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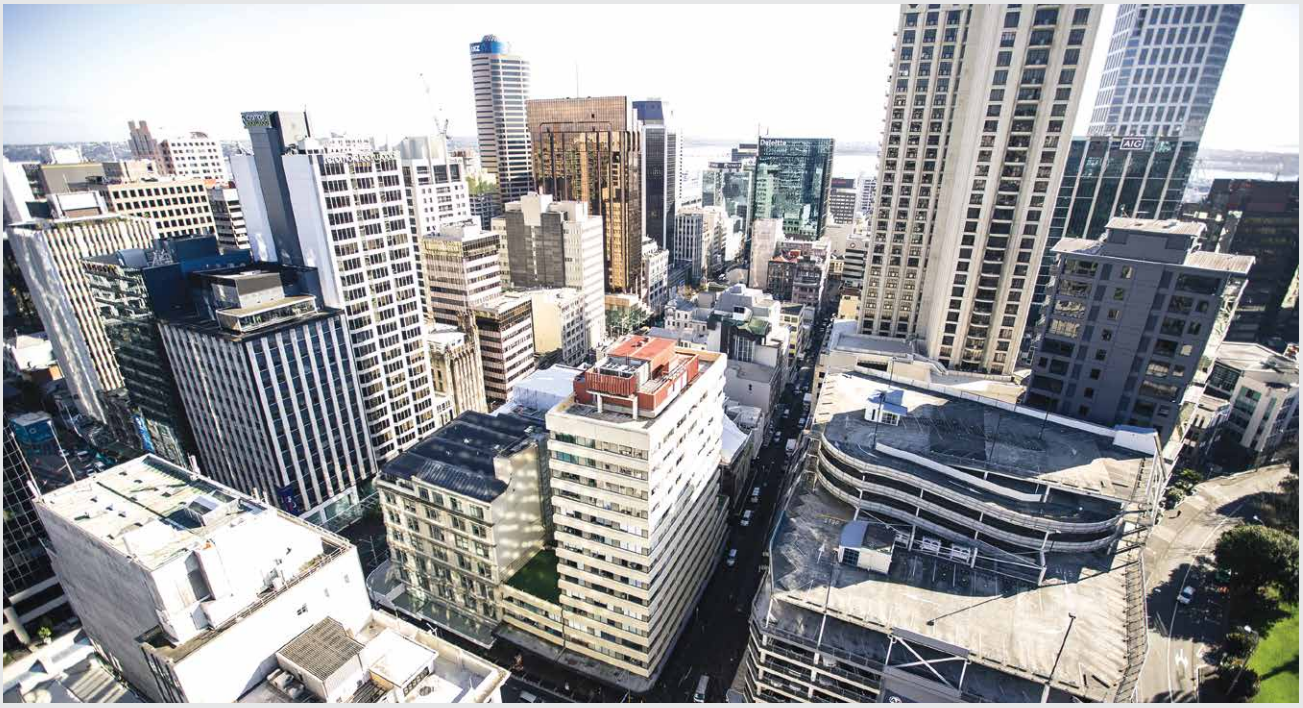
Fire Performance of External Wall Cladding Systems

This guide discusses how external wall cladding systems can be tested to determine their fire performance. It will help industry to demonstrate compliance with the requirements of the New Zealand Building Code.



MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

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Ministry of Business, Innovation and Employment (MBIE)

Hīkina Whakatutuki

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MBIE does this by working with others to help businesses to be more competitive, improving job opportunities and by ensuring quality housing is more affordable.

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Fire Performance of External Wall Cladding Systems

1.0 Introduction

Significant high-rise fire events globally have increased our understanding of how fire spreads externally and within modern facade construction. This has prompted MBIE to review the current methods used to demonstrate compliance of external wall cladding systems with building regulations' fire safety objectives. In particular, how New Zealand requirements should be interpreted and whether international alternative fire test and evaluation methods are suitable for use here.

This guide discusses how external wall cladding systems can be tested to determine their fire performance. This information will help industry to demonstrate compliance with the requirements of the New Zealand Building Code (NZBC), consider the overall risks associated with the building's use, the risk profile of its occupants, the building height and other fire safety systems in the building.

Who is this guidance for?

This document is of interest to fire engineers, architects, facade engineers, building consent and territorial authorities, testing laboratories, and product manufacturers and suppliers.

Fire testing protocols: individual components versus cladding systems

Since 2001 fire testing protocols used for Building Code compliance in New Zealand have been based on either bench scale testing of individual materials or components using AS/NZS 3837 (or more recently ISO 5660) or the larger scale NFPA 285 facade test.

Bench scale fire tests have typically been used in New Zealand for cladding in a way that treats fire spread over the external wall as a surface flame spread phenomena (similar to interior linings). However, it is apparent that in many cases it is the entire system performance that must be considered and not only that of the outermost cladding material.

Large scale fire tests are a way of assessing how an external wall cladding system performs when exposed to flames projecting from an opening in the external wall. Fire performance in these tests can be sensitive to a small change in the system details. External wall cladding systems are complex and can include a multitude of combustible components. It is difficult to determine how each of those individual components contributes to the overall system performance to limit fire spread.

It may therefore not always be possible to confidently evaluate the overall system performance for facades containing combustible components solely based on small scale fire testing of only the individual components.

Questions from industry

This guidance has been prepared to help address the questions from industry such as:

1. Are there any acceptable fire testing protocols other than those currently cited in an Acceptable Solution or Verification Method?
2. How should the fire test criteria be applied to external wall cladding systems?

2.0 Scope of this guidance

This guidance is intended to:

- make it clear what constitutes an external wall cladding system for testing external vertical fire spread and assessing performance against the New Zealand Building Code requirements
- describe the suite of fire testing protocols that could be applied to demonstrate compliance with the Building Code
- scope the parameters that need to be considered when addressing external vertical fire spread.

The guidance does not intend to provide a fire-engineered design solution for individual construction details but covers broad principles requiring consideration in their development. Some of the principles are based on a simplistic risk assessment approach.

3.0 New Zealand Building Code compliance pathways

The Building Code is performance based. Clause C of the Building Code describes the performance criteria for Protection from Fire. Clause C3 describes Functional and Performance Requirements for fire affecting areas beyond the fire source.

Functional Requirements – NZBC Clause C3	
C3.1	*Buildings* must be designed and constructed so that there is a low probability of injury or illness to persons not in close proximity to a *fire source*.
C3.2	*Buildings* with a *building height* greater than 10 m where upper floors contain sleeping uses or other property must be designed and constructed so that there is a low probability of external vertical fire spread to upper floors in the *building*.
C3.3	*Buildings* must be designed and constructed so that there is a low probability of *fire* spread to *other property* vertically or horizontally across a *relevant boundary*.

There are two Performance Clauses that describe the constraints for control of external vertical fire spread:

- Clause C3.5 – limiting the vertical spread of fire
- Clause C3.7 – covering the ignitability of external wall cladding materials.

Three pathways are available to demonstrate compliance with the Building Code Performance Requirements: Acceptable Solutions, Verification Methods and alternative solutions.

Note: CodeMark and Multiproof are alternative means for demonstrating compliance with the NZBC.

The following table outlines the Performance Requirements of the New Zealand Building Code and summarises the associated compliance pathways:

Compliance Pathways for New Zealand Building Code Clause C3 – External Spread of Fire	
C3.5	**C3.7**
Building Code Performance Requirements	
Buildings must be designed and constructed so that *fire* does not spread more than 3.5 m vertically from the *fire* source over the external cladding of multi-level *buildings.*	External walls of *buildings* that are located closer than 1 m to the *relevant boundary* of the property on which the *building* stands must either: (a) be constructed from materials which are not *combustible building material, or* (b) for *buildings* in importance levels 3 and 4, be constructed from materials that, when subjected to a radiant flux of 30 kW/ m^2, do not ignite for 30 minutes, or (c) for *buildings* in importance levels 1 and 2, be constructed from materials that, when subjected to a radiant flux of 30 kW/ m^2, do not ignite for 15 minutes.
Compliance Pathway – Acceptable Solutions C/AS2 to C/AS7	
The Acceptable Solutions (C/AS2 to C/AS7) contain three means of demonstrating compliance: 1. Fire properties of external wall cladding systems must be in accordance with ISO 5660 Reaction-to-fire tests – Heat release, smoke production and mass loss rate – Part 1: Heat release rate (cone calorimeter method), or 2. External wall cladding systems must comprise only materials that individually are classified as non-combustible (exempting a 1 mm combustible finish), or 3. The entire wall assembly must be tested at full scale in accordance with NFPA 285 and must pass the test criteria.	
Compliance Pathway – Verification Method C/VM 2	
The Verification Method (C/VM2) contains four means of demonstrating compliance: 1. Fire properties of external wall cladding systems must be in accordance with ISO 5660.1 or AS/NZS 3837, as per the tables in C/VM2, or 2. The external wall cladding system must use non-combustible materials, or 3. The external wall cladding system must comply with the Acceptable Solutions (for buildings with an importance level not higher than 3).	
4a. Large or medium scale facade type tests must be used to determine the extent of vertical fire spread is not more than 3.5 m above the fire source (C3.5).	

Compliance Pathways for New Zealand Building Code Clause C3 – External Spread of Fire	
C3.5	**C3.7**
Compliance Pathway – Alternative Solution	
An alternative solution proposal must be provided that justifies how the design of the building will not result in fire spread of more than 3.5 m vertically from the fire source over the external cladding of multi-level buildings.	(a) The external wall cladding system must use non-combustible materials (*combustible building materials* is a defined term in the Building Regulations, and "means building materials that are deemed combustible according to AS 1530.1"), or An alternative solution proposal must be provided that justifies how either: (b) for buildings in importance levels 3 and 4, the external wall cladding system is constructed from materials that, when subjected to a radiant flux of 30 kW/ m^2, do not ignite for 30 minutes, or (c) for buildings in importance levels 1 and 2, the external wall cladding system is constructed from materials that, when subjected to a radiant flux of 30 kW/m^2, do not ignite for 15 minutes. The above criteria for b and c can be achieved by the use of bench scale fire tests (e.g. ISO 5660-1) to confirm that materials when exposed to 30 kW/m^2 do not ignite within the specified time period.

4.0 Fire test methods for external wall cladding systems

4.1 Fire testing requirements for an external wall cladding system

To demonstrate compliance with the Building Code for Protection from Fire Performance Clauses C3.5 and C3.7 for external vertical fire spread, the external wall cladding system includes all substantive components within the complete wall assembly. This includes sheet cladding materials, framing, rigid air barrier, any insulation or sheet materials or blanket and the internal lining. Where relevant, the direction of fire exposure to be considered is from the exterior side of the wall.

Recommendations on the different fire testing options to evaluate the fire properties of an external wall cladding system are given in the risk matrix in Section 5.

4.2 Alternative test methods to those currently cited

The New Zealand Building Code Protection from Fire Acceptable Solutions and Verification Method currently cite two fire tests for assessing the fire performance of cladding systems. These are a bench scale independent component test (ISO 5660), and the intermediate scale system test NFPA 285. This guidance broadens the suite of test protocols to include the British Standard BS 8414 with the acceptance criteria provided by BR 135.

BS 8414-1:2015 Fire performance of external cladding systems. Test method for non-loadbearing external cladding systems applied to the masonry face of a building. Amended by BS 8414-1:2015+A1:2017 (June 2017).

BS 8414-2:2015 Fire performance of external cladding systems. Test method for non-loadbearing external cladding systems fixed to and supported by a structural steel frame. Amended by BS 8414-2:2015+A1:2017 (June 2017).

BR 135 Fire performance of external thermal insulation for walls of multi-storey buildings: (BR 135) Third edition, BRE (15 March 2013).

It is also acceptable to test cladding systems using the methods outlined in the Australian Standard AS 5113 to meet the 'EW' (external wall) classification. This classification standard in turn references BS 8414 as a test method.

Test components within cladding systems can also be tested using the methods outlined in EN 13501: 2007+A1:2009 to meet a Euroclass A1 or A2 classification.

Refer to the risk matrix in Section 5 for guidance on where the different test methods may be used.

4.3 BR 135 Fire performance of external thermal insulation for walls of multi-storey buildings – 3rd edition 2013

BR 135: 2013 addresses the principles and design methodologies related to the fire spread performance characteristics of non-loadbearing external wall cladding systems. Although various potential design solutions have been identified and discussed in BR 135, robust design details are not presented. In this rapidly changing market generic solutions are not available where new products and novel design solutions are frequently presented. The illustrations and scenarios presented in BR 135 are based on typical examples of current practice in the UK. To help designers and end users better understand the parameters impacting on the fire-safe design and construction of external wall cladding systems, BR 135 focuses on the issues surrounding the topic of external vertical fire spread.

BR 135 Annex A provides a classification system for the test methodology outlined in BS 8414-1 Fire performance of external cladding systems – Part 1: Test method for non-loadbearing external cladding systems applied to the face of the building.

BR 135 Annex B provides a classification system for the test methodology outlined in BS 8414-2 Fire performance of external cladding systems – Part 2: Test method for non-loadbearing external cladding systems fixed to and supported by a structural steel frame.

Other construction systems such as concrete-framed or timber-framed construction are not considered in BR 135. However, the general principles in the BR 135 guide may still apply, although suitable additional risk assessments and detail design reviews would be required. The risk matrix approach provides an option for considering alternative forms of supporting wall frames.

4.4 What is specifically excluded from external wall cladding systems for compliance with C3.5 and C3.7?

For the purposes of an external wall cladding system as defined in Section 4.1 of this guidance and for demonstrating compliance with the Building Code for Protection from Fire, substantive components may exclude:

- signage and billboards – aggregated area up to 25 m^2
- video screens up to 6 m^2.
- greenwalls – the acceptance of green and living walls will be dependent on the type of system proposed, its support structure and the associated management and maintenance/irrigation procedures. Generally, plants growing on metallic support systems (such as stainless steel wires) will not present an increased fire hazard provided they are adequately maintained. Other systems that include combustible support systems should be proven via fire test evidence to support compliance. For more information on greenwalls refer to:

  ANS Living Walls receive a Fire Safety Standard on the ans global website

  Fire Performance of Green Roofs and Walls on the GOV.UK website
- sunscreens/sunshades/louvres up to 6 m^2 or any area if non-combustible
- any materials used as part of the external wall cladding system for the topmost floor provided the roof does not require a fire resistance rating. (Other requirements to prevent horizontal fire spread to other property may still apply e.g. limits on unprotected area and/or the ignitability of the wall cladding when located within 1 m of the relevant boundary – see Section 5.2.)
- doorsets and window frames (these are not included with the cladding requirements)
- sealants and tapes comprising < 5% of the wall area
- a canopy or balcony at ground floor level of buildings that exceed 10 m in height where it can be shown or is agreed that a fire is unlikely to spread from the area to the main external wall cladding
- minor trim and gutters, downpipes and fascias – limited amounts of materials are excluded from the requirements where it can be shown or is agreed that a fire involving the materials is unlikely to spread fire to the remaining parts of the external wall cladding or where they are remote from the main building cladding.
- Individual components on or within the wall assembly that are non-combustible but include a surface coating not more than 1 mm thick.

Note: the above exclusions are only relevant to each component when taken in isolation. Consideration needs to be given when the above items are combined as part of a whole system to determine the contribution of each component to the overall performance of the cladding system. For example, a video screen meeting the size limitations attached to a non-combustible cladding would require further consideration and might not be appropriate if attached to a combustible sunscreen or rainscreen system.

4.5 In-wall cavities

Continuous vertical channels and cavities within external wall cladding systems are known to promote upward vertical fire spread. Fire researchers have noted that when flames are confined within a vertical cavity or channel they elongate, leading to flame extension of up to five to ten times the expected unconfined flame lengths. This is true even in cavities without additional combustible materials present, but is made worse by the presence of combustible materials. This flame extension effect can support rapid, potentially unseen, fire spread within an external wall cladding system and must be limited.

The provision of cavity barriers within external wall cladding systems is important, particularly when combustible cladding, rigid air barriers (RAB) and insulation products are used.

Cavity barriers based on fire-resisting construction tested to AS 1530.4 or similar and satisfying integrity and insulation ratings for at least 30 minutes are likely to provide an acceptable means of controlling flame spread within cavities. However, additional consideration is needed to ensure that cavity barriers within a facade system located at the junction of fire separations and the external wall assembly have adequate support, can remain in place for the period required, and provide the required level of fire resistance rating.

Examples of other potentially acceptable test standards that may be used for curtain wall systems include:

- ANSI/ASTM E2307 Standard Test Method for Determining Fire Resistance of Perimeter Fire Barriers Using Intermediate-Scale, Multi-story Test Apparatus, or
- BS EN 1364-4:2014 Fire resistance tests for non-loadbearing elements.

5.0 External wall cladding system vertical fire spread – risk assessment approach

A simplified risk assessment approach has been developed to classify a building's level of complexity and fire risk to help identify suitable fire test protocols to assess the cladding system for external vertical spread of fire. The parameters considered are:

- building height
- vulnerability of risk group
- provision of an automatic fire sprinkler system to the requirements of NZS 4541 (as modified by the NZBC).

How to use this table – find the risk level Low, Medium or High applying to the building based on the building height and risk group. Refer to the table key to determine the fire testing options considered acceptable for the applicable risk level.

Table 1. External wall cladding system – risk matrix for fire testing protocols

Building height	Sleeping use* Risk groups SM, SI		Non-sleeping use* Risk groups CA, WB, WS, VP	
	Sprinkler protected	Non-sprinkler protected	Sprinkler protected	Non-sprinkler protected
Single level	Low	Low	Low	Low
0-10 m and up to 2 levels	Low	Low	Low	Low
> 10 m ≤ 25 m	Medium†	High	Medium	Medium
> 25 m and ≤ 60 m	High	n/a	Medium	n/a
> 60 m	High	n/a	High	n/a

* For a building height ≤ 10 m, cladding systems used for importance level 4 buildings or multi-floor buildings incorporating staged evacuation, phased evacuation, or evacuation to a place of relative safety within the building should meet the requirements for risk levels Medium or High given below.

† Where a NZS 4515 residential sprinkler system is installed then the non-sprinkler risk level in column 3 should be used instead (i.e. risk level High given below).

Where risk levels Low, Medium and High are matched to fire testing protocols P1 to P5 as follows:

Low	No requirement for building height ≤ 10 m (NZ Building Code Performance Clause C3.5).
Medium	P1. All cladding and rigid air barriers (RABs) used in the external wall construction may be individually tested using ISO 5660-1 to meet requirements in C/AS2 to C/AS7 Paragraph 5.8. Insulation products, and filler materials (not including gaskets, sealants etc) to be limited combustibility*. All external wall cavities need to be fire stopped using cavity barriers at each floor level and at the junctions to other vertical fire separations. ACP materials must be tested without Aluminium (metal) facing as per C/AS2 to C/AS7 Appendix C7.1.5. Any of options P2-P5 below are also acceptable.
High	P2. External wall cladding system may meet the performance criteria given in BR 135 for cladding systems using full scale test data from BS 8414-1:2002 or BS 8414-2: 2005; or P3. External wall cladding system may pass the NPFA 285 full scale test; or P4. External wall cladding system may meet 'EW' classification in AS 5113; or P5. All cladding, framing**, insulation products**, RAB and filler materials (not including gaskets, sealants etc) used in the external wall construction may be of *limited combustibility**. If vapour barriers, drainage mats, building wraps or similar are not of *limited combustibility** then all external wall cavities need to be fire stopped using cavity fire barriers at each floor level.

* *Limited combustibility* means the product/material meets one or more of the following criteria:

1. A1 or A2 classification in accordance with EN 13501-1:2007+A1:2009.
2. Non-combustible or not combustible when tested to AS 1530.1 or ISO 1182.
3. Concrete, brick/block masonry, stone, glass, ceramic tiles, aluminium and steel with or without paint or similar thin surface coatings not exceeding 1 mm thickness.

** Timber framing (or combustible insulation products within a framed wall assembly) may be used if a robust protective lining material (being of *limited combustibility*) is fixed to the exterior side of the framing and can be demonstrated to remain in place and protect the framing during the period of external fire exposure. 'Protect framing' can be assumed to be achieved if the protective lining material as part of a light timber frame wall exposed to the test conditions of AS 1530.4 can be shown to prevent charring of the timber frame for a period of 30 minutes. One way to determine this is to limit the temperature on the cavity side of the fire-exposed protective lining material during the test period to be no greater than 300 degrees Celsius.

5.1 Use of combustible RAB

A combustible rigid air barrier (RAB), for example, plywood, may be used for any building if it has been included as part of a representative external wall subjected to a full scale fire test and meeting the criteria in P2-P4 in the risk matrix.

5.2 External walls of any height located within 1 m of a relevant boundary

To limit potential horizontal fire spread to and from a neighbouring property, the exterior cladding material shall either be of limited combustibility or be tested using ISO 5660-1 to meet the requirements in C/AS2 to C/AS7 Paragraph 5.8. The test specimen shall comprise the cladding material mounted over a representative substrate if the cladding material is less than 50 mm thick.

NOTE: This is not a vertical fire spread provision and needs to be considered in addition to the requirements of Table 1.

It is also acceptable for the exterior cladding material to be tested using ISO 5660-1 using an external irradiance of 30 kW/m^2 and not ignite within the period of time given in NZBC C3.7.

5.3 Technical assessment in place of test

Cladding products and systems range in nature and complexity. There are also a range of base wall assemblies that may impact upon how the outer weather-facing part of a cladding system product will perform. Examples include:

- Exterior Insulation Finish Systems (EIFS)
- High Pressure Laminates (HPL)
- external thermal insulation composite systems (ETICS)
- rain screen cladding
- structural insulation panel systems (SIPS)
- Expanded Polystyrene Systems (EPS)
- timber cladding.

Key system performance considerations that must be considered in a technical assessment are:

- combustibility of insulation
- combustibility of framing (e.g. timber frame)
- composition of rigid air barrier
- building underlay
- uninterrupted vertical cavity
- continuity of products.

In order for an external wall cladding system to be certified for fire safety performance, it needs to be constructed to replicate the details of the test. This includes, for example, framings, substrate, flashing details, gaskets, sealants and fixing mechanisms.

A technical assessment may be presented as part of the plans and specifications to demonstrate compliance with the performance requirements of the Building Code. Situations may arise where the proposed cladding system installation differs slightly from the absolute details of that described in a fire test report. A technical assessment must be provided by accredited testing laboratory or from a subject matter expert with knowledge and experience in fire science and fire testing.

6.0 Documentation and evidence for building consent

When considering an application for a building consent the building consent authority (BCA) needs to be satisfied on reasonable grounds that the provisions of the Building Code would be met if the building work were properly completed in accordance with the plans and specifications that accompanied the application.

The BCA needs evidence of which compliance pathway you are using to show how the building's cladding system meets the performance requirements of the Building Code and evidence to show how it can be constructed to comply.

BCAs may wish to consider the following when assessing external wall cladding systems case-by-case:

- the extent of combustible products used on the building (i.e. is it a feature or the entire cladding?)
- the building use (occupancy type)
- the active (e.g. alarms and sprinklers) and passive (e.g. firewalls and smoke compartments) fire protection systems throughout the building
- the system tested by the manufacturer or supplier and whether its use is consistent with this (and if not, are the changes likely to negatively affect the building's fire performance?)
- the quality and accuracy of the building consent documentation and detailing in relation to external wall assemblies (i.e. can the cladding system be constructed from the information that has been provided?)
- the height and proximity of the building to other buildings
- the use of plastics (e.g. polyethylene core aluminium composite panel), including the content of the specific product and its use
- whether the design has been reviewed/peer reviewed by a suitably qualified and experienced person.

7.0 Useful resources and references

1. New Zealand Building Code available on the New Zealand legislation website
2. Wade, C.A., (1995), BRANZ, Report Number 133, *Fire Performance of External Wall Claddings under a Performance Based Building Code* available on the BRANZ website.
3. National Fire Protection Association (NFPA) 285, Standard Fire Test Method for Evaluation of Fire Propagation Characteristics of Exterior Non-Load-Bearing Wall Assemblies Containing Combustible Components.
4. AS 5113 Fire propagation testing and classification of external walls of buildings.
5. ISO 5660 Reaction-to-fire tests Part 1 Heat release rate (cone calorimeter method).
6. EN ISO 1182: 2010. Fire Test for Non-Combustibility of Building Products.
7. AS 1530.1 Methods for fire tests on building materials and structures Part 1: Combustibility test for materials.
8. Lamont, S. & Ingolfsson, S. (2018) *High rise Buildings with Combustible Exterior Wall Assemblies: Fire Risk Assessment Tool* available on the National Fire Protection Association (NFPA) website USA.
9. White N. and Delichatsios M., (2014) *Fire Hazards of Exterior Wall Assemblies Containing Combustible Components*, Fire Protection Research Foundation Report (EP142293).
10. BS 8414-1 & 2:2015+A1:2017 Fire performance of external cladding systems. Test method for non-loadbearing external cladding systems applied to the masonry face of a building.
11. BR 135: 2013 Fire performance of external thermal insulation for walls of multi-storey buildings: (BR 135) Third edition. BRE Trust.
12. EN 13501-1:2007+A1:2009. Fire classification of construction products and building elements – Part 1: Classification using data from reaction to fire tests.
13. ANSI/ASTM E2307 Standard Test Method for Determining Fire Resistance of Perimeter Fire Barriers Using Intermediate-Scale, Multi-story Test Apparatus.
14. BS EN 1364-4:2014 Fire resistance tests for non-loadbearing elements.
15. AS/NZS 3837: 1998 Method of test for heat and smoke release rates for materials and products using an oxygen consumption calorimeter.

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