Garden House, Manchester

114 High Street, M4 1HQ

PAS 9980 Fire Risk Appraisal of External Walls (FRAEW)

Revision 01

21 March 2025

Summary

Brief and Scope

Garden House is an existing seven-storey residential building in Manchester. The building has undergone remediation of the external wall cladding systems following a fire engineering assessment of the external wall construction and a fire engineering review of the building.

Following completion of the remediation works, Ician Developments Limited has appointed Design Fire Consultants Ltd ("DFC") to identify the construction details and, for those which require one, conduct a fire risk appraisal of the external walls ("FRAEW") in accordance with PAS 9980.

The scope of the FRAEW is limited to risk of fire spread via the external walls of the building on the health and safety of occupants. Whilst it considers the interaction between fire spread via external walls and other fire precautions (e.g. means of warning, means of escape, inhibition of fire spread within the building and access and facilities for the fire service), it does not assess the adequacy of the other precautions, nor does it consider factors such as brand standards, property valuation or insurer requirements.

The FRAEW does not constitute a suitable and sufficient assessment of risk ("FRA") as required for compliance with the Regulatory Reform (Fire Safety) Order ("FSO"), but it can be used to inform an FRA.

PAS 9980 Risk Outcomes

PAS 9980 includes five risk level outcomes as summarised below:

- Low: The rate and extent of fire spread via the external wall construction is within normal expectation and risk is sufficiently low that no remediation is required.
- Medium (Tolerable): Risk is heighted but is nevertheless considered to be tolerable. There is potential to accept the heightened risk (subject to periodic review) provided any *risk-proportionate actions* are undertaken.
- Medium (Uncertain): Risk might be heighted, but it is not possible to determine that the risk is so high as to require risk reduction or sufficiently low that it can be tolerated.
- Medium (Upper): Risk is heightened to an extent beyond that which can be tolerated, and *risk reduction* is required.
- High: Risk is significantly heightened, and *risk reduction* (*remediation* or *mitigation*) is required.

Proportionality and Uncertainty

The purpose of an FRAEW is to inform and FRA and ultimately to determine whether risk is sufficiently low or whether risk reduction is required. PAS 9980 encourages a proportionate approach to both conducting FRAEWs and any risk reduction. Consequently, the pursuit of certainty is neither necessary nor appropriate, and a proportionate approach should be taken to the gathering of information (particularly the necessity for intrusive surveys, which can be costly, disruptive and damaging), the detail of analysis and evidence required, and any risk reduction/mitigation measures.

Where possible DFC has ensured that there is sufficient information certainty and detail of analysis to confirm that risk is either low enough to be tolerated (i.e. Low or Medium (Tolerable)) or high enough to require risk reduction (i.e. either Medium (Upper) or High). Where this has not been possible, it has been documented in this report and a risk of Medium (Uncertain) allocated.

As-Built External Wall Systems

Following review of construction documentation and the findings of intrusive surveys, the external wall constructions summarised below have been identified and assessed.

Wall Construction	Description	Key Assumptions made in the FRAEW
EWS01 Brick Walls	A brick cavity wall comprising brick cladding, an uninsulated cavity, a bitumen-based fibrous board, non-combustible sheathing board, a structural framing system (“SFS”) with mineral wool insulation and internal plasterboard.	Cavity does not have insulation. Adequate fire barriers are provided to achieve 120EI at both compartment walls and floors. The bitumen-based sheathing board is the only primary product within EWS01 construction that is combustible. However, its extent does not connect apartments in the vertical orientation, and the sheathing board is interrupted by the concrete floor slabs, and the 120EI fire barriers. At vertical and horizontal fire barrier locations, a 15mm non-combustible sheathing board is installed on top of the bitumen-based board.
EWS02a Aluminium Rainscreen Panels	A rainscreen comprising un-insulated solid aluminium panels fixed with non-combustible sheathing board onto an SFS with loose mineral wool insulation and internal plasterboard.	Primary products in the wall construction do not contribute to fire spread. Adequate fire barriers are provided to achieve 90EI at both compartment walls and floors.
EWS02b Feature Cladding	A rainscreen comprising polystyrene insulated panels faced with aluminium on the outside within an aluminium frame fixed to a bitumen-based fibrous board on an SFS with loose mineral wool insulation and internal plasterboard.	The construction has no openings, and as such is not a medium for fire spread or smoke spread between flats and, due to its location (remoteness from adjacent buildings), is not a medium for fire spread between buildings.
EWS03a Insulated Aluminium Rainscreen Panels, 6th Floor		Adequate fire barriers are provided to achieve 90EI at compartment walls. This EWS features only at the top-most occupied floor: 6th Floor, and the façade is recessed away from the building’s cladding curtilage.
EWS03b Insulated Aluminium Rainscreen Panels, Bin Chute		The construction is mechanically fixed to the external brickwork, protruding beyond the building fabric, and, due to its location (remoteness from adjacent buildings), is not a medium for fire spread between buildings.

Wall Construction	Description	Key Assumptions made in the FRAEW
EWS04 Curtain Walling	A glazed curtain walling system with polystyrene insulated aluminium spandrel panels at each floor level.	Adequate fire barriers are provided to achieve 90EI at compartment walls.
EWS05 Juliette Balconies	Metal framing. Located on First to Fifth Floors on multiple elevations.	The primary products are limited to metal and are not a medium for fire spread.
EWS06 Ground Floor Soffits	Polystyrene-backed, aluminium cladding panels fixed to the underside of concrete floor slabs. Located only at Ground Floor, on three elevations; High Street, New George Street, and internal courtyard.	Combustible materials do not span across internal compartmentation and are not a medium for fire spread over the walls of the Property.
Balconies	Projecting balconies comprising metal frames, metal balustrades and timber decking. Located in vertical stacks adjacent to one of the Feature Bays. They do not span flats laterally.	The majority of the primary products are non-combustible. The combustible component (timber decking) do not span across internal compartmentation and are not a medium for fire spread over the walls of the Property.

Assessment and Outcomes

DFC has assessed each wall construction in accordance with PAS 9980 as summarised below.

Construction Type	Remediation Conducted	Likely Fire Spread Rate (compared to normal range)	Resultant PAS Rating
EWS01 Brick Walls	Installation of adequate fire barriers at compartment walls and floors. Installation of 15mm non-combustible sheathing board to provide suitable substrate to fire barrier installation.	*Slightly faster*	Medium (Tolerable)

Construction Type	Remediation Conducted	Likely Fire Spread Rate (compared to normal range)	Resultant PAS Rating
EWS02a Aluminium Rainscreen Panels	Installation of adequate fire barriers at compartment walls and floors. Removal of combustible insulation. Installation of uninsulated aluminium rainscreen panels. Installation of 15mm non-combustible sheathing board.	*Slightly faster*	Medium (Tolerable)
EWS02b Aluminium Rainscreen Panels, Feature Cladding	None	*Normal*	Low
EWS03a Insulated Aluminium Rainscreen Panels (6th Floor)	Installation of adequate fire barriers at compartment walls and floors.	*Slightly faster*	Medium (Tolerable)
EWS03b Insulated Aluminium Rainscreen Panels, Bin Chute	Installation of adequate fire barriers at adjacent compartment walls.	*Normal*	Low
EWS04 Curtain Walling	Installation of adequate fire barriers at compartment walls and floors.	*Slightly faster*	Medium (Tolerable)
EWS05 Juliette Balconies	None	*Normal*	Low
EWS06 Ground Floor Soffits		*Normal*	Low
Balconies		*Normal*	Low

Interim Measures

Whether interim measures are required can only be determined as part of a building wide risk assessment (e.g. an FRA), however, in this instance DFC recommends that:

- There is no reason that a *stay-put* strategy is no longer appropriate due to risk of fire spread via the external wall construction.
- Interim measures are not necessary to mitigate risk of fire spread via the external wall construction.

Form EWS 1

The DFC assessment has been conducted for form EWS 1 purposes, the conclusions of the assessment are that Option B1 would be appropriate.

Recommendations

It has not been possible to confirm with sufficient confidence that the risk associated with all wall constructions 'Low' in accordance with PAS 9980. As such, the risk of fire spread via the external wall constructions is not as low as it should have been when the walls were designed and constructed.

Notwithstanding, it has been confirmed with sufficient confidence that the risk associated with all external wall constructions is at least as low as Medium (Tolerable) in accordance with PAS 9980, and as such, *risk reduction* is not necessary and might not be proportionate.

Therefore, DFC recommends:

- The FRA must be updated to accommodate the findings of the assessment herein.
- For any wall constructions with a risk rating of Medium (Tolerable), any viable ri*sk proportionate actions* should be implemented.

Additionally, if risk is not to be reduced to Low:

- Leaseholders / residents should be notified that the risk associated with the external wall construction might not be as low as it would have been had the construction been built as it should have been at the time of construction and that:
  - The risk has been assessed as being low enough to be tolerable.
  - The relevant stakeholders have decided that no proportionate risk reduction measures can be implemented, and as such, the heightened risk must be tolerated by residents.

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1 Introduction

1.1 Background and Brief

Garden House is an existing seven-storey residential building in Manchester (the "Property").

The building has undergone remediation of the external wall cladding systems following the issue of a fire engineering assessment[1] in accordance with PAS 9980[2] of the external wall construction in March 2024, which concluded that remediation was necessary to ensure that the walls adequately resist fire spread for the purpose of health and safety.

Following the completion of the remediation works, Design Fire Consultants Ltd ("DFC") has been appointed by Ician Developments Limited to assess the external wall constructions in accordance with PAS 9980.

The purpose of the assessment is to:

- Identify the external wall constructions used on the Property in sufficient detail to enable an appropriately accurate and/or conservative assessment in accordance with PAS 9980.
- Determine (and document the associated reasoning) which (if any) external wall constructions can be considered as being low risk in accordance with PAS 9980 without the need for a fire risk appraisal of external wall constructions ("FRAEW").
- Conduct an FRAEW for all external wall constructions for which an FRAEW is required in accordance with PAS 9980.
- For each external wall construction, document the risk of fire spread via the construction as defined by PAS 9980.
- For any wall constructions where risk reduction is likely to be required, identify viable risk reduction measures (interim, repair, remediation and/or mitigation) for evaluation and selection by others.
- Provide information that can be used within a suitable and sufficient assessment of risk ("FRA") as required for compliance with the Regulatory Reform (Fire Safety) Order[3] ("FSO").

1.2 Professional Competence

Details of DFC, the external wall surveyor, and the author and checker of this report can be found in Appendix P and are as summarised below:

- DFC is an independent, registered, limited company that specialises in fire engineering. DFC holds appropriate professional indemnity insurance that includes for assessments in accordance with PAS 9980, determination of necessary risk reduction measures and fire engineering design of remediation works. DFC has a robust quality assurance policy that requires that all advice is either provided or checked by an engineer registered with the Engineering Council via the Institution of Fire Engineers.
- The survey work (including intrusive surveys) has been conducted by competent architects and surveyors.

[1] Design Fire Consultants Ltd, 'Garden House, Manchester, Assessment in Accordance with PAS 9980'. 114 High Street, Manchester, M4 1HQ. Reference: 2273_R001.4, revision 04. Issued 13 March 2024.
[2] British Standards Institution, PAS 9980, 'Fire risk appraisal of external wall construction and cladding of existing blocks of flats – Code of practice', January 2022
[3] Statutory Instruments, '2005 No. 1541 Regulatory Reform, England and Wales, The Regulatory Reform (Fire Safety) Order 2005', 2005

- DFC's external wall technical leaders are Neal Butterworth and Merlyn Forrer. All other authors and checkers have had appropriate training or supervision from Neal and/or Merl.

The DFC assessment has either been conducted and/or reviewed by persons sufficiently competent to conduct the assessment for the building and external wall constructions in question.

A 'Statement of Competence to carry out a Fire Risk Appraisal of External Wall Construction' is also provided in Appendix P.

In signing this report (see page 140), the author and checker confirm that, between them, they have the relevant knowledge, skills and experience to conduct the assessments documented within this report.

1.3 Scope and Exclusions

The scope of the DFC appraisal is limited to the risk to health and safety of occupant from fire spread over the external walls of the building. As such, it:

- Considers risk of fire spread to health and safety only and does not consider other factors such as brand standards, property valuation, risk of damage from fire, insurer requirements, etc.
- Is not aimed at assessing or confirming compliance (or otherwise) with the Building Regulations (current or at the time of construction).
- Does not constitute an FRA but can be used to inform an FRA.
- Cannot provide certainty on the details of the as-built construction beyond that which is documented in the report.
- Being risk-based, is reliant on professional judgement in its assessment and in the conclusions drawn.
- Can inform but cannot define the most appropriate risk reduction measures.

Additional information regarding the legislative context of an appraisal in accordance with PAS 9980 can be found in Appendix A.

1.4 Available Information

The DFC assessment is based on the following:

- Construction documentation (reports, drawings, photographs, etc.) listed in Appendix O.1.
- Material data and fire test data / reports listed in Appendix O.2.
- Intrusive surveys and survey reports as listed in Appendix O.3.

Inevitably construction information is not always accurate and the number of sample locations and extent of 'opening-up' for intrusive inspections are necessarily limited in number and scope. Therefore, DFC's review is based on information available, and our opinion is subjective and includes uncertainty and our conclusions might change if new information becomes available.

Notwithstanding, to ensure conservative / robust conclusions, DFC had gathered information in accordance with principles discussed in Appendix D.3 and made both optimistic and conservative assumptions where there is uncertainty on the as-built construction or the fire performance of the external wall construction as discussed in Appendix D.

1.5 PAS 9980 Compliance

PAS 9980 is a code of practice for fire risk appraisal of external wall construction and cladding of existing blocks of flats.

It sets out a methodology for conducting and recording fire risk appraisals of external walls ("FRAEW"), which can be scaled up or down depending upon the complexity of individual buildings:

- Not all buildings will require an appraisal, and of those that do,
- Not all will require intrusive inspection.

The approach set out in PAS 9980 is intended to determine the need for any risk-proportionate actions in relation to external wall construction required to protect occupants of blocks of flats, including residents and their visitors, anyone working in the building and people in the immediate vicinity of the building.

PAS 9980 does not include a specific method but provides a methodology for risk appraisal and requires the user to develop their own appraisal method. DFC has developed Basic and Scored FRAEW methods (see Appendix D) that are in accordance with the PAS 9980 methodology.

Notwithstanding, there are some fundamental requirements for compliance with PAS 9980 as discussed below.

Statement of Competence: The assessment must be conducted by someone with the appropriate knowledge, skills and experience and the report must include a statement of competence (see Appendix P)

Scope: PAS 9980 is primarily for blocks of flats. If it is used for other building types, the assessor must account for (and document) the key difference between the property in question and block of flats.

Health and Safety: The scope is limited to health and safety of people in and around the building (see Section 1.3).

Assessment Process: DFC's assessment process is in accordance with PAS 9980 Figure 3 as detailed in Appendix D.2 and summarised below:

Step	PAS 9980 Objective	DFC Process
N/A	All relevant information on the building and its external walls and attachments should be established.	Gather relevant building information and conduct facade differentiation in accordance with PAS 9980 Annex G.2.1. Gather enough information about the external wall constructions to do Step 1.
1	Confirm that a full FRAEW is required.	Use principles of PAS 9980 Figure 4 to determine whether a full FRAEW is required.

Step	PAS 9980 Objective	DFC Process
2	Gather all necessary information to complete the FRAEW.	As per PAS 9980 Annex J, it is important to gather enough information to enable an FRAEW, but equally, it is important to avoid unnecessary intrusive surveys. Therefore, for each relevant wall type, DFC gathers enough information to enable Upper and Lower Bound FRAEW. Where the FRAEW does not provide adequate certainty, additional information might be gathered (e.g. via intrusive surveys) to enable a reduction in the conservatism associated with the Upper Bound and/or the optimism associated with the Lower Bound.
3	Identify and group factors that are significant in determining the risk rating.	For each relevant wall type, categorise the construction in accordance with PAS 9980 Annex G.2.2 and identify the key assessment considerations in accordance with PAS 9980 Annex G.2.3.
4	Consider each group of risk factors to determine their potential contribution to the overall risk.	For each relevant wall type, determine a risk rating based on the fire performance, facade configuration and fire strategy factors as per PAS 9980 Figure 1.
5	Review the risk factor analysis against benchmark success criteria to determine an outcome.	For each relevant wall type, review the risk factor analysis against benchmark success criteria to determine an outcome.

Risk Based Method: The appraisal must be risk based. As such it is not to be solely based on compliance with documents such as Approved Document B (“ADB”) or the Building Regulations at the time of construction. Instead, it must consider the probable consequence of fire spread via the external wall constructions (see Appendix D.4). Whilst ADB provides a useful benchmark for acceptable risk, care must be taken not unduly bias the FRAEW or risk mitigation towards ADB compliance.

Risk Factors: As a minimum, the framework requires consideration of risk factors (see Appendix D.4.2). Each of these is scored in accordance with the Positive, Neutral and Negative concepts within PAS 9980 in and used to determine the overall risk rating for the wall construction in question.

- Fire Performance Factor: a measure of the rate, extent and heat of potential fire spread via a wall construction.
- Facade Configuration Factor: a measures of any geometric features of the facade that might affect the rate, extent and or heat of fire spread.
- Fire Strategy Factor: a measure of how fire spread via an external wall construction could impact on the fire strategy of the building and vice versa.

Risk Rating: The assessment must define a risk rating of High, Medium (Upper), Medium (Tolerable) or Low, which much be benchmarked against a ‘normal range’ (see Appendix D.5.2).

Tolerable Risk: PAS 9980 acknowledges that zero risk is neither necessary nor practical. It also accepts that in some instances the risk of fire spread might be heightened from that which would have been expected when the building was built, but that the risk might still be low enough to be tolerable (see Appendix D.5).

Confidence: It is neither possible nor necessary to have absolute certainty about the details of the as-built construction. However, there needs to be sufficient confidence in the risk rating attributed to each construction. This will require that the details of the external wall constructions be determined with sufficient certainty to either enable an accurate assessment and/or the assessment includes sufficient conservatism to mitigate uncertainty (see Appendix D.4 and D.5).

Proportionality: PAS 9980 emphasizes the importance of proportionality in relation to risk and associated mitigation measures, including considerations of benefit gained, practicality and cost (see Appendix D.5.3).

1.6 PAS 9980 Risk Levels

Buildings constructed after 1985 were required, by the Building Regulations, to be constructed such that they secure a reasonable standard of health and safety from fire for those in and around the completed building.

PAS 9980 accepts that this was not always the case, and for wall constructions where it is not, PAS 9980 requires that the assessor confirms whether:

- The heightened risk is low enough to be tolerated (by the residents), or
- Risk reduction or risk mitigation is required.

As such, PAS 9980 includes five risk level outcomes as summarised below:

- Low: The rate and extent of fire spread via the external wall construction is within normal expectation and risk is sufficiently low that no remediation is required.
- Medium (Tolerable): Risk is heighted but is nevertheless considered to be tolerable. There is potential to accept the heightened risk (subject to periodic review) provided any *risk-proportionate actions* are undertaken.
- Medium (Uncertain): Risk might be heighted, but it is not possible to determine that the risk is so high as to require risk reduction or sufficiently low that it can be tolerated.
- Medium (Upper): Risk is heightened to an extent beyond that which can be tolerated and *risk reduction* is required.
- High: Risk is significantly heightened, and *risk reduction* (*remediation* or *mitigation*) is required.

1.7 Definitions and Terminology

This report uses technical definitions and terminology. These are *italicised* within the report and defined or described in Appendix B.

2 Building Information

2.1 The Building

2.1.1 General

- Approximate construction completion date: June 2003
- Purpose group (type of occupancy): 1(a) Flat.
- Number of flats: 47
- *Evacuation zones*: The building is not separated into different evacuation zones.
- Intended evacuation strategy: *Stay-put*.
- Number of storeys: Seven.
- *Storey height*: 18.7m.

The building does not meet any of the criteria that would exclude it from requiring appraisal (see Appendix D.2.1.1).

Figure 1 shows the general arrangement floor plans for Ground and First Floors as an indication.

Figure 1: Ground Floor (Left), and First Floor (Right) General Arrangement Plan

2.2 The Fire Strategy

2.2.1 Principles

The DFC assessment needs to consider the impact that fire spread via the external wall constructions might have on the overall fire strategy for the building, but it does not need to identify or document the detailed fire strategy for the building.

Therefore, the following sections summarise the key principles of the probable fire strategy for the building so far as has been possible and so far as is necessary to determine for the purposes of the DFC assessment.

Where assumptions have been made (e.g. because there is no fire strategy documentation available and it has not been able to ascertain from survey documents or data), the assumptions have been made based on the minimum measures that would have been required for compliance with design guidance at the time of construction.

This is a reasonable and conservative approach. Furthermore, if any of the assumptions are found to be incorrect, it is likely that either an alternative fire strategy is in place (e.g. if there are not protected entrance halls, flats might be sprinkler protected), or the measure needs to be correct (e.g. if compartmentation is not adequately installed or fire stopped, this would have to be rectified).

2.2.2 Assisted Evacuation

The following assumptions are made:

- For escape from within flats to a place of temporary, ‘relative’ safety (i.e. a protected stair), either:
  - Residents are able to self-evacuate, or
  - Bespoke provisions are put in place for assisted evacuation.
- For escape from a place of temporary, ‘relative’ safety (i.e. a protected stair) to outside the building, either:
  - Residents are able to self-evacuate, or
  - Management provisions are put in place to provided assisted evacuation (e.g. via the firefighting lifts or via ‘carry-down’), or
  - Residents will wait to be assisted by the fire service (e.g. via the firefighting lifts or via ‘carry-down’).

The assessment herein ensures that any heightened risk of fire spread via the external wall constructions does not compromise or hinder the above procedures. This is typically achieved by ensuring that the risk of fire spread to protected stairs is not increased by any heightened risk of fire spread via the external wall constructions.

2.2.3 Means of Warning

Based on available information, it is reasonable to assume that:

- All flats are protected by self-contained, in-flat fire alarms comprising at least one smoke detector within protected entrance halls.
- There is no common fire alarm system other than any detectors required to active automatic smoke venting systems.

2.2.4 Means of Escape

Within Flats

Some flats have been inspected, and each case the flat had a protected entrance hall. Therefore, it is reasonable to assume that all flats include a protected entrance hall enclosed in *30EI* construction with *FD20* doors.

Common Corridors

There is a single, central stair that serves First to Sixth Floor, and discharges via an exit passageway directly to outside at Ground Floor.

At each upper-floor there are two common corridors from the stair. Each common corridor is less than 7.5m long.

The following assumptions would typically have been required for compliance with approved guidance at the time of construction (and as such are reasonable) and should be ensured (i.e. if they are not correct, measures need to be taken to comply with the assumptions as opposed to requiring change to the FRAEW):

- The stair is enclosed in construction that achieves at least *60EI* and that has *FD60(s)* doors.
- The stair is protected by a passive / natural smoke vent at the head of the stair.
- All common corridors are enclosed in construction that achieves at least *60EI* and that all flats have *FD30(S)* doors.
- All common corridors are protected by a passive / natural smoke venting system.

The stair, and common corridors do not have openings (windows) onto any of the external wall constructions.

The stair discharges via an exit passageway directly to outside at Ground Floor.

2.2.5 Compartmentation

The following assumptions would typically have been required for compliance with approved guidance at the time of construction (and as such are reasonable) and should be ensured (i.e. if they are not correct, measures need to be taken to comply with the assumptions as opposed to requiring change to the FRAEW):

- All floors are compartment floors that achieve at least *60EI*.
- All flats are enclosed in construction that achieves at least *60EI*.
- Common corridors are enclosed in construction that achieves at least *60EI*.
- Stairs, lifts shafts and risers are enclosed in construction that achieves at least *60EI* with FD60(s) doors.

2.2.6 Sprinklers

No parts of the building are protected by an automatic sprinkler system.

2.2.7 Separation between Buildings

Unless confirmed otherwise, it is assumed that:

- Any unprotected areas (i.e. parts of the external wall construction that do not achieve at least *60E 15I*) are sufficiently small for the purposes of preventing fire spread between adjacent buildings.
- No part of the building is within 1m of a relevant boundary.

2.2.8 Fire Service Access and Facilities

Unless confirmed otherwise, it is assumed that the building has an internal fire service access strategy and therefore:

- Access is available to within 18m of the fire service entry point for fire service vehicles.
- The building has a firefighting lift.
- The building has a dry riser that results in adequate coverage for fire service hoses.
- The stair and common corridor are protected by adequate smoke venting system(s).

3 As-Built External Wall Constructions

3.1 Information Certainty

DFC has been provided with drawings and photos showing the details of this external wall construction. Development of this external wall construction has also been observed by DFC at periodic inspections on site during the remediation works.

3.2 External Wall Constructions

3.2.1 Elevations

Figure 2 and Figure 3 indicate extent and location of wall types for reference.

Figure 2: Elevation 1 (High Street) indicating wall types

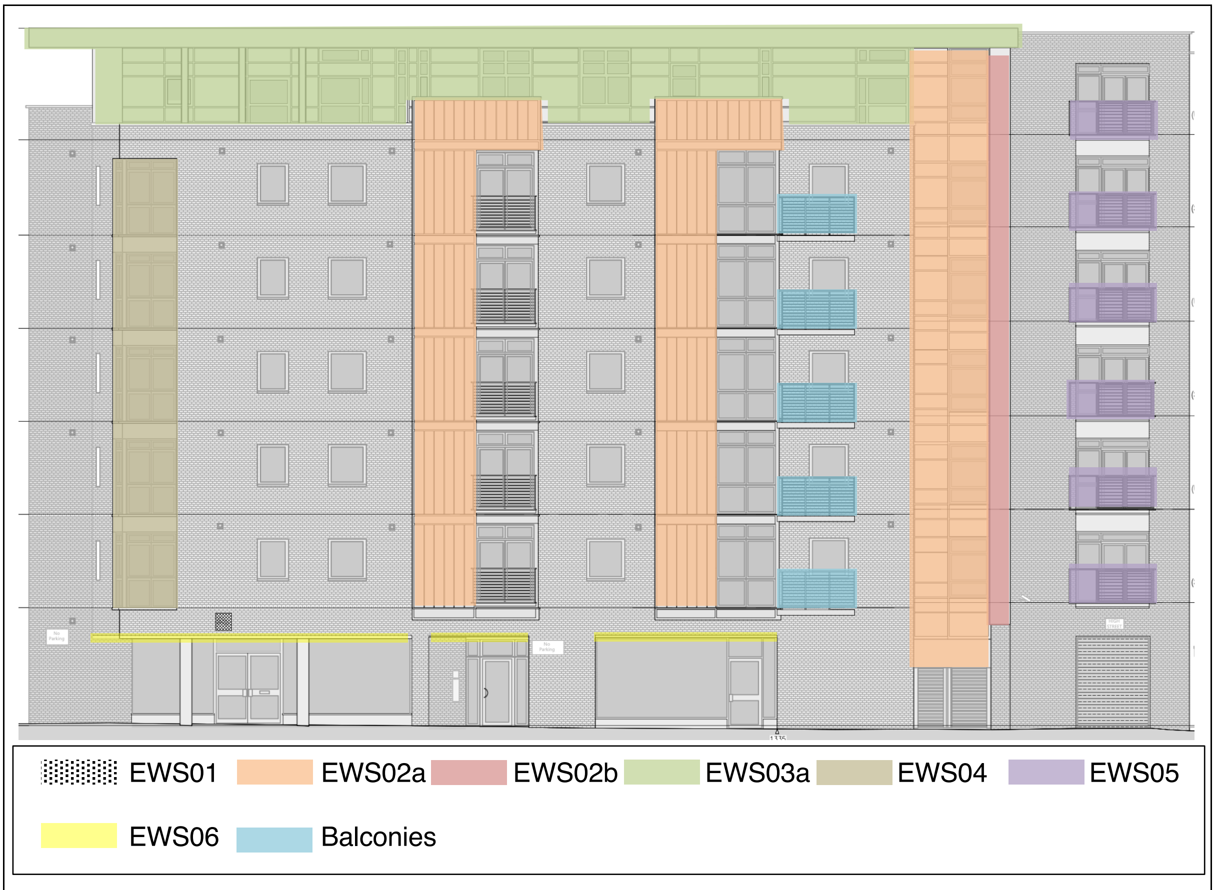
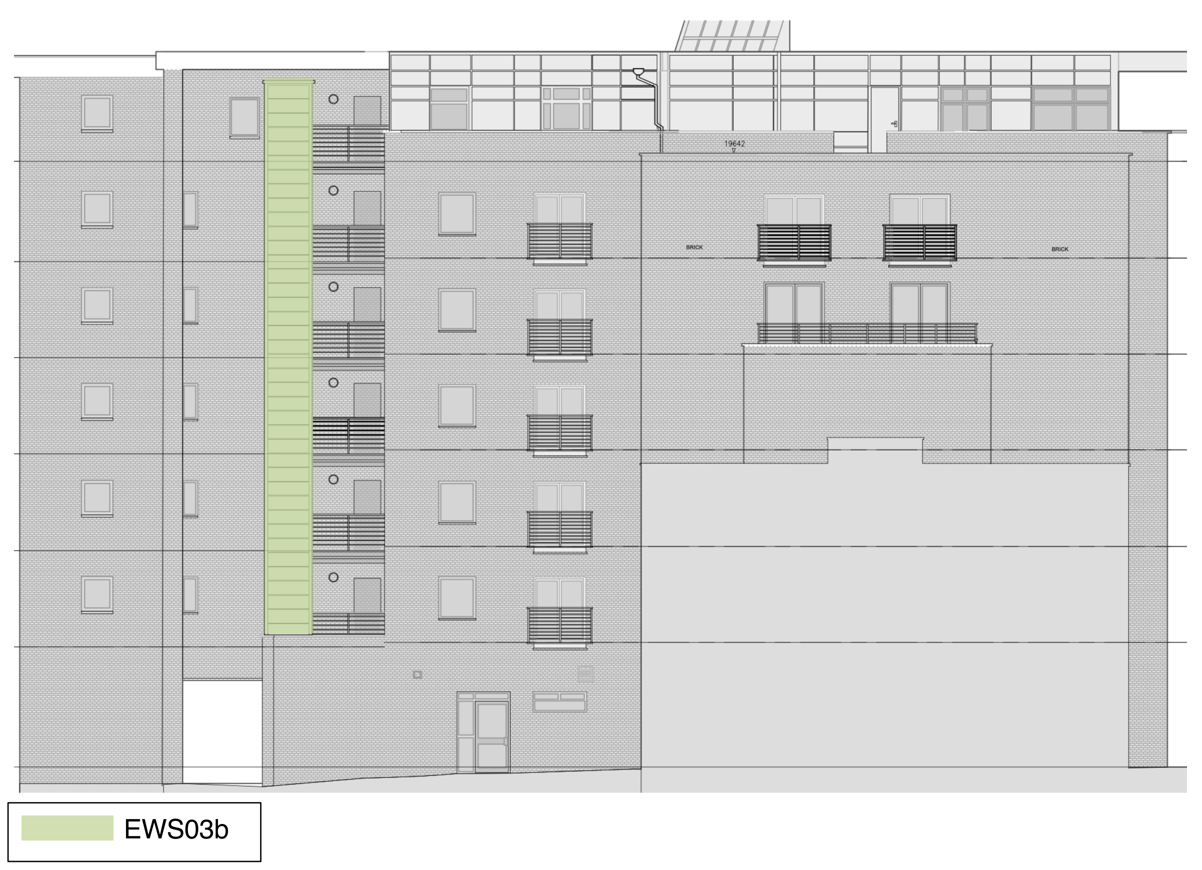


Figure 3: Elevation 5 – Inner Courtyard, indicating EWS03b (Insulated Rainscreen – Bin Chute)



3.2.2 Summary of External Wall Systems

Table 1 below details a brief description of the external wall systems; their locations and the remediation works conducted (where appropriate).

Table 1: Summary of External Wall Systems and remediation conducted

Construction Type	Location	Description	Remediation Conducted
EWS01 Brick Walls	Located on multiple elevations from Ground Floor to Sixth Floor.	A brick cavity wall comprising brick cladding, an uninsulated cavity, a bitumen-based fibrous board, non-combustible sheathing board, a structural framing system ("SFS") with mineral wool insulation and internal plasterboard	Installation of adequate fire barriers at compartment walls and floors. Installation of 15mm non-combustible sheathing board to provide suitable substrate to fire barrier installation.
EWS02a Aluminium Rainscreen Panels	Located on multiple elevations from	A rainscreen comprising un-insulated solid	Installation of adequate fire barriers at

Construction Type	Location	Description	Remediation Conducted
	Ground to Sixth Floors.	aluminium panels fixed with non-combustible sheathing board onto an SFS with loose mineral wool insulation and internal plasterboard.	compartment walls and floors. Removal of combustible insulation. Installation of uninsulated aluminium rainscreen panels. Installation of 15mm non-combustible sheathing board.
EWS02b Aluminium Rainscreen Panels, Feature Cladding	Elevation 1 (High Street). Narrow vertical strip adjacent to bedroom windows of flats 103, 203, 303, 403 and 502, and 602.	A rainscreen comprising polystyrene insulated panels faced with aluminium on the outside within an aluminium frame fixed to a bitumen-based fibrous board on an SFS with loose mineral wool insulation and internal plasterboard.	None
EWS03a Insulated Aluminium Rainscreen Panels (6th Floor)	Located on multiple elevations, only on 6th Floor (top-most occupied storey).		Installation of adequate fire barriers at compartment walls and floors.
EWS03b Insulated Aluminium Rainscreen Panels, Bin Chute	Inner Courtyard – Elevation 5; from First to Sixth Floors.		Installation of adequate fire barriers at adjacent compartment walls.
EWS04 Curtain Walling	Located on numerous elevations from Ground Floor to Sixth Floor in vertical strips. The construction is only associated with living rooms.	A glazed curtain walling system with polystyrene insulated aluminium spandrel panels at each floor level.	Installation of adequate fire barriers at compartment walls and floors.
EWS05 Juliette Balconies	Located on First to Fifth Floors on multiple elevations	Metal frame balcony.	None.
EWS06 Ground Floor Soffits	Located only at Ground Floor, on three elevations; High Street, New George	Polystyrene-backed, aluminium cladding panels fixed to the underside of concrete floor slabs.	None.

Construction Type	Location	Description	Remediation Conducted
	Street, and internal courtyard.		
Balconies	Located in vertical stacks adjacent to one of the Feature Bays. They do not span flats laterally.	Projecting balconies comprising metal frames, metal balustrades and timber decking.	None.

4 PAS Step 1: Need for FRAEWs

4.1 Principles

There are some wall constructions that are obviously low risk without having to conduct any assessment of FRAEW (see Appendix D.2.1.2).

It is reasonable to exclude these constructions from assessment at the outset.

4.2 Qualifying External Wall Constructions

In this instance, the following constructions are clearly low risk without the need for further assessment or any need for an FRAEW.

Table 2: Summary of obviously Low risk constructions

Wall Construction	Location / Description	Reason for Low Risk
EWS02b Aluminium Rainscreen Panels Feature Cladding	Elevation 1 (High Street). Narrow vertical strip adjacent to bedroom windows of flats 103, 203, 303, 403 and 502, and 602.	The construction has no openings, and as such is not a medium for fire spread or smoke spread between flats and, due to its location (remoteness from adjacent buildings), is not a medium for fire spread between buildings.
EWS03b Insulated Aluminium Rainscreen Panels Bin Chute	Inner Courtyard – Elevation 5; from First to Sixth Floors.	The construction does not span internal compartment walls, and compartment floors. The construction is mechanically fixed to the external brickwork, protruding beyond the building fabric, and, due to its location (remoteness from adjacent buildings), is not a medium for fire spread between buildings.
EWS05 Juliette Balconies	Located on First to Fifth Floors on multiple elevations.	The *primary products* are limited to metal and are not a medium for fire spread.
EWS06 Ground Floor Soffits	Ground Floor; Elevations 1 (High Street) Elevation 4 (New George Street) Elevation 2 (Internal Courtyard)	Combustible materials do not span across internal compartmentation and are not a medium for fire spread over the walls of the Property.

Wall Construction	Location / Description	Reason for Low Risk
Balconies	Located on First to Fifth Floors on multiple elevations.	As per Appendix G, the fuel load is low (limited to horizonal timber decking) and the consequences are medium (accessible to fire service).

4.3 EWS02b (Aluminium Rainscreen—Feature Cladding)

The construction details of this external wall system is as detailed in Section 5.4.

4.4 EWS03b (Aluminium Rainscreen—Bin Chute)

The construction details of this external wall system is as detailed in Section 5.4.

4.5 EWS05 Juliette Balcones

4.5.1 *Products*

Primary products are limited to metal framing.

Secondary products are limited to seals, sealants, gaskets, membranes, doors, windows, fire barriers and similar items that are not a medium for fire spread between internal compartments or over the walls of the building.

4.5.2 Concealed Spaces (Cavities)

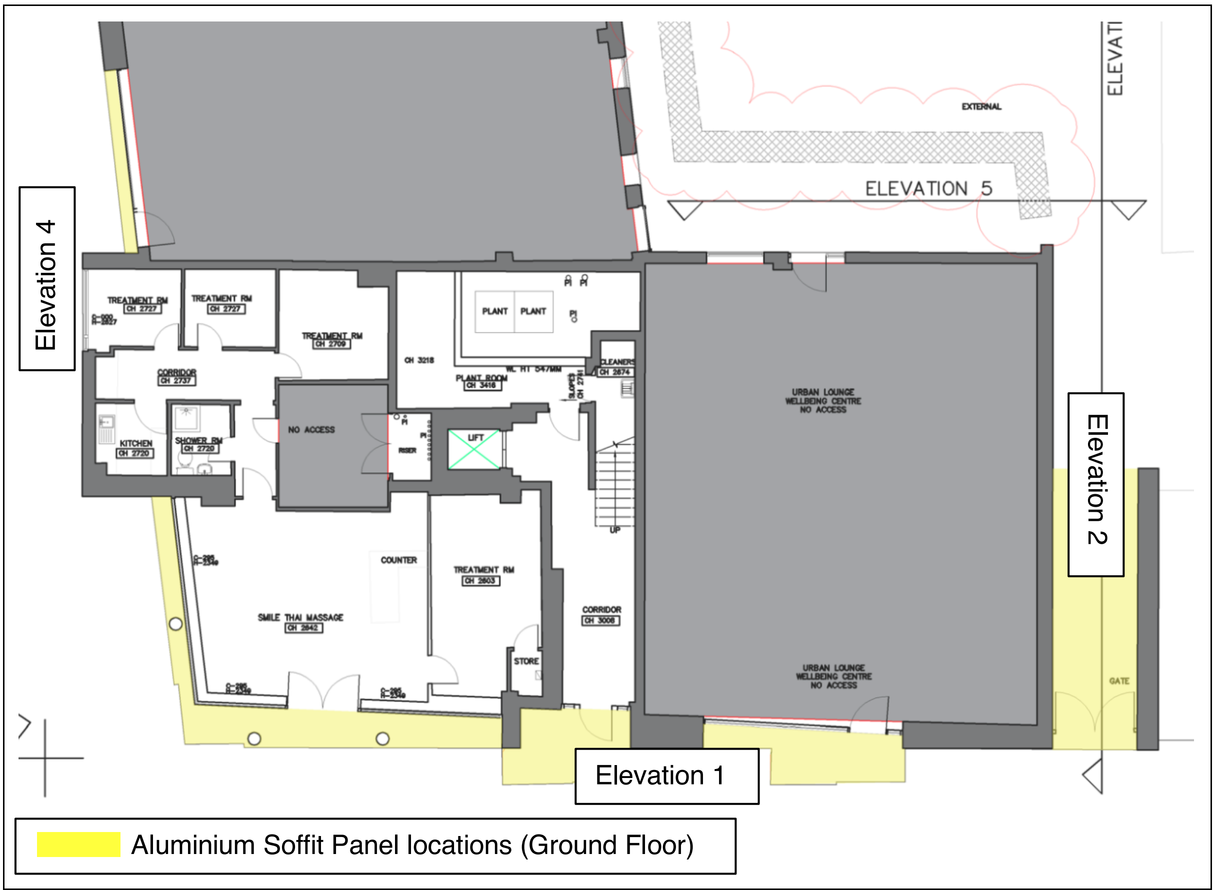
There are no cavities.

4.6 EWS06 Ground Floor Soffits

4.6.1 Location

The aluminium soffit panels are located as shown below.

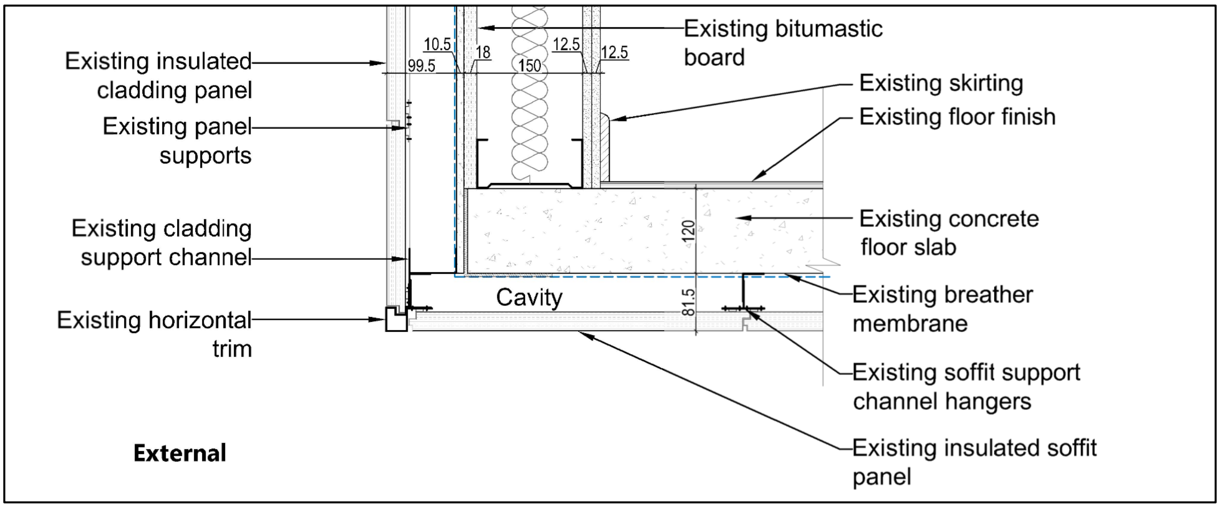
Figure 4: Soffit locations (Ground Floor)



4.6.2 *Products*

A list of the *primary products* used in the construction are shown in the figure below.

Figure 5: Typical construction detail



Secondary products are limited to seals, sealants, gaskets, membranes, doors, windows, fire barriers and similar items that are not a medium for fire spread between internal compartments or over the walls of the building.

4.6.3 Concealed Spaces (Cavities)

There are no *cavity barriers* installed.

4.7 Balconies

4.7.1 Products

There are projecting balconies comprising metal frames, metal balustrades and timber decking.

5 Basic FRAEWs

5.1 Qualifying External Wall Constructions

DFC's Basic FRAEW methodologies are described in Appendix E along with a brief description of the criteria against which the suitability of the system for Basic FRAEW.

In this instance, the following constructions are suitable for a Basic FRAEW as summarised below.

Table 3: Summary of obviously Low risk constructions

Wall Construction	Location / Description	Reason for Basic FRAEW
EWS01 Brick Wall	Located on multiple elevations from Ground Floor to Sixth Floor.	A full FRAEW is required because the as-built construction does not comply with any of the options listed in Appendix D.2.1.2.
EWS02a Aluminium Rainscreen Panels	Located on multiple elevations from Ground to Sixth Floors.	
EWS03a Insulated Aluminium Rainscreen Panels (6^{th} Floor)	Located on multiple elevations, on Sixth Floor only.	
EWS04 Curtain Walling	Located on numerous elevations from Ground Floor to Sixth Floor in vertical strips. The construction is only associated with living rooms.	

5.2 EWS01 Brick Walls

5.2.1 *Products*

A list of the *primary products* used in the construction is provided in the table below.

Table 4: Construction products and build-up

	Product	Generic Description
Substrate (SFS)	Plasterboard	2 layers of internal 12.5mm plasterboard
	Cavity with metal frame and loose fill mineral wool insulation	Metal Frame with Mineral Wool
	Calcium Silicate Board 'Benx Y-Wall'	15mm non-combustible sheathing board
	Bitumen based sheathing board	*Combustible* sheathing board[Note 1]

	Product	Generic Description
Cavity	Cavity with brick support system and cavity trays	Cavity
Cladding	Brick cladding	Brick

Notes:
1 Confirmed by testing conducted by Sandberg

Error! Reference source not found. and **Error! Reference source not found.** show the typical; construction details at slab-level, and at party-wall junction for the Brick wall construction.

Figure 6: Typical construction details at slab-level (Brick wall)

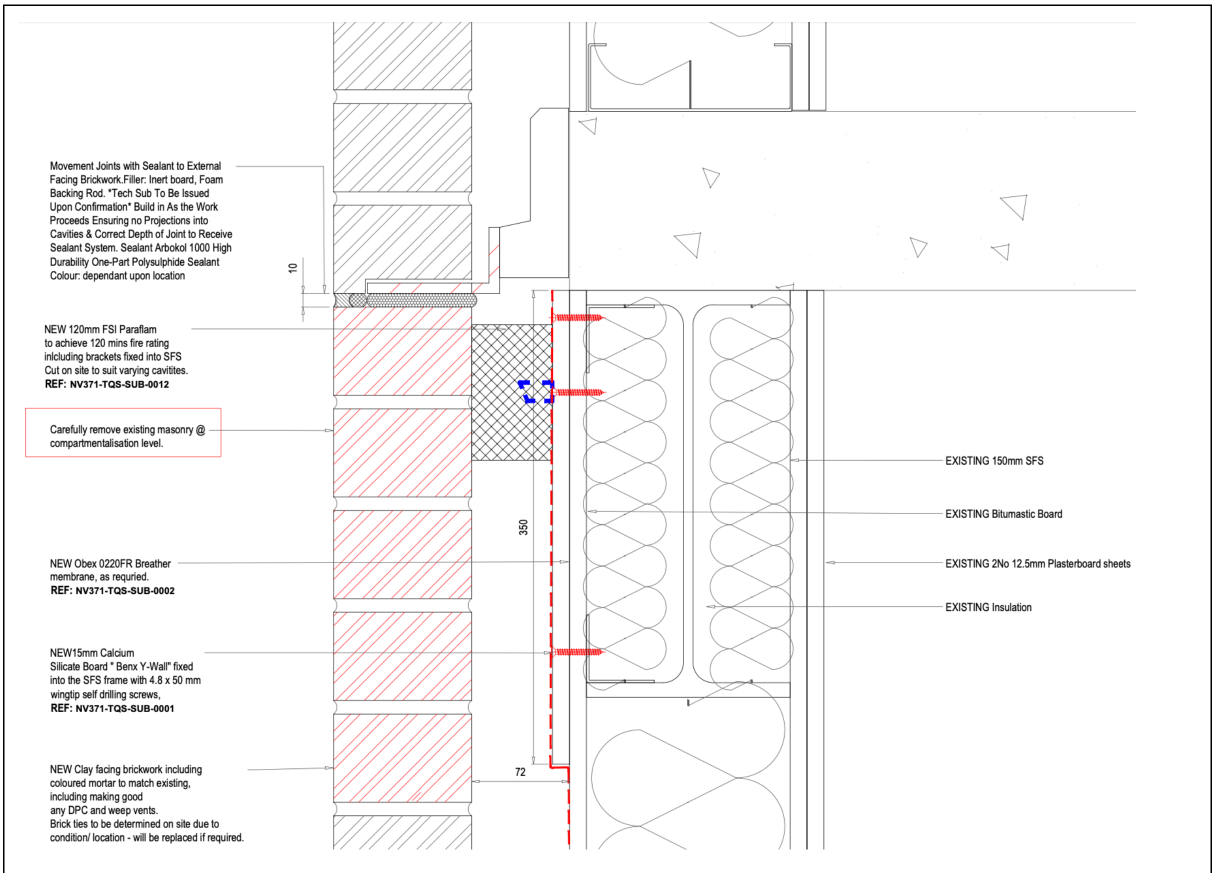
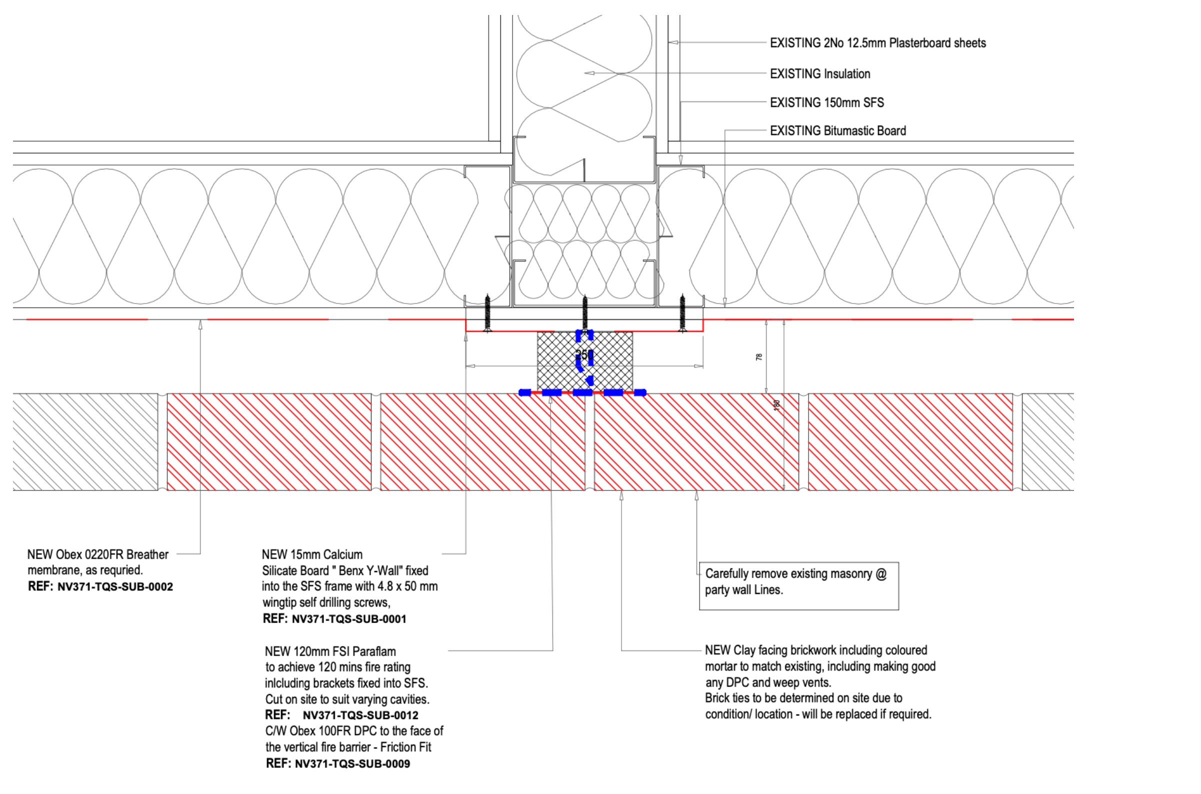


Figure 7: Typical construction details at party-wall junction (Brick wall)



Secondary products are limited to seals, sealants, gaskets, membranes, doors, windows, fire barriers and similar items that are not a medium for fire spread between internal compartments or over the walls of the building.

5.2.2 Concealed Spaces (Cavities)

As part of the remedial works, fire barriers have been provided within the external wall construction in the gaps at junctions with compartment walls, and compartment floors.

From the information provided (as referenced in Appendix O), **Error! Reference source not found.** details the cavity barrier provisions.

Table 5: Cavity barrier provisions

Location	*Product*
Edges at Heads	No provision unless at compartment floor locations.
Edges at Bases	
Edges at Sides	No provision unless at compartment wall locations.
Edges at Interfaces	No subdivision at interface between Brick and Aluminium Cladding Panels unless at compartment floor and wall locations.

Edges at Openings	No provision.
Compartment Floors	120mm FSI Paraflam fire barrier to achieve 120EI.
Compartment Walls	Fischer FCFcl 75 fire barrier at apartment party walls to achieve 120EI at First to Sixth Floors. 120mm FSI Paraflam to achieve 120EI at wall junction of stair discharge route at Ground Floor.

5.2.3 Quality of Construction and Workmanship

During the remediation works, Thomasons and Sweco Building Control undertook regular inspections. DFC also carried out periodic site inspections to check the quality of installations.

5.2.4 PAS 9980 Step 2: As-Built Construction Information

Key Components

The construction is a cavity wall. Therefore, the key materials and products (see Appendix I.2) and system components (see Appendix I.3.2) have been identified in Section 5.2.1.

5.2.5 PAS 9980 Steps 3 and 4: Risk Appraisal

5.2.6 Materials and Products

The thermodynamic and thermomechanic characteristics of relevant products that are used to assess the fire performance factor are summarised below.

Bitumen Board

The bitumen board has been tested by Sandberg and been confirmed as comprising wood fibres in a bitumen binder and being both combustible (Sandberg definition: ignitable by a Bunsen burner) and flammable (Sandberg definition: continue to burn after source of heat is removed).

Whilst Bunsen burner test is not relevant to construction industry definitions of combustible, the composition of the boards is such that they are *combustible*.

Based on the composition and experience from similar boards that have been tested, the ignition and combustion characteristics of the boards are likely to be:

- When faces are exposed:
  - Faces are readily ignitable.
  - Boards will gradually burn including away from the original heat source.
- When faces are sandwiched between elements that are not combustible (e.g. cavity barriers or metal studs):
  - Leading edge is readily ignitable.
  - Boards will gradually burn but a char layer will form preventing / inhibiting continued combustion.

DFC has been informed that the boards are friable.

Therefore, the characteristics of boards are:

- Thermodynamic: When ‘unprotected’ the boards are ignitable and will burn. If the faces are protected, the boards will ignite and burn locally, but not significantly longitudinally.
- Thermomechanic: When ‘free’, the boards could deteriorate or be damaged. When ‘supported’, the boards will remain in place and can act as a substrate for cavity barriers.

Fire Performance Factor

The fire performance has been assessed using the method defined in Appendix E against the key components (with conservative assumptions to account for any uncertainty) as summarised below.

Table 6: Fire performance assessment

Component	Assessment	Factor
Insulation	Insulation within the SFS is mineral wool; a non-combustible product that does not contribute significantly to fire, and is not considered a medium for fire spread over the walls.	Positive
Cavity	The cavity is sub-divided at junctions with internal compartment floors and walls by fire barriers that achieve 120EI. However, cavity barriers are not provided elsewhere (e.g., between different external wall types) to subdivide cavities. The substrate features Bitumen Board; confirmed as combustible and flammable.	Neutral
Cladding	The cladding is brick, a non-combustible material that does not contribute to fire spread.	Positive

The resultant overall fire performance factor is defined against PAS 9980 ratings and benchmark example wall constructions as summarised below.

Figure 8: Fire performance benchmarking

Benchmark Examples	Cat 3 ACM, Polystyrene, HPL Standard	Thin timber, Thick timber	HPL Fire Retardant, Category 2 ACM	BR 135 compliant, Linear Route, Brick cavity wall
EWS01			■	
Rating	High	Medium	Tolerable	Low
Likely Rate	*Very fast*	*Fast*	*Faster*	*Normal*
Likely Extent	*Uncontrolled*	*Far*	*Further*	*Normal*
Likely Heat	*Very high*	*High*	*Higher*	*Normal*

Notes:
1 The benchmarks are based on experience and professional judgement, and as such are approximate. DFC is funding research to enable quantified benchmarking of different systems and will publish the information in due course.

Therefore, the risk rating is Medium (Tolerable) when considering the fire performance factor in isolation and risk has been confirmed as being sufficiently low without the need to consider the facade configuration or fire strategy factors.

5.2.7 PAS 9980 Step 5: Risk Rating

It has been confirmed with sufficient confidence and/or conservatism that the risk rating is at least as low as Medium (Tolerable) because the fire performance and facade configuration factors are clearly such that the construction is not a medium for fire spread between flats, or over the walls of the building, or between buildings.

5.2.8 Confidence

A Medium (Tolerable) rating is reasonable due to the following:

- The junctions with compartment walls, and compartment floors are provided with adequate fire barriers (to achieve 120EI). Therefore, reducing the likelihood of extensive fire spread between floors, and apartments.

- The bitumen-based sheathing board is the only primary product within EWS01 construction that is combustible. However, its extent does not connect apartments in the vertical orientation, and the sheathing board is interrupted by the concrete floor slabs, and the 120EI fire barrier.

5.2.9 Recommended Action

Even under conservative assumptions the risk is sufficiently low that it can be tolerated, and as such, the resultant actions are:

- The *FRA* should be updated to accommodate the findings of this assessment.

- Consideration should be given as to whether risk can be reduced further via *risk-proportionate action* through the *FRA* process.

- Subject to confirmation from the *FRA*, a *stay-put* evacuation strategy remains viable.

5.3 EWS02a Aluminium Rainscreen Panels

5.3.1 *Products*

A list of the *primary products* used in the construction is provided in the table below.

Table 7: Construction products and build-up

	Product	**Generic Description**
Substrate (SFS)	Plasterboard	2 layers of internal 12.5mm plasterboard
	Cavity with metal frame and loose fill mineral wool insulation	Metal Frame with Mineral Wool

	Product	Generic Description
	Calcium Silicate Board 'Benx Y-Wall'	15mm non-combustible sheathing board
Cavity	Cavity with 50mm Rockwool DuoSlab mineral wool insulation.	Cavity with mineral wool insulation fixed to substrate.
Cladding	3mm aluminium rainscreen cladding; Metalline Unity A2 DF with recessed joints. Includes mechanically fixed OSCI barrier insert within the panel at fire barrier locations.	Aluminium cladding panel.

Error! Reference source not found. and **Error! Reference source not found.** show the typical construction details at slab-level, and through a horizontal section for the aluminium rainscreen panel construction.

Figure 9: Typical construction details at slab-level (Aluminium Rainscreen Panel)

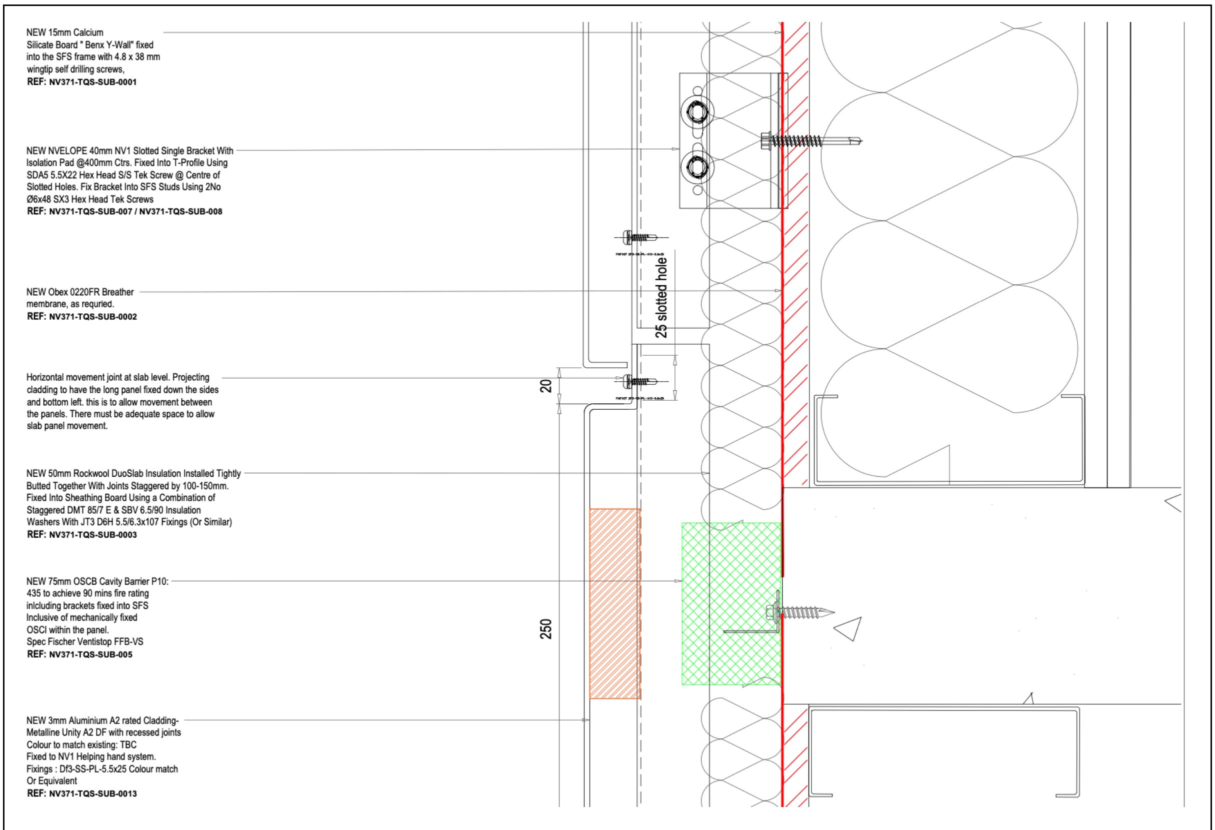
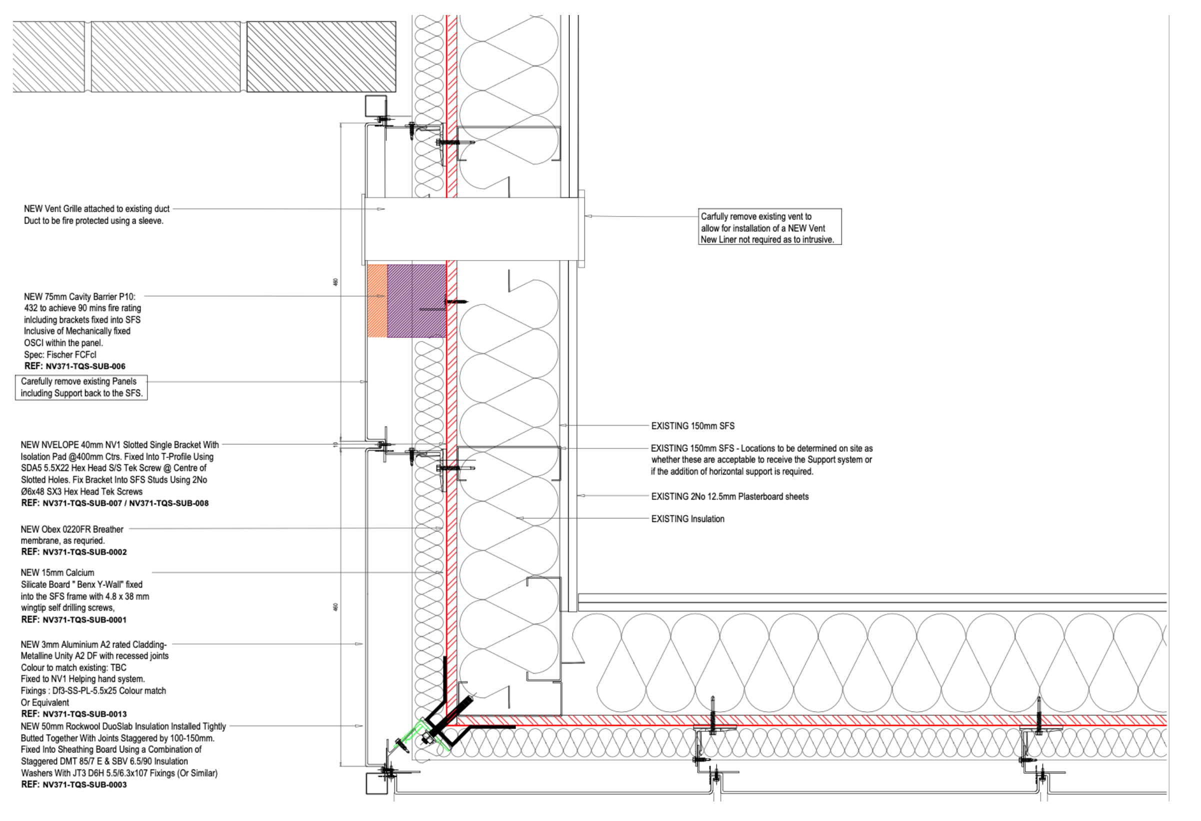


Figure 10: Typical construction detail—horizontal section (Aluminium Rainscreen Panel)



Secondary products are limited to seals, sealants, gaskets, membranes, doors, windows, fire barriers and similar items that are not a medium for fire spread between internal compartments or over the walls of the building.

5.3.2 Concealed Spaces (Cavities)

As part of the remedial works, fire barriers have been provided within the external wall construction in the gaps at junctions with compartment walls, and compartment floors.

From the information provided (as referenced in Appendix O), **Error! Reference source not found.** details the cavity barrier provisions.

Table 8: Cavity barrier provisions

Location	***Product***
Edges at Heads	No provision unless at compartment floor locations.
Edges at Bases	
Edges at Sides	No provision unless at compartment wall locations.
Edges at Interfaces	No subdivision at interface between Brick and Aluminium Cladding Panels unless at compartment floor and wall locations.

Location	*Product*
Edges at Openings	No provision.
Compartment Floors	75mm OSCB (open state) fire barrier to achieve 90EI, with a mechanically-fixed OSCI barrier insert within the aluminium cladding panel.
Compartment Walls	75mm Fischer FCFcl fire barrier at apartment party walls to achieve 90EI, abutting against a mechanically-fixed OSCI barrier insert within the aluminium cladding panel.

5.3.3 Quality of Construction and Workmanship

During the remediation works, Thomasons and Sweco Building Control undertook regular inspections. DFC also carried out periodic site inspections to check the quality of installations.

5.3.4 PAS 9980 Step 2: As-Built Construction Information

Key Components

The construction is a rainscreen system. Therefore, the key materials and products (see Appendix I.2) and system components (see Appendix I.3.2) have been identified in Section 5.3.1.

5.3.5 PAS 9980 Steps 3 and 4: Risk Appraisal

5.3.6 Materials and Products

The thermodynamic and thermomechanic characteristics of relevant products that are used to assess the fire performance factor are summarised below.

Aluminium

Aluminium is a metal and is not *combustible*. It starts to lose strength at around 300°C and melts at around 600°C.

Therefore, it does not burn. Whether it melts depends on its thickness and the extent of fire exposure. Thin aluminium (e.g. that used in *ACM* panels) would heat up quickly and is likely to melt when exposed to flames. However, thicker aluminium (e.g. 3mm thick aluminium cladding panels and cladding rails) does not necessarily melt, particularly if heat can be conducted and radiated away from the *product*.

Therefore, the characteristics of aluminium are:

- Thermodynamic: Aluminium will not burn and does not contribute to the heat of fire or spread of fire.
- Thermomechanic: Aluminium can melt and distort.

Fire Performance Factor

The fire performance has been assessed using the method defined in Appendix E against the key components (with conservative assumptions to account for any uncertainty) as summarised below.

Table 9: Fire performance assessment

Component	Assessment	Factor
Insulation	Insulation is mineral wool; a non-combustible product that does not contribute significantly to fire, and is not considered a medium for fire spread over the walls.	Positive
Cavity	The cavity is sub-divided at junctions with internal compartment floors and walls by fire barriers that achieve 90EI. However, cavity / fire barriers are not provided elsewhere (e.g., between different external wall types) to subdivide cavities. The sheathing board is non-combustible; comprises calcium silicate board.	Positive
Cladding	The cladding is un-insulated aluminium, a non-combustible material that does not contribute to fire spread, but is likely to distort.	Positive

The resultant overall fire performance factor is defined against PAS 9980 ratings and benchmark example wall constructions as summarised below.

Figure 11: Fire performance benchmarking

Benchmark Examples	Cat 3 ACM, Polystyrene, HPL Standard	Thin timber, Thick timber	HPL Fire Retardant, Category 2 ACM	BR 135 compliant, Linear Route, Brick cavity wall
EWS02				
Rating	High	Medium	Tolerable	Low
Likely Rate	*Very fast*	*Fast*	*Faster*	*Normal*
Likely Extent	*Uncontrolled*	*Far*	*Further*	*Normal*
Likely Heat	*Very high*	*High*	*Higher*	*Normal*

Notes:

1 The benchmarks are based on experience and professional judgement, and as such are approximate. DFC is funding research to enable quantified benchmarking of different systems and will publish the information in due course.

Therefore, the risk rating is Medium (Tolerable) when considering the fire performance factor in isolation and risk has been confirmed as being sufficiently low without the need to consider the facade configuration or fire strategy factors.

5.3.7 PAS 9980 Step 5: Risk Rating

It has been confirmed with sufficient confidence and/or conservatism that the risk rating is at least as low as Medium (Tolerable) because the fire performance and facade configuration factors are clearly such that the construction is not a medium for fire spread between flats, or over the walls of the building, or between buildings.

5.3.8 Confidence

A Medium (Tolerable) rating is reasonable due to the following:

- The junctions with compartment walls, and compartment floors are provided with adequate fire barriers (to achieve 120EI). Therefore, reducing the likelihood of extensive fire spread between floors, and apartments.
- The primary products in the EWS02 construction are non-combustible, and therefore do not contribute to extensive fire growth and spread.

5.3.9 Recommended Action

Even under conservative assumptions the risk is sufficiently low that it can be tolerated, and as such, the resultant actions are:

- The *FRA* should be updated to accommodate the findings of this assessment.
- Consideration should be given as to whether risk can be reduced further via *risk-proportionate action* through the *FRA* process.
- Subject to confirmation from the *FRA*, a *stay-put* evacuation strategy remains viable.

5.4 EWS03a Insulated Aluminium Rainscreen Panels (6th Floor)

5.4.1 *Products*

A list of the *primary products* used in the construction is provided in the table below.

Table 10: Construction products and build-up

	Product	**Generic Description**
Substrate (SFS)	Plasterboard	2 layers of internal 12.5mm plasterboard
	Cavity with metal frame and loose fill mineral wool insulation	Metal Frame with Mineral Wool
	Bitumen based sheathing board (with occasional cement particle board)	*Combustible* sheathing board[Note 1]
Cavity	Cavity with cladding support system	Cavity

	Product	Generic Description
Cladding	Polystyrene backed aluminium cladding panels	Aluminium with polystyrene backing.

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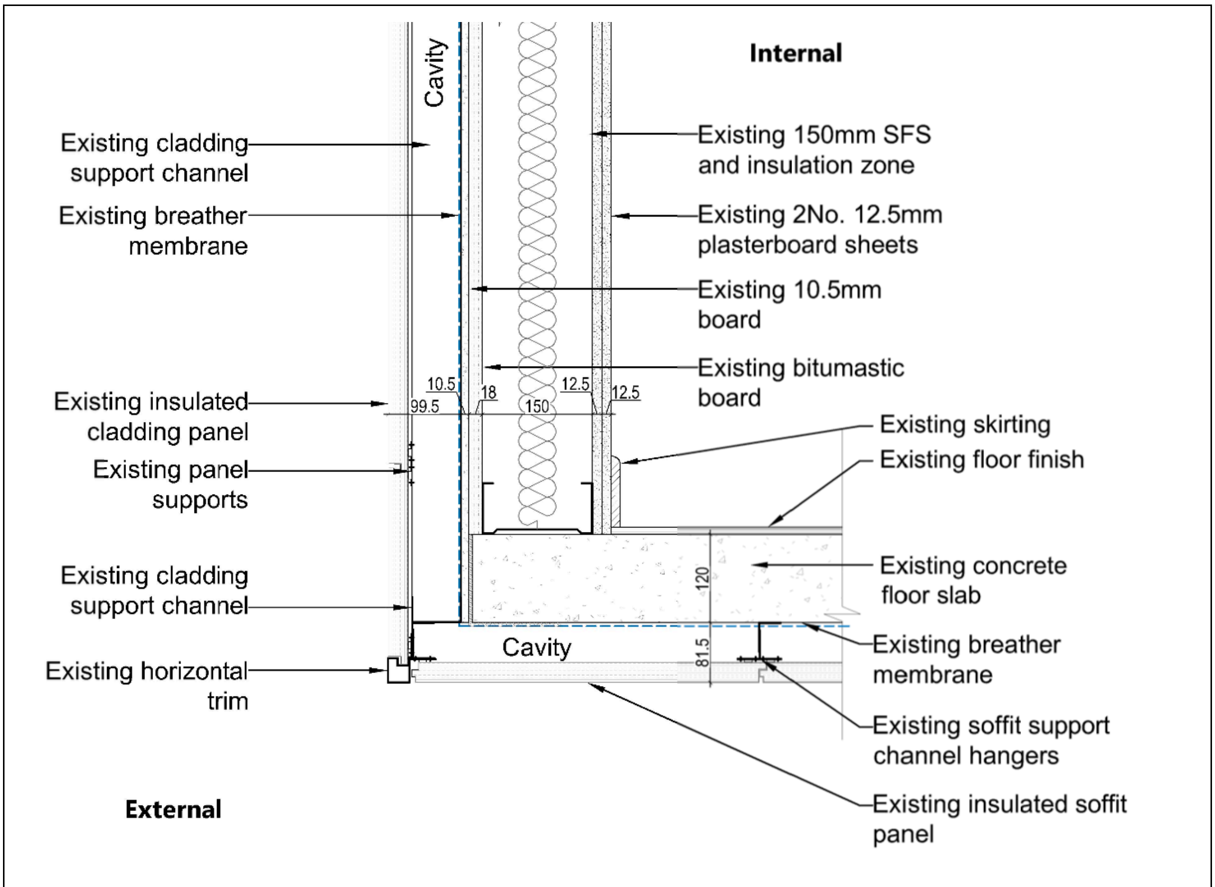
Figure 12: Typical construction details at slab-level (Insulated Aluminium Rainscreen Panel)



Secondary products are limited to seals, sealants, gaskets, membranes, doors, windows, fire barriers and similar items that are not a medium for fire spread between internal compartments or over the walls of the building.

5.4.2 Concealed Spaces (Cavities)

As part of the remedial works, fire barriers have been provided within the external wall construction in the gaps at junctions with compartment walls.

From the information provided (as referenced in Appendix O), **Error! Reference source not found.** details the cavity barrier provisions.

Table 11: Cavity barrier provisions

Location	*Product*
Edges at Heads	No provision.
Edges at Bases	
Edges at Sides	No provision unless at compartment wall junctions.
Edges at Interfaces	No subdivision unless at compartment floor and wall junctions.
Edges at Openings	No provision unless at compartment floor junctions.
Compartment Floors	75mm OSCB (open state) fire barrier to achieve 90EI, with a mechanically-fixed Fischer Ventistop FFB-VS fire barrier insert within the aluminium cladding panel.
Compartment Walls	75mm Fischer FCFcl fire barrier at apartment party walls to achieve 90EI, abutting against a mechanically-fixed OSCI barrier insert within the aluminium cladding panel.

5.4.3 Quality of Construction and Workmanship

During the remediation works, Thomasons and Sweco Building Control undertook regular inspections.

5.4.4 PAS 9980 Step 2: As-Built Construction Information

Key Components

The construction is a rainscreen system. Therefore, the key materials and products (see Appendix I.2) and system components (see Appendix I.3.2) have been identified in Section 5.4.1.

5.4.5 PAS 9980 Steps 3 and 4: Risk Appraisal

5.4.6 Materials and Products

The thermodynamic and thermomechanic characteristics of relevant products that are used to assess the fire performance factor are summarised below.

Aluminium

As discussed in Section 5.3.6.

Polystyrene

Polystyrene is a rigid, closed cell, thermoplastic foam material with a low thermal inertia. When exposed to temperatures of approximately 200°C it melts or sublimes and combusts.

Typically, polystyrene that is used in external wall construction is in one of two forms; extruded polystyrene ("XPS") and expanded polystyrene ("EPS"). These products can have different properties at low heat fluxes, but at higher heat fluxes (as would occur in a building fire), they have similar properties.

Polystyrene has a heat of combustion of around 40MJ/kg.

This means that it is readily ignitable and can support self-sustaining combustion.

It will ignite when exposed to a naked flame around 360℃ and autoignite around 427℃. Once ignited it can sustain ignition and spread rapidly over its surface via dripping and flaming droplets with the ability to burn away from its source of ignition.

Therefore, the characteristics of polystyrene insulations (both XPS and EPS) are:

- Thermodynamic: The surface material is readily ignitable and can be a medium for fire spread beyond the area of flames (even in the absence of other combustible materials).
- Thermomechanic: The material burns, melts and can result in voids being created.

Fire Performance Factor

The fire performance has been assessed using the method defined in Appendix E against the key components (with conservative assumptions to account for any uncertainty) as summarised below.

Table 12: Fire performance assessment

Component	Assessment	Factor
Insulation	Insulation is mineral wool; a non-combustible product that does not contribute significantly to fire, and is not considered a medium for fire spread over the walls.	Positive
Cavity	The cavity is sub-divided at junctions with internal compartment walls by fire barriers that achieve 90EI. However, cavity / fire barriers are not provided elsewhere (e.g., between different external wall types) to subdivide cavities. The substrate features Bitumen Board; confirmed as combustible and flammable	Neutral
Cladding	The cladding is a composite: aluminium panels insulated with polystyrene. During fire, polystyrene burns, melts, and is readily ignitable; presents a medium for fire spread beyond the area of ignition.	Negative

The resultant overall fire performance factor is defined against PAS 9980 ratings and benchmark example wall constructions as summarised below.

Figure 13: Fire performance benchmarking

Benchmark Examples	Cat 3 ACM, Polystyrene, HPL Standard	Thin timber, Thick timber	HPL Fire Retardant, Category 2 ACM	BR 135 compliant, Linear Route, Brick cavity wall
EWS03al				
Rating	High	Medium	Tolerable	Low
Likely Rate	*Very fast*	*Fast*	*Faster*	*Normal*
Likely Extent	*Uncontrolled*	*Far*	*Further*	*Normal*
Likely Heat	*Very high*	*High*	*Higher*	*Normal*

Notes:
1 The benchmarks are based on experience and professional judgement, and as such are approximate. DFC is funding research to enable quantified benchmarking of different systems and will publish the information in due course.

Therefore, the risk rating would be Medium (Upper) when considering the fire performance factor in isolation and risk cannot be confirmed as being sufficiently low without consideration of the facade configuration factor.

Facade Configuration Factor

The facade configuration is such that the wall construction comprising combustible products is limited to the Sixth Floor only.

Therefore, the fire performance factor can be ‘modified’ as summarised below.

Table 13: Facade configuration assessment

Component	Assessment	Factor
Rate of spread	The rate of fire spread is likely to be within the ‘fast’ range due to the thermodynamic and thermomechanical properties of polystyrene during fire. Once ignited polystyrene can sustain ignition and spread rapidly over its surface via dripping and flaming droplets with the ability to burn away from its source of ignition.	Negative

Component	Assessment	Factor
Extent of spread	Pathways for fire spread to adjacent apartments limited by adequate fire barrier provision at junctions with compartment walls. There are no apartments above the external wall construction. The external wall construction is located recessed away from the building façade line / footprint. There extent of spread is likely to be within the 'normal' range.	Positive
Heat of spread	The combustible components of EWS03 is limited to the polystyrene insulation enclosed by aluminium, and the bitumen-based sheathing board. The heat of spread is likely to be in 'higher' range.	Neutral

Therefore, the risk rating when considering fire performance and facade configurations is as below.

Figure 14: Fire performance and facade configuration benchmarking

EWS01				
Rating	High	Medium	Tolerable	Low
Likely Rate	*Very fast*	*Fast*	*Faster*	*Normal*
Likely Extent	*Uncontrolled*	*Far*	*Further*	*Normal*
Likely Heat	*Very high*	*High*	*Higher*	*Normal*

Therefore, the risk rating is Medium (Tolerable) when considering the fire performance and facade configuration factors in isolation and risk has been confirmed as being sufficiently low without the need to consider fire strategy factor.

5.4.7 PAS 9980 Step 5: Risk Rating

It has been confirmed with sufficient confidence and/or conservatism that the risk rating is at least as low as Medium (Tolerable) because the fire performance and facade configuration factors are clearly such that the construction is not a medium for fire spread between flats, or over the walls of the building, or between buildings.

5.4.8 Confidence

A Medium (Tolerable) rating is reasonable due to the following:

- This external wall construction features a relatively limited area; only on the top-most occupied storey (Sixth Floor); there are no apartments above this wall type.
- The junctions with compartment walls are provided with adequate fire barriers (to achieve 90EI). Therefore, reducing the likelihood of extensive fire spread between apartments.

5.4.9 Recommended Action

Even under conservative assumptions the risk is sufficiently low that it can be tolerated, and as such, the resultant actions are:

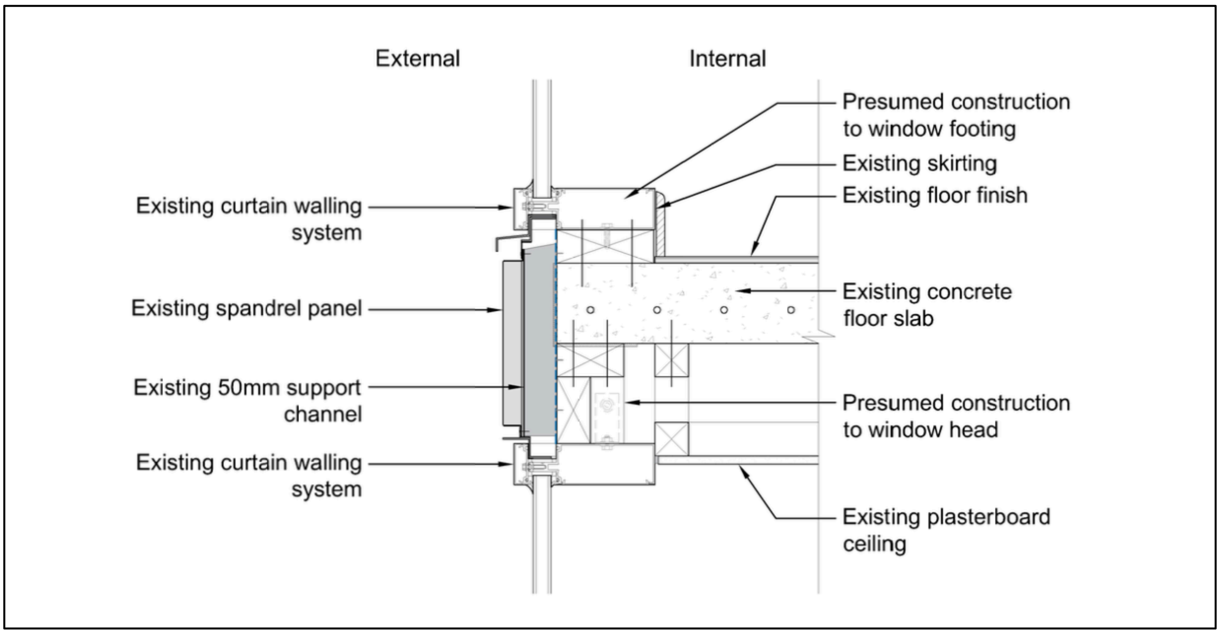
- The *FRA* should be updated to accommodate the findings of this assessment.
- Consideration should be given as to whether risk can be reduced further via *risk-proportionate action* through the *FRA* process.
- Subject to confirmation from the *FRA*, a *stay-put* evacuation strategy remains viable.

5.5 EWS04 Curtain Walling

5.5.1 Products

A list of the *primary products* used in the construction are shown in the figure below.

Figure 15: Typical construction detail (Curtain Wall Polystyrene-backed Aluminium Spandrel Panels)



Secondary products are limited to seals, sealants, gaskets, membranes, doors, windows, fire barriers and similar items that are not a medium for fire spread between internal compartments or over the walls of the building.

Intrusive investigations by Fill UK have shown that there are potential gaps between the inside of flats to the spandrel panels that are not adequately sealed (see **Error! Reference source not found.**).

Figure 16: Photo showing spandrel detail once the panel has been removed

5.5.2 Concealed Spaces (Cavities)

As part of the remediation works, horizontal closed-state fire barriers (Fischer FCFcl 75) are installed to achieve 90 EI above the spandrel panels, at the junction between the compartment floors and the external wall construction

5.5.3 PAS 9980 Step 2: As-Built Construction Information

Key Components

The construction is a curtain wall system. Therefore, the key materials and products (see Appendix I.2) and system components (see Appendix I.3.2) have been identified in Section 5.5.1.

5.5.4 PAS 9980 Steps 3 and 4: Risk Appraisal

5.5.5 Materials and Products

The thermodynamic and thermomechanic characteristics of relevant products that are used to assess the fire performance factor are summarised below.

Aluminium

As discussed in Section 5.3.6.

Polystyrene

As discussed in Section 5.4.6.

Glass

Glass is *non-combustible*, but laminated glass has *combustible* interlayers. That said, the hazard associated with typical laminated glazing is low to negligible.

Glass panels can crack and fracture when exposed to fire. Therefore, the governing characteristics of glass are:

- Thermodynamic: Glass is not *combustible* and as such does not contribute to the rate or total heat release, nor is it a medium for fire spread over the walls of the building.
- Thermomechanic: Glass does not significantly degrade materially, but it can crack, fracture and detach.

Timber

Wood is an organic, *charring* solid. The heat of combustion of dry wood is ranges between 15 to 20MJ/kg.

The ignition, flame propagation and combustion of timber properties depend on many factors such as species, density, grain orientation and thermal thickness.

For woods used for timber cladding, the properties are most sensitive to:

- Whether the timber has been treated with a flame retardant.
- The thermal thickness of the timber (and number of sides exposed).
- The orientation of and gaps around individual timbers.

Typically, untreated timber is assumed to achieve *Class C* or *Class D* (*Class 3* or *Class 4*).

Timber treated with a fire retardant can achieve *Class B* and *Class 0*.

Since its inception, for situations where it recommends that external wall surfaces achieve *Class 1*, Approved Document B has stated that timber at least 9mm thick can also be used.

This recommendation has its genus in experimental work conducted for the 1965 Building Regulations and appears to be a mis-quote of experimental test configuration (the test used timber 7/8th inch thick fitted to a substrate, whereas 9mm is 3/8th inch). Therefore, it cannot be assumed that timber 9mm thick is equivalent to Class 1.

Furthermore, experimental work conducted for BR135: 1988 showed that rapid, accelerating fire spread can occur via timber that is 20mm thick when exposed on both faces (i.e. thermally thin).

Therefore, when used to support curtain wall construction and not treated with a reliable flame retardant, the characteristics of timber cladding are as follows:

- Thermodynamic: The timber is readily ignitable when exposed to the magnitude of heat flux that would result from a fire protruding from a compartment opening (50kW/m^2 or more). If exposed on both faces, the timber would burn readily and self-propagating, accelerating fire spread could occur.
- Thermomechanic: The product would char and eventually burn through where exposed to direct heat, but not rapidly. Thermal expansion would be limited.

Fire Performance Factor

The fire performance has been assessed using the method defined in Appendix E against the key components (with conservative assumptions to account for any uncertainty) as summarised below.

Table 14: Fire performance assessment

Component	Assessment	Factor
Insulation	No insulation as there is no cavity behind the spandrel panel construction.	Positive

Component	Assessment	Factor
Cavity	The junction between the compartment floor slab, and the spandrel panel is fitted with fire barriers that achieve 90EI to limit the spread of fire between apartments.	Positive
Cladding	The cladding comprises of glazed curtain walling, and polystyrene-backed spandrel panels located at floor slab level. The glazed units are do not contribute to fire growth and spread. There polystyrene enclosed in the spandrels present a medium for fire spread beyond the area of ignition.	Neutral

The resultant overall fire performance factor is defined against PAS 9980 ratings and benchmark example wall constructions as summarised below.

Figure 17: Fire performance benchmarking

Benchmark Examples	Cat 3 ACM, Polystyrene, HPL Standard	Thin timber, Thick timber	HPL Fire Retardant, Category 2 ACM	BR 135 compliant, Linear Route, Brick cavity wall
EW004				
Rating	High	Medium	Tolerable	Low
Likely Rate	*Very fast*	*Fast*	*Faster*	*Normal*
Likely Extent	*Uncontrolled*	*Far*	*Further*	*Normal*
Likely Heat	*Very high*	*High*	*Higher*	*Normal*

Notes:

1 The benchmarks are based on experience and professional judgement, and as such are approximate. DFC is funding research to enable quantified benchmarking of different systems and will publish the information in due course.

Therefore, the risk rating is Medium (Tolerable) when considering the fire performance factor in isolation and risk has been confirmed as being sufficiently low without the need to consider the facade configuration or fire strategy factors.

5.5.6 PAS 9980 Step 5: Risk Rating

It has been confirmed with sufficient confidence and/or conservatism that the risk rating is at least as low as Medium (Tolerable) because the fire performance and facade configuration factors are clearly such that the construction is not a medium for fire spread between flats, or over the walls of the building, or between buildings.

5.5.7 Confidence

A Medium (Tolerable) rating is reasonable due to the following:

- The junctions with compartment floors are provided with adequate fire barriers (to achieve 90EI). Therefore, reducing the likelihood of extensive fire spread between floors.
- The glazed units do not contribute to fire growth and spread; there is no cavity behind the spandrel panels.
- The polystyrene within the spandrel panels is combustible however, it is enclosed by the aluminium sheets; a non-combustible with material resistance to elevated temperatures.
- The spandrel panels is interrupted by fire barrier and glazing in the vertical orientation, and interrupted by brick wall construction in the horizontal orientation. The spandrel panels, therefore, do not connect multiple apartments.

5.5.8 Recommended Action

Even under conservative assumptions the risk is sufficiently low that it can be tolerated, and as such, the resultant actions are:

- The *FRA* should be updated to accommodate the findings of this assessment.
- Consideration should be given as to whether risk can be reduced further via *risk-proportionate action* through the *FRA* process.
- Subject to confirmation from the *FRA*, a *stay-put* evacuation strategy remains viable.

6 RICS Form EWS 1

6.1 Background

6.1.1 Purpose and Scope

In 2019, RICS published Form EWS 1.

The intent of the form was to ensure that ensuring that external the resistance to fire spread via external wall construction of residential buildings was assessed by suitably qualified persons and to provide a simple, consistent means of documenting the conclusions of the assessment.

The form is a construct for property valuation, but the assessment of adequacy required for the form is for the purposes of health and safety of occupants only (i.e. the assessment itself is not required to consider property value or risk of damage from fire).

Following the Fire Safety Act amendment to the FSO and publication of PAS 9980 in January 2022, RICS published the third edition of the form[4]. This addition of the form requires that the assessment of adequacy be in accordance with PAS 9980.

Therefore, neither an EWS 1 assessment or the option selected on the form can be used to confirm, assess, or determine requirements of Part B.

6.1.2 Difference between Options

The form require that the signatory of the form documents the finding of their assessment by selecting one of Options A1, A2, A3, B1 or B2.

The sole reason for creating A and B options (as confirmed by Notes 2 and 3 of the form) was to differentiate between the competency required to assess risk of fire spread as opposed to categorising buildings by risk of fire spread (i.e. it cannot be inferred that the risk of fire spread to health and safety an Option A1 building is any less than that of an Option B1 building, or vice versa).

Options A1, A2 and A3 are for buildings, “Where the external wall materials are unlikely to support combustion,” and requires the signatory to confirm that, “to the best of my knowledge the **primary** [emphasised herein only] materials used meet the criteria of limited combustible or better, and cavity barriers are installed to an appropriate standard in relevant locations.

The form states that primary materials would typically be insulation, filler materials and cladding.

6.2 DFC Assessment Outcome

In this instance, it is in DFC’s opinion that the appropriate option would be:

- Option B1 because:
  - There is at least one wall construction that includes primary materials that are not of limited combustibility or better.
  - The DFC assessment in accordance with PAS 9980 concludes that *risk* is sufficiently low that remedial works are not required.

[4] Building Societies Association, RICS and UK Finance, ‘Form EWS1: External Wall Fire Review’, Third Edition, 16 March 2022

7 Conclusions

7.1 As-Built Construction

Following review of construction documentation and the findings of intrusive surveys, the external wall constructions summarised in Table 15 have been identified and assessed.

Table 15: As-built external wall constructions and assessment assumptions

Wall Construction	Description	Key Assumptions made in the FRAEW
EWS01 Brick Walls	A brick cavity wall comprising brick cladding, an uninsulated cavity, a bitumen-based fibrous board, non-combustible sheathing board, a structural framing system ("SFS") with mineral wool insulation and internal plasterboard.	Cavity does not have insulation. Adequate fire barriers are provided to achieve 120EI at both compartment walls and floors. The bitumen-based sheathing board is the only primary product within EWS01 construction that is combustible. However, its extent does not connect apartments in the vertical orientation, and the sheathing board is interrupted by the concrete floor slabs, and the 120EI fire barriers. At vertical and horizontal fire barrier locations, a 15mm non-combustible sheathing board is installed on top of the bitumen-based board.
EWS02a Aluminium Rainscreen Panels	A rainscreen comprising un-insulated solid aluminium panels fixed with non-combustible sheathing board onto an SFS with loose mineral wool insulation and internal plasterboard.	Primary products in the wall construction do not contribute to fire spread. Adequate fire barriers are provided to achieve 90EI at both compartment walls and floors.
EWS02b Feature Cladding		The construction has no openings, and as such is not a medium for fire spread or smoke spread between flats and, due to its location (remoteness from adjacent

Wall Construction	Description	Key Assumptions made in the FRAEW
		buildings), is not a medium for fire spread between buildings.
EWS03a Insulated Aluminium Rainscreen Panels, 6th Floor	A rainscreen comprising polystyrene insulated panels faced with aluminium on the outside within an aluminium frame fixed to a bitumen-based fibrous board on an SFS with loose mineral wool insulation and internal plasterboard.	Adequate fire barriers are provided to achieve 90EI at compartment walls. This EWS features only at the top-most occupied floor: 6th Floor, and the façade is recessed away from the building's cladding curtilage.
EWS03b Insulated Aluminium Rainscreen Panels, Bin Chute		The construction is mechanically fixed to the external brickwork, protruding beyond the building fabric, and, due to its location (remoteness from adjacent buildings), is not a medium for fire spread between buildings.
EWS04 Curtain Walling	A glazed curtain walling system with polystyrene insulated aluminium spandrel panels at each floor level.	Adequate fire barriers are provided to achieve 90EI at compartment walls.
EWS05 Juliette Balconies	Metal framing. Located on First to Fifth Floors on multiple elevations.	The primary products are limited to metal and are not a medium for fire spread.
EWS06 Ground Floor Soffits	Polystyrene-backed, aluminium cladding panels fixed to the underside of concrete floor slabs. Located only at Ground Floor, on three elevations; High Street, New George Street, and internal courtyard.	Combustible materials do not span across internal compartmentation and are not a medium for fire spread over the walls of the Property.
Balconies	Projecting balconies comprising metal frames, metal balustrades and timber decking. Located in vertical stacks adjacent to one of the Feature Bays. They do not span flats laterally.	The majority of the primary products are non-combustible. The combustible component (timber decking) do not span across internal compartmentation and are not a medium for fire spread over the walls of the Property.

7.2 Appraisal of As-Built Construction

DFC has assessed each wall construction in accordance with PAS 9980. To account for uncertainty, the rating in accordance with PAS 9980 is determined from assessments based on upper and lower bound assumptions. Table 16 summarises the results of the assessment for each wall construction.

Table 16: Summary of assessment

Construction Type	Remediation Conducted	Likely Fire Spread Rate (compared to normal range)	Resultant PAS Rating
EWS01 Brick Walls	Installation of adequate fire barriers at compartment walls and floors. Installation of 15mm non-combustible sheathing board to provide suitable substrate to fire barrier installation.	*Slightly faster*	Medium (Tolerable)
EWS02a Aluminium Rainscreen Panels	Installation of adequate fire barriers at compartment walls and floors. Removal of combustible insulation. Installation of uninsulated aluminium rainscreen panels. Installation of 15mm non-combustible sheathing board.	*Slightly faster*	Medium (Tolerable)
EWS02b Aluminium Rainscreen Panels, Feature Cladding	None	*Normal*	Low
EWS03a Insulated Aluminium Rainscreen Panels (6th Floor)	Installation of adequate fire barriers at compartment walls and floors.	*Slightly faster*	Medium (Tolerable)
EWS03b Insulated Aluminium Rainscreen Panels, Bin Chute	Installation of adequate fire barriers at adjacent compartment walls.	*Normal*	Low

Construction Type	Remediation Conducted	Likely Fire Spread Rate (compared to normal range)	Resultant PAS Rating
EWS04 Curtain Walling	Installation of adequate fire barriers at compartment walls and floors.	*Slightly faster*	Medium (Tolerable)
EWS05 Juliette Balconies	None	*Normal*	Low
EWS06 Ground Floor Soffits		*Normal*	Low
Balconies		*Normal*	Low

7.3 Evacuation Strategy and Interim Measures

Whether interim measures are required must be considered as part of the suitable and sufficient assessment of risk (the FRA) for the building as required by the FSO.

In this instance, DFC considers that the risk of fire spread via the external walls is such that:

- There is no reason that a *stay-put* strategy is no longer appropriate due to risk of fire spread via the external wall construction.
- Interim measures are not necessary to mitigate risk of fire spread via the external wall construction.

7.4 Form EWS 1

Whilst the DFC assessment has not been conducted for form EWS 1 purposes, the conclusions of the assessment are that Option B1 would be appropriate.

7.5 Recommendations

It has not been possible to confirm with sufficient confidence that the risk associated with all wall constructions ‘Low’ in accordance with PAS 9980. As such, the risk of fire spread via the external wall constructions is not as low as it should have been when the walls were designed and constructed.

Notwithstanding, it has been confirmed with sufficient confidence that the risk associated with all external wall constructions is at least as low as Medium (Tolerable) in accordance with PAS 9980, and as such, *risk reduction* is not necessary and might not be proportionate.

Therefore, DFC recommends:

- The FRA must be updated to accommodate the findings of the assessment herein.
- For any wall constructions with a risk rating of Medium (Tolerable), any viable ri*sk proportionate actions* should be implemented.

Additionally, if risk is not to be reduced to Low:

- Leaseholders / residents should be notified that the risk associated with the external wall construction might not be as low as it would have been had the construction been built as it should have been at the time of construction and that:

- The risk has been assessed as being low enough to be tolerable.
- The relevant stakeholders have decided that no proportionate risk reduction measures can be implemented, and as such, the heightened risk must be tolerated by residents.

Appendix A – Scope of Assessment and Legislative Context

A.1 Fire Safety Order

The Regulatory Reform (Fire Safety) Order[5] (FSO) requires that *responsible person(s)* must make a suitable and sufficient assessment of the *risks* to which *relevant persons* are exposed for the purpose of identifying the *general fire precautions* they need to take to comply with the requirements and prohibitions imposed on them by or under the FSO.

Whilst the assessment herein considers *general fire precautions* within the building (e.g. means of warning, means of escape, inhibition of fire spread within the building and access and facilities for the fire service), it does not assess adequacy of those provisions nor seek to verify the as-built condition of anything other than the external walls.

Consequently, the assessment does not constitute an FRA but can inform or be part of an FRA.

A.2 Building Regulations

PAS 9980 is not intended for assessing compliance with the Building Regulations (current or at the time of construction). Therefore, the assessment herein is not aimed at assessing compliance with the Building Regulations.

However, Regulations 4 and 8 of the Building Regulations 2010[6] require that building works be carried out so that it complies with Part B of Schedule 1 to the regulations (Part B) and that Part B shall not require anything to be done except for the purposes of securing reasonable standard of health and safety for persons in or about buildings.

Therefore, because the assessment considers health and safety of occupants, it can be used to inform compliance with Part B and/or any remediation that might be required to comply with Part B.

[5] Statutory Instruments, '2005 No. 1541 Regulatory Reform, England and Wales, The Regulatory Reform (Fire Safety) Order 2005', 2005
[6] Statutory Instruments, '2010 No. 2214 Building and Buildings, England and Wales, The Building Regulations 2010' (as amended).

Appendix B – Definitions and Terminology

B.1 Regulatory Reform (Fire Safety) Order

- Responsible person(s) means:
  a. in relation to a workplace, the employer, if the workplace is to any extent under his control;
  b. in relation to any premises not falling within paragraph (a)-
  – (i) the person who has control of the premises (as occupier or otherwise) in connection with the carrying on by him of a trade, business or other undertaking (for profit or not); or
  – (ii) the owner, where the person in control of the premises does not have control in connection with the carrying on by that person of a trade, business or other undertaking.
- Relevant persons means:
  c. any person (including the responsible person) who is or may be lawfully on the premises; and
  d. any person in the immediate vicinity of the premises who is at risk from a fire on the premises.
- General fire precautions means:
  a. measures to reduce the risk of fire on the premises and the risk of the spread of fire on the premises;
  b. measures in relation to the means of escape from the premises;
  c. measures for securing that, at all material times, the means of escape can be safely and effectively used;
  d. measures in relation to the means for fighting fires on the premises;
  e. measures in relation to the means for detecting fire on the premises and giving warning in case of fire on the premises; and
  f. measures in relation to the arrangements for action to be taken in the event of fire on the premises, including-
  – (i) measures relating to the instruction and training of employees; and
  – (ii)measures to mitigate the effects of the fire.
- Risk: The probable *consequence* to the safety of persons from fire.
- Fire Risk Assessment (FRA): The suitable and sufficient assessment of risk required by the FSO.

B.2 Risk and Risk Reduction

- Consequence: The impact a *hazard* poses on safety of persons. Typically, a consequence is in respect to the fire strategy (e.g. means of escape, fire spread between compartments, fire spread between buildings and/or access and facilities for the fire service).
- Hazard (see also *consequence*): The potential to cause harm as a result of fire or smoke spread via the external wall construction. Typically, this would be a function of the potential rate and/or extent of fire or smoke spread via the external wall construction.

- Mitigation: Measures to reduce the probability and/or *consequences* of fire spread via an external wall construction. Mitigation does not reduce *hazard* and is unlikely to require works to the external wall system itself.

- Remediation: Measure to reduce *hazard* of fire spread via an external wall construction. Remediation is likely to require works to the external wall system itself.

- Risk: The probable *consequence* to the safety of persons from fire.

- Risk-proportionate Action[7]: Action taken to reduce risk where the cost of the action is proportionate to the magnitude of risk being reduced and the magnitude of the risk reduction. Cost is in the widest context and includes capital and operational expenditure, time, disruption and practicality. For example, the cost of risk-proportionate action would less for a medium-risk construction than a high-risk construction and action would only be risk-proportionate where the resultant reduction in risk is commensurate with the cost of the action.

B.3 Building Features and Parameters

- Evacuation zones: zones within a building that have been separated by fire resisting construction to enable different zones to be evacuated independently of each other.

- Stay-put evacuation strategy:

  – Occupants of flat(s) of fire origin / alarm evacuate.

  – Occupants of other flats are safe to remain within their flats until instructed otherwise.

  – All occupants are safe to evacuate should they choose to do so.

- Simultaneous evacuation: All occupants within an evacuation zone are required to escape on detection of fire and/or activation of the fire alarm.

- Gallery: A floor which is less than one-half of the area of the space into which it projects.

- Element of structure: structural frames, beams, columns, loadbearing walls (internal and external), floor structures and gallery structures.

- Storey: includes any gallery if its area is more than half that of the space into which it projects and a roof unless it is accessible only for maintenance and repair.

- Storey height: height of top storey measured from upper floor surface of top floor to ground level on lowest side of building (excludes roof-top plan areas and any top storeys consisting exclusively of plant rooms.

- Building height: mean roof level to mean ground level.

B.4 Materials, Components and Products

- Material: single basic substance or uniformly dispersed mixture of substances, e.g. metal, stone, timber, concrete, mineral wool with uniformly dispersed binder or polymers.

- Component: a material which forms part of a product.

- Product: material, element or component.

- Primary products: *products* within the external wall construction that are used in sufficient coverage that they could be a medium for fire spread over the walls of the building and in sufficient volume

[7] PAS 9980 refers to but does not define risk-proportionate action. Therefore, this definition has been inferred.

that fire spread could result in a risk to health and safety. Primary products would constitute insulation, filler material, cladding, etc. in the context of ADB, MHCLG advice and Form EWS1.

- Secondary products: *products* within the external wall construction that are either not used in sufficient coverage to constitute a medium for fire spread over the walls of the building (e.g. sealants and gaskets) and/or that do not have sufficient volume for fire spread to result in a risk to health and safety (e.g. membranes). Secondary products would constitute gaskets, sealants and similar in the context of ADB 2006. Secondary products include the permitted exemptions listed in Regulation 7(3) of the 2018 amendment to the Building Regulations.

B.5 Cladding Products:

- Aluminium Composite Material (ACM): A cladding panel comprising a core (typically around 3mm to 4mm thick) faced on each side with aluminium (typically 0.5mm thick). From a fire perspective, there are three generic types:
  - Category 3 (aka ACM PE): ACM panels with an unmodified polyethylene core.
  - Category 2 (aka ACM FR or ACM Plus): ACM panels with a polyethene core that include cement particulate (or similar) to reduce the combustibility of the core.
  - Category 1 (aka ACM A2): ACM panel that achieve *Class A2*.
- High Pressure Laminate (HPL): A cladding panel comprising cellulosic material bonded in a resin under high pressure. From a fire perspective, there are two generic types:
  - Standard Grade: Panels that do not include a fire retardant.
  - Fire Resistant (aka FR Grade): Panels that include a fire retardant to improve the reaction to fire classification.

B.6 Wall Systems

- External wall construction: the full depth of the wall construction from the inside face of the internal linings to the outside face of outermost surface including cavity barriers, window frames, spandrel panels, infill panels etc.
- Internal Components: The components of the *external wall construction* that maintain the integrity of the *external wall construction* between *cavity barriers* at junctions with compartments, *cavity barrier*s at junctions between compartment walls and *cavity barriers* (or similar) at cavity edges around openings (including window openings). Typically, the inner construction is an inner leaf of blockwork or a *structural framing system*.
- Cavity wall: An external wall system comprising two skins / leaves (inner and outer) to create a hollow centre (cavity). The key components are inner leaf/skin, cavity and outer leaf/skin.
- External Thermal Insulation Composite System (ETICS): ETICS were developed to improve the thermal insulation of existing wall constructions (they would be applied to the outside of existing external walls). Herein, the term is used more generally to describe a layered system (typically comprising insulation with an external surface finish such as render) applied to a substrate. The key components are substrate, insulation and topcoat.
- Rainscreen: An external wall system where the cladding stands off from the moisture resistance surface of an air/water barrier applied to the sheathing board of the substrate to create a cavity to allow drainage and evaporation. The key components are a substrate, ventilated cavity and rainscreen cladding.

- Spandrel Panel: A panel that is applied at the junction of a floor or wall that is different from the rest of the external wall construction surrounding it. Spandrel panels form junctions with internal compartment floors and/or internal compartment walls.
- Structural framing system (SFS): an *internal component* of an *external wall construction* comprising plasterboard, a structural frame (potentially insulated) and a sheathing board.
- Window / Infill Panels: Infill panels are that are provide within the surrounds of another external wall construction. Infill panels do not form junctions with internal compartment floors or internal compartment walls.

B.7 Fire Spread Rates

- Normal: The rate of fire spread via the external construction is likely to be in the normal range (where ADB compliance is used as the benchmark of the normal range). for the building in question.
- Faster: The rate of fire spread via the external wall construction is faster than the normal range but might not be significantly so.
- Fast: The rate of fire spread via the external wall construction is significantly faster than the normal range to an extent that it is likely to constitute a high risk unless there are mitigating facade configuration or fire strategy factors in place.
- Very Fast: The rate of fire spread via the external wall construction is significantly faster than the normal range to an extent that it is likely to constitute an unacceptable risk unless there are mitigating facade configuration or fire strategy factors in place.

B.8 Fire Spread Extents

- Normal: The external wall construction does not contribute to fire spread and as such fire spread via the external walls is limited to that associated with flame projecting from any openings such as windows.
- Further: The external wall construction does contribute to fire spread and but only to the extent that fire spread via the external walls is limited to the vicinity of flames projecting from any openings such as windows.
- Far: The external wall construction is such that fire spread via the external walls could be significantly beyond the vicinity of flames projecting from any openings such as windows.
- Uncontrolled: The external wall construction is such that fire spread via the external walls could extend the full extent of the wall construction.

B.9 Fire Spread Heats

- Normal: The external wall construction does not contribute to the heat of the fire.
- Higher: The external wall construction would slightly increase the heat of the fire.
- High: The external wall construction would significantly increase the heat of the fire.
- Very High: The external wall construction would considerably increase the heat of the fire.

B.10 Fire Resistance Standards

Fire resistance standards in accordance with BS EN 1363-1[8] or BS 476-20[9], and are expressed as:

nREI, nR, nEI or nE nI

where:

n - the fire resistance standard expressed in minutes.

R - loadbearing capacity: resistance to collapse (loadbearing capacity), which applies to loadbearing elements only.

E - integrity: resistance to fire penetration through separating elements.

I - insulation: resistance to the transfer of excessive heat on unexposed faces of separating elements.

B.11 Reaction to Fire

European Class

Where possible, *products'* reactions to fire are specified in accordance with BS EN 13501-1[10] (i.e. European class).

The classification is designated as Class A1, Class A2-sx, dx or Class B2-sx, dx, Class C, Class D or Class E.

where:

sx – is the smoke production index

dx – is the droplet index

National Class

Where appropriate or necessary, products' combustibility and surface spread of flame characteristics are specified in accordance with the national system, where:

- Non-combustible is a product that achieves Class A1, or has been tested as such in accordance with BS 476-4 or BS 476-11, or is a material listed in Table A6 of ADB:2013.
- Limited combustibility is a product that achieves Class A2 or has been tested as such in accordance with BS 476-11, or any material listed in Table A7 of Approved Document B:2013.
- Combustible is a material that is not either non-combustible or of limited combustibility.
- Class 0 means national class 0 in accordance with ADB and BS 476-6 and BS 476-7.
- Class 1 means national class 1 in accordance with ADB and BS 476-7.

European vs National Classes

- A product that is *Class A1/non-combustible* also achieves *Class A2/limited combustibility*.

[8] BS EN 1363-1, 'Fire resistance tests. General Requirements', 2012
[9] BS 476-20, 'Fire tests on building materials and structures. Method for determination of fire resistance of elements of construction (general principles)', 1987
[10] BS EN 13501-1:2007+A1:2009, 'Fire classification of construction products and building elements. Classification using data from reaction to fire tests', 2009

- A product that is *Class A2/limited combustibility* also achieves *Class B/Class 0*.

B.12 Foam Insulations

- Thermoset: A charring, thermoset polymer insulation such as phenolic foam or polyisocyanurate (PIR).
- Thermoplastic: A thermoplastic insulation such as polystyrene derivatives.
- Charring: The process of char formation when a material (e.g. wood or some thermosetting polymers) sublimes on heating an a char residue forms near the surface of the material.

B.13 Fire Barriers

For protection of junctions, ADB uses two terms:

- Firestopping is a continuation of any compartment floor or wall and is required to achieve the same fire resistance standard as the floor or wall, and
- Cavity barrier is a barrier used within a cavity that is required to achieve *30E 15I* [for protection of cavity edges around window openings, ADB includes alternatives to cavity barriers].

Depending on the specific details of an external wall construction, DFC considers that there are instances where cavity barriers are required to protect compartmentation as well as prevent spread of fire and smoke within the cavity (i.e. they are barriers in a cavity but are required to achieve a higher fire resistance standard than a cavity barrier).

Therefore, the term ‘fire barrier’ is used in this report for both firestopping and cavity barriers, and the required fire resistance standard is explicitly specified.

Fire barriers can take either of the following forms:

- Closed-state: a barrier that forms a continuous seal across the gap in which it is installed. There are no active components.
- Open-state: a barrier that leaves holes or gaps within the gap in which it is installed. There is an active component (an intumescent) which seals the gaps when it gets hot. Such barriers are typically installed in ventilated cavities to allow the cavity to be ventilated in normal conditions.

B.14 Picture Framing

The junctions between external walls and compartment floors and compartment walls should be adequately protected such that the external wall construction does not provide a medium for spread of fire around the compartmentation.

ADB recommends cavity barriers that achieve *30E 15I* (or ADB compliant alternatives at openings) at junctions with compartment floors and cavity edges (including around openings).

An alternative to the ADB provisions that would meet the intent of ADB would be to continue the fire resistance of the compartmentation through the external wall construction to the outside of the building (i.e. forming a continuous line of fire resistance to the outside of the building). Where the compartmentation is continued via *fire barriers*, the barriers must achieve the same standard of fire resistance as the compartmentation.

DFC has called the above concept “picture framing”.

Appendix C – MHCLG Advice

C.1 Status

Whilst MHCLG's Consolidated Advice Note[11] (CAN) has been repealed following enactment of the Fire Safety Act and publication of PAS 9980 the items in this appendix remain relevant.

C.2 Reviewing the Safety of External Walls

C.2.1 Responsibility

Building owners[12] are responsible for ensuring the safety of their buildings. Building owners should have an up to date suitable and sufficient assessment of risk (FRA) and following the Fire Safety Act amendment to the Regulatory Reform (Fire Safety) Order 2005, the FRA must include consideration of *risk* of fire spread via external wall constructions.

C.2.2 Test Evidence

A successful BR135 classification following a BS 8414 test is an acceptable route to adequacy.

BS 8414 tests that have led to a BR135 certification should be available from manufacturers and can sometimes be accessed via their websites.

Where the system, or any product in the system, is to be assessed in lieu of carrying out a specific test, this should be carried out by a Chartered Engineer registered with the UK Engineering Council with suitable experience in the fire safety of high-rise residential buildings.

C.3 Aluminium Composite Material Panels

ACM cladding (and other metal composite material cladding) with unmodified polyethylene filler (category 3) presents a significant fire *hazard* on residential buildings at any height with any form of insulation.

Whilst the CAN concluded the following in relation to ACM cladding with fire retardant polyethylene filler (category 2) and neither statement is incorrect, evidence presented by Luke Bisby at the Grenfell Enquiry casts uncertainty on both:

- Category 2 ACM presents a notable *hazard* on residential buildings over 18m when used with rigid polymeric foam.
- Category 2 ACM used with non-combustible insulation (e.g. stone wool) can be safe on residential buildings at any height, where materials have been fitted and maintained appropriately, including provision for adequate fire breaks and cavity barriers.

ACM cladding with A2 filler (category 1) can be safe on residential buildings at any height with foam insulation or stone wool insulation, if materials have been fitted and maintained appropriately, including provision for adequate fire breaks and cavity barriers.

[11] Ministry of Housing, Communities and Local Government, 'Advice for Building Owners of Multi-storey, Multi-occupied Residential Buildings', 20 January 2020.
[12] For the purposes of this MHCLG Advice the term 'building owner' means the owner of the building or the person, group, company or other entity on whom duties are imposed or enforcement action could be taken under the following legislation: (i) the Housing Act 2004 in relation to certain hazards; or (ii) the Regulatory Reform (Fire Safety) Order 2005 to ensure the safety of occupants of a building from fire (see Articles 3 & 5 of Regulatory Reform (Fire Safety) Order 2005 for those with duties).

C.4 High Pressure Laminate Panels

High Pressure Laminate (HPL) panels can have a wide range of fire performance and it is important that building owners are aware of the fire performance of the panels that have been installed.

The Expert Panel has received no evidence that there is a public safety risk arising from adequately installed and maintained systems involving Class B-s1, d0 HPL panels and stone wool insulation.

Systems using Class C-s3, d2 or D-s3, d2 HPL panels on residential buildings of 18m or more to the height of the top occupied storey would not have met the functional requirements of Part B.

Building owners who have Class C-s3, d2 or D-s3, d2 HPL panels on residential buildings under 18m should also consider the risk from fire spread irrespective of building height.

C.5 Spandrel Panels

Spandrel panels (including window panels, infill panels, etc) are part of the external wall of the building. Therefore, the principles set out in the advice on external walls above apply.

C.6 Balconies

Balconies made with combustible materials are a potential source of rapid fire spread. The design of balconies should not assist fire spread along the external wall.

Building owners should therefore ensure that they understand the materials used in the construction of balconies.

The removal and replacement of any combustible material used in balcony construction is the clearest way to prevent external fire spread.

Where there is doubt over the materials used, or risk presented, building owners should seek professional advice. Assessment of risk should follow the principles of Appendix C.1.

C.7 Short-Term Interim Measures

C.7.1 General Measures

Risk Assessment

Ensure that an FRA has been carried out within the last 12 months and actions have been completed and the assessment is up to date with any changes, or immediately instruct such an assessment.

The responsible person should ensure that the FRA is suitable and sufficient and that it acknowledges the external wall constructions as defined herein and the conclusions and recommendations of this report.

To be suitable and sufficient, DFC recommends that the risk assessment should be conducted against the fire strategy for the building and as a minimum it should:

- Be conducted by a competent person.
- Confirm adequacy of internal compartmentation (in particular between commercial units and the residential parts, between flats and common areas and around stairs and service risers).
- Confirm that any smoke control systems (including cause and effect) are working correctly.
- Confirm that fire fighting equipment (lifts and dry risers) are working correctly and adequate access is available for fire service vehicles.

Resident Engagement and Advice

The FRA should be communicated to leaseholders and residents (particularly if there is a change to the evacuation strategy). Regardless of any change to the evacuation strategy, there is considerable confusion and misinformation about the intent of a stay-put evacuation strategy. The principles of the stay-put strategy are as below and should be communicated to leaseholders and residents.

- Any people within an apartment in which there is fire or smoke should evacuate via any of the stairs. People requiring assistance should go to the closest stair and call or wait for assistance.
- Apartments and escape routes are enclosed in fire resisting construction. Therefore, people within apartments in which there is not fire or smoke are safe to remain within their flats unless otherwise directed to do so by building management or the fire service.
- Escape routes are enclosed in fire resisting construction. Therefore, anyone wishing to evacuate is also safe to do so.
- Unless otherwise directed, residents should make their own decision as to whether to evacuate their apartments.

In addition, leaseholders and residents should be advised:

- How to maintain and test the fire alarm system within each flat.
- Protected entrance halls within flats are there to protect against fire and help with escape from within flats. Residents should ensure that doors are closed whenever a room is not in use.
- Of any limitations with respect to barbeques, chimeneas, smoking and storage of combustible materials on balconies.

C.7.2 Assessment of Appropriateness of Stay-put

MHCLG advice recommends that assessment of stay-put should consider the following:

- Fire and Rescue Service Attendance Time influences whether the fire service can assist with evacuation or inhibit fire spread before spread becomes a risk to health and safety.
- General Fire Precautions in the Building influences whether there are either enhanced measures to mitigate risk of fire spread via the external wall construction or conversely whether there are deficiencies that when considered in conjunction with the external wall construction mean that a stay-put evacuation strategy is no longer appropriate.
- Height of the Building influences the *hazard* posed by fire spread over external walls (because the rate of vertical fire spread and heat released increases exponentially with respect to the height of burning) and whether fire spread can be inhibited by the fire service from outside.
- Provision of Sprinklers might mitigate any risk associated with fire spread over external walls.
- Number of Flats influences the number of people at risk from fire spread, the number of people that might be required to evacuate simultaneously and the resource and complexity of fire service incident management.
- Type and Extent of Cladding System influences the likelihood, rate and extent fire spread.
- Number of Escape Stairways influences the reliance being placed on individual escape routes.
- Proximity of the Cladding System to Windows or Vents influences whether fire spread over the external walls is likely to spread back into the building.

- Risks of Ignition include fire spread from within the building, fire spread from outside the building to the external walls (e.g. from ignition of combustible materials outside the building and from balconies) and fire spread from within the wall construction (e.g. lighting and electric cables).

C.7.3 Simultaneous Evacuation

MHCLG Advice

Where simultaneous evacuation is adopted, it will need to be managed, should an evacuation be necessary in the event of a fire. This is likely to require the presence of a “waking watch” on a 24/7 basis. A simultaneous evacuation policy is also likely to necessitate some form of fire alarm system to alert residents of the need to evacuate, unless there are sufficient staff in the “waking watch” to detect fire and initiate an evacuation at an early stage of a fire in the building.

MHCLG references the National Fire Chiefs’ Council guidance (NFCC Guide[13]) for guidance on the measures required to affect a simultaneous evacuation.

NFCC Guidance

The NFCC Guide provides guidance on changing to a simultaneous evacuation strategy. It does not provide guidance on when a simultaneous evacuation is required (relying instead on competent assessment), but does state:

“Buildings that have, for example, been identified as having an external wall system that does not adequately resist the spread of fire over the walls (e.g. ACM identified as hazardous by MHCLG because of large scale fire tests carried out on their behalf) is one example of circumstances where a simultaneous evacuation strategy may be needed.”

The NFCC Guide recommends a change to a simultaneous evacuation strategy should only be temporary and lists two essential principles of a temporary simultaneous evacuation strategy: early detection and warning of occupants, and management of the evacuation.

The NFCC Guide recommends approaches from an automatic means to fully human measures to achieve the above. However, adoption of a fully staffed waking watch approach should be limited to a short-term period of time (time needed to formulate a longer-term plan but should not exceed 12 months). Beyond this, a form of common alarm system should be installed.

The NFCC Guide recommends that a cost benefit analysis should be carried out to determine the suitable interim solution; installation of a common fire alarm system may be more beneficial than a fully staffed waking watch as an interim measure.

The NFCC Guide is generic and therefore by necessity comprehensive. It recognises that adequate mitigation may be achieved by alternative means and without 24/7 onsite staff presence to manage evacuation. However, this should be informed by the review of the fire risk assessment with the intended measures defined.

[13] National Fire Chiefs Council, ‘Simultaneous Evacuation Guidance: Guidance to support a temporary change to a simultaneous evacuation strategy in purpose-built blocks of flats’, 1 October 2020

Appendix D – DFC Appraisal Process

D.1 Principles

DFC has developed the following methodology in accordance with PAS 9980[14] and in recognition of MHCLG Advice (see Appendix C).

An assessment in accordance with PAS 9980 is called (by the PAS) a fire risk appraisal of external wall constructions ("FRAEW").

PAS 9980 supplements the information given in PAS 79-2: 2020[15].

D.2 Process

Prior to starting the PAS 9980 approach, it is necessary to identify all different external wall constructions. Then, for each wall construction, the PAS 9980 Figure 3 five step approach (see Table 17) is applied.

Table 17: PAS 9980 Figure 3

Step	Objective
1	Confirm that a full FRAEW is required (EWS Triage)
2	Gather all necessary information to complete the FRAEW
3	Identify and group factors that are significant in determining the risk rating
4	Consider each group of risk factors to determine their potential contribution to the overall risk
5	Review the risk factor analysis against benchmark success criteria to determine an outcome

D.2.1 PAS 9980 Step 1: Confirm that a full FRAEW is Required

D.2.1.1 Building Review

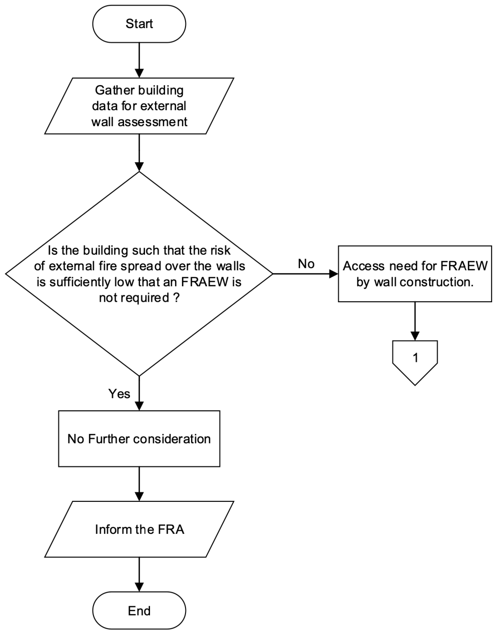
Figure 18 shows the parts of PAS 9980 Figure 4 that are relevant to the building level review of whether a full FRAEW is required.

PAS 9980 Section 0.2 and PAS 9980 Figure 4 recognises that:

- An FRAEW will not be required for all blocks of flats. In many cases is will be manifestly obvious that risk to life from fire spread does not warrant an FRAEW.
- FRAEWs require specialist skills and resource available for FRAEWs is limited and should be used judiciously (i.e. where risk of fire spread is sufficiently low, this should be accepted without further appraisal).

[14] British Standards Institution, PAS 9980, 'Fire risk appraisal of external wall construction and cladding of existing blocks of flats – Code of practice', January 2022
[15] British Standards Institution, PAS 79-2, 'Fire risk assessment, Housing, Code of practice', 2020

Figure 18: Building review component of PAS 9980 Figure 4



With consideration of PAS 9980 Section 0.2, Table 18 defines the buildings for which DFC considers risk of fire spread is sufficiently low such that no further appraisal is required provided there is no significant, visually obvious evidence to the contrary.

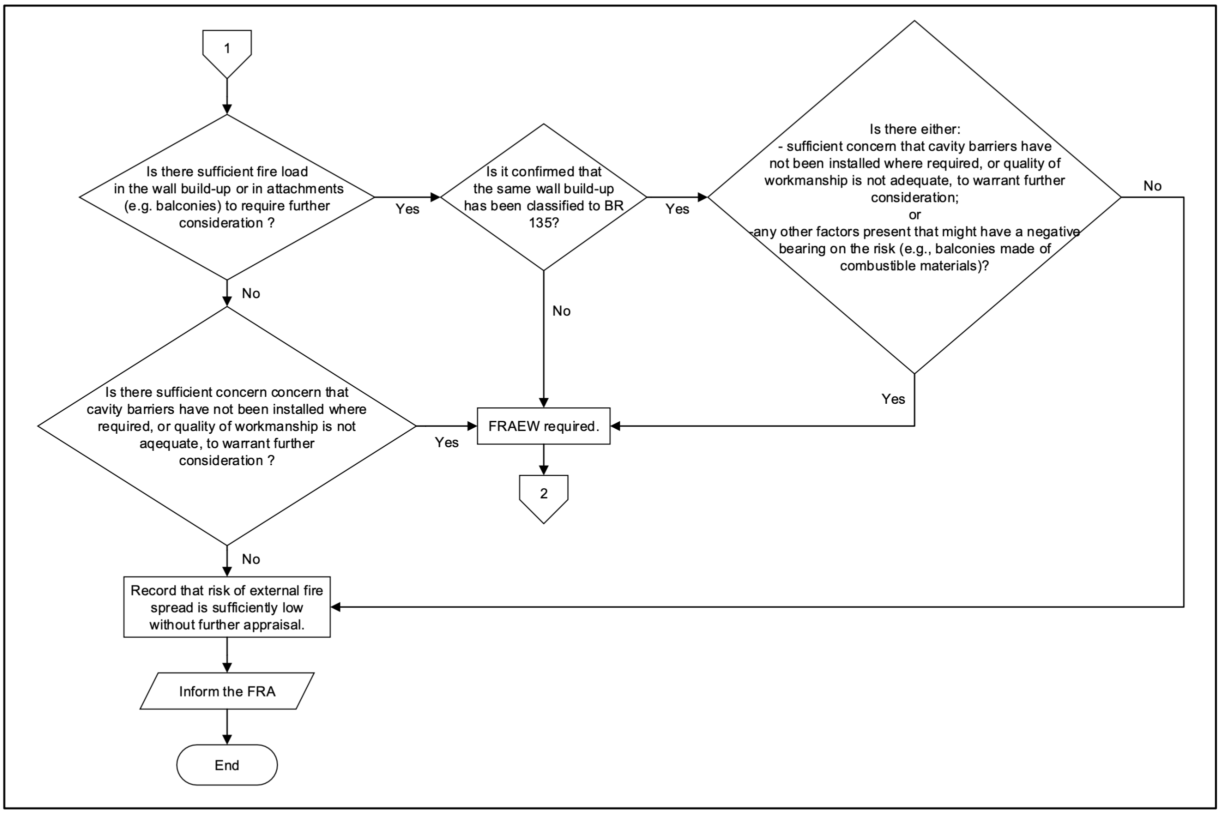
Table 18: Buildings not requiring appraisal in accordance with PAS 9980

Option	Number of Storeys	Wall Construction
1	Not more than 2	Any, but no Category 3 (i.e. polyethylene cored) ACM/MCM permitted.
2	Not more than 4	No Category 3 (i.e. polyethylene cored) ACM/MCM permitted and the combined area of any of the following should not exceed 25% of the total wall area (for each elevation separately): • External walls incorporating rainscreen cladding, with or without insulation within any associated cavity, • External thermal insulation composite systems (ETICS), • Insulated core (“sandwich”) panels, • Glazed facades with infill/spandrel panels, • Substrates including structural framing systems (SFS), timber framing and structural insulated panels (SIPs), and • Curtain walling.
3	Any	Walls wholly constituting masonry/concrete cavity walls (each leaf being either masonry or concrete) or solid masonry construction without a cavity.

D.2.1.2 External Wall Review

PAS 9980 Figure 4 and PAS 9980 Section 13 commentary to Step 1 indicate a full FRAEW is not required in any of the circumstances described below, and that in such situations the risk rating of ‘low’ can be assigned without further assessment.

Figure 19: Wall construction review component of PAS 9980 Figure 4



Fire Load

In answering the question about fuel load, there would not be sufficient fire load if:

- *Primary products* and any attachments are of *limited combustibility* or better, or
- Any *primary products* that are *combustible* are within a cavity wall construction with adequately constructed brick (or concrete or concrete block) inner and outer leaves, or
- The extent of coverage of the wall construction is sufficiently limited and isolated that the construction would clearly not be a medium for fire spread between.

BR 135 Classification

A full FRAEW is not required if the construction is the same wall build-up as a system that met the BR 135 performance criteria, and:

- There are not sufficient concerns that cavity barriers not been installed where required, or quality of workmanship is not adequate, and
- There are no other factors (e.g. balconies made of combustible materials) that might have a negative bearing on risk.

For this option, DFC requires sufficient information to confirm the materials used in the build-up of the external wall construction and some evidence that cavity barriers have been installed correctly.

Cavity Barriers

In answering the question about cavity barrier concerns, there would not be sufficient concern if:

- The construction does not span across internal compartment floors or walls (because cavity barriers would not be required), or
- There is sufficient evidence to show that cavity barriers have been installed correctly, such as:
  - Construction photographs showing adequate installation.
  - Construction site inspection records.
  - Intrusive surveys.

D.3 PAS 9980 Step 2: Gather Information

D.3.1 Principles

PAS 9980 encourages a proportionate approach to FRAEWs and risk reduction. By implication, this requires a proportionate approach to gathering information and in particular the necessity for intrusive surveys (which can be costly, disruptive and damaging).

The amount of information required depends on the potential risk and the types and coverage of external wall construction, and it is possible that Steps 2 to 5 need to be iterated with more information required in each iteration of Step 2.

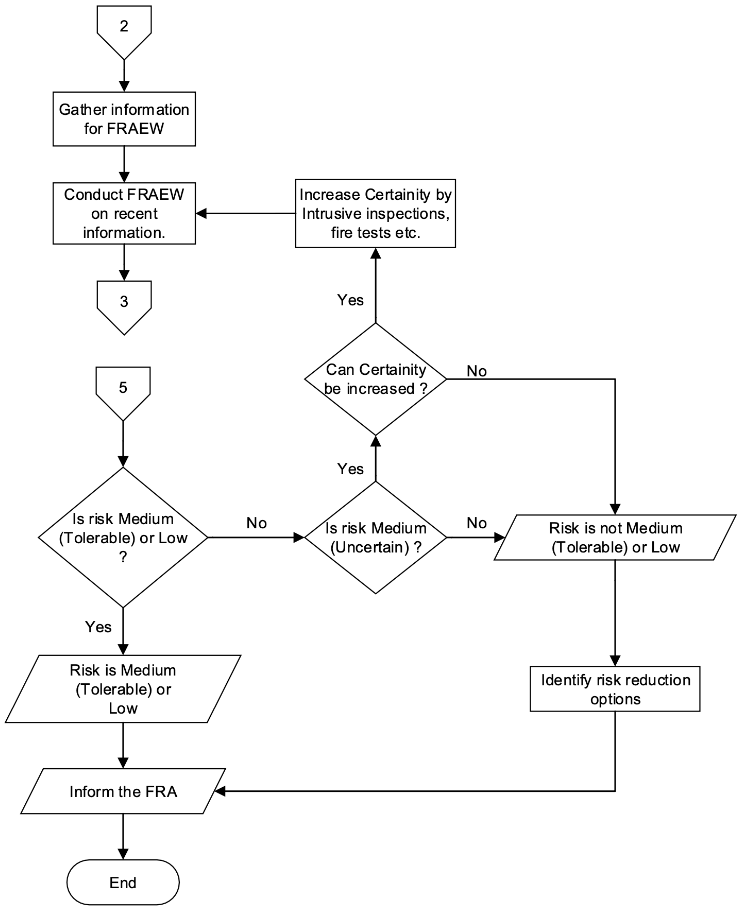
For example, where the building risk is low or external wall types are implicitly low risk (e.g. brick cladding with an SFS substrate), the amount / detail of information required might be low comparted to a higher risk building or a higher risk wall construction (e.g. a rainscreen with combustible cladding or combustible insulation).

Similarly, in a first iteration conservative assumptions can be made. For example, it can be assumed that there are no positive fire strategy features in the building or that cavity barriers are missing. If the risk is tolerable despite these conservative assumptions, additional information is not required. Alternatively, if the risk is not tolerable, additional information might be required to determine if the conservative assumptions can be refined for a second iteration of appraisal.

Therefore, DFC applies an iterative approach to PAS 9980 Steps 2, 3, 4 and 5 as defined in Figure 20, and summarised below:

- Step 2: Enough information is gathered to make a first FRAEW (and subsequent FRAEWs if required).
- Steps 3 and 4: Depending on the situation, either a Basic FRAEW or a Fire Engineered FRAEW is conducted.
- Step 5:
  - If the FRAEW confirms with sufficient confidence that risk is low enough to be Tolerable, end.
  - If the FRAEW confirms with sufficient confidence that risk is high enough to require risk reduction, identify appropriate risk reduction options and end.
  - If the FRAEW cannot confirm with sufficient confidence that risk is low enough to be Tolerable and it is not possible to increase confidence, identify appropriate risk reduction options and end.
  - Otherwise, gather additional information (e.g. by intrusive surveys, fire testing, etc.) to increase confidence and repeat from Step 2.

Figure 20: Iterative process applied to Step 2, 3, 4 and 5 to ensure intrusive surveys are proportionate



D.3.2 Building Information

The building information required will vary between appraisals (see Appendix D.3.1). Typically, some or all of the following might be required:

- Evacuation strategy (i.e. stay-put, simultaneous or hybrid).
- General arrangement plans for each floor level.
- Elevational drawings to show building heights and locations of external wall constructions.
- Fire protection features and system, such as sprinklers, fire alarm, smoke control and fire service systems.
- Site plan or information about proximity of adjacent buildings.
- Building egress and access locations.

D.3.3 External Wall Constructions

The external wall information required will vary between appraisals (see Appendix D.3.1). Typically, some or all of the following might be required:

- Construction typology (e.g. rainscreen, curtain wall, cavity wall, external wall insulation such as render systems, or architectural wall panels).

- Materials used within the external wall construction, including, cladding, insulation, membranes, and sheathing boards.
- Where there are cavities, details of junction protection and cavity edge protection.

The information can be gathered using a combination of drawings and site investigations (which might need to be intrusive).

As per PAS 9980 Annex J, it is important to gather enough information to enable assessment, but equally, it is important to avoid unnecessary intrusive surveys. Therefore, DFC's approach to information gathering is an iterative one (in some instances, only one iteration is required):

- In the first iteration DFC gathers enough information to enable Upper and Lower Bound FRAEW. Where there is uncertainty in the as-built construction the Upper Bound FRAEW makes conservative assumptions and the Lower Bound FRAEW makes optimistic assumptions.
- If both the Upper Bound and Lower Bound FRAEWs conclude that risk is at least as low as Medium (Tolerable), no further information is required (because even based on the conservative assumptions of the Upper Bound FRAEW risk is low enough to be tolerated and increased certainty cannot increase risk).
- If both the Upper Bound and Lower Bound FRAEWs conclude that risk is not at least as low as Medium (Tolerable), no further information is required (because even based on the optimistic assumptions of the Lower Bound FRAEW risk is not low enough to be tolerated and increase certainty cannot reduce risk).
- Where the FRAEW does not provide adequate certainty (i.e. the Upper Bound risk is not at least as low as Medium (Tolerable) and the Lower Bound risk is at least as low as Tolerable) and, as such, either (depending which is more practicable and proportionate):
  - Additional information is required (e.g. via intrusive surveys or fire testing) to enable a reduction in the conservatism associated with the Upper Bound FRAEW and/or the optimism associated with the Lower Bound FRAEW. In this instance, additional information is gathered and the appraisal repeated; or
  - Risk reduction measures must be implemented such that the Upper Bound FRAEW concludes that risk is at least as low as Medium (Tolerable) even when conservative assumptions are made regarding the as-built construction.

D.4 Steps 3 and 4: Risk Appraisal

D.4.1 Principles

D.4.1.1 Risk-Based Benchmark Criteria

In the context of a risk-based approach, the risk of fire spread via an external wall is a combination of:

- The probability of combustible materials being ignited.
- If ignited, the probability of undue fire spread over the external walls of the building.
- The probable *consequences* of any such fire spread to occupants.

D.4.1.2 Acceptability Criteria for a Risk-Based Approach

PAS 9980 clause 5.5 requires that a risk-based approach includes consideration of the following in determining whether an existing block of flats is safe:

- The combustibility and fire performance of external wall construction and cladding.

- The likelihood of secondary fires.
- Whether a secondary fire is likely to result in direct harm to occupants or prevent them escaping.
- The role of fire and rescue service intervention, its effectiveness and its limitations.
- The time it might take for adverse *consequences* to occur and whether this can be mitigated by, for example, suitable fire safety design.
- The extent and effectiveness of fire safety management for the building.

In accordance with the commentary to PAS 9980 clause 5, the *consequences* of an external fire set out below are deemed as not unsafe and can form the basis of acceptability criteria for a risk-based approach. The below has therefore been adopted as the basis of the benchmark with which to judge an existing building's external wall construction.

- Fire spread that that is likely to result in only limited secondary fires and/or either occur at a rate within expectations for a building of this height, or at a higher but still tolerable rate, given the circumstances at the building in question.
- Occupants in places to which fire has spread are not unduly harmed, or prevented from escaping, by the time such secondary fires occur.
- Secondary fires do not compromise the communal means of escape before those needing to use the escape routes have left the building.
- Fire and rescue service intervention is likely to be effective in avoiding undue secondary fires, or in ensuring that occupants at risk are not prevented from escaping or can be rescued.

From the above, the following (singly or in combination) are indicative of a situation which is unsafe:

- Extremely rapid external fire spread.
- Fire spread that gives rise to widespread secondary fires, resulting in occupants being harmed or unable to escape.
- A fire that spreads in such a way that communal means of escape are compromised before occupants can use them.
- A fire that compromises fire and rescues entry or exit points or the inability of the fire and rescue service intervention to prevent the above.

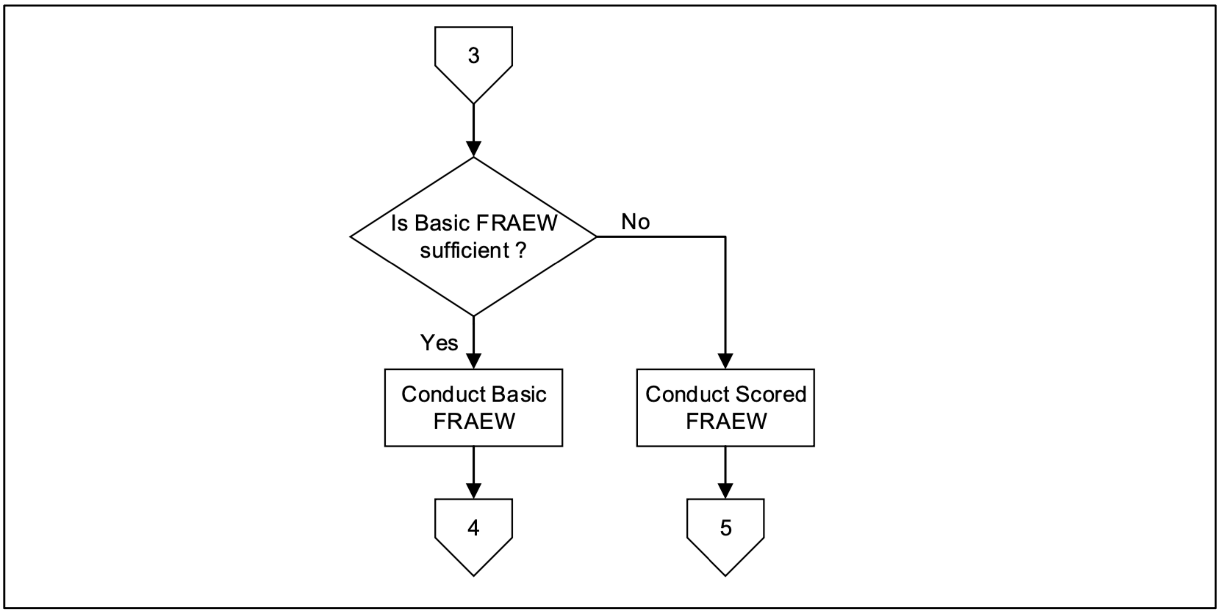
D.4.2 Risk Rating (Methods)

PAS 9980 Section 7 states that risk should be scaled (relative to 'normal' external wall construction) from low to high, with examples of masonry construction being cited as low, and Category 3 ACM being cited as high.

PAS 9980 also expects that the level of detail required for the FRAEW be proportionate to the risk and or complexity of the external wall construction, and it includes for a Basic or a Fire Engineered appraisal.

Therefore, the first part of PAS 9980 Steps 3 and 4 is to determine the appropriate FRAEW method (see Figure 21).

Figure 21: Selection of appropriate FRAEW method



Basic FRAEW

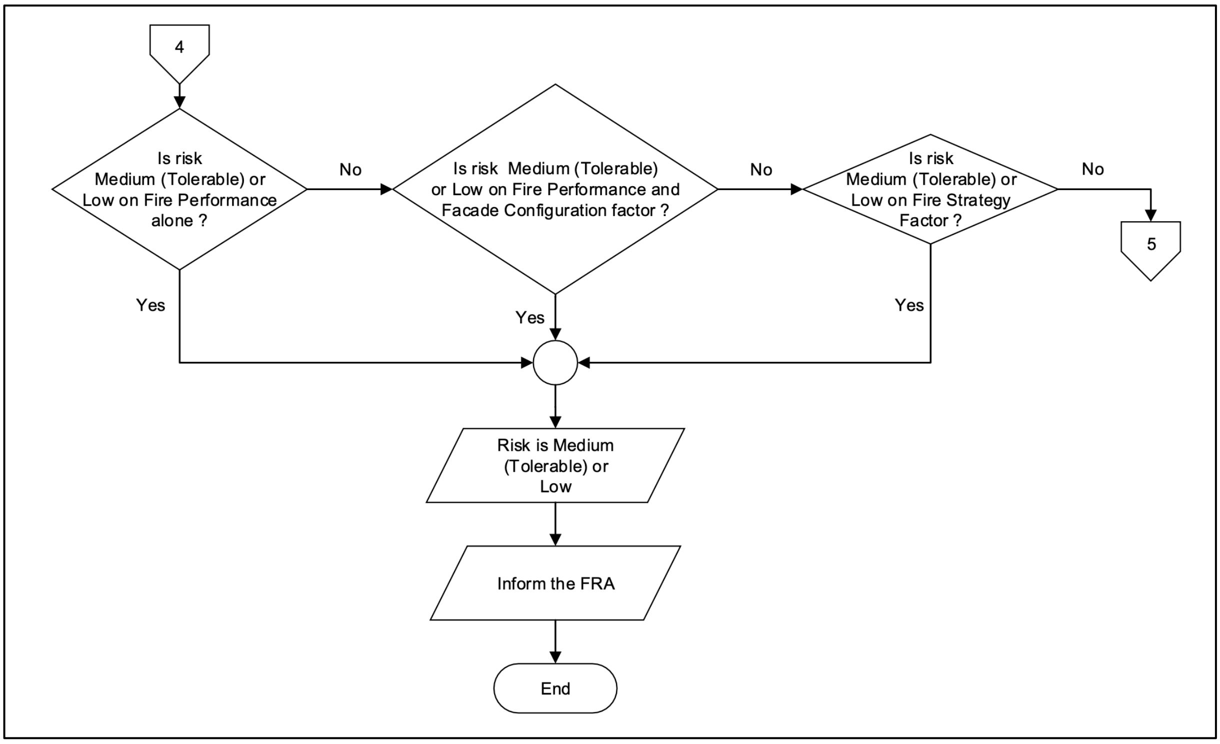
DFC's Basic FRAEW methods are described in Appendix E.

A Basic FREAW would be appropriate if it can be confirmed with sufficient certainty that:

- The fire performance factor is likely to be such that the rate, extent and heat of fire spread are in the normal range or only slightly higher than the normal range, and/or
- There are factors that would reduce the probability of fire spread via the construction (for example sprinkler protection), and/or
- The facade configuration factor is likely to be such fire would not spread to multiple flats or rapidly between flats, over the walls of the building or between buildings, and/or
- The fire strategy factor is likely to be such fire spread via the construction would not compromise any aspect of the fire strategy (including means of escape and fire service access and facilities).

The above process is shown in Figure 22.

Figure 22: The DFC Basic appraisal method



Fire Engineered FRAEWs

DFC's Fire Engineered FRAEW methods are described in Appendix H.

The methods combine PAS 9980 Steps 2, 3 and 4.

D.5 Step 5: Review and Determine Outcome

D.5.1 Risk Rating (Scores and Categorisation)

PAS 9980 Step 5 is to benchmark risk and determine an overall risk rating.

With reference PAS 9980 Figure 2 and associated informative text, PAS 9980 uses risk rating terminology as summarised below:

- Low: The rate and extent of fire spread via the external wall construction is within normal expectation and risk is sufficiently low that no remediation is required.
- Medium (Tolerable): Risk is heighted but is nevertheless considered to be tolerable. There is potential to accept the heightened risk (subject to periodic review) provided any *risk-proportionate actions* are undertaken.
- Medium (Uncertain): Risk might be heighted, but it is not possible to determine that the risk is so high as to require risk reduction or sufficiently low that it can be tolerated.
- Medium (Upper): Risk is heightened to an extent beyond that which can be tolerated and *risk reduction* is required.
- High: Risk is significantly heightened, and *risk reduction* (*remediation* or *mitigation*) is required.

Any assessment in accordance with PAS 9980 is subjective and includes uncertainty. Therefore, DFCs assessment methodology requires scores be allocated for at least two scenarios:

- Lower Bound: Scores are allocated to reflect the as-built construction as accurately as possible, and where there is uncertainty, score err towards optimism.
- Upper Bound: Scores are allocated to reflect the as-built construction as accurately as possible, and where there is uncertainty, score err towards conservatism.

D.5.2 Benchmarking of Risk Ratings

PAS 9980 Step 5 requires that the overall risk rating be benchmarked against known outcomes.

DFC has used the guidance in PAS 9980, fire incident data, fire testing data and engineering knowledge and experience to derive the benchmarking of risk as shown in Figure 23.

Figure 23: DFC benchmarking of risk ratings and outcomes

Benchmark Examples	Cat 3 ACM, Polystyrene, HPL Standard	Thin timber, Thick timber	HPL Fire Retardant, Category 2 ACM	BR 135 compliant, Linear Route, Brick cavity wall
Rating	High	Medium	Tolerable	Low
Likely Rate	*Very fast*	*Fast*	*Faster*	*Normal*
Likely Extent	*Uncontrolled*	*Far*	*Further*	*Normal*
Likely Heat	*Very high*	*High*	*Higher*	*Normal*

Notes:

1 The benchmarks are based on experience and professional judgement, and as such are approximate. DFC is funding research to enable quantified benchmarking of different systems and will publish the information in due course.

D.5.3 Risk Reduction Action

Unless there is clearly only one single credible means by which risk can be reduced identification, evacuation and selection of risk reduction options requires input from multiple stake holders.

Therefore, in such circumstances, it is not possible for risk reduction measures to be defined by an assessment in accordance with PAS 9980 or an external wall risk appraiser in isolation and a separate study is required.

Appendix E – DFC Basic FRAEW Methods

E.1 External Wall Constructions (General)

E.1.1 PAS 9980 Step 4: Identify Risk Factors

PAS 9980 Figure 1 identifies three key risk factors that should be considered in a Basic FRAEW:

1. **Fire performance risk factors** – are those influencing the likely speed and extent of fire spread by virtue of the fundamental properties, and fire behaviour, of the materials, components and systems comprising the external wall construction, how they are configured together and the quality of their installation within the wall build-ups on the building.

2. **Facade configuration risk factors** – are those factors influencing the likely speed and extent of fire spread by virtue of, for example:

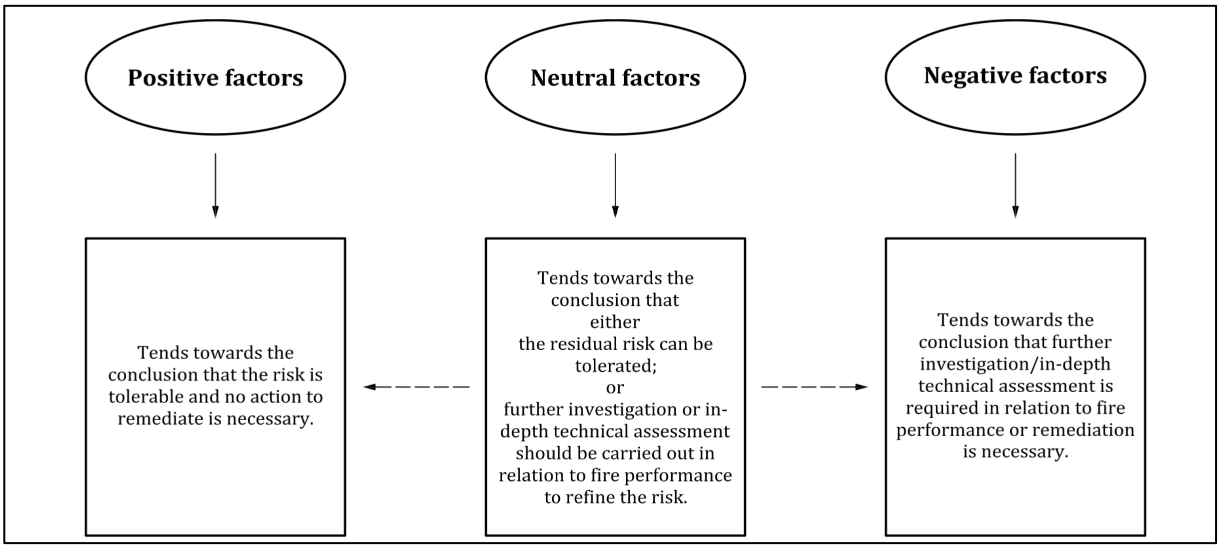
   - The extent to which the building is covered by combustible cladding and external wall construction (e.g. partially clad or fully clad),
   - The continuity of combustible cladding sections and their orientation (e.g. horizontal or vertical),
   - The presence or otherwise of continuous cavities and how they are protected against undue fire spread via the cavity.
   - The extent of openings in the external building envelope that would allow ignition of the cladding from flaming combustion originating inside the building and entry routes back in, and
   - The location of the cladding in relation to the potential for fires of external origin to ignite the cladding.

3. **Fire strategy/ hazard risk factors** – are those which influence the ability of occupants to escape once fire occurs and spreads via the external wall construction to other parts of the building. It also includes those that influence the ability of the fire and rescue service to intervene effectively. Such factors relate to elements of the fire safety design of the building.

E.1.2 PAS 9980 Step 4: Consider Contribution to Overall Risk

PAS 9980 Step 4 recommends that the key contributors to overall risk be considered in terms of positive, neutral and negative impacts (see Figure 24).

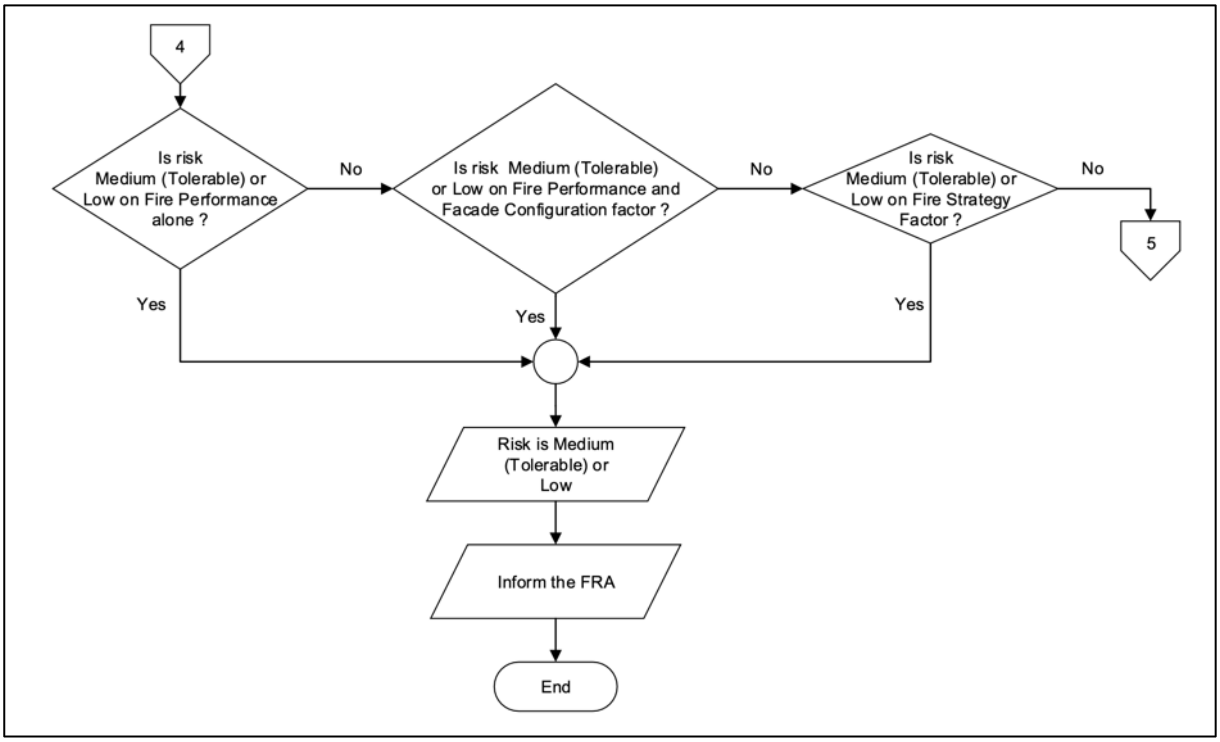
Figure 24: PAS 9980 Figure 5 – possible outcome of risk factor weighting



As per PAS 9980 Figures 6, 7, 8 and these contributors are applied sequentially to the fire performance factor, facade configuration and fire strategy factor in accordance with process defined below and in Figure 25 to arrive at an overall risk rating.

1. As a baseline, the highest risk of external fire spread on this scale equates to the extremely rapid fire spread seen in the fire at Grenfell Tower and in other fires involving similar cladding systems with metal composite material, particularly Category 3 ACM.
2. Risk factor analysis is intended to enable the positioning of the particular risk somewhere to the right of this baseline starting point. It is a three-stage process.
3. The fire performance factor considers whether fire spread via the external wall construction is unduly rapid (i.e. not low enough to be tolerable) or whether here is sufficient evidence to suggest that, while the rate of fire spread might be higher than normal expectations, it is still tolerable.
4. If by consideration of the fire performance factor alone, risk is not sufficiently low, the next step is to consider the facade configuration factor.
5. If by consideration of the fire performance factor and the facade configuration factor, risk is not sufficiently low, the next step is to consider the fire strategy factor.

Figure 25: Sequential application of contributors to overall risk rating



E.2 Spandrel Panels

Where appropriate, the risk associate with spandrel panels is assessed in accordance with the methodology defined in Appendix F.

E.3 Balconies

The risk associated with any balconies is assessed in accordance with the methodology defined in Appendix G.

Appendix F – Spandrel Panel Basic FRAEW

F.1 Description and Type

Spandrel panels are typically used within other systems (e.g. glazed curtain walling systems) to cover junctions with internal floors or walls.

The scope of this Appendix is limited to sandwich panels comprising an internal face, a core and an external face. The following types of spandrels are within the scope of this Appendix. In all cases, it is assumed that there is no fire barrier within the panel.

Table 19: Spandrel panel types

Type	Inner Face	Core	Outer Face
1	None or not *combustible*	Not *combustible*	None or not *combustible*
2	None or not *combustible*	*Thermoset, charring*	Not *combustible*
3	Steel	*Thermoplastic*	Not *combustible*
4	Not steel	*Thermoplastic*	Any

Spandrel panels also vary in size as summarised below.

Table 20: Spandrel panel sizes

Size	Panel Height
A	Floor or wall zone only
B	Less than half a storey-height or flat width
C	More than half a storey-height or flat width

F.2 Fire Performance

Provided fire stopping to the rear of any spandrel panel is adequate, the fire performance of the panel types is as summarised below:

- Type 1: No *combustible materials*: *hazard* is no greater than that associated with ADB.
- Type 2: *Thermoset* insulations have a low thermal inertia and do ignite readily when their surfaces are *exposed*. However, the likelihood of ignition is reduced by encapsulating the insulation and they also char and do not exhibit self-sustaining combustion. Therefore, the *hazard* is slightly greater than that associated with ADB.
- Type 3: The *hazard* is not significantly greater than that associated with ADB provided at least the internal face of the panel is steel because the steel ‘protects the insulation’ and reduces the likelihood of fire spread via the spandrel.
- Type 4: Fire can spread rapidly and extensively via thermoplastics. Therefore, the *hazard* is greater than that associated with ADB.

Therefore, the fire performance benchmarks for spandrel panels are as summarised below.

Table 21: Fire performance benchmarking for spandrel panel types

Benchmark Examples	Type 4		Type 3, Type 2	Type 1
EWSxxx				
Rating	High	Medium	Tolerable	Low
Likely Rate	*Very fast*	*Fast*	*Faster*	*Normal*
Likely Extent	*Uncontrolled*	*Far*	*Further*	*Normal*
Likely Heat	*Very high*	*High*	*Higher*	*Normal*

Therefore, the risk rating is at least as low as Medium (Tolerable) for Types 1, 2 and 3 when considering the fire performance factor in isolation and risk can be confirmed as being sufficiently low without the need to consider the facade configuration or fire strategy factors.

F.3 Facade Configuration

For Type 4, the hazard is a function of the size, as summarised below:

- Size A: The panel is limited to the internal compartmentation zone, and as such, the probability of fire spread between flats via the panel is no greater than that associated with fire spread via windows or openings. Additionally, the panels are not large enough to constitute a medium for fire spread over the walls of the building. As such, the risk of fire spread is no greater than that associated with ADB.
- Size B: The panel size is such that the probability of fire spread between flats via the panel is greater than that associated with ADB, but the panels are small enough that they do not constitute a medium for fire spread over the walls of the building. As such, the risk of fire spread is slightly greater than that associated with ADB.
- Size C: The size of the panel is sufficiently large that panels could be a medium for fire spread over the walls of the building.

Therefore, the fire performance benchmarks for Type 4 panels can be modified as function of panel size as summarised below.

Table 22: Fire performance benchmarking for spandrel panel types

Benchmark Examples	Size C		Size B, Size A	
Rating	High	Medium	Tolerable	Low

Therefore, the risk rating is as least as low as Medium (Tolerable) for Size A and Size B Type 4 panels when considering the fire performance and facade configuration factors in isolation and risk can be confirmed as being sufficiently low without the need to consider fire strategy factor.

For Type 4 Size C panels, the risk cannot be confirmed as being at least as low as Medium (Tolerable) when considering fire performance and facade configuration factors only, and as such, consideration must be given to the fire strategy factor.

Appendix G – Balcony Basic FRAEW

G.1 Regulations and Guidance

G.1.1 Building Regulations

Paragraph B4 of Schedule 1 to the Building Regulations 2010[16] (Part B) states that, "*The external walls of the building shall adequately resist the spread of fire over the walls and from one building to another, having regard to the height, use and position of the building.*"

Therefore, whether balconies are within the scope of Part B depends on whether they are included within the definition of "external walls of the building". The Building Regulations do not include a definition of "external walls".

G.1.2 Approved Document B

ADB does not make explicit recommendations for the construction of balconies, but it requires that floors are constructed as compartment floors, and paragraph 12.5 also set out that, "*The external envelope of a building should not provide a medium for fire spread if it is likely to be a risk to health or safety.*"

Therefore, it could be inferred that compliance with ADB requires:

- Any balconies that could be considered as floors (e.g. winter gardens) to achieve at least *30REI*.
- The materials and configuration of construction should not constitute a medium for fire spread that is likely to be a risk to health and safety.

G.1.3 MHCLG Advice

MHCLG consolidated advice[17] includes the following recommendations:

- *Balconies made with combustible materials are a potential source of rapid fire spread on the external wall of residential buildings. It is the view of the Expert Panel that as a result the design of balconies should not assist fire spread along the external wall. Balconies including combustible materials may not meet an appropriate standard of safety and could pose a risk to the health and safety of residents and other building users.*
- *The view of the Expert Panel is that the removal and replacement of any combustible material used in balcony construction is the clearest way to prevent external fire spread from balconies and therefore to meet the intention of building regulation requirements and this should occur as soon as practical.*
- *There have been several incidents of balcony fires which have led to external fire spread. BRE Global published examples of this in their 2016 report "Fire safety issues with balconies" which can be accessed at: www.bre.co.uk/filelibrary/Fire and Security/FI---Fire-safety-and-balconies-July-16.pdf*
- *The BRE report concluded that "...managers and risk assessors all need to be mindful of the potential fire risk associated with fires on balconies from their incorporation in to the building...". The Expert Panel supports this advice.*

[16] Statutory Instruments, '2010 No. 2214 Building and Buildings, England and Wales, The Building Regulations 2010' (as amended).
[17] Ministry of Housing, Communities and Local Government, 'Advice for owners of Multi-storey, Multi-occupied Residential Buildings', 20 January 2020

- *The BRE Global report quoted above also identifies that there are additional risks from materials used to prevent heat loss through thermal bridging that may increase fire spread.*

- *Building owners should check that adequate appropriate measures are in place to manage the fire safety of external wall systems (in line with the principles set out in section 3 above). They should also ensure that any risks arising from balconies are considered as part of the fire risk assessment and information provided to residents.*

- *Where there is doubt over the materials used, or risk presented, building owners should seek professional advice. Where combustible materials have been used and it is assessed that there is a notable risk of fire spread as a result, building owners should seek professional advice and take appropriate action to address that risk.*

- *The fire risk on balconies can also be increased due to the use of balconies as storage. A significant number of balcony fires start from the unsafe disposal of smoking materials and the misuse of barbeques. Building owners may have existing policies in place as to what can and cannot be stored and used on balconies by residents and may wish to review these in the light of the materials used in the balcony construction. They may also wish to communicate with residents to develop their understanding of these risks.*

G.1.4 BRE Research

The BRE[18] research identified the potential *hazard* that can result from fire spread via balconies, but also acknowledges that the BRE has not identified any report deaths cause by fire spread from a fire on a balcony.

G.2 Fire Incident Data

G.2.1 Samuel Garside House

MHCLG advice on balconies was initially published following the fire at Samuel Garside House in Barking in 2018, where fire spread via balcony construction from second floor to sixth floor in less than 10 minutes. The fire also spread into flats at each level leading to extensive damage within flats.

This fire clearly showed that balcony construction could be a medium for fire spread (as evidenced by the extent of spread), and that such fire spread is likely to be a risk to health and safety (as evidenced by the rate of spread and that occupants had to evacuate their flats to remain safe).

However, the construction at Samuel Garside included some unusual features that significantly impacted the rate and extent of fire spread:

- The decking and balustrades were made from timber. The mass of *combustible* material was relatively high per balcony and over the walls of the building.

- The decking and balustrades comprised individual elements of timber with gaps around them. This allowed fire spread within and through the construction and allowed multiple surfaces of elements to be burning simultaneously.

- The balconies were at each level (i.e. stacked above each other) and balustrades were full height in multiple locations. This meant that there were continuous, connected, vertical planes of fuel over which fire could spread.

- The balustrades were constructed from vertical timber ‘sticks’ approximately 50mm x 50mm in cross section at spacings of about 50mm. The timber dimensions are sufficiently small to make the timber easy to ignite, the vertical configuration encourages rapid vertical spread and the spacing is

[18] C Holland, M Shipp and D Crowder, ‘Fire safety issues with balconies’, July 2016, BRE

large enough to allow oxygen flow and small enough that each burning stick radiates to adjacent sticks increasing the rate of burning (via radiative feedback).

Therefore, whilst Samuel Garside evidenced that fire spread via balconies can be a risk to health and safety, it cannot be taken as evidence that fire spread could occur via more typical balconies and that such spread is likely to be a risk to health and safety.

G.2.2 Orwell Building

In July 2018 there was fire that spread via balcony construction on the Orwell Building, West Hampstead, London. The fire spread from third floor to sixth floor within 19 minutes. DFC has been unable to find reliable data about fire spread into flats from the balconies.

In this instance the balconies were small (about 3m by 3m in plan area), cantilevered balconies and the only *combustible* components were decking. DFC has been unable to identify the product used for the decking, but it appears that it was a composite decking plank. Such decking is typically made from wood mixed with polyethylene.

The fire shows that fire spread can occur between small balconies that comprise combustible decking only. It is unclear whether the fire spread is likely to be a risk to health and safety.

It is not clear how much of the fire spread was due to the use of composite decking.

G.2.3 Lighthouse

A balcony fire at the Lighthouse / Pall Mall, Manchester is believed to have started on the ninth floor and spread floors 8, 10 and 11, but did not spread laterally between balconies.

The construction comprised timber decking and the external wall included timber cladding. There were also vertical dividers between balconies.

Photographic evidence suggests that the fire spread most significantly against the timber walls and vertical dividers. It does not appear that the decking (other than locally to the corners) was burned.

The fire evidenced that fire spread between balconies comprising timber decking is not inevitable (because the decking only burned locally to corners) and that fire spread is more likely if the external wall construction is combustible and that fires are drawing upward in corners.

G.2.4 Limehouse Lodge

The fire at Limehouse Lodge was similar to at the Lighthouse and similarly evidences that fire spread is more likely in balcony configurations with that have corners into which flames can be drawn.

G.2.5 Evidence of Risk

The above fires evidence that fire spread via balconies can occur and provides evidence as to factors that would influence the likelihood, rate and extent of fire spread.

There is also evidence that (particularly from Samuel Garside), that fire spread via balconies can be a risk to health and safety.

However, given the number of balconies with combustible decking that exist across England, there is little or no evidence to show that the risk of fire spread via balcony construction is unduly high. That is to say, there are there is little data to show that fire spread via balcony construction is resulting in an unacceptable injuries or fatalities.

Therefore, even if assessment shows that fire spread between balconies is credible, it does not mean that such fire spread results in a standard of safety that is not reasonable (or a risk that is not tolerable).

G.3 Risk of Fire Spread

G.3.1 Likelihood

For balconies, potential ignition sources include fires starting on balconies themselves, fire originating outside buildings and fires spreading to balconies from within flats. Factors that influence whether balconies are likely to be ignited:

- Balcony Location: Balconies not located near ground level are unlikely to be ignited from external fires around the building perimeter. Similarly control of ignition sources and fuel load around building perimeters can reduce likelihood of ignition.
- Sprinklers: Sprinkler to protection to flats reduces the likelihood of fire spread from flats to balconies.
- Fuel: Absence of fuel load in a configuration that is readily ignitable reduces likelihood of ignition.

It is difficult to quantify and/or eliminate likelihood of ignition. Therefore, it is assumed that ignition can occur and that assessment of risk should concentrate on *hazard* and *consequence*, but that reducing the likelihood of ignition can be used as a risk reduction or risk mitigation measure where necessary.

G.3.2 Hazard

All timber is combustible and as such all timber can burn. However, whether timber burns in building situation and the rate and extent on burning depends on the following:

- Thermal Thickness: The thermal thickness of a solid fuel plays a vital role in its burning behaviour. Thermally thin fuels will heat uniformly all over the material and can be heated easily when ignition occurs. On the other hand, thermally thick fuels are harder to ignite, and a temperature gradient can be expected when they are exposed to heat. According to Bisby[19], a large log will be classified as thermally thick while wood shavings will be classed as thermally thin.
- Orientation: When combustible materials are in a horizontal configuration, the flame (which is vertical) is not concurrent with the orientation of the fuel, and as such the re-radiation from the flame is low. However, when the fuel is in a vertical orientation, the flame is concurrent with the fuel and there is a positive, increased radiation feedback. This means that fire spread over vertically orientated fuel is more likely and more rapid than horizontal.
- Oxygen Supply: If the surfaces of a fuel are ‘exposed’ to oxygen, the rate of burning can be governed by the availability of oxygen.
- Proximity to other burning Items: Where burning items are ‘close’ to each other there is a positive heat feedback between them such that heat produced by one increases burning rate of the other.
- Continuity: The extent of continuous fuel coverage can influence the extent (i.e. how far) of fire spread. When combustible materials are connected, a faster rate of fire spread can be expected.

G.3.3 Consequences

The more people that could be at risk and the greater the likelihood of them being harmed by a *hazard* the greater the *consequences* of a fire. Therefore, the following influences the *consequences* of fire spread:

- The number of flats that are connected by balconies (i.e. the number of flats to which fire spread could as a result of fire spread via balconies).

[19] Bisby L., ‘Grenfell Tower Inquiry. Phase 1 – Expert Report”, 2018.

- Whether the extent of fire spread can be influenced by external fire fighting.
- Whether fire spread is likely to result in harm depends on whether fire would spread back into flats and whether people would be aware of such fire spread in time for them to evacuate.

G.3.4 Risk Categorisation

Based on the above, Table 23 and

Table 24 provide some examples of *hazard* and *consequences* that would be low, medium and high.

Table 23: Hazard categorisation

Hazard	**Examples**
Low	All materials are of *limited combustibility* or better or shielded from beneath by non-combustible materials, OR *Combustible products* are limited to horizontal timber decking or similar.
Medium	Construction that includes timber, *thermoset* foam insulation that is not low *hazard*.
High	Construction that includes composites, *thermoplastic* insulation, or polyethylene, OR Construction that includes combustible materials configured vertically more than half a storey high.

Table 24: Consequence categorisation

Consequence	**Number of People at Risk**
Low	Balconies configured such that fire spread via the balconies would not lead to fire spread to multiple bedrooms.
Medium	Balconies within reach of external fire service intervention, OR Balconies configured such that fire spread via the balconies would not lead fire spread to multiple flats (but not multiple bedrooms).
High	Balconies out with reach of external fire service intervention that could lead to fire spread to multiple bedrooms.

Table 25 provides some examples of risk categorisation for different balcony types and configurations.

Table 25: Balcony risk categorisation

	Low *Hazard*	**Medium *Hazard***	**High *Hazard***
Low *Consequence*	Low: Balconies with low or protected fuel load that do not connect multiple bedrooms.	Medium (Tolerable): Balconies with *combustible* decking that do not connect multiple bedrooms.	Medium (Upper): Balconies with vertical *combustible* components that do not connect multiple bedrooms.
Medium *Consequence*	Medium (Tolerable): Balconies with low or protected fuel load that connect to multiple flats but either not to bedrooms or there is adequate external fire service access.	Medium (Upper): Balconies *combustible* decking that connect to multiple flats but either not to bedrooms or there is adequate external fire service access.	High: Balconies with vertical *combustible* components that connect to multiple flats but either not to bedrooms or there is adequate external fire service access.
High *Consequence*	Medium (Upper): Balconies with low or protected fuel load that connect multiple bedrooms without adequate external fire service access.	High: Balconies *combustible* decking that connect multiple bedrooms without adequate external fire service access.	High: Balconies with vertical *combustible* components that connect multiple bedrooms without adequate external fire service access.

G.4 Mitigation Measures

Risk can be reduced by reducing the *hazard* and/or reducing *consequence*. Table 26 some examples of *risk-proportionate actions* for different risk categories to reduce risk to Medium (Tolerable).

Table 26: Balcony risk mitigation options

	Low *Hazard*	**Medium *Hazard***	**High *Hazard***
Low *Consequence*	Not required.	Any practical measures to reduce fire load, e.g. management of storage of combustible materials on balconies.	Not required, but consider removal of some *combustible* materials, particularly vertically oriented.

	Low *Hazard*	Medium *Hazard*	High *Hazard*
Medium *Consequence*	Not required.	Not required but consider removal of some *combustible* materials, particularly vertically oriented and/or provide local point smoke detection in any bedrooms that are adjacent to balconies.	Remove some or all *combustible* materials or control fuel load and protect flats with sprinklers.
High *Consequence*	Not required, but consider local point smoke detection in any bedrooms that are adjacent to balconies.	Remove some or all *combustible* materials or control fuel load and protect flats with sprinklers.	Remove some or all *combustible* materials.

G.5 Conclusions

Balconies can be a medium for fire spread that is likely to be a risk to health and safety. However, given the number of balconies in existence and lack of reported deaths or injuries resulting from balcony fires, it is also feasible that the risk of fire spread is sufficiently low.

DFC has considered and ranked the *hazard* of fire spread and *consequences* of fire spread such that risk of fire spread can be qualified for different balcony construction and configurations. Additionally, potential risk reduction and mitigation options have been identified for each risk category.

Appendix H – DFC Fire Engineered FRAEW Methods

This content of this appendix has been deleted because the assessment for the building in question does not require fire engineered assessment.

Appendix I – Fire Performance Factors for FRAEWs

I.1 Principles

The fire performance factor reflects the external wall's resistance to fire spread, which is a function of the combustibility of the materials used in the external walls and any fire resistance provided by the internal construction or within the external walls. It is specific to the wall construction, but not influenced by the building specific usage of the wall construction (i.e. extent of coverage).

Where there is uncertainty about the materials used in the external wall construction or the resistance to fire spread within the wall construction, it should be conservatively assumed that the *hazard* associated with the wall construction is 'high'.

I.2 Materials and Products

The thermodynamic and thermomechanic characteristics of relevant products that are used to assess the fire performance factor are summarised below.

Brick

Brick is *non-combustible*. Non-loadbearing walls constructed from clay or concrete bricks at least 75mm thick achieve *60EI* from each side separately. Brick has a high thermal inertia and as such acts as a heat sink.

Therefore, the governing characteristics of brick are:

- Thermodynamic: Brick is not *combustible* and as such does not contribute to the rate or total heat release, nor is it a medium for fire spread over the walls of the building. Brick can also act as a heat sink and 'remove' heat from a fire (particularly heat within cavities).
- Thermomechanic: Provided it has been installed correctly, brick will remain in place and not deteriorate mechanically. As such it provides a high degree of encapsulation to cavities.

Glass Reinforced Concrete (GRC)

GRC is *non-combustible*. GRC cladding panels can also achieve fire resistance. GRC does not degrade in fire, but panels can crack and fracture.

Therefore, the governing characteristics of brick are:

- Thermodynamic: GRC is not *combustible* and as such does not contribute to the rate or total heat release, nor is it a medium for fire spread over the walls of the building.
- Thermomechanic: Provided it has been installed correctly, GRC will remain in place and not deteriorate mechanically. As such it provides a degree of encapsulation to cavities. However, it can also crack and fracture and so it is possible that cavities would be exposed at some point in a fire.

Cement Particle Boards

Cement particle boards comprise timber particulate in an inorganic, cement-based binder. They typically achieve *Class A1*, *Class A2* or *Class B* depending on the proportion of timber particulate to inorganic binder.

However, products that achieve *Class B* typically have a heat of combustion of less than 7MJ/kg and some are only marginally over the 3MJ/kg threshold for *Class A2*.

Furthermore, heat of combustion measurement requires that a sample of board be ground up and tested in a bomb calorimeter. This process 'releases' the timber particulate from the inorganic binder so that its contribution to the total heat of combustion is measured. In practice, the timber particulate is bound in the inorganic binder such that it does not readily burn.

Therefore, whilst cement particle boards used on existing buildings might not be of *limited combustibility* or better, their in-practice performance is likely to be similar to *Class A2* boards and the following characteristics are reasonable:

- Thermodynamic: The boards are not readily ignitable, and they are not a medium for fire spread. Any burning would be limited to the immediate vicinity of any flames and the contribution to fire growth or overall heat of combustion is sufficiently low to be negligible.
- Thermomechanic: The product would degrade if exposed to direct heat, but not rapidly. Thermal expansion is low.

Polyisocyanurate (PIR) Insulation

Polyisocyanurate ("PIR") is a combustion modified, *thermoset*, *charring* polymer with low thermal inertia.

This means that the surface of the *product* is readily ignitable, and flame can spread rapidly over the surface, but that as the *product* pyrolyses a char forms that prevents / inhibits further combustion.

Many such insulation *products* include foil facings that inhibit ignition and inhibit / prevent flame spread across the surface.

PIR insulation *products* have a heat of combustion of around 26MJ/kg to 29MJ/kg. They are *combustible* and can have classifications of *Class B*, *Class C* or *Class D* (as influenced by the foil facing). Whilst these ratings are indicators of ignitability and rate of surface flame spread (in a room enclosure), they are not necessarily indicators of the relative contribution to fire spread, rate of heat release or total heat release in an external wall system.

Therefore, regardless of classification, the governing characteristics of PIR insulations are:

- Thermodynamic: The surface readily ignitable and rapid flame spread over the surface could occur. Unless used in combination with other *combustible products*, any burning would be limited to the immediate vicinity of any flames and the contribution to fire growth or overall heat of combustion is low.
- Thermomechanic: The *product* would char and eventually burn through where exposed to direct heat, but not rapidly. Thermal expansion is negligible. The rate of char is such that PIR and phenolic boards can achieve fire resistance (both to structural framing systems and when used behind cavity barriers).

Phenolic Insulation

Phenolic is a combustion modified, *thermoset*, *charring* polymers with low thermal inertia.

This means that the surface of the *product* is readily ignitable, and flame can spread rapidly over the surface, but that as the *product* pyrolyses a char forms that prevents / inhibits further combustion.

Many such insulation *products* include foil facings that inhibit ignition and inhibit / prevent flame spread across the surface.

Phenolic insulation *products* have a heat of combustion of around 26MJ/kg to 29MJ/kg. They are *combustible* and can have classifications of *Class B*, *Class C* or *Class D* (as influenced by the foil facing). Whilst these ratings are indicators of ignitability and rate of surface flame spread (in a room enclosure), they are not indicators of the relative contribution to fire spread, rate of heat release or total heat release in an external wall system.

Therefore, regardless of classification, the governing characteristics of phenolic insulations are:

- Thermodynamic: The surface readily ignitable and rapid flame spread over the surface could occur. Unless used in combination with other *combustible products*, any burning would be limited to the immediate vicinity of any flames and the contribution to fire growth or overall heat of combustion is low.

- Thermomechanic: The *product* would char and eventually burn through where exposed to direct heat, but not rapidly. Thermal expansion is negligible. The rate of char is such that PIR and phenolic boards can achieve fire resistance (both to structural framing systems and when used behind cavity barriers).

Polyurethane (PUR) Insulation

Polyurethane ("PUR") is a thermally thin, *thermoset* polymer.

This means that the surface of the *product* is readily ignitable, and flame can spread rapidly over the surface, and that the product can continue to burn away from any flaming region.

PUR insulation *products* have a heat of combustion of around 26MJ/kg to 32MJ/kg.

Therefore, the characteristics of PUR insulations are:

- Thermodynamic: The surface readily ignitable and rapid flame spread over the surface could occur. The product can also be a medium for fire spread beyond the area of flames (even in the absence of other combustible materials).

- Thermomechanic: The *product* ablates and can degrade rapidly. Thermal expansion is negligible.

Polystyrene

Polystyrene is a rigid, closed cell, thermoplastic foam material that with a low thermal inertia. When exposed to temperatures of approximately 200°C it melts or sublimes and combusts.

Typically, polystyrene that is used in external wall construction is in one of two forms; extruded polystyrene ("XPS") and expanded polystyrene ("EPS"). These products can have different properties at low heat fluxes, but at higher heat fluxes (as would occur in a building fire), they have similar properties.

Polystyrene has a heat of combustion of around 40MJ/kg.

This means that it is readily ignitable and can support self-sustaining combustion.

It will ignite when exposed to a naked flame around 360℃ and autoignite around 427℃. Once ignited it can sustain ignition and spread rapidly over its surface via dripping and flaming droplets with the ability to burn away from its source of ignition.

Therefore, the characteristics of polystyrene insulations (both XPS and EPS) are:

- Thermodynamic: The surface material is readily ignitable and can be a medium for fire spread beyond the area of flames (even in the absence of other combustible materials).

- Thermomechanic: The material burns, melts and can result in voids being created.

Timber Cladding

Wood is an organic, *charring* solid. The heat of combustion of wood used in timber cladding is approximately 18MJ/kg.

The ignition, flame propagation and combustion of timber properties depend on many factors such as species, density, grain orientation and thermal thickness.

For woods used for timber cladding, the properties are most sensitive to:

- Whether the timber has been treated with a flame retardant.
- The thermal thickness of the timber (and number of sides exposed).
- The orientation of and gaps around individual timbers.

Typically, untreated timber is assumed to achieve *Class C* or *Class D* (*Class 3* or *Class 4*).

Timber treated with a fire retardant can achieve *Class B* and *Class 0*.

Since its inception, for situations where it recommends that external wall surfaces achieve *Class 1*, Approved Document B has stated that timber at least 9mm thick can also be used. This recommendation has its genus in experimental work conducted for the 1965 Building Regulations and appears to be a mis-quote of experimental test configuration (the test used timber 7/8th inch thick fitted to a substrate, whereas 9mm is 3/8th inch). Therefore, it cannot be assumed that timber 9mm thick is equivalent to Class 1.

Furthermore, experimental work conducted for BR135: 1988 showed that rapid, accelerating fire spread can occur via timber that is 20mm thick when exposed on both faces (i.e. thermally thin).

Therefore, when used as cladding in a rainscreen construction and not treated with a reliable flame retardant, the characteristics of timber cladding are as follows:

- Thermodynamic: The timber is readily ignitable when exposed to the magnitude of heat flux that would result from a fire protruding from a compartment opening (50kW/m^2 or more). If exposed on both faces, the timber would burn readily and self-propagating, accelerating fire spread could occur.
- Thermomechanic: The product would char and eventually burn through where exposed to direct heat, but not rapidly. Thermal expansion would be limited.

Standard Grade HPL

High pressure laminate (HPL) boards are typically manufactured by layering sheets of wood or paper fibre with a resin and bonding them under high pressure.

Standard grade HPLs do not include any fire retardants.

Standard grade HPLs have a heat of combustion or around 20MJ/kg to 25MJ/kg. They typically achieve *Class C* or *Class D*.

Therefore, the characteristics of Standard Grade HPLs are similar to timber, and as such are as follows:

- Thermodynamic: The HPL is readily ignitable when exposed to the magnitude of heat flux that would result from a fire protruding from a compartment opening (50kW/m^2 or more). If exposed on both faces, the HPL would burn readily and self-propagating, accelerating fire spread could occur.
- Thermomechanic: The product would char and eventually burn through where exposed to direct heat. Thermal expansion would be limited.

FR Grade HPL

High pressure laminate (HPL) boards are typically manufactured by layering sheets of wood or paper fibre with a resin and bonding them under high pressure.

FR Grade (or fire rated) HPLs include fire retardants that delay the time to ignition and slow the rate of combustion. The retardant can leach out of the product over time. As such, it is possible that FR Grade HPL can tend towards Standard Grade HPL over time. Similarly, the retardant is not always effective at the sorts of heat resulting from external building fires.

FR Grade HPLs have a heat of combustion or around 20MJ/kg to 25MJ/kg. They typically achieve *Class B*.

Therefore, the characteristics of FR Grade HPLs are:

- Thermodynamic: The *product* can be ignited and will burn; however, the burning does not significantly contribute to the fire and the *product* is not a medium for fire spread beyond the fire (on its own). It is possible that the fire retardant is not fully effective in severe fires.
- Thermomechanic: The *product* burns and will deteriorate.

Category 2 ACM

Aluminium composite material with a modified polyethylene core comprise a polyethylene and cement particulate core faced with thin sheets of aluminium. The products typically achieve *Class B*.

When exposed to fire, the aluminium can melt and/or de-bond; thereby, exposing the core to flames. However, the cement particulate within the core inhibits ignition and combustion of the polyethylene.

Whilst the *product* burn, they do not significantly contribute to the heat produced by the fire. Similarly, the core does not de-bond and does not rely on flame retardants; therefore, the product is not a medium for fire spread beyond the original fire.

Therefore, the characteristics of *Category 3 ACM* are:

- Thermodynamic: The *product* can be ignited and will burn; however, the burning does not significantly contribute to the fire and the *product* is not a medium for fire spread beyond the fire.
- Thermomechanic: The *product* burns and will deteriorate. This is not a rapid process.

Category 3 ACM

Aluminium composite material with an unmodified polyethylene core comprise a polyethylene core faced with thin sheets of aluminium.

When exposed to fire, the aluminium melts and/or de-bonds; thereby, exposing the core to flames. If heat is allowed to dissipate (e.g. the ACM is not associated with an insulated cavity), the melting and de-bonding can be limited to the immediate vicinity of the heat source / fire. However, where the heat cannot dissipate (e.g. when used in conjunction with an insulated cavity); the melting, de-bonding and burning can extend rapidly beyond the source of heat / fire.

Polyethylene is readily ignitable and *combustible*. It has a heat of combustion of approximately 45MJ/kg.

Therefore, the characteristics of *Category 3 ACM* used in conjunction with an insulated cavity are:

- Thermodynamic: The product can be ignited and will burn. The rate of burning is rapid and is likely to lead to upwards and downwards self-sustaining fire spread.
- Thermomechanic: The material burns and will deteriorate rapidly.

Plywood

Plywood is made from sheets of wood bonded with a binder. Wood is an organic, *charring* solid. The heat of combustion of wood used in timber cladding is approximately 18MJ/kg.

The ignition, flame propagation and combustion of timber properties depend on many factors such as species, density, grain orientation and thermal thickness.

For plywood, the properties are most sensitive to:

- Whether the plywood has been treated with a flame retardant.
- The thermal thickness of the plywood (and number of sides exposed).

Typically, untreated plywood is assumed to achieve *Class C* or *Class D* (*Class 3* or *Class 4*).

Plywood treated with a fire retardant can achieve *Class B* and *Class 0*.

- Thermodynamic: Plywood is readily ignitable when exposed to the magnitude of heat flux that would result from a fire protruding from a compartment opening (50kW/m² or more). If exposed on both faces, the plywood would burn readily and self-propagating, accelerating fire spread could occur.
- Thermomechanic: The product would char and eventually burn through where exposed to direct heat, but not rapidly. Thermal expansion would be limited.

Oriented Strand Board ("OSB")

OSB does not have low thermal inertia but can be readily ignited if they are geometrically thin so as to be thermally thin.

When it burns, it chars, but being a layered product, the char can delaminate exposing new timber.

Being mostly wood with some resin, OSB has a heat of combustion of around 20MJ/kg to 25MJ/kg.

Therefore, the characteristics of OSB are:

- Thermodynamic: The *product* can be ignited and will burn. The rate of burning depends on whether it is exposed on one or both faces and the thickness of the material.
- Thermomechanic: The material burns and will deteriorate.

Aluminium

Aluminium is a metal and is not *combustible*. It starts to lose strength at around 200°C and melts at around 600°C.

Therefore, it does not burn. Whether it melts depends on its thickness and the extent of fire exposure. Thin aluminium (e.g. that used in *ACM* panels) would heat up quickly and is likely to melt when exposed to flames. However, thicker aluminium (e.g. 3mm thick aluminium cladding panels and cladding rails) does not necessarily melt, particularly if heat can be conducted and radiated away from the *product*.

Therefore, the characteristics of aluminium are:

- Thermodynamic: Aluminium will not burn and does not contribute to the heat of fire or spread of fire.
- Thermomechanic: Aluminium can melt and distort.

Zinc

Zinc is a metal and is not *combustible*. It melts at around 420°C.

Therefore, it does not burn. Whether it melts depends on its thickness and the extent of fire exposure. However, it is reasonable to assume that zinc used in external wall constructions would be relatively thin and would melt if exposed to fire.

Therefore, the characteristics of zinc are:

- Thermodynamic: Zinc will not burn and does not contribute to the heat of fire or spread of fire.

- Thermomechanic: Zinc would melt.

Glass

Glass is *non-combustible*, but laminated glass has *combustible* interlayers. That said, the hazard associated with typical laminated glazing is low to negligible.

Glass panels can crack and fracture when exposed to fire.

Therefore, the governing characteristics of brick are:

- Thermodynamic: Glass is not *combustible* and as such does not contribute to the rate or total heat release, nor is it a medium for fire spread over the walls of the building.
- Thermomechanic: Glass does not significantly degrade materially, but it can crack, fracture and detach.

Brick Slips

Brick slips are either made by slicing brick into thinner sections or by bonding brick particulate in a resin. The former are likely to achieve *Class A1* or *Class A2-s1, d0* and the latter are likely to achieve Class B.

The brick slips are then incorporated into a brick slip system. The overall performance of the system is a function of system specific characteristics (e.g. the insulation used and the means of fixing the brick slips).

However, the characteristics of the slips themselves are:

- Thermodynamic: Depending on the manufacturing process, the slips can be ignited and can burn. However, the heat of combustion is such that they would not significantly contribute to fire and are not a medium for fire spread on their own.
- Thermomechanic: The slips will provide some protection to the underlaying layers within the system. However, they typically de-bond and fall off; thereby exposing the underlying layer.

Terracotta

Terracotta is *non-combustible*. When exposed to high heat, it can crack and fracture.

Therefore, the characteristics of terracotta tiles are:

- Thermodynamic: They would not ignite, burn or contribute to fire and are not a medium for fire spread.
- Thermomechanic: Subject to any gaps around the edges of each tile, they would provide protection to the cavity but they might facture and fall of locally to a severe fire.

Kingspan Architectural Wall Panels

Kingspan architectural wall panels comprise polyisocyanurate (“PIR”) insulation encapsulated in steel facings.

PIR is a combustion modified, *thermoset*, *charring* polymer with low thermal inertia.

This means that the surface of the *product* is readily ignitable, and flame can spread rapidly over the surface, but that as the *product* pyrolyses a char forms that prevents / inhibits further combustion.

When used in wall panels, the steel encapsulation prevents surface spread and delays pyrolysis.

The panels have been shown meet the BR 135 performance criteria when tested in accordance with BS 8414, have Loss Prevention Certification Board certification to LPS 1181: 2003, Grade and EXT B, and are Factory Mutual approval to Standard 4880 without height restrictions.

Therefore, the governing characteristics of Kingspan wall panels are:

- Thermodynamic: Unless used in combination with other *combustible products*, any burning would be limited to the immediate vicinity of any flames and the contribution to fire growth or overall heat of combustion is low.

- Thermomechanic: The insulation within the *product* would char and burn where exposed to direct heat, but not rapidly. The panels retain their integrity and do not detach or de-bond from the railing system.

MetSip Panels

MetSip panels are structural insulated panels comprising polyurethane (PUR) insulation cores encapsulated on each face by a single layer of cement particle board.

Whilst the core is *combustible*, the panels achieve at least *60EI* from each side separately (some panels achieve *90EI*). This means that fire would not spread to the external wall from a fire within the building.

Similarly, and in addition because the cement particle boards are not combustible, the core is adequately protected from an external fire to an extent that it would not burn. This has been evidenced by tests in accordance with BS 8414[xxx].

Therefore, for the purposes of external wall constructions, the characteristics of MetSip panels are:

- Thermodynamic: The panels achieve adequate fire resistance that the core would not contribute to the heat of combustion of an external fire and nor are the panels a medium for fire spread over the walls of buildings or within external wall cavities.

- Thermomechanic: The panels achieve at least *60EI* from each side separately.

I.3 Systems

I.3.1 Rainscreen Constructions

Hazards and Strategy Identification

PAS 9980 Annex G recommends that potential fire and smoke spread *hazards* be identified along with the associated strategy(s) for resisting fire and smoke spread. The purpose of this is to identify the components of the wall system that most important in resisting fire spread.

Rainscreens comprise four key components:

- Substrate: The inner part of the wall construction. They are typically brick, block, structural faming systems (“SFS”) or structural insulated panels (“SIPs”) that are constructed from the top surface of one floor to the underside of the floor above (“infill” systems).

- Cavity and insulation: There is a cavity (typically ventilated) between the substrate and the cladding. The cavity typically contains insulation fixed to the substrate and a framing system (fixed to the substrate) onto which the cladding is fixed.

- Cladding: The cladding typically comprises panels that are fixed to the framing system and there are typically gaps around the cladding panels to allow the cavity to be ventilated.

- Cavity barriers: There are *cavity barriers* within the cavity to resist fire and smoke spread within the cavity. Horizontal barriers are typically *open-state* to allow sufficient airflow for the cavity to be ventilated, but vertical barriers can be *closed-state*.

The potential *hazards* associated with rainscreens are:

- Pathways for fire and smoke spread around internal compartment walls or internal compartment walls if:
  - The substrate and cavity edge protection at openings do not adequately resist fire spread into and out of the cavity, and
  - Cavity barriers at junctions with internal compartment floors and internal compartment walls do not maintain the fire resistance of the respective floors and walls.
- Fire spread and smoke within the cavity if:
  - Cavity barrier provisions are not sufficient to adequately resist fire and smoke spread, or
  - The cladding allows fire and smoke spread to bypass cavity barriers.
- Fire spread via *combustible* materials within the cavity if cavity barriers provisions are not sufficient to adequately resist fire spread via the combustible materials.
- Fire spread via the *combustible* cladding.

The *hazard* reduction strategy includes the following:

- Isolation (i.e. limiting coverage): The location and extent of coverage of a wall construction system is such that:
  - it is not a medium for fire spread (e.g. is limited to a small area of coverage such as spandrel and infill panels); and/or
  - fire spread over the construction is not possible (e.g. there are no external ignition sources and no openings through which fire could spread from inside the building to the wall construction) or is not likely to be a risk to health or safety (e.g. the wall construction system is only located on an elevation with no window or vent openings through which fire could spread from outside to inside).
- Encapsulation: *Combustible materials* and cavities are encapsulated by construction that is not *combustible* and is adequately fire-resisting (i.e. prevents fire penetration to the *combustible* material/cavity).
- Restricting fire spread in the absence of a cavity (cavity absence): There are no cavities, and the *hazard* of fire spread via *materials* and surfaces is adequately low.
- Compartmentation continuation: The internal fire-resisting construction continues through to the outside of the building such that any cavities and combustible materials do not span between compartments.
- Limiting combustibility: The combustibility of *materials* is such that they would not be a medium for fire spread.
- Subdivision: *Combustible* materials and/or cavities are subdivided by construction that adequately resists fire spread.

Rainscreen construction resists fire spread by subdivision (see PAS 9980 Annex G.3.5), such that *combustible* materials and/or cavities are subdivided by construction that adequately resists fire spread.

Therefore, (as discussed in Appendix M) adequacy of resistance to fire spread around internal compartment walls and internal compartment floors, within concealed spaces and over the walls of the building is sensitive to:

- The fire resistance of the substrate.
- The contribution of any *combustible* materials within the substrate (if not adequately encapsulated) and/or the cavity to fire spread within the cavity.
- Provision and efficacy of cavity barriers and the efficacy of the cladding at inhibiting fire spread around cavity barriers.
- The combustibility of the cladding.

Key Fire Performance Factors

Therefore, the principles summarised in table below are applied to fire performance factors and scoring where appropriate.

Table 27: Fire performance principles for rainscreen cladding

Component	Positive	Neutral	Negative
Substrate Fire Resistance (PAS 9980 K.7)	Enhanced Resistance *30EI* or more	Some Resistance *15EI* to *30EI*	Reduced Resistance Less than *15EI*
Substrate Contribution to Fire (PAS 9980 K.8)	Materials are not *combustible* or sheathing board encases *combustible* materials.	Materials are not *combustible* or sheathing board is *Class B*.	Materials are *combustible* and sheathing board does not encapsulate *combustible* materials.
Insulation Contribution to Fire (PAS 9980 K.6)	No insulation and substate is positive or insulation is not *combustible*.	No insulation and substate is neutral or insulation is *thermoset* and charring.	No insulation and substate is negative insulation is *thermoplastic*.
Cavity Subdivision (PAS 9980 K.5)	Cavity barrier provisions are enhanced (e.g. matching internal compartmentation).	*Cavity barrier* provisions are similar or equivalent to ADB compliance.	Cavity barriers are missing or include workmanship defects.
Cladding Protection of Cavity (PAS 9980 K.2 & K.3)	Cladding does not burn, does not warp and does not have large gaps.	Cladding provides some protection to the cavity.	Cladding burns quickly, has large gaps or warps; thereby exposing the cavity.
Fire Spread via Cladding (PAS 9980 K.4)	Cladding is not *combustible*.	Cladding is homogeneous and achieves *Class B* without fire retardants.	Cladding is readily ignitable and can lead to fire spread beyond the original fire.

In attributing scores for each element, the influence of one element on another is considered. For example, the cavity and insulation score would be high if the cladding is sufficiently combustible that it would result in fire spread via the cavity or insulation.

I.3.2 Cavity Wall Construction

Hazards and Strategy Identification

PAS 9980 Annex G recommends that potential fire and smoke spread *hazards* be identified along with the associated strategy(s) for resisting fire and smoke spread. The purpose of this is to identify the components of the wall system that most important in resisting fire spread.

Cavity walls comprise four key components:

- Substrate: The inner part of the wall construction. They are typically brick, block, structural faming systems ("SFS") or structural insulated panels ("SIPs") that are constructed from the top surface of one floor to the underside of the floor above ("infill" systems).
- Cavity and insulation: There is a cavity (typically unventilated but might have a drainage cavity or weep holes) between the substrate and the cladding. The cavity might contain insulation that fills the cavity, insulation that partially fills the cavity or no insulation.
- Cladding: For cavity walls, the cladding is more of an outer leaf of wall construction than a cladding system. It is typically sealed (or has small holes such as weep holes) and encapsulates the cavity (as opposed to being a rainscreen).
- Cavity barriers: Whether or not *cavity barriers* are required depends on the degree of encapsulation provided to the cavity by the substrate and cladding. Where there is a high degree of encapsulation (e.g. brick substrate and cladding), *cavity barriers* are not required, but where the encapsulation is less robust, *cavity barriers* might be required.

The *hazards* associated with the construction are:

- Pathways for fire and smoke spread within the construction if the encapsulation and/or cavity barriers are not adequate.
- Fire spread via the cladding if it is *combustible*.

The *hazard* reduction strategy is a combination of:

- Isolation (i.e. limiting coverage): The location and extent of coverage of a wall construction system
- Encapsulation: *Combustible materials* and cavities are encapsulated by construction that is not *combustible* and is adequately fire-resisting (i.e. prevents fire penetration to the *combustible* material/cavity).
- Subdivision: *Combustible* materials and/or cavities are subdivided by construction that adequately resists fire spread.

Cavity wall construction resists fire spread by encapsulation or a combination of partial encapsulation and partial subdivision or partial (see PAS 9980 Annex G.3.5). Therefore, adequacy of resistance to fire spread around internal compartment walls and internal compartment floors, within concealed spaces and over the walls of the building is sensitive to:

- The fire resistance of the encapsulation (i.e. the substrate, the cladding, and cavity edge protection including around openings), or
- When encapsulation is partial, the fire resistance of any *cavity barriers* within the cavity.
- The combustibility of the cladding.

It can be shown (see Appendix N) that cavity walls comprising inner and outer leaves that achieve at least *60EI* from each side separately and a *limited combustibility* or better outer leaf adequately resist fire spread (i.e. have a positive fire performance factor in the context of PAS 9980).

Key Fire Performance Factors

Therefore, the principles summarised in table below are applied to fire performance factors and scoring where appropriate.

Table 28: Fire performance principles for cavity wall construction

Component	Positive	Neutral	Negative
Inner Wall Fire Resistance	*60EI*.	*30EI*.	Less than *30EI*.
Cavity Edge Fire Resistance	*30EI* or more.	Sealed so as to prevent air flows.	Not adequately sealed.
Cavity Materials (where encapsulation is total)	Any *combustibility*.	N/R.	N/R.
Cavity Materials (where encapsulation is not total)	No insulation or *Class B* or better.	*Class C* insulation.	*Class D* or worse insulation.
Cavity Subdivision (where encapsulation is total)	Subdivision not required.	N/R.	N/R.
Cavity Subdivision (where encapsulation is not total)	Fire resistance equal to compartment floors and walls.	*60EI*.	Less than *60EI*.
Cladding Fire Resistance	*60EI*.	*30EI*.	Less than *30EI*.
Fire Spread via Cladding	Cladding is not *combustible*.	Cladding is homogeneous and achieves *Class B* without fire retardants.	Cladding is readily ignitable and can lead to fire spread beyond the original fire.

In attributing scores for each element, the influence of one element on another must be considered. For example, the cavity and insulation score would be positive if they are encapsulated by inner and outer leaves that achieve approximately *60EI*.

I.3.3 Imperforate Cladding Systems (Compartment Continuation)

Hazards and Strategy Identification

PAS 9980 Annex G recommends that potential fire and smoke spread *hazards* be identified along with the associated strategy(s) for resisting fire and smoke spread. The purpose of this is to identify the components of the wall system that most important in resisting fire spread.

Imperforate cladding system could adequately resist fire spread via compartment continuation (see PAS 9980 Annex G.3.3). To qualify, the system would have to include two key components:

- Cladding: The cladding would have to be adequately imperforate, fire resisting and not combustible to maintain compartmentation at the interface with internal compartmentation.
- Firestopping: Adequate fire stopping from the outside face of internal compartmentation (e.g. compartment floors and compartment walls) and the inside face of the cladding.

The *hazards* associated with the construction are:

- Pathways for fire and smoke spread via any *firestopping* that has not been installed adequately.
- Any movement of the cladding at the interface with *firestopping* that results in gaps between the cladding and *firestopping*.
- Material degradation of the cladding that allows fire or smoke to bypass the *firestopping*.
- Fire bypassing the fire stopping via the cladding it is *combustible*.

Compartment continuation is sensitive to:

- The efficacy of fire stopping.
- The fire resistance and combustibility of the cladding.

Key Fire Performance Factors

Therefore, the principles summarised in table below are applied to fire performance factors and scoring where appropriate.

Table 29: Fire performance principles for compartment continuation

Component	Positive	Neutral	Negative
Substrate Fire Resistance	*30EI* or more.	No fire resistance.	N/A.
Substrate Contribution to Fire	Materials are not *combustible* or thermoset and *charring*.	Materials do not include *thermoplastics*.	Materials include *thermoplastics*.
Insulation Contribution to Fire	Materials are not *combustible* or *thermoset* and *charring*.	Materials do not include *thermoplastics*.	Materials include *thermoplastics*.

Component	Positive	Neutral	Negative
Cavity Subdivision	*Firestopping* is adequately installed.	*Firestopping* is less fire resistant than the internal compartmentation or has workmanship defects.	*Firestopping* is not adequate.
Cladding Protection of Cavity	Cladding achieves same fire resistance as internal compartmentation.	Cladding does not burn, does not warp and does not have large gaps.	Cladding provides some protection to the cavity.
Fire Spread via Cladding	Cladding is not *combustible*.	Cladding is homogeneous and achieves *Class B* without fire retardants.	Cladding is readily ignitable and can lead to fire spread beyond the original fire.

I.3.4 External Thermal Insulation Composite Systems (ETICS)

Hazards and Strategy Identification

PAS 9980 Annex G recommends that potential fire and smoke spread *hazards* be identified along with the associated strategy(s) for resisting fire and smoke spread. The purpose of this is to identify the components of the wall system that most important in resisting fire spread.

ETICS, sometimes called rendered systems as they typically feature an externally applied render coat as the weatherproof surface, construction resists fire spread in different ways depending on the components within the construction:

- ETICS comprising insulation that is not combustible and without a cavity would typically be compliant with ADB by limiting combustibility and restricting fire spread in the absence of a cavity (see PAS 9980 Annex G.3.2 and G.3.4). In this scenario, the external wall build up is unlikely to require an FRAEW as it inherently low risk.
- ETICS that do not rely on limiting combustibility and/or include a defined cavity in the build-up. In these construction types, the primary method of limiting fire spread is by a combination of encapsulation (see PAS 9980 Annex G.3.1) and sub-division (see PAS 9980 Annex G.3.5).

The latter is the topic of this section.

ETICS comprise four key components:

- Substrate: The inner part of the wall construction. They are typically brick, block, structural faming systems (“SFS”) or structural insulated panels (“SIPs”) that are constructed from the top surface of one floor to the underside of the floor above (“infill” systems).
- Drained Cavity: There is sometimes a drained cavity between the substrate and insulation.
- Insulation: Typically, polystyrene or mineral wool but can be other foam insulants.
- Topcoat: The topcoat is typically a render. This can be organic or inorganic and can vary in thickness.

- Cavity barriers: If there is a drained cavity, typically *open-state cavity barriers* are required.
- Fire Barriers: If the insulation is combustible, *fire barriers* is typically required.

The potential *hazards* associated with rainscreens are:

- Pathways for fire and smoke spread around internal compartment walls or internal compartment walls if:
  - The substrate does not adequately resist fire spread into and out of the cavity, and
  - Cavity barriers at junctions with internal compartment floors and internal compartment walls do not maintain the fire resistance of the respective floors and walls.
- Fire spread and smoke within the cavity if:
  - Cavity barrier provisions are not sufficient to adequately resist fire and smoke spread, or
  - The cladding allows fire and smoke spread to bypass cavity barriers.
- Fire spread via any *combustible* insulation if there are not adequate fire barriers, or if the topcoat is not sufficiently thick, or if the top coat is not adequately fixed to prevent delamination from the insulation.

The *hazard* reduction strategy includes the following:

- Isolation (i.e. limiting coverage): The location and extent of coverage of a wall construction system is such that:
  - it is not a medium for fire spread (e.g. is limited to a small area of coverage such as spandrel and infill panels); and/or
  - fire spread over the construction is not possible (e.g. there are no external ignition sources and no openings through which fire could spread from inside the building to the wall construction) or is not likely to be a risk to health or safety (e.g. the wall construction system is only located on an elevation with no window or vent openings through which fire could spread from outside to inside).
- Restricting fire spread in the absence of a cavity (cavity absence): There are no cavities and the *hazard* of fire spread via *materials* and surfaces is adequately low.
- Limiting combustibility: The combustibility of *materials* is such that they would not be a medium for fire spread.
- Subdivision: *Combustible* materials and/or cavities are subdivided by construction that adequately resists fire spread.

Where insulation is combustible, adequacy of resistance to fire spread around internal compartment walls and internal compartment floors, within concealed spaces and over the walls of the building is sensitive to:

- Substrate Performance. Whether the substrate is likely to resist spread of fire from inside the building to the external wall (i.e. protect the external wall construction) and whether the substrate itself (e.g. sheathing board) is likely to be a medium for fire spread itself.
- Cavity and Insulation. Whether the materials within the cavity (typically insulation) are a medium for fire spread, whether the surface finish will adequately stay in place and continue to protect the insulation and whether the cavity is adequately protected (by cavity barriers) to prevent the cavity itself being a medium for fire and smoke spread.

- Surface Finish. Whether the surface finish applied to the insulation is a medium for fire spread. Where the surface finish does not adequately protect the insulation, the cavity protection score (K.5) should be modified accordingly.

Key Fire Performance Factors

Therefore, the principles summarised in table below are applied to fire performance factors and scoring where appropriate.

Table 30: Fire performance principles for ETICS

Component	Positive	Neutral	Negative
Fire Resistance of Substrate (K.7)	Substrate with high fire resistance, that are not *combustible.*	Substrate with some fire resistance and some *combustible* materials.	Substrate with little fire resistance and/or significant *combustible* materials.
Sheathing board (K.8)	*Class B* or better with good workmanship.	*Class B* or better with minor workmanship issues.	Not *Class B*, poor workmanship or missing.
Cavity materials (K.6)	No insulation or *thermoset, charring* insulation and substrate can act as a heat sink.	*Class C* insulation or *thermoset* insulation.	*Class D* or worse insulation.
Cavity protection (K.5)	Cavity is protected by adequate *fire barriers* and surface finish is mechanically fixed and likely to stay in place during a fire.	Cavity is only partially protected, or *fire barriers* have workmanship issues.	Cavity is not significantly protected by *fire barriers* and the surface finish.
External surface finish (K.10)	$H_c \sim 3$MJ/kg or *Class B* or better that would be involved in fire.	$H_c < 30$MJ/kg or *Class C* that would be involved in fire.	$H_c > 30$MJ/kg or *Class D* or worse that would be involved in fire.

In attributing scores for each element, the influence of one element on another is considered. For example, the cavity and insulation score would be high if the surface finish is sufficiently combustible or fitted in such a way that it is unlikely to remain in place and protect the insulation.

I.3.5 Curtain Wall Construction

Curtain wall systems typically comprises a curtain walling system and might include some inner construction (e.g. a dry lined structural framing system) behind non-glazed parts of the curtain wall (e.g. opaque glazing or infill panels).

The curtain walling system typically comprises:

- Areas of glazing and/or windows in a framing system.
- Spandrel zones / panels around floors and or internal walls.

- Opaque sections of glazing or infill panels.

Therefore, the fire performance factor is determined from the inner construction performance, the spandrel performance and the ‘cladding’ performance (where the cladding is glazing and any infill panels).

Each element of the construction is scored from 1 (low *hazard*) to 5 (high *hazard*) in accordance with Table 31, Table 32 and Table 33.

Inner Construction Performance

The inner construction score considers whether the inner construction is likely to be a medium for fire spread itself.

Table 31: Inner construction fire performance

Sub-Item	Positive	Neutral	Negative
Combustible materials	Only small, isolated amounts of *combustible* inner construction.	*Combustible* materials are limited to thermoset, charring polymers such as Phenolic and PIR.	Extensive *combustible* materials that are not thermoset, charring polymers.
Protection of *combustible* materials	*Combustible* materials are encapsulated in fire resisting construction.	*Combustible* materials are encapsulated in construction that is not *combustible*, or *combustible* materials are contained within separate compartments by firestopping.	*Combustible* materials are exposed and could be a medium for extensive fire spread.

Spandrel Zone Performance

The spandrel zone provides resistance to fire spread around internal compartmentation via the external wall system and provides a potential ‘fire break’ to fire spread via the external surface of the cladding system.

Table 32: Spandrel zone fire performance

Sub-Item	Positive	Neutral	Negative
Internal Fire Spread	Spandrels are adequately fire stopped to the same standard as internal compartmentation.	Spandrels have some resistance to fire spread around internal compartmentation.	Spandrels would provide little resistance to fire spread around internal compartmentation.

Sub-Item	Positive	Neutral	Negative
External Fire Spread	Spandrels are not *combustible* or steel encased, thermoset, charring foam and are large enough to inhibit fire spread around internal compartmentation.	Spandrels are steel encased foam, or metal encased thermoset, charring foam and are large enough to inhibit fire spread around internal compartmentation.	Spandrels are *combustible* or not large enough to inhibit fire spread around internal compartmentation.

Cladding Performance

The cladding performance score considers whether the cladding (glazing and infill panels) is a medium for fire spread.

Table 33: Cladding fire performance score

Sub-Item	Positive	Neutral	Negative
Combustible Materials	$H_c \sim 3$MJ/kg or *Class B* or better that would be involved in fire.	$H_c < 30$MJ/kg or *Class C* that would be involved in fire.	$H_c > 30$MJ/kg or *Class D* or worse that would be involved in fire.
Panel construction	Will not fall off or deteriorate in fire and there small or no gaps within cladding.	Might fall off or deteriorate in fire and/or there are gaps within cladding.	Likely to fall off or deteriorate in fire and/or there are large gaps within cladding.

Appendix J – Facade Configuration and Fire Strategy Factors

The content of this appendix has been deleted because scored facade configuration and fire strategy factors are not required for the assessment of the building in question.

Appendix K – Risk Reduction

K.1 Principles

PAS 9980 includes five levels of risk as summarised below:

- Low: The rate and extent of fire spread via the external wall construction is within normal expectation and risk is sufficiently low that no remediation is required.
- Medium (Tolerable): Risk is heighted but is nevertheless considered to be tolerable. There is potential to accept the heightened risk (subject to periodic review) provided any *risk-proportionate actions* are undertaken.
- Medium (Uncertain): Risk might be heighted, but it is not possible to determine that the risk is so high as to require risk reduction or sufficiently low that it can be tolerated.
- Medium (Upper): Risk is heightened to an extent beyond that which can be tolerated and *risk reduction* is required.
- High: Risk is significantly heightened, and *risk reduction* (*remediation* or *mitigation*) is required.

Therefore:

- Where risk is not Low, the risk is heightened.
- Where risk is Medium (Tolerable), whilst risk is low enough to be tolerated, the risk is higher than what it would have been had the external wall construction been designed and built to achieve the standard required at the time of construction. Regardless, there still might be *risk-proportionate* action that can be taken (see Appendix D.5.1).
- Where risk is not at least as low as Medium (Tolerable), *risk reduction* is required.

Risk reduction should constitute an appropriate combination of *mitigation*, *repair* and *remediation*.

In the context of PAS 9980, risk is the probability of harm to occupants of the building as a result of fire spread via the external wall constructions. Therefore, risk can be reduced by any or a combination of the following:

- Option 1: Reducing the probability of fire igniting or spreading to the external wall construction (e.g. removing ignition sources or installing sprinklers).
- Option 2: Reducing the probability, rate and/or extent of fire spread via the external wall construction if it were to be ignited or fire were to spread to the construction (e.g. removing combustible materials or repairing or installing cavity barriers).
- Option 3: Reducing the *consequence* of fire spread via the external wall construction (e.g. providing early warning to those at potential harm or increasing protection around means of escape routes).

Whilst all three options can reduce risk, they reduce risk in different ways.

Options 1 and 3 constitute *mitigation* (as opposed to *remediation*) because they reduce the probability of the *hazard* manifesting and/or the probability of the *hazard* resulting in harm (as opposed to reducing the *hazard* itself). Option 2 constitutes *remediation* because it reduces the *hazard* of fire spread via the external wall construction.

The importance of the difference between *mitigation* and *remediation* needs to be considered in the context of societal risk:

- Society is less tolerant of high *consequence* risk events than low *consequence* risk events (even if the risk is the same). For example, society would be less tolerant of a single 100-fatality event than 100 single-fatality events even if the probability of the single-fatality even was 100 times that of the 100-fataility event (i.e. the risk was the same).

- In the context of fire spread via external walls, society would be less tolerant of the risk associated with fire spread that would result in multiple secondary fires than it would be of the risk associated with single secondary fires.

- Therefore, where the *hazard* of fire spread via the external wall construction is high (e.g. it could lead to multiple secondary fires), society would be less tolerant of risk reduction via mitigation than risk reduction via remediation (because mitigation reduces the probability of fire spread not the *consequence* of fire spread).

- In practice, this means that where fire spread via an external wall construction could lead to harm being caused to multiple people, for *mitigation* to be appropriate, the reduction resulting from the *mitigation* must be greater than the risk reduction that would be achieved by *remediation*.

For example, consider a block of flats with a *stay-put* evacuation strategy and a wall construction that spans across 11 flats and that has *combustible* insulation and missing *cavity barriers* (i.e. fire spread via the construction could lead to 10-secondardy fires).

- For a block of flats with a *stay-put* evacuation strategy, the probability of a single secondary fire via the external wall construction should be low (i.e. the *consequence* should be limited to a single secondary fire).

- Therefore, the consequence) of fire spread via the wall construction is 10 times that which it should be for a *stay-put* evacuation strategy. [This assumes that the *consequence* of 10-secondardy fires is not greater than 10 times the *consequence* of a single secondary fire, which is probably not the case].

- The risk associated with the construction could be *mitigated* by reducing the probability of the 10-secondardy fire occurring by 10 times.

- This could be achieved by installing a sprinkler system that is at least 90% reliable (i.e. reducing the probably of ignition by 0.1). [This assumes that ignition of the external wall would be prevented in situations where sprinklers activate successfully].

- However, society would be less accepting of the risk associated with a 10-secondardy fire event than the single secondary fire event, and so the risk would have to be less. This could be up to an order of magnitude less (i.e. the risk of a 10-secondary fire event might have to be 10 time less than the risk of a single-secondary fire event). This in turn would require the sprinkler system to 99% reliable.

Therefore, DFC considers that:

- *Remediation* is preferable to *mitigation*.

- *Mitigation* is only viable where the resultant risk reduction is high compared to the *consequences* of fire spread via the external wall construction.

Whilst the most appropriate risk reduction measures cannot be determined from assessment in accordance with PAS 9980 in isolation, assessment in accordance with PAS 9980 can be used to assess whether risk reduction measures would reduce risk sufficiently so as to be Low or Medium (Tolerable).

K.2 *Repair*

Where risk is Medium (Tolerable) or higher as a result of construction / workmanship defects, it might be possible to reduce risk to at least as low as Medium (Tolerable) by repairing the defect (e.g. installing missing cavity barriers or repairing cavity barriers that have not been installed correctly).

In most instances, such works are unlikely to constitute building works, and as such the repair would not have to be compliant with current Building Regulations. This requires assessment and confirmation by the building control authorities.

K.3 *Remediation*

K.3.1 Principles

Remediation (as opposed to *mitigation*) requires work to the wall construction itself to reduce risk (e.g. removal of combustible materials or inserting or fixing cavity barriers). *Remediation* reduces the *hazard* of fire spread via a wall construction.

Efficacy of *remediation* options can be investigated by conducting the PAS 9980 scoring method on the basis that *remediation* is conducted.

The ADB at the time of construction defined an adequate benchmark for compliance with the Part B at the time of construction. Therefore, *remediation* can be 'compliant' or 'non-compliant' as discussed below.

Compliant Remediation

If *remediation* results in the wall construction complying with the ADB at the time of construction, ADB compliance can be used to evidence that the resultant risk of fire spread is sufficiently low.

'Non-compliant' Remediation

Where *remediation* does not result in the wall construction complying with the ADB at the time of construction, whether the *remediation* is adequate is unavoidably subjective.

Therefore, before agreeing to 'non-compliant' *remediation*, DFC recommends that:

- Stakeholders must be informed of and agree to the subjectivity of the proposed remediation.
- The fire service (as enforcers of the FSO) be consulted.
- If uncertainty is high, either fire testing or a peer review be conducted to reduce uncertainty or increase confidence in the proposed *remediation*.

K.3.2 *Remediation* Options

The *hazards* associated with fire and smoke spread via external wall constructions are:

- Pathways: The external wall can constitute a pathway for fire and smoke spread around internal compartmentation either by virtue of combustible materials or routes for fire spread (e.g. cavities) that are not adequately protected.
- Unseen Fire and Smoke Spread: As above.
- Fire Spread to Adjacent Buildings: Any *combustible* products within an external wall construction can increase the probability of fire spread to an adjacent building by increasing the area of a fire or the heat release rate of a fire.
- Fire Spread from External: The external surfaces of a wall construction can be a medium for fire spread if they could be ignited from an external source (e.g. an adjacent building).

Therefore, depending on the *consequences* that need to be reduced, the following *remediation* options are available:

- Pathway protection: Protect pathways for fire spread between internal compartments via the external wall construction (e.g. by installing *fire barriers*).
- Remove combustible products: Removal of *combustible products* that could be a medium for fire spread around internal compartmentation or to adjacent buildings.
- Remove ignitable surfaces: Removal of surface *products* that could be ignited by an external fire.

K.4 *Mitigation*

K.4.1 Principles

Mitigation is a means of reducing risk without remediating the wall construction (e.g. enhancing fire alarm provision or fitting sprinklers). *Mitigation* reduces probability and/or *consequences* of fire spread via the external wall construction(s) but does not reduce the *hazard*.

Permanent

Mitigation can be permanent if it does not require unrealistic or unsustainable management. For example, sprinklers could constitute permanent *mitigation*, but waking watch could not be permanent *mitigation*.

Temporary (a.k.a. Interim Measures)

Some *mitigation* measures are only appropriate as a temporary measure until risks is reduced by remediation or permanent *mitigation*. Temporary *mitigation* (e.g. waking watch) is most likely to be appropriate where risk is Medium (Upper) or higher and permanent risk reduction is not possible in the short term. Temporary *mitigation* measures should be proportionate to the risk.

K.4.2 *Mitigation* Options

The risk of fire spread via external wall constructions can be mitigated by either:

- Reducing the probability of fire igniting or spreading to the external wall construction.
- Reducing the *consequence* of fire spread via the external wall construction.

Therefore, depending on the *consequences* that need to be reduced, the following *mitigation* options are available:

- Pathway protection: Protect pathways for fire spread between internal compartments via the external wall construction (e.g. by installing *fire barriers*).
- Remove combustible products: Removal of *combustible products* that could be a medium for fire spread around internal compartmentation or to adjacent buildings.
- Remove ignitable surfaces: Removal of surface *products* that could be ignited by an external fire.

Appendix L – Relevant ADB 2006 Advice

The following paragraphs list the Approved Document B for ADB: 2006[20], ADB: 2007[21] and ADB: 2013[22] that are relevant to external wall construction. Paragraph numbers are quoted from ADB: 2013.

L.1 Part B3: Internal Fire Spread (Structure)

L.1.1 Fire Resistance

All elements of structure are required to achieve *nR*, where n is defined in ADB Table A2 depending on the *storey height*.

All floors are required to achieved *nREI*, where n is defined in ADB Table A2 depending on the *storey height*.

All party walls between flats are required to achieved *nEI*, where n is defined in ADB Table A2 depending on the *storey height* or *60EI*, whichever is the lesser.

L.1.2 Maintaining Compartmentation

Paragraph 8.17

All floors should be constructed as compartment floors.

Paragraph 8.25

"Where a compartment wall or compartment floor meets another compartment wall or an external wall, the junction should maintain the fire resistance of the compartmentation. Fire-stopping should meet the provisions of paragraphs 10.17 to 10.19."

Paragraph 10.17 is not relevant to external walls. Paragraph 10.18 makes recommendations to prevent fire stopping being displaced during a fire. Paragraph 10.19 makes recommendations as to what constitutes effective fire stopping.

Fire stopping should achieve the same fire resistance standard as the compartment wall or floor which is being fire stopped.

Paragraph 8.26

"At the junction of a compartment floor with an external wall that has no fire resistance (such as a curtain wall) the external wall should be restrained at floor level to reduce the movement of the wall away from the floor when exposed to fire."

L.1.3 Concealed Spaces (Cavities)

Paragraphs 9.3 and 9.9

Paragraph 9.3 and 9.9 recommend that cavity barriers be provided:

- To enclose the edges of cavities, including around openings.

[20] HM Government, The Building Regulations 2000, Approved Document B (Fire Safety), Volume 2 – Building other than dwellinghouses, 2006', HMSO
[21] HM Government, The Building Regulations 2000, Approved Document B (Fire Safety), Volume 2 – Building other than dwellinghouses, 2006 edition amended 2007', HMSO
[22] HM Government, The Building Regulations 2010, Approved Document B (Fire Safety), Volume 2 – Building other than dwelling houses, 2006 edition incorporating 2007, 2010 and 2013 amendments', HMSO

- At the junction between an external cavity wall (except where the cavity wall complies with Diagram 34) and every compartment floor and compartment wall.
- For Purpose Groups other than Purpose Group 1, the maximum dimension in any direction between cavity barriers must not exceed:
  - 20m where the cavity surfaces and products are class 1 (national class) or class C-s3, d2 or better (European class), or
  - 10m where the cavity surfaces and products are not class 1 (national class) or class C-s3, d2 or better (European class).

Diagram 34

Diagram 34 recommends that:

- Cavities be faced internally and externally by brick or concrete each at least 75mm thick.
- Cavities be closed around openings.
- Cavities be enclosed at the top of the wall (unless the cavity is totally filled with insulation).

L.1.4 Cavity Barrier Construction

Paragraph 9.13

"Every cavity barrier should be constructed to provide at least 30 minutes fire resistance. It may be formed by any construction provided for another purpose if it meets the provisions for cavity barriers (see ADB Appendix A, Table A1, item 15).

Cavity barriers in a stud wall or partition, or provided around openings may be formed of:

- *a. steel at least 0.5mm thick;*
- *b. timber at least 38mm thick;*
- *c. polythene-sleeved mineral wool, or mineral wool slab, in either case under compression when installed in the cavity; or*
- *d. calcium silicate, cement-based or gypsum- based boards at least 12mm thick."*

L.1.5 DFC Interpretations of Recommendations

Junction and Cavity Edge Protection

The junctions between external walls and compartment floors and compartment walls should be adequately protected such that the external wall construction does not provide a parthway for spread of fire around internal compartmentation.

ADB diagram 33 provides one option for achieving this requirement, as summarised below:

- Firestopping: Fire stopping must be provided from the end of the internal compartmentation to the internal components of the external walls.
- *Internal Components*: Whilst not specified in ADB, it must be inferred that the *internal components* of the external wall must achieve an adequate fire performance (otherwise fire spread could occur via the internal components bypassing the fire stopping and cavity barrier.
- Opening Protection: Any openings in the internal components of the external wall must be adequately protected.

- Cavity Barriers: Cavity barriers must be provided between the internal components of the external wall and the outermost components.

An alternative to the ADB provisions that would meet the intent of ADB would be to continue the fire resistance of the compartmentation through the external wall construction to the outside of the building (i.e. forming a continuous line of fire resistance to the outside of the building).

Therefore, DFC considers that either of the following must be applied:

- *Picture framing:* Firestopping is provided in line with compartment floors or walls from the outside face of the floor or wall to the outside of the external wall. In this instance it is possible that protection around openings can be omitted.

- Conventional ADB: A layer (e.g. an inner blockwork layer) of the external wall construction achieves a fire resistance standard of 60 minutes (integrity and insulation). Fire stopping is provided at the junction between compartment floors and walls and the inside face of the fire resisting layer of the external wall. Cavity barriers are provided around any openings through the fire resisting layer of the external wall from the outside face of the layer to the outside of the building.

Cavity Barrier Construction

Where cavity barriers are required, ADB recommends that they achieve a fire resistance standard in accordance with BS 476-22. These do not comply with the requirements of BS 476-22 because at the start of the test there is an integrity 'failure' until the barrier activates and closes the gap to the back of the cladding. When the barriers close, they achieve a fire resistance standard in accordance with ADB recommendations. Whilst the barriers don't necessarily comply with ADB, this does not mean that they do not achieve an adequate standard.

L.2 Part B4: External Fire Spread

L.2.1 Flame Spread

Paragraph 12.5

"The external envelope of a building should not provide a medium for fire spread if it is likely to be a risk to health or safety. The use of combustible materials in the cladding system and extensive cavities may present such a risk in tall buildings.

External walls should either meet the guidance given in paragraphs 12.6 to 12.9 or meet the performance criteria given in the BRE Report[23] (BR 135) for cladding systems using full scale test data from BS 8414-1[24] or BS 8414-2[25].

The total amount of combustible material may also be limited in practice by the provisions for space separation in Section 13 (see paragraph 13.7 onwards)."

Paragraph 12.6

"The external surfaces of walls should meet the provisions in Diagram 40."

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[23] S Colwell and T Baker, 'Fire performance of external thermal insulation for walls of multistorey buildings: (BR 135) Third edition', 2013, BREPress

[24] BS 8414: Part 1, 'Fire performance of external cladding systems. Test methods for non-loadbearing external cladding systems applied to the face of building', 2002

[25] BS 8414: Part 2, 'Fire performance of external cladding systems. Test methods for non-loadbearing external cladding systems fixed to and supported by a structural steel frame', 2005

For a residential building greater than 18m in height with no part of any external wall within 1000mm of any boundary, Diagram 40 requires that:

- The external surface of any part of any external wall higher than 18m above adjacent ground must:
  - achieve class 0 (national standard) or class B-s2, d2 or better (European class), or
  - be profiled or flat steel sheet at least 0.5mm thick with an organic coating of no more than 0.2mm thickness.
- The external surface of any part of any external wall less than 18m above adjacent ground must:
  - achieve Index (I) not more than 20 (national standard) or class C-s2, d2 or better (European class) or better, or
  - be timber cladding at least 9mm thick.

L.2.2 Materials and Products

Paragraph 12.5 (General)

For paragraph 12.5 see Appendix L.2.1.

Paragraphs 12.6 to 12.9 (Limited Combustibility Option)

For paragraph 12.6 see Appendix L.2.1.

Paragraph 12.7 states, *"In a building with a storey 18m or more above ground level any insulation product, filler material (not including gaskets, sealants and similar) etc. used in the external wall construction should be of limited combustibility (see Appendix A). This restriction does not apply to masonry cavity wall construction which complies with Diagram 34 in Section 9."*

Paragraph 12.8 states, *"Cavity barriers should be provided in accordance with Section 9."*

Paragraph 12.9 states, *"In the case of an external wall construction, of a building which, by virtue of paragraph 9.10d (external cladding system with a masonry or concrete inner leaf), is not subject to the provisions of Table 13 Maximum dimensions of cavities in non-domestic buildings, the surfaces which face into cavities should also meet the provisions of Diagram 40."*

BR 135 Performance Criteria (Fire Testing Option)

The BR 135 requirements and performance criteria are:

- *The test specimen should be installed with all the relevant components, and should be assembled in accordance with the manufacturer's instructions.*
- *The system must have been tested to the full test-duration requirements of BS 8414 without any early termination of the full fire-load exposure period.*
- *The start time, t_s, for fire spread is initiated when the temperature first recorded by any external thermocouple at level 1 equals or exceeds a 200 °C temperature rise above the start temperature, T_s, and remains above this value for at least 30s.*
- *Failure due to external fire spread is deemed to have occurred if the temperature rise above T_s of any of the external thermocouples at level 2 exceeds 600°C for a period of at least 30s, within 15 min of the start time, t_s.*
- *Failure due to internal fire spread is deemed to have occurred if the temperature rise above T_s of any of the internal thermocouples at level 2 exceeds 600°C, for a period of at least 30s, within 15 min of the start time, t_s.*

- *Ongoing system combustion following extinguishing of the ignition source shall be included in the test and classification reports, together with details of any system collapse, spalling, delamination, flaming debris or pool fires. The nature of the mechanical performance should be considered as part of the overall risk assessment when specifying the system.*

In addition, for BS 8414-2 tests the following criterion is applied for internal fire spread:

- *Where system burn-through occurs so that fire reaches the internal surface, failure is deemed to have occurred if continuous flaming, defined as a flame with a duration in excess of 60s, is observed on the internal surface of the test specimen at or above a height of 0.5 m above the combustion chamber opening within 15 min of the start time, t_s.*

Diagram 34 (Encapsulation Option)

Combustible materials can be placed within a cavity within an external wall provided that complies with Diagram 34.

Appendix M – Rainscreen Cladding System Performance

M.1 Principles

By considering the relevant fire performance characterises of different external wall systems and reviewing common characteristics of systems that have been shown to meet (and fail) the BR 135 performance criteria, it is possible to identify critical success factors for different systems.

For example:

- Fire spread via combustible products can be resisted by limiting the combustibility or by preventing ignition (e.g. by encapsulation).
- Fire spread via cavities can be resisted subdividing cavities to resist fire spread within the cavity or by encapsulating cavities to prevent fire entering cavities.

M.2 Rainscreens

M.2.1 Rainscreen System Components

Rainscreen systems typically comprise the following components (from outside to inside):

- Substrate: typically a masonry wall or a structural framing system (SFS) comprising plasterboard, a metal frame (with or without insulation) and a sheathing board.
- Cavity: a cavity (with or without insulation). The cavity is often ventilated to allow vertical air flow through the cavity to 'dry' any moisture that enters the cavity.
- Rainscreen cladding: cladding panels supported by a framing system that is fixed to the substrate.

M.2.2 Rainscreen Test Performance

M.2.2.1 Data Summary

Table 34 summarises the test configurations and results for BS 8414 tests on the Kingspan website and MHCLG websites for systems that have met the BR 135 performance criteria.

Test reports are listed below and can be provided on request:

- Test 1_105536_BS8414-2 Kingspan Insulation PN 303930 test report iss 3.pdf (3 July 2018)
- Test 2_104881_BS 8414-2 P100184-1000 issue 3.pdf (28 November 2016)
- Test 3_104877_BS 8484-1 P107017-1000 issue 1.pdf (14 December 2017)
- Test 4_104875_BS 8414-1 DLR1448.pdf (March 2018)
- Test 5_105071_BS 8414-1 DLR1453.pdf (May 2018)
- Test 6_109744_Kingspan Insulation Ltd_BS 8414_P109938-1000_Issue 2.pdf (14 August 2018)
- Test 7_104879_BS 8414-1 P109939-1000 issue 1.pdf (11 January 2018)
- Test 8_105217_BS 8414-1 P109971-1000 issue 1 Mitsubishi.pdf (18 January 2017)
- Test 9_105219_BS 8414-1 P109973-1000 Mitsubishi.pdf (1 March 2018)
- Test 10_135780_P114679-1000_BS 8414-1_Kingspan Insulation_Issue1.pdf (7 February 2020)
- Test 11_Fire_test_report_DCLG_BS_8414_test_no.3.pdf (3 August 2017)

- Test 12_DCLGtest5_BS_8414_Part_1_test_report_Issue_1.1.pdf (10 August 2017)
- Test 13_DCLGtest7_BS8414_Part_1_test_report_Issue_1_0.pdf (18 August 2017)
- Test 14_DCLGtest4_BS_8414_Part_1_test_report_final_issue1.1.pdf (9 August 2017)
- Test 15_DCLGtest6_BS8414_Part_1_test_report_Issue_1_0.pdf (25 August 2017)
- Test 16_112815_DLR1515 Rev.0.pdf.pdf (September 2017)
- Test 17_112814_DLR1547 Rev.0.pdf.pdf (September 2017)
- Test 18_109568_BS 8414 – 1 DLR1516 Rev.0.pdf.pdf (August 2018)
- Test 19_125850_DLR1567 Rev 0.pdf.pdf (August 2018)
- Test 20_BRE 299185 (Report not available)

Table 35 summarises the test configuration and results for systems that failed to meet the BR 135 performance criteria.

The data has been sorted to assist with interpretation of the system components and characteristics that have the greatest influence on performance.

The maximum external temperature at Level 2 (in the BR 135, 15 minute assessment period) has been used as the indicator of performance because in all cases, it was the external temperature which was the highest (i.e. the cavity temperature and insulation temperatures were lower than the external temperature) and as such governs whether the system meets the BR 135 performance criteria.

However, it is not always the case that a system with a higher maximum external temperature than another system would have higher cavity and insulation temperatures. This means that external temperature alone cannot be used to assess the relative performance of systems as a whole, but because the external temperature is always higher than cavity and insulation temperatures it can be used to determine the system characteristics that influence whether the system as a whole would meet the BR 135 performance criteria (because if the external temperatures do not exceed 600°C, the cavity and insulation temperatures will not exceed 600°C).

Table 34: BS 8414 test data summary for rainscreen systems that meet the BR 135 criteria

Test Ref.	Subst.	Insulation	Cladding	Cavity	Panel Gap	Max. Level 2 Temp.	Early Termin.
Test 9	Block	100mm K15	Cat 1 ACM	38mm	20mm	350°C	No
Test 7	Block	100mm K15	Cat 2 ACM	50mm	10mm	350°C	No
Test 8	Block	100mm K15	Cat 1 ACM	50mm	20mm	375°C	No
Test 15	Block	180mm Wool	Cat 1 ACM	50mm	20mm	380°C	No
Test 13	Block	180mm Wool	Cat 2 ACM	50mm	20mm	380°C	No
Test 3	Block	100mm K15	Cat 2 ACM	50mm	4mm	400°C	No

Test Ref.	Subst.	Insulation	Cladding	Cavity	Panel Gap	Max. Level 2 Temp.	Early Termin.
Test 12	Block	100mm PIR	Cat 1 ACM	50mm	20mm	400°C	No
Test 20	SFS	120mm Xtratherm	Cat 1 Board	Unknown	Unknown	425°C	No
Test 11	Block	100mm PIR	Cat 2 ACM	50mm	20mm	450°C	Yes
Test 14	Block	100mm K15	Cat 2 ACM	50mm	20mm	380°C	Yes
Test 1	SFS	140mm K15	Cat 1 Tile	69mm	0mm	375°C	No
Test 2	SFS	140mm K15	Cat 1 Tile	69mm	12mm	375°C	No
Test 6	SFS	100mm K15	Cat 1 ACM	50mm	10mm	400°C	No
Test 10	Block	60mm K15	Cat 1 Panel	40mm	10mm	550°C	No
Test 4	Block	100mm K15	Aluminium	85mm	20mm	550°C	No

Table 35: BS 8414 test data summary for remaining systems

Test Ref.	Subst.	Insulation	Cladding	Cavity	Panel Gap	Max. Level 2 Temp.
Test 19	SFS	100mm K15	Cat 1 ACM	50mm	10mm	650°C
Test 18	SFS	160mm K15	Cat 1 ACM	85mm	20mm	629°C
Test 17	Block	180mm Wool	Cat 1 ACM	50mm	20mm	650°C
Test 5	Block	100mm K15	Cat 2 ACM	85mm	20mm	700°C
Test 16	SFS	100mm K15	Aluminium	80mm	20mm	900°C

M.2.2.2 Minimum Requirements for Adequate Performance

Rainscreen systems resist fire spread by:

- Limiting combustibility of materials to limit heat produced by the system and protecting the cavity to limit the influence of cavity fire dynamics (thereby meeting external the temperature criterion), and
- Subdividing the cavity to resist fire spread within the cavity (thereby meeting cavity and insulation temperature criteria).

Each of the systems that met the BR 135 criteria had the following components, which can be viewed as being critical to the success of rainscreen cladding systems in meeting the criteria:

- Substrate fire resistance: The substrate and insulation need to have adequate fire resistance to prevent fire spread from the outside of the wall construction to the inside.
- Cladding reaction to fire: The cladding is *Class B, Class A2 or Class A1*. This is to ensure that fire does not spread too rapidly or beyond the top of the test rig.
- Insulation characteristics: The insulation should be mineral wool, PIR or phenolic foam. This is to ensure that the external performance criteria are not exceeded and that the area of burning above the second horizontal fire barrier is limited to a localised area.
- Cavity barriers: There are cavity barriers below Level 1 and Level 2. The location of the first horizontal fire barrier is not a critical because the fire bypasses it and BR 135 does not specify performance criteria below Level 2 thermocouples. The location of the second horizonal cavity barrier is important because it is high enough to not be bypassed by the flame and it 'protects' the Level 2 thermocouples. Therefore, for rainscreen cladding systems there needs to be at least one cavity barrier below Level 2, but which is also high enough not to be bypassed by the flames. In practice, this would mean horizontal cavity barriers at a minimum spacing of just under 5m between each barrier.
- Cavity barrier performance: The cavity barriers achieve *90EI*. I have found no reason why 90EI is used in tests or that 90EI is necessary to adequately resist fire spread. In fact, it is likely that 30EI is adequate based on the severity of a BS 8414 crib.
- Construction configuration: The BS 8414 test configuration comprises two vertical, perpendicular walls of construction. The as-built construction should not include configurations that might result in a greater risk of fire spread than that of the BS 8414 test configuration.
- No additional combustibles: The as-built construction should not include or be adjacent to significant quantities of combustible materials that were not part of the tested configuration (e.g. combustible materials in balconies, reveals or adjacent wall constructions).

M.2.2.3 Sensitivity to System Component Details

Examination of the test data shows that the overall performance of the system is sensitive to the following:

- Substrate Type: External temperatures of systems with a block substrate are lower than those with an SFS substrate. This is because the blockwork acts as a heat sink 'removing' heat from the system; whereas, an SFS does not remove heat.
- Insulation Type: External temperatures of systems with mineral wool insulation are lower than those with rigid foam insulation. This is because the mineral wool is not combustible and has a higher thermal inertia (i.e. mineral wool does not add additional heat to the system and 'absorbs' more heat). However, the sensitivity is low because combustion of rigid foam insulation is an endothermic reaction (it absorbs more heat than it produces) and both materials are insulators (i.e. the heat absorbed by mineral wool is not significant).
- Cladding Combustibility: External temperatures are sensitive to the combustibility of the cladding. However, for ACM systems, provided the cladding is *Class B* (i.e. Category 2 ACM) or better; the sensitivity is low. This is because the contribution to fire of *Class B* ACM is small (compared to the fire itself) and *Class B* ACM does not support self-sustaining combustion.
- Access to Cavity: External temperatures are sensitive to the amount of fire and oxygen that can flow into and through the cavity because this influences the efficiency of combustion, whether the

cladding is exposed on two surfaces as opposed to just the outside face and the rate of burning of any combustible insulation in the cavity. Therefore, the external temperature is sensitive to:

- Gaps around cladding panels: Tests conducted using cladding panels with a gap around the cladding panels of 20mm have result in higher external temperatures than those with gaps of 10mm or less.
- Cladding robustness: If the cladding burns, melts or falls of during fire it provides access to the cavity. However, if the cladding ceases to exist entirely there is no cavity.
- Cavity thickness: Thicker cavities allow increased flow within the cavity. However, this is only relevant if fire can penetrate the cavity in the first place.
- Opening protection: The protection of the cavity edge at the opening around the crib influences how readily fire can penetrate the cavity. However, for protection of compartmentation, ADB compliance requires that cavity edges (including around openings) are protected to 30-minute standard (or an ADB compliant alternative). These would provide adequate protection to the cavity for the purposes of meeting BR 135 performance criteria.

The system performance is not sensitive to the following characteristics:

- SFS Details: The Kingspan and MHCLG tests do not include variation in SFS details so as to enable direct assessment of sensitivity. However, provided the SFS achieves adequate fire resistance, the details of the system would have little influence on overall performance. This is because:
  - Small variations in the system (e.g. component dimensions and whether the SFS is insulation) would not significantly change the thermal inertia of the system as a whole.
  - The SFS is sufficiently protected (by the cavity barrier, cladding and insulation) at Level 2 that it does not reach temperatures that would influence its performance.
- Insulation Thickness: For mineral wool insulation, the insulation thickness would have negligible impact on external temperatures because it is a relatively inert, inactive part of the overall system. External temperature might be sensitive to variations in thickness of foam insulation because increased thickness results in more combustible material, but this would not be significant in the practical range of foam thickness. This is because the rate of burning of rigid foam insulation and duration of assessment of temperatures (15 minutes) is such increased thickness would not result in increased temperatures during the period of assessment. Furthermore, the crib is extinguished at 30 minutes and rigid foam insulation is “self-extinguishing” meaning that increased thickness of insulation does not increase the likelihood of early termination (provided there is adequate protection to Level 2 via the cladding and cavity barriers).

M.2.3 System Characteristics for Success

The test data for rainscreen systems shows (see Section M.2.2) that rainscreen system would meet the BR 135 performance criteria provided that:

- Substrate: The substrate is shown to be adequate through BS 8414 testing or it is an SFS system that achieves at least *30EI*.
- Insulation: The insulation is mineral wool, phenolic foam or polyisocyanurate (PIR).
- Cavity: The cavity is not significantly greater than 50mm thick. Thicker cavities might be viable provided the gaps around cladding panels are small.
- Cladding: The cladding is *Class A2* or better (in some instance *Class B* is adequate) with gaps around the cladding panels no greater than 10mm.

- Fire Barriers: Fire barriers at each floor level. *90EI* has been shown to be adequate, but it is likely that *30EI* would be sufficient due to the known fire severity of BS 8414 tests.
- Cavity Edge Projection: Cavity edges (including around openings) should be protected in accordance with ADB recommendations (i.e. cavity barriers that achieve *30E 15I* or an ADB compliant alternative).

Appendix N – Cavity Walls

N.1 ADB: 2006 Diagram 34 Compliance

Compliance with ADB: 2006 Diagram 34 requires the construction to comprise:

- Cladding: Brick or concrete at least 75mm thick.
- Substrate: Brick or concrete at least 75mm thick.
- Cavity Edges: Closed (performance ambiguous).

If the above requirements are met, there is no restriction on the use of combustible insulation within the cavity and no requirement for cavity barriers at junctions with internal compartment floor or internal compartment walls.

N.2 Analysis

N.2.1 Performance Requirements

ADB: 2006 Diagram 34 provides a standard detail that is deemed (by ADB: 2006) to achieve an adequate fire performance standard for compliance with Parts B3(3), B3(4) and B4(1) of Schedule 1 to the Building Regulations 2010.

It stands to reason that the Diagram 34 standard detail is not the only cavity wall detail that would achieve an adequate fire performance standard for compliance with Parts B3(3), B3(4) and B4(1).

To that end, any detail that achieves a fire performance standard at least as good as that delivered by the Diagram 34 standard detail must also achieve an adequate fire performance standard for compliance with Parts B3(3), B3(4) and B4(1).

However, ADB: 2006 does not state the fire performance standard that is achieved by the Diagram 34 standard detail, and so one must be inferred.

As outlined below, it can be inferred that the fire performance standard is 60 minutes (integrity and insulation) from each side separately and that the outer leaf must be of *limited combustibility* by:

- Researching the origins of ADB: 2006 Diagram 34 and showing that it was a common building situation standard detail for achieving at least 60 minutes (integrity and insulation).
- Rationalising that construction achieving at least 60 minutes (integrity and insulation) from each side separately would meet the requirements of Parts B3(3), B3(4) and B4(1).
- Identifying that there are no other credible implicit fire performance requirements.

It is also shown below (by reference to ADB: 2020) that there is no implicit fire performance requirement for closures at cavity edges at windows for compliance with ADB: 2006 Diagram 34.

N.2.2 ADB: 2006 Diagram 34 Fire Resistance Requirements

N.2.2.1 Origins of ADB: 2006 Diagram 34

ADB Diagram 34 (or similar) has been in editions of the approved document since at least 1985.

The ADB: 1985 version of ADB: 2006 Diagram 34 and ADB: 2006 Diagram 34 are shown in Figure 26.

The requirements are substantially similar, and specifically both editions refer to inner and outer leaves of brick or concrete at least 75mm thick.

Figure 26: ADB:1985 Diagram G2 and ADB: 2006 Diagram 34

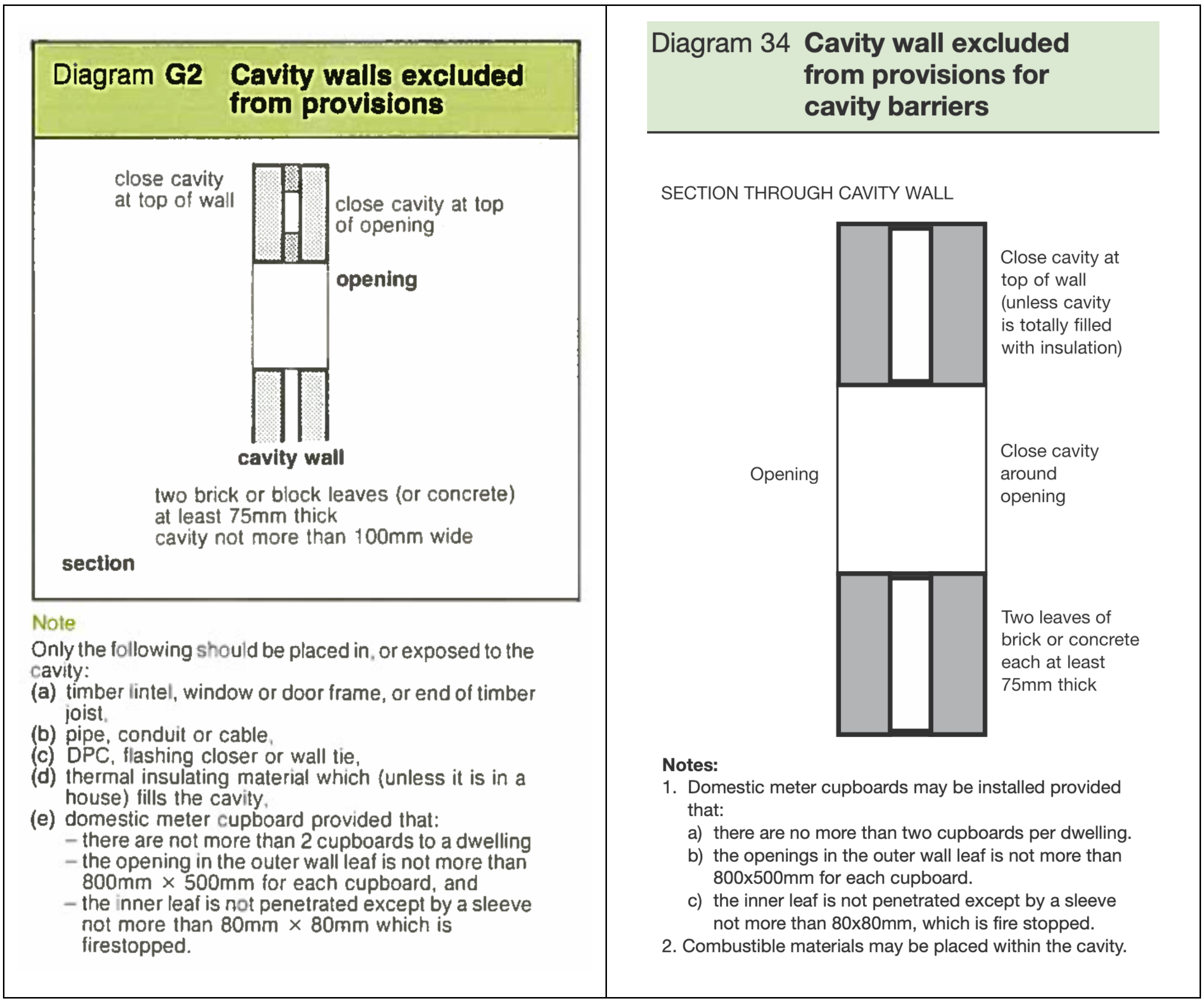


Table A3 Item 13 of Approved Document B2/3/4[26] (ADB: 1985) states that a 75mm non-loadbearing solid masonry external wall achieves 60 minutes (integrity and insulation).

There are no other forms of external wall construction listed in ADB: 1985 as achieving 60 minutes (i.e. for compliance with ADB: 1985, the only documented construction that would achieve 60 minutes (integrity and insulation) was 75mm solid masonry).

Similarly, BR 128[27] (first published in 1982) Table 1 Rows 6, 7, 8, 9 and 11 state that brick and concrete at least 75mm thick achieve 60 minutes (integrity and insulation).

Importantly, BR 128 Table 1 Rows 6, 7 and 8 require thickness of 90mm brick, bricks of concrete or concrete to achieve 90 minutes (i.e. it can be inferred that a 75mm thick wall would not achieve more than 60 minutes).

Therefore, it can be concluded that 75mm of brick or concrete achieves at least 60 minutes (integrity and insulation) but not as much as 90 minutes).

[26] Department of the Environment and The Welsh Office, ‘The Building Regulations 1985, Approved Document B2/3/4 – Fire spread’, 1985, HMSO
[27] W A Morris, R E H Head and G M E Cooke, ‘Guidelines for the construction of fire-resisting structural elements (BR 128)’, 1993, BREPress

Therefore, it can be concluded that the fire performance requirement for compliance with ADB: 2006 (and hence Parts B3(3), B3(4) and B4(1)) is 60 minutes (integrity and insulation) and does not need to be more than 60 minutes.

N.2.2.2 Why 75mm Brick or Concrete

It could be questioned, why Diagram 34 specified 75mm of brick or concrete instead of 60 minutes (integrity and insulation) if in fact the actual fire performance requirement required for compliance with Parts B3(3), B3(4) and B4(1) was meant to be two leaves of 60 minutes (as opposed to two leaves of brick or concrete).

This is reasonably answered by considering the scope of ADB:

- Under Regulation 6 of the Building Act, the purpose of ADB is to provide practical guidance for compliance with Part B (i.e. the guidance in ADB is meant to be practical).
- In 1985 (as documented in BR 128), the only common form of external non-loadbearing form of construction that achieved 60 minutes was brick or block at least 75mm thick.

At the time, brick and concrete cavity walls would have been commonplace.

Therefore, it is reasonable to conclude that ADB:1985 specified brick or concrete at least 75mm thick (as opposed to a fire resistance standard) because such a specification is more practical than specifying 60 minutes and no less restrictive (because 75mm thick brick or block was the only common form of external wall construction that been shown through testing to achieve 60 minutes).

It is also reasonable to conclude that the standard detail was not changed in editions of ADB after 1985 (when Table A3 Item 13 was removed) by accident / convenience as opposed to a deliberate retention of the standard detail (i.e. it was not because only brick or concrete is capable of achieving an adequate standard).

N.2.3 Rationalisation of Part B Compliance

N.2.3.1 Part B3(3)

For external wall constructions, compliance with Part B3(3) would be achieve if the route for fire spread around internal compartmentation is no less fire resisting than the internal compartmentation.

The highest standard of compartmentation required for compliance with ADB: 1985 was 120 minutes. This remains the case for all subsequent editions of ADB.

Whilst fire resistance standards cannot be numerically added (e.g. two walls of 60 minutes do not necessarily have a combined fire resistance of 120 minutes), it is not uncommon to add fire resistances and to do so would be reasonable in the context of this rationalisation.

For construction complying with Diagram 34, for fire to spread between compartments via the external wall construction, it would have to either:

- Break from one compartment into the cavity through the inner leaf of the cavity wall (from inside to outside) and back out of the cavity into another compartment through the inner leaf (from outside to inside), or
- Break from one compartment into the cavity through the outer leaf of the cavity wall (from outside to inside) and back out of the cavity into another compartment through the inner leaf (from outside to inside).

In both cases, this would be through two constructions that achieve 60 minutes (integrity and insulation) in the required direction, which in turn would be an equivalent fire resistance to the highest fire resistance standard of any internal compartmentation (i.e. 120 minutes).

Therefore, provided both leaves of construction achieve 60 minutes (from each side separately), pathways for fire spread around any internal compartmentation would be protected to at least the same standard as the internal compartmentation.

Therefore, a cavity wall with inner and outer leaves that achieve at least 60 minutes (integrity and insulation) from each side separately would comply with Part B3(3).

N.2.3.2 Part B3(4)

Similarly, for fire or smoke to spread from one part of the building to another via the external wall construction it would have to either go by one of the pathways described above or by breaking into a cavity via a cavity edge at an opening.

The former route is adequately protected (as described for Part B3(3)) and the latter route could not happen without the fire or smoke being seen.

Therefore, a cavity wall with inner and outer leaves that achieve at least 60 minutes (integrity and insulation) from each side separately would comply with Part B3(3).

N.2.3.3 Part B4(1)

For fire to spread between buildings via the external wall construction, it would have to either:

- Spread from inside the building to an adjacent building via the external wall construction, or
- Spread from an adjacent building to inside the building via the external wall construction, or
- Result in the external surface of the building being ignited.

Fire spread via the construction would not be possible if both leaves achieve 60 minutes (integrity and insulation) and if the outer leaf is of *limited combustibility* it would not be ignited.

Therefore, a cavity wall with inner and outer leaves that achieve at least 60 minutes (integrity and insulation) from each side separately and an outer leaf that is of *limited combustibility* or better would comply with Part B4(1).

N.2.4 Discounted Implied Performance Factors

N.2.4.1 Robustness of Brick vs SFS

It is sometimes alleged (by others) that brick walls are inherently more robust than other forms of construction (e.g. structural framing systems (SFS)) because brick retains its strength and stiffness to a higher temperature than other materials (e.g. steel).

Whilst brick retains its strength and stiffness to a higher temperature than steel, the above allegation relies on two implicit assumptions; neither of which is true:

- The fire resistance of a 75mm brick or concrete wall is strength or stiffness governed.
- The steel in an SFS would reach the same temperature as brick in a brick wall when subjected to the same fire exposure.

A 75mm brick or concrete wall is slender (i.e. the hight to thickness ratio is large). As such, when exposed to single sided heating (as is the case in an external wall), the wall bows towards the fire (due to differential temperature through the cross section of the wall) and the wall buckles (i.e. the fire resistance wall assembly is slenderness governed as opposed to strength governed).

Similarly, whilst concrete strength might not reduce significantly with respect to temperature, concrete spalls when exposed to fire. Thin concrete is more likely to spall than thick concrete.

Significantly, both buckling and spalling are brittle, rapid and catastrophic failure modes (i.e. it cannot be assumed that ADB specifically specifies brick to concrete as a means of preventing brittle failures).

BR 128 Figure 3 (see left image in Figure 27) clearly shows failure of a thin concrete wall (likely to be a result of spalling) and BR 128 Figure 10 (see right image in Figure 27) clearly shows failure of a thin concrete block wall as a result of buckling.

Figure 27: Figure 3 and Figure 10 from BR 128

Figure 3 Concrete wall panel after test in a vertical furnace

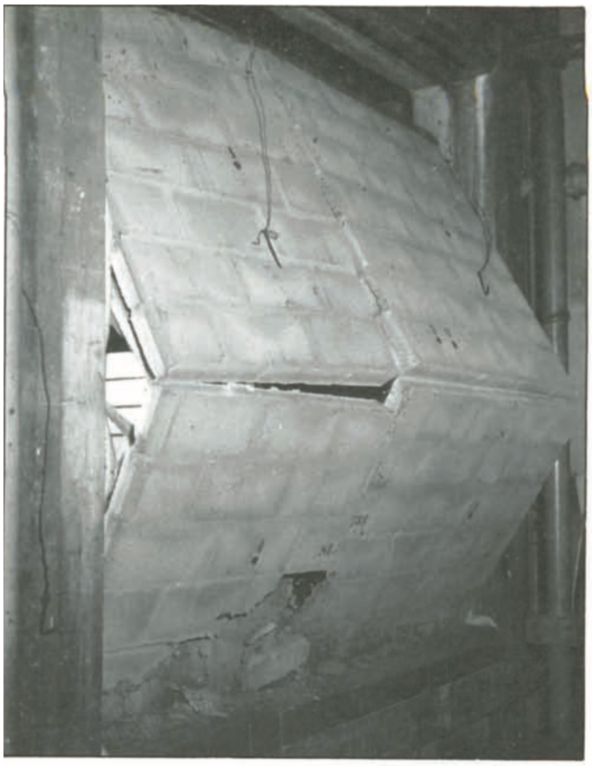


Figure 10 Loadbearing block wall at structural failure

Whilst steel loses strength and stiffness at lower temperatures than brick or concrete, SFS construction achieves fire resistance by encapsulating the steel in fire resisting constructure (i.e. plasterboards). In other words, the fire resistance is achieved by protecting the steel so that it retains its strength (as opposed to relying on steel retaining its strength at elevated temperature).

Any construction that has been tested to achieve 60 minutes achieves 60 minutes, by definition. As such, a 75mm brick or concrete (non-loadbearing) wall that achieves 60 minutes (integrity and insulation) but does not achieve 90 minutes does not and cannot be assumed to achieve a higher fire resistance standard than any other form of construction has been shown by testing to achieve 60 minutes.

Therefore, it would be incorrect to consider that 75mm of brick or concrete achieves a higher fire resistance standard than any other construction that achieves 60 minutes and it is not credible to consider that that 75mm of brick or concrete is more robust than any other construction that achieves 60 minutes.

In fact, the brittle failure mode of brick or concrete walls is such that they might be less robust than other constructions that achieve 60 minutes, but which do not exhibit brittle failure.

Therefore, the ADB: 2006 Diagram 34 specification of brick or concrete (as opposed to 60 minutes) cannot be driven by robustness or resilience.

N.2.4.2 Heat Sink

Brick and concrete have high thermal inertia and as such they can absorb heat during fire thereby reducing fire severity. In my opinion this is not a relevant factor because:

- There is nothing in ADB preventing the inner or outer leaves Diagram 34 compliant construction being insulated; thereby, eliminating any heat sink effect.
- The primary benefit of heat sink would be in respect of resisting fire spread over the walls of the building, which is resisted by virtue of the outer leaf achieving 60 minutes and being of limited combustibility.

N.2.4.3 Restraint

It possible that the specification of brick or concrete relates to an assumed likelihood of such construction being adequately restrained and resistant to movement in fire such that gaps do not open and create a pathway for fire spread during fire.

This is feasible, but any system that achieves 60 minutes (integrity) would also to achieve adequate restraint to meet that standard. As such, provided any alternative system is adequately retrained / fixed to the primary structure (which it would have to be to achieve 60 minutes), it would achieve an equivalent standard to a brick or concrete wall.

N.2.4.4 Life-cycle Integrity

It is possible that the specification of brick or concrete relates to an assumed likelihood of such walls retaining their integrity over the life of the building in that they are less likely be compromised accidentally (e.g. by service alterations).

This is feasible, but regardless of construction type, it would be necessary to show that the integrity of the inner and outer leaves can be credibly maintained over the life of the building.

N.2.4.5 Quality of Construction

It is possible that the specification of brick or concrete relates to an assumed likelihood of such walls being built correctly (or an assumed likelihood of other types of construction not being built correctly).

This is feasible, but regardless of construction type, it would be necessary to ensure an adequate quality of construction.

N.2.5 Cavity Closures

ADB: 2006 paragraph 9.3 makes recommendations as to when cavity barriers are required. Cavity barriers are not required for compliance with ADB: 2006 paragraph 9.3 where construction complies with ADB Diagram 34. Compliance with ADB: 2006 Diagram 34 requires cavities to be closed at the top of the wall and around openings. ADB: 2006 Diagram 34 does not state any performance for cavity closures.

Therefore, there is no explicit performance requirement for cavity closures for compliance with ADB: 2006 Diagram 34.

ADB: 2006 Diagram 33 uses similar terminology as ADB: 2006 Diagram 34 for closing of cavities, but it also includes a key that makes it clear that closure of cavities at the top of the cavity and around openings must constitute cavity barriers in accordance with ADB Table A1, item 15 (i.e. 30 minutes integrity and 15 minutes insulation).

Therefore, either of the following could (but not necessarily should) be inferred:

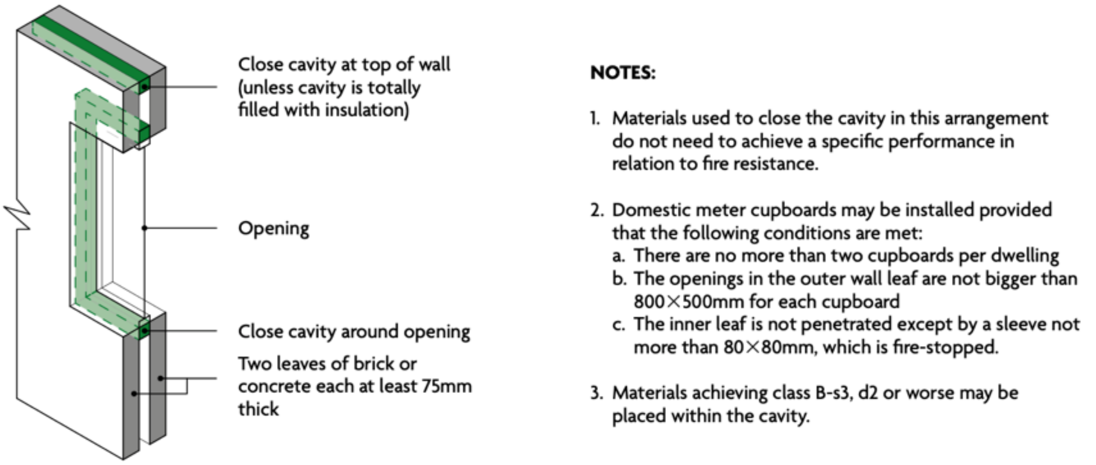
- Compliance with ADB: 2006 Diagram 34 is ambiguous, but unambiguous compliance with ADB Diagram 34 can be achieved by ensuring cavity closures at tops of walls and around windows to achieve 30 minutes integrity and 15 minutes insulation, and/or

- Compliance with ADB: 2006 Diagram 34 requires cavity closures at tops of walls and around windows to achieve 30 minutes integrity and 15 minutes insulation.

In Approved Document B[28] (ADB: 2020), Diagram 34 has been updated (therein referenced as Diagram 8.2) see Figure 28. Note 1 to ADB: 2020 Diagram 8.2 states that, "Materials used to close the cavity in this arrangement do not need to achieve a specific performance in relation to fire resistance." This note removes any ambiguity as to whether cavity closures need to achieve fire resistance.

Therefore, by reference to ADB: 2020 Diagram 8.2 it could be confirmed that compliance with ADB Diagram 34 does not require cavity closures at tops of walls and around openings to achieve any fire resistance.

Figure 28: ADB: 2020 Diagram 8.2



Therefore, it is reasonable to assume that ADB: 2006 Diagram 34 compliance requires cavity edges (including around openings) to be sealed, but not necessarily with fire resisting construction. This is a functionally defendable conclusion because sealing cavity edges limits oxygen (for combustion) and air flow (for fire spread).

[28] HM Government, The Building Regulations 2010, Approved Document B (Fire Safety), Volume 1 – Dwellings 2019 edition incorporating 2020 amendments (for use in England).

Appendix O – Referenced Documentation

O.1 Construction Documentation

- Drawings from NOVO Facades and Thomasons showing elevation and section drawings:
  - EL0001 Elevation 1 1:125 A3 P1 C
  - EL0002 Elevation 2 1:125 A3 P1 C
  - EL0004 Elevation 4 1:125 A3 P1 C
  - EL0005 Elevation 5 1:125 A3 P1 C
  - EL0006 Hidden Elevation on 1&2 1:125 A3 P1 C
  - EL0007 Hidden Elevation on 4 1:125 A3 P1 C
  - EL1000 Elevation 1 - Aluminium Panels 1:125 A3 P1 C
  - EL1001 Elevation 4 - Aluminium Panels 1:125 A3 P1 C
  - EL1002 Hidden Elevations from 1&2 Aluminium Panels 1:125 A3 P1 C
  - EL1003 Hidden Elevations from 4 Aluminium Panels 1:125 A3 P1
  - DE1001 Brickwork At Corner 1:5 A3 P1 C
  - DE1002 Brickwork At Floor Slab 1:5 A3 P1 C
  - DE1003 Brickwork At Floor Slab Unsupported 1:5 A3 P1 C
  - DE2000 Typical Spandrel Panel Section 1:5 A3 P1 C
  - DE3000 Cladding to Projecting façade horizontal section 1:3 A3 P1 C
  - DE3001 Cladding to Projecting façade Vertical Section 1:3 A3 P1 C
  - DE3002 Movement joint in projectng cladding 1:2 A3 P1 C
  - FB5001 Fire Barrier GA- Elevation 1 1:125 A3 P1 C
  - FB5002 Fire Barrier GA- Elevation 2 1:125 A3 P1 C
  - FB5004 Fire Barrier GA - Elevation 4 1:125 A3 P1 C
  - FB5005 Fire Barrier GA - Elevation 5 1:125 A3 P1 C
  - FB5006 Fire Barrier GA - Hidden Elevations 1&2 1:100 A3 P1 C
  - FB5007 Fire Barrier GA - Hidden Elevations 4 1:100 A3 P
- Hughes & Associates Property Services Ltd, '114 High Street, Manchester M4 1HQ, Proposed Fire Strategy Report', document reference: HAPS-RIV-114H, issued 30 March 2023. Draft Revision.

O.2 Material Data and Fire Test Reports

- Sandberg LLP 'The Garden House, Manchester Analysis of Insulation Samples'.
  Report reference: 69764/C, issued 28 April 2021.
- NOVO Facades, 'Project Technical Submission Document, Garden House'. Nullifire Sealant.
  Document reference: NV371-TQS-SUB-0014. Received 23 July 2024.

- NOVO Facades, ‘Project Technical Submission Document, Garden House’. Vertical Fire Break: FSi ParaFlam SEB. Document reference: NV371-TQS-SUB-00012. Issued 03 July 2024.

O.3 Intrusive Surveys

- Fill UK Ltd, Façade Investigation to Brickwork, to William Fairburn Way (Elevation 3), on 09 April 2021.

O.4 Inspection Report (i.e. Thomasons Inspection Reports)

Halliday Meecham Architects, ‘5540 – Garden House – Condition Report’, issued May 2023. Revision v3.

Appendix P – Professional Competence

P.1 Design Fire Consultants

P.1.1 Technical Competence

Design Fire Consultants Ltd ("DFC") provides fire safety engineering expertise for the design, construction and operation of buildings. As an independent fire engineering consultancy, we combine a high level of expertise whilst prioritising dedication to quality, client value and communication on every project.

The Directors have a combined experience of more than 85 years in the development of fire and life safety designs for buildings across all sectors, in the UK and internationally. They know understand sector specific value and arrive at reliable solutions quickly and efficiently using the most appropriate combination of best practice and bespoke fire engineering.

Our employees are Members of the Institution of Fire Engineers (IFE) and many hold Chartered Engineer status with the Engineering Council through the IFE. This level of qualification and accreditation is integral to the ability of the company to deliver on our commitment to technical

The DFC team has been heavily involved in external wall related work post-Grenfell. This includes:

- Advice to government on risk of fire spread via external wall constructions.
- Representation on competency steering groups for fire engineering, quality assurance and products and building control / building standard inspectors.
- Representing the Institution of Fire Engineers ("IFE") at a Mayor of London planning policy review post Grenfell.
- Co-chairing the IFE Special Interest Group on external wall constructions.
- Involvement on codes and standards committees including PAS 9980, BS 8414 and BS 9414.

DFC has also been involved on the inspection and review of multiple external wall constructions. This work includes:

- Intrusive surveying of external wall constructions.
- Assessments in accordance with PAS 9980.
- Commissioning and witnessing tests in accordance with BS 8414.
- Materials testing and ad-hoc systems testing.
- Peer review of work by others, which helps us ensure that we are meeting or exceeding the standards of other fire engineers.

Finally, DFC is committed to the technical development of our staff. To that end we encourage and enable formal and informal CPD and in particular we have bespoke, annual training from the University of Edinburgh. This has included:

- Ignition and combustion properties of external wall products and materials.
- Materials testing and classifications.
- Mechanisms of heat transfer.
- Ignition, combustion and mechanical response of timber.

P.1.2 Quality Management

DFC believes that the market expects a continually improving service. We aim to perpetually improve the service we provide to meet our client's requirements and to deliver a consistently high-quality product.

The company aims to achieve the above by implementing a management system that complies with the international standard of good practice BS EN ISO 9001[29]. It is committed to continual development of the system to ensure it remains effective. It is also committed to meet the requirements of our clients, learn from feedback, as well as legal and regulatory obligations.

All personnel within the company are responsible for the quality of their work. The company provides training and has established systems to assist all personnel to achieve the standards required. While we endeavour to produce work and offer a service that we can be proud of, we have to recognise that we will not always achieve our own standards. When a mistake or client complaint occurs, we are committed to investigating the mistake or complaint and will do our best to put it right and to prevent re-occurrence.

The Quality Manager is responsible for quality and reports regularly to the Board on implementation of the system.

The objectives of DFC are set out in the Business Plan. Objectives for individual projects are to undertake works to the satisfaction of the client in accordance with the agreed contract.

P.1.3 Insurance

DFC has, and will continue to maintain (provided it is commercially viable to do so), professional indemnity insurance. At the time of writing, this insurance is in the aggregate and does not exclude assessments in accordance with PAS 9980.

[29] BS EN ISO 9001, 'Quality Management System Requirements', 2015

P.2 Neal Butterworth (BEng, MPhil, CEng, MIFireE)

P.2.1 Professional Qualifications

NEAL BUTTERWORTH, DIRECTOR

Qualifications: 1996 – BEng (Hons) in Civil and Structural Engineering, University of Sheffield
1998 – MPhil in Structural Fire Engineering, University of Sheffield
2003 – Chartered Engineer, The Engineering Council UK
2018 – Bond Solon Expert Witness Certificate, Cardiff University

Memberships: 2003 – Member, Institution of Fire Engineers (MIFireE)

Neal is registered as a chartered engineer with the Engineering Council ("EC") l via the Institution of Fire Engineers ("IFE") (i.e. CEng MIFireE). As such, Neal is bound by IFE Code of Conduct and the EC Statement of Ethical Principles and he is required to:

- Identify and inform relevant parties of any potential conflicts of interest.
- Act with honesty and integrity.
- Maintain respect for life, law, the environment and public good.
- Always act with care.
- Perform services only in areas in which he is currently competent or under competent supervision.
- Keep his knowledge and skills up to date.
- Present and review theory, evidence and interpretation honestly, accurately, objectively and without bias, while respecting reasoned alternative views.
- Identify, evaluate, quantify, mitigate and manage risks.
- Not knowingly mislead or allow others to be misled.

P.2.2 Knowledge and Skills

In the context of external wall constructions, Neal's degrees included the following key fundamental knowledge:

- Material properties at ambient and elevated temperatures.
- Structural mechanics at ambient and elevated temperatures.
- Fluid dynamics.
- Fire dynamics (including enclosure and external flaming fire dynamics).
- Heat transfer.

Neal has also received the following relevant training post-graduation:

- Ignition and combustion properties of materials and products including insulations and timber.
- Lateral and vertical flame spread.
- Background to regulations and guidance associated with external wall constructions.

P.2.3 Experience

P.2.3.1 Employment Record

Neal has over 25 years of experience in fire engineering. His key strengths are his ingenuity, quality of thinking and the ability to form strong team working relationships. He prides himself on his continuous acquisition of technical knowledge, which enables him to deliver practical, high value solutions for his clients. In this regard, he has a proven track record across sectors, project stages and fire engineering specialisms both nationally and internationally.

Neal is nationally and internationally recognised within the fire engineering community. His active engagement and volunteering with the Institution of Fire Engineers, industry and academia since 2003 ensures that he leads industry standards and he is able to deliver state of the art technologies and methodologies.

Neal has had many expert witness instructions. This work has made sure that Neal understands the regulations and associated guidance in detail and through this work Neal has learned the importance and how to evaluate data impartially to reach considered and defendable opinions.

November 2015 – Present: Design Fire Consultants Ltd

Director

Neal joined DFC in November 2015 as a Director based in the Leeds office. In addition to fire safety engineering, Neal leads our research and innovation work, forming close relationships with academia and actively engages with the Institution of Fire Engineers. He is internationally recognised for his work within the fire engineering community.

August 2010 – November 2015: Ove Arup & Partners Limited

Associate Director

At Arup, Neal was the Associate Director responsible for fire engineering skills strategy, development and training for a team of over seventy engineers. Neal also contributed to international skills development.

August 1998 – Augst 2010: Buro Happold

Technical Director

Joining Buro Happold as a Graduate Fire Engineer, Neal progressed through to Technical Director of the fire team. He was responsible for the technical strategy, development and training for a team of over twenty engineers.

P.2.3.2 Industry Standing – Publications

- Co-authored and part of the drafting committee for PAS 9980 Fire risk appraisal of external wall construction and cladding of existing blocks of flats – Code of Practice.
- Section 7 of BS 9999: 'Code of practice for fire safety in the design […]', 2008 and PD7974: 'Part 3 Structural response and fire spread beyond the enclosure of origin, 2011': Co-authored.
- Input to draft the Institution of Fire Engineers' response to the Dame Judith Hackitt's request for evidence as part of her review of fire safety legislation, guidance, process and enforcement.
- Structural Timber Association – Volume 6. Part of the stakeholder review group for the STA structural timber buildings fire safety in use guide.

P.2.3.3 Industry Standing – Key Speaker at Conference

- 2022 – Exploring PAS 9980 Conference by the Institution of Fire Engineers (IFE).
- 2021 – Local Authority Building Control Conference (LABC).
- 2016 – British Standards Institution (BSI) Fire Safety Conference.
- 2014 – Second International Tall Building Fire Safety Conference.

P.2.3.4 Industry Standing – Special Committee Member Representation

- 2003 ongoing – Founding Chair of the Institution of Fire Engineers' Special Interest Group on Competency and Ethics.
- 2003 ongoing – Active Member of steering panels and project teams for three Building Research Establishment (BRE) research and testing projects in relation to Approved Document B.
- 2003 ongoing – Represents the Institution of Fire Engineers on the CIC Working Group 3 (Competency of Fire Engineers) set up in response to the Dame Judith Hackitt Building Regulations Review Report.
- 2003 - ongoing – Represents the Institution of Fire Engineers on the British Standards Institute's FSH/24 Committee, responsible for the development and revisions of fire engineering codes and standards.
- 2023 - ongoing – Fire Expert to the Collaborative Reporting for Safer Structures UK (CROSS-UK).
- 2003 – 2020 – Member of the Institution of Fire Engineers' Registrants Group.
- 2003 – Founding Chair of the Institution of Fire Engineers' Special Interest Group on Fire Modelling.
- 2003 – Represented the Institution of Fire Engineers on the Fire Sector Federation Review of Approved Document B.

P.3 Merlyn Forrer (MEng (Hons), CEng, FIFireE)

Merlyn Forrer, Senior Associate

Qualifications:
2017 – MEng (Hons) in Fire Engineering, University of Central Lancashire
2022 – Bond Solon Expert Witness Certificate, Cardiff University
2016 – Level 5 Diploma in Fire Safety Engineering, Xact Fire Safety and Fire Engineering
2016 – Level 4 Diploma in Fire Safety Inspector and Fire Safety, Xact Fire Safety and Fire Engineering
2016 – Level 4 Award in Intermediate Incident Command in Fire and Rescue Services (QCF), SFJ Awards
2015 – Level 4 Diploma – Fire Risk Assessor

Memberships:
2008 – Fellow, Institution of Fire Engineers (FIFireE)
2019– Professional Member, Society of Fire Protection Engineers (MSFPE)

P.3.1.1 Career History

Merlyn joined Design Fire Consultants Ltd (DFC) in 2019 and is based in the Manchester office. Merlyn has over 24 years' professional experience in the operational, supervisory and regulatory environment from working at the Fire and Rescue Service as Station Manager for Greater Manchester. He has worked in various operational and technical roles including fire behaviour, incident command and fire safety. Before joining DFC, he was the lead on external fire spread for the Greater Manchester High Rise Task Force, enforcing the Regulatory Reform (Fire Safety) Order 2005.

His academic research for both bachelor's and master's dissertations focussed on the fire performance of externally thermally insulated cladding systems and the use of organic polymer foams. Through his research, experience and knowledge, Merlyn is well recognised for his expertise within the industry.

He represented the National Fire Chiefs Council (NFCC) researching the fire performance of Aluminium Composite Panel systems for the Ministry of Housing, Communities and Local Government. He represented NFCC on Dame Judith Hackitt's review of Building Regulations and Fire Safety. Merlyn is also an active member of the Institution of Fire Engineers, conference speaker and works as a technical expert on a number of BSI and ISO committees developing national and international standards.

May 2019 – Present: Design Fire Consultants Ltd

Senior Associate

Merlyn joined DFC in 2019 as an Associate and was promoted in November 2022 to Senior Associate. In addition to his fire engineering capabilities, Merlyn is involved with the running of the Manchester office, training programmes, research and development, and health and safety.

January 2016 – April 2019: Greater Manchester Fire and Rescue Service

Fire Protection Manager, Station Manager and Flexi Duty Officer

Merlyn moved into fire safety as the Fire Safety Manager responsible for the Manchester Borough, providing fire safety and enforcing the Regulatory Reform (Fire Safety) Order 2005 for one of the largest and most complex metropolitan boroughs in the UK. This included reviewing and advising on bespoke fire safety solutions for historic, listed, and complex buildings.

September 2011 – January 2016: Greater Manchester Fire and Rescue Service

Training, Development and Auditing Manager, Fire Safety Protection

Merlyn moved into fire safety as a fire protection office working in Manchester Borough before moving to GMFRS headquarters as the Fire Safety Training, Development and Auditing Manager in June 2012 responsible for providing training and development of 64 fire protection staff, auditing fire safety regulators and providing development training for operational staff in fire safety.

May 2006 – September 2011: **Greater Manchester Fire and Rescue Service**

Fire Fighter and Recruit Fire Fighter Trainer

Merlyn progressed to Recruit Fire Fighter Training becoming an instructor for Breathing Apparatus (BAI), Compartment Fire Behaviour Training (CFBTI) and Incident Command (IC) training.

May 2000 – February 2006: **Norfolk Fire and Rescue Service**

Fire Fighter and Crew Manager

Merlyn joined Norfolk Fire and Rescue Service as a Firefighter in 2000 serving at Norwich Fire Station progressing to Crew Manager from January 2005 serving at Thetford Fire Station

P.3.1.2 Industry Standing – Publications

- Co-authored and part of the drafting committee for BS 9414 Fire Performance of External Cladding Systems – the application of Results from BS 8414-1 and BS 8414-2 tests
- Drafting committee for BS 8414-1 and BS 8414-2 Fire Performance of External Cladding Systems.

P.3.1.3 Industry Standing – Key Speaker at Conference

- Panel member. 7th International Tall Building Fire Safety Conference, London. Topic 'Is stay put still valid' discussed by panel of fire safety experts.
- 2022 – 89th edition (globally), 6th edition (UK), ZAK World of Facades. Topic 'Fire Engineering: The Pendulum Effect'.
- 2019 – 21st Annual Building Control Northern Ireland Fire Safety Conference.
- 2021 – 23rd Annual Building Control Northern Ireland Fire Safety Conference. Topic 'The Evolution of Regulation: Lessons and Opportunities for Construction'.
- 2023 – 25th Annual Building Control Northern Ireland Fire Safety Conference. Topic 'Changes to Building Regulations'.

P.3.1.4 Industry Standing – Special Committee Member Representation

- 2017 - 2019 – Key contributor, National Fire Chiefs Council (NFCC). Working on response initiatives and updating national guidelines in the aftermath of the Grenfell fire tragedy. WG6 Quality Assurance and Products. Competency Steering Group (WG6 – Building Standards Professionals and WG12 Products)
- 2012 – Date – Committee member, British Standards Institution (BSI) for FSH 21 and FSH 22.
- 2017 – Date – Chair of FSH/21-18 (BS 9414), British Standards Institution (BSI).
- 2020 – Date – Chair of FSH/21-19 (BS 8135 – replacement of BR 135), British Standards Institution (BSI).
- 2021 – Date – Chair of FSH/21-20 (BS 8414), British Standards Institution (BSI).
- 2020 – Date – Committee member, for CEN/TC 92 SC1 WG7 full and intermediate reaction to fire tests.

- 2024 – Date – Chair of FSH 21 Reaction to Fire, British Standards Institution (BSI)
- 2006 – Date – Active member and Fellow of the Institution of Fire Engineers (IFE).
- 2024 – Date – Member of Single Building Assessment for Scottish Government (project number 652).
- 2020 – 2022 - Committee member for Building Standards Fire Safety Review Panel for Scottish Government (project number BSFSR M2-01).
- 2023 – Date - Committee member for the IFE Special Interest Group on Facades.

P.4 Statement of Competence to Carry out an FRAEW

The author(s) and checker(s) of this report are members of the Institution of Fire Engineers.

The DFC assessment has been conducted and reviewed by persons that have:

- Read and understood the commentary and provisions relating to the competence of external wall assessors set out in Section 8 and Annex H of PAS 9980:2022.
- Adequate and relevant competence to undertake the FRAEW.
- Sufficient knowledge, skills and experience in relation to fire safety of external walls to be able to complete an assessment at the level required.
- The relevant skill, knowledge, and experience to manage and interpret the results of intrusive inspections.
- The competence to appraise and assess the nature of external wall construction in terms of fire performance and provide an opinion on the risk.

The DFC assessment has been conducted under the conditions that:

- No conflicts of interest of any kind, other than any which are disclosed in the report.
- Conclusions of the report are the author's independent assessment of the risks and remedial actions and have not been influenced in any way by the opinions or actions of others except where stated.
- DFC holds Professional Indemnity Insurance (PII) of not less than £1 million with no policy exclusions relating to fire safety and cladding. The PII certificate can be provided on request.

P.5 Evidence of Competence

Content of Appendix A to Appendix G is evidence of knowledge used to undertake the FRAEW.

The author and checker understand the extent of these appendices to the level required by this FRAEW. DFC have the professional experience in conducting similar assessments, this is evidenced in Appendix P.5.1.

In addition, each FRAEW is authored by or checked by a Chartered Engineer with the Engineering Council through the Institution of Fire Engineers (IFE).

As such, this report has been authored or checked by person(s) who have been assessed by peers in accordance with Engineering Council requirements as being able to demonstrate:

- The theoretical knowledge to solve problems in new technologies and develop new analytical techniques.

- Successful application of the knowledge to deliver innovative products and services and/or take technical responsibility for complex engineering systems.
- Accountability for project, finance and personnel management and managing trade-offs between technical and socio-economic factors.
- Skill sets necessary to develop other technical staff.
- Effective interpersonal skills in communicating technical matters.

P.5.1 Evidence of Relevant Professional Experience in Conducting Similar Investigations

Company Profile

Design Fire Consultants is an independent fire engineering consultancy that provides fire safety engineering expertise for the design, construction and operation of buildings.

The Directors have a combined experience of more than 85 years in the development of fire and life safety designs for buildings across all sectors, in the UK and internationally.

Each fire engineer employee is a member of the IFE and many hold Chartered Engineer status with the Engineering Council through the IFE.

Relevant Expertise

The DFC team has been heavily involved in external wall work post-Grenfell. Work has been based around technical input to benchmark testing of external wall systems including many BS 8414 full scale tests.

DFC has also worked closely with the Ministry of Housing, Communities and Local Government (MHCLG). This includes;

- Being active members of Working Group 3 (Fire Engineering) who are advising the government on the definition of competency.
- Being invited to comment by senior officials on a working draft of by MHCLG recently published (20 January 2020) consolidated advice to building owners for external wall construction.
- Working with MHCLG and RICS on the EWS 1 form to provide a benchmark for documenting adequate safety achieved in buildings.
- Representing the Institution of Fire Engineers (IFE) at a Mayor of London planning policy review post Grenfell.

DFC team members have also been:

- Involved, on behalf of the National Fire Chiefs Council (NFCC), in Working Group 6 (Quality Assurance and Products) as part of Hackitt's Independent Review of Building Regulations and Fire Safety.
- Involved in the Competence Steering Group (CSG), which has been set up by the Industry Response Group (IRG) to tackle competency failings identified in the Hackitt Review 'Building a Safer Future', following the Grenfell Tower fire. This includes involvement in Working Group 6 (Building Control/Building Standards Inspectors) and Working Group 12 (Products).
- Working closely with The University of Edinburgh on an ad-hoc basis to provide material testing for clients who are undertaken external wall analysis. DFC has also committed to sponsoring a PhD research student into the behaviour of composite materials in fire.

Quality Assurance

This report has been prepared for the use by, and takes into account the particular instructions and requirements of, our Client. It is not intended for use by any third party, and Design Fire Consultants Ltd shall not be liable for the reliance on or use of the report by any third party.

The signatures provided below are declarations that the Author and Checker confirm the content of Appendix P to be correct.

Revision	Date	Issue Description	Author	Checked
01	21 March 2025	Revised issue based on client feedback.	A Ogunleye	N Butterworth
00	20 February 2025	Initial issue for comment.	A Ogunleye	N Butterworth