CBOS
Consumer, Building & Occupational Services
Promoting a fair marketplace

Condensation in Buildings – Tasmanian Designers' Guide - Version 2

Consumer, Building and Occupational Services
Department of Justice

Tasmanian Government

Consumer, Building and
Occupational Services

P 1300 654 499

E cbos.info@justice.tas.gov.au

W www.cbos.tas.gov.au

This Guide is a resource and reference document and is for general information only.

Director of Building Control
Consumer, Building and Occupational Services
April 2019

ISBN 978-0-9954065-8-2
Published April 2019

Contents

Introduction

Condensation has emerged as a significant problem in southern Australian homes. Increased energy efficiency requirements have led to the construction of 'air tight' buildings. This, combined with a lack of ventilation, traps water vapour in building envelopes. This is a particular problem in cooler climates as the greater difference in internal and external air temperatures causes more water vapour to build up inside homes. Condensation in homes can cause mould growth, structural failure and serious health issues for occupants.

As condensation is a problem in cool climates like Tasmania, CBOS funded research projects on condensation in 2014 and 2017 by the University of Tasmania School of Architecture & Design. The initial research found that condensation is a major issue in Tasmanian buildings, and led to the development of a designers' guide. The most recent research examined the risk of condensation in wall and roof systems that comply with the National Construction Code. This Guide incorporates the findings of this research, and provides strategies to help minimise the risk. The Guide focuses on principles that can be included in new home designs. However, strategies like roof space ventilation and draft sealing can be implemented in existing homes if necessary.

Scope

This Guide must be read in conjunction with the National Construction Code (NCC), which provides the mandatory minimum standards for buildings in Tasmania. The strategies in this Guide exceed the NCC requirements for condensation management, but are strongly recommended to assist in minimising condensation in cool climates like Tasmania.

All example designs in this Guide are diagrammatic only. They are intended to show ventilation, insulation and sarking installation techniques for minimising condensation. Other aspects of the diagrams may not be reflective of all current NCC requirements or construction practices.

Readers are encouraged to review other research reports and guidance documents on minimising condensation, such as the Australian Building Codes Board Handbook on Condensation in Buildings. Links to further reference material are included at the end of this Guide.

What causes condensation?

All air contains water vapour. The warmer the air, the more water vapour it can hold. Warm air loses water vapour at night as it cools, which can cause fog and condensation on the ground and other surfaces.

For example, when air cools from 21°C to 13°C, condensation will form on cooler surfaces. This is why condensation forms on the inside of single glazing and uninsulated bedroom walls.

Why does condensation occur in homes?

There are two main causes of condensation and mould in many homes:

1. thermal bridging
2. too much water vapour in the home.

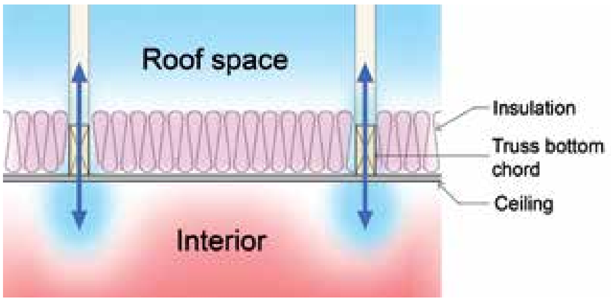


Fig. 1. Thermal bridging in roof space

Thermal bridging

Thermal bridges are paths where heat can transfer through walls, ceilings or floors, regardless of insulation. Thermal bridging occurs where a more conductive or poorly insulated material provides a pathway for heat to flow across a thermal barrier.

When the warm air comes into contact with cooler air or cooler surfaces, the loss of energy will cause the water vapour to condense.

When a building is designed or constructed, thermal bridging and air leakage needs to be considered and managed.

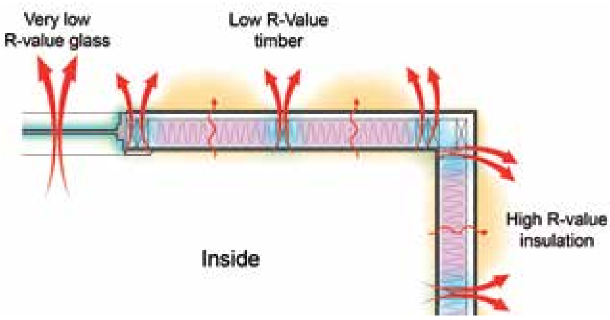


Fig. 2. Thermal bridging in wall space

Too much water vapour in the home

The amount of water vapour that accumulates in a building depends on the number of occupants, and the activities they engage in such as dishwashing, showering and cooking. An adult contributes to about 3 litres of water vapour per day being released into the home environment just by breathing.

The main methods to remove water vapour are:

- ventilation
- vapour permeable building fabrics (materials which allow water vapour to pass through them).

All example designs in this Guide are diagrammatic only.

Ventilation

Some methods of ventilation to manage water vapour in homes include:

- externally vented kitchen rangehood and bathroom extraction fan
- externally ducted flue for gas appliances
- externally ducted exhaust fan for clothes dryer in laundry
- roof space, wall cavity and subfloor ventilation.

Ventilation can assist with removing water vapour from homes. However, it cannot provide all day and year-round water vapour management. Also, ventilation will not remove water vapour trapped within walls. To do this, vapour permeable building fabric is needed.

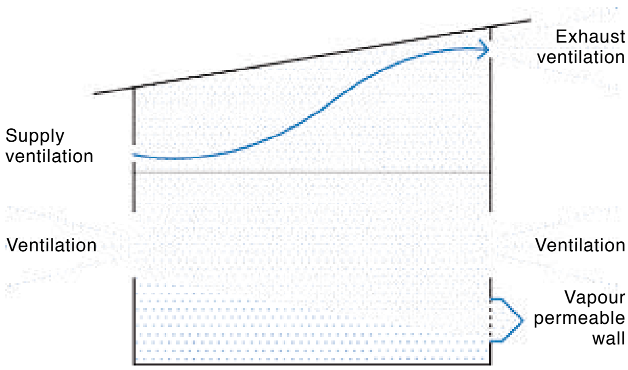


Fig. 3. Excess water vapour escaping from a building (plan view)

Vapour permeable building fabrics

A vapour permeable building fabric allows water vapour to passively flow into and out of buildings.

Examples of permeable building fabrics:

- plasterboard
- timber
- clay bricks
- some pliable building membranes

Examples of non-permeable building fabrics:

- glass
- aluminium
- steel
- some pliable building membranes

Whilst glass and steel are important building elements, building system choices need to be carefully considered.

Pliable membranes (or building wrap) help seal a building and hold insulation within the wall frame. Vapour permeable building wrap should be used to allow water vapour to escape from wall cavities. Perforated wraps do not have the same permeability properties as breathable wraps.

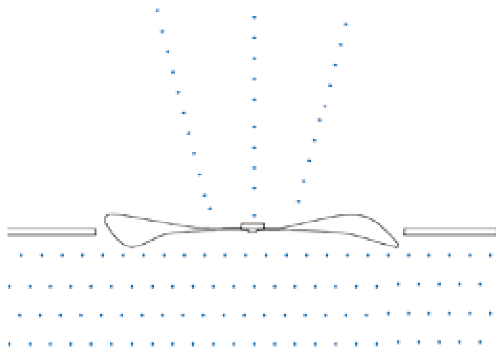


Fig. 4. Moisture moving into roof space through exhaust fans

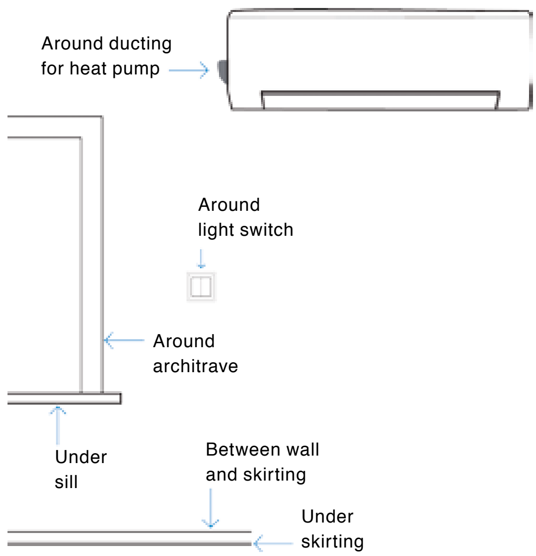


Fig. 5. Moisture moving into walls through openings for services

All example designs in this Guide are diagrammatic only.

Strategies for minimising condensation

Strategies for owners	Strategies for designers and builders
Open windows during and after showering and when cooking in kitchens	Duct gas appliances, kitchen rangehoods, clothes dryers and bathroom exhaust fans to outside air
Ensure (non-condensing) clothes dryers are ducted to outside air	Consider make up air strategies, for example, undercut doors, install vents
Keep lids on pans during cooking, avoid unnecessary steam production	Control dampness in subfloors and under croft spaces by covering soils with sealed impervious membranes
Don't store large quantities of fire wood inside the home in unventilated spaces	Use second generation vapour permeable wall wraps (not punched sarkings)
Keep lids on aquariums	Consider the use of bonded foil/insulation for roofs, in conjunction with ventilated roof spaces
Dry clothes in rooms that are well ventilated and warm and shut off from the rest of the building	Create air spaces and ventilate cavities where hardboard, cement sheet or other solid materials are used for external wall claddings
Provide increased ventilation to rooms containing spas and saunas and open windows in these rooms more often	Use eaves and soffit vents (with bushfire mesh where required) to vent roof voids
Avoid the use of unflued gas heaters	Minimise use of cold surface materials that directly contact with conditioned warm air spaces
Avoid introducing plants or water features into rooms that are not ventilated	Ventilate spaces between cold surface materials and conditioned warm air spaces
	Avoid light fittings that allow warm moist air into colder roof spaces by using surface mounted lights or sealed downlights
	Habitable rooms under decks will require additional consideration, including ducting gas appliances, kitchen rangehoods, clothes dryers and bathroom exhaust fans to outside air

Roof space

Main causes of condensation in roof spaces

1. Vapour passing into roof spaces through the ceiling or through exhaust fans which are not externally ducted. This is a particular problem in kitchens and bathrooms.
2. Thermal bridging:
   - between roofing and sarking materials
   - between sarking and ceiling insulation
   - between uninsulated and insulated areas of the ceiling
   - from metallic and vented ceiling lamps
3. Lack of ventilation to remove unwanted water vapour

Fig. 6. Thermal bridging between roofing and sarking

Fig. 7. Thermal bridging around downlight

Fig. 8. Thermal bridging due to lack of insulation around downlight

Key ways to minimise condensation in roof spaces

- Extraction systems which duct moist air outside the building
- Installing supply and exhaust ventilation to remove water vapour from roof space
- Moving sarking to underneath battens to minimise thermal bridging
- Ventilating the sarking space
- Using vapour permeable sarking

These methods are demonstrated in the diagrams on the following pages.

Typical roof

No ventilation. Sarking in contact with roofing causing condensation on cold surfaces.

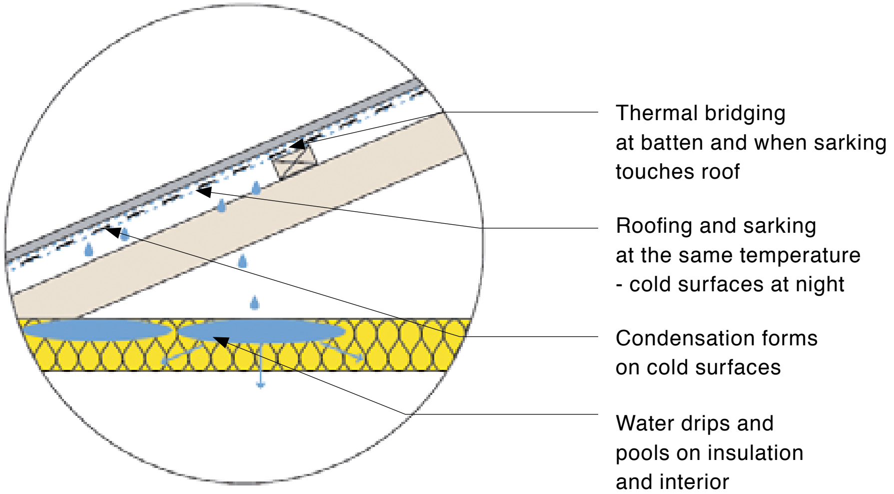


Fig. 9. Typical roof

Sarking under battens

Install sarking underneath battens to minimise thermal bridging

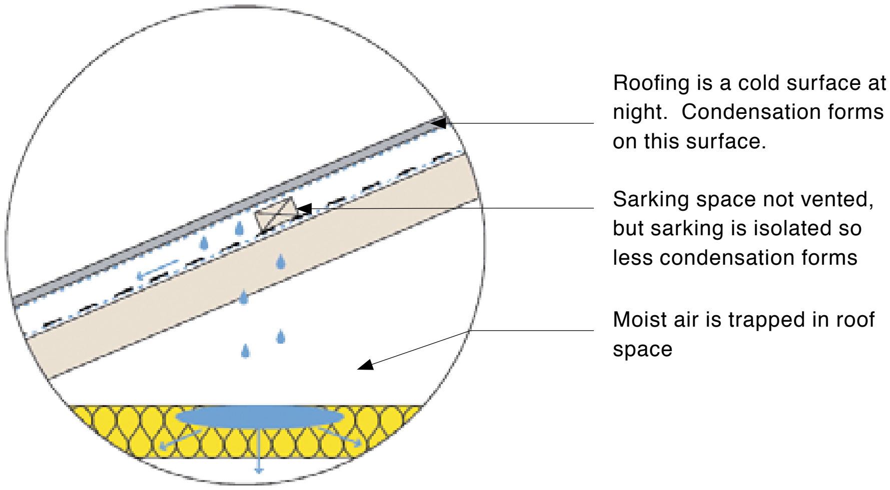


Fig. 10. Sarking under battens

Sarking under battens and ventilation

Install sarking underneath battens to minimise thermal bridging. Ensure ventilation in both sarking zone and roof space. These steps combined will minimise condensation in the roof space.

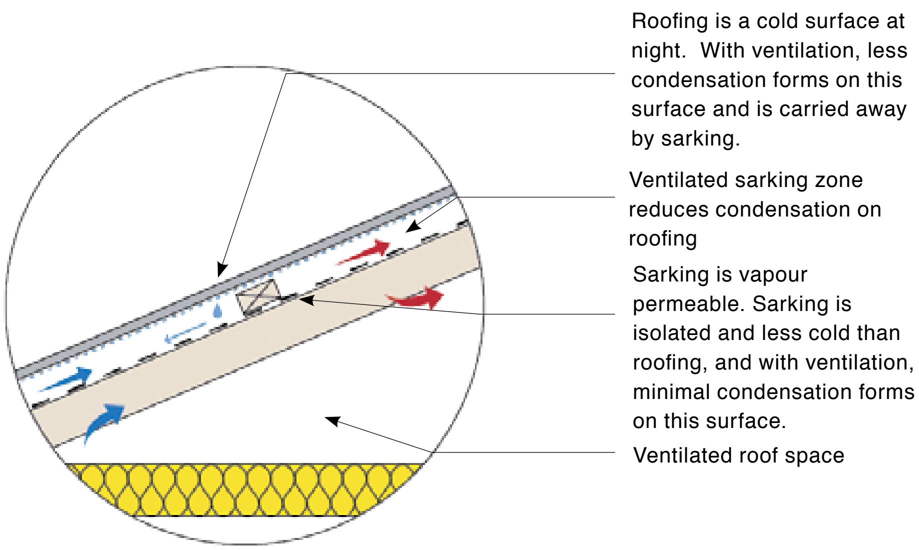


Fig. 11. Sarking under battens and ventilation

All example designs in this Guide are diagrammatic only.

Ventilation supply and exhaust

There are three methods to add supply ventilation and exhaust ventilation to roof spaces:

1. continuous gaps
2. regularly spaced vents
3. mechanical ventilation systems
    - Use continuous gaps in the eaves or roof vents to provide adequate roof ventilation
    - Ensure the defined minimum air space height is maintained along the path between supply and exhaust (see below)

Continuous gap

Supply	Exhaust
Continuous gap at eaves is: 25mm for <16˚ pitch 10mm for >16˚ pitch	Continuous gap at ridge is at least 5mm for all roof pitches

Roof vents

The minimum vent area should be:

a) Ceiling area/150 for <16˚ pitch, or

b) Ceiling area/300 for >16˚ pitch

Supply	Exhaust
75% of ventilation should be supply	25% of ventilation should be exhaust

Vent at gable should be within 900mm of ridge.

Fig. 12. Continuous eave vent

Fig. 13. Continuous gap in sarking along ridge

Fig. 14. Regularly spaced eave vent

Fig. 15. Regularly spaced gable or parapet vents

Pitch

Air space in the sarking zone ensures a path for water vapour to escape from the roof space. The minimum air space height required is dependent on roof pitch.

Low pitch roof <5°

Typical systems have no air gap between the sheet metal roofing and the sarking and utilise a foil blanket system

Instead, sarking should be installed under battens, and there should be a minimum 25mm air gap in the roof space

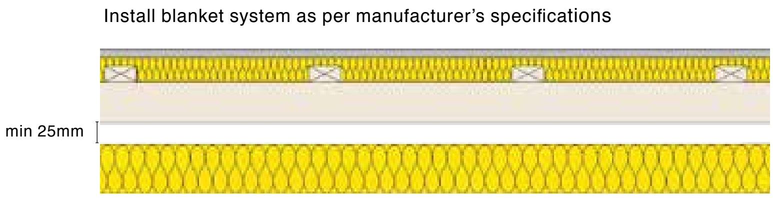


Fig. 16. Low pitch roof ventilation

Medium pitch roof >5° to <16°

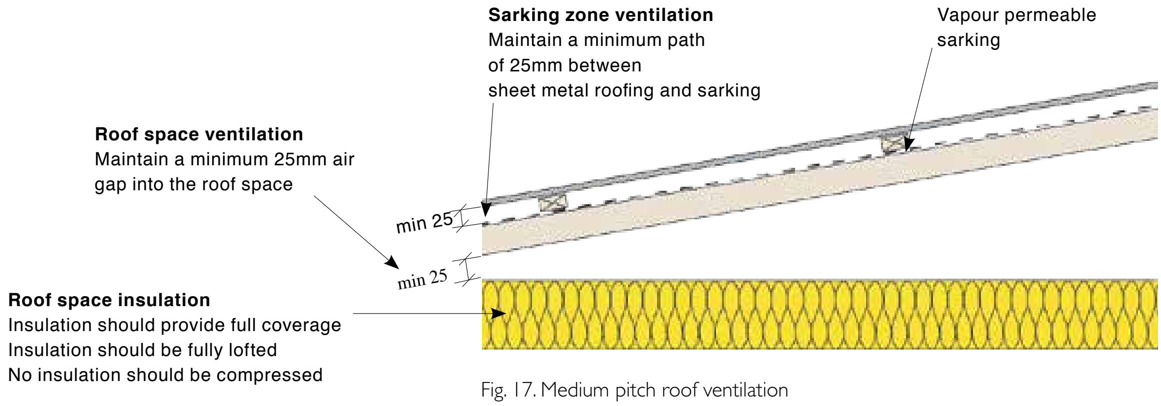


Fig. 17. Medium pitch roof ventilation

High pitch roof >16°

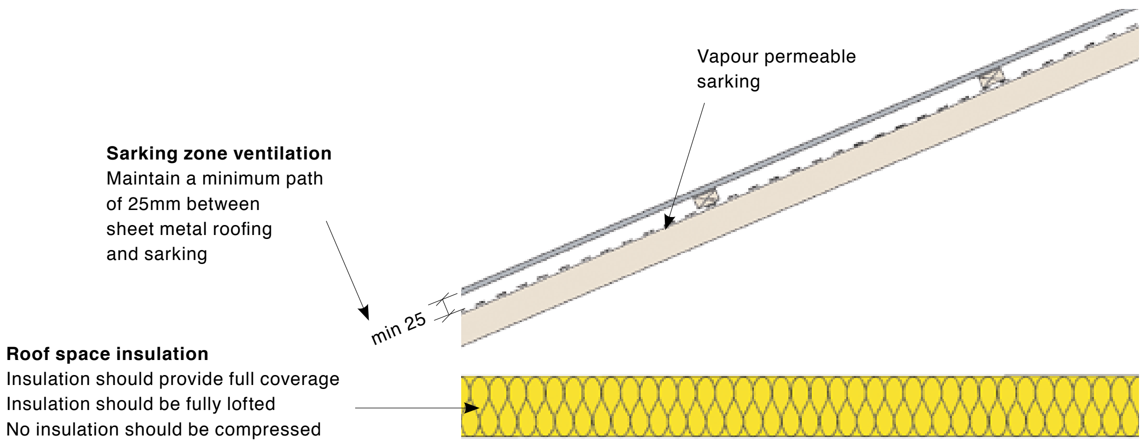


Fig. 18. High pitch roof ventilation

All example designs in this Guide are diagrammatic only.

- For all diagrams, the amount of ventilation required depends on roof pitch (see pages 11 and 12).
- In bushfire-prone areas, ventilation will need to comply with Australian Standard AS 3959:2018 *Construction of buildings in bushfire-prone areas*. Some of the requirements in this standard for ventilation are shown on diagrams where indicated.
- All example designs in this Guide are diagrammatic only. They are intended to show ventilation, insulation and sarking installation techniques for minimising condensation. Other aspects of the diagrams may not be reflective of all current NCC requirements or construction practices.

Supply vent reference diagrams

Fig. 19. Typical eaved roof

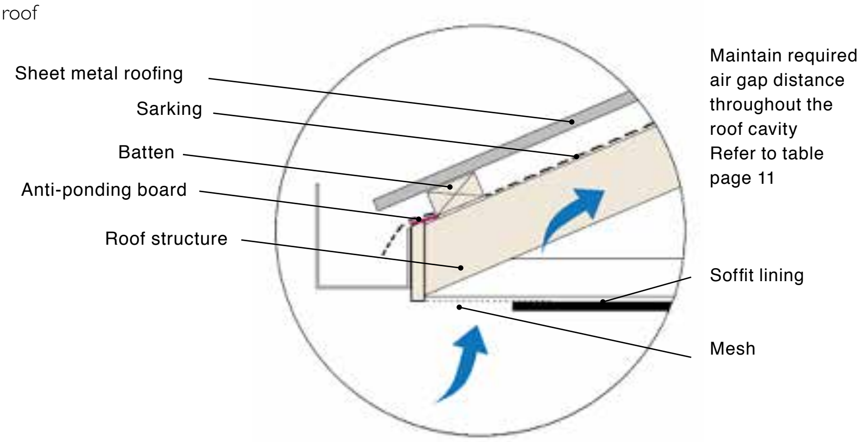


Fig. 20. Eaved roof with some bushfire considerations shown

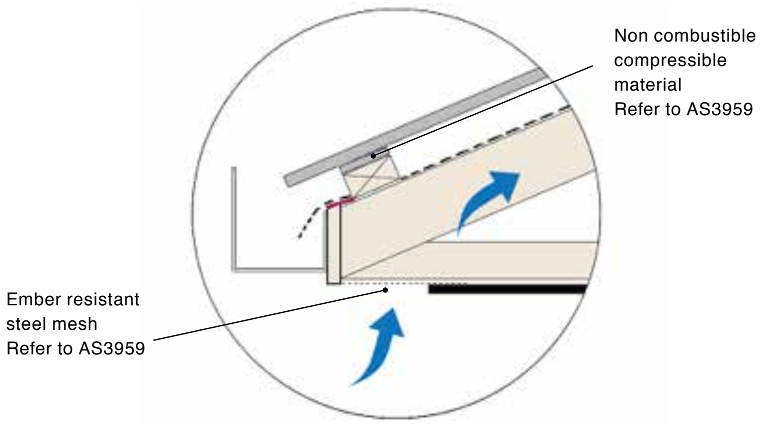
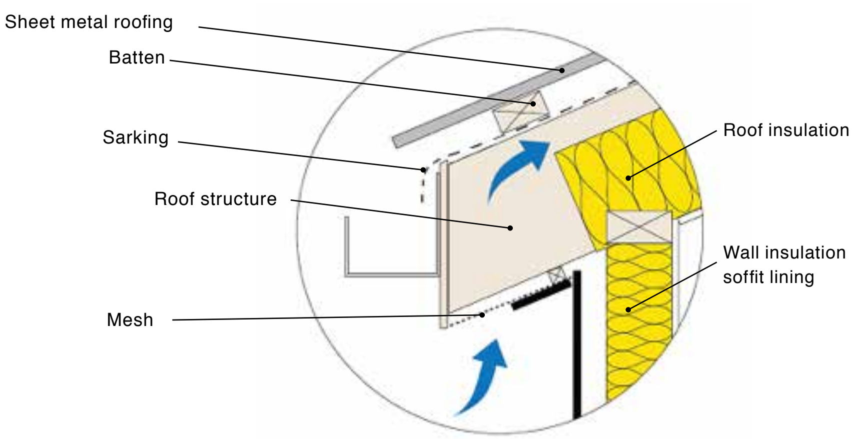


Fig. 21. Typical cathedral roof



All example designs in this Guide are diagrammatic only.

Fig. 22. Cathedral roof with some bushfire considerations shown

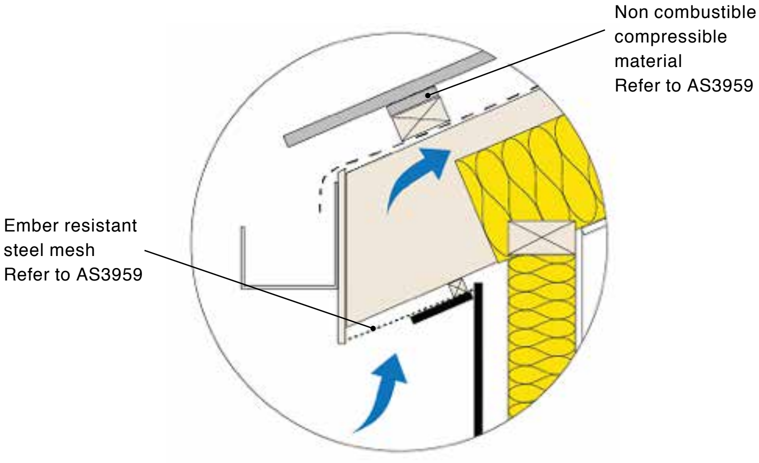


Fig. 23. Eaved roof with eave vent

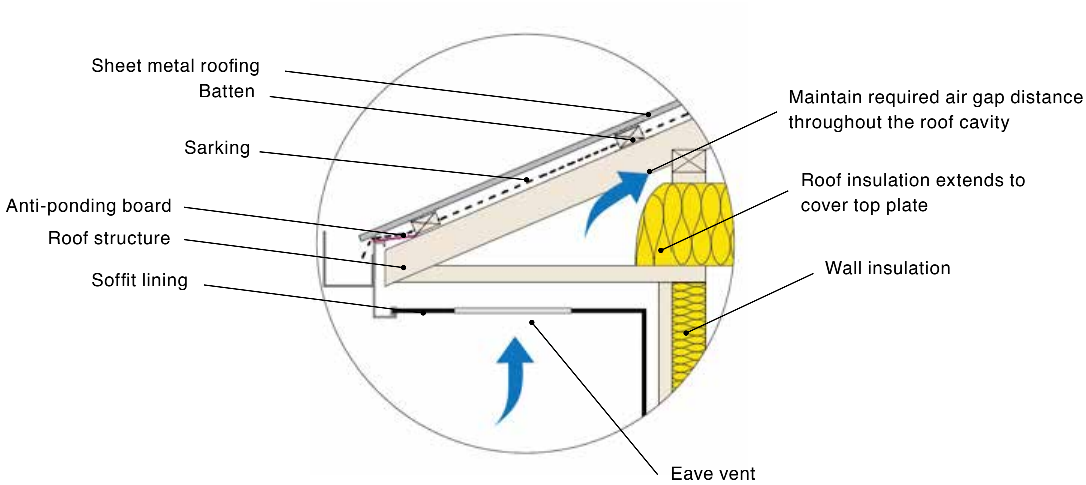
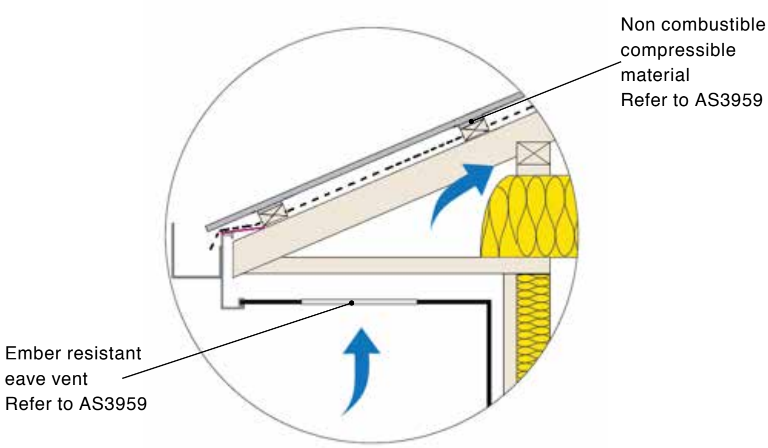


Fig. 24. Eaved roof with eave vent with some bushfire considerations shown



All example designs in this Guide are diagrammatic only.

Fig. 25. Eave vent

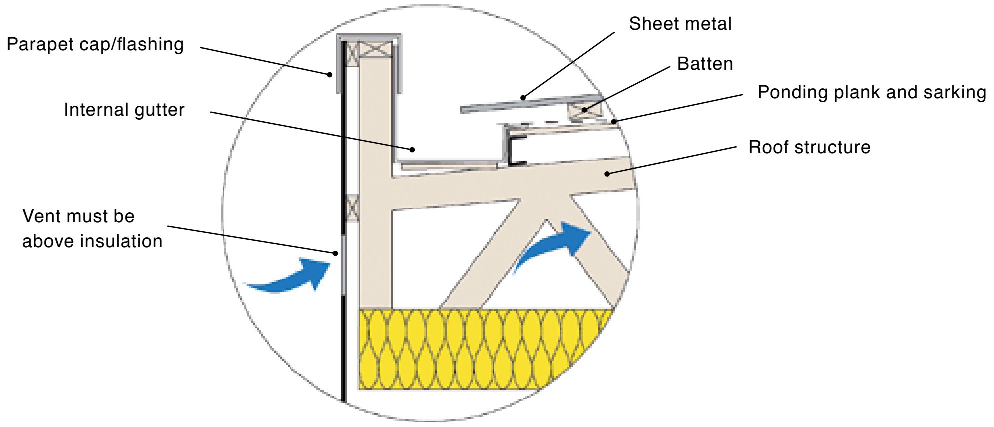
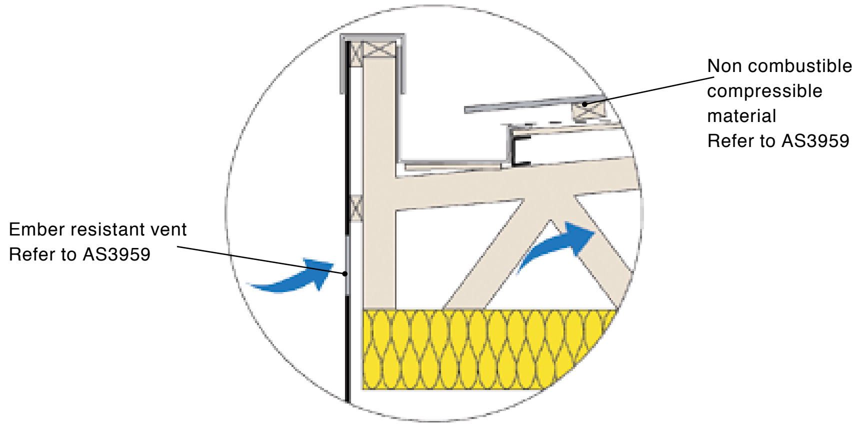


Fig. 26. Eave vent with some bushfire considerations shown



All example designs in this Guide are diagrammatic only.

- For all diagrams, the amount of ventilation required depends on roof pitch (see pages 11 and 12).
- In bushfire-prone areas, ventilation will need to comply with AS3959. Some of the requirements in this standard for ventilation are shown on diagrams where indicated.

Exhaust vent reference diagrams

Fig. 27. Ridge cap continuous gap

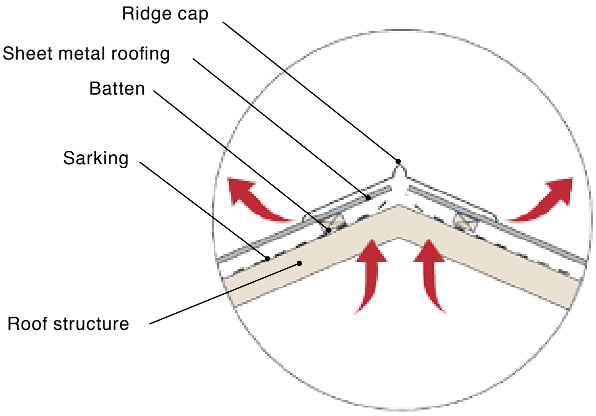


Fig. 28. Ridge cap continuous gap with some bushfire considerations shown

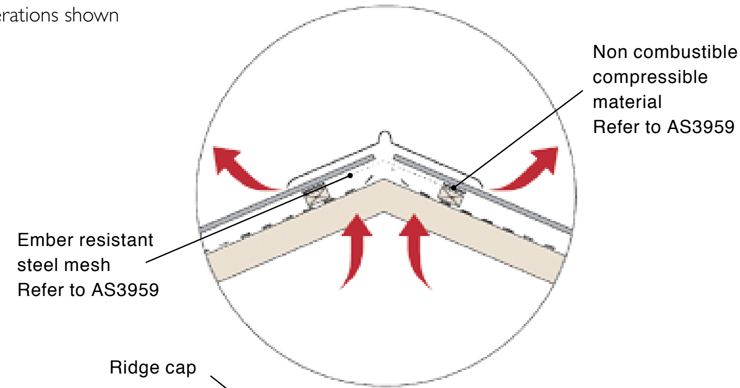


Fig. 29. Gable vent

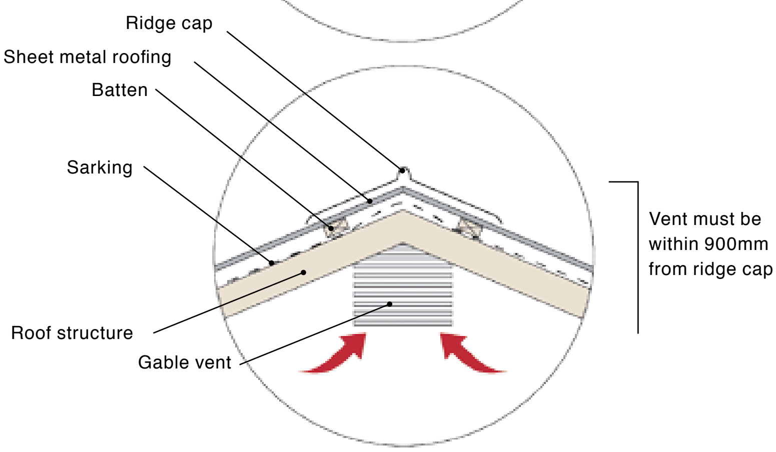
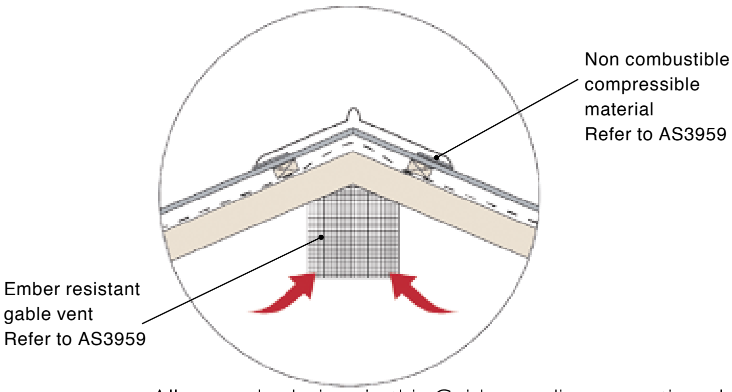


Fig. 30. Gable vent with some bushfire considerations shown



All example designs in this Guide are diagrammatic only.

Fig. 31.Typical cathedral vent

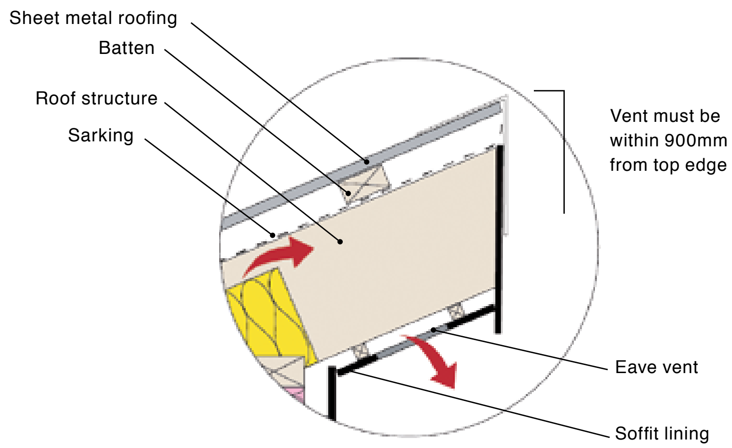


Fig. 32. Cathedral vent with some bushfire considerations shown

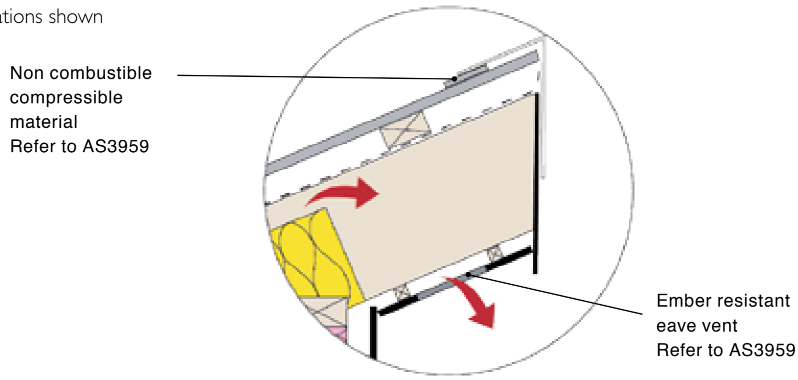


Fig. 33. Parapet vent

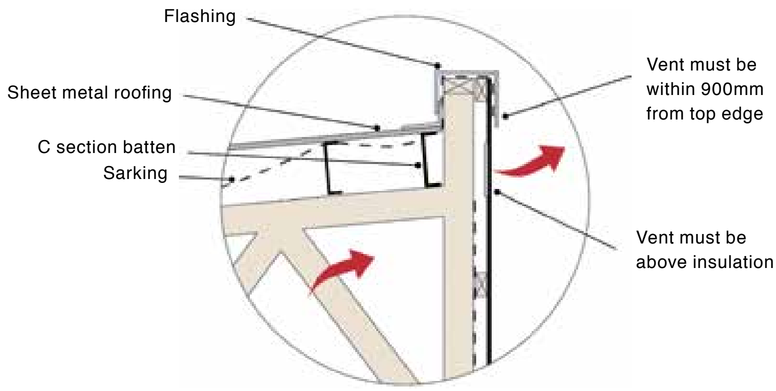
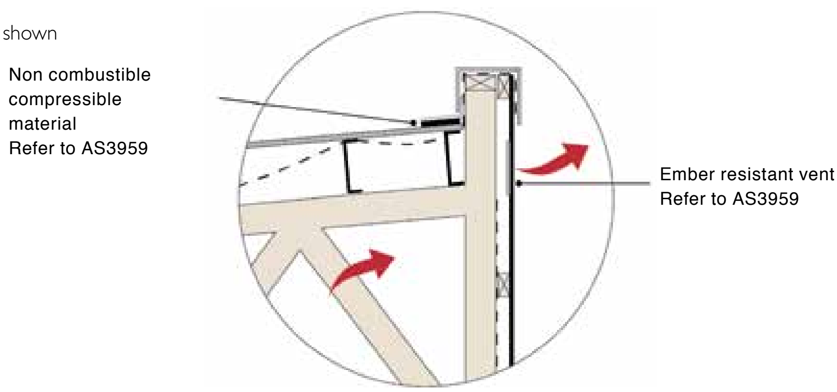


Fig. 34. Parapet vent with some bushfire considerations shown



All example designs in this Guide are diagrammatic only.

Walls

Key causes of condensation in walls

The key causes of condensation in walls are:

- vapour impermeable pliable wall membranes (building wrap), paints or wall coverings
- thermal bridging
- air leakage.

Vapour impermeable wall elements trap moisture inside the wall cavity, which causes moisture to build up when temperatures cool.

Thermal bridging occurs where a more conductive or poorly insulated material provides a pathway for heat to flow across a thermal barrier such as steel penetrations through insulation.

Air leakage can occur at the top and bottom of pliable wall membranes, in service penetrations and at the edges of walls and in corners where a building envelope is poorly constructed.

Fig. 35. Vapour impermeable building wrap traps water vapour in walls

Vapour permeability

To ensure that water vapour can freely and passively leave the building, all materials which are combined to make an external wall should be vapour permeable.

This includes internal finishes, internal linings, wall insulation and pliable wall membranes.

If a cladding system is in direct contact with the pliable wall building membrane, condensation and subsequent mould growth may occur inside the wall. To avoid this, a vented vapour cavity should be designed and constructed between the vapour permeable pliable building membrane and the external cladding.

Fig. 36. Mould and rot in wall structure caused by air leakage

Limiting air leakage

To limit air leakage, pliable building membranes should be installed in a way which ensures there is no path for air to escape at the top and bottom of walls.

All joins in the pliable membrane and all penetrations for services, doors and windows, should be sealed to limit air leakage. One way this can be achieved is by taping them with a durable tape.

In new buildings, a pressurisation test can be completed when the doors, windows and membrane is installed to ensure there is no unwanted air leakage.

- In bushfire-prone areas, ventilation will need to comply with AS3959. Some of the requirements in this standard for ventilation are shown on diagrams where indicated.

Fig. 37. Suspended timber floor with horizontal battens

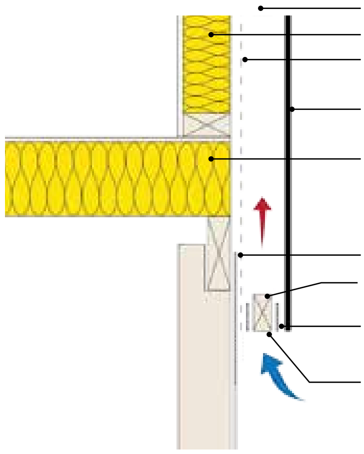


Fig. 38. Suspended timber floor with vertical battens

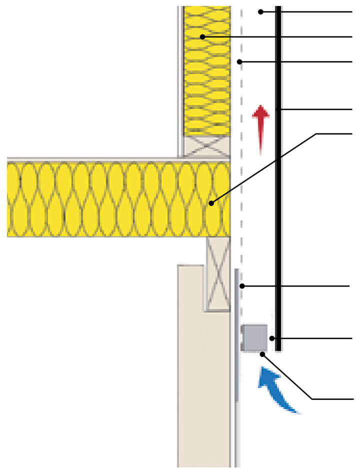
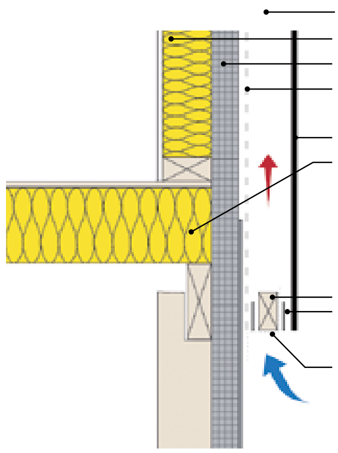


Fig. 39. Suspended timber floor horizontal battens and rigid insulation



All example designs in this Guide are diagrammatic only.

Fig. 40. Concrete floor horizontal battens

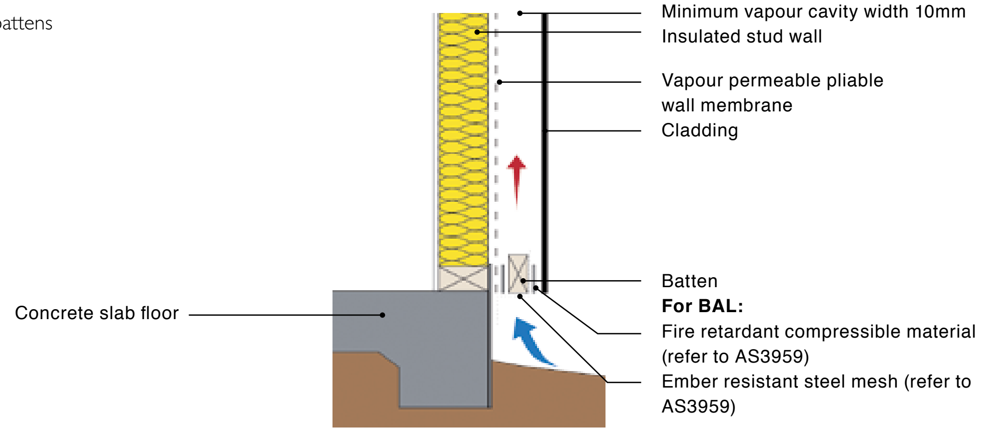


Fig. 41. Concrete floor with vertical battens

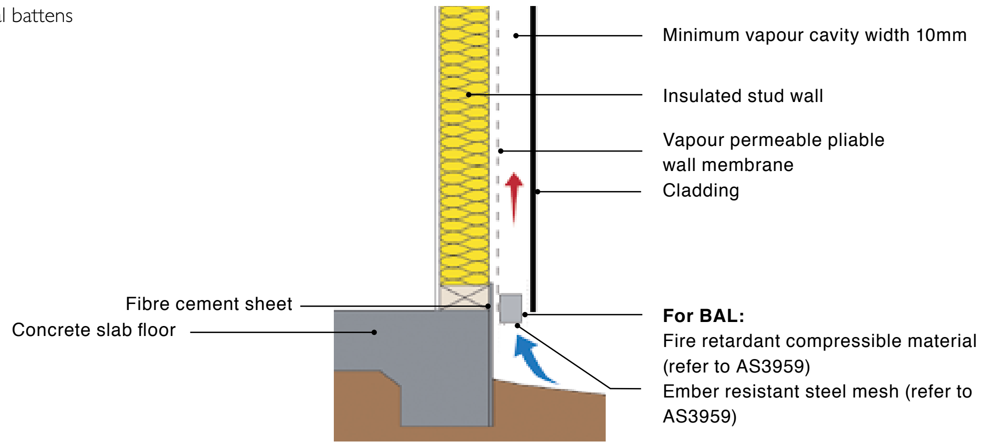
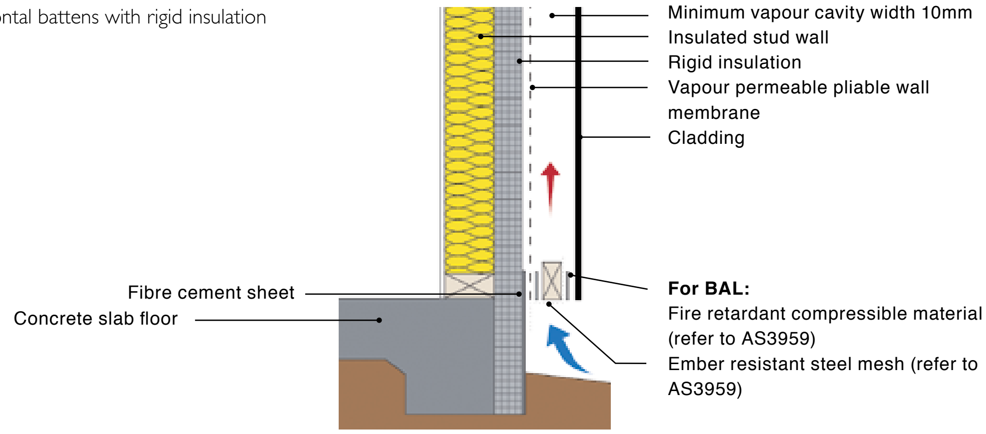


Fig. 42. Concrete floor with horizontal battens with rigid insulation



All example designs in this Guide are diagrammatic only.

Subfloor

Causes of condensation

There are three main causes of excessive moisture and mould growth in subfloors:

1. non-compliant subfloor ventilation
2. excessive ground moisture from a lack of site drainage
3. excessive ground moisture from water table.

Subfloor ventilation

The National Construction Code (NCC) prescribes minimum subfloor ventilation rates for housing with a platform floor. This required ventilation must be applied to all enclosed perimeter platform floored buildings.

Some urban locations may have limited access to ground level cross ventilation. In these cases, the NCC ventilation requirement should be exceeded.

When extending a building, consideration should be given to whether additional subfloor vents are needed. Additional subfloor vents may also be needed where new external paving could affect existing subfloor ventilation.

Site moisture and drainage

Site planning and site drainage are critical components of the design and construction of new buildings. The NCC and Australian Standard AS 2870:2011 *Residential slabs and footings* describe how site drainage should be designed and constructed for new housing. The same principles apply to non-residential buildings.

If a home has excessive subfloor moisture, more appropriate site drainage should be the first action. If subfloor moisture persists, the ground can be covered with a layer of sand.

Fig. 43. Evenly spaced subfloor vents in masonry wall

Fig. 44. Subfloor vents in clad wall

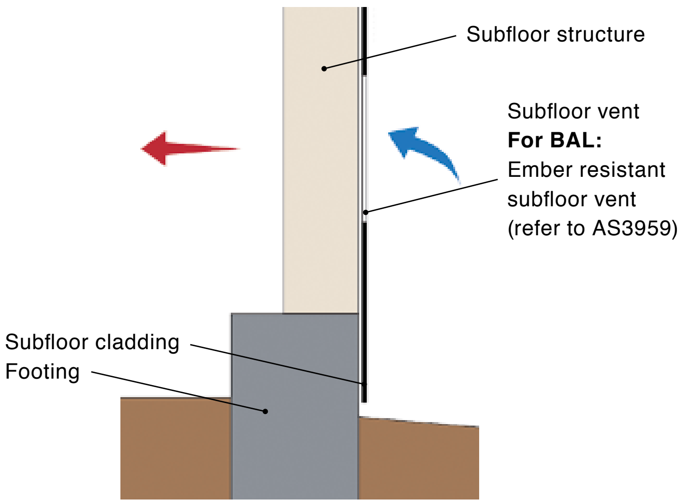


Fig. 45. Subfloor vents

All example designs in this Guide are diagrammatic only.

Acknowledgements

The content of this Guide was prepared by Dr Mark Dewsbury with the assistance of Abdel Soudan, Freya Su, Dr Detlev Geard, Anna Cooper, Dr Tim Law, School of Architecture & Design, University of Tasmania.

Additional information

Condensation risk mitigation for Tasmanian housing
http://ecite.utas.edu.au/126292

Renovating a pre-1980s weatherboard home: what about condensation?
http://ecite.utas.edu.au/122563

Temperate climates, warmer houses and built fabric challenges
http://ecite.utas.edu.au/124706

Recent increases in the occurrence of condensation and mould within new Tasmanian housing
http://ecite.utas.edu.au/112429

Investigation of destructive condensation in Australian cool-temperate buildings
http://ecite.utas.edu.au/108742

Condensation scoping study completed for the Australian Building Codes Board
https://www.abcb.gov.au/Resources/Publications/Research/Scoping-Study-of-Condensation-in-Residential-Buildings

Condensation in buildings non-mandatory handbook published by the Australian Building Codes Board
https://www.abcb.gov.au/Resources/Publications/Education-Training/Condensation-in-Buildings

Tasmanian Government

www.cbos.tas.gov.au

Email: cbos.info@justice.tas.gov.au Phone: 1300 654 499 PO Box 56, Rosny TAS 7018