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Site planning and design for bushfire

Light House Architecture and Science in collaboration with Ember Bushfire Consulting

Cover image. This house designed by Thomas Caddaye Architects to Bushfire Attack Level—Flame Zone (BAL—FZ) requirements survived the 2020 Rosedale fires in NSW (Image: Ross Caddaye).

Abstract

The climate is changing. In the past decade Australia has experienced increased levels of bushfire frequency, unpredictability and severity in Australia. Disasters such as Black Saturday in 2009 catalysed advances in legislation, guidelines and public awareness for building and living in bushfire-prone areas. The Black Summer of 2019/2020 tested many of these advances and will no doubt spur further changes.

This Note provides guidance, case studies and methodologies in relation to bushfire attack for siting and landscaping, planning and design, and the issues of active defence and emergency shelter. It has a particular focus on residential structures.

This Note significantly updates DES 55 Planning and design for bushfire protection by Nigel Bell. It should be read in conjunction with Development in Australian bushfire prone areas.

1.0 Introduction

The increasing density and sprawl of the built environment, coupled with the onset of longer-lasting and more intense fire seasons, makes the issue of better preparation for and mitigation against the threat of bushfire in Australia complex and urgent (RFS 2019).

Historically, when large-scale and intense bushfire events have impacted communities – resulting in the loss of life and destruction of property – a cycle of analysis, review, recommendation and implementation has occurred at both government and social levels. There have been at least 18 major bushfire inquiries in Australia since 1939, including state and federal parliamentary committee inquiries, COAG reports, coronial inquiries and Royal Commissions (Commonwealth of Australia 2009). This does not include the recent Royal Commission into the Black Summer Bushfires of 2019/2020.

Fields that have evolved significantly as a result of past bushfire events include strategic land-use planning, building design, building standards, and construction materials and techniques.

Effective bushfire protection requires a combination of measures working in unison. At the core of bushfire protection is a strong planning system that aims to moderate, rather than eliminate, the threat of bushfire, with tools to assess the threat level and a range of measures available to deploy to reduce the threat level. The recently released NSW *Planning for Bushfire Protection* (RFS 2019) is an excellent example of bushfire protection standards and planning policy that aims for a balance between environmental considerations, community safety and housing affordability.

Under the National Construction Code (NCC), a residential structure in a bushfire-prone area is viewed as a shelter or refuge for its occupants. Therefore, it needs to be designed and built for this purpose (ABCB 2019). If the appropriate planning processes have been followed at the development stage, the extra design and construction requirements of the building are likely to be relatively low and commensurate to the risk.

Where the planning system has not considered bushfire protection at the development stage, the residual risk may be extreme. The result is that far greater reliance is placed on the building to offer a place of refuge and, therefore, necessary constraints and extra requirements are placed on the design and construction of the structure.

Since 1991, the *Australian Standard 3959 Construction of Buildings in Bushfire-Prone Areas* (Standards Australia 2018a) has provided a manual for the assessment of bushfire threat. This has been defined as the Bushfire Attack Level (BAL) rating since 2009. AS 3959:2018 outlines the design and construction requirements associated with each BAL.

One of the greatest responsibilities granted to a designer is the safety and wellbeing of the project's occupants. This Note aims to provide a better understanding of bushfire and the intent and consideration of the structures placed in bushfire-prone environments. It is intended to provide broad knowledge and understanding of bushfire protection and planning concepts. Further reading and investigation is recommended for a more comprehensive appreciation of this topic.

While the information provided here is largely relevant to all jurisdictions and environmental settings, it is guided by NSW bushfire planning policy. It may not apply to all scenarios. For example, in NSW buildings subject to BAL—FZ (the highest level of bushfire construction) must comply with specific conditions of development consent for construction at this level (ABCB 2019). The reader is encouraged to review the applicable bushfire planning policy within their own jurisdiction from their local emergency services authority or planning department.

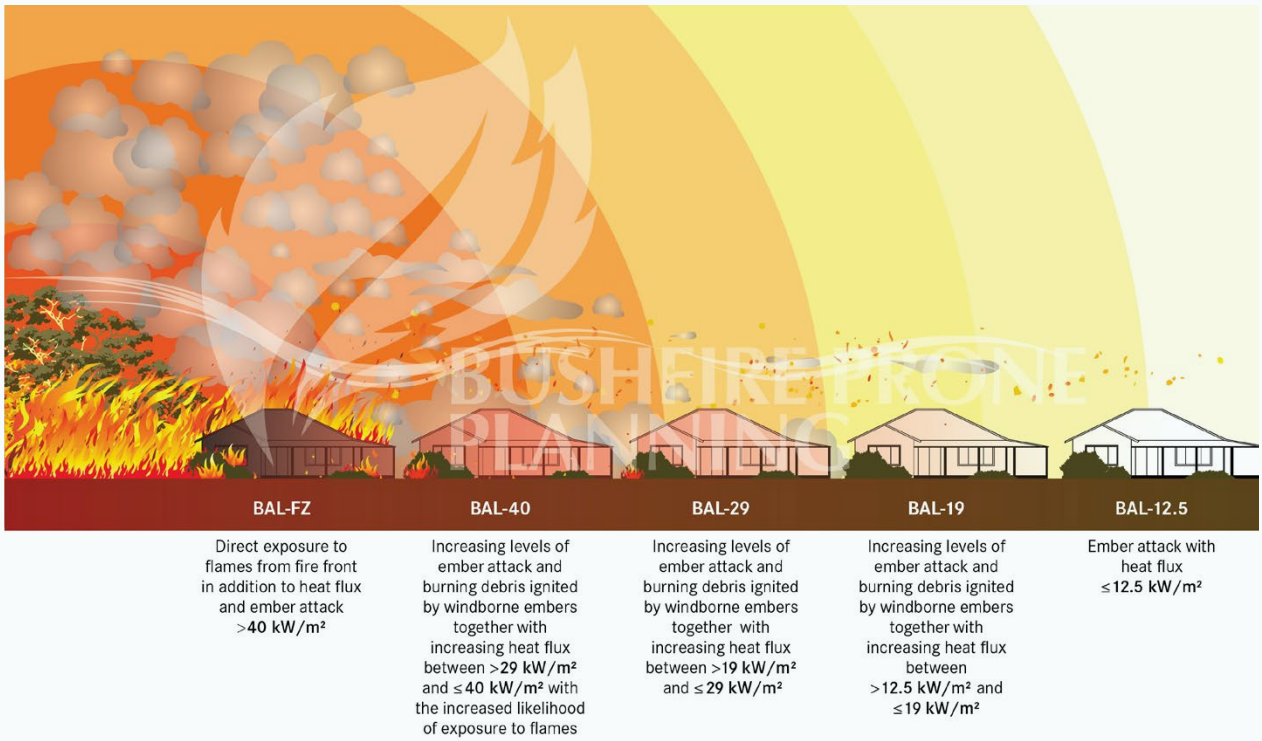


Figure 1. BAL Comparison (Source: Bushfire Prone Planning 2021)

1.1 Assumed knowledge

Refer to the companion document: Development in Australian bushfire prone areas (Bell 2019) for an outline of:

- the Forest Fire Danger Index (FFDI or FDI)
- Bushfire Attack Level (BAL) (Figure 1) and;
- the five mechanisms of bushfire attack:
  - ember attack
  - radiant heat
  - flame contact
  - convective heat
  - and strong winds.

2.0 Site planning for buildings in bushfire-prone areas

2.1 Location

Some locations are inherently vulnerable to bushfire. Building in locations that are remote, with a single access approach, surrounded by bush and with little support infrastructure or potential for a firebreak should be considered unsuitable for habitable construction or reconstruction (Western Australia Planning Commission 2017; RFS 2019; CFA 2014).

Bushfire-prone land is land that has been identified as being able to support a bushfire or likely to be subject to bushfire attack (Standards Australia 2018a). In all state jurisdictions and the ACT, regulatory processes are in place to designate bushfire-prone land. These designations trigger extra building and planning controls on building in these areas. While AS 3959 Construction of Buildings in Bushfire Prone Areas is universally referenced in the NCC, each state and territory has their own variations and unique requirements. For further background, refer to Development in Australian bushfire prone areas (Bell 2019).

It's worth noting 10% of homes destroyed by fire in NSW during the Black Summer were not in mapped bushfire-prone land (Rogers 2020).

When planning to build on bushfire-prone land, providing an opportunity for active defence and refuge if the client so desires, it is imperative that early engagement is undertaken with bushfire, environmental and landscape consultants, as well as the local government planning authority and relevant emergency services. It's important to establish an understanding of the restraints and opportunities that a bushfire-prone development brings and the extent of bushfire protection measures that need to be implemented.

Primary considerations include understanding the environmental constraints, site access, how best to site the building, low risk landscaping solutions, ease of maintenance, local emergency management arrangements, active defence solutions, and on-site refuge options.

2.2 Environment

When planning to build on previously undeveloped land, particularly on rural blocks, it is important that an environmental impact study and bushfire assessment be undertaken for the construction site. The environmental impact study will identify threatened ecological communities, environmental offset schemes, and any other state and local government restrictions. These might impact the ability to clear the land to achieve an appropriate asset protection zone (as identified in the bushfire assessment).

There are strong legislative requirements across all Australian governments that limit removal of trees and vegetation (Lensink 2012). However, most jurisdictions allow clearing of vegetation on bushfire-prone land to some extent, to maintain a defendable space around a building.

2.3 Siting

Where a building is sited is very important to its performance during a bushfire attack. Vegetation, landscape features, ignition sources, slope, aspect and access must all be considered. Again, engaging with a specialist bushfire consultant in the early stages of site planning will assist in choosing the most appropriate location.

When planning for a building on a lot in a residential subdivision, three main considerations are:

- The subdivision's location in relation to the surrounding environment
- The lot's location within the subdivision
- The building's position within the lot.

Vegetation (fuel) is necessary for bushfire growth and development. It is a determinant of fire intensity. While closed heath land or open shrubs may burn with an intensity of 11 to 14 kW/m², woodland might be 18 to 30 kW/m² and a well-developed forest fire from 48 to 77 kW/m² (Standards Australia 2018a).

Choosing a site location where the vegetation hazard is minimised is desirable, for example where:

- The vegetation density is low or not continuous
- The vegetation species/type does not burn readily
- There is effective distance between the vegetation and the building.

Where buildings are located near fire-prone vegetation, more attention to landscaping and building matters will be required. The potential for fuel reduction as a key part of bushfire management depends on:

- The size of the subdivision and/or lot
- Ownership and/or management of adjacent lots and countryside
- The site's location within the subdivision – on the exposed fire edge or more sheltered side
- Required building setbacks that enable fuel management /reduction on the site.

Landscape features that may increase or reduce the fuel load must be considered. The aim should be to keep a fuel-reduced area between the source of bushfire hazard and buildings. Useful measures from a fire perspective include lakes, dams, swimming pools, lawns, lush gardens and sporting facilities (eg ovals, tennis courts). Strategic planting of appropriate plant species can minimise embers, reduce radiant heat and mitigate wind effects.

Ignition sources that are downwind and/or downslope must be planned for, be they recreational or industrial areas. Depending on the landscape, sources should be taken into account well beyond the immediate vicinity. Ignition sources arise anywhere that careless practices could occur (eg barbeques, cigarettes).

Slope considerations are crucial. The rate of a bushfire's spread can double on upslopes of 10 degrees and double again at 20 degrees (Webster 2012).

The location of buildings on level or gentle slopes is preferable to steeper slopes or the tops of ridges – no matter what the view.

Conversely, burning embers can spread fire downslope over considerable distances.

Aspect is another key factor, as prevailing winds, sun radiation and topography can all intensify bushfires.

2.4 Site access

It is vital emergency services can access a building easily and residents can evacuate in a bushfire situation. Ease of access and egress options ensure the efficient use of resources and safe evacuation routes.

A property access road to a new building site on a rural property needs to be carefully planned. Considerations include providing all-weather water crossings, clearance of overhead vegetation and structures, providing a secondary access/egress road, and appropriately sized, graded and maintained surfaces to ensure safe and unobstructed access.

Planning requirements may require onsite water supplies for fire fighting. It is essential to provide access to these supplies.

2.5 Asset Protection Zone (APZ)

An APZ is a fuel-reduced area surrounding a built asset or structure (RFS 2019) (Figure 2). This can include any residential building or major building such as farm and machinery sheds, or industrial, commercial or heritage buildings.

An APZ provides:

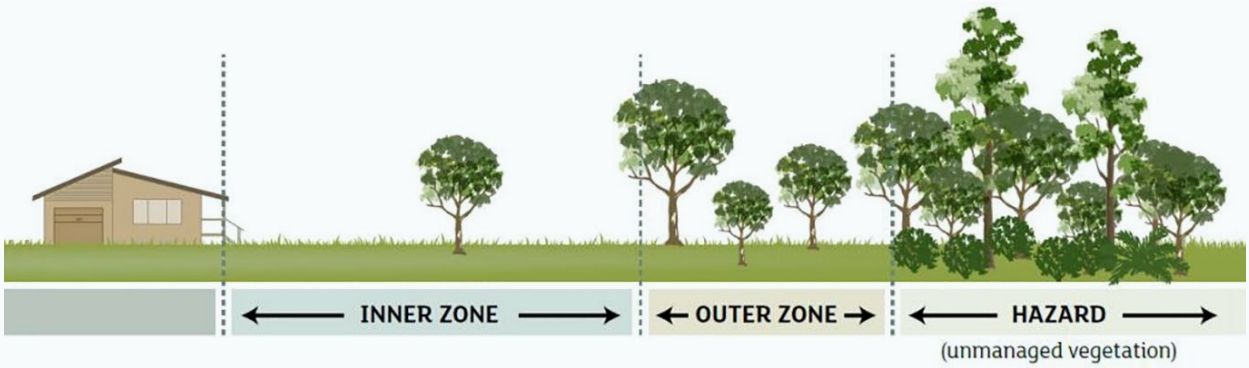
- A buffer zone between a bushfire hazard and an asset
- An area of reduced bushfire fuel that allows suppression of fire
- An area from where backburning may be conducted, and
- An area that allows emergency services access and provides a relatively safe area for fire fighters and homeowners to defend their property.

Potential bushfire fuels should be minimised within an APZ. This is so that the vegetation within the planned zone does not provide a path for the fire to transfer to the asset, either from the ground level or through the tree canopy.

What will the APZ do?

An APZ, if designed correctly and maintained regularly, will reduce the risk of:

- Direct flame contact on the asset
- Damage to the built asset from intense radiant heat, and
- Ember attack on the asset.



Cross section of inner and outer zones

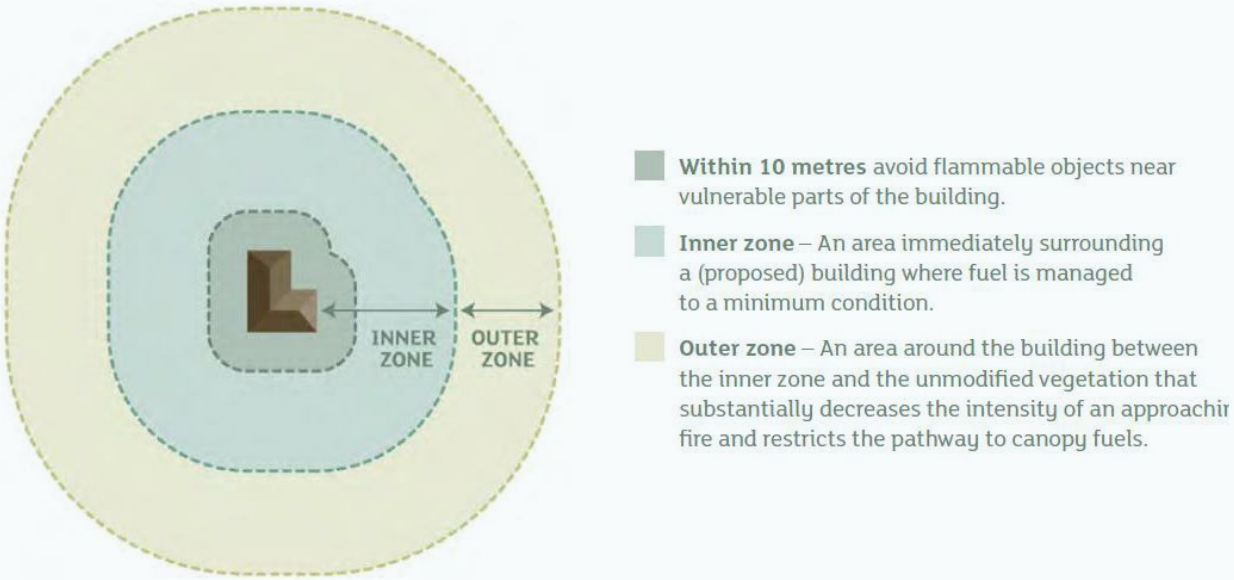


Figure 2. Components of the Asset Protection Zone (Source: CFA 2014)

Components and specifications of an APZ:

Defendable space – the area immediately surrounding the building providing a workable space where a person can protect their property against the passage of a bushfire.

- Vegetation to be heavily managed to a distance of 10 metres around the building (CFA 2014)
- No flammable shrubs to be located under doors or windows
- Grass to be kept short (100 mm) and if possible green.

Inner protection area (IPA) – an area where vegetation is managed to reduce heat intensities at the building surface (Figure 2):

- Tree canopy covers less than 15%, with a minimum separation of 2 metres between canopies (RFS 2019)
- Tree canopy greater than 2 metres from any roof line (RFS 2019)
- Lower tree limbs removed up to a height of 2 metres above the ground (RFS 2019)
- Flammable shrubs not to be located under trees, and
- Grass to be kept to maximum 100 mm in length (CFA 2014, RFS 2019).

Outer protection area (OPA) – An area where vegetation is managed to reduce fire-flame length, rate of spread, filter embers and to suppress the crown fire (Figure 2).

- Tree canopy cover is less than 30% and the understory is managed with all shrubs and grasses treated on an annual basis prior to the start of the bushfire season (RFS 2019).

2.6 Landscaping

Landscaping associated with construction in bushfire-prone areas requires consideration at the scale of the region, subdivision and the individual lot.

Vegetation management (managed land) concerns existing and new vegetation. For existing vegetation with appropriate authority approval only, the following measures should be considered:

- Reduction of fine fuels by mechanical means or controlled burning
- Thinning of trees to avoid continuous tree canopies (selecting trees of high flammability and/or loose bark for removal)
- Removal of lower limbs from trees to better separate ground fuel from the canopy
- Removal of tree limbs that overhang buildings
- Removal of trees and vegetation adjacent to buildings
- Removal of dead trees and vegetation.

Management of new vegetation includes appropriate selection and placement of species that may reduce the effects of any bushfire. Landscape planning should consider:

- Deciduous trees
- Densely foliated evergreen trees of low ignitability, planted in discrete clumps
- Smooth-barked trees rather than rough or ribbon-barked trees
- Areas of lawn or native grasses
- The effects of garden pine-bark or mulch in carrying a fire to the building.

Windbreaks can protect buildings from bushfires when well designed and maintained. Typically, buildings should be located a distance away from the windbreak that is one to three times the full-grown height of the trees (RFS 2019), to the leeward side. Windbreaks can protect buildings through:

- Reducing wind speed and providing a protected area on the leeward side
- Filtering out flying sparks and debris if there is good leaf-moisture content
- Slowing the spread of fire by slowing the wind speed.

Shielding from radiant heat needs to occur close to a building to be effective. It can be of any non-combustible material – earth, masonry, steel fencing – or even windbreak vegetation in some instances (as long as it doesn't ignite).

Water supplies are essential for three main protective purposes:

- Connection to hand-held hoses to wet down combustible materials and extinguish any spot fires
- Connection to bushfire sprinkler systems
- As water for fire-fighting appliances. When planning water requirements for fire-fighting purposes there are a series of important considerations:
  - A water supply independent from the mains (which can lose pressure or be non-existent during fire emergency)
  - The water supply should last a minimum of two hours at full operation (10,000 litres fills three water tankers, 22,000 litres will service an average sprinkler service for two to three hours) (Bell 2003)
  - The water supply needs enough water pressure ('head'), or a pump will be required
  - Diesel pumps are preferable as electricity often fails and petrol may vaporise in the line
  - All water supply components need to be protected from radiant heat, so metal pipework should be used above ground
  - A suitable connection valve compatible with the local fire authority should be installed
  - Hose points need to be located so all points of the building can be reached.

External water spray systems (both landscaping and structural) are considered a useful further protection in many jurisdictions. However, these are not a complete fail-safe alternative and should be considered one component of an holistic fire management plan. They need appropriate hydraulic design, ground and/or roof installation with appropriate nozzles, and manual activation. *Australian Standard 5414 Bushfire Water Spray Systems* (Standards Australia 2012) sets out general requirements for the design, installation and maintenance of water spray systems intended to provide a degree of building protection against bushfire exposure, including ember attack, together with limited protection against radiant heat exposure (up to BAL—19).

Case study 1: Rosedale house

Architect: Thomas Caddaye Architects. Builder: TLC Constructions.

- Built to a combination of BAL—40 and BAL—FZ requirements, this house survived an intense swirling bushfire threat at Rosedale, NSW, in 2020 while neighbouring buildings were destroyed (Figures 4 and 5).
- Key defensive features include a simple building form, non-combustible fibre-cement cladding, non-combustible subfloor, and BAL—40 rated windows with BAL—40 rated shutters.
- The home sustained superficial damage to some cladding (mainly in the expressed joints), which will be replaced. Window shutters and PVC plumbing were damaged and will be replaced. Only one rubber window seal needs replacing.
- Structurally and internally the house is completely intact. No flames, embers or even smoke entered the structure.
- The cost increase to meet the BAL—40/ BAL—FZ requirements was estimated to be 20% to 25% of the build cost.

Figure 3. A simple form and non-combustible materials are two of the key defensive features of this house (Image: Ross Caddaye).

Figures 4 and 5. Surrounding buildings perished in the intense swirling bushfire threat while this house survived (Images: Thomas Caddaye).

3.0 Designing for bushfire-prone areas

3.1 Design planning

There are five modes of bushfire attack: ember attack, radiant heat, flame contact, convective heat and winds (Bell 2019).

The principles of resisting these five modes are conceptually simple but can be hard to implement. They do not guarantee building survival.

Building shape influences the accumulation of burning debris, the exposure to radiant heat and wind attack on roofs especially (Webster 2012).

Generally, it is suggested that house plans be kept simple with minimal internal corners or deep porches that may catch and accumulate burning debris. Similarly, if there are garages or outbuildings, they should be part of the simple house form under the same roof line or be separated (eg 6 metres plus) (Standards Australia 2018a) to avoid wind-eddy effects.

3.2 Form

Simple elevations are also suggested, without changes of roof pitch at verandas, garages and carports. Projections such as dormer windows, gables, chimneys, roof lights and the like should be minimised or preferably excluded. Webster (2012) suggests that a strong, continuous, 15-degree roof is suitable for ceiling cavity access, fire-wind passage over the house, limiting fire-feeding air space, and allowing for ground observation of roof and works for several roofing types.

'A house that will resist ember attack does not need to be complicated. A single storey with no ceiling space, strong roof, slab floor and protected windows will generally be defendable' (Webster 2012).

3.3 Structure and materials

Design of structure and the choice of materials can influence flammability and vulnerability to radiant heat. These affect the building's protective capability and can threaten the structural integrity.

Roofing

Roofs, roof lights and penetrations need to be designed to minimise the accumulation of flammable debris and ember entry. Potential problem areas are under eaves, at ridges and gables, and any gaps in the joints, ends and overlaps of the roofing material.

Steel corrugated roofs generally provide the best protection, with flat pan profiles favoured for shedding debris. Tight-fitting slate or fibre-cement tiles with extra tie-downs can also provide good protection.

Avoid terracotta, concrete or metal tiles as they are prone to gaps and lifting in wind. Do not use timber shingles.

Roof penetrations such as roof lights and ventilators must be sealed with a non-combustible material and include appropriate ember guard protection at the point of ventilation. Where eaves are present, avoid exposed rafters. It is preferable to box the eave in at 90 degrees to the house. AS 3959 specifies detailed provision for sarking and ember proofing of gaps and ventilation points for each BAL rating.

Gutters present considerable risk for collecting debris and embers. If in place, gutters should be non-combustible and easy to clean. Gutter coverings exist that meet both leaf guard and ember guard functions.

Pergolas should be uncovered. Fibreglass or vine coverings can be made safer with a metal flywire cover.

Floor structure

Floors and underfloors, especially when elevated, can be subject to bushfire attack. This can be from the materials themselves (typically timber) or materials stored underfloor. That is why AS 3959 has adopted for regulatory purposes an underfloor space height of 400 mm as the point below which it should be enclosed with non-combustible material. Above 400 mm it is considered there is sufficient vision and access to deal with any spot fire.

Roof and wall structure

Timber and metal framing are both acceptable in all BAL rated areas as per AS 3959. Neither is perfect. Timber framing can ignite from fire entering a cavity space. Metal frames can warp when exposed to intense heat. The primary protective feature of walls and roofs is the shape, cladding and detailing, more than the structural material. Installing fibreglass or mineral wool batts into cavity spaces can hinder ignition and the spread of fire in cavity spaces.

Decks, railing and exposed structure

Bushfire-resisting timbers may be used up to BAL—29, while non-combustible decking is required for higher risk areas (Standards Australia 2018a). Raised decks should be enclosed to the sides, and all gaps should be minimised or covered with a fine mesh. Tiled, paved and concrete outdoor areas provide the best protection.

It is essential to prevent any supporting posts or columns from igniting and spreading the fire into the building (Figure 6), which could then collapse. Depending upon the heat intensity, combustible materials (timber) may ignite, and steel deform (from adjacent combustibles, not the bushfire). Hence additional fire protection may be required, or non-combustible materials such as brick or concrete used. Vegetation and mulching should not be planted around combustible posts.

Figure 6. Structural timber elements can quickly become a fire conduit into the main home (Image: Nadia Edwards by permission of Author).

Cladding

External walls should be designed to prevent ignition from ember attack. They should not be susceptible to ignition or distortion from heat or flame, nor should wind-borne objects be able to fracture the cladding and allow burning debris to enter.

Non-combustible materials such as masonry, concrete or earth wall construction will obviously resist fire. Framed and clad walls with steel or aluminium sheeting won't burn but may distort and/or transmit the heat inside. This can cause ignition elsewhere, but these materials are permitted in all categories. Fibre-cement sheeting needs to be thicker and preferably autoclaved (eg 9 mm plus), with smooth jointing system. Timber cladding is more vulnerable if it is rough-sawn or has crevices where burning embers can collect. The fire characteristics of most timbers are well established (NTDC 2000; Dunn 2002) with more recent research investigating species that meet the definitions within AS 3959 (Warrington 2001).

AS 3959:2018 specifies that for BAL—12.5 and up:

'All joints in the external surface material of walls shall be covered, sealed, overlapped, backed or butt-jointed' (Standards Australia 2018a).

Windows

Windows tested using AS 1530.8.1 are rated for use to a certain BAL rating, otherwise AS 3959 allows for deemed-to-satisfy provisions. At BAL—29, acceptable frame materials are metal, bushfire resistant timber, and metal reinforced uPVC (Standards Australia 2018a). At BAL—40 only metal frames meet the deemed-to-satisfy provisions, however certain brands of timber and uPVC windows have been tested to achieve BAL—40 ratings under AS 1530.8.1.

Timber windows can ignite but this risk can be greatly reduced by careful species selection, and by smooth, sloped, painted surfaces. Metal windows won't ignite but can warp under intense heat conditions. uPVC is a fire-resistant material and can also warp.

Permanent roll-down shutters or attachable emergency shutters provide protection from wind debris, radiant heat and ember entry. Standard windows may be used at any BAL rating if they are protected by shutters that meet AS 1530.8.1 (or AS 1530.8.2 for BAL—FZ) standards (Standards Australia 2018b, Standards Australia 2018c).

Metal screening provides some radiant protection as well as physically protecting from debris and embers. Under deemed-to-satisfy provisions, screening is required for all glazing at BAL—40 and higher, while lower risk areas only require screens to the openable portion. (Proprietary systems may be certified otherwise).

Glazing must be safety glass or toughened safety glass, to different thicknesses depending on the BAL rating (Standards Australia 2018a).

Doors

Flush panel solid-core external doors will generally provide adequate protection when fitted with non-combustible weather strips and draft excluders to prevent ember entry. In many cases, a self-closing metal-mesh screen door is required for protection when solid doors are open. Garage doors require similar considerations around combustibility and draught (ember) sealing.

Details, gaps and joints

Whatever material is selected for the level of fire hazard that exists, the integrity of the system as a barrier to ember attack, heat and flame contact must be maintained. AS 3959 is very particular in what materials are acceptable.

Shutters, metal-mesh flywire, gap filler, insulation and sprinklers are all effective protective measures against ignition by embers. AS 3959:2018 requires:

'All gaps including vents, weepholes and the like shall be screened, except for weepholes to the sills of windows and doors' (Standards Australia 2018a).

Fences

Case studies presented at the Australian Bushfire Building Design Conference 2020 suggested an under-addressed concern was house-to-house ignition. Non-combustible fencing can considerably reduce this risk (Leonard 2010). Appropriately selected and managed hedging can also inhibit a fire's path.

3.4 Services

Any above-ground service pipes should be metal to reduce the risk of failure from melting plastic service pipes (Standards Australia 2018a).

Water

Static water supplies should be stored in a metal or concrete tank fitted with metal taps and metal or underground pipes. It should be signed as Static Water Supply (SWS) or have a household-use tap located part way up to reserve the required portion for fire-fighting purposes (RFS 2019). Tanks should be fitted with a large outlet, gate valve and a coupling for fire tanker hose connection (compatible with local authority specifications).

The capacity of water storage required will depend on the size of the property and the area to be defended. Most local jurisdictions have minimum storage requirements for new homes.

Sprinkler systems can aid in protecting a structure and the APZ during a bushfire but should not be seen as a total bushfire defence strategy, but as a first line of defence (See External water spray systems above).

Gas

Significant concern has been raised for bottled gas services. If included, bottles should be shielded and pressure relief valves (and gas meters) should face away from combustibles. Bottles should be installed on a flat concrete surface.

Case study 2: Blue Mountains house

Architect: ECOdesign Architects. Builder: Owner-builder.

- Designed to suit an abandoned partial build (north-south slab), this house demonstrates that you don't need to start from scratch to achieve a great result.
- Located at Dargan near Lithgow in NSW, the house survived a hot fire that intensified up a steep western slope around New Year 2020. Neighbouring homes were destroyed.
- Key defensive features include a low built form, Timbercrete cladding, non-combustible external materials, stainless steel patio screens to separate the window glazing from fire risk (and excessive western sun).

During the emergency, firefighters assessed the house as saveable and sheltered behind the building as the fire front passed.

- Hebel blockwork terracing (using abandoned material) with well-watered low-lying vegetation and grasses also aided in the defence of the house.
- The house was designed to solar-passive principles, demonstrating that existing conditions, designing for bushfire risk and sustainability can be considered simultaneously.
- The cost increase to meet the BAL—FZ requirements was estimated to be 20% of the project cost.

Figures 7, 8 and 9. Photos of house that survived 2020 bushfires in the Blue Mountains (Images: Nigel Bell)

4.0 Functional considerations

4.1 Maintenance

Fire authorities emphasise the need for fire management plans for individual properties, with ongoing community education aimed at avoiding public complacency between bushfire emergencies.

Forward planning and maintenance are critical to mitigate bushfire risk. The design of the building and surrounding landscape should allow occupants to conduct regular maintenance checks, easily remove flammable debris (eg safely accessible gutters), and to maintain lawns, gardens and trees.

4.2 Active defence

Planning to stay and defend a building during a bushfire requires careful preparation, forethought and resources. Most jurisdictions encourage a written and practised bushfire plan. Advice from authorities during a bushfire event is usually to leave, and leave early.

Research suggests that even among those who intend to leave, evacuation is often left to the last minute, and is not always possible (Whittaker 2019). Therefore, designing for active defence is preferable regardless of the homeowner's stated intentions.

In the instance that a homeowner stays and defends (whether by choice or otherwise), the design of the house and its surrounding landscape is critical.

Designers should make it clear that by planning to support active defence, they are not encouraging this option, but are supporting the ability to defend should the situation ever arise. Refer also to Projects in bushfire-prone areas for guidance on communicating this to your client.

Design considerations for property defence, primarily based on the CFA 'Defending Your Property booklet (2019), include:

- Designated indoor and outdoor storage locations for protective gear, communications equipment and fire-fighting equipment. Survival kits should be located on the leeward side of the house and in a well-insulated and sealed location.
- Provision for loss of power, water pressure or telecommunications. Landline installation is often skipped these days but may be seen as a desirable back-up in bushfire-prone areas. Power generation backup for water supply is essential. Easy access to switch off electricity and gas.
- Sufficient external taps with metal fittings to access all defendable areas and an internal fitting to connect a hose for internal defence (ie washing-machine fitting). Somewhere inside to easily fill buckets.
- Design for easy ability to block downpipes and flood gutters. Air-conditioning units should be easily accessible so air intake can be blocked off. Roof mounted evaporative models are not recommended.
- A safe place to put pets in refuge.
- Allow for more than one exit in every room to be used as a shelter. A window may be considered an exit point. Allow for at least one shelter location on each side of the house, allowing for observation of a fire front approaching from any direction.
- Design to allow movement from one end of the house to another through rooms with two or more exits and to allow for zoning between areas, preferably with solid hinge doors. The ability to move furniture away from windows while maintaining safe access between rooms is also desirable.
- If there is a ceiling cavity, provide sufficient access to monitor ceiling space (eg an access-hole where a ladder can be left set up, with sightlines to extent of roof cavity). Proximity of ceiling access to internal hose fitting should allow for extinguishing fire within roof space.

5.0 Private bushfire shelters – life savers or death traps?

Private bushfire bunkers are purpose-built structures to provide temporary shelter from a bushfire. They can provide protection from direct flames, radiant heat and smoke. Bunkers can be above or below ground but are separate from a house.

It is important to understand the purpose of a fire bunker:

- They are a suitable solution for certain circumstances only, ie for remote/inaccessible areas. They are not recommended for peri-urban locations where evacuation is the safest option. Bunkers should not be seen as encouragement for people to stay.
- Bunkers are for life safety only. The use of a bunker is not without risk and there is no guarantee it will save a person's life.
- Bunkers form the emergency management phase of the overall bushfire protection system. They must be part of a bushfire survival plan.
- They should be a plan B option only - a backup plan when all has gone wrong. Plan A should be to evacuate and/or leave early.
- Bunkers present a potential performance-based solution to free up design constraints in high-risk areas.

After the 2009 Victorian Bushfires, the Royal Commission findings led to the development of standards and regulations for Private Bushfire Shelters. While Private Bushfire Shelters (Class 10c structures) are not mandated under the NCC, where a decision is made to construct a shelter they must meet the performance requirement (P.2.7.6) for Class 10c structures under this code. Although the NCC does not provide deemed-to-satisfy provisions for this performance requirement, the Australian Building Codes Board Performance Standard for Private Bushfire Shelters (ABCB 2014) does contain guidance for their construction.

Victoria currently has accreditation for bunkers. Other states are not so encouraging.

During the 2019-20 fire season, there were six known instances in Victoria where individuals sheltered inside bunkers during burnovers of varying intensity (Kachel 2020). Burnovers occur when a fire overruns a location too fast for people to retreat.

In all six instances, these bunkers were provided by accredited suppliers and no injuries or deaths occurred, yet three of the six houses were destroyed (Kachel 2020).

A personal refuge is different to a bunker. A refuge is often discussed as a place within the home with additional protection. Refuges offer the appeal of not needing to move to another location, but are criticised for potentially creating a false sense of security and relying on the integrity of the main building (ie they are still part of plan A).

Figure 10. Bunkers have become controversial since the 2009 Black Saturday fires. Rules remain inconsistent between states (Image: Jeff Dau by permission of Author).

Conclusion

Reducing the risk to life during bushfire events is a shared responsibility between authorities, communities and individuals. Many scenarios must be considered, including variations in fire events, weather conditions, and residents' intents and actions. Reducing risk and designing a defensive house must be an holistic consideration, as a house's defences and a household's plan are only as strong as their weakest link.

Planning and designing for bushfire means that defensive approaches, including siting and access, are considered from the very start. This must include building design as well as landscaping and maintenance requirements to reduce risk.

The site planning, form, materials and services of the building should be thought of as complementary systems working in synergy. Architects are well placed to apply their problem-solving skills to design to reduce bushfire risk beyond the limits of applying AS 3959 as an end-of-project check-box activity.

'There needs to be more understanding of the role good design can play in mitigating risk from bushfires' (Bell 2020).

This does not mean that architects should go it alone. Architects are trained lead consultants and a project will benefit greatly from early and collaborative involvement from a suitably qualified bushfire consultant and an experienced landscape design consultant. The importance of an appropriately experienced builder must also be valued, alongside assessment and sign-off of the completed works from the bushfire consultant.

This Note demonstrates that houses in bushfire-prone areas need not be complex or require highly expensive technical or material solutions. Keeping it simple often results in a more defensive home. However, they do require a well-informed, considered and collaborative design approach based on the principles outlined in this paper and beyond. Architects and designers have a critical role to play in designing housing that is responsive to a changing climate and increasing weather-event intensities.

Glossary

The terms and their meanings listed below are mostly sourced and adopted from Planning for Bushfire Protection (RFS 2019) and AS 3959:2018 (Standards Australia 2018a).

Acceptable solution

Measures that have been deemed to meet the specified performance criteria.

Asset Protection Zone (APZ) (NSW)

A fuel-reduced area surrounding a built asset or structure which provides a buffer zone between a bushfire hazard and an asset. The APZ includes a defendable space within which firefighting operations can be carried out. The size of the required APZ varies with slope, vegetation and FFDI.

Bushfire assessment report

A report submitted with the Development Application (DA) that establishes compliance with jurisdictional requirements. The report determines the extent of bushfire attack and the proposed mitigation measures.

Bushfire Attack Level (BAL)

A means of measuring the severity of a building's potential exposure to ember attack, radiant heat and direct flame contact. In the NCC, the BAL is used as the basis for establishing the requirements for construction to improve protection of building elements.

Bushfire

An unplanned fire burning in vegetation. It is also referred to as wildfire.

Bushfire hazard

Any vegetation that has the potential to threaten lives, property or the environment.

Bushfire-prone land (BFPL)

An area of land that can support a bushfire or is likely to be subject to bushfire attack, as designated on a bushfire-prone land map.

Bushfire protection measures (BPMs)

A range of measures used to minimise the risk from a bushfire that need to be complied with. BPMs include APZs, construction provisions, suitable access, water and utility services, emergency management and landscaping.

Bushfire resistant timber

Timber that is in solid, laminated or reconstituted form that meets the criteria specified in AS 3959:2018.

Bushfire risk

The likelihood and consequence of a bushfire igniting, spreading and causing life loss or damage to buildings of value to the community.

Bushfire shutter

A shutter that is constructed and fitted to the exterior of a building to protect a window or a door from exposure to bushfire attack.

Classified Vegetation

Vegetation that has been classified in accordance with AS 3959:2018 or jurisdictional based policy.

Combustible

Combustible as determined by AS 1530.1.

Consent authority

As defined by jurisdictional legislation in relation to development consents, usually the local council.

Ember Attack

Attack by smouldering or flaming windborne debris that is capable of entering or accumulating around a building, and that may ignite the building or other combustible materials and debris.

Fire Danger Index (FDI)

The chance of a fire starting, its rate of spread, its intensity and the difficulty of its suppression, according to various combinations of air temperature, relative humidity, wind speed and both the long and short-term drought effects.

Fire Resistance Level (FRL)

The nominal grading period, in minutes, that is determined by subjecting a specimen to the standard time temperature curve regime as set out in AS 1530.4, to specify

(a) structural adequacy

(b) integrity

(c) insulation,

which are expressed in that order.

Flame Zone

The highest level of bushfire attack due to direct exposure to flames from the fire front in addition to heat flux and ember attack.

Managed land

Land that has vegetation removed or maintained to a level that limits the spread and impact of bushfire. This may include developed land (residential, commercial or industrial), roads, golf course fairways, playgrounds, sports fields, vineyards, orchards, cultivated ornamental gardens and commercial nurseries. Most common will be gardens and lawns within curtilage of buildings. These areas are managed to meet the requirements of an APZ.

National Construction Code (NCC)

The NCC, published by the Australian Building Codes Board, comprises the Building Code of Australia as Volumes One and Two, and the Plumbing Code of Australia as Volume Three.

Non-combustible

Not deemed combustible as determined by AS 1530.1 or not deemed combustible in accordance with the NCC.

Outer Protection Area (OPA)

The outer component of an APZ, where fuel loads are maintained at a level where the intensity of an approaching bushfire would be significantly reduced. Applies to forest vegetation only.

Setback

The distance required by planning provisions to separate a building from the bushfire hazard, street frontage or from adjacent buildings or property boundaries.

Short fire run

A parcel or area of vegetation which is considered a lower risk than the design fire associated with that in AS 3959 due to its size, shape, and orientation to buildings. This has a design fire head width of less than 100 metres.

Slope

The slope under that classified vegetation which most influences the bushfire attack.

Special fire protection purpose (SFPP) developments

Developments where the vulnerable nature of the occupants means that a lower radiant heat threshold needs to be accommodated. This is to allow occupants to evacuate and for emergency services.

Suitably qualified bushfire consultant

A consultant providing bushfire assessments and BAL Certificates who has been accredited by a recognised accreditation scheme.

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