



Building in bushfire-prone areas

Updated 2009 Edition

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Cover: As well as utilising the natural fire protection afforded by brickwork, this attractive house has double-glazed windows to provide additional heat resistance to these vulnerable building elements, brass mesh shielded vents to exclude sparks, valley and gutter guards to reject leaves, and stainless steel fittings to the decking. Photography: Roger du Buisson.



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Photo: Bushfire CRC

The bushfire hazard

This publication discusses the detailing and construction of brick housing – Australia’s most popular form of construction – to cover the specific provisions and practices that will increase housing safety in bushfire-prone areas. Although the focus is on brick housing, many of the suggestions may also be applicable to other construction forms.

In the temperate areas of Australia, wet winter and spring weather is often followed by a hot dry summer. Vigorous growth of vegetation, some of which contain flammable oils, results in a build-up of fuel load. The actions of hot winds from the arid interior and very low levels of humidity then create potentially dangerous fire conditions over large areas of the most densely-populated part of the continent.

In this situation summer bushfires are a fact of Australian life. From time to time fires occur that are of such intensity and cause such loss of life and property as to generate widespread public interest in measures that could be taken to reduce both the hazard and the damage.

Research and investigation after major fires in New South Wales, Victoria, South Australia and Tasmania between 1945 and 1985^{1,2} has resulted in a considerable body of information on the problems posed by bushfires. One significant outcome was the 1991 publication of Australian Standard AS 3959 *Construction of Buildings in Bushfire-Prone Areas*. This standard was revised in 1999 and 2009 and is being further reviewed following the devastating fires that occurred in Victoria in February 2009.

The provision of refuges with a higher level of protection against bushfire attack is being considered as part of this on-going review. A number of other publications are also available on the nature of bushfires, fire prevention, fire fighting, and site selection³ and management⁴.

This publication does not detail these matters but concentrates on planning, design, materials selection and building details for brick houses in bushfire-prone areas.

The general philosophy is that good design, careful construction and sensible maintenance will produce a house that not only provides protection from normal weather and storms, but also from bushfires. Any extra costs arising from measures taken to improve the chances of a brick house (and its contents) surviving a bushfire are small when compared to the cost of replacing a house and contents that have been destroyed, even after allowing for an insurance payout.

This is consistent with studies that have shown that houses that are attended during bushfires have significantly better chances of survival than vacant houses,^{5,6,7} and that fewer people die in houses than in the open or in vehicles.

“Good design, careful construction and sensible maintenance will produce a house that not only provides protection from normal weather and storms, but also from bushfires”

The nature of bushfires

Contributing factors

The intensity of a bushfire will depend on:

- The fuel load, its type and distribution;
- Moisture content of the fuel;
- Wind velocity and its direction;
- Topography; and
- Ambient temperature and humidity.

Of these factors, fuel load is the most important, particularly ground-level fuel such as leaves, grass and twigs up to 6 mm diameter. In practical terms fire intensity effectively increases as the square of the fuel load: doubling the load quadruples the intensity and halving the load quarters the intensity.

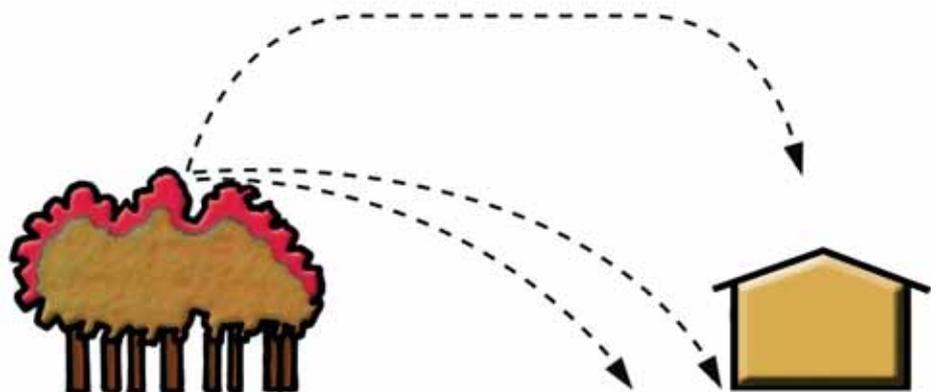
Modes of attack

There are four “weapons” with which bushfires attack buildings. The first, burning brands and sparks, often have their effect before and after the passage of the fire-front. “Burning embers blown ahead of a bushfire are the most common cause of bushfires igniting houses and causing damage,” states an NSW Rural Fire Service report⁸. The other three are associated with the passage of the fire-front. Although they operate for only a short period they may open serious breaches in the outer fabric of the building, through which flame, sparks and smoke may enter.

Burning brands and sparks

For some time, perhaps up to thirty minutes before the fire front arrives, a building can be showered with sparks and burning fragments carried up in the plume of hot gases above the fire. In the strong winds that accompany bushfires these burning brands and sparks can travel considerable distances but are at their most severe up to 500 metres from the fire-front, where direct spotting by burning bark or twigs can occur.

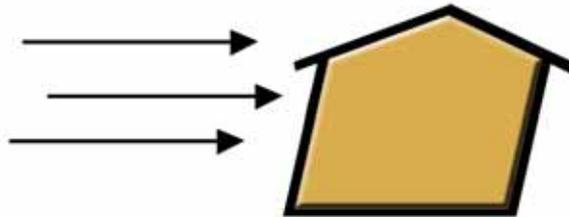
Attack by burning fragments and embers can continue after the fire-front has passed, so the period of exposure to this source of danger is to be measured in hours rather than minutes. There are numerous reports of unattended houses burning down several hours after the fire-front has passed as a result of earlier entry of burning materials.



A house should be located beyond the potential direct spotting distance of Eucalypt forests

High wind speeds

Large fires generate their own wind and speeds may exceed 150 km/h (42 m/s) near the fire-front. Such speeds will not be maintained for very long, but the potential for serious damage is great enough to warrant special attention to roof attachment and the protection of windows, both of which are vulnerable to wind damage.



High levels of radiation

At the fire-front, the flames could emit radiation levels of 150 kW/m². This may rise to more than 200 kW/m² for short periods if the fuel load is high. The intensity of radiation received at the building depends upon the distance to and the size of the flame front. AS 3959–2009 provides construction requirements corresponding to radiation exposure thresholds (Bushfire Attack Level or BAL) ranging from low to 40 kW/m². The flame zone is considered to have exposure in excess of 40 kW/m². Radiation intensity could readily reach levels sufficient to fracture glass and ignite timber in the absence of sparks or brands but the combination of high levels of radiation, burning brands and sparks constitutes a major weapon of the bushfire attack.



Flame contact

Direct flame contact with exterior parts of the building, particularly projections such as eaves, verandahs or pergolas, may occur if there are fuel sources such as vegetation or wood heaps close to the house.





Photo: Country Fire Authority

Building in brick in bushfire prone areas

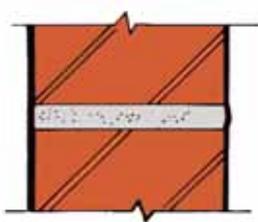
During manufacture clay bricks are fired at temperatures as high as or higher than anything reached even at the heart of a large bushfire and are in the kiln for much longer than it takes for the front of a bushfire to pass a given point. It follows that the bricks themselves are incombustible.

The CSIRO survey of houses in the Otway Ranges in Victoria that were exposed to the 1983 Ash Wednesday fires⁶, showed that masonry walls significantly reduce the chances of a house being destroyed by bushfire. The use of bricks confers a number of other planning and design advantages. It has been shown in the Manual 3 *The Full Brick Manual* (see Further Reading), that full-brick construction is thermally comfortable and energy efficient, while at the same time minimising noise problems and maintenance costs.

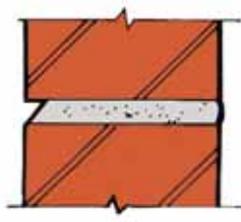
So far as brickwork construction methods are concerned, the details given in Manual 9 *Detailing of Clay Masonry Walls* and Manual 10 *Construction Guidelines for Clay Masonry* should be followed (see Further Reading). For bushfire-prone areas it is advisable not to rake back the mortar joints, but to use a flush ironed or weatherstruck joint. These joint types are less affected by heat than raked joints and more easily re-pointed should extreme exposure to heat cause deterioration of the mortar surface.

It is accepted that bricks and the mortar are not combustible and that well-designed and constructed brick walls have an inherently high level of fire resistance. However many other structural components (and furnishings) may burn and lead to the destruction of everything except the brick walls. The rest of this publication gives details of design principles and construction practices that improve the survival chances of a brick house exposed to bushfires.

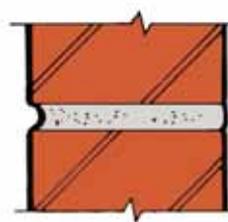
“Masonry walls significantly reduce the chances of a house being destroyed by bushfire”



Flush



Weatherstruck



Ironed



Raked

How much bushfire protection?

There are many ways, both active and passive, for improving the survival prospects of houses in bushfire prone areas. Which ones are used and how much money is spent on them will depend on individual judgement of the hazard level that exists and the level of risk the property owner is prepared to accept (after laying off some of the risk by means of fire insurance).

In making such a judgement it should be recognised that although insurance can offset some (but rarely all) of the financial loss associated with the destruction of

a home in a bushfire, it cannot compensate for the disruption and the trauma of losing personal possessions and being left homeless.

It is not possible to give a simple set of answers that apply to all houses. This publication describes the design and construction procedures that are appropriate to the general level of bushfire hazard, and to indicate the level of protection which would be adopted by a prudent owner who is prepared to maintain an average level of property management.

If the local building authority requires it, the methodology of AS 3959 must be followed. This involves a detailed assessment of the building site for Bushfire Attack Level (BAL) on the basis of climate, slope of ground and vegetation. AS 3959 sets out construction requirements for each of the six levels of BAL. It should be noted that the building code requirements of AS 3959 are a minimum requirement, which balances safety and cost, and that building owners can specify a higher level of protection.

Planning and design

Questions related to site selection and layout are well treated in other publications³ and will not be repeated here. So far as the shape and layout of the house are concerned, a simple rectangular floor plan, covered by a low-pitched roof having no re-entrant corners or valleys, is to be preferred. For reasons related to thermal performance it is preferable to have the long axis of the house running east-west if possible.

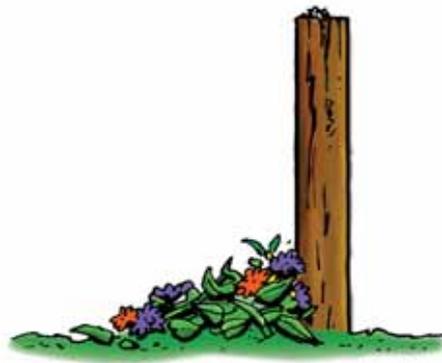


Construction Details

General

Field evidence shows that the most vulnerable parts of a building are:

- The ground/wall junction where combustible material can accumulate. Timber posts, cladding and battens, particularly rough sawn timber and sections which may split or crack, are all sources of risk;
- All penetrations of the walls. Doors, windows and vents all provide gaps and openings where sparks or embers may enter the building; and
- Roof penetrations and eaves. Skylights, vents and the eaves provide points-of-entry to the roof space, where the start of a fire is most difficult to detect and fire fighting measures most difficult to apply.



Protection against spark entry

There is ample evidence from field studies that the entry of sparks or fire brands, particularly into roof spaces and under suspended floors, is the most frequent cause of ignition of houses by bushfire. Carefully fixed corrosion resistant steel or bronze mesh with a maximum aperture size of 2 mm provides cheap and effective protection for vents and openings into sub-floor, wall or roof spaces. Such screening should be considered the irreducible minimum fire protection for all houses in bushfire-prone areas.



Footings and floors

If slab-on-ground construction for the footings and floors is used:

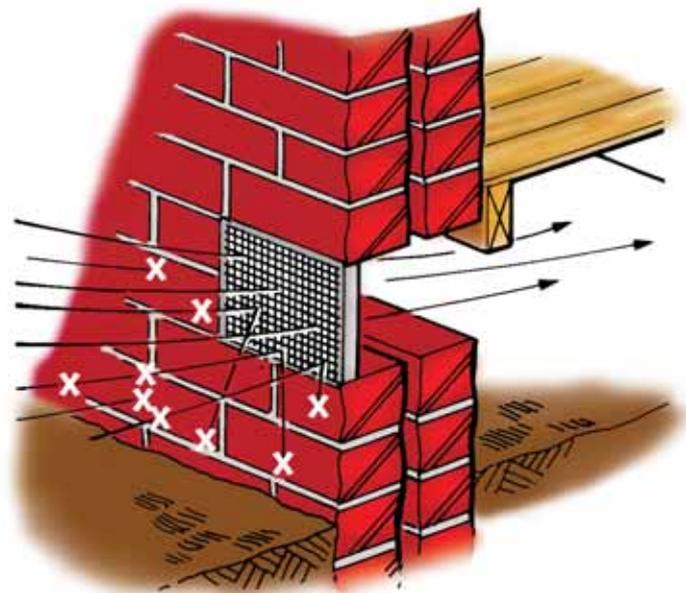
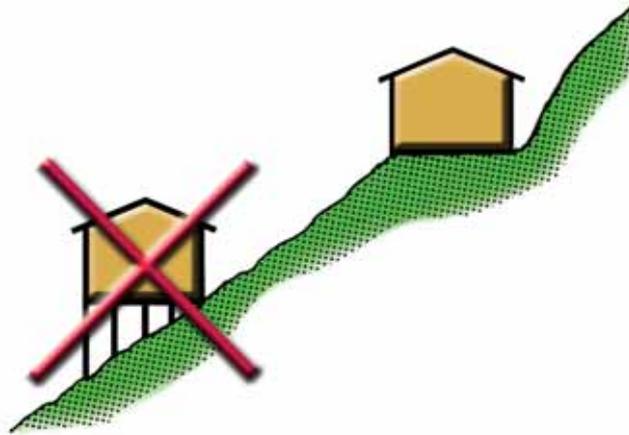
- Sparks and embers cannot enter and the material of the floor is non combustible;
- Flammable materials cannot accumulate or be stored under the house; and
- The profile of the building is lowered, reducing wind loadings.

On sloping sites, where practical, it is advantageous to set the house into the slope on a slab-on-ground system³. On steep sites where a suspended floor is necessary the structural members (beams, piers and columns) supporting the floor should be built from non-combustible materials. In some cases it might be advisable that the floor and its supports be of fire-resistant construction.

Suspended timber floors at ground level require careful attention. They must be ventilated if they are to be durable, but all vents must be protected by mesh (as described in the previous section). These screened vents must be protected from accidental damage or damage by animals and regularly inspected to ensure that they remain effective.

Balconies, decks and verandahs

Suspended timber decks are difficult to protect from fire. In bushfire hazard areas high-set houses and suspended features such as timber balconies and decks are best avoided. If they are used, particular attention should be paid to reduction of fuel loads around the building, to minimise radiation and flame contact.



External walls

Cladding

Brick walling, of either cavity or veneer construction, is generally to be preferred in bushfire areas since it withstands the heat radiation and significantly reduces the likelihood of fire starting along the otherwise vulnerable ground/wall junction. No special methods are needed in building brick walls for houses in fire-prone areas. As previously stated, flush, ironed or weather-struck joints should be used.

It is also advisable to modify the weep holes that are required to drain away water that might collect on the flashings. Open head or perpend joints forming weepholes should be protected against entry of sparks by a piece of folded corrosion resistant steel or bronze mesh with a maximum aperture size of 2 mm.

Doors

All external doors should be of the solid core or fire-resistant type, with no letter slots or other penetrations. Doors should fit closely to frames all round and be protected from sparks by an effectively latched tight-fitting screen door on the outside. Again the screen should be made from corrosion resistant steel or bronze mesh with a maximum aperture size of 2 mm. Sliding doors should be treated as windows.

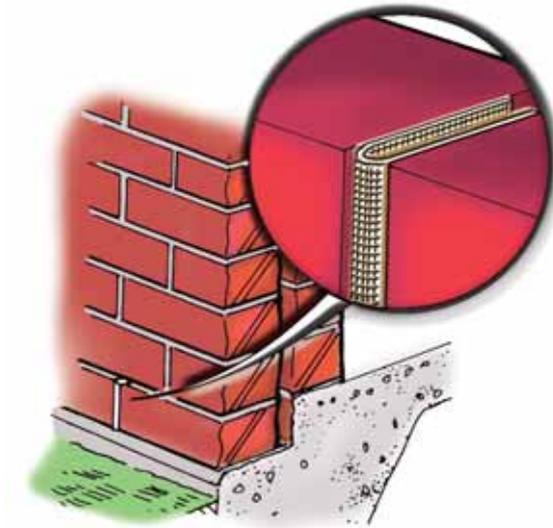


Photo: Country Fire Authority

Because of its non-flammable qualities, brickwork commonly survives even the fiercest bushfire. However it is essential to give proper attention to other details such as spark entry and shielding or eliminating vulnerable materials such as glass and plastic.

Windows

Windows are the most vulnerable parts of the external fabric of buildings and are the most difficult to protect. Large glass areas should be screened from radiation to reduce the chance of glass breakage and ignition of the building contents. The minimum acceptable protection is close fitting corrosion resistant steel or bronze mesh screening over both fixed glass and opening sashes. If the window frames and sills are of wood the screens (and fire shutters if provided) should be mounted so as to prevent the accumulation of burning debris in the angle between the sill and the frame.

Effective screening is much more easily provided for sliding windows than for casement or awning types, where screens are usually fixed on the inside.

Protection of windows against flying debris should be. Hinged or removable shutters of cellulose-cement or perforated metal probably offer the cheapest solution. They should be close fitting, particularly under the eaves, and designed so as not to provide horizontal ledges where burning material could lodge. If removable, shutters should be manageable in high wind conditions by no more than two people, and should be able to be quickly and positively attached to the building.

Even where fire shutters are provided, corrosion-resistant steel or bronze mesh screening is essential. The fact that it is permanently installed means that it is sure to be in place when it is needed (which the shutters may not) and the fact that screening serves a dual purpose improves its chances of being properly maintained.

Vents in walls

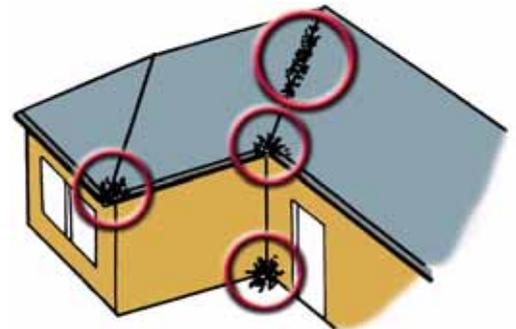
Building regulations no longer require vents in walls in houses because it has been shown that they serve no useful purpose and are an unnecessary expense. In bushfire-prone areas imperfectly screened wall vents may admit sparks or embers and their use should be avoided. Special purpose vents, as in kitchens and bathrooms, must be well sealed to the wall to prevent burning material lodging between the wall and the unit and be fully screened against spark entry.

Roofs

Pitch and form

The roof space is one of the most fire-vulnerable parts of a house and the larger it is the more it is at risk. From this it follows that there are advantages in using a low-pitch roof of simple shape and without re-entrant angles which could allow the build-up of debris.

Cathedral ceilings, which eliminate the roof space, have advantages, but if there is a roof space, convenient access to it is essential. The ceiling access-hole should command a clear view of the whole roof space and be large enough to allow easy passage of fire-fighting personnel and equipment.



Attachment

Although the wind speeds (up to 150 km/h or 42 m/sec) associated with bushfires are below the lower end of the cyclonic wind range (198 km/h or 55 m/sec), they are high enough to warrant careful attachment of the roof structure to the building. The requirements of the local authority should be followed.

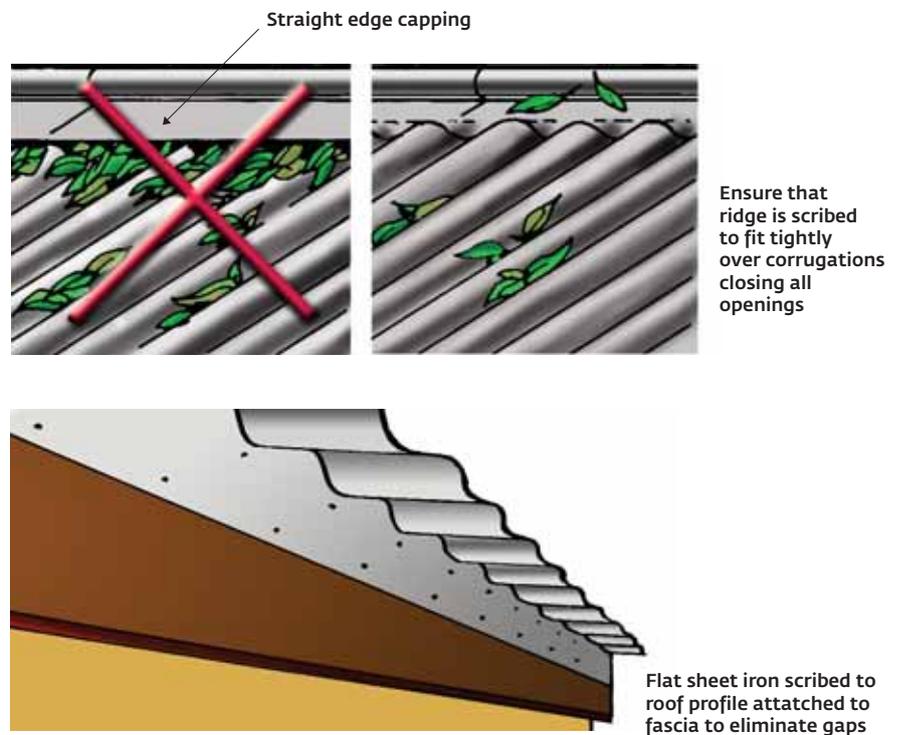
Cladding, sarking and insulation

Steel sheeting or tiles are the most suitable cladding materials. Timber shakes or shingles must not be used. Of sheet materials, trough-profile sheeting is preferred because there are fewer end-stopping problems at eaves and ridges than with corrugated sheets. Tiled roofs must be fully sarked over the entire roof area including the ridge.

All sarking and insulating materials used in bushfire-prone areas must have a Flammability Index less than 5 when tested in accordance with the Australian Standard AS 1530.2 Tests for Flammability of Materials.

Skylights and rooflights

Plastic roof tiles or sheets and plastic domelights are all hazardous in fires and should be avoided in bushfire-prone areas. Thermoplastic sheet in a metal frame may be used for a skylight provided the diffuser installed at ceiling level is made of wired or toughened glass in a metal frame.



Gutters, barges and eaves

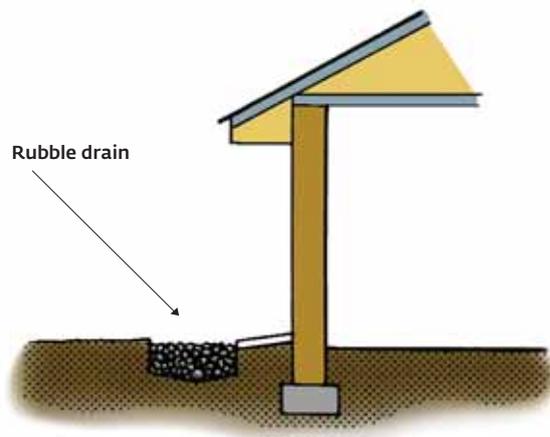
Ignition of leaves in roof gutters, followed by the spread of the fire to the roof space, is widely recognised as a source of hazard in bushfires. Keeping roof gutters free from leaves requires significant and sustained effort on the part of the occupant and is better dealt with in other ways. Two possible approaches are:

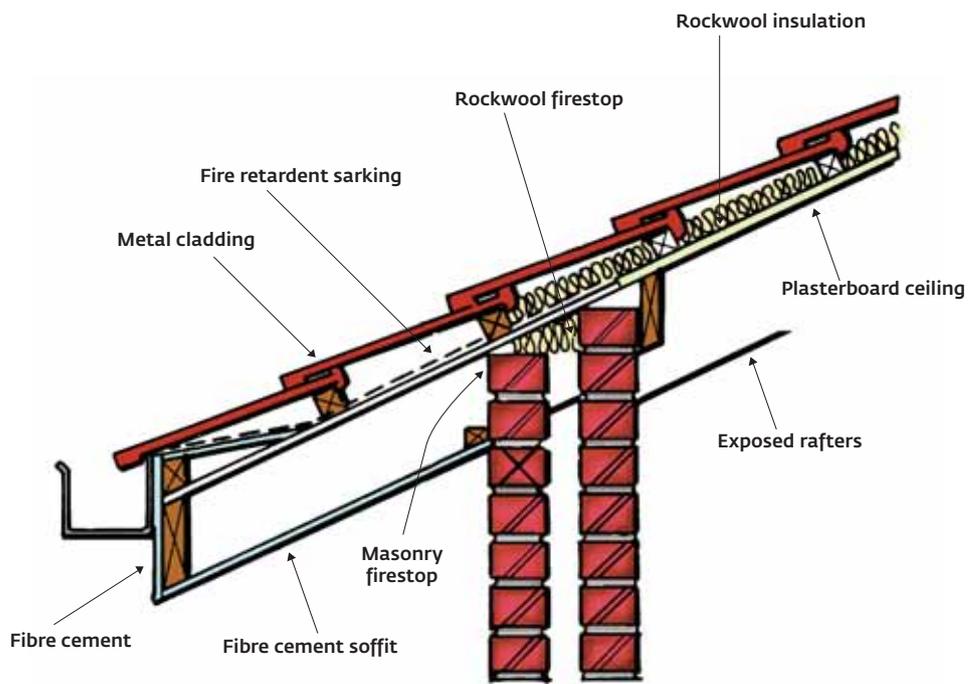
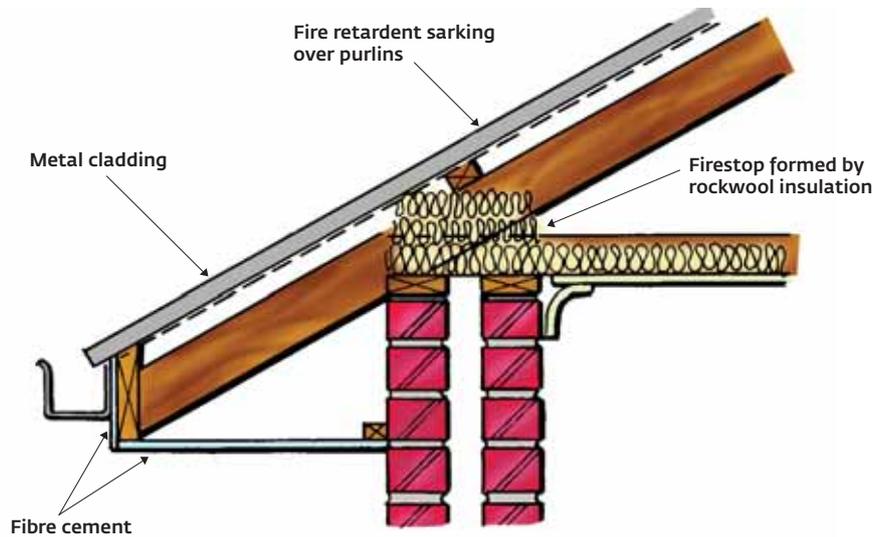
- Do without roof gutters and lay a rubble drain around the house to collect and remove stormwater; or
- Use a leaf-proof guttering system, together with non-flammable materials such as cellulose-cement board or metal for barge boards and eaves linings.

The first alternative looks attractive on paper and works well if rain is not accompanied by wind, which is seldom the case. Also it is impractical where water collection and storage is important.

If the second alternative is chosen it is essential to seal the eaves effectively, especially at the eaves lining/wall junction, where significant positive pressure can develop in windy conditions. Fibreglass or mineral fibre insulation batts on top of the eaves lining have been suggested as a useful aid to sealing eaves.

The junction of the fascia or bargeboard and the roof cladding is also important. As previously noted, trough-profile roofing leaves fewer gaps than corrugated profiles and is therefore preferred.





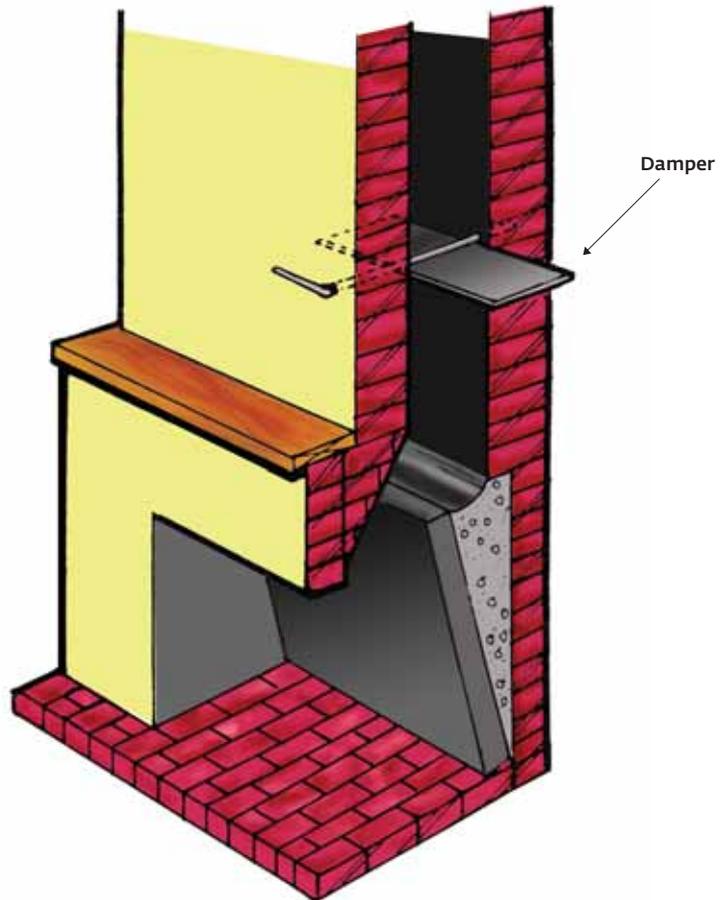
Vents and openings

All vents and openings in roofs and eaves must be spark proofed with corrosion resistant steel or bronze mesh screening. Internal dampers are advisable in chimneys and close-fitting spark-proof firescreens are essential over fireplace openings.

Ceilings

Whether a house is ignited by a bushfire, a pan of burning fat on the stove or a cigarette butt in a bed, the fire often spreads from room to room through the ceiling and the roof space. It is therefore important to reduce the fire vulnerability of this part of the building as much as possible.

As previously noted, a cathedral ceiling, with glass or mineral fibre insulation between the ceiling lining and roof cladding is a suitable form of construction for houses in bushfire areas. For suspended ceilings a non-flammable lining material such as plasterboard is essential. Hardboard, softboard or plastic lining materials should never be used as they ignite easily and burn or melt rapidly in the hot conditions prevailing during bushfires. Ceilings should be insulated with glass or mineral fibre batts or loose fill insulations of non-combustible material packed between and over rafters.



Further reading

The following publications are available from the Think Brick Australia in PDF (Adobe Acrobat) formats (www.thinkbrick.com.au).

Manual 3, *The Full Brick Manual*

Manual 9, *Detailing of Clay Masonry Walls*

Manual 10, *Construction Guidelines for Clay Masonry*

Contact Standards Australia (www.standards.com.au) for information on any Australian Standards referenced in this publication.

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- ² R.H. Luke & A.E. McArthur, *Bushfires in Australia*, AGPS, Canberra 1978
- ³ Ministry for Planning and the Environment & Country Fire Authority, Design and Siting Guidelines: *Bushfire Protection for Rural Houses*, Melbourne, 1980, 1983
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- ⁵ A.A. Wilson & I.S. Ferguson, Fight or Flee? – A Case Study of the Mt Macedon Bushfire, *Australian Forestry*, 47,4,2 1984
- ⁶ How Bushfires Set Houses Alight: Lessons from Ash Wednesday, *Ecos*, 43, Autumn 1985
- ⁷ G. Caird Ramsey, N.A. McArthur & V.P. Dowling, A Survey of Houses Involved in the Otway Ranges Fire, February 16 1983, unpublished paper, CSIRO Division of Building Research, Melbourne 1985
- ⁸ NSW Rural Fire Service, *Bush Fire Protection for New and Existing Houses in Urban Area*, Sydney 1997