A review of the regulations for managing fire in roofs lower than adjacent buildings

BRANZ reviewed the current building regulations for managing fire spread from roofs to adjacent taller buildings and compared them with the regulations in five other countries. New Zealand has the most stringent requirements for fire protection in this specific context, but general wall and roof requirements in other countries can provide a similar or greater level of protection. New Zealand regulations require fire protection across 9 m height in adjacent external walls or 5 m width in lower roofs. BRANZ investigated the origin of this requirement and found this approach most likely came from international code NFPA 80A *Recommended practice for protection of buildings from fire exposure*.

The increasing demand for housing is driving higher-density development in urban areas in New Zealand. This increases the risk of fire spreading between buildings, including from roofs that are lower than the walls of nearby adjacent buildings.

Fires from roofs are not well understood but can be significant. During a fire, a fire plume above a roof can be caused by:

- a fire within the building penetrating and exiting through an opening in the roof
- ignition within the roof itself or on the external surface of the roof if the roof has combustible parts
- flames from a large fire exiting windows or gaps in the external walls and reaching above the roof.

Whatever the source, a fire plume above a roof may damage or spread to the external walls of adjacent buildings (Figure 1). Weather conditions, especially wind, may also influence the size and shape of the flame plume and the amount of heat on adjacent walls.

Comparing New Zealand and overseas regulations

BRANZ compared New Zealand regulatory building requirements (Figure 2) with those in Australia, Canada, Sweden, the UK and the US. These countries have a similar tiered approach to building regulation (with some variation).

This type of fire spread is covered in performance-based and prescriptive requirements. The prescriptive requirements include specific requirements for fire spread from lower roofs and also general roof and external wall requirements that can apply to fire spread from lower roofs.

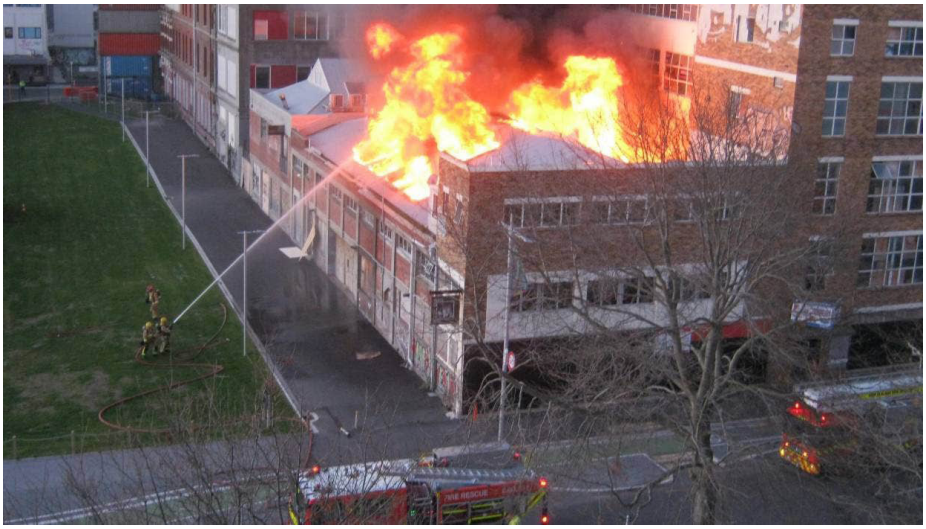


Figure 1. Roof fire and adjacent taller buildings at risk (Sol Square, Christchurch, July 2016). Photo: Brian Dimbleby. Reproduced with permission.

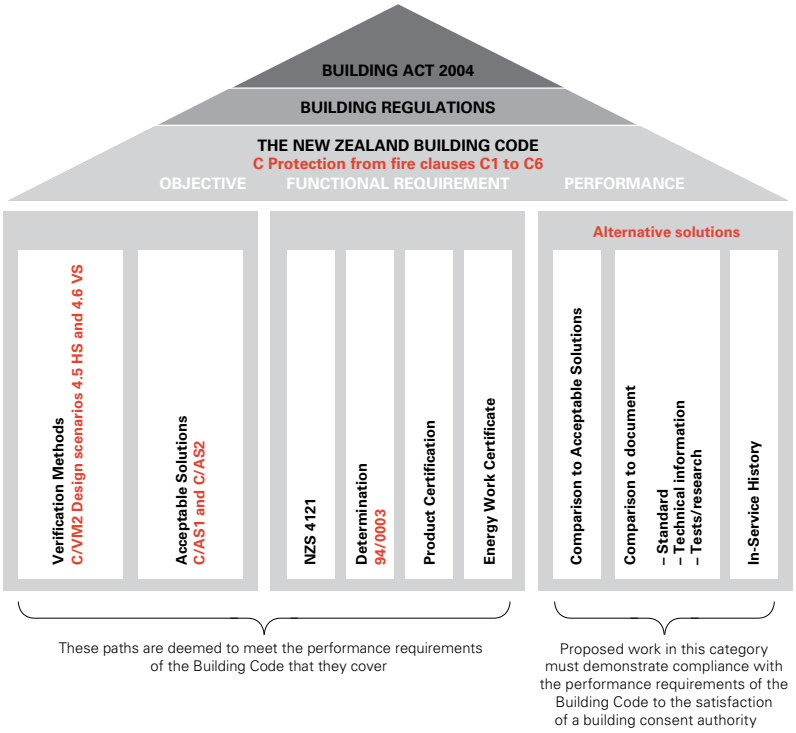


Figure 2. The red text indicates the parts of the New Zealand Building Code that apply to fire spread from lower roofs to adjacent buildings.

How fire spread from lower roofs is addressed can depend on the situation outlined in the country's regulations, so the regulations were compared in three areas:

- Performance-based requirements and verification methods.
- Specific prescriptive requirements for fire spread from lower roofs.
- General roof and external wall requirements.

Performance-based requirements

All of the countries reviewed, including New Zealand, have performance-based requirements that cover the potential for fire spread from lower roofs. They range from broad fire safety objectives (in most cases) to more specific quantitative requirements (as in New Zealand and Australia).

The UK has the only qualitative performance criteria that specifically mentions fire spread involving roofs. The US, UK and Canada do not provide quantitative requirements within their performance criteria or objectives. New Zealand and Australia provide limits for heat fluxes in the New Zealand Building Code or Australian Verification Method. Buildings must be designed so that they will not produce heat fluxes in excess of these limits if they experience a fire. Buildings adjacent to fires must also withstand heat fluxes up to these limits without ignition. The New Zealand Building Code specifies these heat fluxes for external wall materials up to 1 m from the boundary, whereas the Australian Verification Method has heat flux requirements for up to 6 m from the boundary.

Specific prescriptive requirements for fire spread from lower roofs

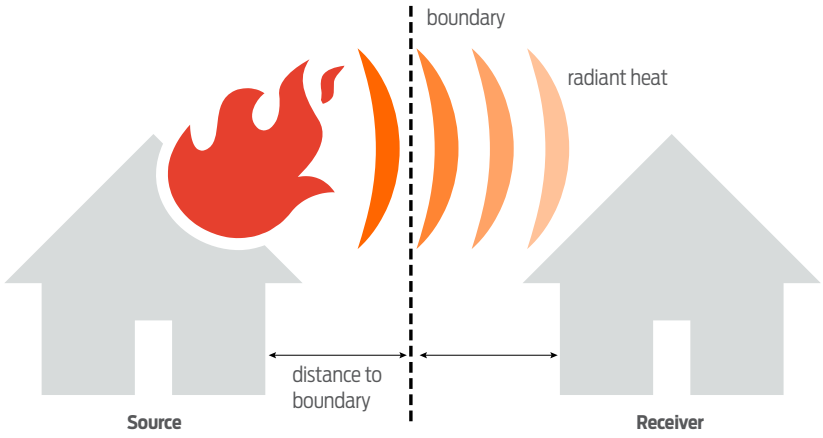
New Zealand, Australia, Sweden and the US all specify fire resistance requirements for external walls above and adjacent to lower roofs and for the roofs themselves (Table 1). New Zealand has the most stringent specific prescriptive requirements for the extent of fire-rated construction of all the countries considered. Canada limits openings in the roof but does not specify a fire resistance rating for walls. The UK's requirements are limited to buildings used for assembly (entertainment, sport, worship, eating or drinking).

General roof and external wall requirements

Although New Zealand has the most stringent prescriptive requirements for the specific scenario of fire spread from lower roofs, some of the other countries have general roof and external wall requirements that exceed New Zealand requirements, particularly in situations involving two separate buildings or a property boundary. This means that the mechanism of fire spread from lower roofs will be covered in most cases by the general construction requirements. These requirements - including minimum fire resistance ratings, allowable unprotected openings and, in some cases, reaction-to-fire requirements - are often a function of the building typology and geometry. See the original compliance documents for more details.

Origin of New Zealand prescriptive requirements

The specific requirements in New Zealand Acceptable Solutions for ensuring a fire resistance rating on either lower roofs or



COUNTRY	DISTANCE	SOURCE: MAXIMUM HEAT FLUX PRODUCED	RECEIVER: MUST RESIST IGNITION UP TO SPECIFIED HEAT SOURCE
New Zealand	<1 m	30kW/m²	30kW/m²
	>1 m	16kW/m²	—
Australia	<1 m	80kW/m²	80kW/m²
	1 m - 3 m	40kW/m²	40kW/m²
	3 m - 6 m	20kW/m²	20kW/m²
	>6 m	10kW/m²	10kW/m²

Table 1. Summary of specific building regulation requirements for lower roofs for New Zealand, Australia, Sweden, the US, Canada and the UK.

COUNTRY	DOCUMENT	AREA WHERE FIRE RESISTANCE RATING (FRR) REQUIRED		REQUIREMENTS
		EXTERNAL WALL ABOVE LOWER ROOF (M)	LOWER ROOF AREA ADJACENT TO HIGHER WALL (M)	
New Zealand	C/AS1, 2, 3, 5*	9.0	5.0	FRR varies depending on Acceptable Solution
Australia	National Construction Code, ABCB (2016)	6.0	3.0	Same FRR as lower firewall
Sweden	Boverket Building Regulations (2016)	5.0	8.0	Exterior wall: FRR equal to requirement of separating structure (up to 20% of area can be windows with 30 min integrity and radiation FRR) Lower roof: 60 min
USA	International Building Code (2015)	4.6	3.0	1-hour FRR with 45 min protective assemblies on openings
Canada	National Building Code, CCBFC (2015)	-	5.0	No skylights in roof if windows are within 3 storeys vertically and 5 m horizontal to roof
UK	Approved Document B, HM Government (2013)	10.0		Reaction to fire for assembly buildings (no FRR)

* Acceptible Solutions C/AS2–7 were combined into C/AS2 after this research was completed.

adjacent higher exterior walls are shown in Figure 3. There are two options for providing fire protection in this situation (also known as the '9 m or 5 m' rule):

- 9 m of the vertical wall adjacent to the lower roof (with no unprotected areas), or
- 5 m of the lower roof horizontally from the wall.

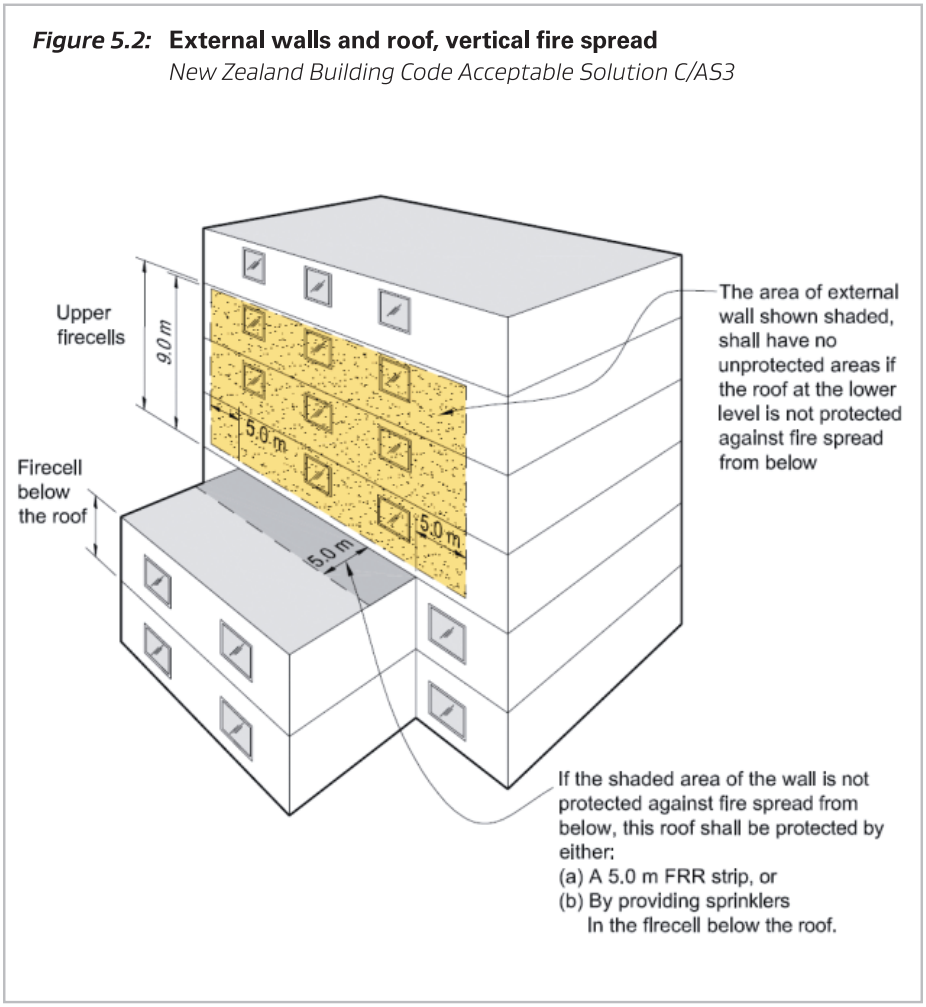
The fire resistance of the wall or the roof must also extend laterally 5 m past the extremity of the other. No fire resistance is required if the fire cell below the lower roof has a sprinkler system.

This requirement is included in Acceptable Solutions C/AS1 and C/AS2. The '9 m or 5 m' specifications have been in place since 1992, but BRANZ found that the justification for these rules is not clear in historical or present documentation. Similar requirements were traced back to DZ 4226:1984 *Design for fire safety*. DZ 4226:1984 was a draft standard intended to replace the existing model fire safety code (NZS 1900:1963 chapter 5) but was never published. DZ 4226:1984 included a '10 m or 6 m' rule rather than a '9 m or 5 m' rule. It derived this requirement from NFPA 80A *Recommended practice for protection of buildings from fire exposure*, which includes a range of requirements depending on the number of storeys contributing to the fire and is more nuanced than the New Zealand Acceptable Solutions.

Recommendations

- The specific requirements for 9 m vertical protection in walls or 5 m roof protection or horizontal separation in the current New Zealand Acceptable Solutions do not seem overly conservative when compared with other countries. However, using a single requirement for all building geometries may be overly simplistic.
- Any changes to the New Zealand specific prescriptive requirements for fire spread from lower roofs should be made in context with the general roof and wall fire protection requirements.
- Future work to develop experimental validation data at appropriate scales could improve confidence in or constrain the requirements, and investigation of actual fire incident data could improve understanding of the risk of fire spreading from lower roofs with typical building geometry configurations in New Zealand.

Figure 3. C/AS requirements for prevention of fire spread from lower roofs



Further reading

Study Report SR409 *Fire spread from lower roofs*

BRANZ Research Now: Fire safety design #5 *Estimating the heat flux on walls from fires in adjacent lower roofs*

MBIE. (2014). *C/VM2 Verification Method: Framework for Fire Safety Design For New Zealand Building Code Clauses C1-C6 Protection from Fire (Amendment 5)*. Wellington, New Zealand: Ministry of Business, Innovation and Employment.

ABCB. (2016). *National Construction Code Volume One: Building Code of Australia Class 2 to Class 9 Buildings*. Canberra, Australia: Australian Building Codes Board.

Boverket. (2016). Boverket's mandatory provisions and general recommendations, BBR: BFS 2011:6 with amendments up to BFS 2016:6. Stockholm, Sweden: Boverket - the Swedish National Board of Housing, Building and Planning.

ICC. (2014). *International Building Code*. Washington, DC: International Code Council.

CCBFC. (2015). *National Building Code of Canada*. Ottawa, Canada: Canadian Commission on Building and Fire Codes, National Research Council of Canada.

HM Government. (2010). *The Building Regulations 2010* (S.I. 2010/2214). London, UK: HM Government.

HM Government. (2013). *Approved Document B: Volume 2 - Buildings other than dwellinghouses*. London, UK: HM Government.