improve the capacity of the system, but their design and siting must be carefully considered. Modern ogee guttering is slightly wider than the traditional profile, allowing greater carrying capacity. Its use may be acceptable in some cases, usually where replacement guttering is required.
- Downpipes were usually round, and formed from galvanised iron sheet, but rectangular ones were not uncommon. Any new downpipe should be located to minimise visual disruption of the façade, while providing a good spread of outlets around the roof. The profile should match the original with some way of distinguishing between the new and the old on close inspection. If anything, simplify the roof drainage system; do not make it more complex.



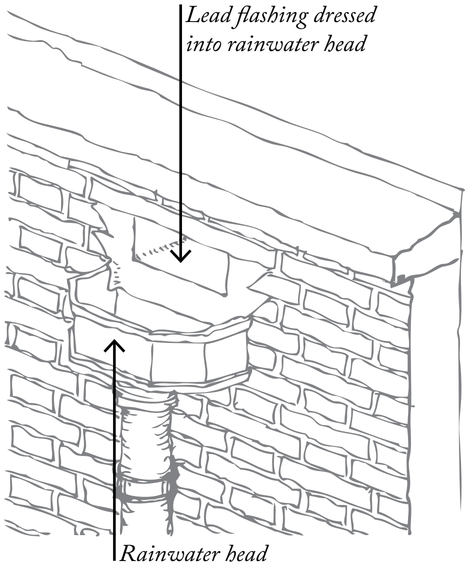
Gutter and down pipe replacement

Here the replacements are in galvanised steel, the gutter and downpipe of the appropriate profiles with soldered joints. However the kink in the downpipe to avoid the post moulding is likely to cause blockages.

Maintenance

Gutters are particularly susceptible to corrosion due to the build-up of leaves, bird droppings and air pollutants. The resulting weak organic acids and salts promote corrosion in an environment already at risk due to water lying for long periods in shallow, slow-draining guttering. The regular cleaning of gutters and stormwater disposal systems is an essential maintenance strategy.

- Occasional checking to ensure that gutters fall the right way is also important. The slope of a gutter may change with time due to distortion of the roof framing and to settlement or ground heave beneath parts of the building. The resulting build-up of water and debris may weaken gutter supports, causing further sagging. Old gutters may require support by over-strapping to enable the fall to be maintained.
- Valley gutters are located at the junction between sloping roofs and, as with box gutters, they carry concentrations of rain water run-off and are susceptible to blockage by leaf matter and other debris. They are often not clearly visible from the ground and should be checked regularly. Similarly, flashings at the back of chimneys and other vertical elements protruding through sloping roofs can concentrate rain water run-off and must be kept clear.
- Box gutters are the weak link in the drainage system of the roof as they are out of sight and are often neglected. If they leak or overflow, a large volume of water may be discharged into the building. Box gutters and valley gutters are particularly vulnerable to blockages caused by accumulations of leaves and other obstructions such as dead birds or rodents. A build-up of hail can also create a short-term blockage. Strategically placed leaf guards may prevent this.
- Box gutters usually discharge into a rainwater head. These are essentially boxes on top of the downpipe that provide a large catchment area to slow and dissipate the energy of the horizontally moving water from the gutter. The mass of water in the head then drives the water down the pipe more efficiently .The rain water head must be kept clear and should always have an overflow outlet. Rainwater heads make attractive nesting places for birds and should be regularly inspected.



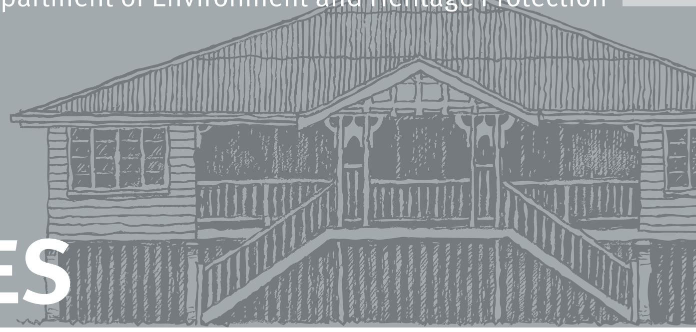
Rain water head at parapet wall

- Rainwater is naturally slightly acidic. When affected by certain atmospheric conditions, such as industrial pollution or proximity to the coast, rainwater can become more acidic. The effect of this acidity is neutralised to some extent if the rain water falls on zinc-coated materials or unglazed cement tiles by the chemical reaction with these materials. If the rain falls on a neutral surface, such as a painted roof of any material, Zincalume® or glazed terracotta tiles, and is then concentrated onto localised areas of galvanised iron (as with the gutter below a corrugated roofing sheet), the acid effect will accelerate corrosion at points below each corrugation. If left unchecked, the gutter will quickly rust through.
- The rainwater collected from the roof must be directed away from the building. The base of the downpipe must discharge into an underground disposal system, usually through a gully trap or into a surface drain. If allowed to soak into the ground at the base of the building, rainwater may undermine the building's footings and exacerbate rising damp problems. Discharge outlets of downpipes should be checked for blockages when it is raining.

Repair of gutters and downpipes

Principles to follow when repairing guttering and downpipes on a heritage-listed building:

- If there have never been eaves or gutters on the place do not add them without good reason and careful design.
- As far as possible, prolong the life of the existing gutters through patching, treating rusting areas and painting the internal surfaces of the gutter.
- Replace only those parts that are damaged or missing. Replace like with like—gutter and downpipe profiles should match the original unless they are unobtainable or the sizes are clearly inadequate, in which case the replacements must be carefully selected and appropriate to the building.
- Gutter brackets should have the correct profile. Re-use existing brackets wherever possible.
- Gutter brackets should be carefully fixed to the fascia and should not pierce through the back-face of the timber.
- It is important that gutters slope towards the outlets (a minimum gutter fall of 1 in 500 is recommended). Without this slope, ponding will occur and reduce the life of the gutter.
- Gutters generally fail at the joints. Remove the rusted areas and re-solder joins. Joints in new guttering and downpipes should be soldered.
- Small leaks may be repaired with silicon, but makeshift repairs are unlikely to last.
- Downpipe locations should be as originally intended. If downpipes are missing, the original discharge locations will be apparent in the gutters. If necessary, insert additional downpipes and ensure they are carefully designed and sited.
- Downpipe fixings (either straps or spiked hooks) should match the existing fixings and should be painted to match the adjacent paint surfaces.
- PVC replacements or COLORBOND® modern profile gutters and downpipes should not be used as their appearance will be out of character with the building.
- Rainwater heads should be carefully patched if damaged.



5. ROOF STRUCTURES

Purpose

This section looks at the broad range and function of roof structures to be found on heritage-listed buildings. It examines the defects that occur in these structures and suggests methods of repair. Defects are usually the result of a failure in some other element of the building, such as waterproofing, guttering and structural movements. Mechanical damage may be the result of extreme weather or termite attack.

Context

The roofs of heritage-listed buildings are often the least altered part of the building and may provide clues to its history. They are also the least visited part of the building and, as a consequence, are liable to suffer from lack of maintenance. The function of the roof structure is to support the weather-proof covering and provide the slope that allows rain water to be carried away from the building. Apart from sheltering the occupants and contents of the place, the covering protects the roof structure from decay.

The roof structure must be adequately braced and anchored to not only support the roofing covering materials but also resist lateral and uplift wind forces, and to brace the building as a whole.

There is a long tradition of using timber for roof-supporting structures. Most old buildings have comparatively steeply pitched triangulated roofs with varying degrees of elaboration and complexity. Sometimes, they include features such as ornamental towers, pinnacles, gables and parapets. Roofs of domestic buildings are almost invariably of timber construction, while industrial buildings with their larger spans are usually of steel construction.

Some 'modern' domestic and commercial buildings feature flat or near-flat roofs where designers wished to achieve clean, horizontal lines. These roofs are usually made from reinforced concrete, waterproofed with mastic asphalt or roofing felt.

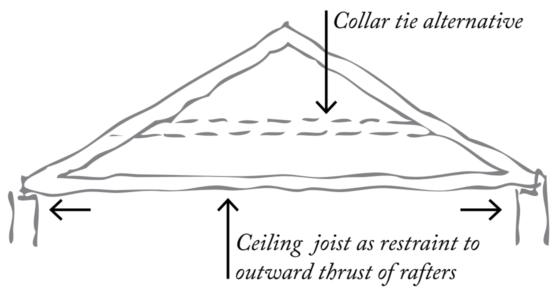
Roof form and framing

Timber roofs

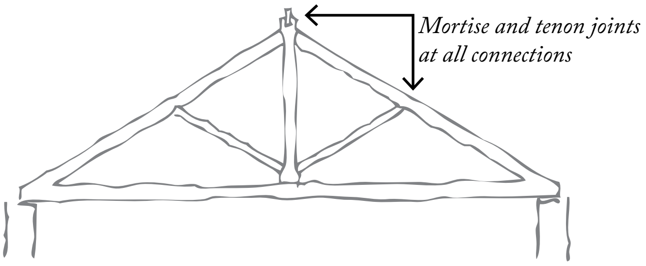
The simplest form of roof structure is the mono-pitch lean-to (or skillion) roof. Rafters, at a pitch appropriate to the covering material, are supported on walls or posts. A verandah is usually a lean-to, supported by a wall plate attached to the wall of the building, and the lower end by verandah posts.

Some small, early buildings have triangulated pitched timber roofs simply supported on the walls, which must then resist the outward thrust of the rafters. The span of these roofs may be increased by supporting the rafter on a purlin. The outward thrust of the rafters may be restrained by a ceiling joist, tie or collar tie, forming a roof frame or truss. A roof truss is a triangulated frame that transfers the load of the roof via the wall plate onto the external walls. The triangle is the strongest form of framed structure as it cannot be deformed if the members are adequate and the joints are rigid.

The detail of the roof structure is determined by the weight of the roof covering, the weight of the roof structure itself, and the span between the supporting walls. Roof coverings of terracotta tiles, slate or asbestos cement sheets are much heavier than corrugated steel sheet and require far more robust framing. Slate roofs usually had a boarded sarking fixed to the rafters, which added to the weight of the supporting structure.



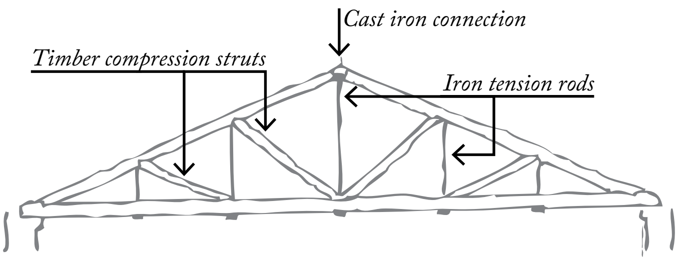
Simple timber roof truss



King post timber roof truss

Timber and iron roofs

The various members of a roof truss are exposed primarily to compressive or tensile stresses. Timber performs well under compression, while the tensile strength of iron is much greater than that of timber. Replacing the tie beam of the truss with an iron rod, and in combination with cast iron connections, it was possible to construct an efficient truss on site without complicated carpentry.



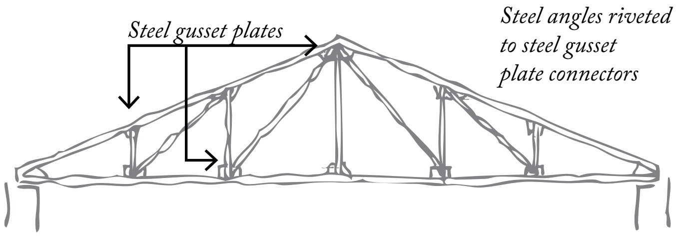
Timber and iron roof truss

Iron and steel roofs

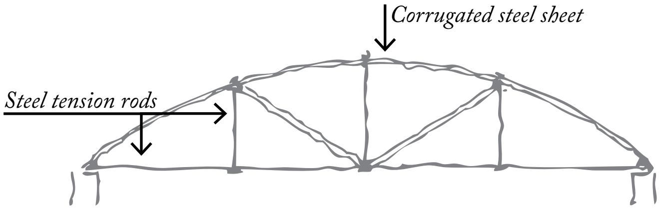
The availability of wrought iron, and later steel, during the last half of the 19th century, made it possible to make roof trusses that achieved the greater spans required by railway and industrial buildings. These generally followed the triangular form of the timber truss. The need for natural lighting in industrial buildings saw the development of the saw-tooth roof, formed from a rectangular truss spanning between walls or columns with mono-pitched frames spanning between the trusses.

Roofs of an arched configuration, and using a corrugated steel covering, usually have a triangulated-frame supporting structure. Some roofs, however, make use of the arched form of the corrugated steel to span the distance between the supporting walls with minimal supporting structure.

Portal frames are a comparatively recent form of construction where rafters and columns form part of the same frame. The rigid connection between rafter and column transfers some of the bending moments of the rafter to the column, allowing a larger span to be achieved. Portals are generally steel, precast concrete or laminated timber. The buildings are usually single bay and single storey.

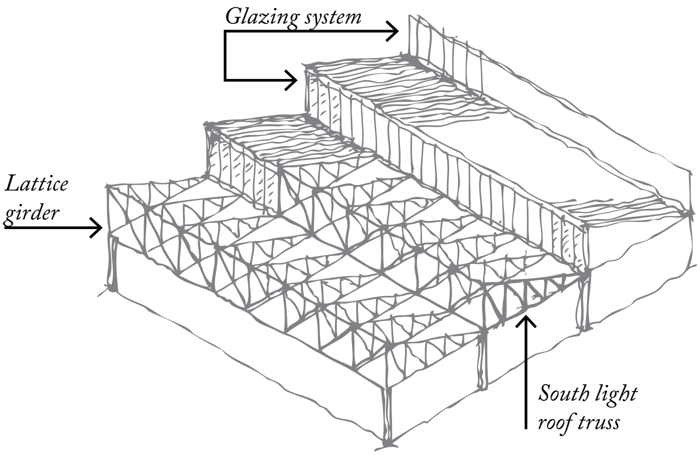


Steel roof truss made of paired angle iron members



Arched corrugated steel sheet as structural member

Typical portal frame—material could be timber (laminated or ply), steel or concrete



Saw-tooth (south light) roof system

Lattice girders supported on columns carry south light trusses which support the roof covering.

Flat roofs

Flat roofs are uncommon in older heritage-listed buildings in Queensland and may occur as links between pitched roofs which function effectively as box gutters. They are formed from timber joists with a tongued and grooved board cover and set at an incline to the rainwater outlet. Waterproofing with lead sheeting was the most appropriate material, given its durability. Various forms of bituminous felt were a cheaper alternative, but had a comparatively short life span. A number of waterproofing membranes have become available over the years and may be found where repairs have been carried out.

Flat, reinforced concrete roofs are found on some mid-20th century heritage-listed buildings. Waterproofing was always a problem for these roofs. Well-laid and protected mastic asphalt could be expected to have a reasonable life-span, but the bituminous felts and similar systems broke down quickly in Queensland's climate. Most waterproofing membranes will have been replaced several times and it is not uncommon to find a low-pitched corrugated steel roof added over a persistently leaking concrete roof. Present-day waterproofing membrane systems are more reliable and generally do not present conservation problems.

During the 1960s, several new steel roofing sheet profiles were introduced. These were roll-formed from coil strip, enabling continuous sheets of up to 12m lengths to be produced. An innovative product called Klip-Lok® 'Sixteen' had three ribs, 41mm deep. When fixed, the side ribs of adjacent sheets interlocked and did not require additional fastening. Klip-Lok® was especially suitable for near-flat roofs, which usually are simply supported on beams or rafters.

Joints and fastenings

Timber roofs

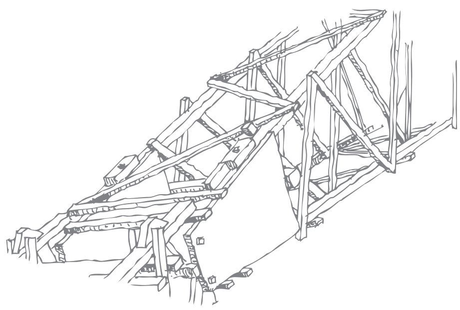
For roof frames to function, the joints needed to be rigid and this was achieved in traditional timber construction using mortise and tenon joints secured with hardwood wedges. Early settler buildings relied on a combination of wrought iron nails and bolts to achieve rigid joints.

Roof framing for large or complex buildings was usually prepared in the workshop where complex mortise and tenon joints could be accurately machined. The trusses were assembled on site and the joints and connections secured with steel bolts and straps.

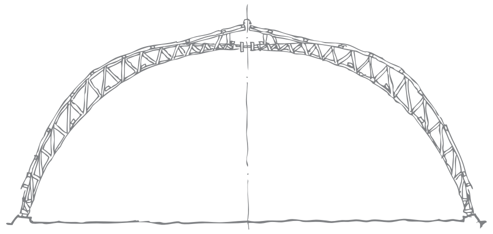
Roofs combining timber and iron relied on patented cast or wrought iron connections to tension the tie rods and king bolts. These roof trusses could not support a ceiling and were best suited to industrial uses.

Built-up roof trusses were formed on-site and made of much lighter paired timbers bolted together at the joints. In the ordinary bolted connection the stress was concentrated at the outer surfaces at the interface. Using timber connectors distributed the stress over a wider area and transmitted the load more effectively. The two types of connector most commonly used were the toothed plate and split ring.

During World War Two, shortages of steel and the need for large span structures saw the innovative construction of wide span arched trusses made up of short lengths of hardwood nailed together in jigs on-site. The increased demand for speedy construction at the time meant traditional timber roof construction was replaced by increased use of glued and nailed plywood gussets or simply nailed joints to form trusses. Post-war, the trends continued and the nail plate connector was introduced in 1952. Combined with rolling press fabrication, it has made it possible to produce engineered trusses with a minimum of material.

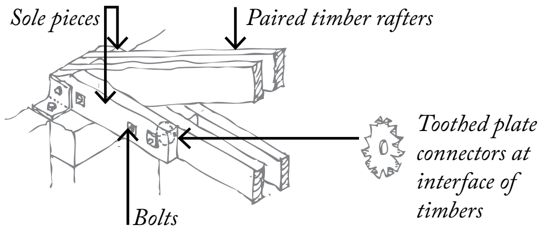


Archerfield Igloo—detail of boxed truss at base. Boxed truss made up of light hardwood timbers nailed together. Span of 57.45m.

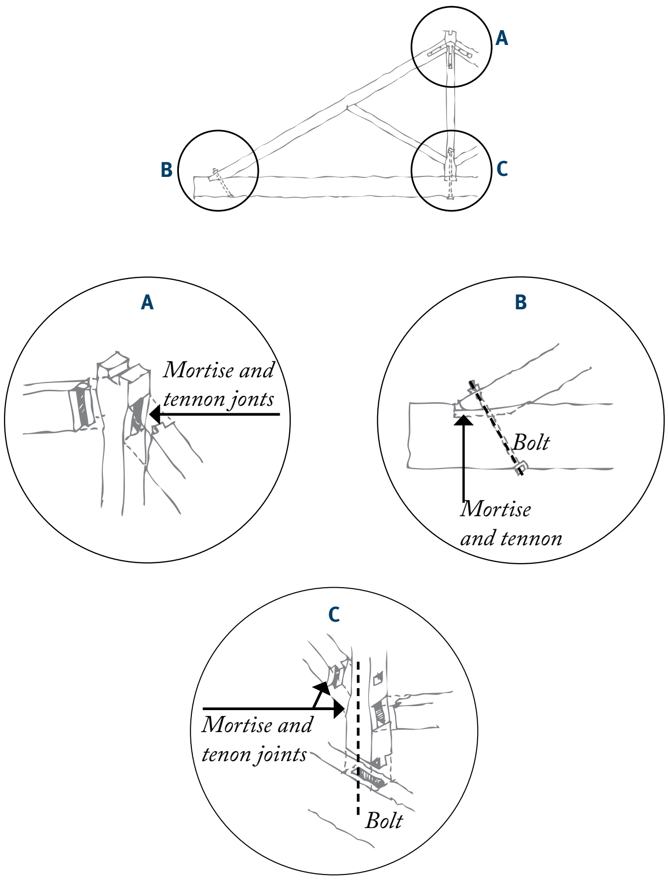


Rocky Creek Igloo—cross section. Paired trusses made up from light hardwood timbers nailed together. Span of 16.9m.

WWII timber roof truss construction



Built-up timber roof truss connections

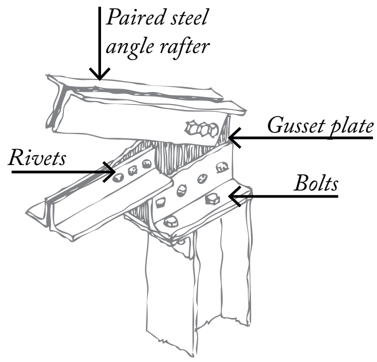


Timber, king post roof truss connections

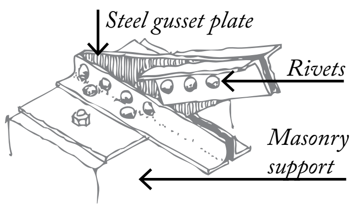
Iron and steel roofs

Iron and steel trusses were usually made up in segments from steel angles. The members of the truss are joined together by means of rivets or bolts and thin plates called gussets. Small trusses could be fabricated in the workshop, but larger trusses were fabricated in parts and bolted together on site.

Welding of steel in construction became widespread in Australia during the 1930s, effectively replacing riveted connections and simplifying roof truss fabrication. Welding is best done in the workshop—trusses were still fabricated in parts in the workshop and bolted together on-site.



Steel column support



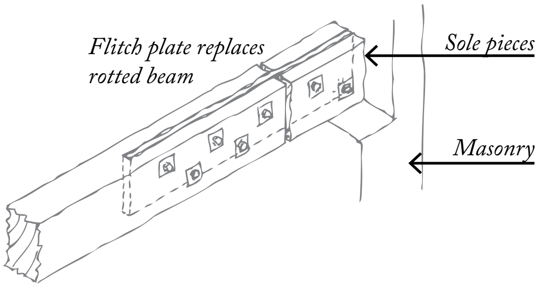
Steel roof truss connections

Common defects in roof structures

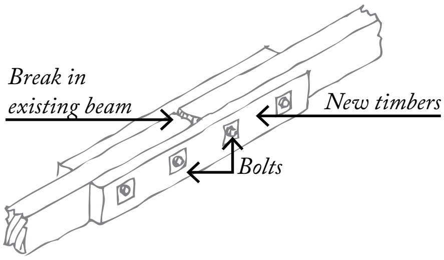
The timber framing of most heritage-listed buildings is usually robust, with a wide safety margin. Similarly, iron and steel roof structures, although wide spanning, generally only have a light roof cladding and, with wind bracing, are sufficiently robust. Defects in both types of roof structure usually result from inadequate maintenance and neglect or damage resulting from extreme weather events.

Timber roof structures

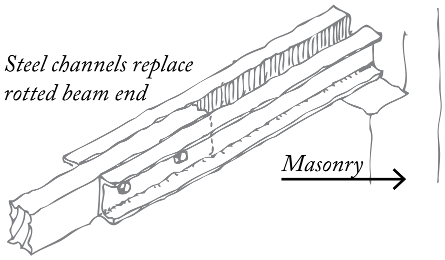
- Over a long period, roof leaks cause localised portions of timber roof structures to rot. This usually affects beam or rafter ends where water runs down the rafter, creating a damp condition at the junction between wall plate, ceiling joist and rafter. If unchecked this can cause the rafter to become detached and put lateral pressure on the wall top.
- Leaking, blocked and overflowing box, parapet and valley gutters have the same affect, where regular cycles of wetting and drying lead to timber decay. Damp masonry will encourage rot in beam ends set into masonry walls.



Steel flitch plate



Timber bolted fishplate



Steel channel bolted fishplate

- Damp conditions in walls will encourage termite infestation. Damage caused by these insects can spread rapidly throughout the roof space if undetected and can have serious structural consequences due to the loss of cross-sectional area of the timbers.
- Decay resulting from damp conditions and insect attack will most often occur at the eaves of the roof and will affect the junction between wall plate and roof truss. If the decay is severe, the joint will no longer function and the outward pressure of the rafter will bear down on the wall.
- Large timber beams may, over time and as a result of changes in moisture content, develop longitudinal cracks that can affect their structural adequacy.
- Roof trusses may be affected by ill-judged alterations where struts or ties have been removed to make way for alterations within the roof space—for example, to install a water tank or insert a room and dormer windows. Unless there has been appropriate reinforcement, unequal loadings may cause the structure to distort.
- Mechanical damage may result from extreme weather or other events such as structural subsidence or falling trees. Damage should be assessed by an engineer.

Steel roof structures

- Iron and steel structures are also affected by damp conditions. Corrosion occurs where areas of the metal are in contact with water of a different oxygen concentration, thus acting as an electrode and causing areas of rust to form. As long as water is present, the process continues. If the air is contaminated, usually with sulphates and chlorides, which is common in industrial situations, the corrosion rate increases.
- Galvanic corrosion occurs where dissimilar metals are in contact in a damp environment. In the case of steel structures, it is most likely to occur where unprotected stainless steel has been used for repair work.
- Steel roof structures, particularly those of the early 20th century, often rely on back-to-back angles riveted together through gusset plates. This creates locations that cannot drain. In a heavily polluted atmosphere, such as in railway sheds, small amounts of water over a long period can cause severe corrosion.
- Mechanical damage may result from extreme weather or other events such as structural subsidence or falling trees. Damage should be assessed by an engineer.

Repairs and alterations to roof structures

Damage to the roof structure is generally limited to specific areas or structural members. Repairs to timber members should be limited to replacing or reinforcing the decayed or damaged material. In carrying out repair work, ensure that the original cause of decay or damage is eliminated.

Replacing roof sheeting may not require repairs to the roof structure. However, if the sheeting is fixed to current code requirements, the tie-downs of the roof structure should be examined by an engineer to determine if they are adequate. While previously roof sheets might be blown away in severe weather, if the roof sheeting has been securely fixed, and the structure itself is not adequately tied down, there is a risk that the entire roof may be carried away.

Generally, assessing condition and specifying repairs should be carried out by a structural engineer.

Timber roof structures

- Cut away decayed or damaged areas of timber and replace with matching timber of similar moisture content. Ensure that all timber affected by fungal decay is removed back to sound timber. The new timber should be scarf-jointed to the existing timber and secured with stainless steel bolts or screws.
- In some instances it may be acceptable to replace the decayed or damaged timber with a steel end-piece or flitch plate.
- The decayed timber may, in some instances, be repaired with resin. This would require reinforcing bars set into the sound timber. Entire joints should not be formed in this way.
- Longitudinal cracks in timbers may be filled with resin. Ensure that the entire void is filled with resin.
- An alternative to replacing the decayed or damaged timber is to leave the original fabric in place and introduce new material to carry the load. This may consist of new timbers or steel plates or angles bolted to the existing timbers. This will not be appropriate where fungal decay has occurred.

Steel roof structures

- In assessing the degree to which steelwork has decayed by corrosion, remember that rust occupies six to 10 times the volume of the original material and decay may not be as severe as it appears. Assuming that the steelwork has survived for 50 to 100 years, and is not likely to be subjected to a worse environment, removing the rust by wire brushing down to bright metal, in preparation for zinc-rich priming and several coats of an air-excluding and water-excluding paint, should be adequate.
- Where steelwork is liable to suffer continued corrosion in an aggressive environment, it will be necessary to clean it back to bright metal, usually done by grit blasting. It must then be given a zinc-rich primer followed by several coats of air- and water-excluding paint. Thorough cleaning down may require the structure to be dismantled. This poses further problems with riveted joints, as dismantling would require drilling out the rivets, which may not be an acceptable heritage outcome.
- Repairing badly corroded steelwork may be comparatively straightforward if welded reinforcement is considered to be acceptable. As a process it is non-reversible and reduces the integrity of the original fabric. Additional structural support, such as new beams and columns, could be an alternative where this is visually acceptable.

6. ROOF INSTALLATIONS

Purpose

This section is designed to assist owners and managers of heritage-listed buildings when fitting new technologies and services on the roof of their building. The best way to preserve a heritage-listed building is to ensure its continued use and introducing these technologies may help secure a future for the place. While the roof may be a logical location for them, any installation must not diminish the place's heritage significance.

Context

Installations vary in form and function and may be grouped under the following headings:

- **Energy:** The desire to introduce environmentally sustainable practices, combined with financial incentives, has encouraged installation of devices to generate electricity and hot water using solar radiation. Wind power is also an option for generating electricity.
- **Communications:** Various television, radio and telecommunication devices have become part of everyday life and must therefore be considered when adapting a heritage-listed building to a new use. The devices all require antennae that generally function best at higher elevations. The technology is constantly changing, requiring regular replacement of equipment.
- **Services:** Extracting fumes from food preparation and other processing areas requires plant and ducting, with the final vent as high as possible on the building. Large spaces within buildings are required to be protected by smoke exhaust systems located on the roof. Air conditioning condenser units are often located on rooftops.
- **Safety:** The need to maintain the roof of a heritage listed building in good order requires that regular inspections and, where necessary, repairs be carried out. For uncomplicated low structures, this may not be an issue, but high buildings with complex roofs may require installations to facilitate safe access. Further, installing the devices referred to above requires the need for safe access for both installation and servicing.

Guiding principles

Installations on the roof of a heritage-listed building should have as little impact as possible upon the heritage significance of the place. Since they are likely to require regular updating, they should also be fully reversible.

Further considerations common to all installations:

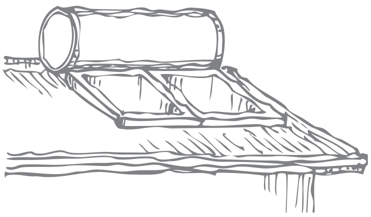
- Make sure that the significance of the place, both in terms of its fabric and its setting, are not negatively impacted by the proposal.
- To ensure minimal impact on the values of the place, all alternatives that have less impact on the values of the place must be explored before a particular course of action is finalised.
- Installations should not be located on the principal elevations of the building and as far as possible should not be visible to the public.
- The scale, form, colour and reflectivity of the installation should not detract from the significance of the place.
- The installation should not require alterations to significant fabric.
- Mounting brackets, cabling and wiring must not damage significant fabric. Ensure that metals used are compatible with the roof covering.
- Ensure that the existing structure is capable of supporting the load.
- Ensure that the watertightness of the roof is not affected and that the installation does not encourage the build-up of leaf matter and debris.
- Ensure that maintenance traffic will not damage significant fabric.

Photovoltaic panels

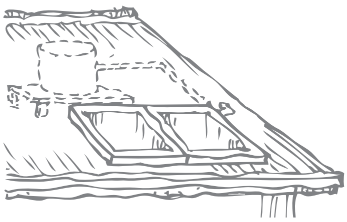
- Consider alternative locations on the ground or on non-historic buildings.
- Find an orientation of the heritage-listed building compatible with that required by the panels. The ideal orientation for the panels may be unacceptable to the appearance of the place e.g. brackets to achieve a north orientation may be unsightly.
- Choose panels with a low profile and install them as close to the surface of the roof covering as practical.
- Ensure the roof covering is sufficiently robust to support the panels.
- Set panels back from the edge of flat roofs.
- Avoid disjointed, multi roof installations.
- Colour panel supports and conduits to blend into their location.

Solar water heating panels

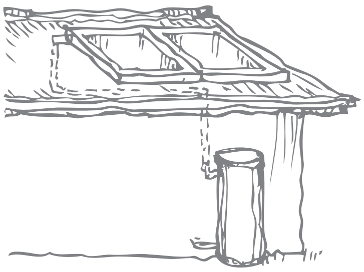
- Apply the same considerations as for photovoltaic panels .
- Systems that include the hot water storage tank may not be appropriate for the building because of their bulk and weight. The storage tank may need to be located on the ground or within the building.



Storage tank on roof is most obtrusive



Storage tank in the roof space is the least conspicuous—if there is space



Storage tank on the ground—less conspicuous than roof

Alternative locations for hot water storage from solar collectors

Wind turbines

- Wind turbines are commonly located away from buildings. While small turbines can be fixed to a building the performance of such a wind turbine will be reduced and the practice is not encouraged.
- Assess the structural load on the building to determine if it is capable of supporting a turbine.

Satellite dishes

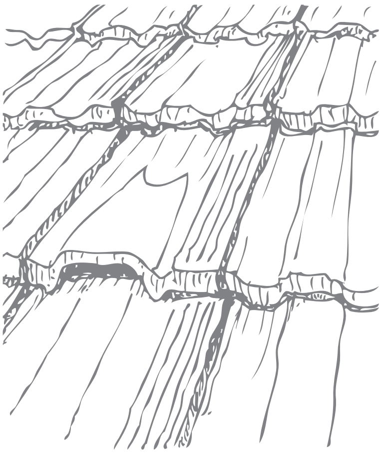
- Locate satellite dishes at the rear of the building where they are not visible from main frontages. Also consider their impact upon more distant views of the place and, where relevant, views from above.
- In situations of multiple ownerships or occupancy, require joint use of these devices wherever possible.
- Paint the devices to match the surrounding building.
- Use a dish with the smallest possible diameter.

Aerials, antennae

- As these installations vary considerably in size, height and complexity, assess their effect on the significance of the place accordingly.
- In situations of multiple ownerships or occupancy, require joint use of these devices wherever possible.
- Do not attach them to chimneys as the wind loading on these devices can be considerable, and take care locating the fixings for stays.

Services

- Kitchen exhaust ducting and vents can be very unsightly. Take care to design them to ensure they fit into the roofscape of the building.
- Where possible, make use of existing ventilators to vent roof spaces. Inconspicuous slimline ventilators are available that do not interrupt the roof line and are less intrusive than whirlybird ventilators.

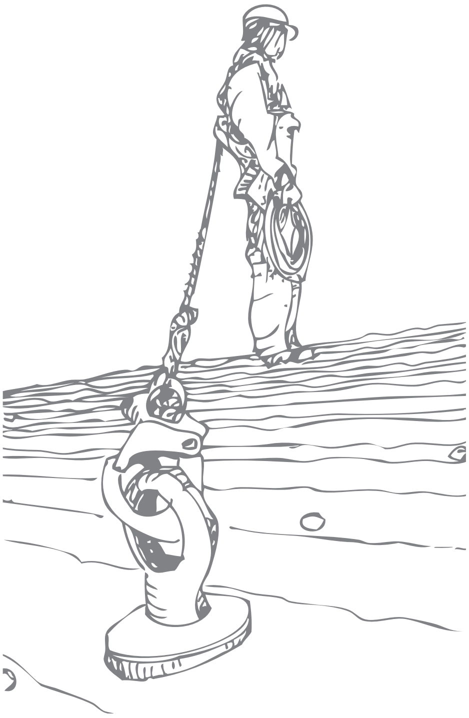


Low profile roof vent in marseille tile

- Ensure that the metals and finishes of the installations are compatible with the roof covering.
- As air conditioning condenser units are bulky and heavy, consider locating them on the ground where possible.

Safety devices

- Make a detailed assessment of the heritage-listed building to determine what level of access to the roof is required to carry out maintenance and repairs to the fabric of the roof and to roof installations.
- Hazards relate primarily to the risk of falls from the roof. Provide protection in extreme cases by constructing walkways or, more usually, by installing fixings to which safety harnesses may be attached. Points of attachment must be capable of restraining and distributing the anticipated loads.
- Consider complementary safety measures appropriate to the place.



Basic fall arrest fixing

FURTHER READING

General

Walker M and Marquis-Kyle P, *The illustrated Burra Charter: good practices for heritage places*. Australia ICOMOS Inc, Burwood, 2004.

Metal roofs

Bell, Peter 1984, *Timber and Iron Houses in North Queensland Mining Settlements 1861 –1920*, University of Queensland Press, St Lucia, Qld.

BlueScope Lysaght website at www.lysaght.com provides information on all Lysaght products currently in production.

BlueScope Steel Limited website at www.bluescopesteel.com.au provides technical bulletins on a range of topics including:

- CTB – 3: *Corrosion – Zinc coatings on steel* 2003
- CTB – 12: *Corrosion – Dissimilar metals* 2003

Evans, Ian 1989, *Caring for Old Houses*, The Flannel Flower Press Pty Ltd, NSW.

Fielders website at www.fielders.com.au provides information on all Fielders products currently in production.

Lucas, C 1979, *Conservation and Restoration of Buildings: Conservation of roofs*, Australian Council of National Trust, Sydney, NSW.

Miles, J 1995, *Conserving the Queensland House* (brochure series, nos. 1-12) National Trust of Queensland, Brisbane.

Queensland Government Websites on Asbestos

These provide information on safe work practises and legal issues associated with asbestos.

'Asbestos', Queensland Government, www.deir.qld.gov.au/asbestos

'Asbestos in the Home', Queensland Health, www.health.qld.gov.au/asbestos

History of the introduction of asbestos

Lewis, M, 'Asbestos', in *Australian Building: A Cultural Investigation*, www.mileslewis.net/australian-building/pdf/07-cement-concrete/7.10-asbestos.pdf, accessed 2013.

'New Parramatta Industry', *Cumberland Argus and Fruitgrowers Advocate*, 4 August 1917.

James Hardie advertisement, *Sydney Morning Herald*, 2 June 1917, p9

Terracotta tile and slate roofing

Ashurst, J and Nicola, 1988, *Practical Building Conservation: Brick, terracotta and earth*, Gower Technical Press, Aldershot, UK.

Cedar Shake and Shingle Bureau, Mission, British Columbia, at www.cedarbueau.org provides information on new building with Western Red Cedar including:

- *New Roof Construction Manual*, September 2011

Evans, Ian 1989, *Caring for Old Houses*, The Flannel Flower Press Pty Ltd, NSW.

Lucas, C 1979, *Conservation and Restoration of Buildings: Conservation of roofs*, Australian Council of National Trust, Sydney, NSW.

Roof drainage

BlueScope Steel Limited at www.bluescopesteel.com.au provides technical bulletins on topics including:

- TB – 15: *Selection and use of steel gutter, downpipe and fascia products* 2011
- CTB – 3: *Corrosion – Zinc coatings on steel* 2003
- CTB – 12: *Corrosion – Dissimilar metals* 2003
- CTB – 25: *Inert catchment* 2008

Evans, Ian 1989, *Caring for Old Houses*, The Flannel Flower Press Pty Ltd, NSW.

Lucas, C 1979, *Conservation and Restoration of Buildings: Conservation of roofs*, Australian Council of National Trust, Sydney, NSW.

Roof structures

Beckmann, P and R Bowles 2011, *Structural Aspects of Building Conservation*, Spon Press, Abingdon, UK.

Bell, Peter 1984, *Timber and Iron Houses in North Queensland Mining Settlements 1861 –1920*, University of Queensland Press, St Lucia, Qld.

BlueScope Steel Limited website at www.bluescopesteel.com.au provides technical bulletins on topics including:

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- CTB – 12: *Corrosion – Dissimilar metals* 2003

Evans, Ian 1998, *Caring for Old Houses*, The Flannel Flower Press Pty Ltd, NSW.

Lucas, C 1979, *Conservation and Restoration of Buildings: Conservation of roofs*, Australian Council of National Trust, Sydney, NSW.

Miles, J 1995, *Conserving the Queensland House* (brochure series, nos. 1-12) National Trust of Queensland, Brisbane.

Stapleton, I 2008, *How to restore the old Aussie House*, Flannel Flower Press, Myocum, NSW

Roof installations

Australian Standards AS/NZS 1891.4:2009. Industrial fall arrest systems and devices. Selection use and maintenance.

English Heritage has the following publications at its website www.helm.org.uk

- Small-scale solar thermal energy and traditional buildings
- Energy conservation in traditional buildings
- Micro wind generation and traditional buildings

BlueScope Steel Limited website at www.bluescopesteel.com.au provides technical bulletins on topics including:

- TB-36: *Guide to good practice – Steel roofing and photovoltaic panels*. 2011

Safe Work Australia website at www.safeworkaustralia.gov.au has the following publications. Model Codes of Practice:

- Preventing Falls in Housing Construction. 2012
- Managing the Risks of Falls at Workplaces. 2012