This Briefing provides guidance on the design and construction of all new buildings, concentrating on solutions incorporating concrete and masonry materials. It is fundamental to this document that any building envelope, in any bushfire-prone area of Australia, should be built with non-combustible materials. Non-combustible materials are a practical and effective measure for bushfire mitigation.

**PREFACE**

This Briefing presents concrete- and masonry-based solutions for the design and construction of a range of building types in bushfire-prone areas. It draws on the rationale used to design an award-winning, bushfire-resistant house after the 1983 ‘Ash Wednesday’ bushfire. Subsequent observation of building survival, damage or destruction in more-recent bushfire events, including ‘Black Saturday’ of 2009, has been considered. Australian Standard AS 3959 *Construction of buildings in bushfire-prone areas* is also cited.

This document complements Cement Concrete & Aggregates Australia publication *Houses for Bushfire-prone Sites*. The latter contains useful information on the nature of bushfire attack, retrofitting existing houses for bushfire defence, and landscaping to improve building safety in bushfires.

This publication is intended for use by anyone involved in the design and construction of buildings in bushfire-prone areas including building designers, architects, builders, local authorities, developers and owners.
INTRODUCTION
Bushfires are inevitable in many parts of both rural and urban Australia – and experience shows weather conditions are becoming more extreme. Summer months in many areas now have a week or more of temperatures above 40°C accompanied by low humidity and high winds, changing the bushfire risk in such areas from ‘low or moderate’ to ‘very high or extreme’. For this reason, regardless of the Fire Danger Index (FDI) or Bushfire Attack Level (BAL), all buildings within one kilometre of temperate or subtropical Australian bush land should be designed as for high risk areas. There is also additional radiation and flame exposure created by combustible building surroundings such as fencing, stored materials, vehicles or other nearby buildings.

With that proviso, building designers are encouraged to adopt appropriate BCA4 and AS 3959 provisions (specially glazing), together with relevant State or Territory requirements.

Since the publication of TN 663 which deals with houses in bushfire-prone areas, an increasing need for the application of bushfire-resistant construction principles to other building types has become apparent. This document provides guidance on the design and construction of all new buildings, concentrating on solutions incorporating concrete and masonry materials. It is fundamental to this document that any building envelope, in any bushfire-prone area of Australia, should be built with materials that are robust and always non-combustible.

Whether or not people or animals are evacuated before a bushfire event is not in question. It is prudent to design buildings that will themselves survive a bushfire (albeit with some repairable damage) and in so doing provide a refuge for occupants who chose to stay, or were unable to evacuate. People (and animals) who are not evacuated stand a better chance of survival inside a properly designed and prepared building than if they are outdoors or in a vehicle.

BUSHFIRE ATTACK
Threats
Conditions leading to increased bushfire risk and subsequently during bushfire attack must be considered when defining the environment in which a building is to perform. Ambient conditions consistent with severe fire weather are:

- **Prolonged high temperatures** with maximums above 40°C and minimums little below 30°C.
- **Very low humidity** over several days.
- **Frequent moderate winds** with high gusts.

These conditions, particularly in combination, create a situation where all buildings and their surroundings are hot and dry. Any combustible material (whether part of the building or around it) will be in optimum condition to ignite readily and burn vigorously. The situation will be exacerbated if there is only a limited supply of water, either piped or stored.

When a bushfire is in the region, the **high winds** that precede a fire front result in wind-borne debris, which in the worst case may include tree branches and sheet roofing material.

The critical stage is when a bushfire reaches a building and the conditions include:

- **Heat** from hot air blown ahead of a fire and/or radiant heat as the fire nears may raise flammable materials to ignition temperatures.
- **Direct flame** occurs when part of the building is flammable or a building is close to combustible vegetation or wind-gathered flammable debris.

Factors influencing bushfire risks
AS 3959 provides for the assessment of Bushfire Attack Levels (BAL). The factors taken into account include:

- Vegetation type
- Distance from vegetation
- Slope of land
- Prevailing climate
- History.

While these factors give guidance, it should be noted that climatic conditions are becoming more extreme. AS 3959 provides for short term survival during the fire event, not survival after the event. It also assumes a certain fire weather intensity, this intensity is regularly exceeded and was exceeded in Ash Wednesday and Black Saturday. The Standard ignores combustible elements like fences, cars and stored materials close to the building. A non-combustible facade is good insurance against the additional flame exposure that these elements create. Also the Standard only considers continuous forest fuels and it is wise to design for higher fire weather intensity and for higher than expected wind speeds and exposure.

In most cases a building owner will have the Fire Danger Index (FDI) or the Bushfire Attack Level (BAL) assigned by the relevant authority. On a rural property or similar circumstance the owner may be able to influence fire risk by removing nearby, unsatisfactory vegetation species and flammable objects.

Experience of Ash Wednesday and Black Saturday bushfires shows that it is prudent to adopt a conservative index or level for a building that may be subjected to a variety of conditions through its service life.

It is advisable to monitor weather predictions provided by the Bureau of Meteorology, relating their forecasts to the local Fire Danger Index (FDI). In areas with an FDI around 40 some building loss due to bushfires is expected, where the FDI is 70 extensive building loss is expected while a potential loss of thousands of buildings is predicted with an FDI of 100. For each of these situations, buildings with non-combustible envelopes have far greater survival potential.
NEW BUILDINGS – DESIGN PRINCIPLES

The object of building design and construction for a bushfire-prone site is to significantly reduce the risk to people and animals, and limit the damage (and therefore the restoration cost) caused by a bushfire. The information in this document is relevant, but not limited to the following building types:

- Farm and backyard sheds
- Garages and workshops
- Houses, individual, group, multi-storey and units
- Commercial buildings (shops, cafes, offices)
- Community buildings (churches, halls, clubs).

Any of these buildings, properly designed, built and prepared have the potential to provide a refuge for people and animals. Community or commercial buildings may be considered as community refuges or evacuation centres and sign-posted as such.

Buildings for bushfire-prone sites need to be designed primarily for performance in the conditions of a major bushfire, without compromising their function during their normal service conditions. The materials and construction methods proposed here are readily available, it is a matter of selecting the appropriate material, detailing it correctly, then preparing it appropriately at times of bushfire threat.

- All materials for the building’s envelope should be non-combustible and robust.

Non-combustibility removes the possibility of portions of the building being ignited then spreading into the building, or adding to a bushfire’s fuel. Robustness has several critical advantages. As a bushfire passes there is exposure to intense heat for a short time, during which robust, bulky, dense building materials that heat slowly suffer only insignificant heat stress; as well, wind-borne debris associated with bushfires has little effect if it strikes robust building elements; finally, buildings made of robust, stout, solid materials engender a feeling of confidence and security in their occupants, especially in times of danger such as a bushfire threat.

Concrete, masonry or steel fulfills these criteria of non-combustibility and robustness. Concrete may be site-cast or precast; masonry may be concrete, clay or stone, all of which will survive a fire event. Concrete or masonry may discolour and mortar may need to be repointed after a fire. Steel should survive a fire without adding to fuel, but galvanising or paint coatings may be damaged.

- Anything around the building, such as pavements, steps, handrails, fences, seating, lighting, signage, meter boxes, bottled gas stores, should also be built of non-combustible, robust materials.

- The external shape of buildings should be simple. External niches or insets on plan where wind-borne debris may accumulate should be avoided. (Where insets are required they may be covered by fire screens.) Roof valleys, parapets and boxed gutters should also be avoided. A roof that will not trap wind-borne debris, a shape that allows debris blown onto it to be as easily blown off is desirable.

- Roofing material (sheet or tile) should be fixed as required by the BCA for wind speeds in the range of N1 to C4. The roof structure should be tied down through the walls to slab or footings to allow for winds from any direction. Also, a non-combustible roof space is good insurance against roof cavity ignition. This is achieved by using steel roof trusses and appropriate insulation.

- Windows and doors should have metal frames (steel for doors and robust-section, powder-coated aluminium for windows typically). Window seals should be appropriate for the exposure conditions. Glazing should be heat-reflective and be 5 mm toughened glass in all but small panes, if metal shutters are not used.

- Window and door protection is necessary against wind-borne debris, flying embers and flame exposure. This can be provided for doors with available metal-framed security screen doors with a metal...
grille on the outside of steel screen material. It is necessary that airflow and vision from inside, through the screen be maintained. Shutters of similar material (metal frame and screen cover) are needed for windows. For small windows (less than 1 m\(^2\)) the screening may be permanently fixed perforated security screens. For other windows or recesses, roll-up screens, shutters fixed to the building, as side or top hinged or in sliding tracks are appropriate. There should be obvious means of access into and out of a building via door screens when all fire screens/shutters are deployed.

- Landscaping immediately around buildings should incorporate only fire-retardant varieties of trees and shrubs. Where possible they should be planted as wind breaks or hedge barriers to trap wind-borne embers and debris. Non-combustible ground cover (eg decorative aggregates) adjacent to building should be used rather than mulch or bark.

INDIVIDUAL BUILDING ELEMENTS

Floors
It is advisable to keep buildings low, where possible following the contours of the ground. Where cut and fill is necessary, the cut should be maximised and the fill depth minimised. A slab floor, laid as a footing slab or slab-on-ground is efficient. A reinforced concrete slab, in contact with the ground avoids the possibility of floor ignitions and fire access underneath a building.

Suspended floors should also be reinforced concrete (insitu or precast), especially where sections of the raised floor project beyond support walls. Where sub-floor voids occur, the perimeter of the building should have a robust, non-combustible sub-floor wall (refer to TN 66\(^b\)). This will protect the structure and services.

The junction of building and ground is where debris can accumulate, making non-combustible material such as a concrete slab edge and/or masonry or concrete walling essential.

Floor finishes should be selected to provide optimum performance in fire threat. Coloured, polished concrete is increasingly used in commercial and residential buildings and provides an economic robust, non-combustible floor surface. Stone or fired clay floor tiles are equally serviceable finishes against embers or fire.

If installed, wall-to-wall carpet should have low flammability. Rugs can be of any material, as long as they are rolled up and stored when bushfires threaten.

Walls
Primarily, the external walls of any building should be of a non-combustible material. Brick is traditionally favoured, and when laid with flush mortar joints, performs well under fire exposure. However, it is necessary to structurally tie the roof structure to the slab or footing, and this is easier when hollow concrete masonry is used. Hollow concrete blocks with partial reinforcing and grout fill acts as a structural tie between roof and footing. Reinforced masonry, in the form of single-leaf block walling is an established, successful form of construction in cyclonic areas and is detailed in the Building Code of Australia (Part 3.3 Reinforced Masonry\(^4\)). It can be designed for wind conditions equal to or greater than those often experienced with major bushfires. For habitable spaces, these external single-leaf masonry walls need to be insulated.

Panel walls of reinforced concrete offer an alternative to masonry (T54\(^b\)). AS 3850\(^6\) defines concrete panel construction as ‘flat concrete panels frequently cast in a horizontal position… then lifted into position’. These wall panels may be cast either on-site as tilt-up panels, or offsite in a precast factory. Both types are readily available and often used for commercial buildings, but are practical and economically applicable for houses, garages or sheds in bushfire-prone areas. Further information on tilt-up and precast panels can be found elsewhere\(^7\,\,8\).
Insitu reinforced concrete cast in vertical formwork is another option for structurally suitable, non-combustible walling. For habitable spaces concrete panel or insitu walls need insulation, which can be provided in the middle of a sandwich panel, fixed outside and rendered over, or fixed inside and sheeted over. For optimum bushfire performance and economy, the latter is preferred.

**Doors and windows**

Buildings typically have access doors on two sides. These can be adequately bushfire-protected with security screen doors, which are readily available. They should have a metal frame and grille backed by expanded steel mesh with no more than 3-mm gaps and no more than 3-mm diameter punched stainless steel screen, or heavy woven wire screen with 1-mm wire and 2-mm square holes – not light insect wire or fabric.

In residential buildings, security screen doors are normally closed. For garages or sheds the same residential security screen doors should be installed. When fitted to community or commercial buildings, security screen doors are usually fixed open during operating hours, but when unoccupied or at times of bushfire threat they are closed. However, at times of fire threat, these doors should be closed, but not locked, so that egress is quick and access is possible by people seeking refuge (this provision has to be weighed against the threat of looting).

Windows should have heavy-section powder-coated aluminium frames with high temperature seals and heat-reflective glass. Heat-reflective double-glazing is available and is the optimum for bushfire conditions if cost allows. Where metal shutters are not used windows with the appropriate fire resistance (FRL or BAL) should be used. Buildings on bushfire-prone sites should use nothing less than a window with an FRL of -/-30/- and they should have tight fitting frames with no gap in the closed window over 3 mm wide.

---

**Door threshold section**

**Door jamb section**

**Head section**

**Sill section**
Bushfire shutters

Shutters on glazed openings of buildings in bushfire-prone areas fill a number of critical roles: they screen the glass from the radiant heat of the fire, they prevent embers or debris lodging on sills or in window setbacks, and they protect glass from being broken by flying wind-borne debris. At other times, they provide privacy, and they may be used to shade windows from summer sun, eliminating the need for eaves protection of windows on some elevations.

Bushfire shutters must be permanently fixed to a building and be manually opened and closed from inside or outside the building. This can be achieved with metal roll-up shutters, sliding screens in tracks on the outer wall, or hinged steel window shutters. They should be fitted so that when closed there is no more than a 2-mm gap around the perimeter of the shutter and the building wall, head or sill.

It is recommended that window bushfire shutters be fabricated from non-combustible material such as a steel frame supporting expanded metal mesh with a maximum of 2-mm gaps, or drilled stainless steel with 2-mm holes and not more than 20% voids. The latches of all shutters and the tracks of sliding types should also be non-combustible (eg steel). Steel framed and sheeted shutters are preferred to withstand the impact of flying debris such as tree branches or roof sheet material. These shutters may be dented or the paintwork damaged, but the glazed window behind will be protected. It is advisable to paint bushfire shutters and screens with engine enamel (either gloss or ‘crinkle’ finish).

Roofs

The roof structure needs to be designed for high positive and negative wind loads and be structurally connected, through the walling, to the footing. Typically, pitched, gabled or skillion roofs (preferably with a maximum pitch of 25°) are framed with timber and/or steel. As the roof structure need not be exposed externally, its fire protection relies on the roof covering, sarking, facia and eaves lining materials.

The available non-combustible coverings for such roofs are concrete or terracotta tile, fibre cement shingle or sheet, and galvanised/painted steel sheet. All these roof claddings can be specified and installed with fixings capable of withstanding high wind loads. Concrete tiles, with a deep profile, have higher impact resistance than flat profile or terracotta tiles. Steel sheet may be dented by impact, while the high-wind fixings will reduce, but not eliminate, the possibility of it being buckled by heat.

Since the battens are above the sarking they need to be non-combustible steel battens with self-tapping screws (eg tek-screw) for tile clips.

The optimum roof for bushfire-exposed buildings is a reinforced concrete slab. This can be formed with permanent steel or conventional formwork and placed insitu, or can be precast, with or without an insitu concrete topping. A roof slab requires a waterproofing membrane, which in turn needs fire protection. This can be provided by rigid insulation boards covered with precast paving slabs. This gives an excellent thermal performance at all times – while protecting the membrane and slab from high winds, embers and the heat and flame of bushfire exposure. Any parapet walls around such a roof should be as low as possible so as not to trap wind-borne debris.
Eaves, facias and gutters

Where roof framing is timber it needs to be protected from flame, usually with 6-mm-thick fibre cement sheet. The facias should be of non-combustible material, such as galvanised and painted steel facia sections with a groove to fit fibre cement eaves lining. Where the eaves lining meets the wall it should be detailed without beading, or if beading is required it should be a metal angle. Such attention to flameproof detail is vital because under the eaves is an area where embers may enter when a bushfire passes and it is critical to protect the roof structure.

There are two ways of dealing with rainwater falling on the roofs of buildings on bushfire-prone sites. The first is to connect conventional galvanised and painted steel gutters to the steel facia, then fit a very fine metal mesh to the gutters (leaf guard). This will prevent gutters becoming a trap for debris. The second is to allow rain water to fall from the roof edge into ground gutters (refer to TN 66).

Attached structures — carports, patios and verandas

Typically, structures attached to a building are of simple post-and-frame construction. For bushfire protection, such structures need to be non-combustible and robust. The pavement or floor of such structures should be a concrete slab, or segmental paving. The posts supporting the roof need to be non-combustible, robust and able to tie the roof structure down to withstand high uplift loads. Steel, masonry with a tie-down rod, precast concrete or in situ reinforced concrete posts are all viable options.

The roof of ancillary structures may be unlined if the roof frame is steel. If timber framing is used it must be flame protected in the same way as eaves, with metal facias, 6-mm-thick fibre cement sheet lining and connections to the building detailed with metal angle beads.

Concrete panel walls with alternative eaves — masonry walls would have similar bushfire-resistant detailing
Fences and retaining walls
Fences that go to ground level form windbreaks and ember traps. Such fences need to be designed to resist high winds, be robust enough to withstand the impact of flying debris and be non-combustible. Precast concrete, reinforced concrete block, or ‘brick-beam’ fences are viable options that meet this specification.

Retaining walls should also be non-combustible and these can be economically built with one of a number of dry-laid, textured, coloured concrete block systems, or conventional masonry. The use of hardwood or treated pine sleepers, which are potentially flammable, should be avoided. They may produce toxic smoke once ignited.

RECOMMENDATIONS FOR SPECIFIC BUILDING TYPES
General
The recommendations made herein can be applied to any building type. It was shown in the Black Saturday bushfires that the risk is not limited to houses and similar-size buildings, but extended to all buildings, from small sheds to large commercial or community buildings. These large buildings can be designed as bushfire resistant structures. Indeed it has been shown to be vital for a community’s recovery after a bushfire that not just its dwellings survive, but that identifiable and important landmarks of the community also survive. It should be recognised that such community buildings have a greater survival imperative because they may be used as evacuation centres or community refuges in times of bushfire and other emergencies.

Most of the building materials and methods detailed above are applicable. The exception is large non-opening windows, which may require fire shutters to be moved into position from some storage area and installed from outside the building.

Houses
TN 663 Houses for Bushfire-prone Sites deals with both new house design and construction and retrofitting of existing houses.

What is not always recognised by designers and builders is that non-combustible building materials are economically and widely available.

A precast reinforced concrete panel house with slab floor and a framed roof and internal walls, for example, can be built economically and in less time than a clad timber framed, or a brick veneer house. The additional cost of extra roof fixing, bushfire shutters and security screens apply equally.

In addition to the choice of material for the external walls themselves, careful consideration should be given to anything that is to be fixed on, or located close to, the exterior face. Items such as water heaters, gas cylinders, waste/recycling bins and air conditioning condensers are best located in recesses fitted with vented, steel screen doors/gates.
Community and commercial buildings
Community and commercial buildings are often not considered at risk from bushfires, but Black Saturday showed that every building in a bushfire-prone location needs to be bushfire resistant. Indeed, community buildings often become a base for emergency services and a focus of possible protection for last-minute evacuations. As well, community buildings can usefully act as a model for members of the community to follow in their own building fire-resistance measures.

All the recommendations in this document apply to such buildings – simple shapes that don’t trap debris, design for high winds, provide door screens and window shutters and use non-combustible, robust exterior materials.

Large, fixed display windows common in commercial buildings will need bushfire shutters that typically cannot be deployed from inside the building. These may be top hinged so that they swing up under awnings. Roller shutters, or shutters stored elsewhere in the building are to be manually deployed when bushfire risk is identified. Areas such as loading docks can be designed as for garages, with roller shutter doors.

Commercial buildings with cooking facilities may have external storage compartments for several large gas cylinders. Doors to these compartments should either be in a south-facing wall or be shaded from direct sunlight. A separate robust structure (eg with reinforced masonry walls, slab floor and roof, and stout, close-fitting, steel vented doors) is preferable. If incorporated into the building, the storage facility should be in the form of a recess, not a projection.

Farm and backyard sheds
While sheds are regarded as less important buildings they may contain expensive equipment or be used as a fire shelter for domestic pets or farm animals. A slab floor, masonry or precast panel walls and a tied-down metal deck or slab roof are appropriate. Then all that is needed is a security screen door and window fire shutters. Typically, such buildings are not adequately sealed against things like wind-borne embers. It is vital that windows and doors are as tightly fitted as those in a house and that the junction of walls and roof is sealed, or vented with appropriate fire-screen material.

Garages
Attached to another building, or freestanding a garage should be like a shed in construction. Its walls do not need to be insulated and may be single-leaf clay or concrete masonry. Roof tie down can be achieved with exposed...
Plumbing and taps associated with the dedicated water storage should be metal, with appropriate large-diameter ball valve or ‘Storz Fittings’ for hose connection. The recommended dedicated water storage capacities (in addition to local authorities’ requirements) are as follows:

<table>
<thead>
<tr>
<th>Building/situation</th>
<th>Dedicated water storage (litres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>House block under 1000 m²</td>
<td>5,000</td>
</tr>
<tr>
<td>Rural house Block up to 1 ha</td>
<td>10,000</td>
</tr>
<tr>
<td>Rural house Block over 1 ha</td>
<td>20,000</td>
</tr>
<tr>
<td>Dual occupancy</td>
<td>2,500/unit</td>
</tr>
<tr>
<td>Townhouses</td>
<td></td>
</tr>
<tr>
<td>apartments</td>
<td>5,000/unit</td>
</tr>
<tr>
<td>Public or commercial buildings</td>
<td>20,000</td>
</tr>
</tbody>
</table>

**Bushfire shelters**

Purpose-built bushfire shelters for people during the passing of a fire are a secondary solution. Such buildings or spaces serve little other purpose and are required only if the house (or other building) is not fire resistant.

**PREPARING FOR BUSHFIRE ATTACK**

**Preparation before the bushfire season**

Each spring, routine maintenance and clearing around buildings in bushfire-prone areas should be undertaken. Advice issued by local fire authorities should be followed. Gutters and leaf guards should be checked; leaf litter should be cleared from around a building, from under shrubs, trees, from gardens and greenbelt barriers. All screens and shutters should be checked to ensure they are intact and can be swung, slid, or readily moved into position and secured.

A Bushfire Threat Checklist relevant to the building should be prepared and copies placed in prominent places so that occupants will be aware of the necessary actions in times of threat.

**Preparation when a bushfire threatens**

When a building has been designed and built to withstand the passing of a bushfire, both it and its occupants need to be organised so that the building will perform to its potential.

- **Bushfire-resistant buildings** need to be clearly identified with signage so that members of the community, fire fighters and other authorities know it is relatively safe without their intervention and offers an emergency refuge if needed.

- When a bushfire warning is raised, authorities should be informed who will be staying in the building to ready it and attend to possible spot fires before and after the arrival of the fire front. Those who stay with a building should follow the orders of police and fire fighters.

- Those who remain to carry out these tasks should be fit. They should wear suitable clothing, eg non-combustible boots, gloves, hats, overalls, shirts and trousers that cover the body, arms and legs. They should have wet towels available.

- Window fire shutters and door screens should be secured. Doors and windows should be closed. While security screen doors are closed they should not be locked – to allow quick and easy access and egress into and out of the building as the situation dictates.

- Easily-flammable items such as curtains, bedspreads and floor rugs should be removed and stored in a cupboard.

- Masonry and concrete walls and pavements should NOT be wetted before or immediately after a bushfire attack. In fire conditions bricks, blocks and concrete perform better when dry.

- If time permits and water is available, combustible material such as grass, and the fire-retardant shrubs, hedges and foliage in greenbelt barriers around buildings should be well wetted.
Brickwork or masonry will generally survive the passing of a fire; smoke stains will need to be cleaned.

- Baths, laundry tubs and buckets should be filled with water for use in wetting towels and hessian bags for spot fire fighting. Metal buckets, possibly kept outside, filled with sand should be used to smother spot fires after a bushfire has passed. (Bucket handles and any outdoor object will be hot, this is where gloves are necessary.)
- Advice from authorities when bushfires threaten is often to tightly close all windows and seal doors. This limits the ingress of hot air, smoke, sparks, or burning embers from minor bushfires or before a major bushfire front arrives.
- Chock open all the internal doors of a building so the whole interior volume can be readily pressure-equalised through the screened/shuttered open windows and/or doors.
- If it is necessary to have any screened doors open to provide ready pressure equalisation, ensure these doors are chocked or propped open from the outer side to prevent them being blown shut by the first out-rush of air.
- As soon as is physically possible after the fire front has passed move to extinguish any spot fires around the outside.

**POST-BUSHFIRE MAINTENANCE**

After a bushfire has passed, damaged or stained materials will need to be replaced or made good.

- Steel roofing, gutters, facias, claddings and window shutters may have painted/galvanised coatings damaged. They should be straightened where necessary, and any damaged galvanising repainted.
- Mortar joints in masonry walls may be heat affected. This is shown by the mortar changing to a pinkish colour and becoming easy to scratch out. This can be scraped out and repointed with flush mortar joints, after the walls are cleaned of soot and smoke deposits.
- Masonry and concrete stained by fire or smoke can be cleaned with a mix of sugar soap and hot water applied by brush, followed by scrubbing with a scouring cleanser. Bicarbonate of soda or household bleach is effective for removing smoke stains. If stains are concentrated, a bleach poultice is effective. Finally, the surface should be washed down with fresh water. If these methods are unsuccessful, painting may be necessary to achieve an acceptable appearance.
- Single-leaf masonry walls typically are finished externally with acrylic paint or clear waterproofing film to prevent moisture penetration. After fire exposure such surface treatments usually have to be reapplied, indeed all exterior painting may have to be redone.
- Joint sealants should be checked and if heat affected should be replaced.

- Burnt or scorched foliage should be pruned. Any non-combustible varieties that are dead should be replaced immediately to allow regeneration of the greenbelt barrier.

**CONCLUSION**

The appropriate building design, construction and materials, along with the recommended pre-attack procedures, can produce buildings that will survive even major bushfires. In particular, the use of concrete and masonry, which are non-combustible and robust, possess inherent qualities vital for buildings in bushfire-prone areas. If buildings in bushfire-prone areas are robust, fire-resistant structures, and their occupants carry out the appropriate preparation, the risk to human and animal lives and the cost of post-bushfire reconstruction would be significantly reduced.

**REFERENCES**

APPENDIX A

Greenbelt barriers
Where possible, flammable trees and shrubs should be removed from within 100 m of buildings and replaced with fire-retardant varieties. Advice of local authorities should be sought on appropriate vegetation species for local conditions.

The formation of ‘greenbelt barriers’ between flammable native vegetation and any building, or group of buildings, is recommended. Greenbelt barriers should be 50 m wide and, where possible, incorporate a track for maintenance and fire-fighting vehicles.

Replacing flammable, volatile species with fire retardant trees and shrubs creates a greenbelt barrier. The barrier will act as a windbreak and will catch some wind-borne debris and embers. While fire-retardant trees may, in the worst case, ignite, they burn less violently than many native species. Such trees and shrubs naturally slow down, and reduce the impact of, a bushfire front and do not add volatile fuel to a fire even if they burn.

Fire-retardant planting around a building, or in corridors between buildings and natural bush, is a more effective bushfire barrier than cleared land. It also makes for a more pleasant living environment.

Species to be removed
Eucalyptus (rough or shredded ribbon-like bark)
All conifers (eg Cypress, Pine, Cedar, Spruce, Fir)
Juniper
Tea-Tree
Wattle
Grevillea
Callistemon
Paperbark

Fire-retardant species
Kurrajong
Lilli-Pilli
Flame Tree
Silky Oak
Native Frangipani

Macadamia
Water Gum
Blackwood
Saltbush
Native Rhododendron
Pigface
Moreton Bay and Port Jackson Fig
Ferns and Cactus

(See Department of Planning and Country Fire Authority, Victoria – Design and Siting Guidelines: Bushfire protection for rural houses for additional information on heights of trees and shrubs as well as typical water demand.)

ACKNOWLEDGEMENT

CCAA acknowledges the contribution made by Mr Max Granger in the preparation of this document.

The review of the technical content by Mr Justin Leonard of CSIRO is gratefully acknowledged.

CCAA OFFICES

SYDNEY: (61 2) 9437 9711
BRISBANE: (61 7) 3227 5200
MELBOURNE: (61 3) 9825 0200
PERTH: (61 8) 9389 4452
ADELAIDE: (61 8) 8274 3758
TASMANIA: (61 3) 6491 1509

WEBSITE: www.ccaa.com.au
EMAIL: info@ccaa.com.au

Disclaimer: Cement Concrete & Aggregates Australia is a not for profit organisation sponsored by the cement, concrete and aggregate industries in Australia to provide information on the many uses of cement, concrete and aggregates. This publication is produced by CCAA for that purpose. Since the information provided is intended for general guidance only and in no way replaces the services of professional consultants on particular projects, no legal liability can be accepted by CCAA for its use.

CCAA respects your privacy. Your details have been collected to provide you with information on our activities, publications and services. From time to time your details may be made available to third party organisations who comply with the Privacy Act such as affiliated associations, sponsors of events and other reputable organisations whose services we think you may find of interest. If you do not wish to receive information from CCAA or wish to be taken off the database please write to the Privacy Officer, CCAA, Locked Bag 2010, St Leonards, NSW, 1590

ISSN 1837-5782