Grenfell Tower Inquiry
Opening Presentations

Dr Barbara Lane

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Issues addressed in my opening presentation

- Original building – description of construction materials and the internal layout of the Tower
- Fire safety requirements in high rise residential buildings in England: Part 1 The Building Regulations
- Break
- Fire safety requirements in high rise residential buildings in England: Part 2 The Active and Passive fire protection measures forming the Stay Put strategy

Issues addressed in my opening presentation

- Summary timeline of key refurbishment works to the Tower since 1974
- Lift replacement works - 2005
- Lunch
- Fire door replacement works – 2011
- Gas supply replacement works – 2016
- Overview of the Primary Refurbishment 2012 – 2016

Grenfell Tower:
The original building construction and layout

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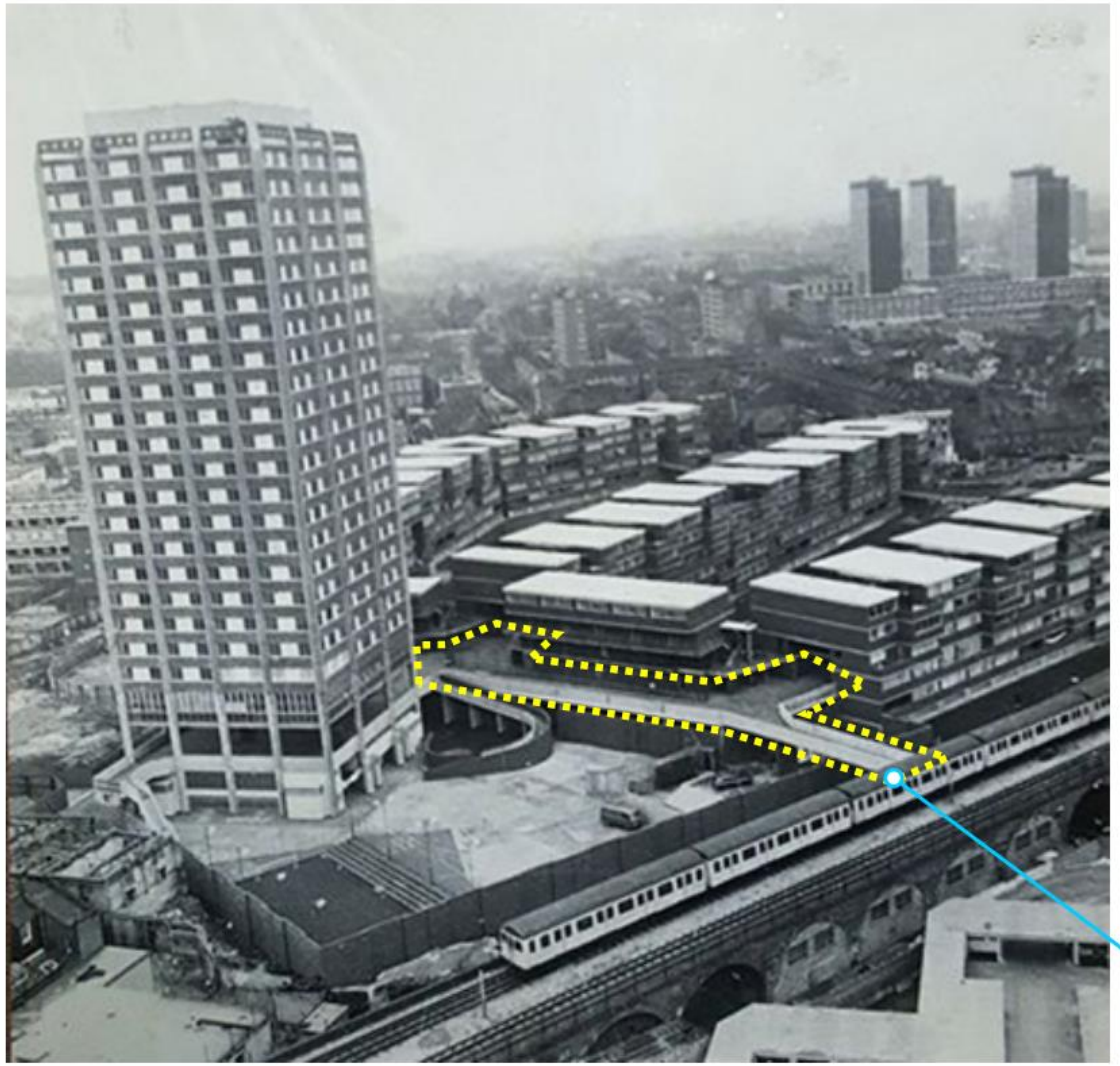
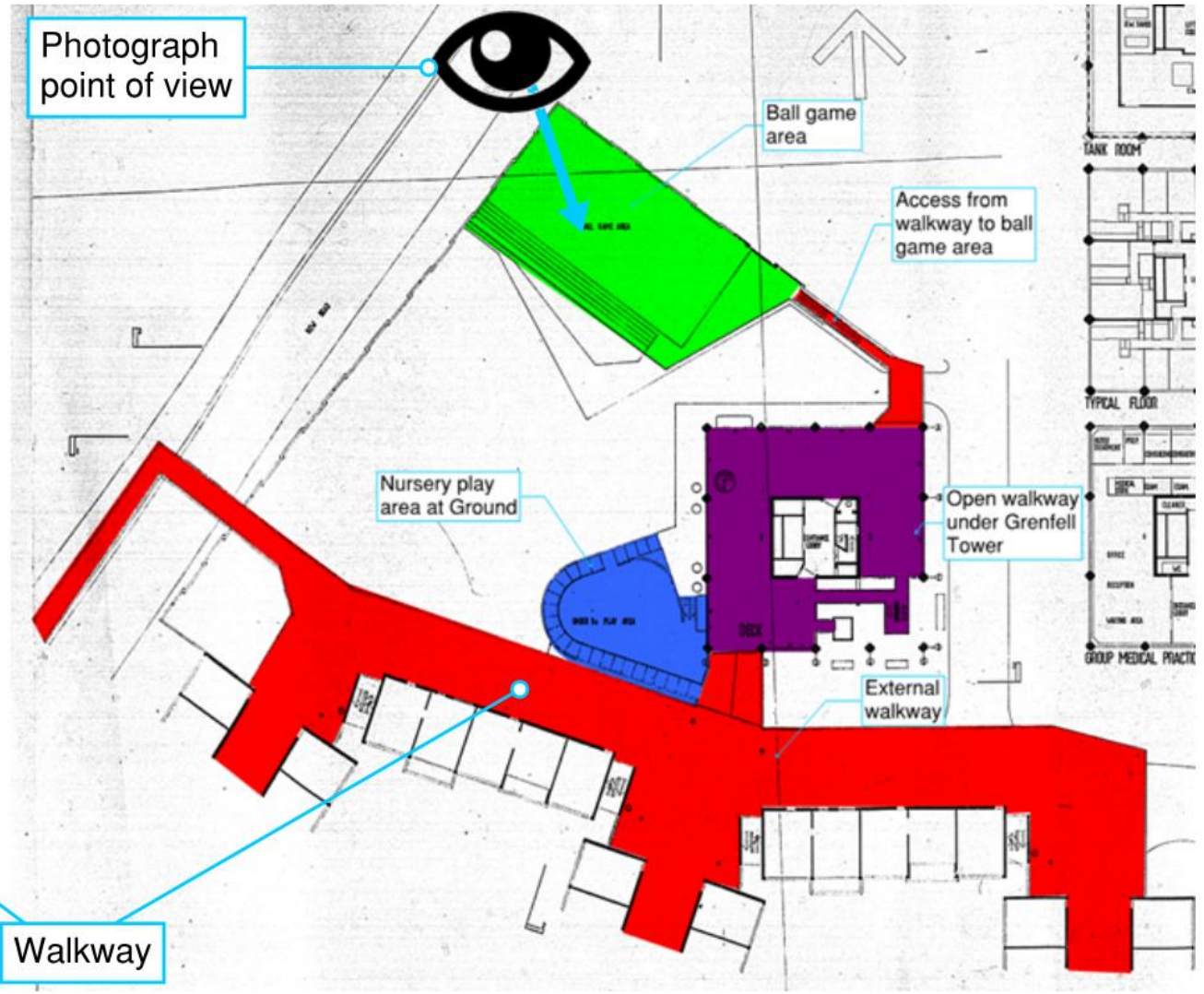
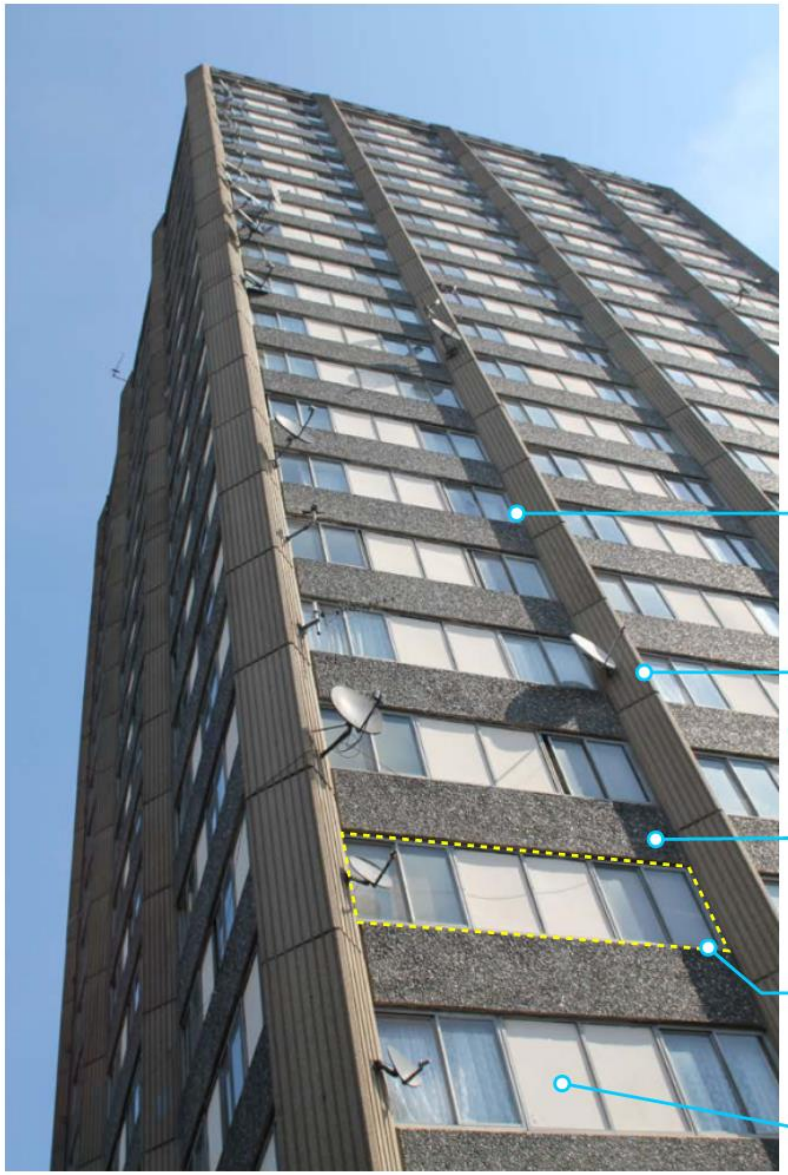
Fire vehicle access to site

External space and fire vehicle access





Original external wall



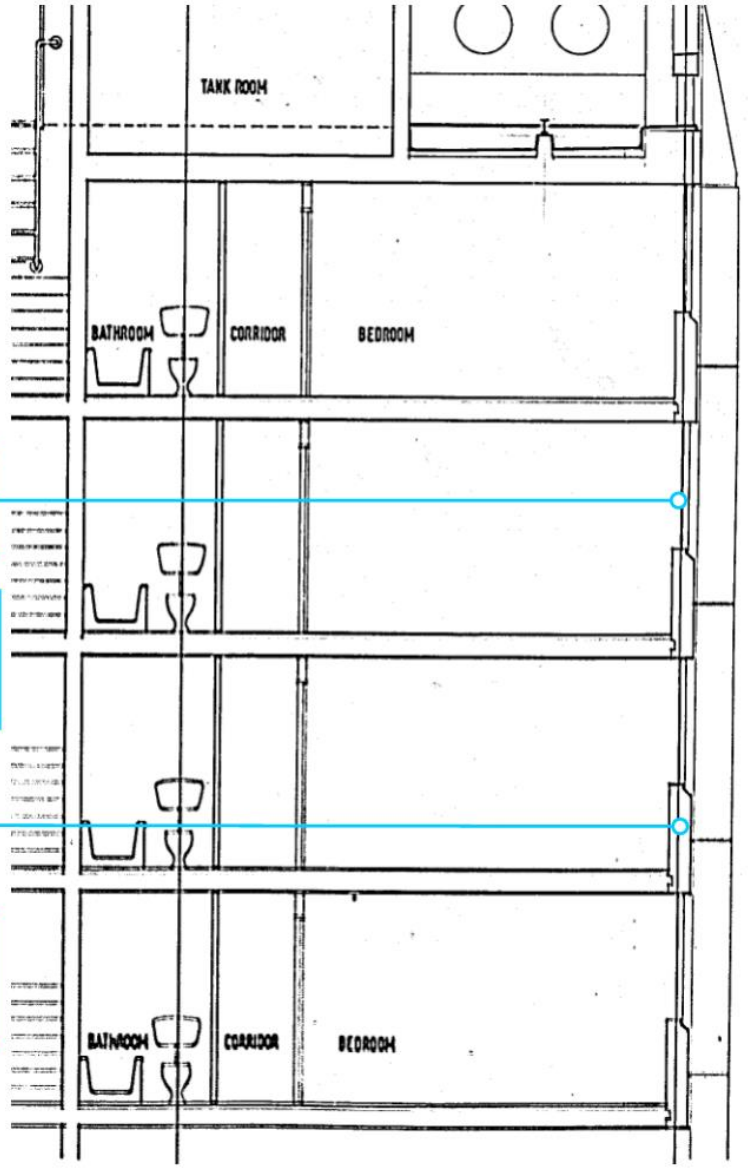
Aluminium frame sliding windows

Decorative pre-cast concrete cladding to columns

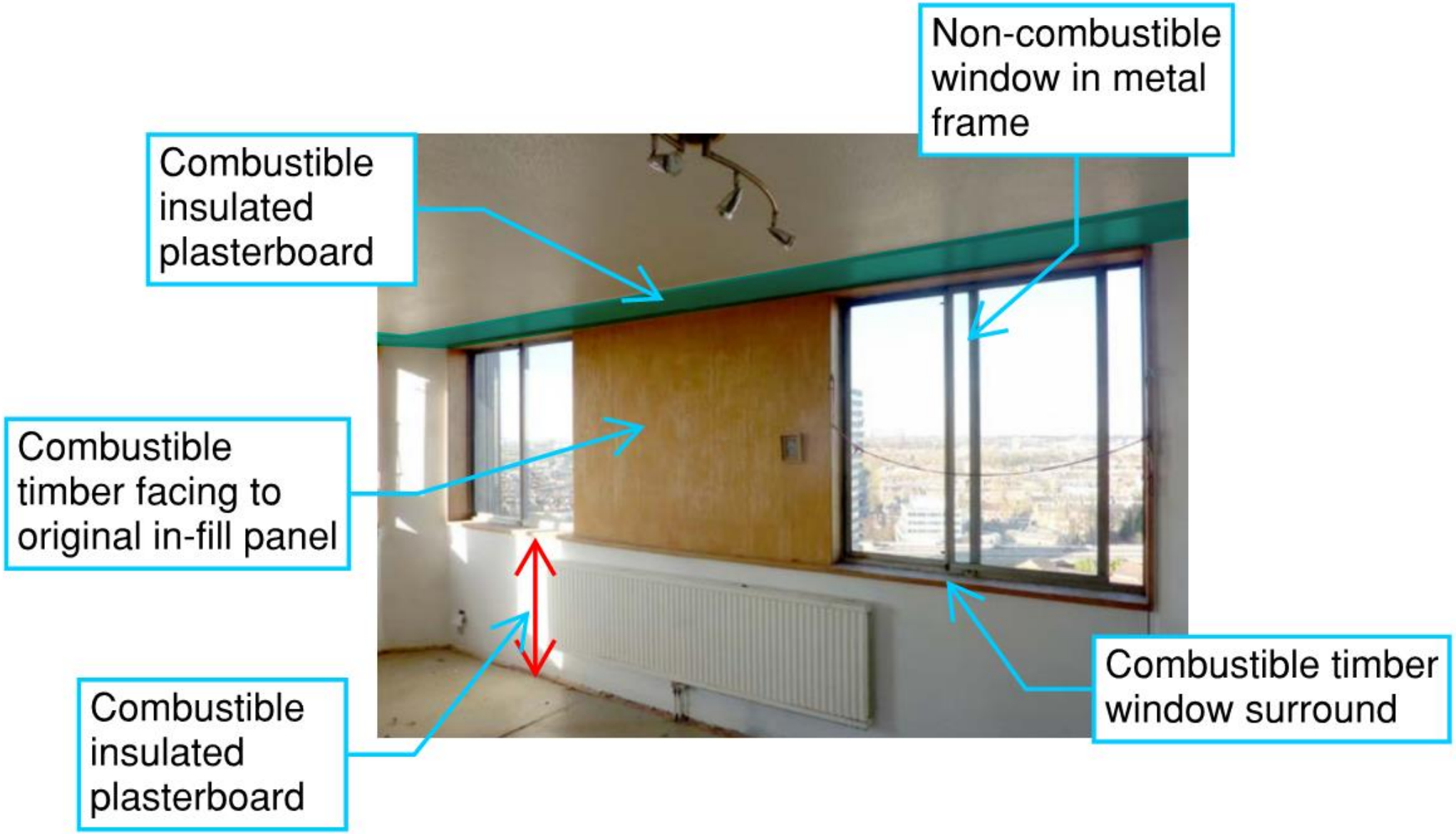
Concrete perimeter beam

Window frames fill entire space in structure

Original infill panel



Original internal window surrounds



Fire Safety in high rise residential buildings in England.

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Part 1

The Building Regulations and the resulting fire safety requirements

STATUTORY INSTRUMENTS

2010 No. 2214

BUILDING AND BUILDINGS, ENGLAND AND WALES

The Building Regulations 2010

Requirements for safety – dealt with in Part B

Building work must be carried out so that it complies with the applicable requirements set out in Parts A to P of Schedule 1 and in complying with such requirements there must be no failure to comply with any other such requirements (regulation 4). The requirements in Schedule 1 relate to structure (Part A), fire safety (Part B), site preparation and resistance to contaminants and moisture (Part C), toxic substances (Part D), resistance to the passage of sound (Part E), ventilation (Part F), sanitation, hot water safety and water efficiency (Part G), drainage and waste disposal (Part H), combustion appliances and fuel storage systems (Part J), protection from falling, collision and impact (Part K), conservation of fuel and power (Part L), access to and use of buildings (Part M), glazing – safety in relation to impact, opening and cleaning (Part N) and electrical safety (Part P). Not all provisions of Schedule 1 apply to all building work.

Approved Documents

The Building Act 1984 gives the Secretary of State power to approve and issue documents containing practical guidance with respect to the requirements contained in these Regulations. The following publications, originally approved for the purposes of the 2000 Regulations, are approved for the purposes of these Regulations.

- Approved Document A – Structure: 2004 edition incorporating 2004 amendments
- Approved Document B – Fire safety: 2006 edition (amended 2010)

Requirements Part B Fire Safety

PART B FIRE SAFETY

Means of warning and escape

B1. The building shall be designed and constructed so that there are appropriate provisions for the early warning of fire, and appropriate means of escape in case of fire from the building to a place of safety outside the building capable of being safely and effectively used at all material times.

Requirement B1 does not apply to any prison provided under section 33 of the Prison Act 1952(**a**) (power to provide prisons etc.).

Requirements Part B Fire Safety

Internal fire spread (linings)

B2.—(1) To inhibit the spread of fire within the building, the internal linings shall—

(a) adequately resist the spread of flame over their surfaces; and

(b) have, if ignited, either a rate of heat release or a rate of fire growth, which is reasonable in the circumstances.

(2) In this paragraph "internal linings" means the materials or products used in lining any partition, wall, ceiling or other internal structure.

Requirements Part B Fire Safety

Internal fire spread (structure)

B3.—(1) The building shall be designed and constructed so that, in the event of fire, its stability will be maintained for a reasonable period.

(2) A wall common to two or more buildings shall be designed and constructed so that it adequately resists the spread of fire between those buildings. For the purposes of this sub-paragraph a house in a terrace and a semi-detached house are each to be treated as a separate building.

(3) Where reasonably necessary to inhibit the spread of fire within the building, measures shall be taken, to an extent appropriate to the size and intended use of the building, comprising either or both of the following—

(a) sub-division of the building with fire-resisting construction;

(b) installation of suitable automatic fire suppression systems.

(4) The building shall be designed and constructed so that the unseen spread of fire and smoke within concealed spaces in its structure and fabric is inhibited.

Requirement B3(3) does not apply to material alterations to any prison provided under section 33 of the Prison Act 1952.

Requirements Part B Fire Safety

External Fire Spread

B4.—(1) 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.

(2) The roof of the building shall adequately resist the spread of fire over the roof and from one building to another, having regard to the use and position of the building.

Requirements Part B Fire Safety

Access and facilities for the fire service

B5.—(1) The building shall be designed and constructed so as to provide reasonable facilities to assist fire fighters in the protection of life.

(2) Reasonable provision shall be made within the site of the building to enable fire appliances to gain access to the building.

Additional Requirement – Fire Safety Information

PART 8

Information to be Provided by the Person Carrying Out Work

Fire safety information

38.—(1) This regulation applies where building work—

(a) consists of or includes the erection or extension of a relevant building; or

(b) is carried out in connection with a relevant change of use of a building,

and Part B of Schedule 1 imposes a requirement in relation to the work.

(2) The person carrying out the work shall give fire safety information to the responsible person not later than the date of completion of the work, or the date of occupation of the building or extension, whichever is the earlier.

Additional Requirement – Fire Safety Information

(3) In this regulation—

(a) "fire safety information" means information relating to the design and construction of the building or extension, and the services, fittings and equipment provided in or in connection with the building or extension which will assist the responsible person to operate and maintain the building or extension with reasonable safety;

(b) a "relevant building" is a building to which the Regulatory Reform (Fire Safety) Order 2005 applies, or will apply after the completion of building work;

(c) a "relevant change of use" is a material change of use where, after the change of use takes place, the Regulatory Reform (Fire Safety) Order 2005 will apply, or continue to apply, to the building; and

(d) "responsible person" has the meaning given by article 3 of the Regulatory Reform (Fire Safety) Order 2005.

Additional Requirement – to make a Full Plans submission

Giving of a building notice or deposit of plans

12.—(1) This regulation applies to a person who intends to—

(a) carry out building work;

(3) A person intending to carry out building work in relation to a building to which the Regulatory Reform (Fire Safety) Order 2005(**a**) applies, or will apply after the completion of the building work, shall deposit full plans.

Full plans

14.—(1) Full plans shall be accompanied by a statement that they are deposited for the purpose of regulation 12(2)(b).

(4) Full plans shall be accompanied by a statement as to whether the building is a building in relation to which the Regulatory Reform (Fire Safety) Order 2005 applies, or will apply after the completion of the building work.

Additional Requirements – completion certificates

Completion certificates

17.—(1) A local authority shall give a completion certificate in accordance with this regulation and as provided for in paragraph (2) where—

(a) they receive a notice under regulation 16(4) or (5) that building work has been completed, or, that a building has been partly occupied before completion; and

(b) they have either—

(i) been notified, in accordance with regulation 14(4), that the building is a building to which the Regulatory Reform (Fire Safety) Order 2005 applies, or will apply after the completion of the work; or

(ii) been requested, in accordance with regulation 14(5), to give a completion certificate.

Additional Requirements – completion certificates

(2) Where in relation to any building work or, as the case may be, to any part of a building which has been occupied before completion, a local authority have been able to ascertain, after taking all reasonable steps, that the relevant requirements specified in the certificate have been satisfied, they shall give a certificate to that effect.

(3) In this regulation "relevant requirements" mean—

(a) in a case mentioned in paragraph (1)(b)(i), the applicable requirements of regulation 38 and Part B of Schedule 1 (fire safety); and

(b) in a case mentioned in paragraph (1)(b)(ii), any applicable requirements of regulations 26 (target CO_2 emission rates for new buildings), 29 (energy performance certificates), 36 (water efficiency of new dwellings) and Schedule 1.

(4) A certificate given in accordance with this regulation shall be evidence (but not conclusive evidence) that the requirements specified in the certificate have been complied with.

Approved Document B Fire Safety

THE APPROVED DOCUMENTS

This document is one of a series that has been approved and issued by the Secretary of State for the purpose of providing practical guidance with respect to the requirements of Schedule 1 to and Regulation 7 of the Building Regulations 2010 (SI 2000/2214) for England and Wales.

At the back of this document is a list of all the documents that have been approved and issued by the Secretary of State for this purpose.

The Approved Documents are intended to provide guidance for some of the more common building situations. However, there may well be alternative ways of achieving compliance with the requirements.

Thus there is no obligation to adopt any particular solution contained in an Approved Document if you prefer to meet the relevant requirement in some other way.

Connection between the Approved Document B and RR(FS) Order 2005

INTERACTION WITH OTHER LEGISLATION

The Regulatory Reform (Fire Safety) Order 2005

The Fire Safety Order reforms the law relating to fire safety in non-domestic premises. Specifically it replaces the Fire Precautions (Workplace) Regulations 1997 and the Fire Precautions Act 1971. It imposes a general duty to take such fire precautions as may be reasonably required to ensure that premises are safe for the occupants and those in the immediate vicinity.

By virtue of the Order, the responsible person is required to carry out a fire risk assessment of their premises. This must be 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 under the Order.

The Order applies to all non-domestic premises, which includes the common parts of block of flats and HMOs.

Connection between the Approved Document B and RR(FS) Order 2005

INTERACTION WITH OTHER LEGISLATION

The Regulatory Reform (Fire Safety) Order 2005

Although these requirements are applicable to premises whilst in operation, it would be useful for the designers of a building to carry out a preliminary fire risk assessment as part of the design process. If a preliminary risk assessment is produced, it can be used as part of the Building Regulations submission and can assist the fire safety enforcing authority in providing advice

at an early stage as to what, if any, additional provisions may be necessary when the building is first occupied.

The Housing Act 2004

3 Local housing authorities to review housing conditions in their districts

(1) A local housing authority must keep the housing conditions in their area under review with a view to identifying any action that may need to be taken by them under any of the provisions mentioned in subsection (2).

(4) In this Part "residential premises" means—

(a) a dwelling;

(b) an HMO;

(c) unoccupied HMO accommodation;

(d) any common parts of a building containing one or more flats.

"common parts", in relation to a building containing one or more flats, includes—

(a) the structure and exterior of the building, and

(b) common facilities provided (whether or not in the building) for persons who include the occupiers of one or more of the flats;

"dwelling" means a building or part of a building occupied or intended to be occupied as a separate dwelling;

The Approved Document B and its definition of the Stay Put Strategy

2.3 The provisions for means of escape for flats are based on the assumption that:

a. the fire is generally in a flat;

b. there is no reliance on external rescue (e.g. by a portable ladder);

c. measures in Section 8 (B3) provide a high degree of compartmentation and therefore a low probability of fire spread beyond the flat of origin, so that simultaneous evacuation of the building is unlikely to be necessary; and

d. although fires may occur in the common parts of the building, the materials and construction used there should prevent the fabric from being involved beyond the immediate vicinity (although in some cases communal facilities exist which require additional measures to be taken).

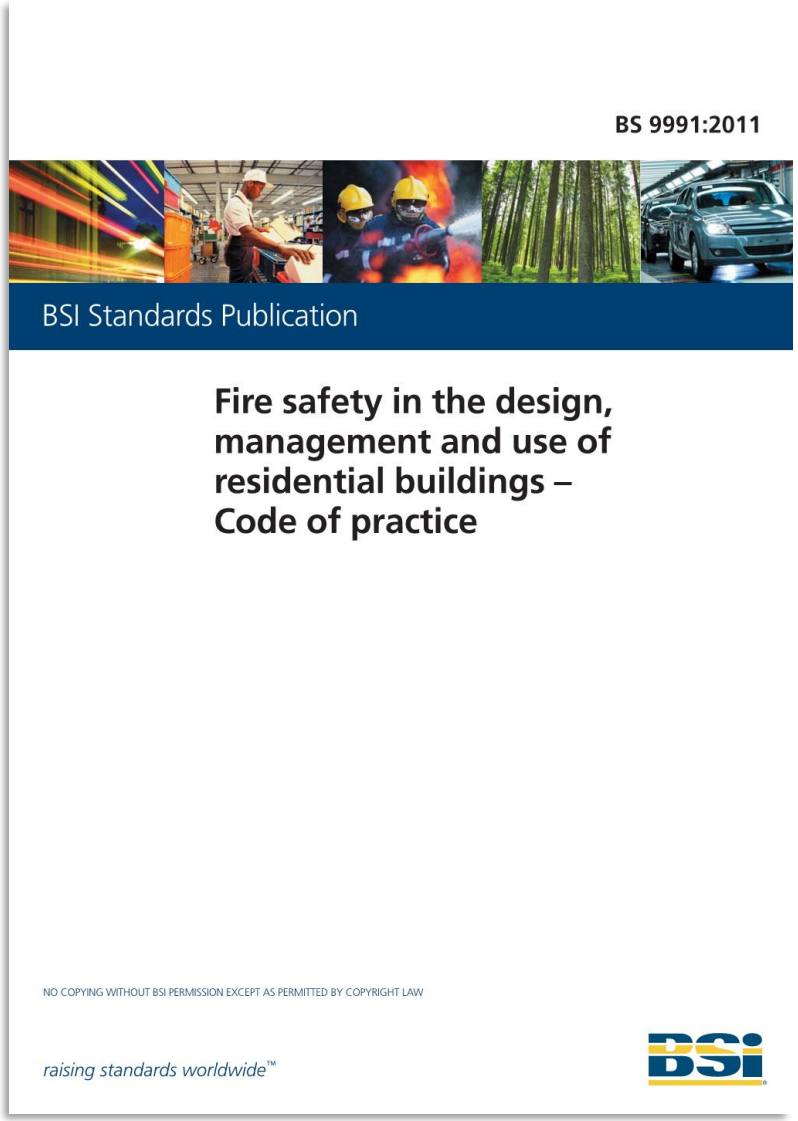
The Approved Document B and its definition of the Stay Put Strategy

Introduction

B1.i These provisions relate to building work and material changes of use which are subject to the functional requirement B1 and they may therefore affect new or existing buildings. They are concerned with the measures necessary to ensure reasonable facilities for means of escape in case of fire. They are only concerned with structural fire precautions where these are necessary to safeguard escape routes.

They assume that, in the design of the building, reliance should not be placed on external rescue by the Fire and Rescue Service nor should it be based on a presumption that the Fire and Rescue Service will attend an incident within a given time. This Approved Document has been prepared on the basis that, in an emergency, the occupants of any part of a building should be able to escape safely without any external assistance.

BS9991 Fire safety in the design, management and use of residential buildings – Code of practice



BS9991 Fire safety in the design, management and use of residential buildings – Code of practice

The provisions for means of escape for flats or maisonettes are based on the assumptions that:

a) fire will occur within the flat or maisonette (e.g. not in a stairwell);

b) there can be no reliance on external rescue (e.g. a portable ladder);

c) the flat or maisonette will have a high degree of compartmentation and therefore there will be a low probability of fire spread beyond the flat or maisonette of origin, so simultaneous evacuation of the building is unlikely to be necessary; and

d) where fires do occur in the common parts of the building, the materials and construction used in such areas will prevent the fire from spreading beyond the immediate vicinity (although in some cases communal facilities exist which require additional measures to be taken).

BS9991 Fire safety in the design, management and use of residential buildings – Code of practice

Whilst a simultaneous evacuation is normally unnecessary (see **E.1** regarding stay put strategy), there will be some occasions where operational conditions are such that the fire and rescue service decide to evacuate the building. In these situations the occupants of the building will need to use the common stair, sometimes whilst fire-fighting is in progress. As such, the measures in this British Standard for the protection of common stairs are designed to ensure they remain available for use over an extended period.

BS9991 Fire safety in the design, management and use of residential buildings – Code of practice

26.1.1 General

In residential buildings designed with a stay put strategy (see **E.1**), additional protection to the staircase should be provided in the form of a smoke control system.

BS9991 Fire safety in the design, management and use of residential buildings – Code of practice

27 Fire resistance

*COMMENTARY ON CLAUSE **27***

*For the purposes of complying with the recommendations for means of escape in case of fire, a 30 min period of fire resistance is generally considered adequate. However, increased periods of fire resistance might be necessary: firstly to allow a fire in a dwelling to burn out while occupants of other dwellings remain in place (see **E.1** regarding stay-put strategy), and secondly to provide adequate safety for fire-fighting.*

BS9991 Fire safety in the design, management and use of residential buildings – Code of practice

29.2 External fire spread over the external faces of buildings

External walls should be constructed using a material that does not support fire spread and therefore endanger people in or around the building.

Flame spread over or within an external wall construction should be controlled to avoid creating a route for rapid fire spread bypassing compartment floors or walls.

This is particularly important where a stay put strategy (see **E.1**) is in place.

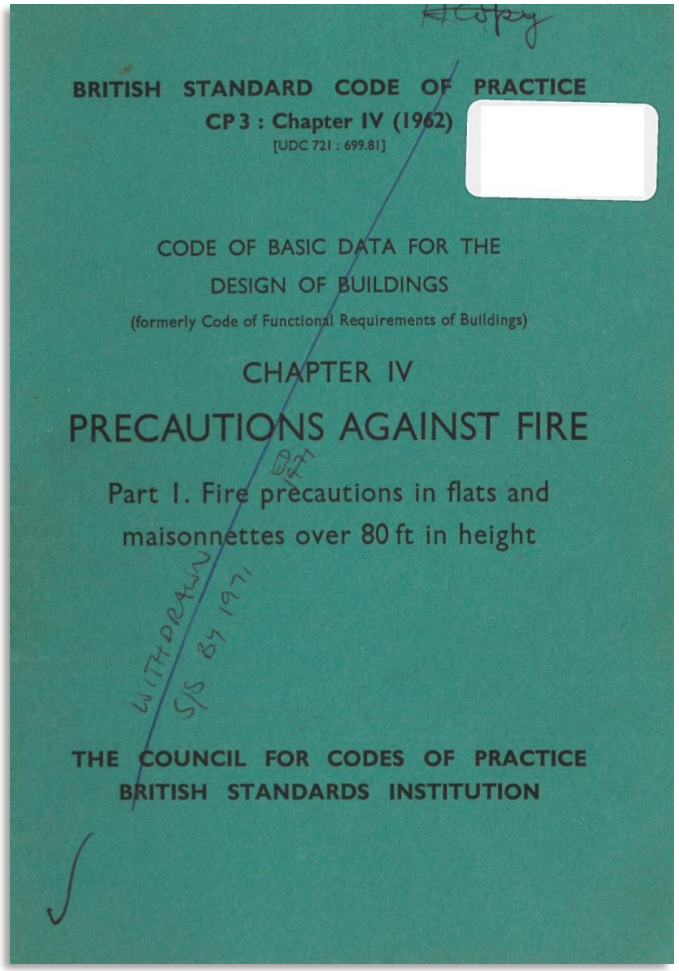
Combustible materials should not be used in cladding systems and extensive cavities.

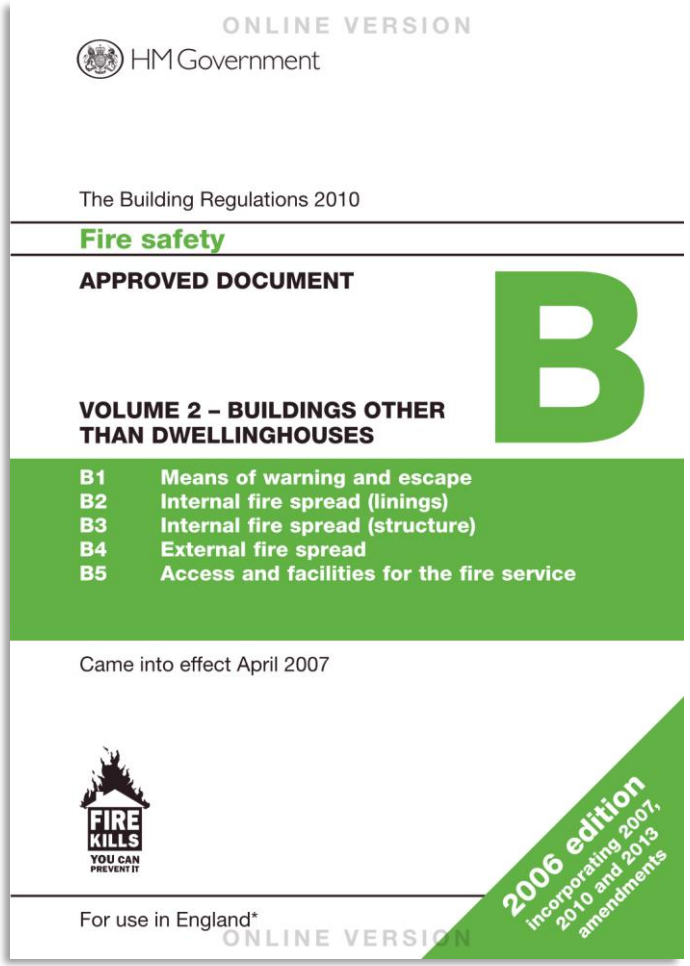
External wall surfaces near other buildings should not be readily ignitable, to avoid fire spread between buildings.

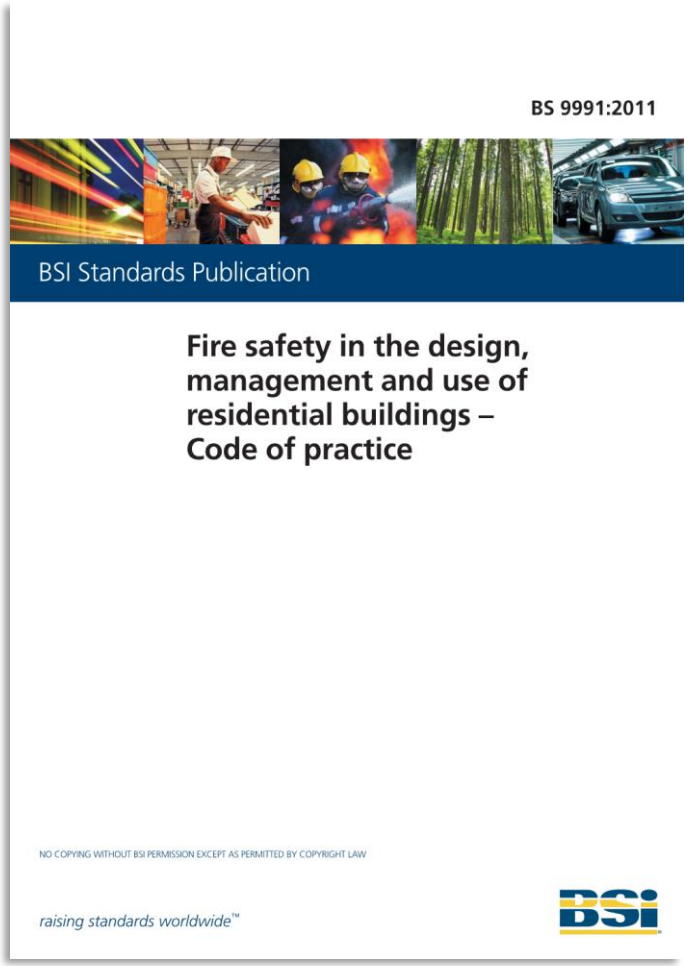
Since 1962:

The assumption should no longer be made that buildings must be evacuated if a fire occurs and high residential buildings should, therefore, be designed so that the occupants of floors above a dwelling which is on fire may, if they choose, remain safely on their own floor. It may be necessary to evacuate the floor on which the fire occurs, and in some circumstances those floors which are in the immediate vicinity of the fire, but the occupants of these floors should be free to reach safety in any other part of the building via the staircase.

Guidance to comply with the Building Regulations



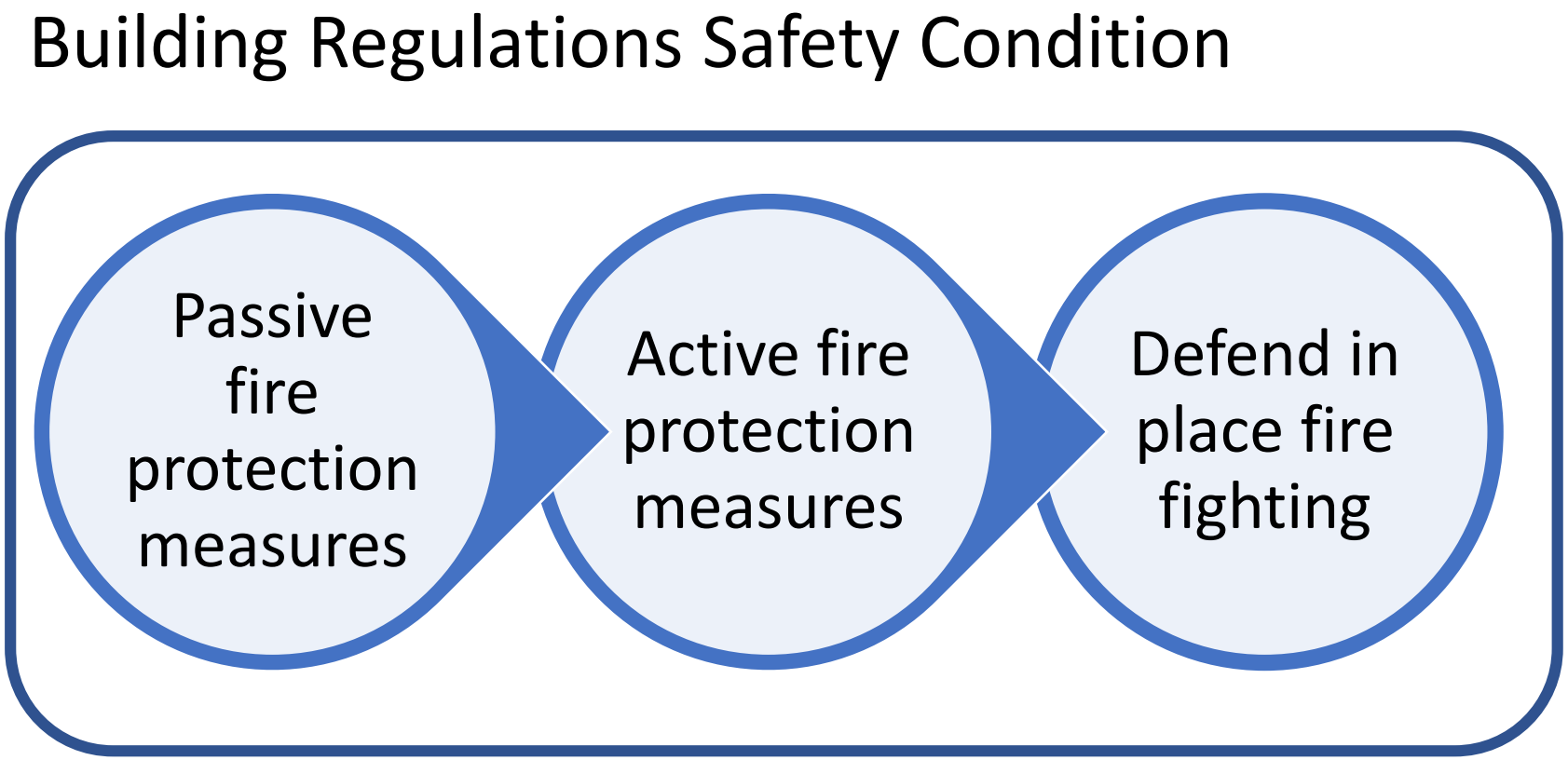




The Stay Put Strategy

During a single flat fire, the occupants of that flat evacuate, and all other occupants are safe if they *“remain where they are”*

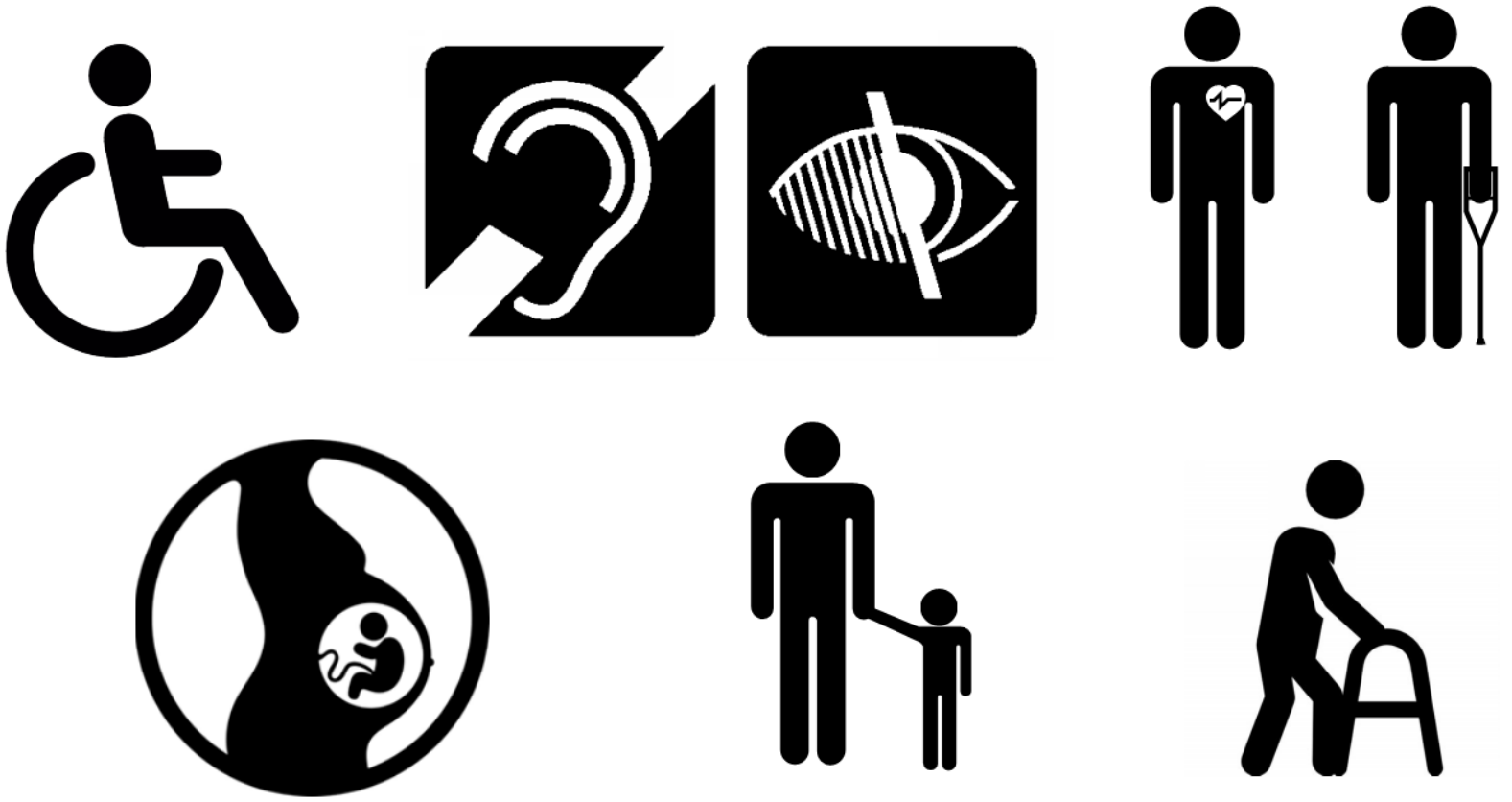
Building Regulations Safety Condition



The issue of applying water early in a fire, and the fire being extinguished early is described as ***“Defend in place”*** fire fighting strategy

How the Stay Put Strategy is designed for high rise residential buildings

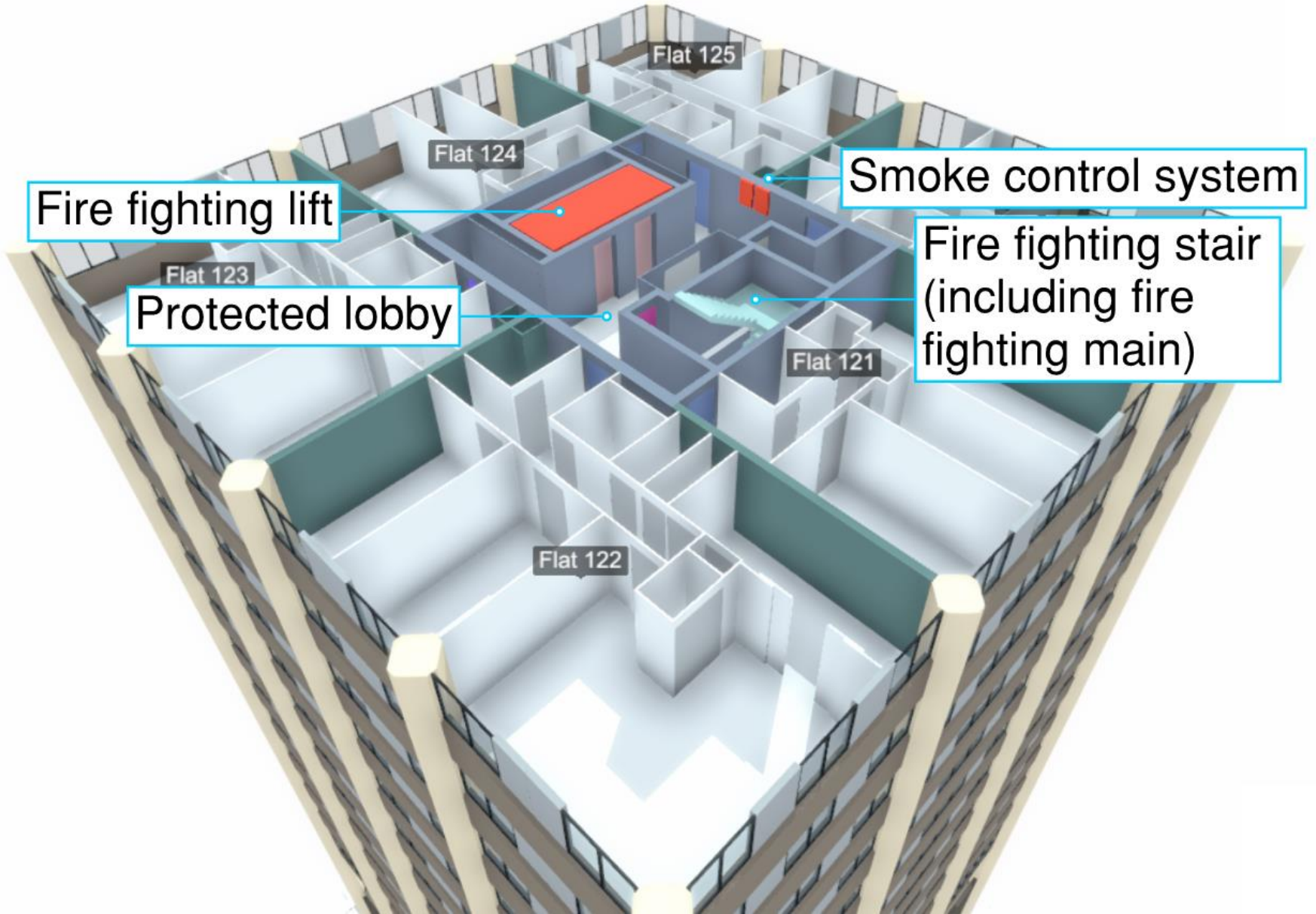
Specific Risk to persons requiring assistance to evacuate during a fire



Defend in place

fire fighting in high rise residential buildings

Defend in place fire fighting



Defend in place – Extinguishing the fire

Image: laoisfiresupplies.com

Image: deltafire.co.uk

Image: emergencytimes.com

The fire fighting bridgehead & sectors

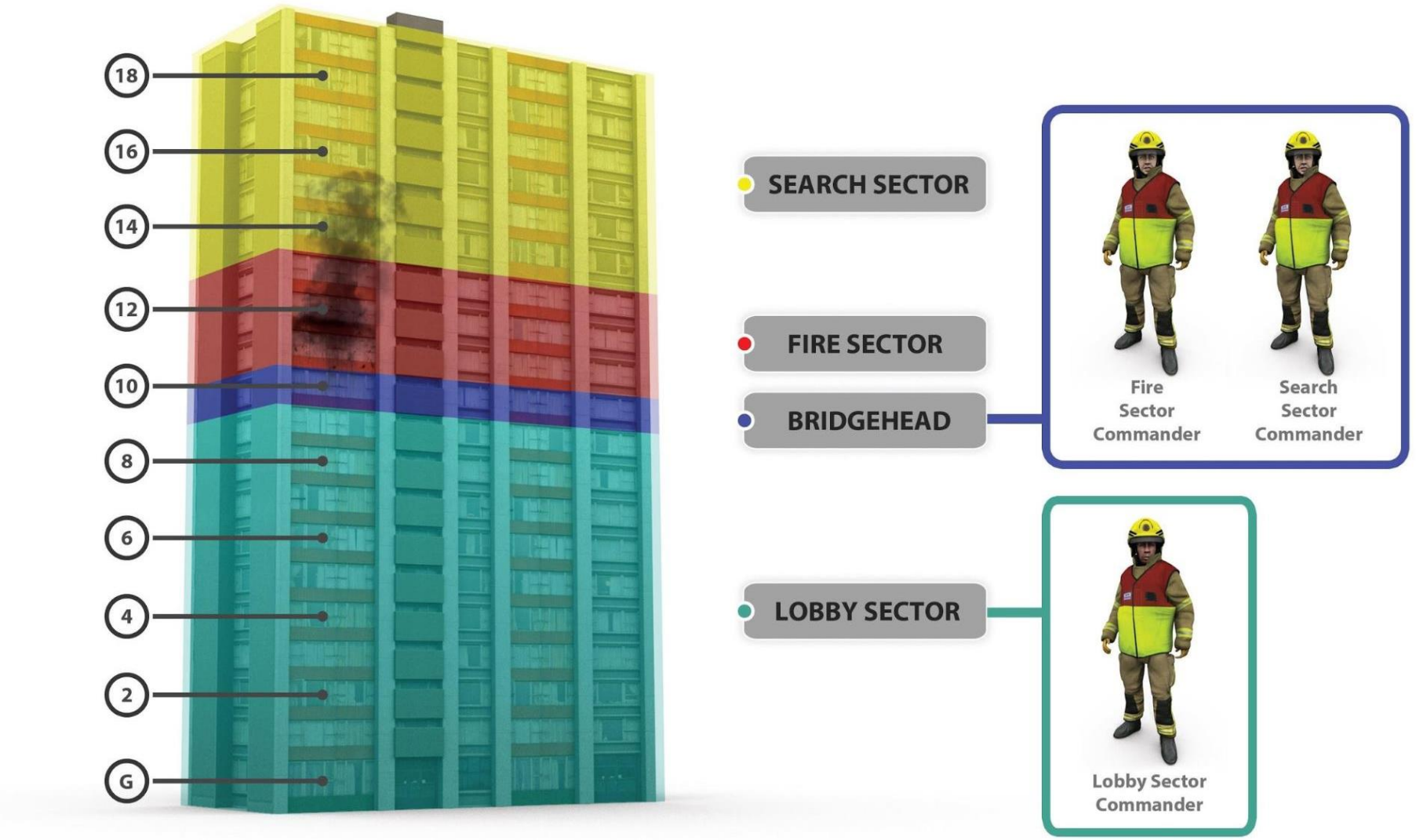
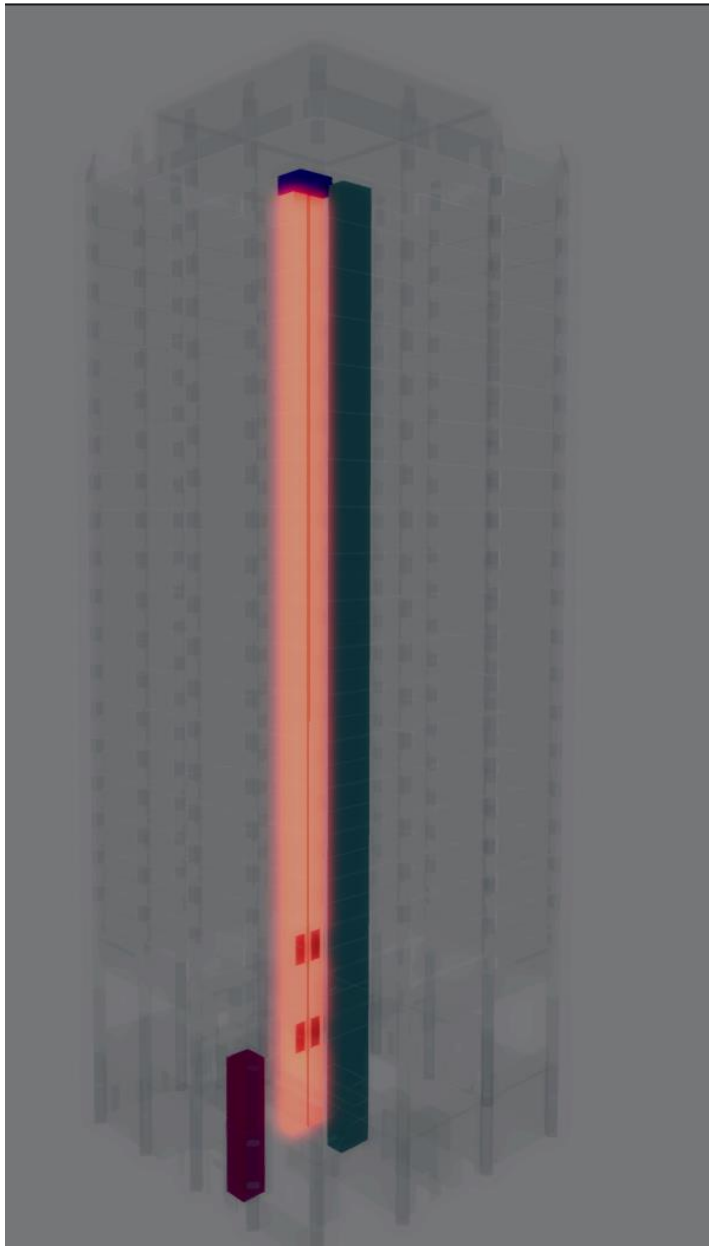


Image: ukfrs.com

Defend in place – Search & Rescue



The Stay Put Strategy –
the single safety condition provided for

There is no Building Regulations
requirement to provide
active or passive fire protection measures
which would allow an alternative
to the Stay Put Strategy

Fire Safety in high rise residential buildings in England.

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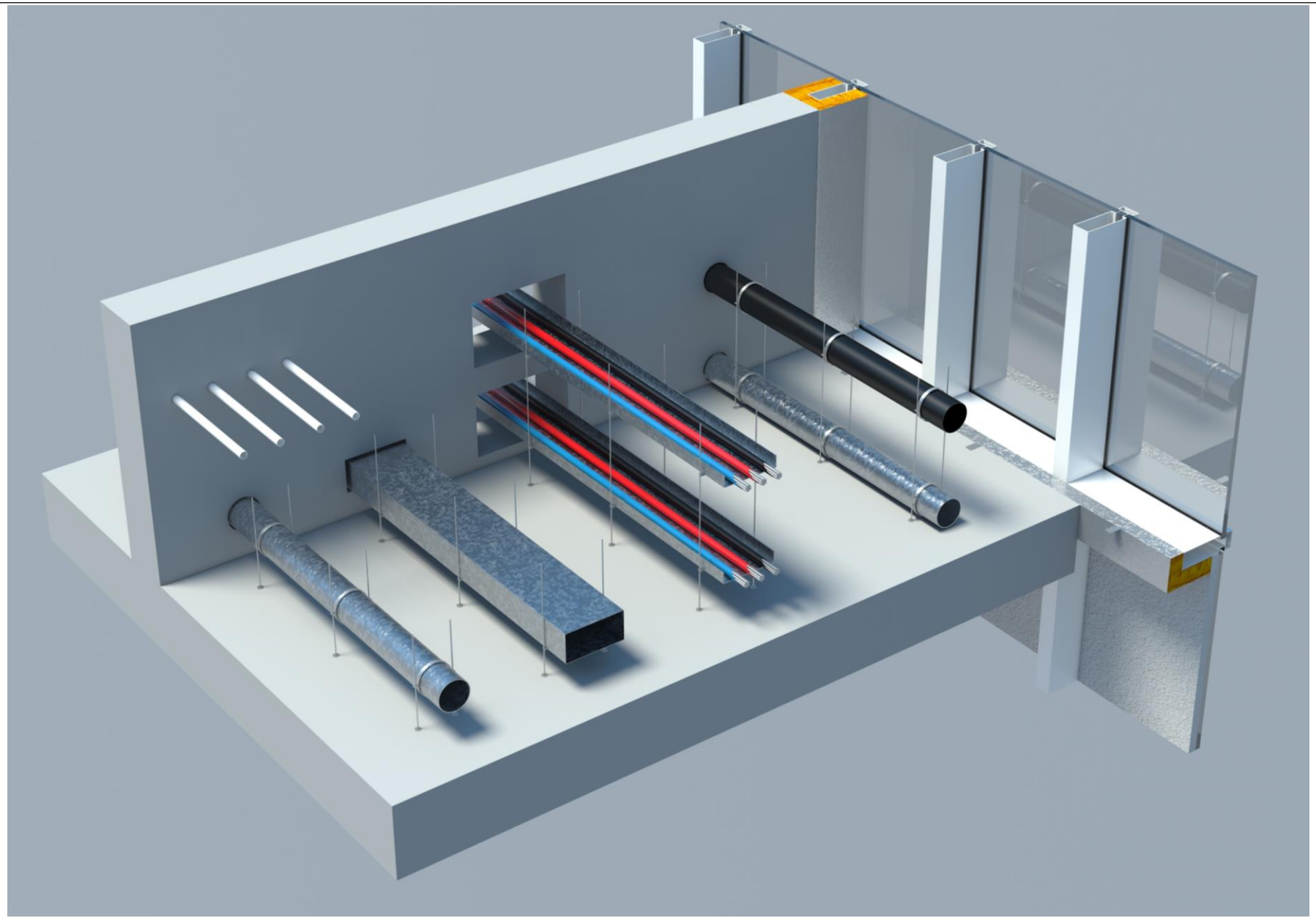
Part 2

The Active and Passive fire protection measures forming the Stay Put Strategy

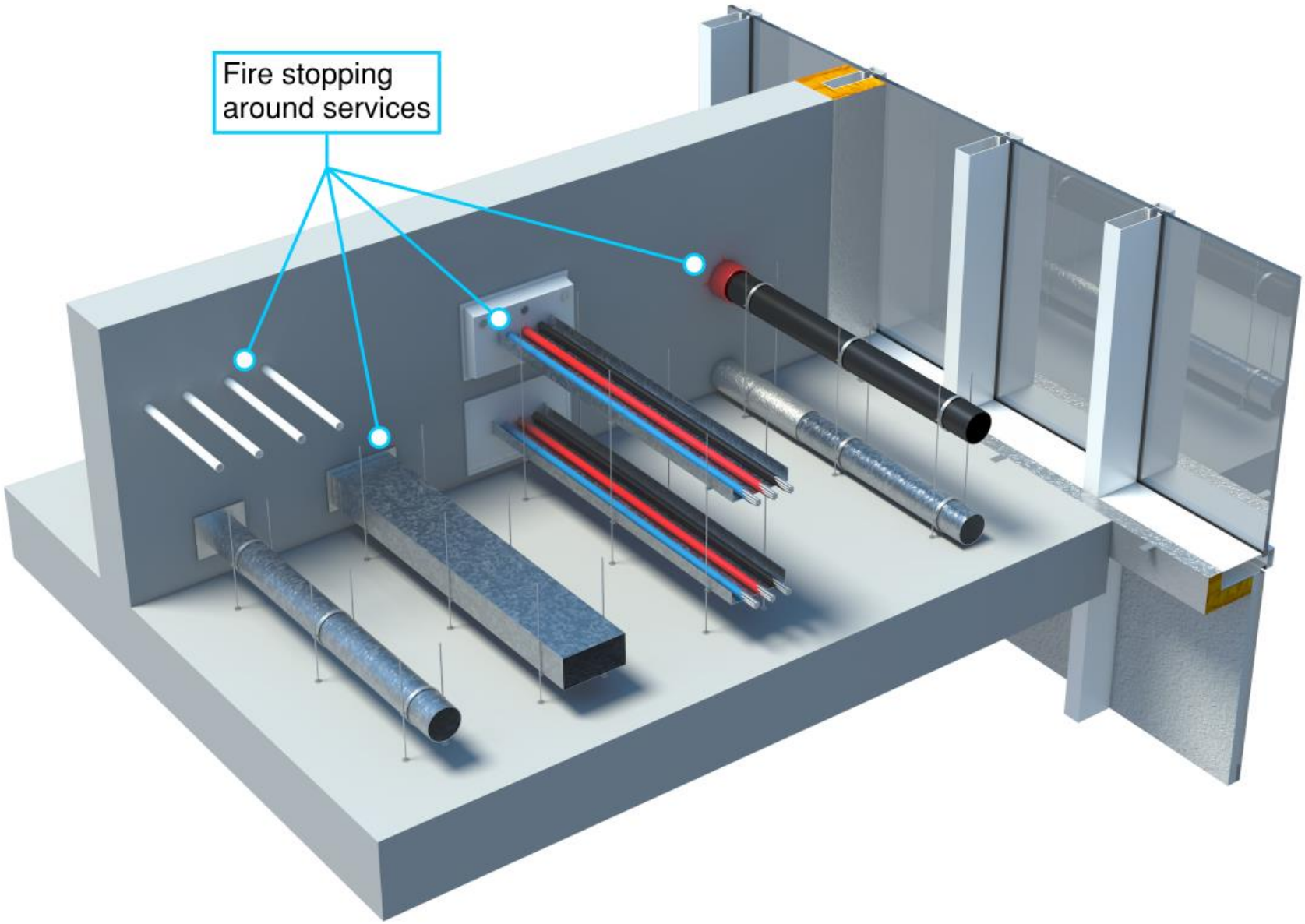
Passive fire protection measures

Fire Protection Measure:
Fire resisting walls and floors

Fire Protection Measure: Openings through fire resisting walls and floors

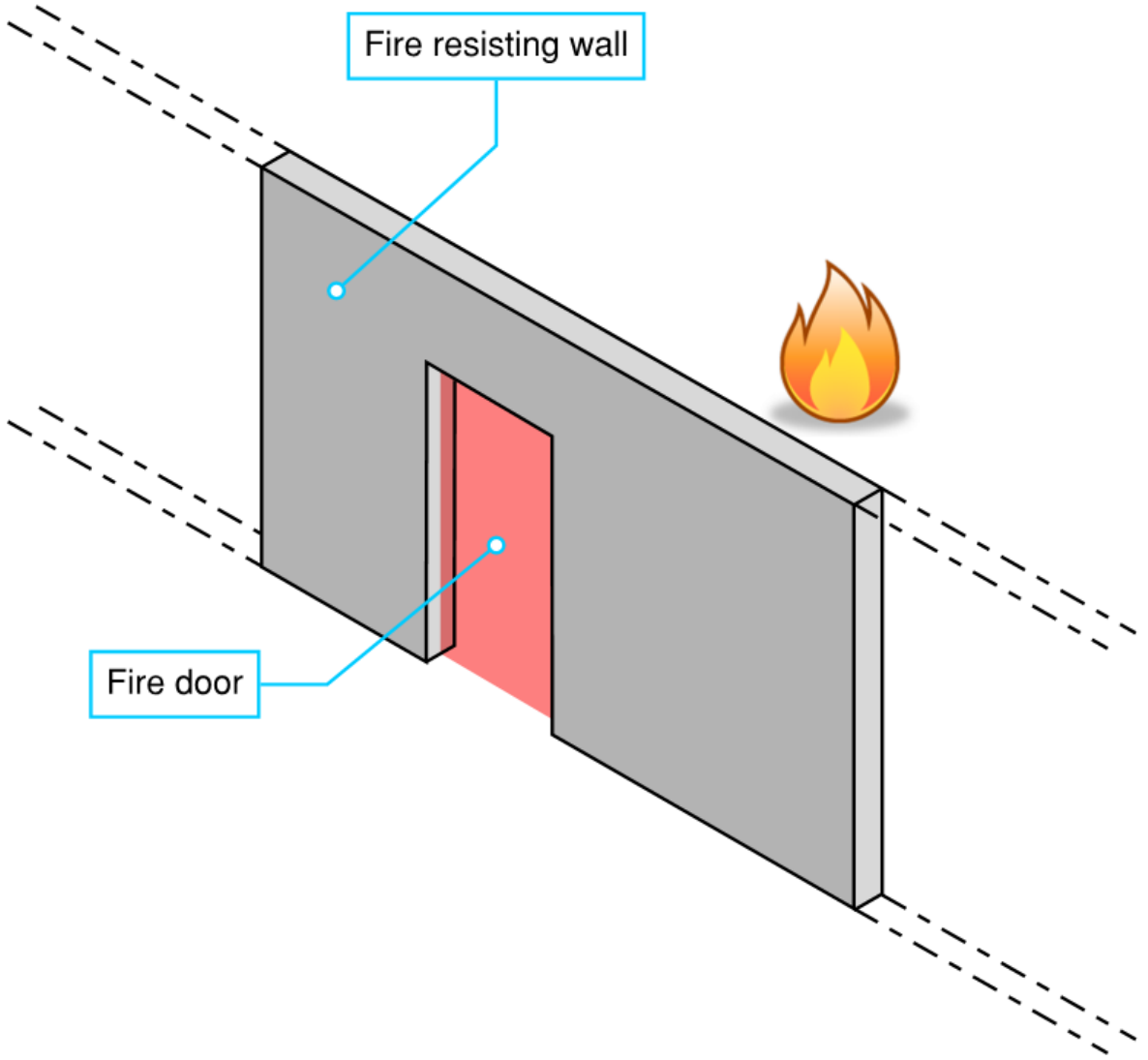


Fire Protection Measure: Openings through fire resisting walls and floors



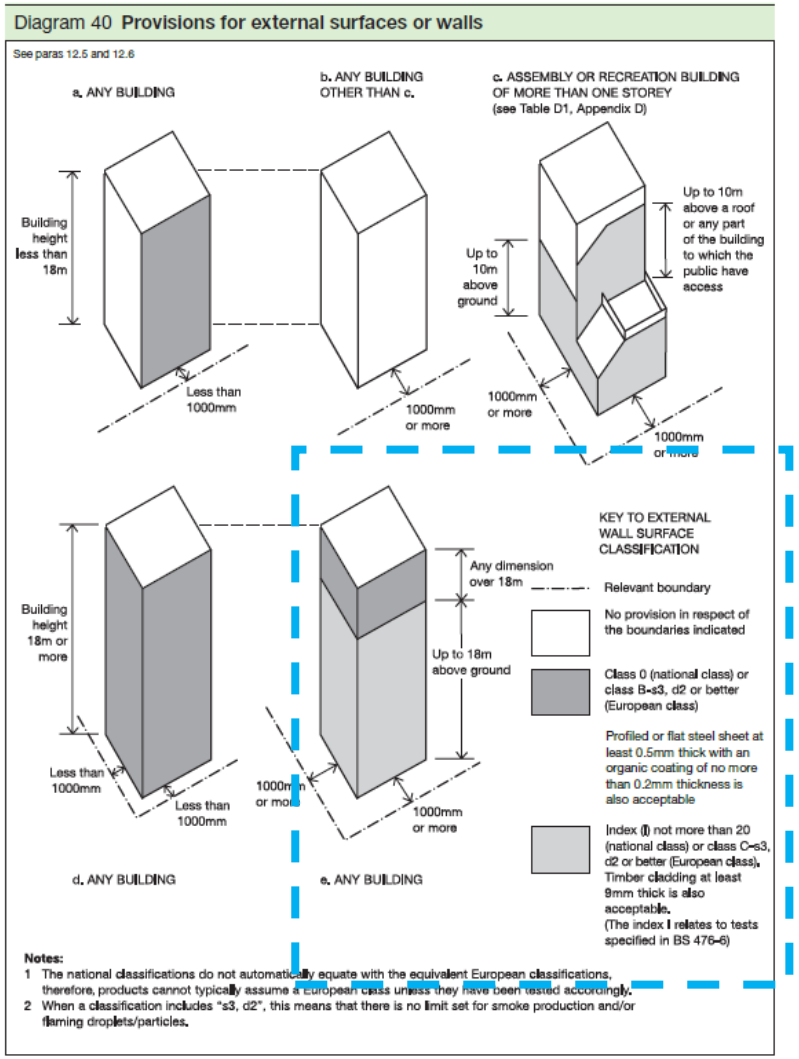
Fire Protection Measure:
Fire Doors

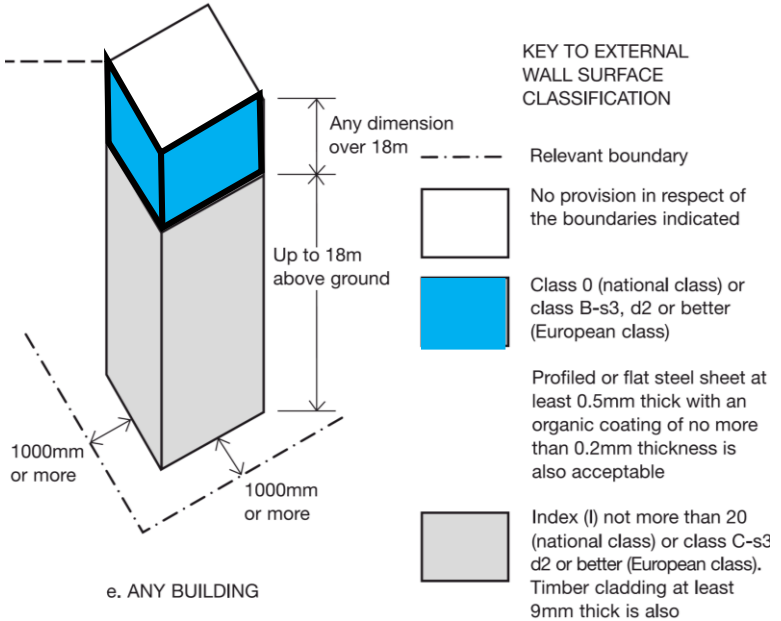
Fire Protection Measure: Fire doors – What is a fire door?



Fire Protection Measure:
Construction of External Walls

Fire Protection Measure: External Surfaces

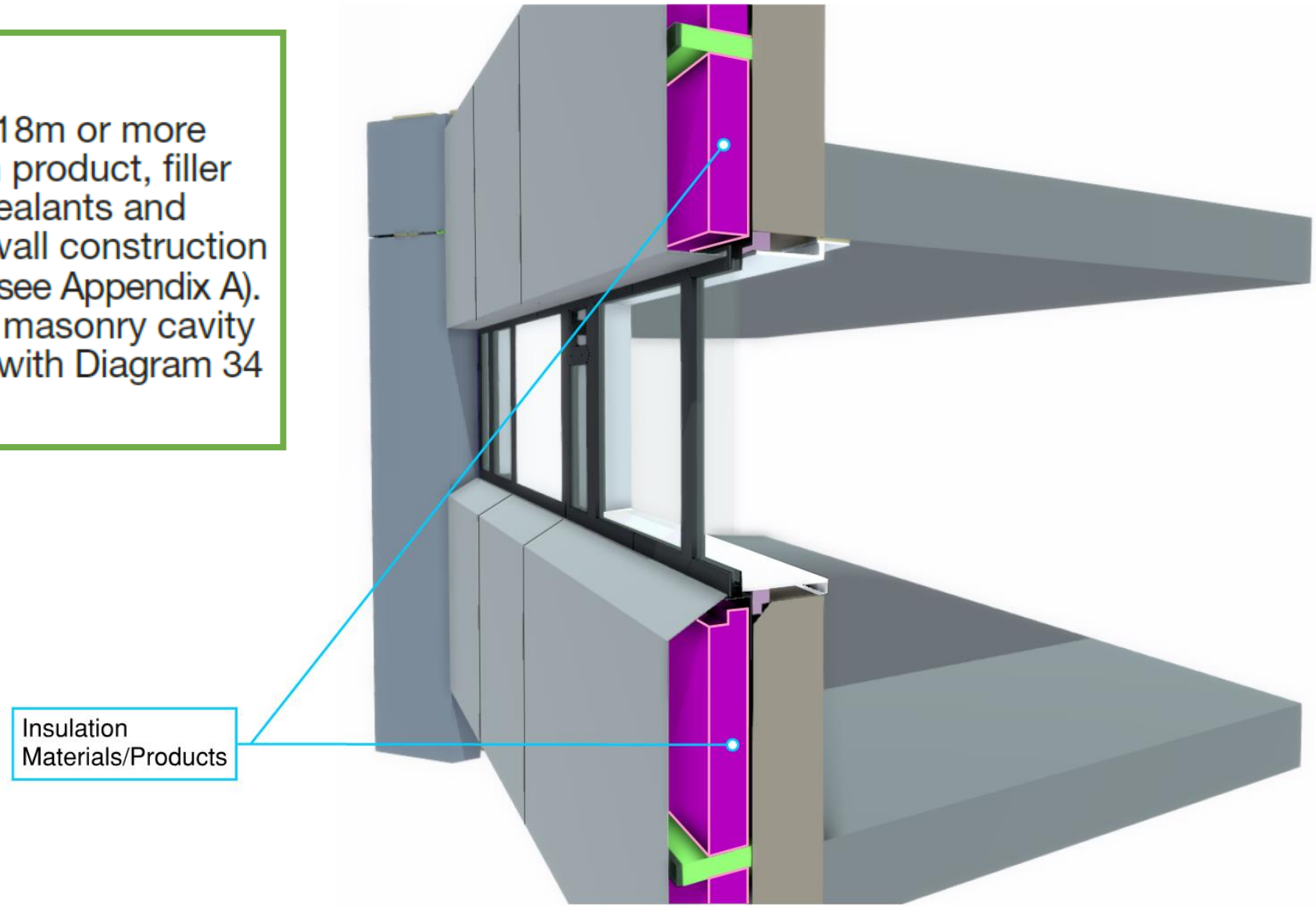




Fire Protection Measure: Insulation Materials/Products

Insulation Materials/Products

12.7 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.

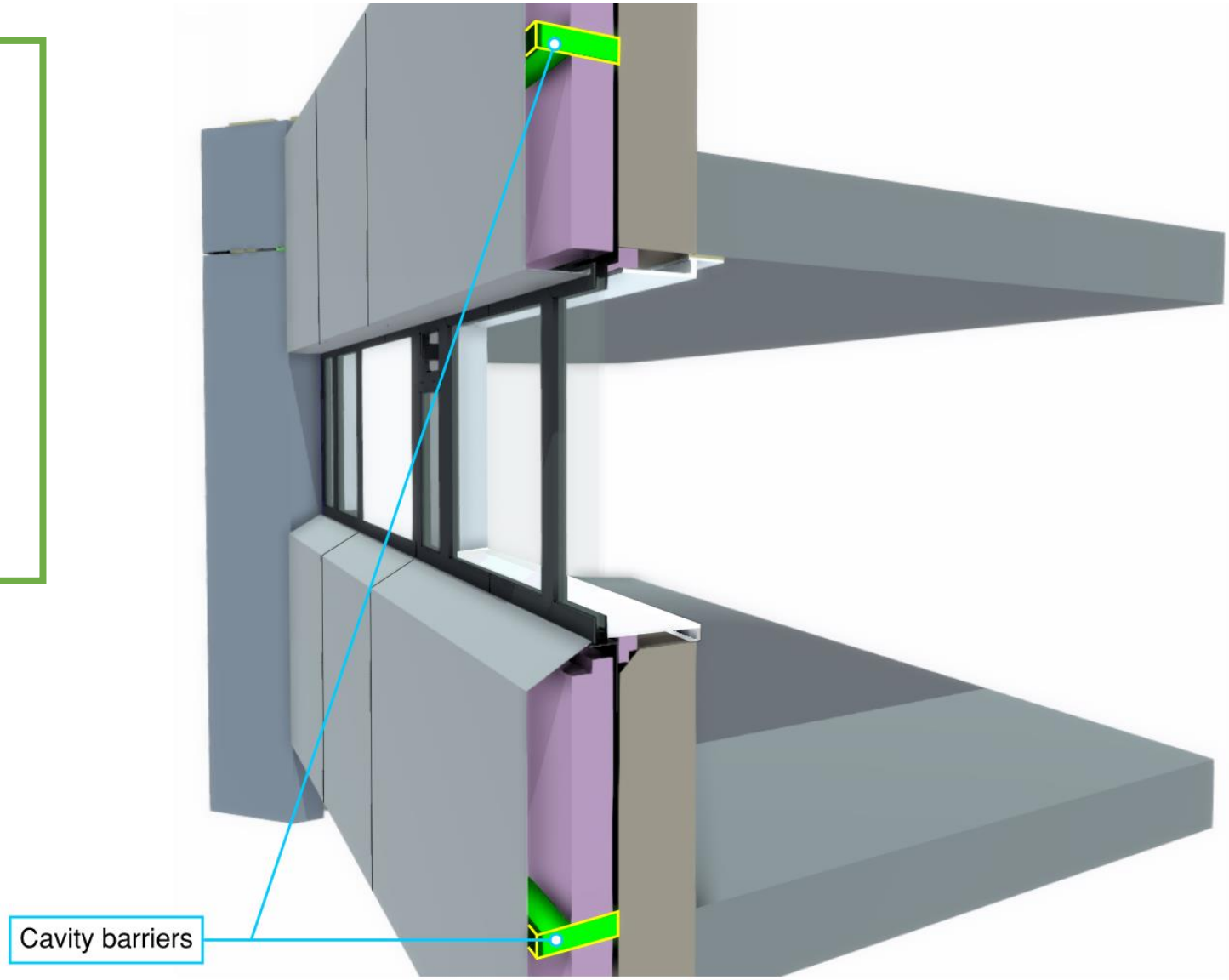


Fire Protection Measure: Cavity Barriers

Cavity barriers

12.8 Cavity barriers should be provided in accordance with Section 9.

12.9 In the case of a 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.

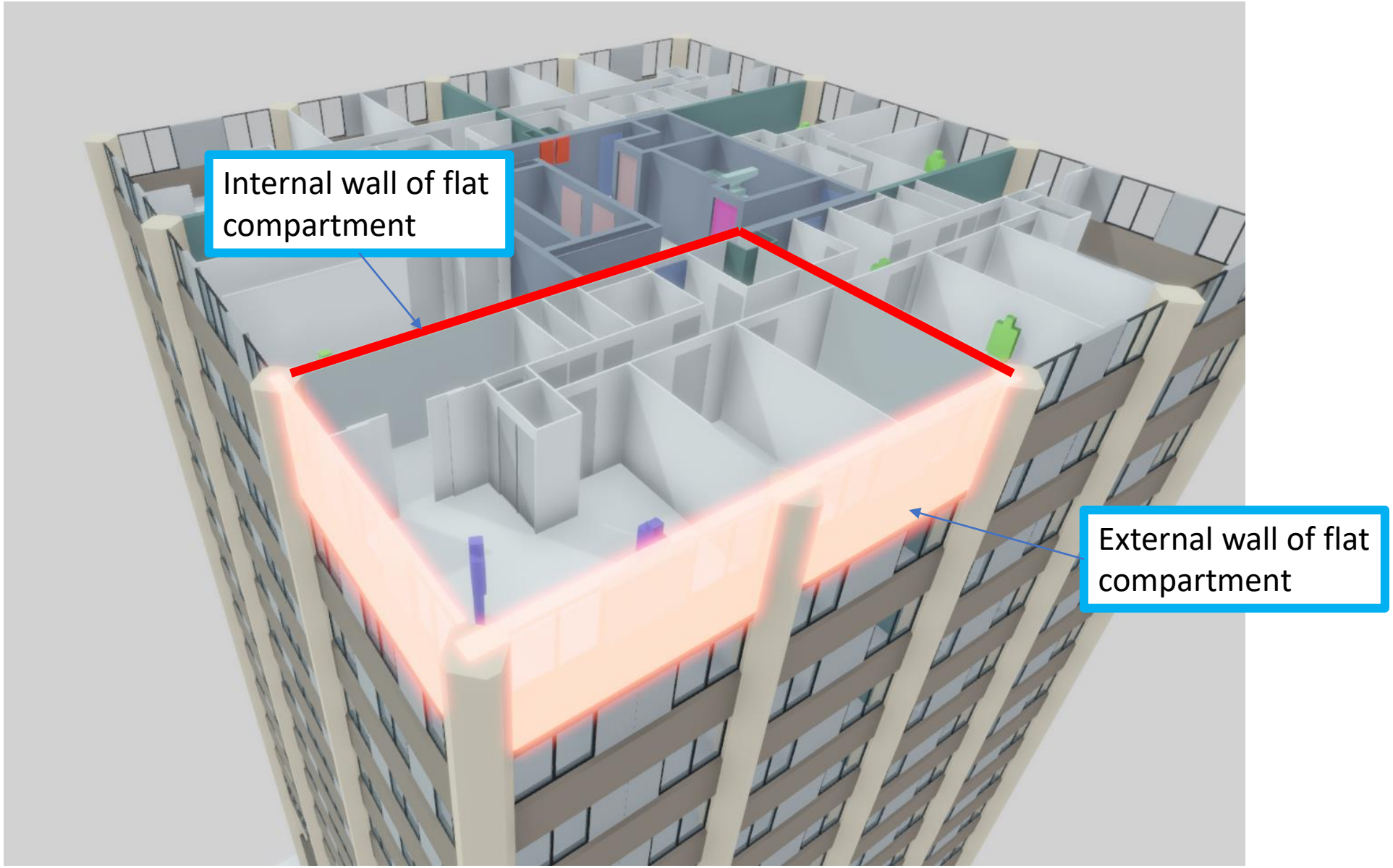


External wall construction

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.

Externall walls should either meet the guidance given in paragraphs 12.6 to 12.9 or meet the performance criteria given in the BRE Report *Fire performance of external thermal insulation for walls of multi storey buildings* (BR 135) for cladding systems using full scale test data from BS 8414-1:2002 or BS 8414-2:2005.

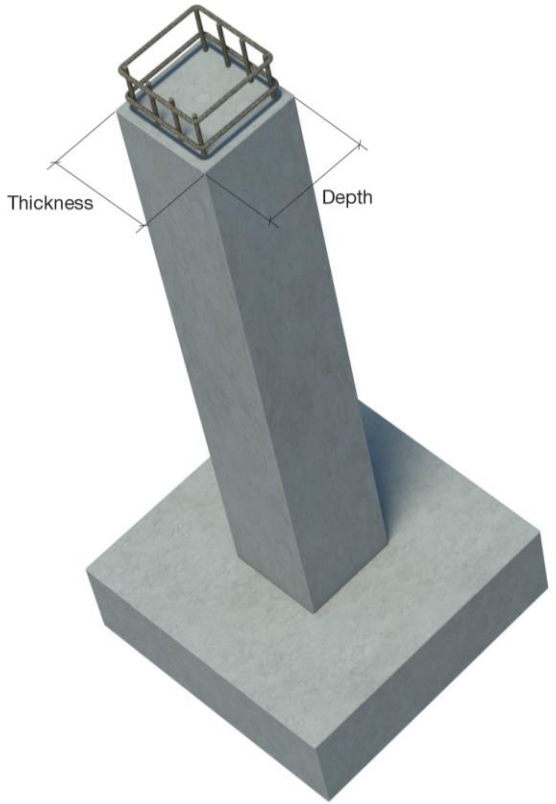
Fire Protection Measure: Construction of External Walls



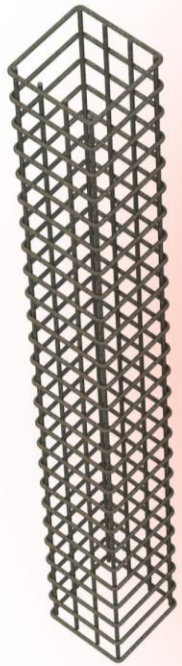
Fire Protection Measure:
Structural Fire Resistance

Fire Protection Measure: Structural fire resistance

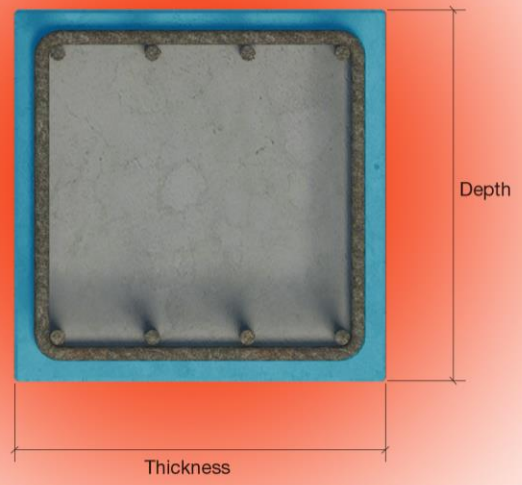
Example:
Concrete column



Concrete Column and Slab



Reinforcing Bars



Insulating layer of concrete around reinforcement

Image from www.structurepoint.org

Fire Protection Measure:
Materials lining the escape route

Fire Protection Measure: Materials of construction of the stair

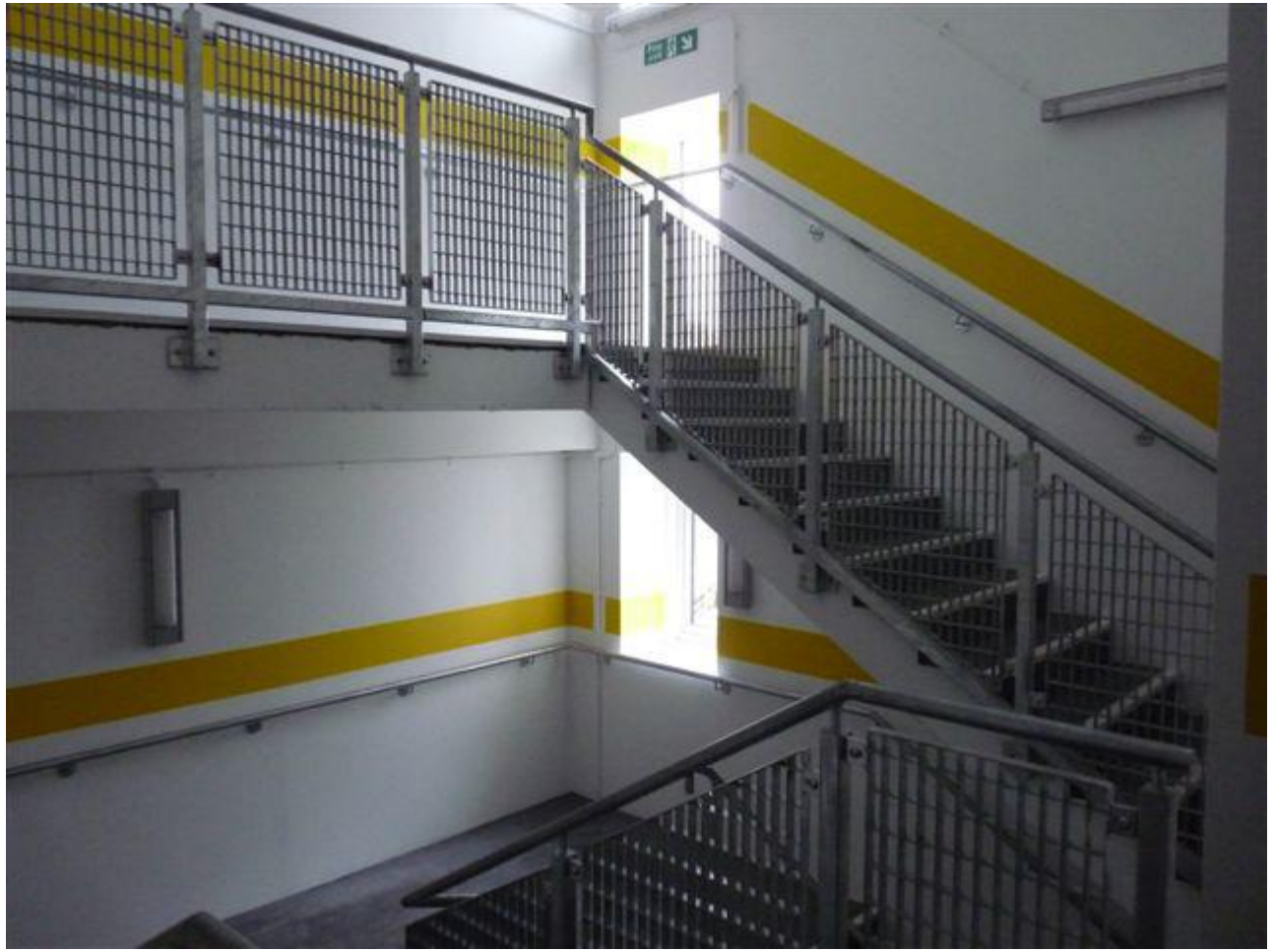


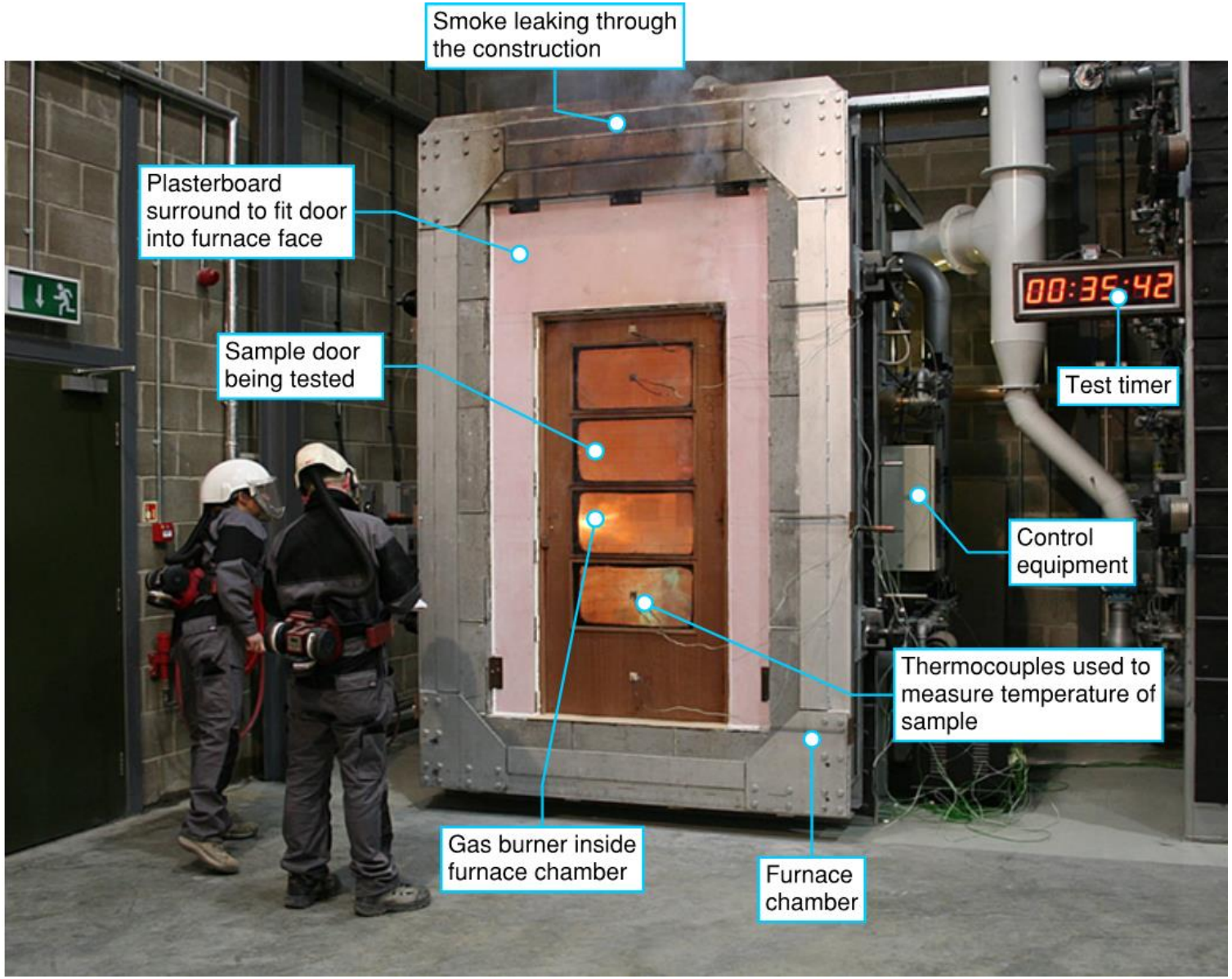
Image: Wilcox Fabrications

Fire performance of materials, products and structures

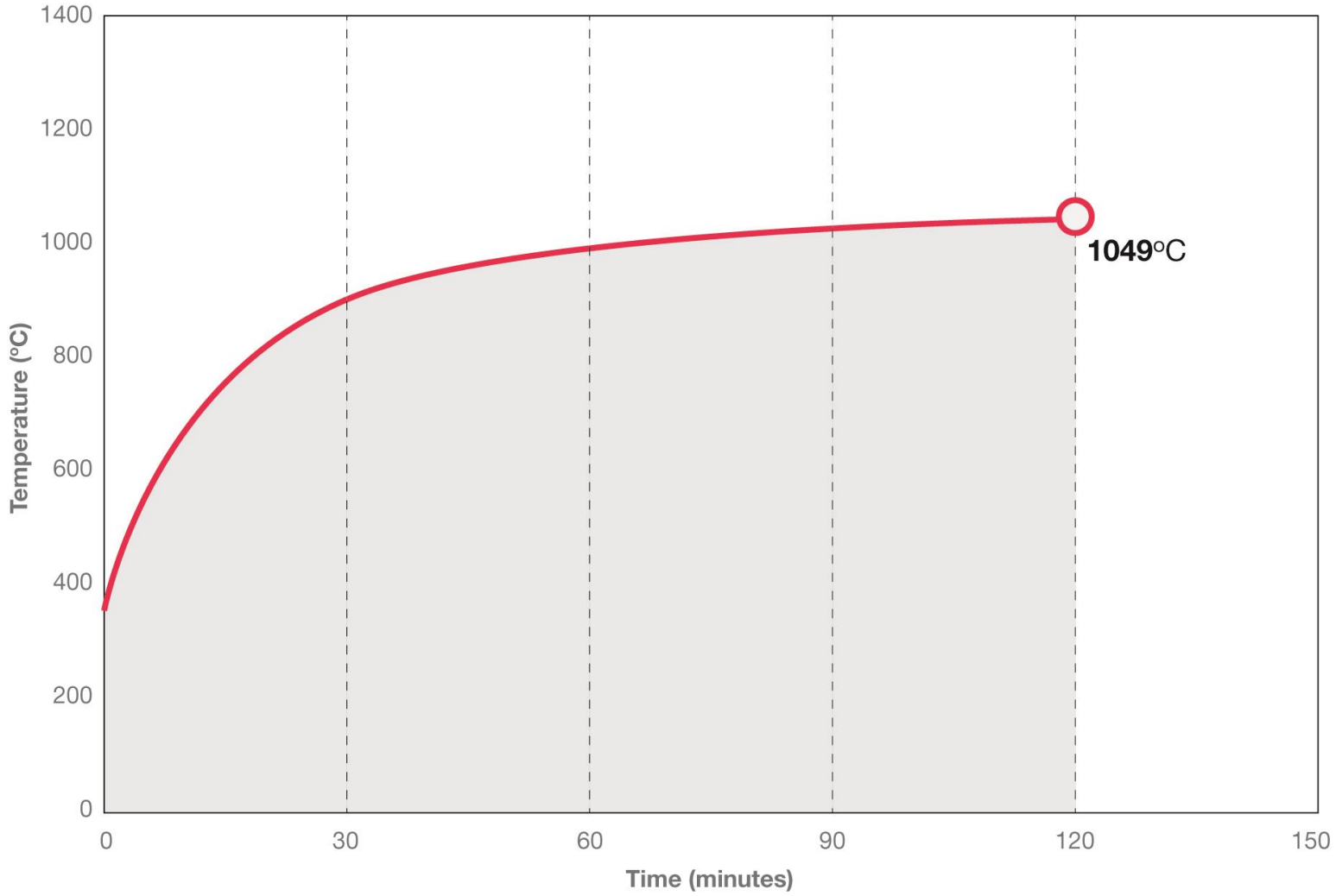
Appendix A: Performance of materials, products and structures

Fire Protection Measure: Fire resisting walls and floors - Testing

Fire Protection Measure: Fire doors - Testing



Fire Protection Measure: Fire resisting walls, floors and doors



Reaction to fire tests and classifications

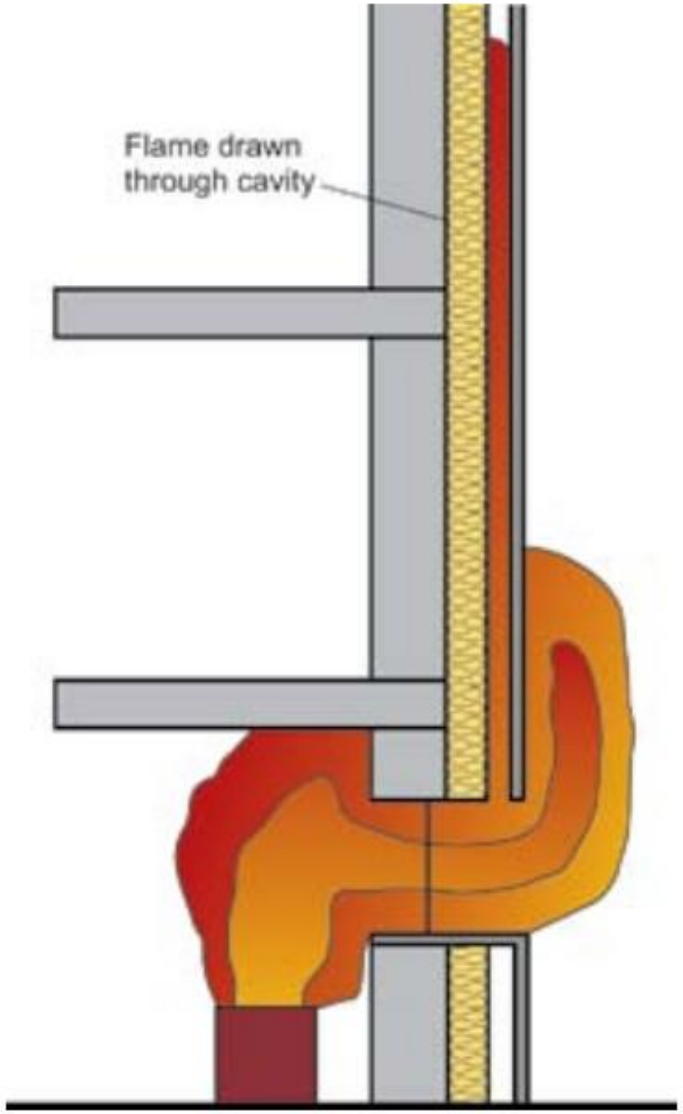
Fire classification of construction products and building elements

- **Part 1: Classification using data from reaction to fire tests**
- **BS EN 13501-1:2007**

List of British Standards from ADB relating to material or assembly testing for external walls and roofs:

- BS 476-4, BS 476-11, BS 476-6, BS 476-7, BS 476-3 BS EN ISO 1182, ENV 1187, BS EN 1364-1, BS EN 1366-3, BS EN 1366-4, BS EN ISO 1716, BS 8414-1, BS 8414-2, BS EN ISO 11925-2, BS EN 13501-1, BS EN 13823

BR 135 and BS 8414



Fire spread through cavities

Example of typical test facility

After the test

Variations in test evidence

The classification applies only to the system as tested and detailed in the classification report. The classification report can only cover the details of the system as tested. It cannot state what is not covered. When specifying or checking a system it is important to check that the classification documents cover the end-use application.

BR 135 Section A2

Note 2: Any test evidence used to substantiate the fire resistance rating of a construction should be carefully checked to ensure that it demonstrates compliance that is adequate and applicable to the intended use. Small differences in detail (such as fixing method, joints, dimensions and the introduction of insulation materials etc.) may significantly affect the rating.

ADB Appendix A1

BS 8414-1 2015

10 Test report

The test report shall include the following information:

d) a full description of the test specimen, together with details of materials and components used and fixing details;

e) details of the apparatus used, including full details of the test frame with a complete description of the installation and fixing methods used to install the system;

Active fire protection measures

Fire Protection Measure:
Residential fire detection system

Fire Protection Measure: Residential fire and detection system

Fire Protection Measure: Emergency lighting

Fire Protection Measure: Emergency lighting

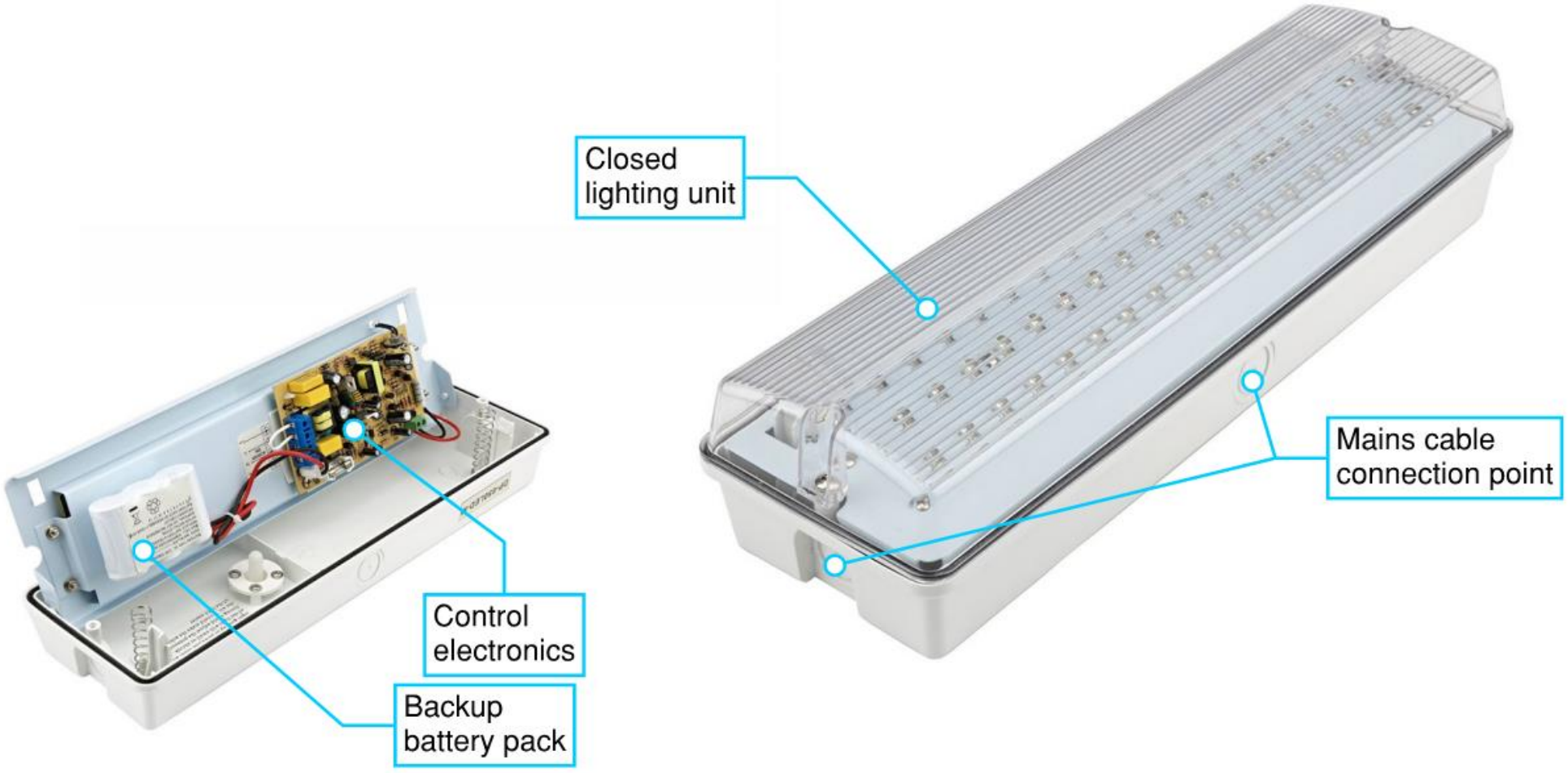
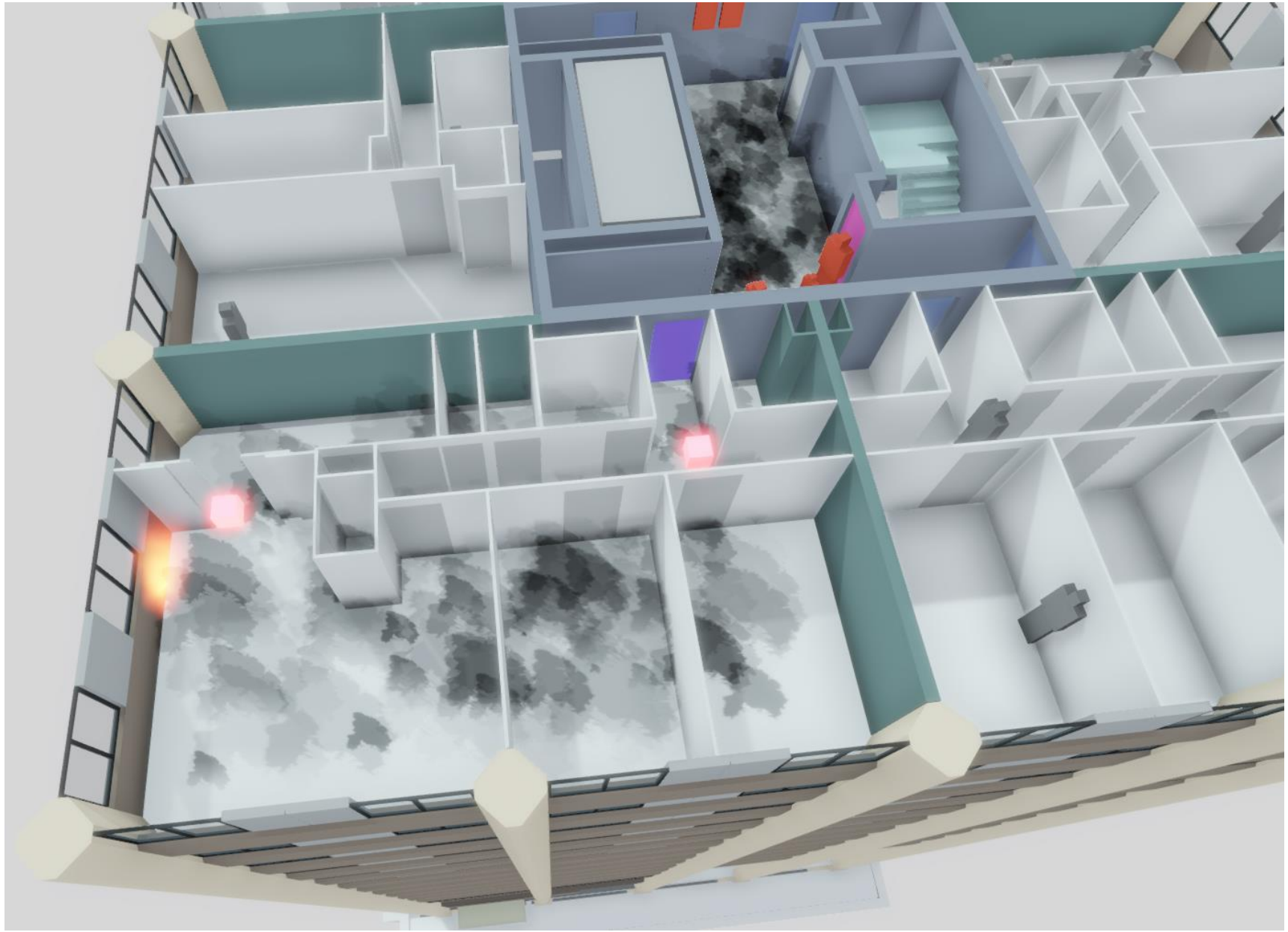


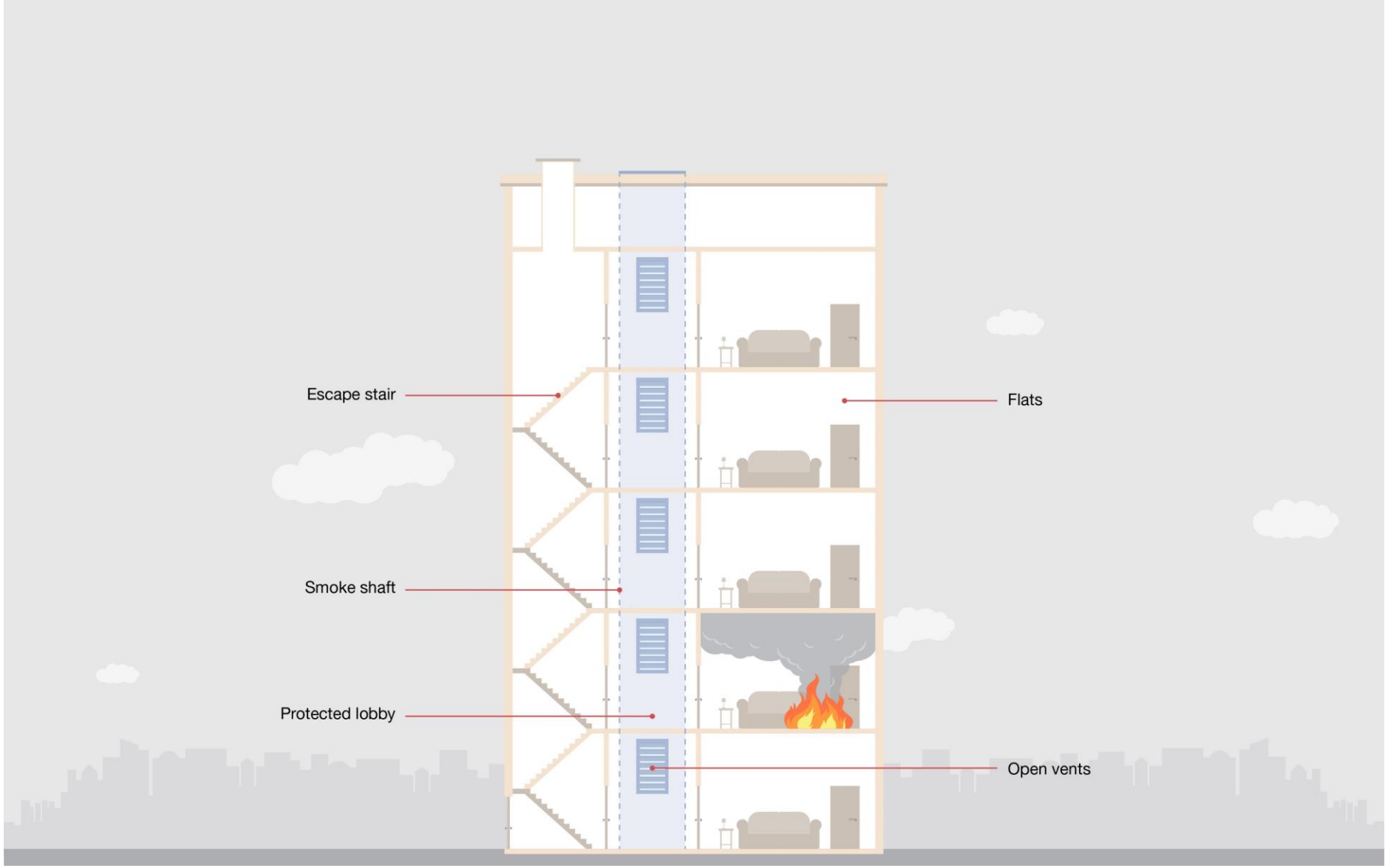
Image: Biard

Fire Protection Measure:
Smoke control of escape routes

Fire Protection Measure: Smoke control in common lobby



Fire Protection Measure: Smoke control in common lobby



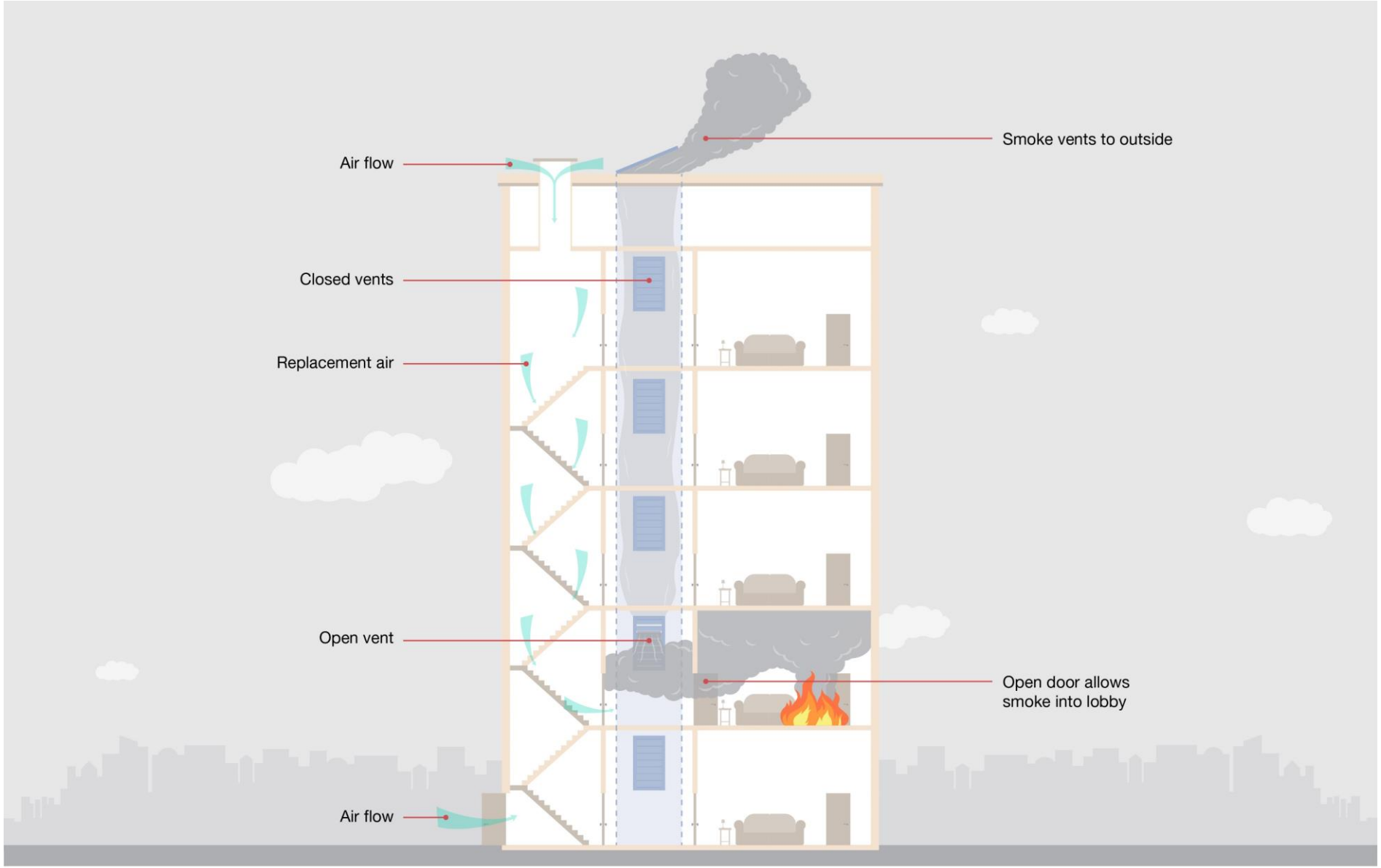
Fire Protection Measure: Smoke control in common lobby

Smoke detector

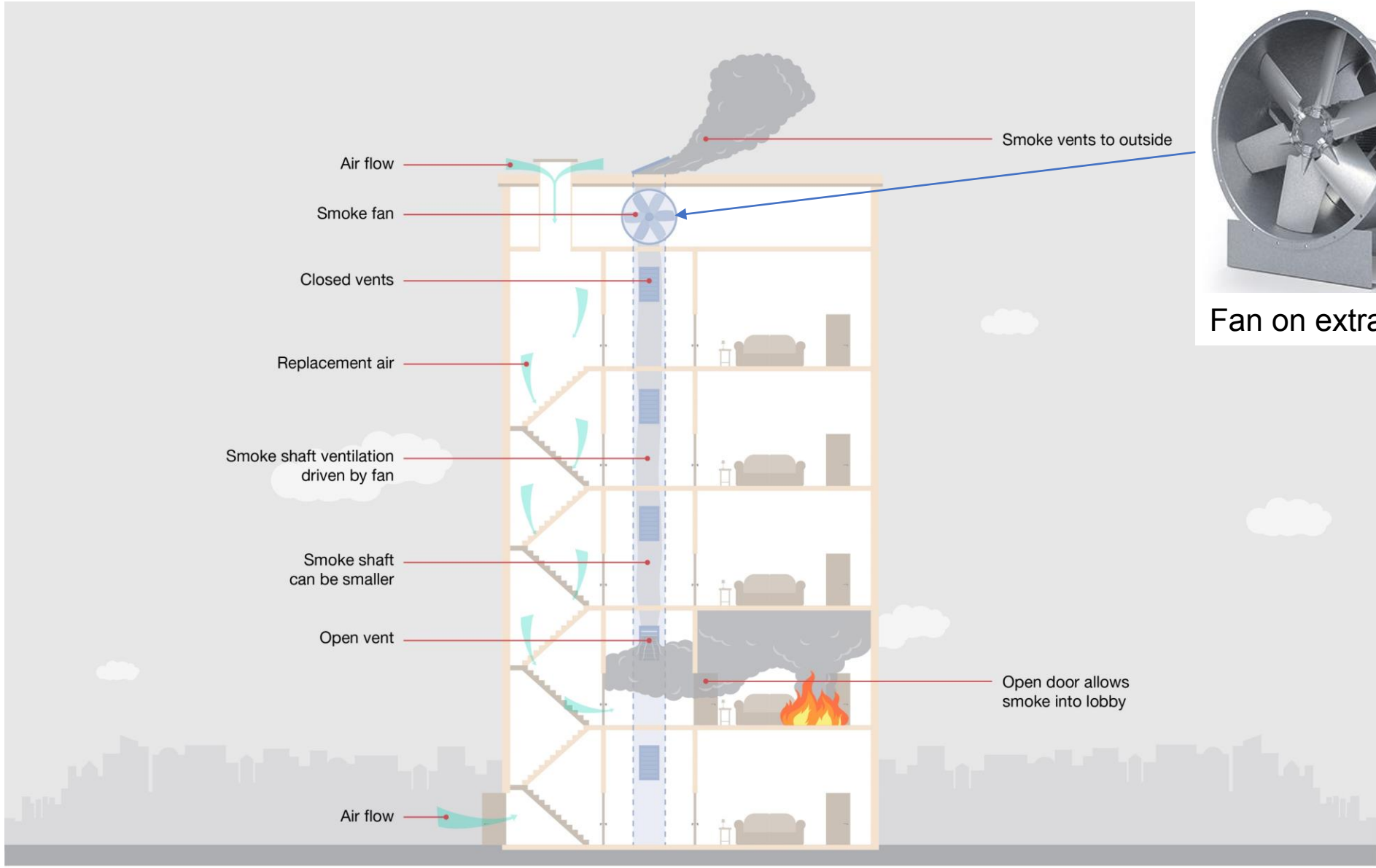
Automatic opening vent

Fan

Fire Protection Measure: Smoke control – Natural Ventilation



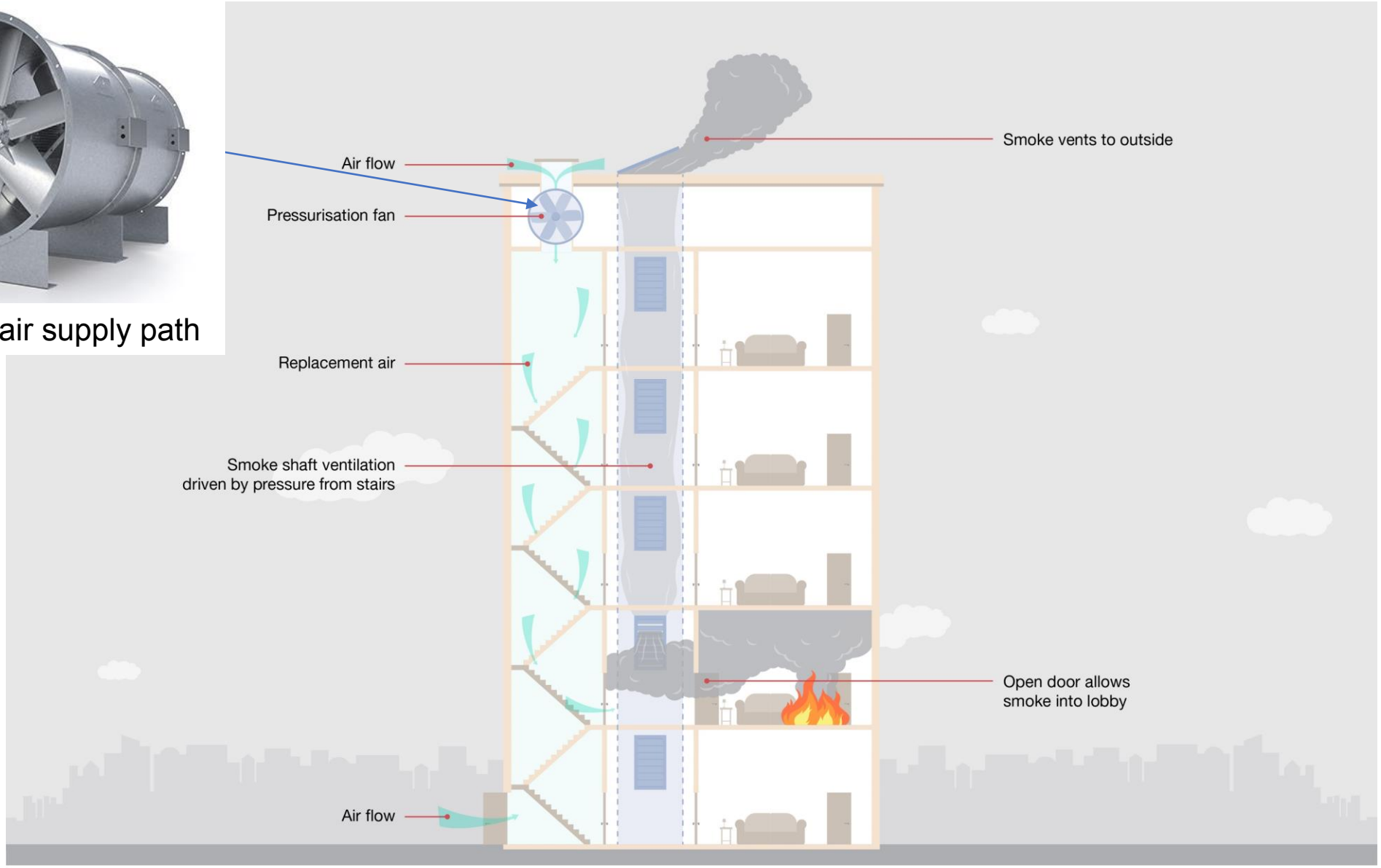
Fire Protection Measure: Smoke control – Mechanical ventilation



Fan on extract path

Fire Protection Measure: Smoke control – Pressurisation

Fan on air supply path



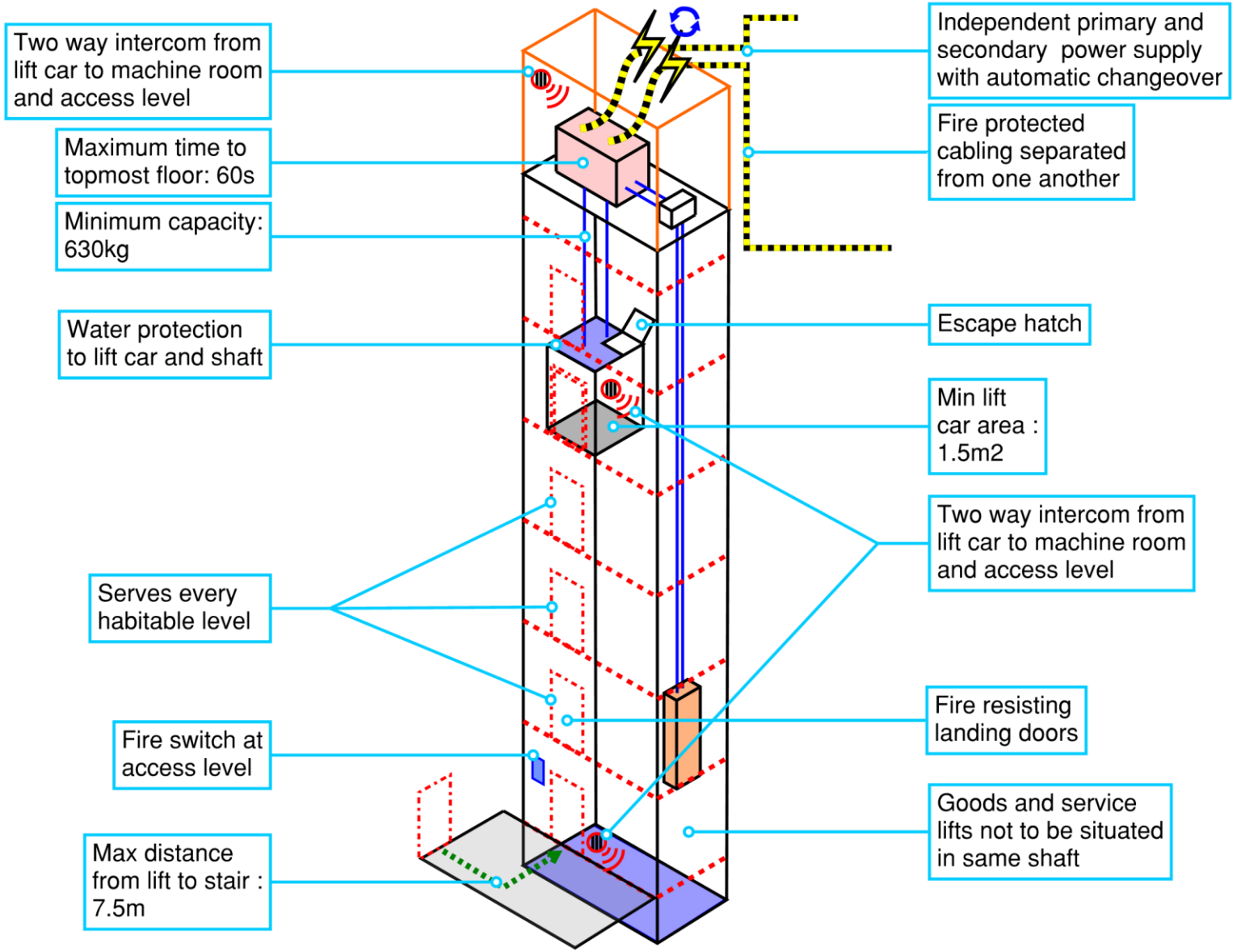
Fire Protection Measure: Smoke ventilation - Components

Smoke Control and the interaction with breathing apparatus

Image: cheshirefire.gov.uk

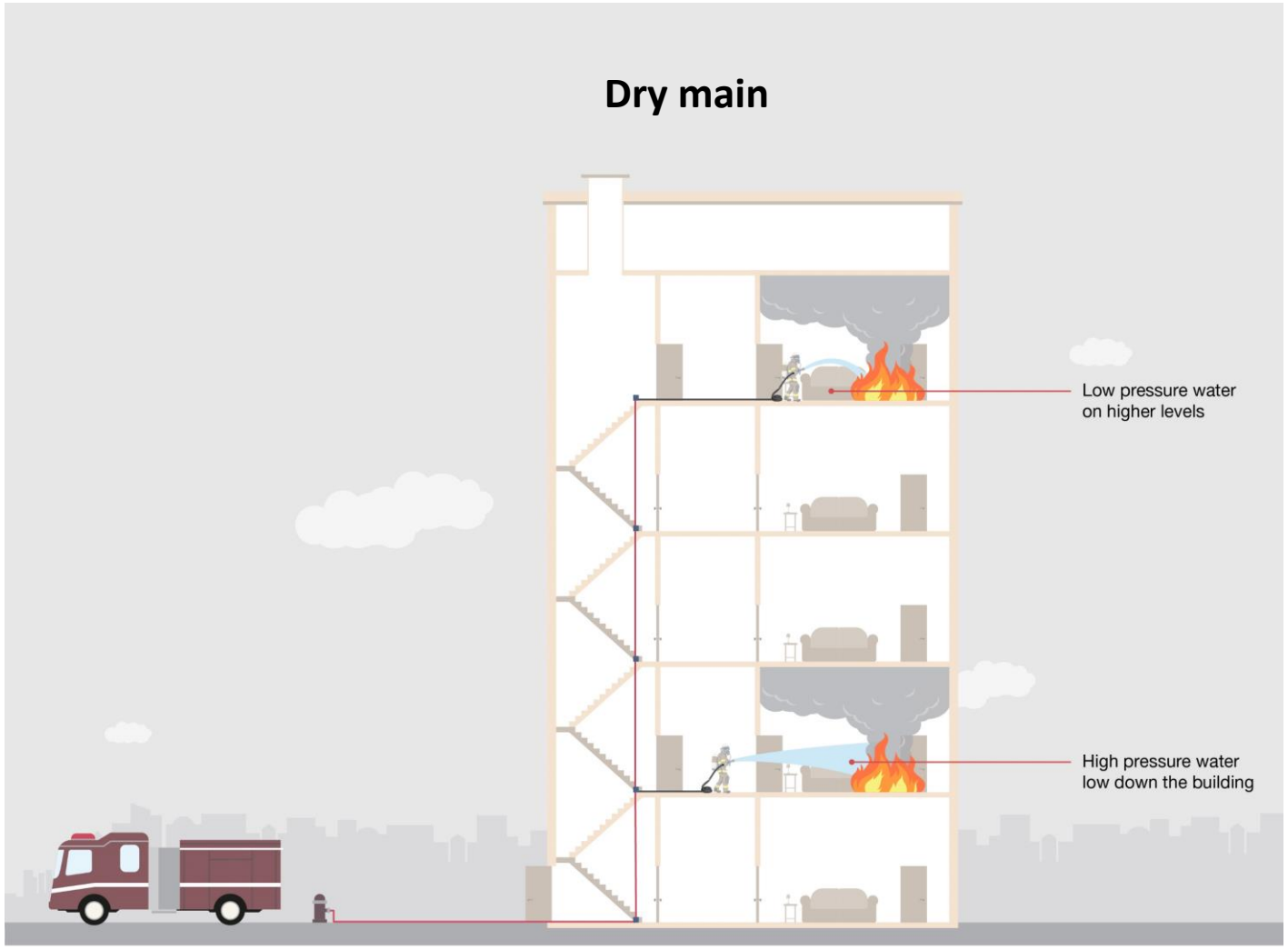
Fire Protection Measure:
Fire fighting lift

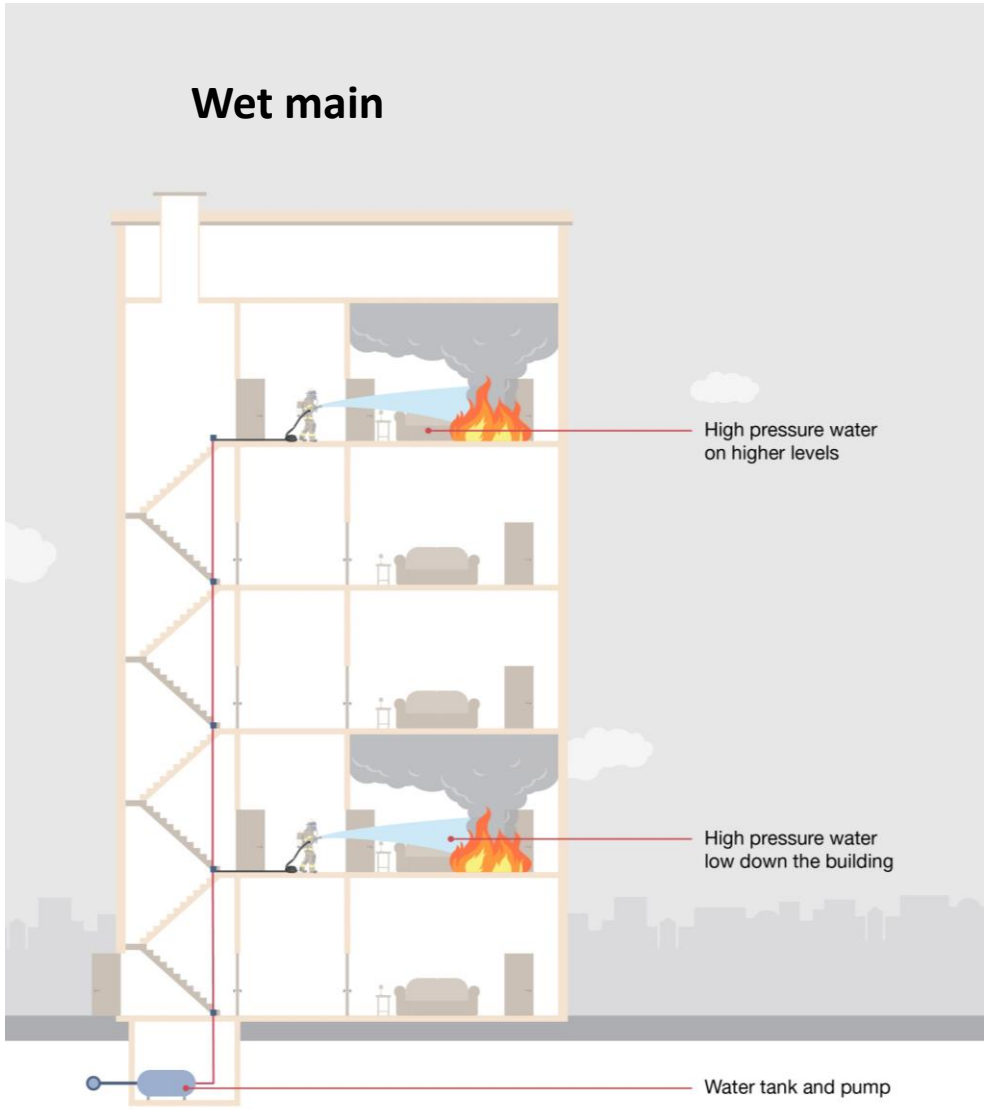
Fire Protection Measure: a firefighting lift – Statutory Guidance



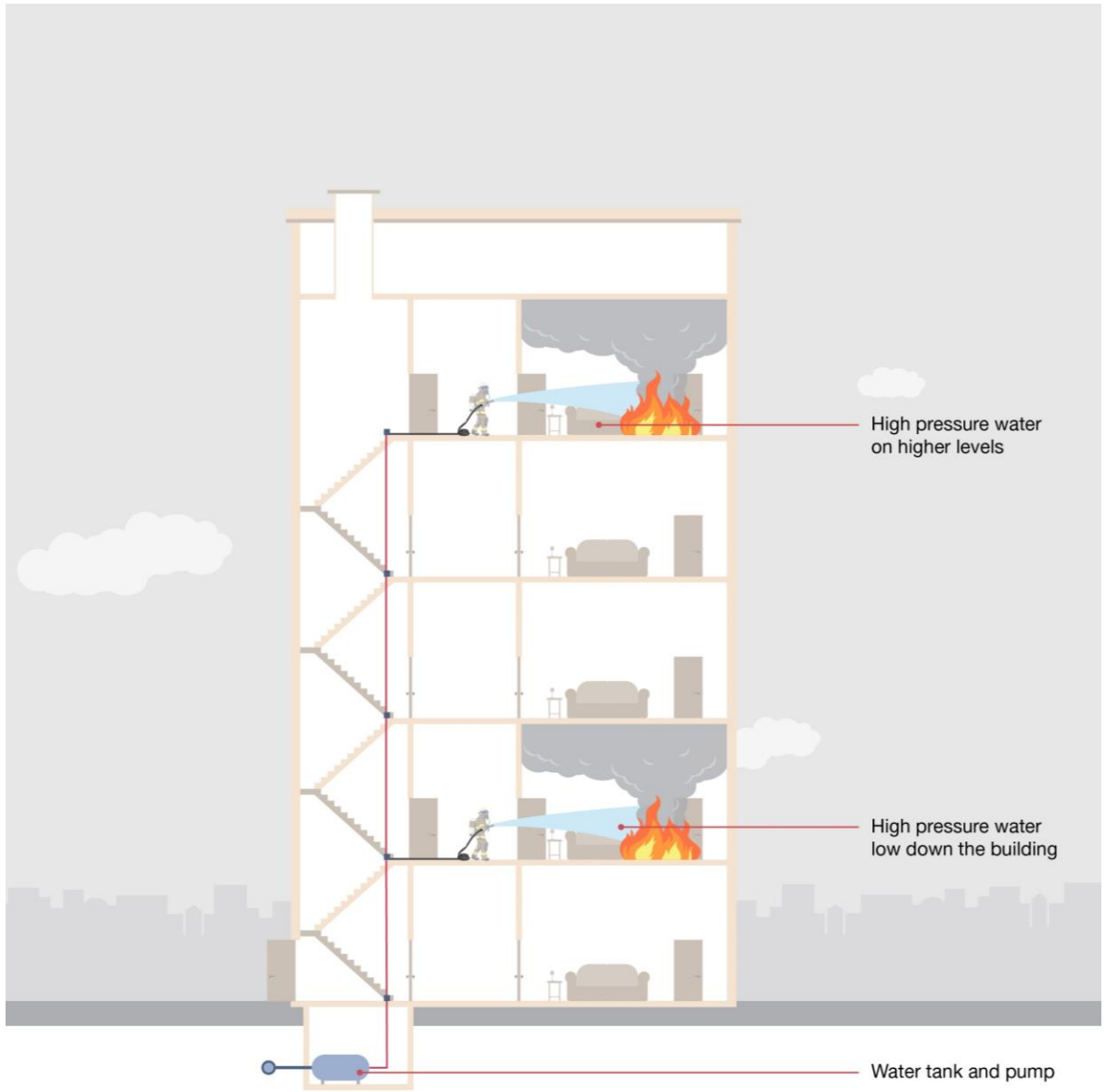
Fire Protection Measure:
Fire main

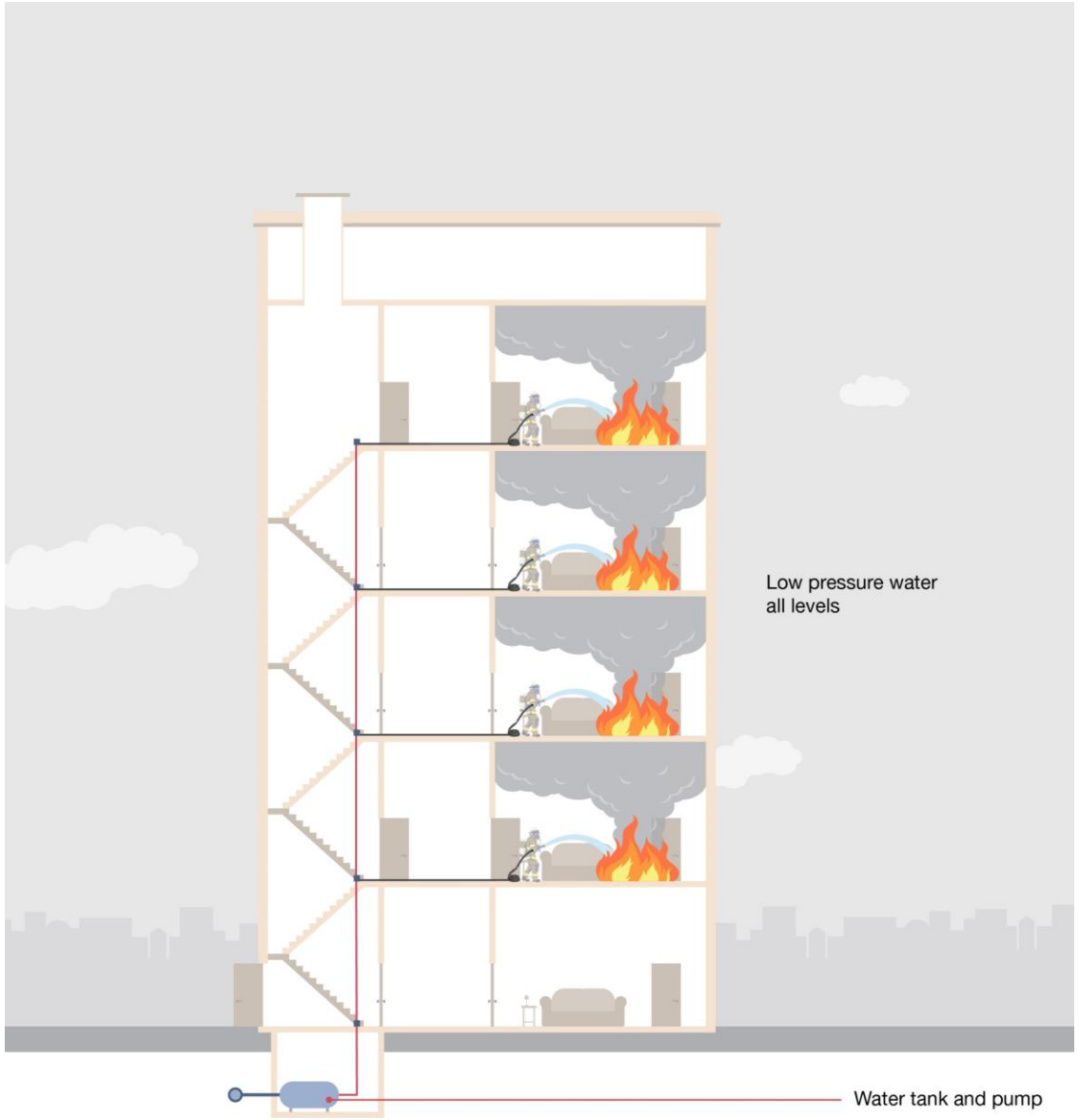
Fire Protection Measure: Fire mains





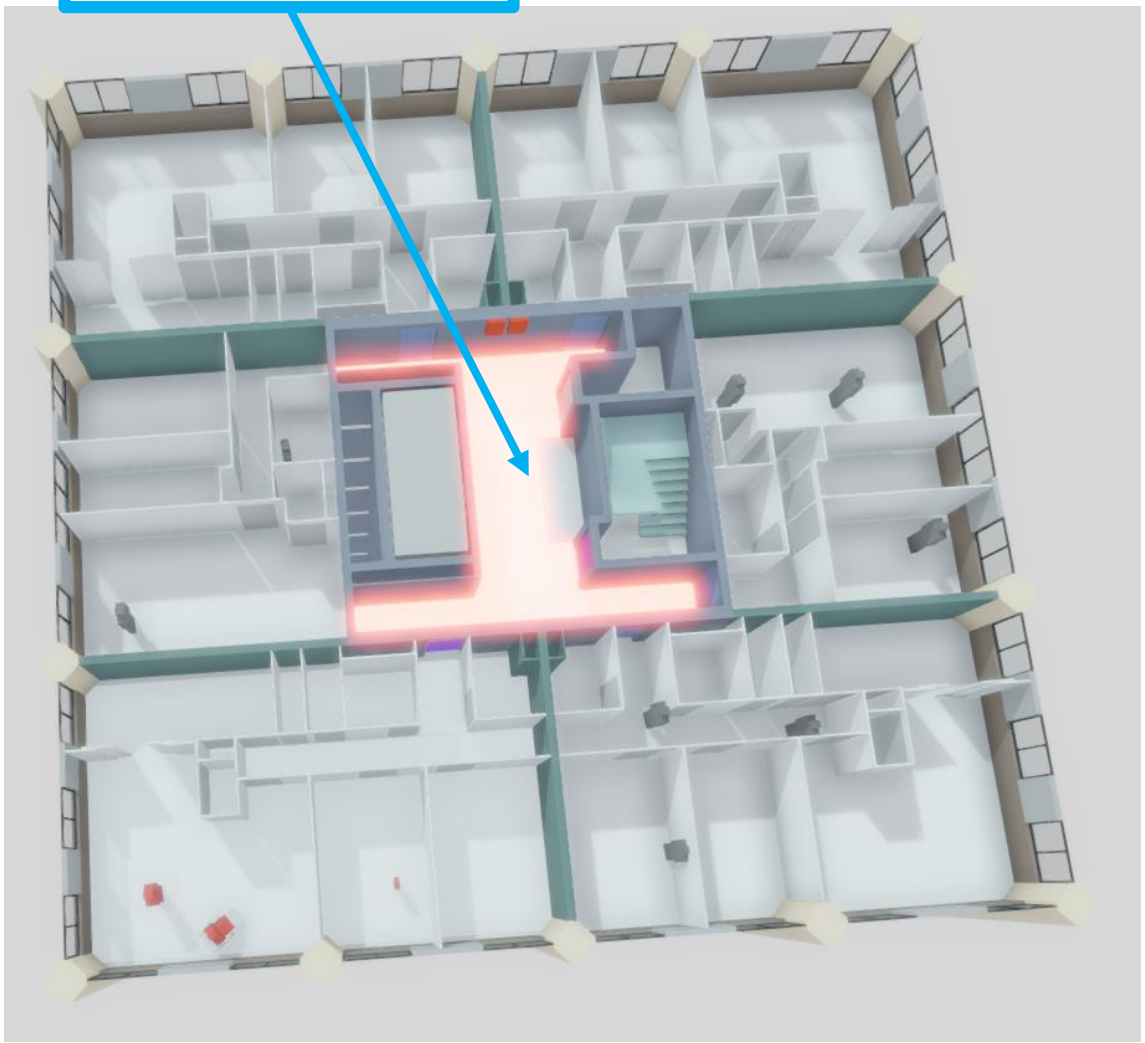
Fire Protection Measure: Capacity of an internal fire fighting main



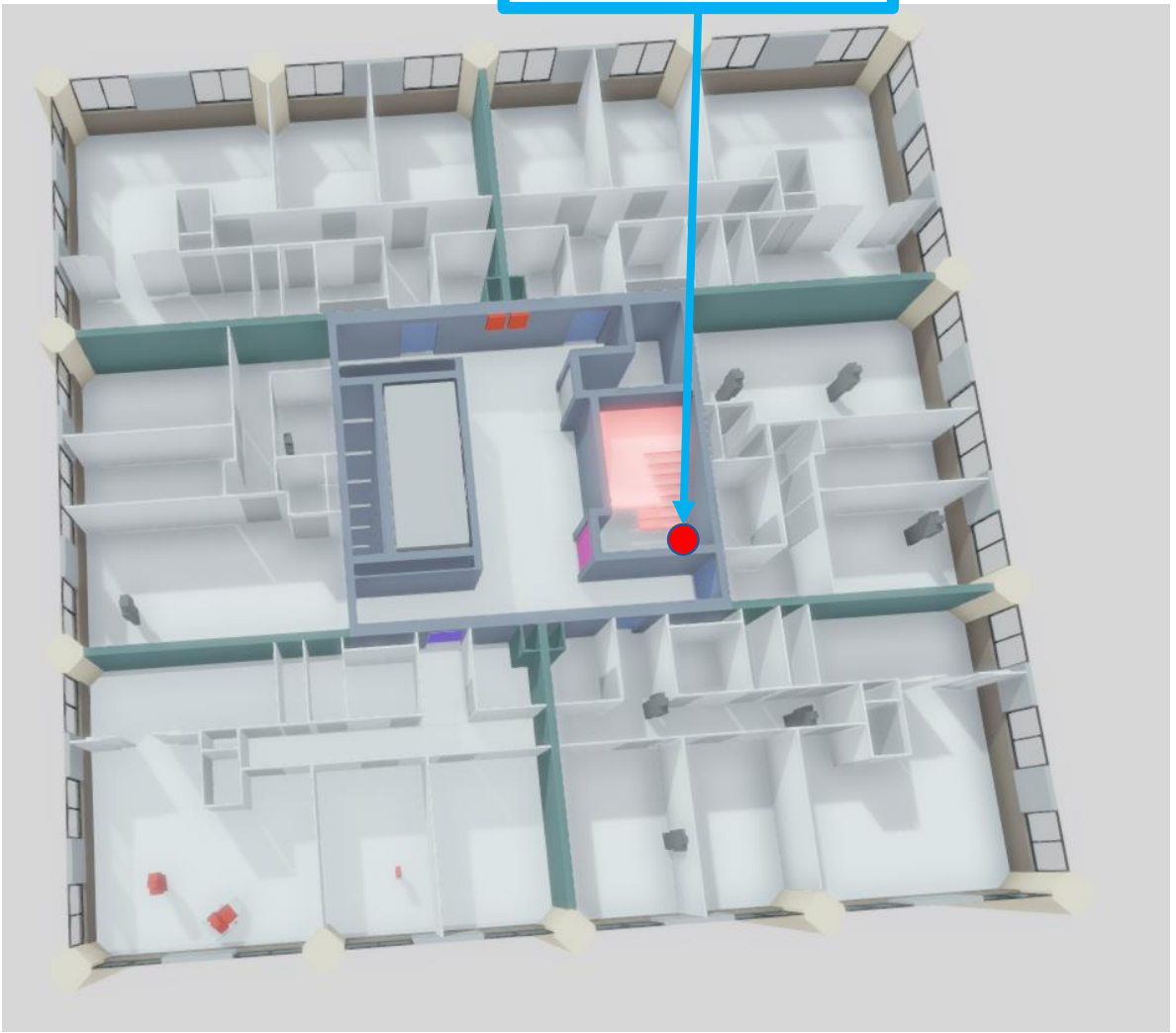


Fire Protection Measure: Location of an internal fire fighting main

Original guidance for location - lobby



Current guidance for location - Stair



Fire Fighting Hose

Image: deltafire.co.uk

'Branch'

Image: laoisfiresupplies.com

Fire hose

Image: emergencytimes.com

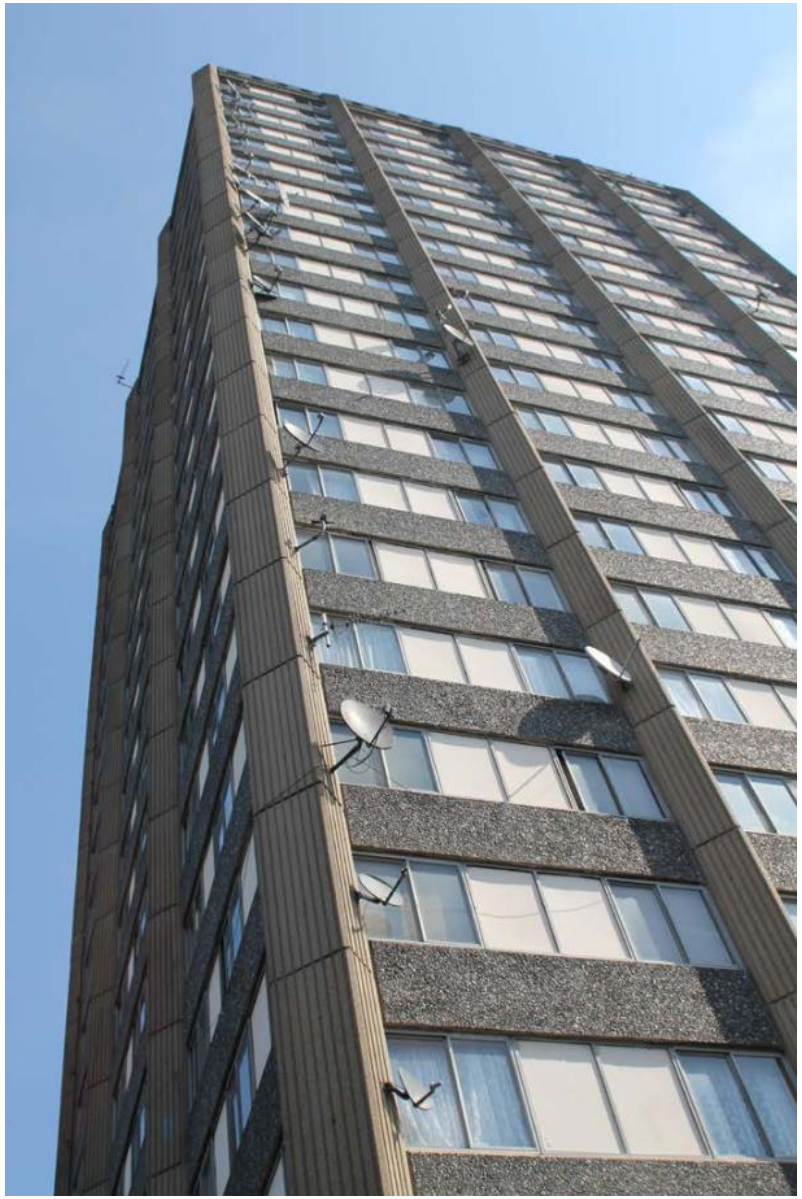
Layers of protection

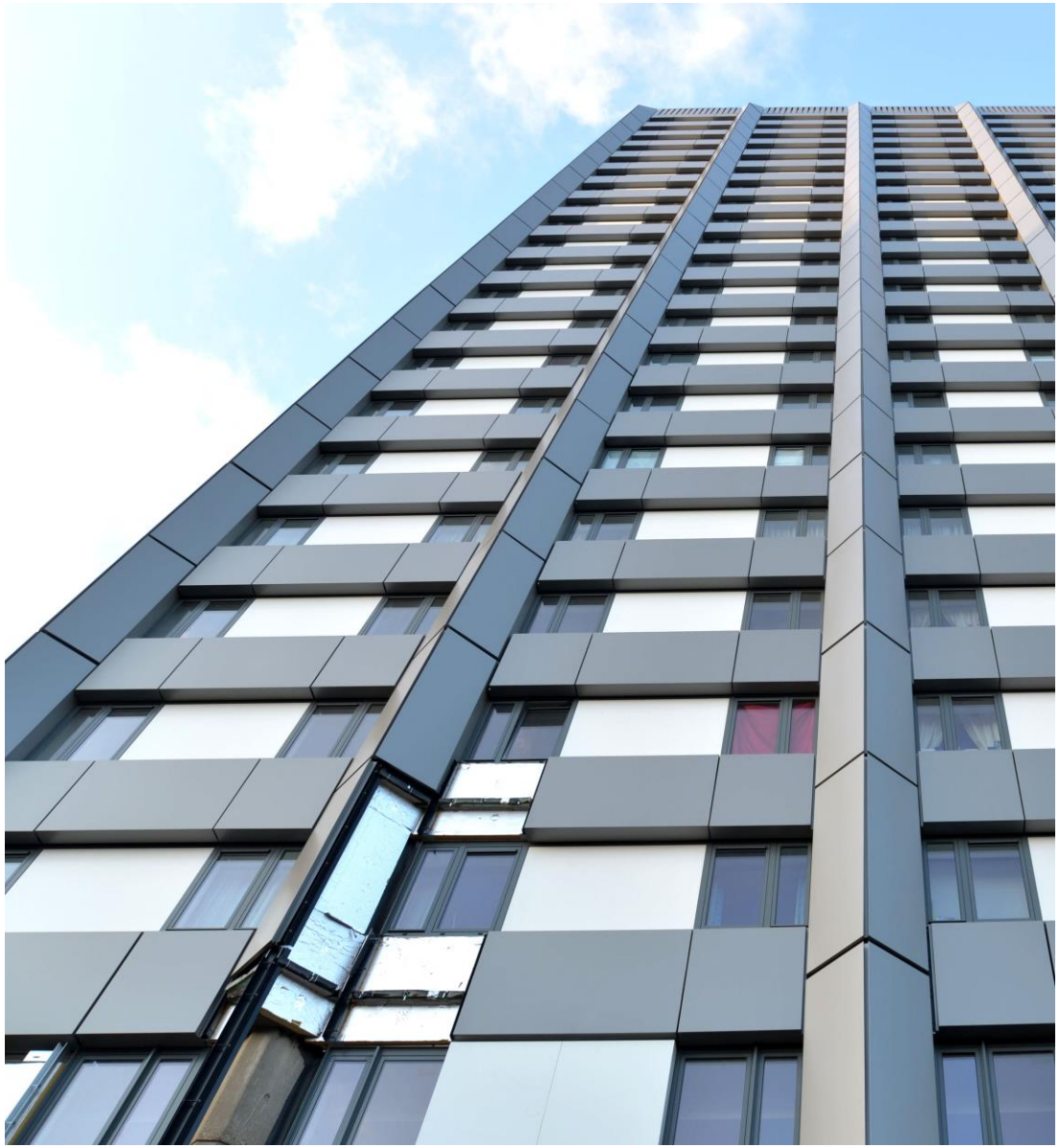
Summary timeline of key refurbishment works at Grenfell Tower

ARUP

Evidence to support the dates of the refurbishment works

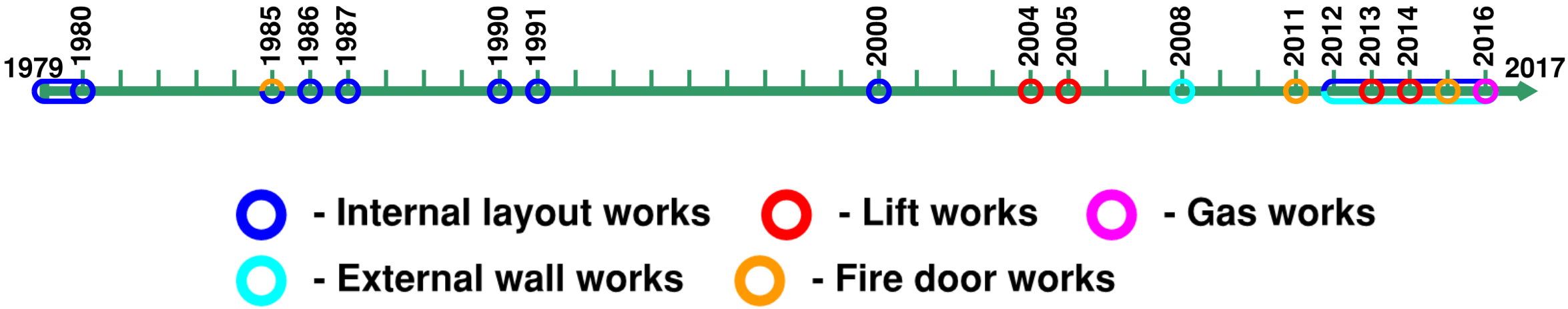
The relevance of the timing and form of any refurbishment works





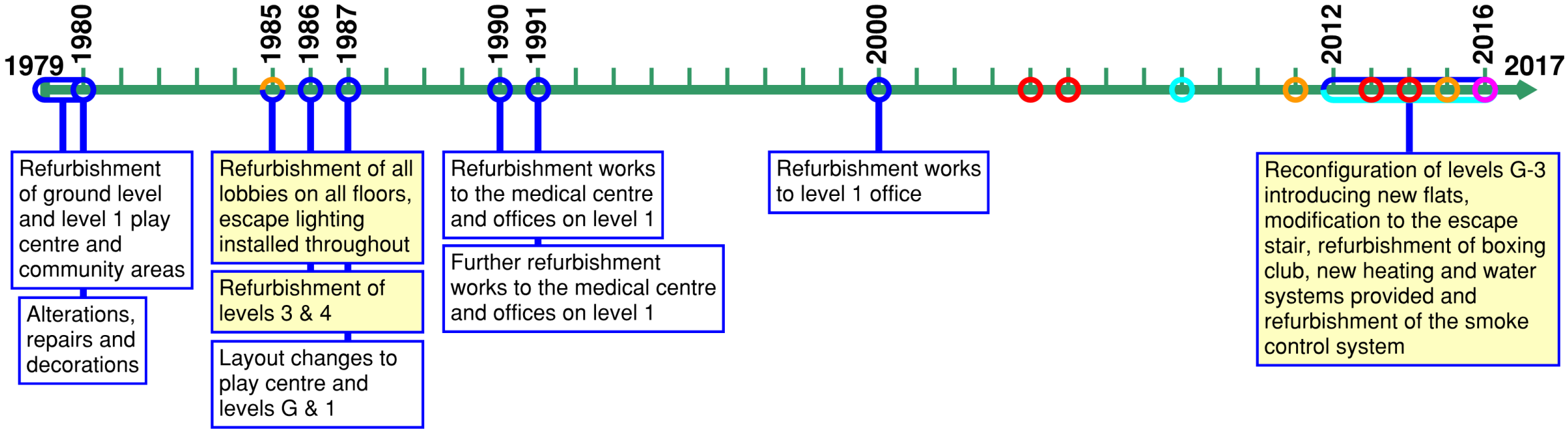
Timeline of recorded refurbishment works

- From 1979 to 2017 there is evidence of 19 different sets of work to the various parts of the building:



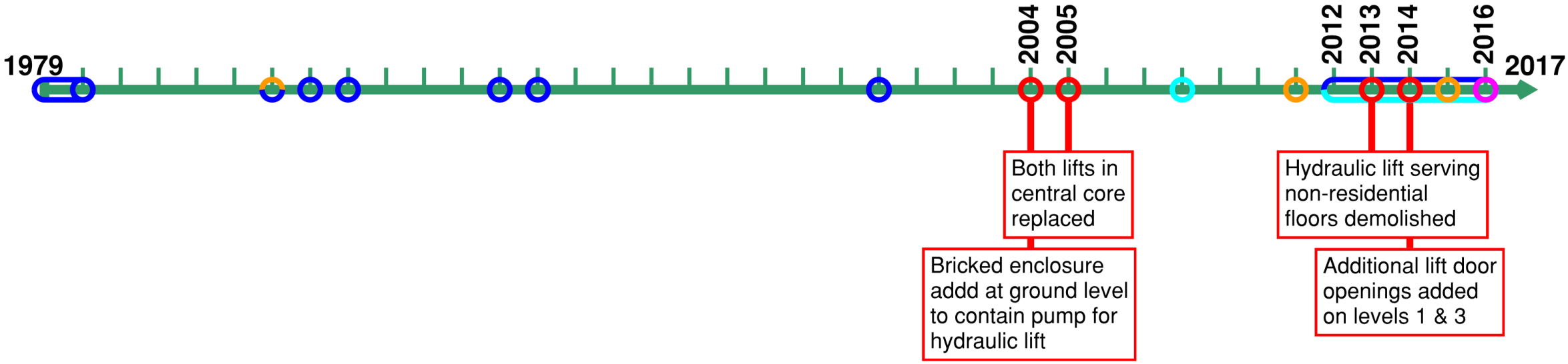
Refurbishment timeline – Works to the internal layout of Grenfell Tower

- There were 9 instances of internal works
  - 3/9 involved the residential floors on L 4-23
  - 5/9 involved only non-residential areas on L G-3
  - 1 unknown location



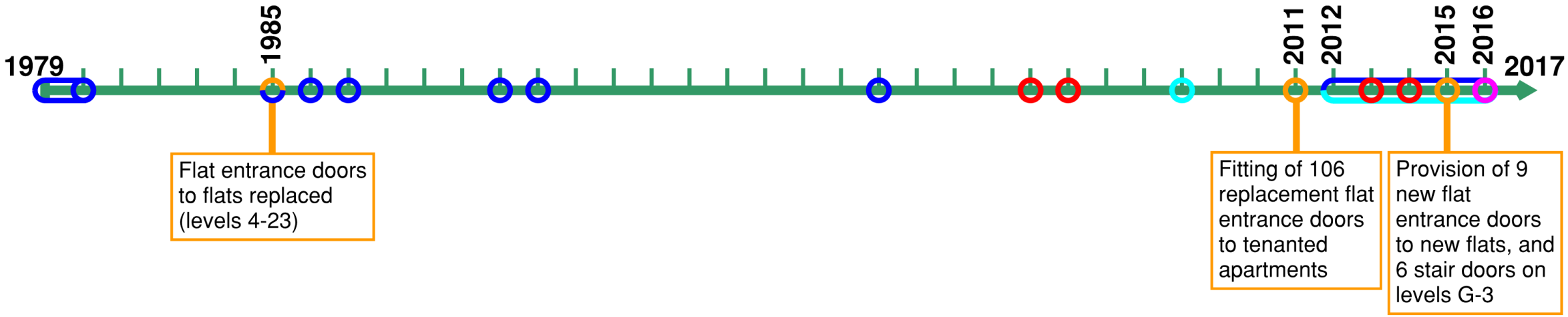
Refurbishment timeline – Lift works

- There were four instances of alterations to the lift installations.



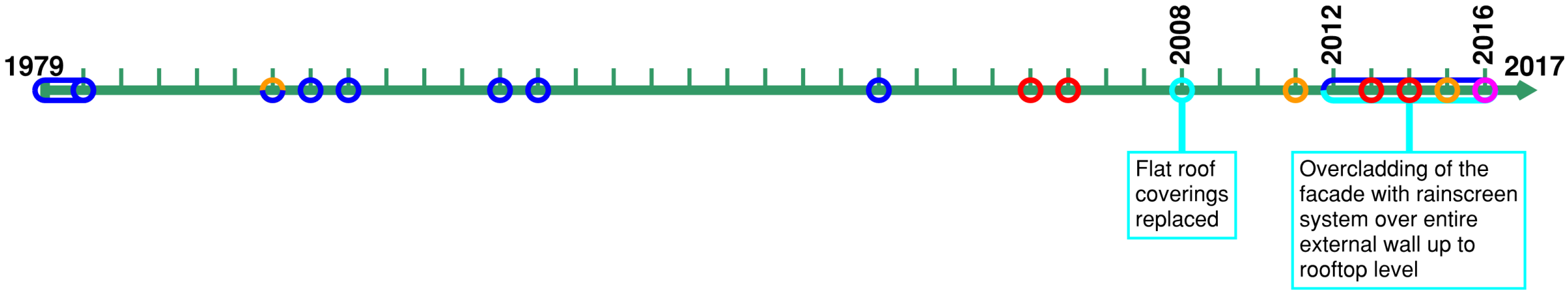
Refurbishment timeline – Fire door works

- There were three instances of alterations to the fire doors (including new flats introduced by 2012-2016 refurb).



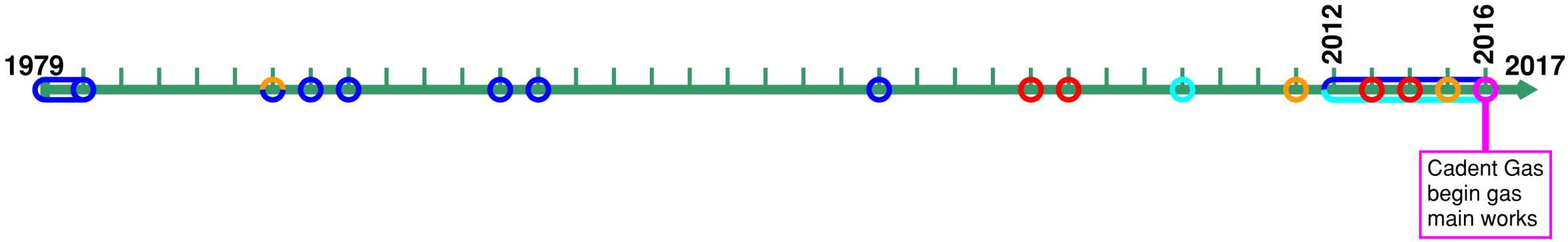
Refurbishment timeline – External wall construction works

- There were two instances of alterations to the external wall construction of the building:



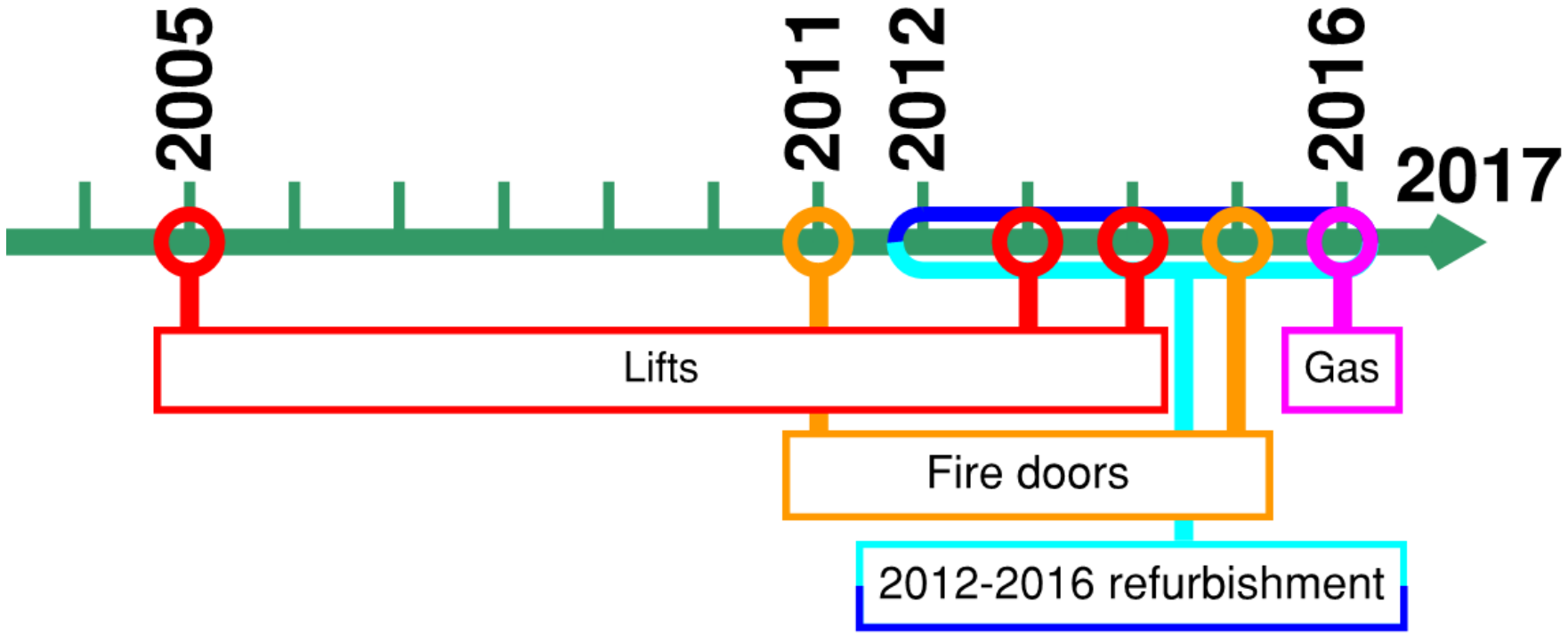
Refurbishment timeline – Gas works

- I will focus on the most recent gas works only, commenced in 2016.



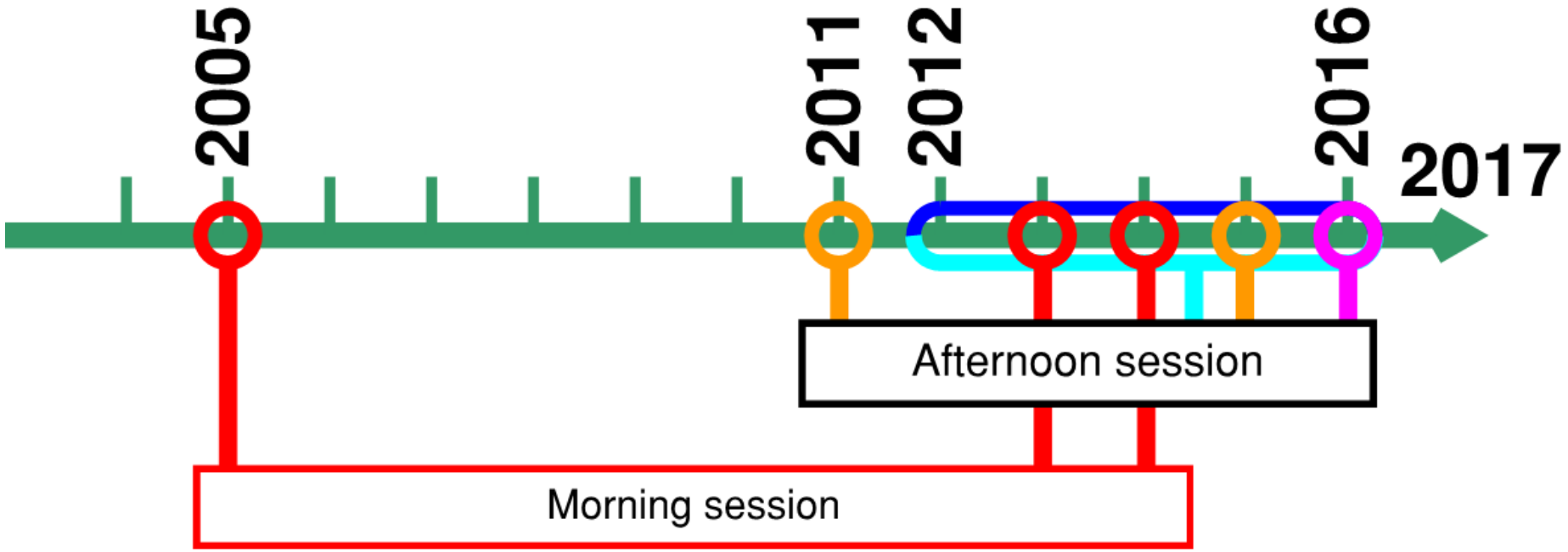
Timeline – works relevant to the fire safety provisions in place on 14th June 2017

- I will focus on the refurbishment works shown here for the remainder of my presentation



Timeline – agenda

- The morning session will present the lift works
- The afternoon session will present the works on the doors and gas as well as the 2012-2016 refurbishment



The Lift Replacement Works
2005 & 2012-2016

ARUP

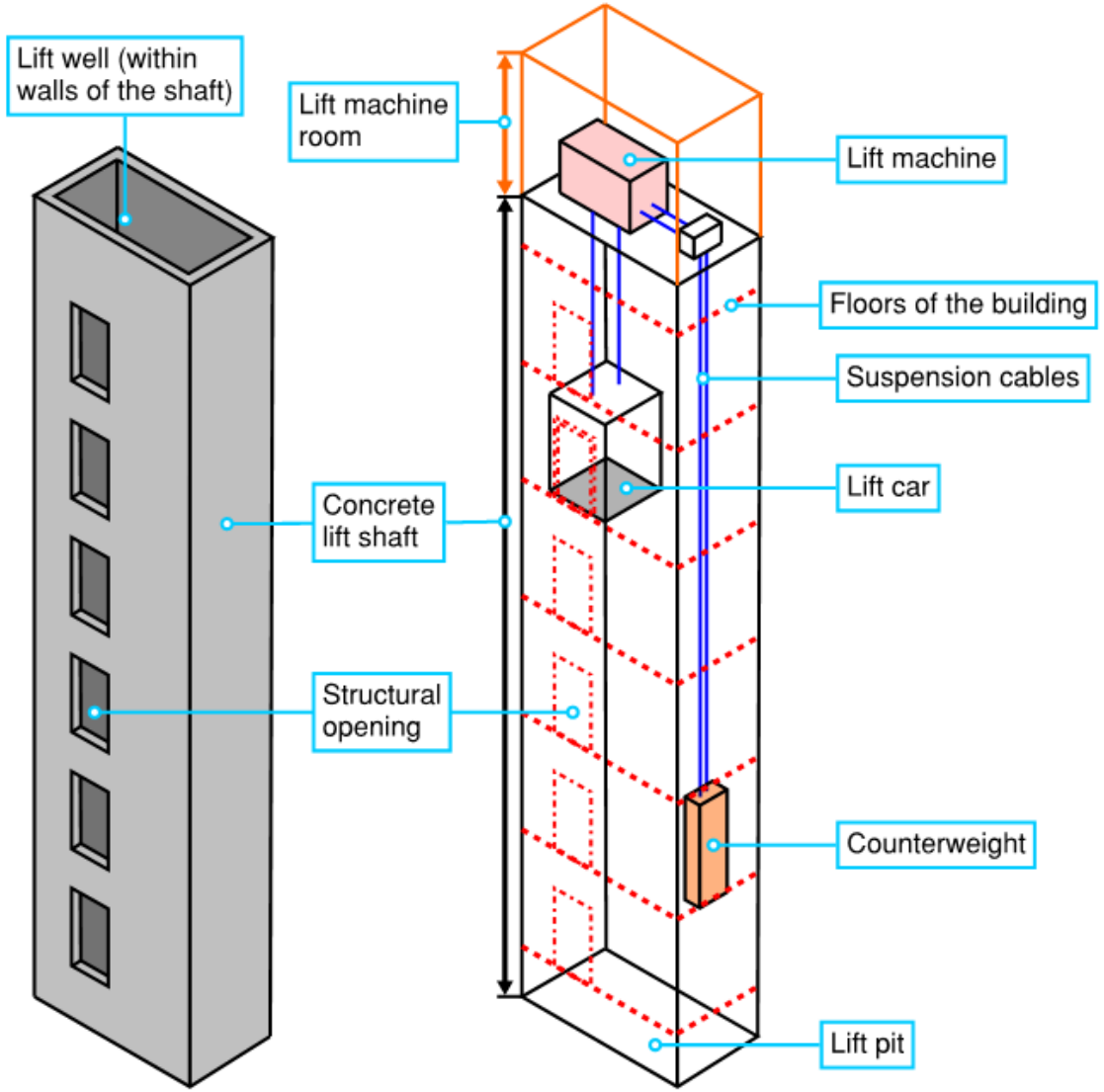
The original lifts installed in Grenfell Tower

The two types of lifts for fire fighting

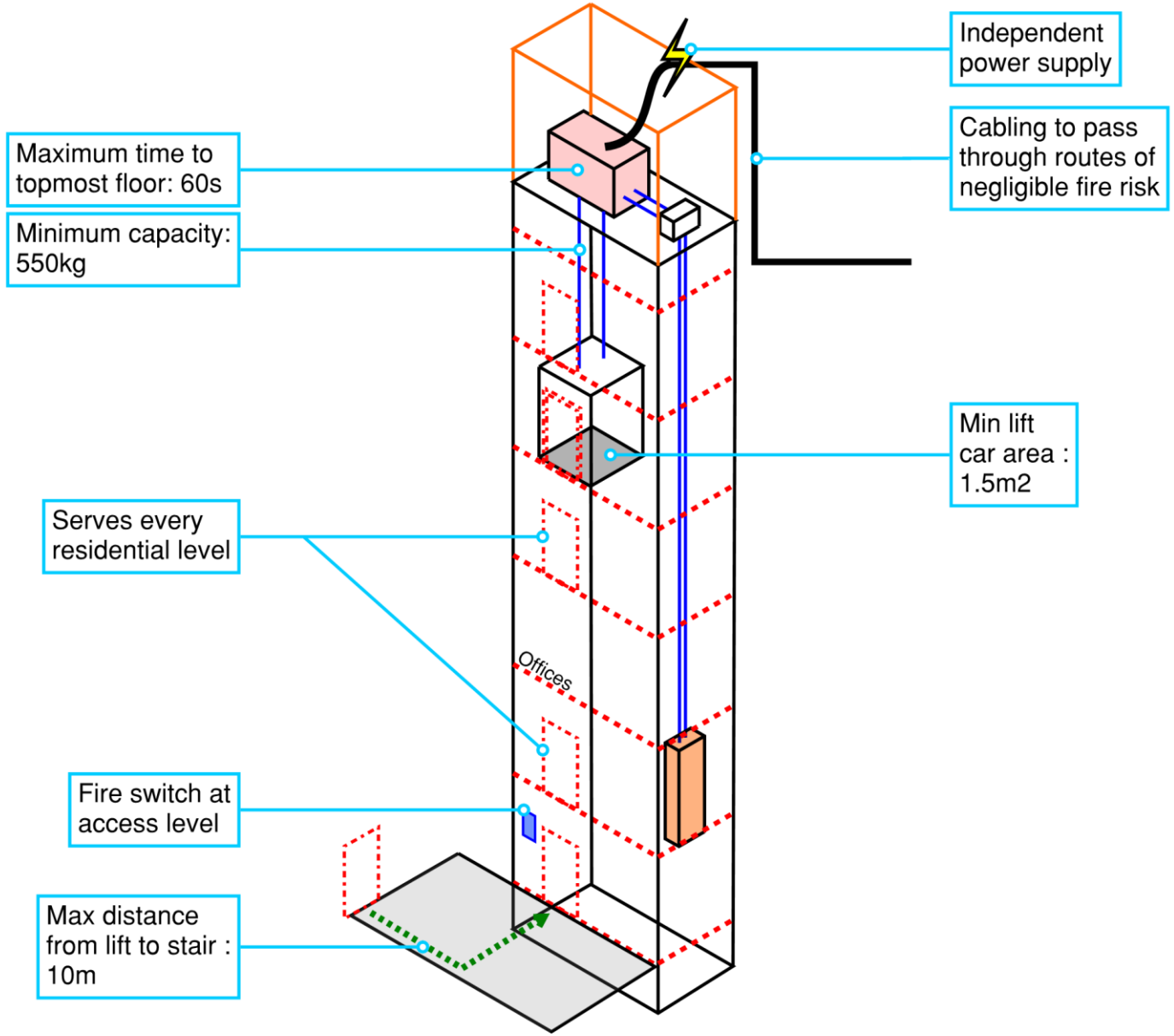
The two types of lifts for fire fighting

British Standard Code of Practice CP3	Approved Document B
1971	1992
“Fire lifts”	“Firefighting lifts”

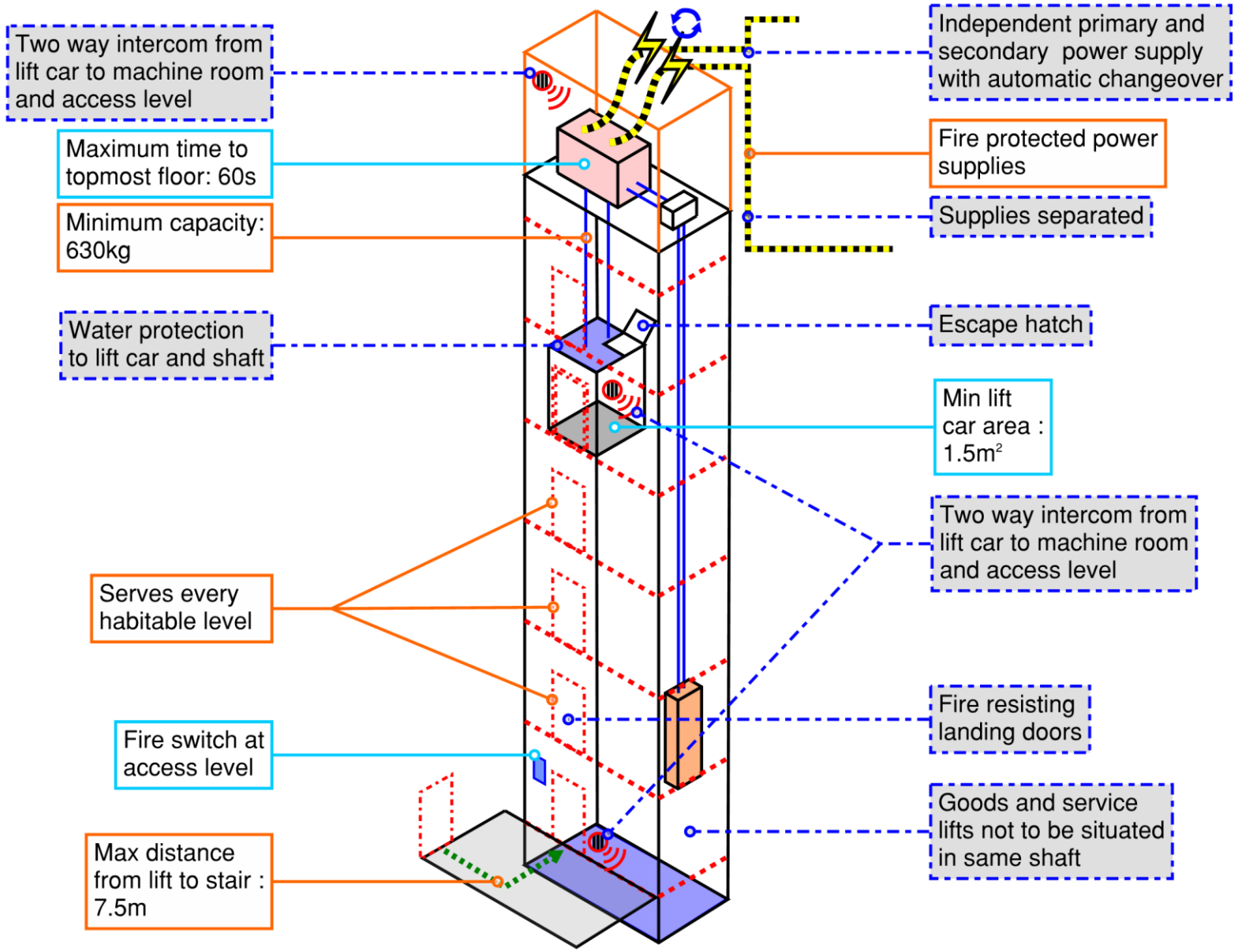
Components of a lift system



“Fire Lifts” – The Requirements



Summary – differences between a “fire lift” and “fire fighting lift”



Legend

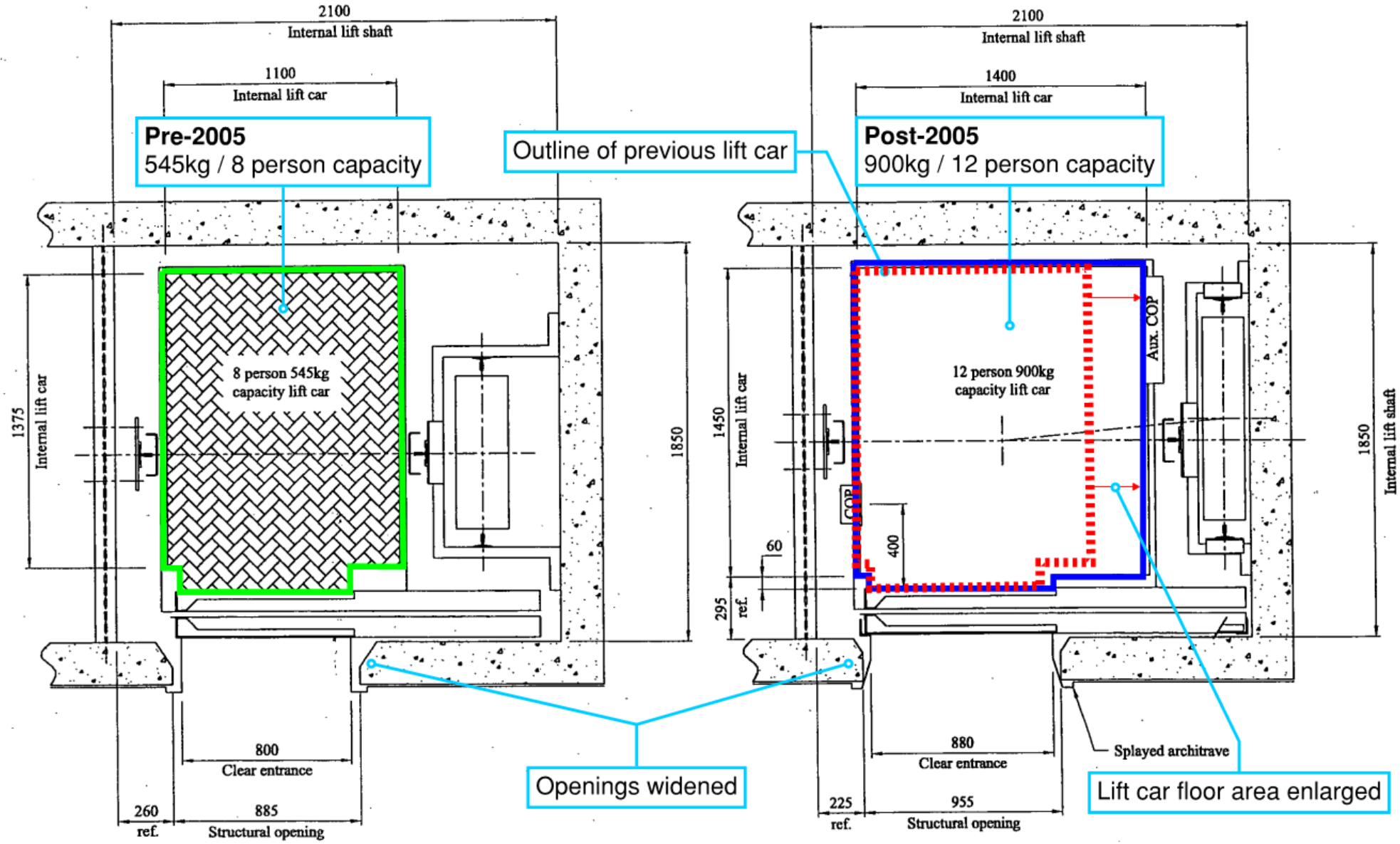
- Requirement identical
- Requirement improved
- New requirement

ADB 2013 Section 5.39 – Use of fire fighting lifts for evacuation

“in some circumstances a lift may be provided as part of a management plan for evacuating people… Where a firefighting lift has been provided to satisfy requirement B5, this can be utilised”

The replacement of the lifts in 2005 & modification in 2012-2016

Lift works 2005 – Changes to the lift car

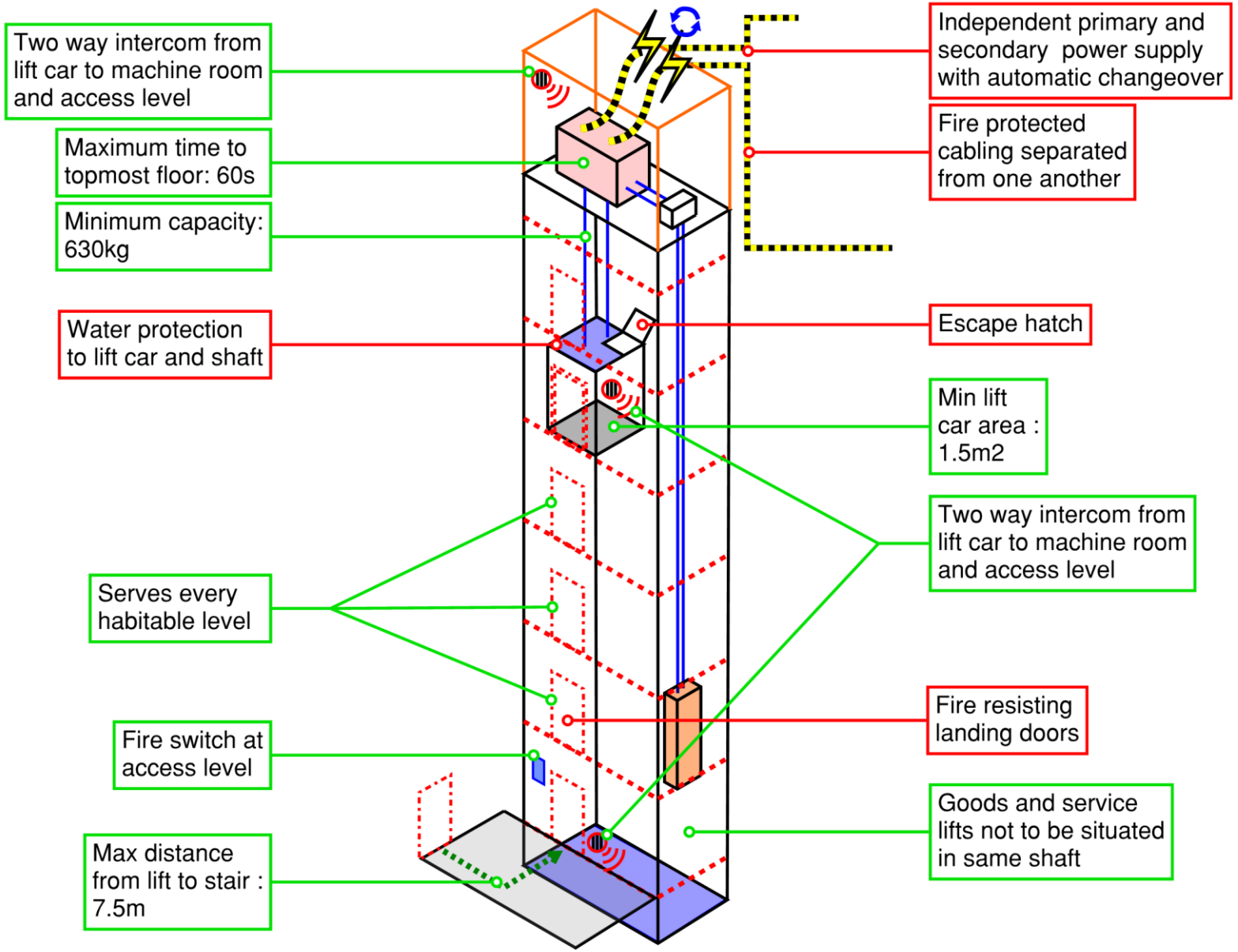


Lift works 2005 – Fire Switch & Emergency intercom

Ground Level Lift Lobby

Level 2 Lift Lobby

Lifts at Grenfell tower – comparison with ‘Firefighting Lifts’



Legend

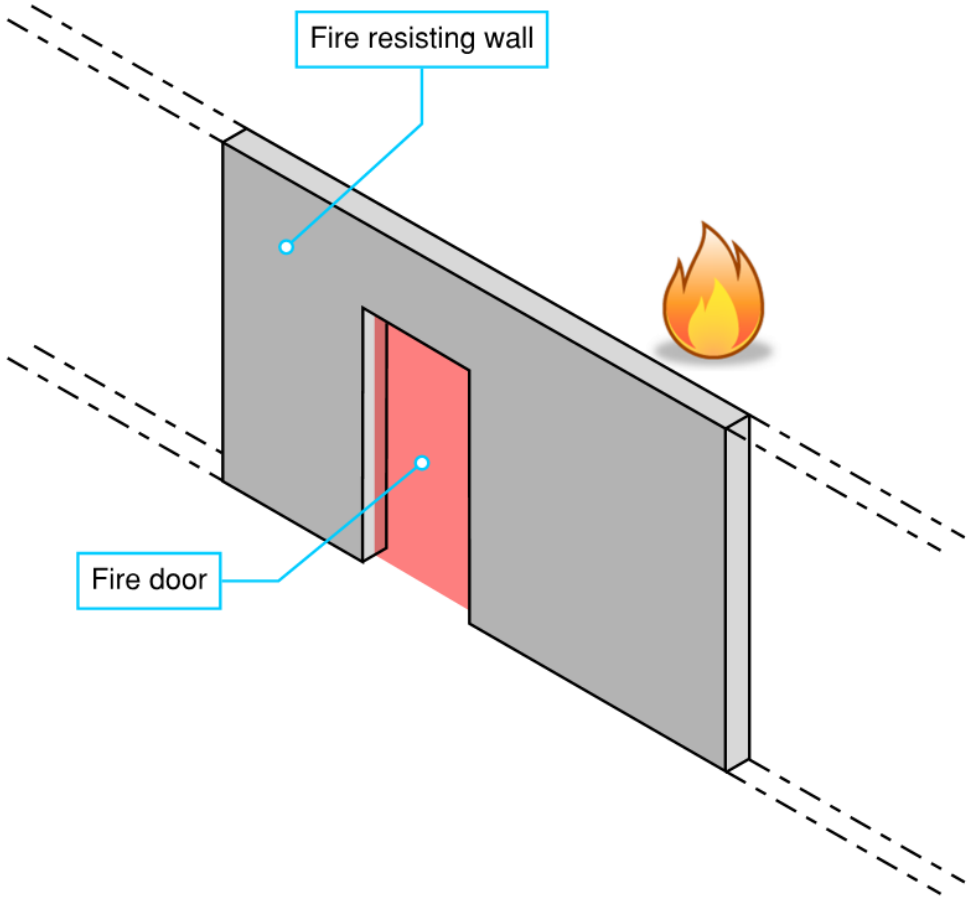
Appears to have been provided

Does not appear to have been provided

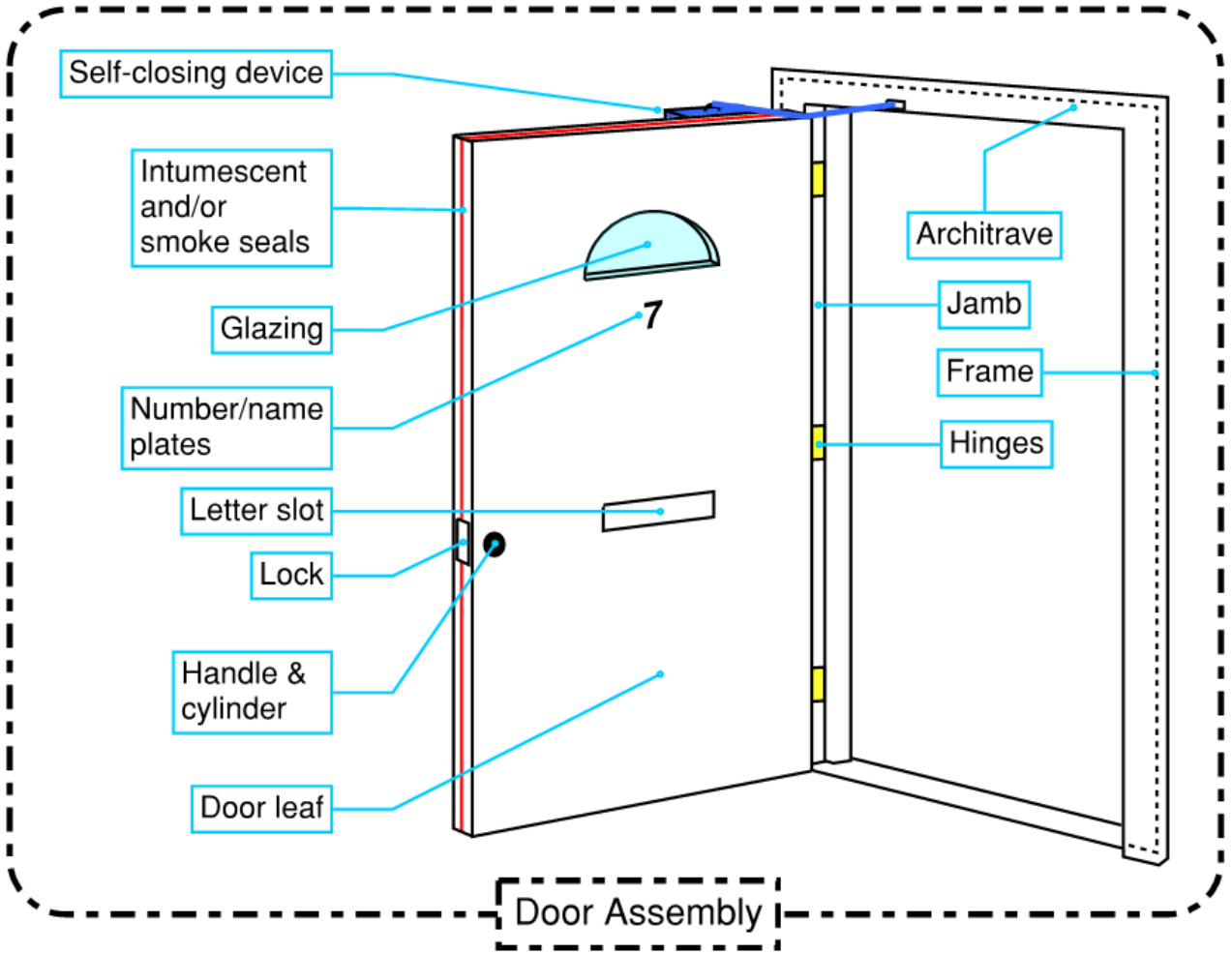
The Fire Door Replacement Works 2011

ARUP

Recap of the role of the fire door in fire safety



The multiple components of a fire door

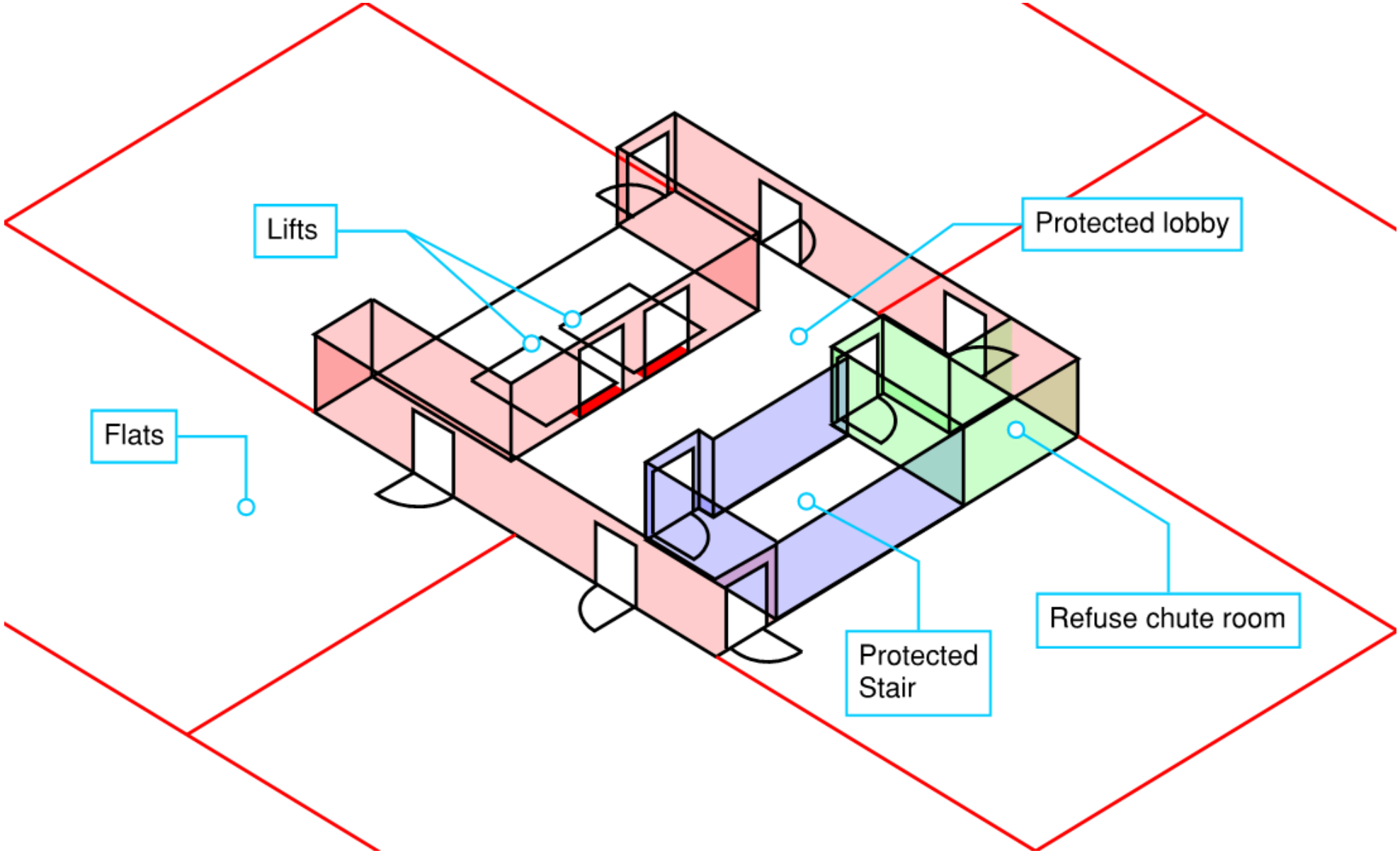


ADB 2013 Appendix B:

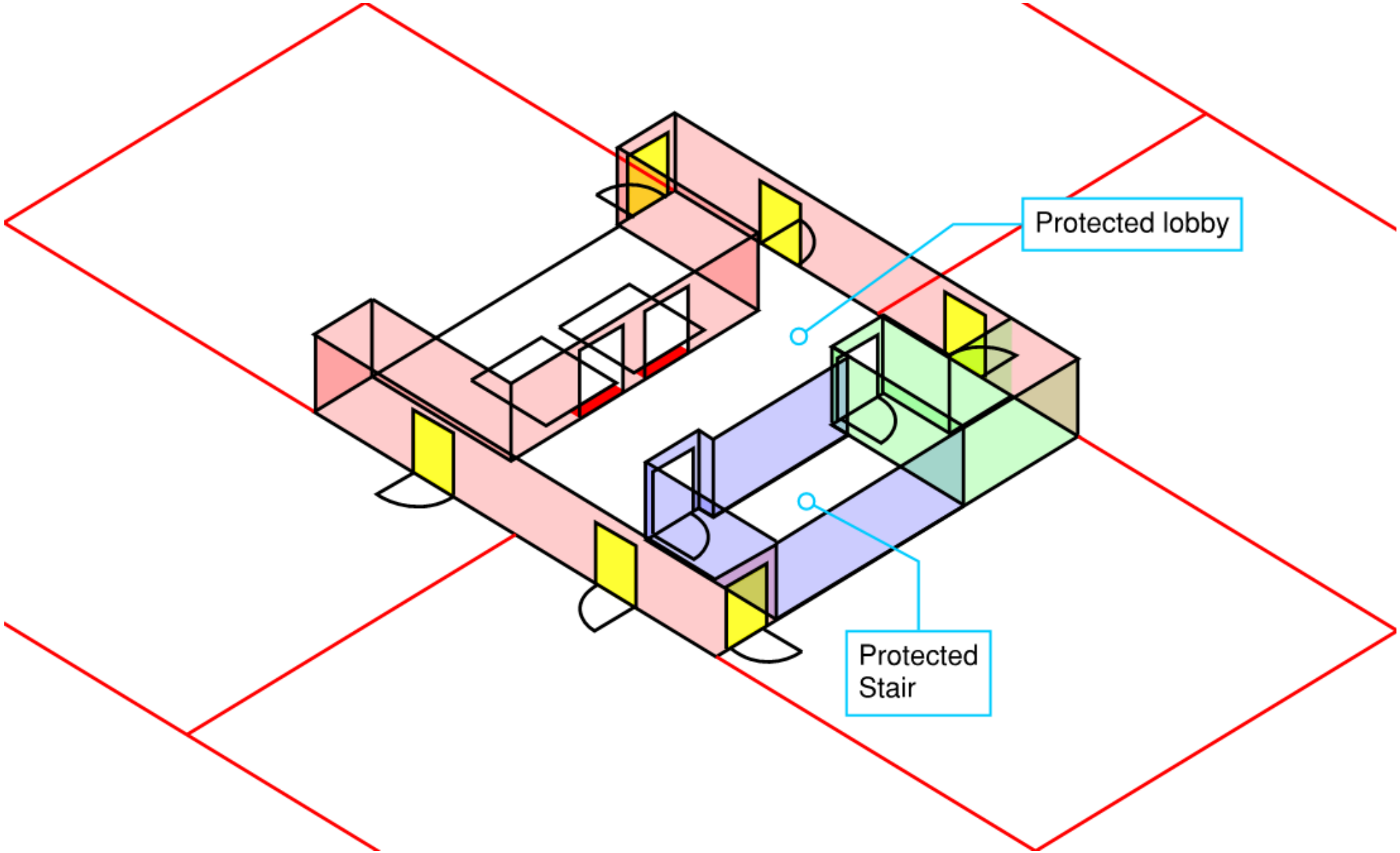
"*Small differences in detail (such as glazing apertures, intumescent strips, door frames and ironmongery etc) may significantly affect the rating*."

The fire doors within Grenfell Tower

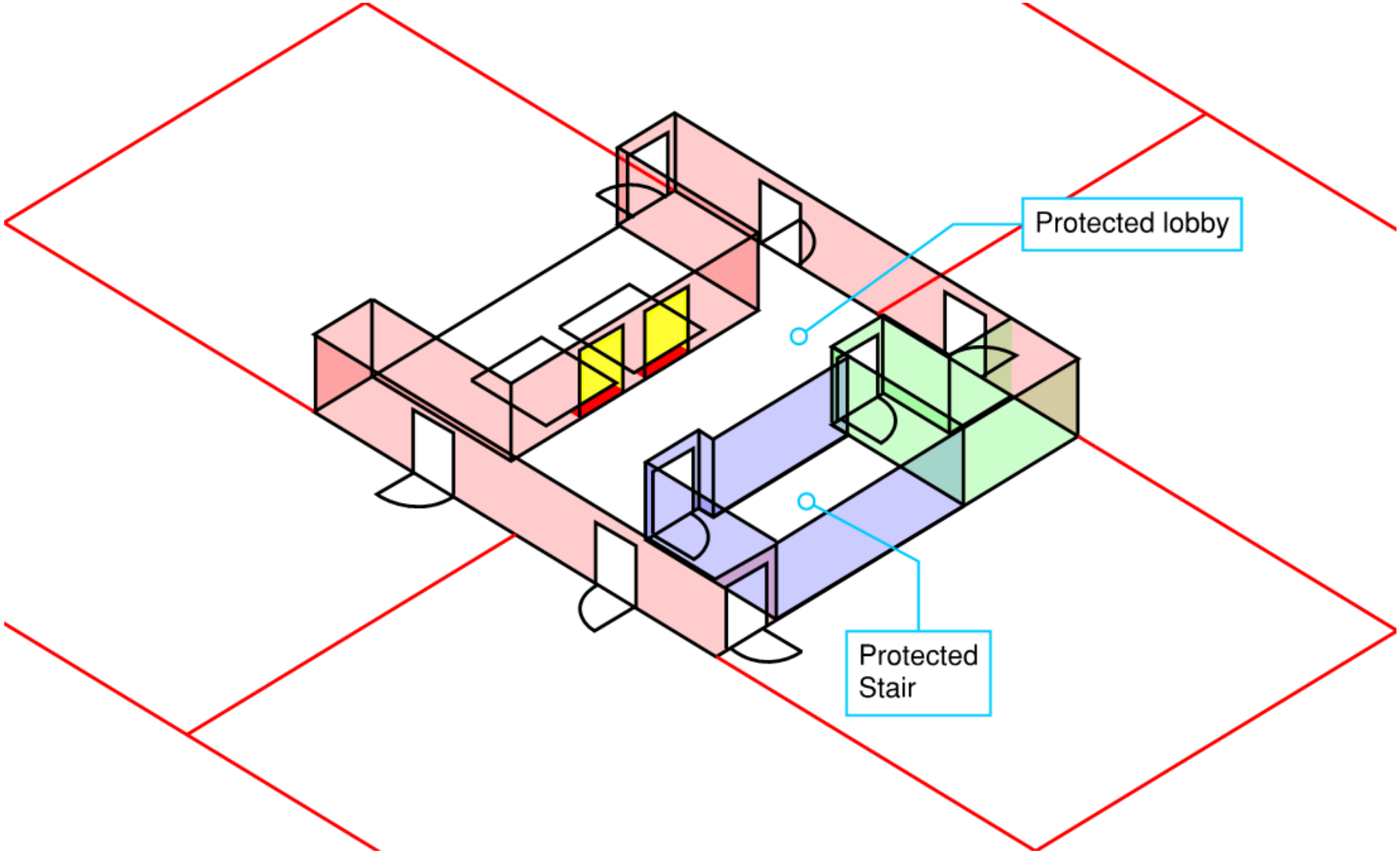
Required location of Fire doors in Grenfell Tower



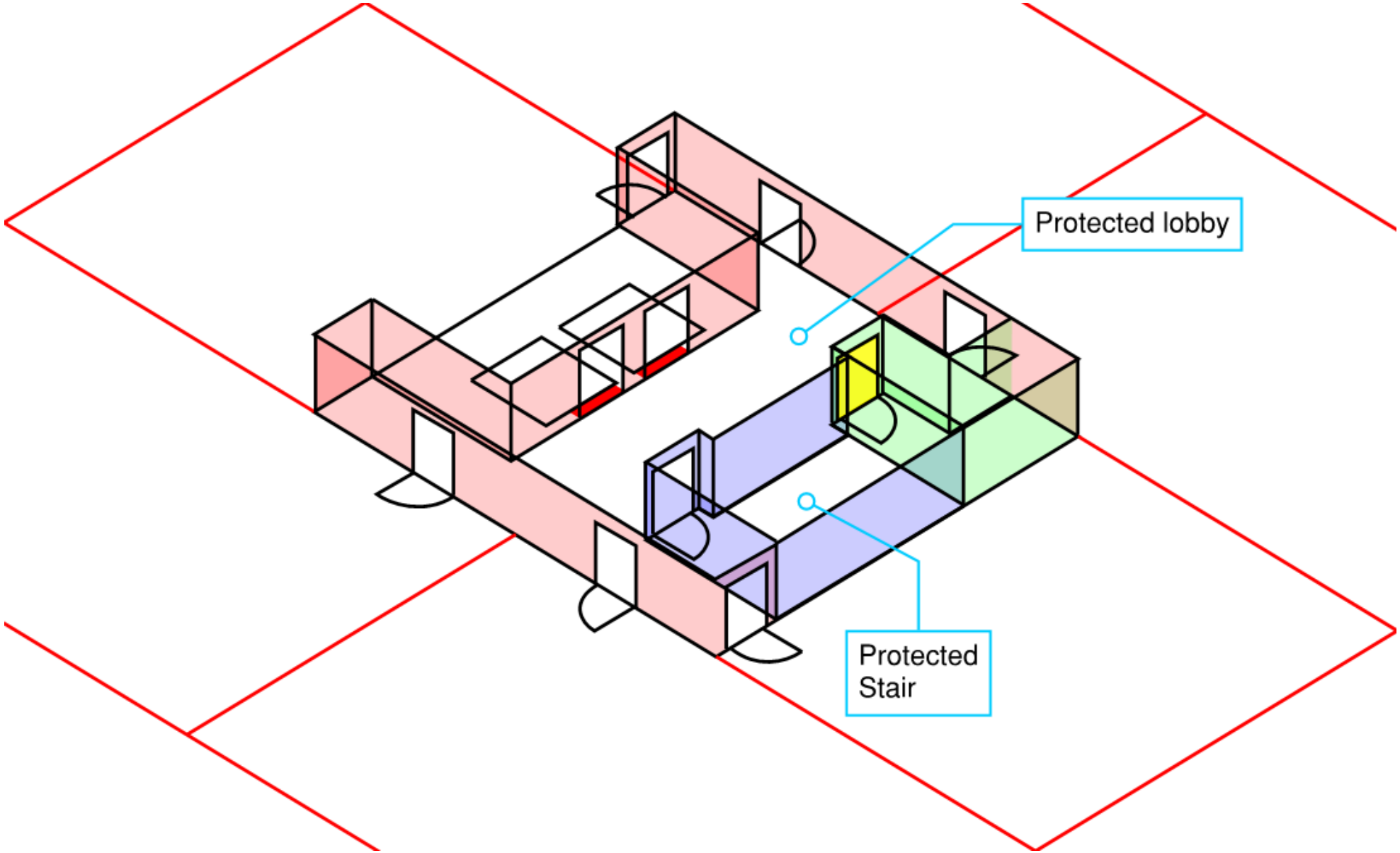
Flat entrance fire doors



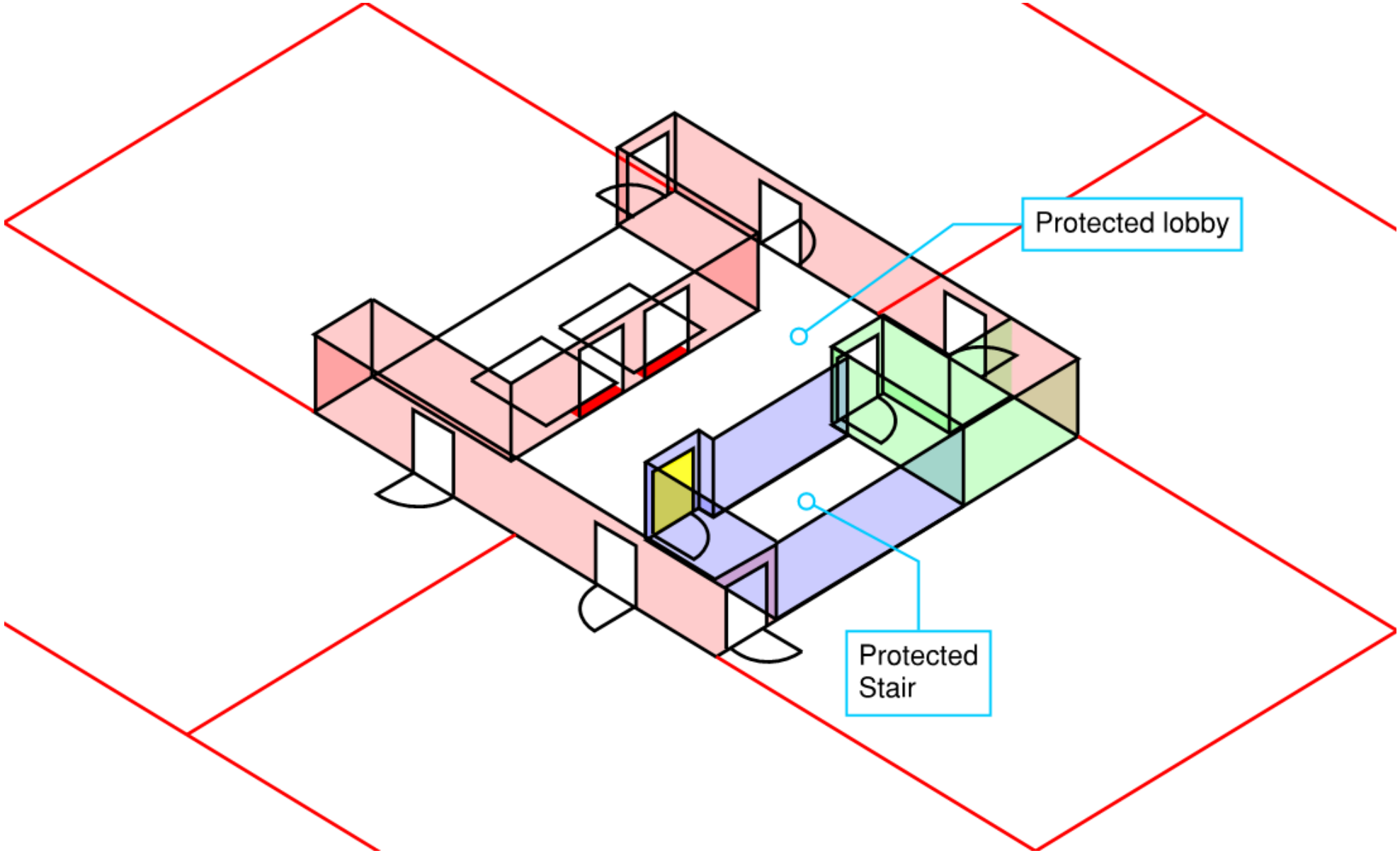
Protected lift shaft fire door



Refuse chute fire door

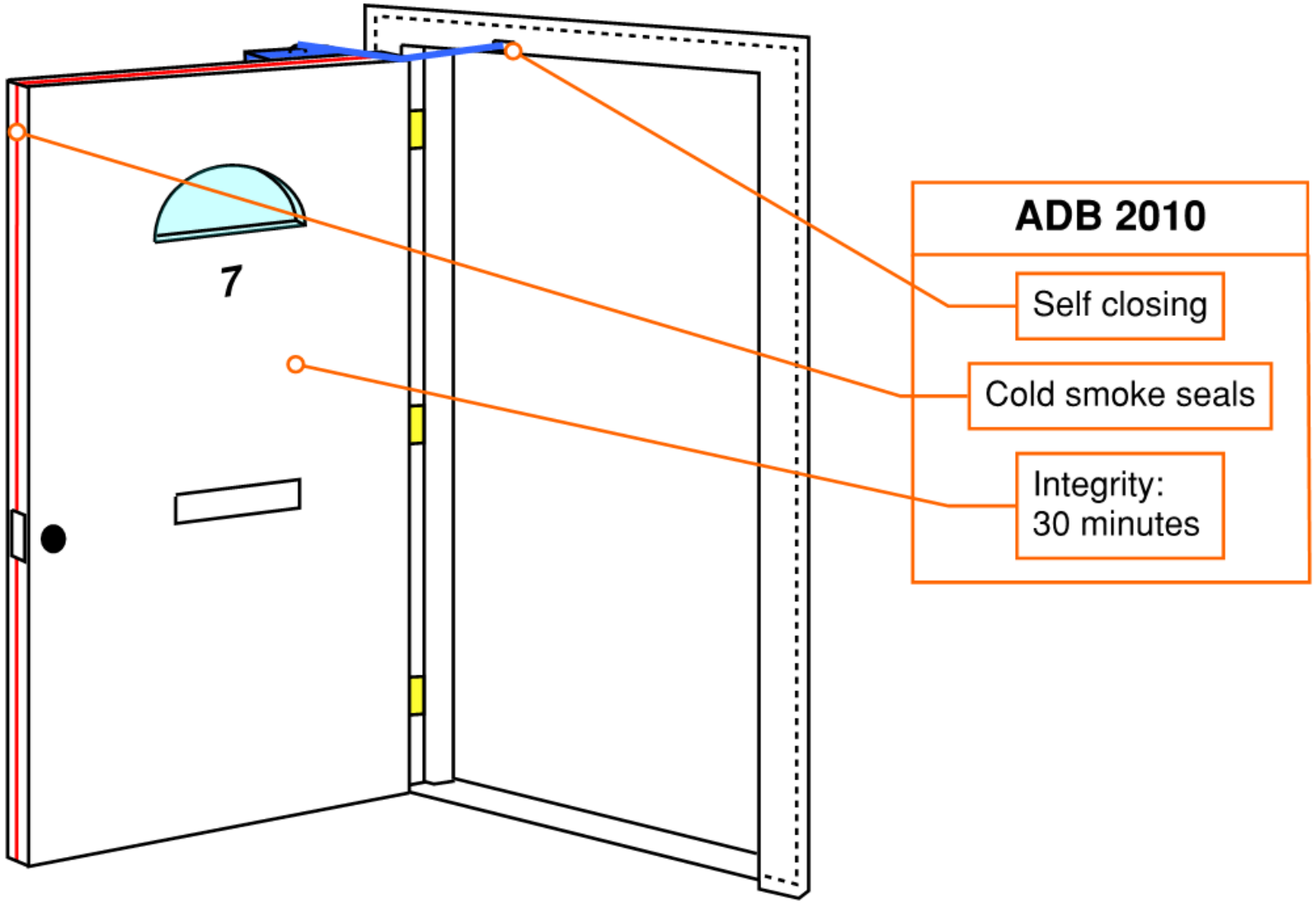


Protected stair enclosure fire door



Fire door replacement works 2011

Flat Entrance Doors Fire requirements at the time of installation [2011]



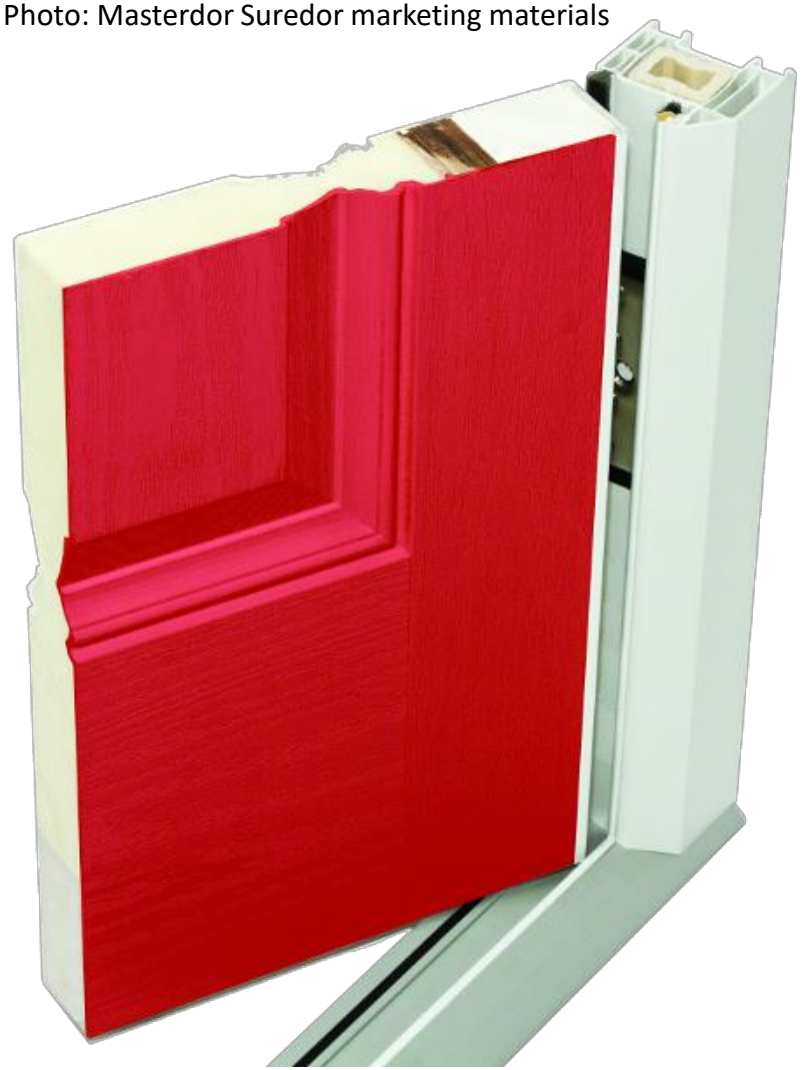
The requirements for glazing in a main flat entrance door

The product specified – Masterdor Suredor

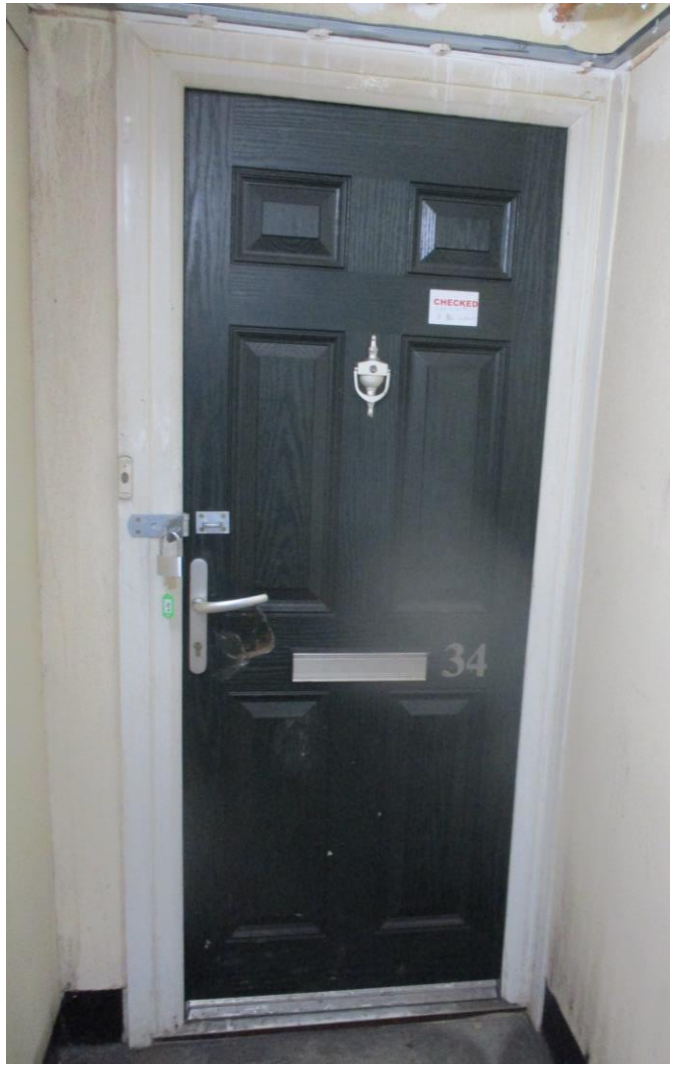
Fire test report referenced in
the Manse Masterdor brochure

masterdor®
suredor

Photo: Masterdor Suredor marketing materials



The installed flat entrance doors

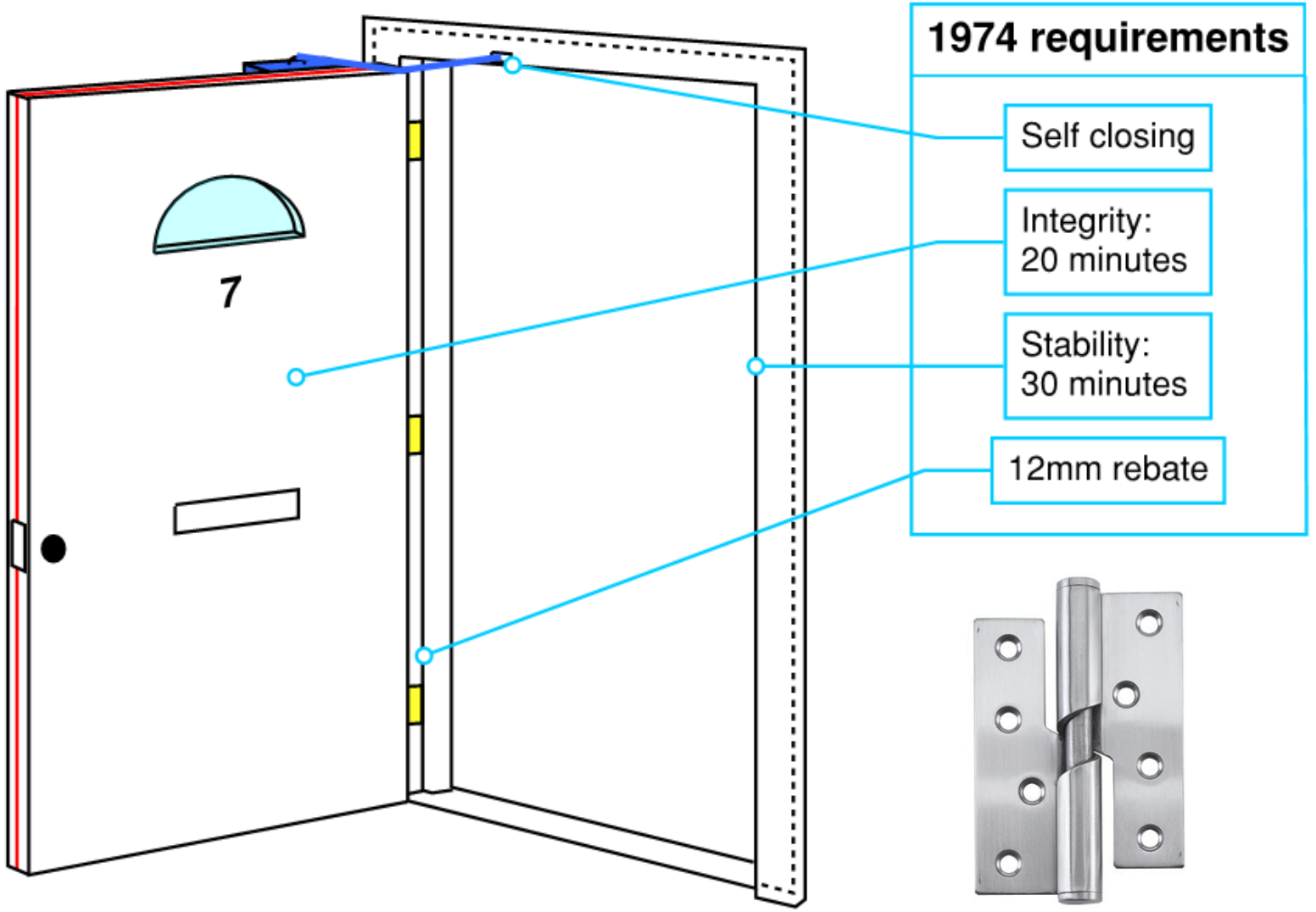


Unglazed Flat Entrance Door (58 doors)

Glazed Flat Entrance Door (48 doors)

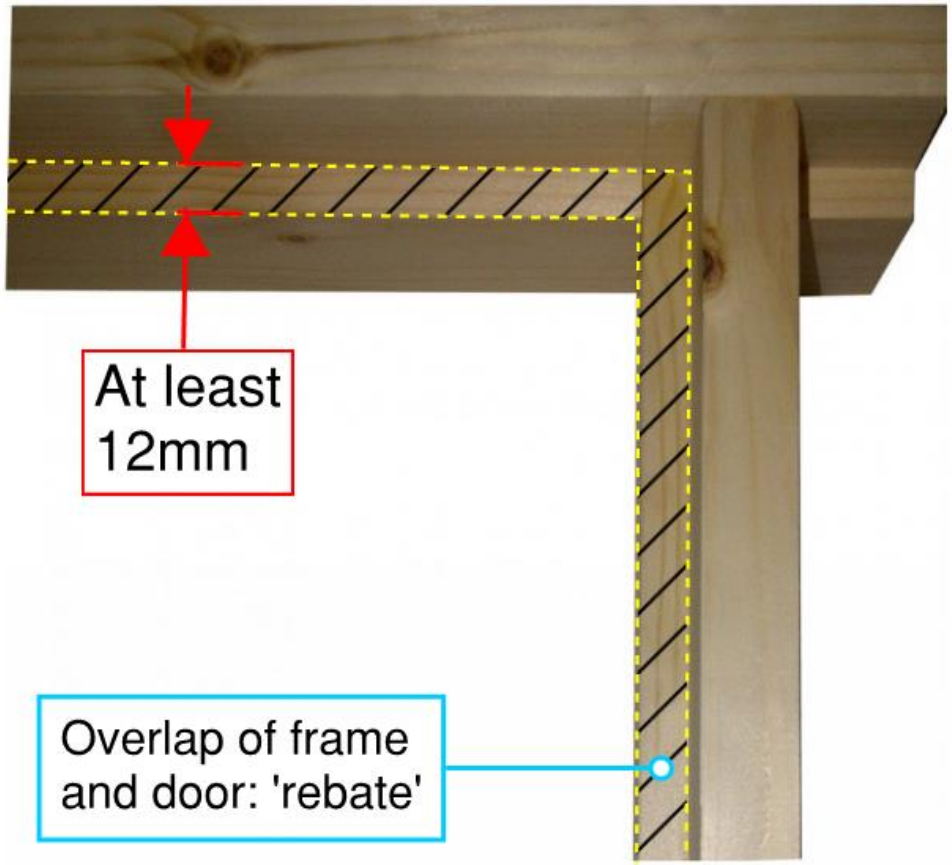
Flat entrance doors not replaced – requirements in 1974

Original or resident replaced Flat Entrance Door (14)

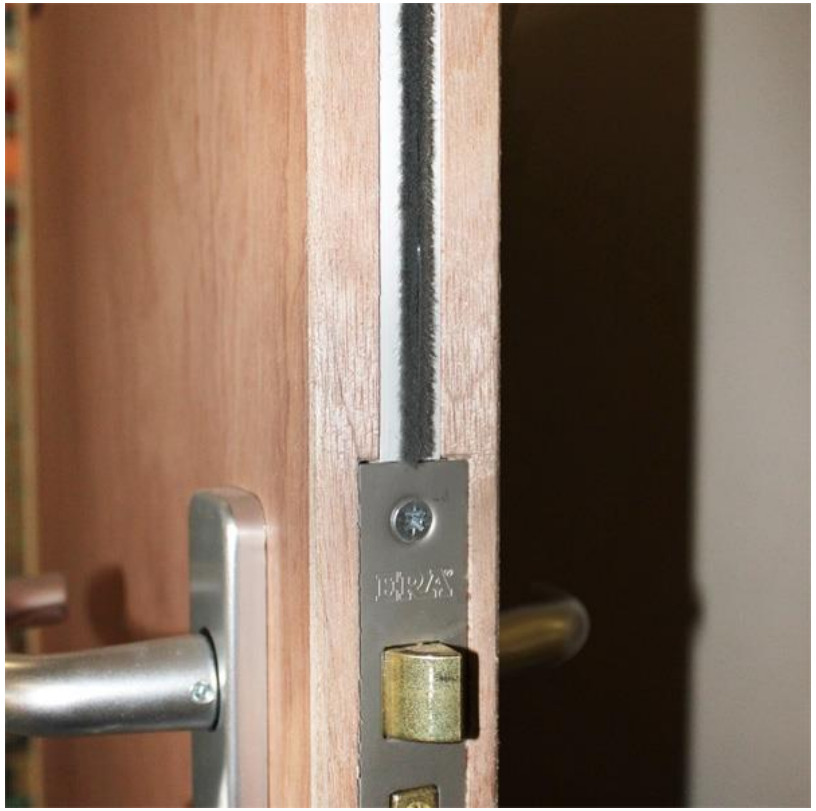


Measures against the spread of smoke

>12mm rebate in frame (1974)

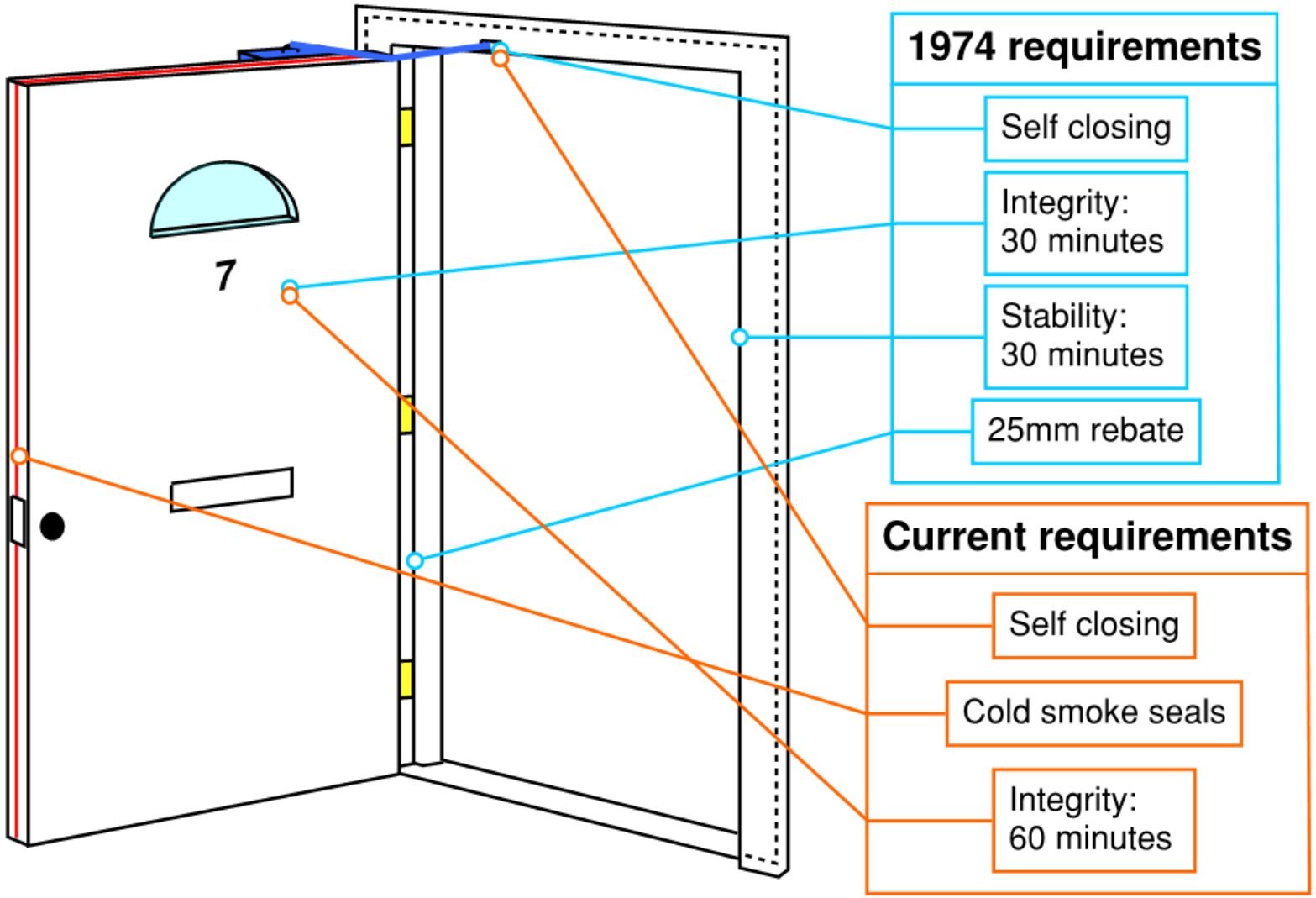


Cold smoke seals (2011)

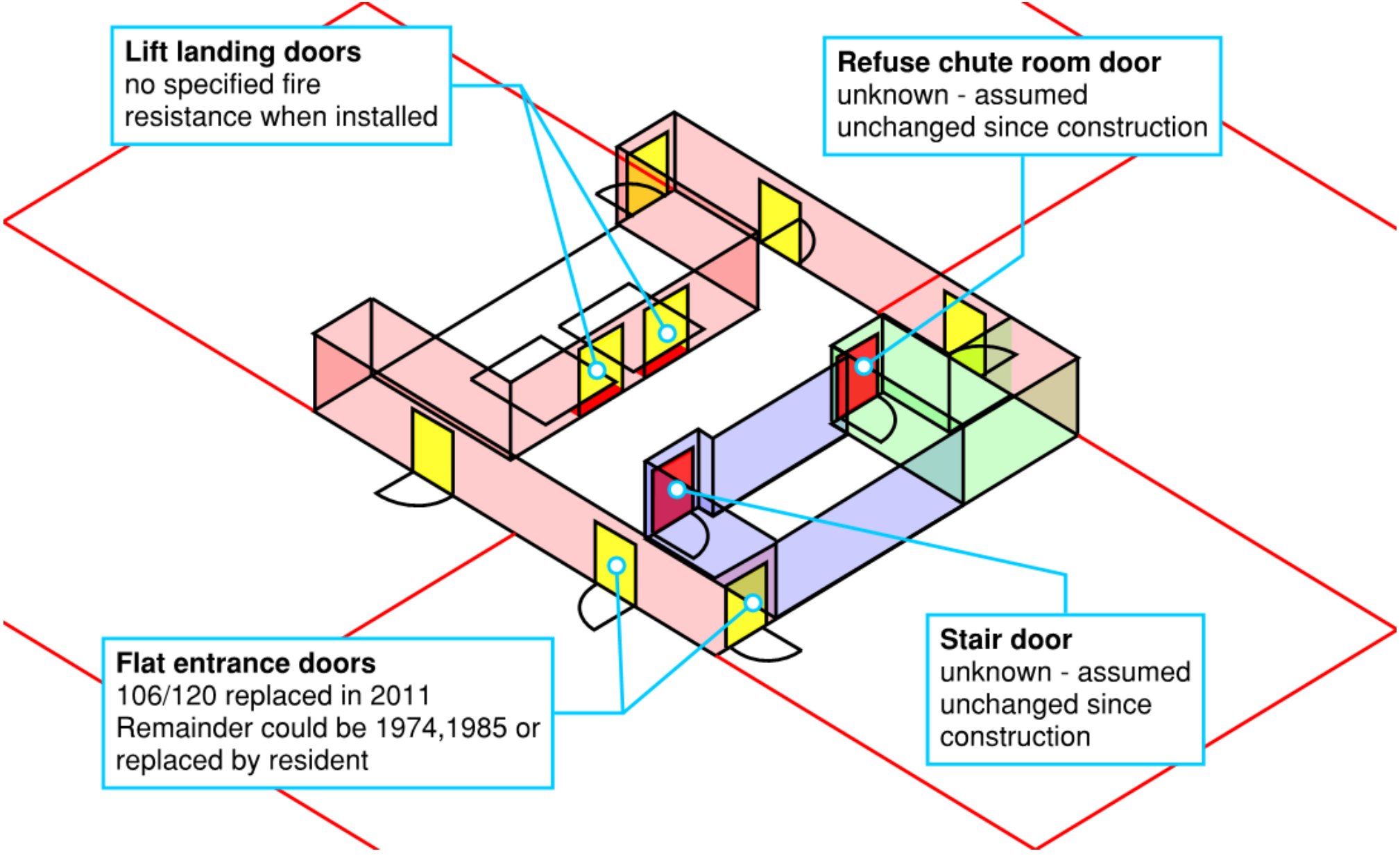


Protected stair doors not replaced – requirements in 1974

Level 6 stair door



Conclusion – Condition on night of 14th June 2017



BS9991 2015 advises

"Fire doors:

Doors in fire-separating elements are one of the most important features of a fire protection strategy, and it is important to select a fire door that is suitable for its intended purpose.

They should normally be self-closing …"

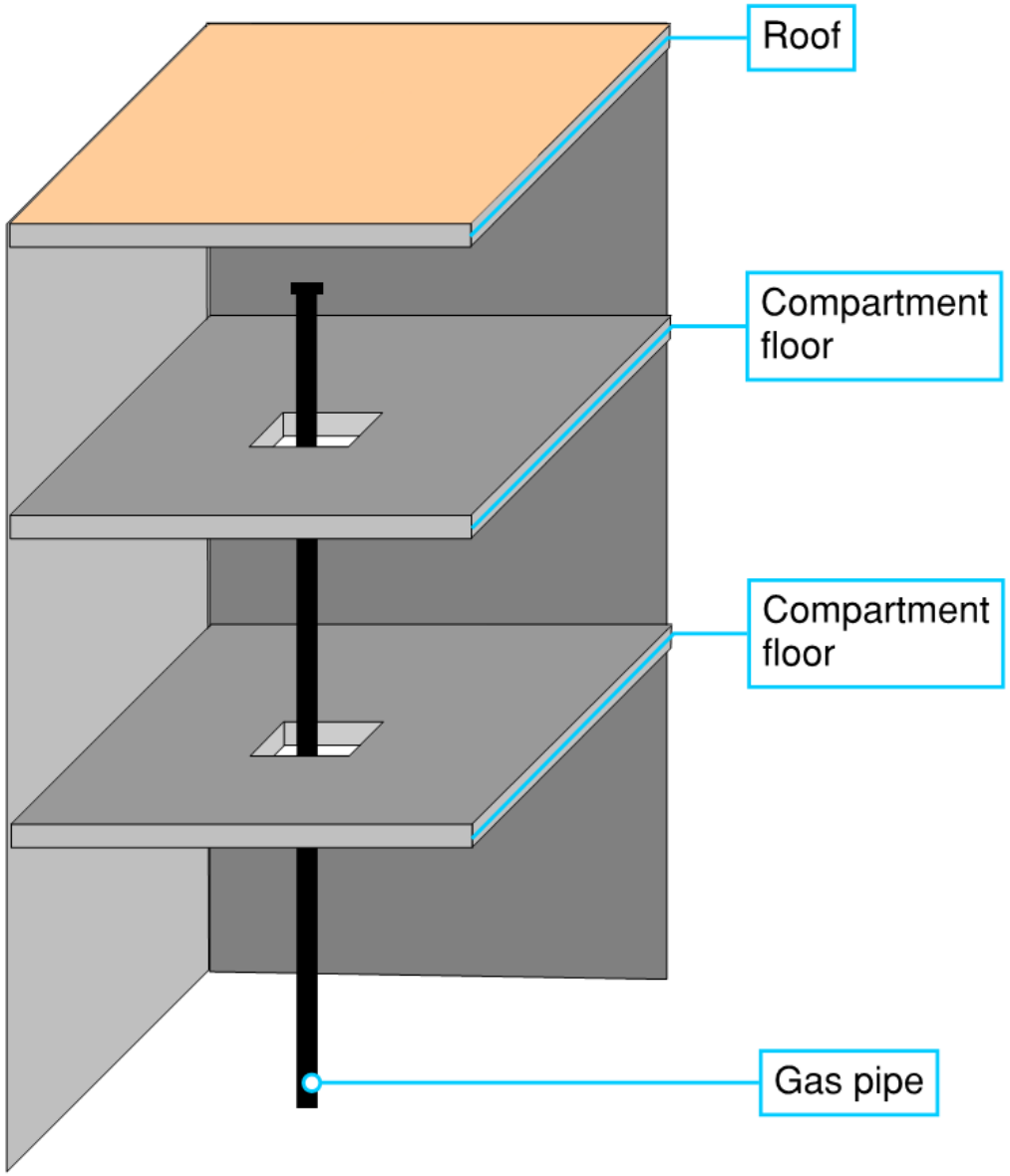
The Gas Supply replacement works 2016

ARUP

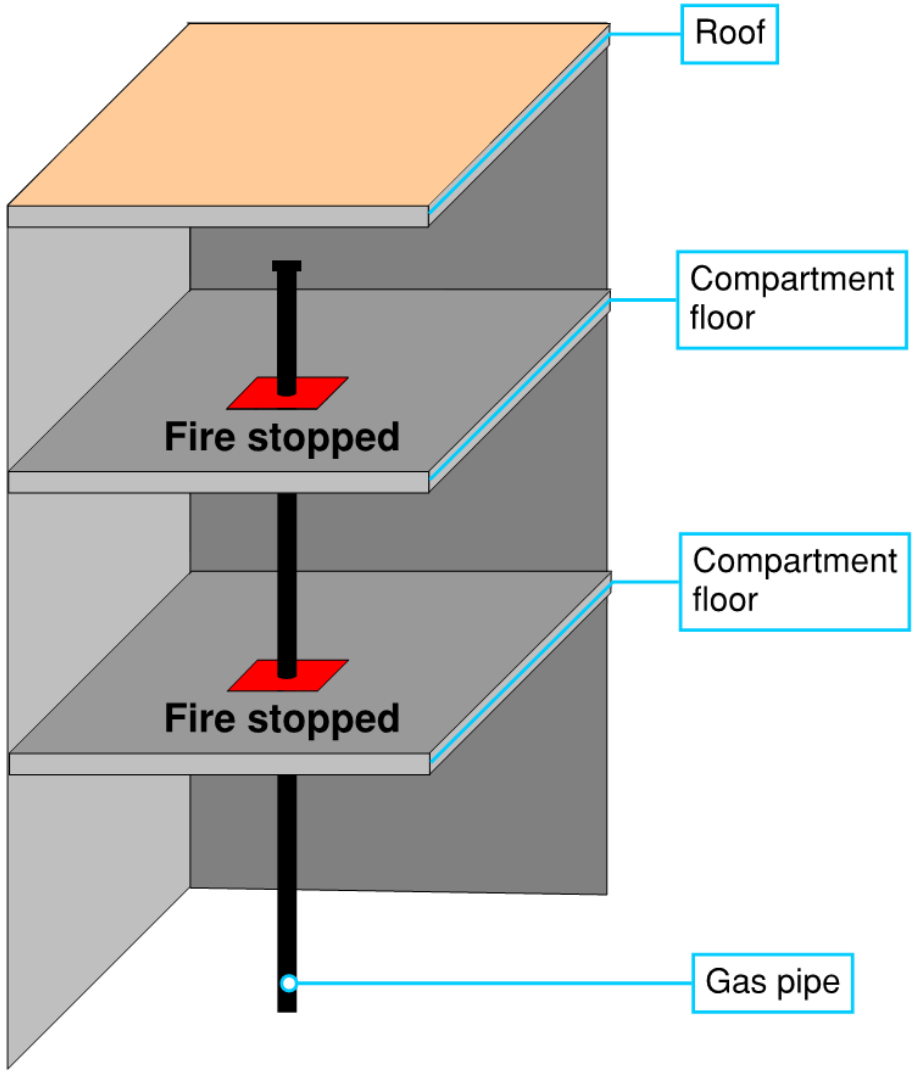
The Original Landlord Gas Supply

The Original Residential Gas Supply

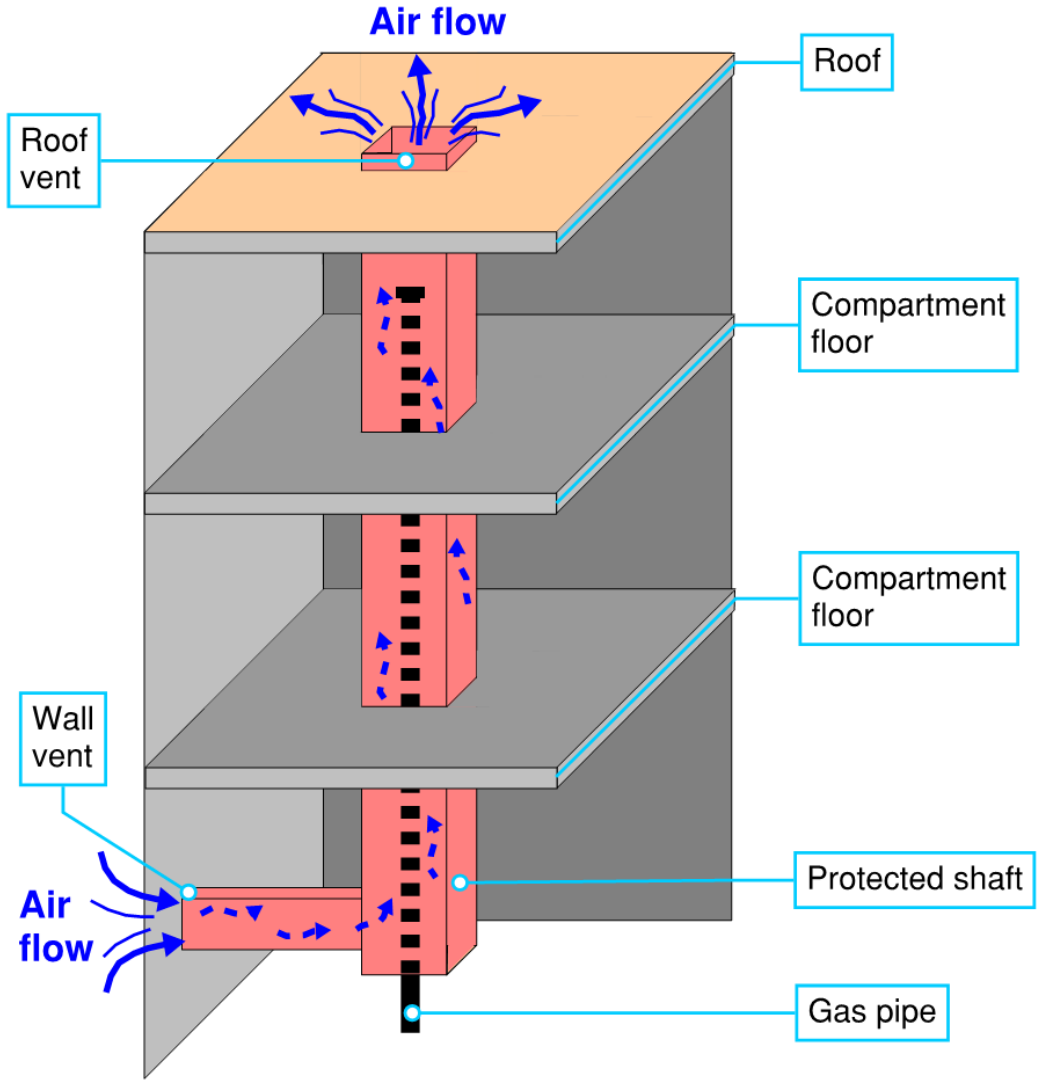
Gas pipes require protection at compartment floors and walls



Two options to protect gas pipes passing through compartmentation



Option 1: Fire stopping



Option 2: Provide a ventilated protected shaft

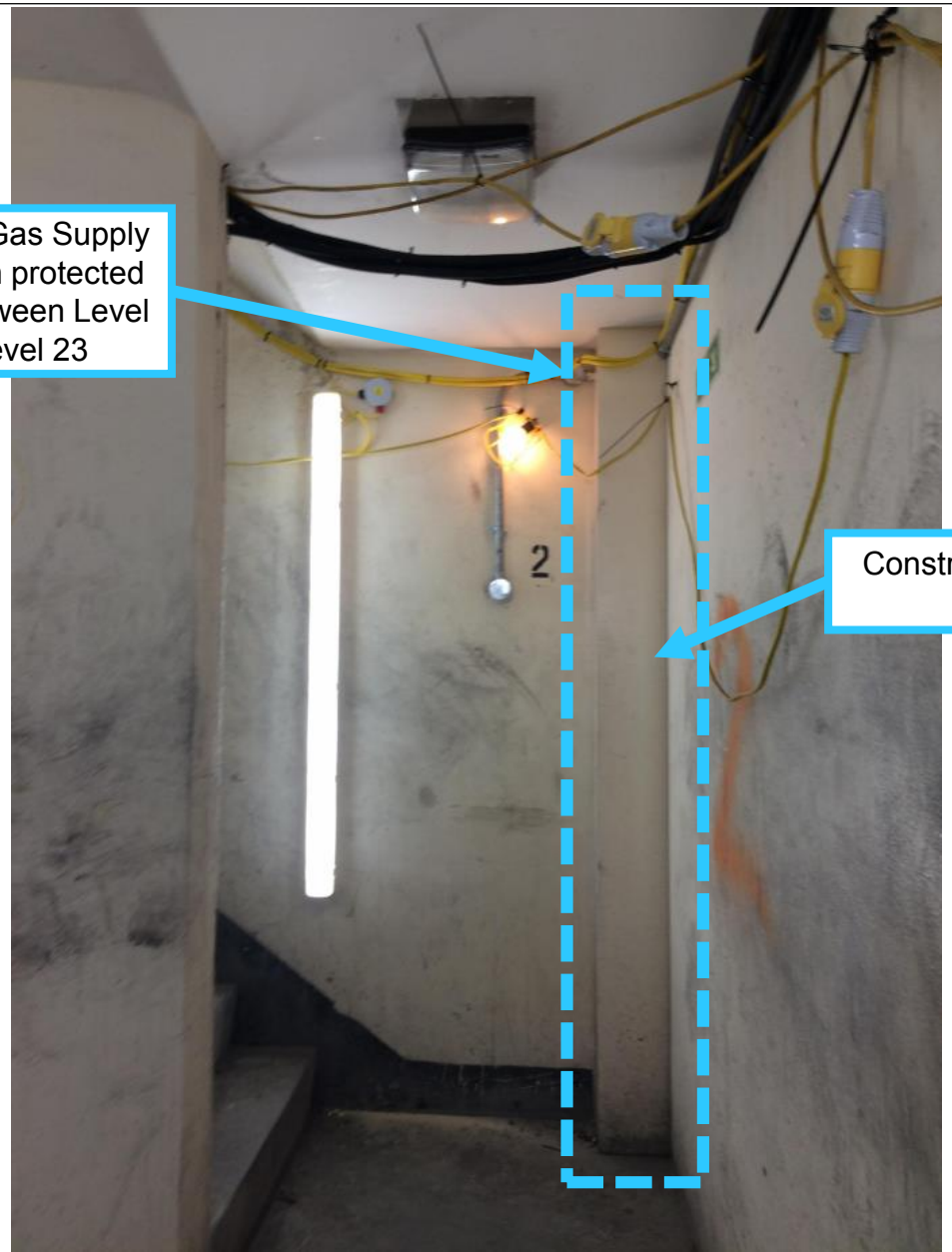
Residential gas replacement works
2016 – 2017

Original residential gas pipe capped at Ground Level

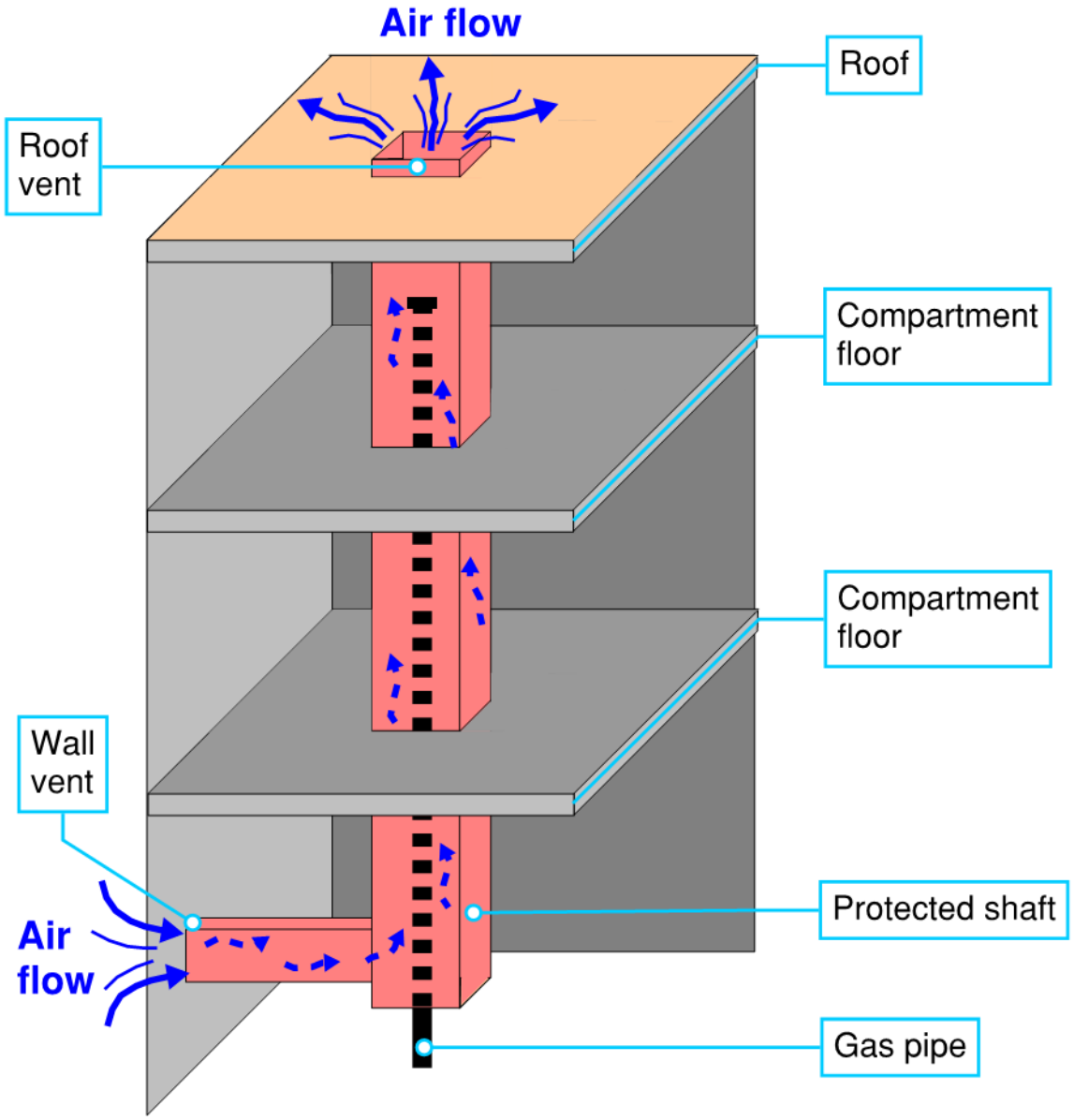
Decommissioned gas riser – original residential gas supply
Capped on Ground Level

Fire safety provisions for the installed gas pipes

Enclosure of the gas pipe within the stair

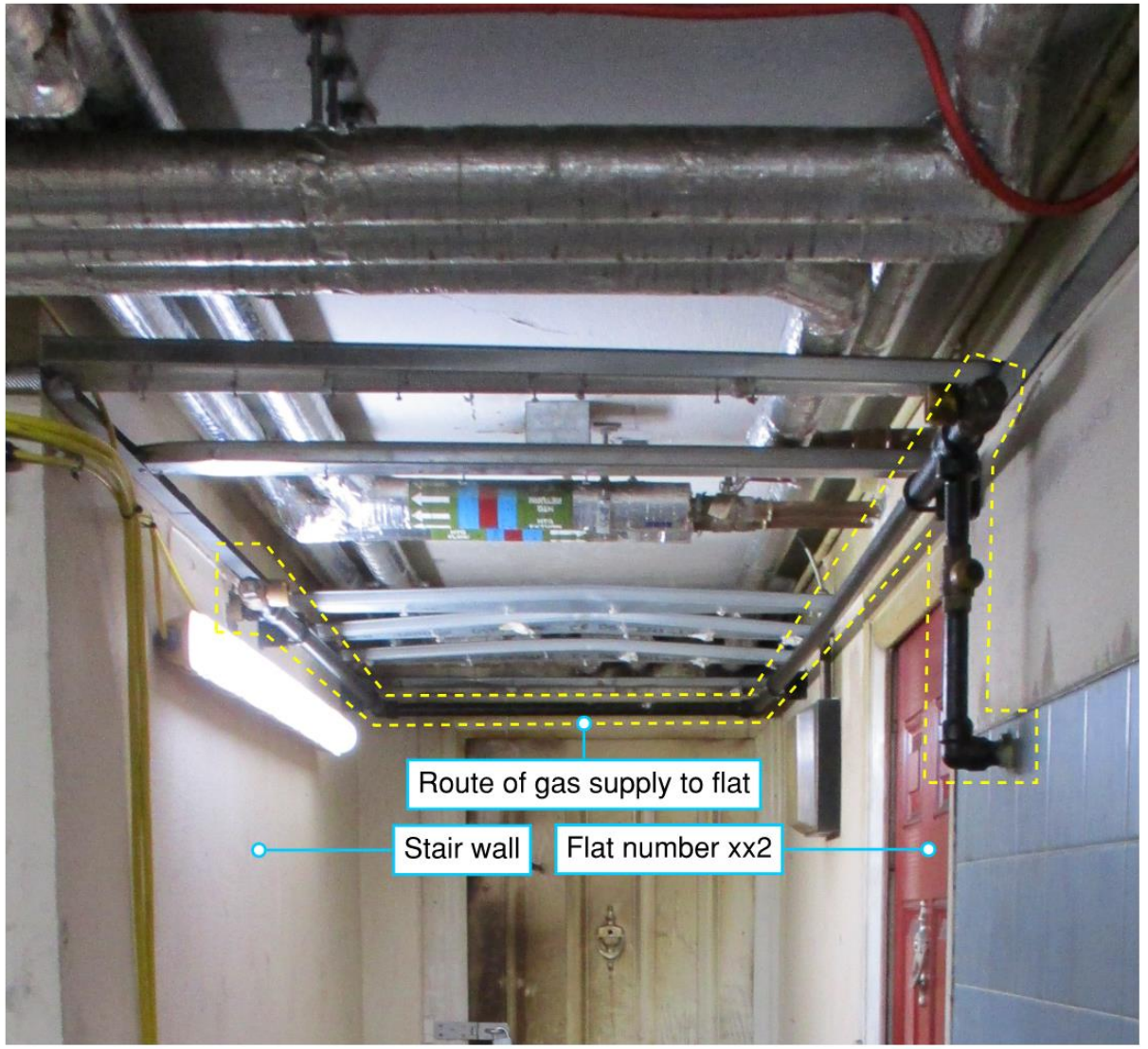


Ventilation of a shaft containing a gas pipe



Fire protection of the penetration through the stair wall

Gas pipe penetration through stair compartment wall



Gas pipe penetration through flat ‘2’ compartment wall

Condition of gas supplies on 14th June 2017

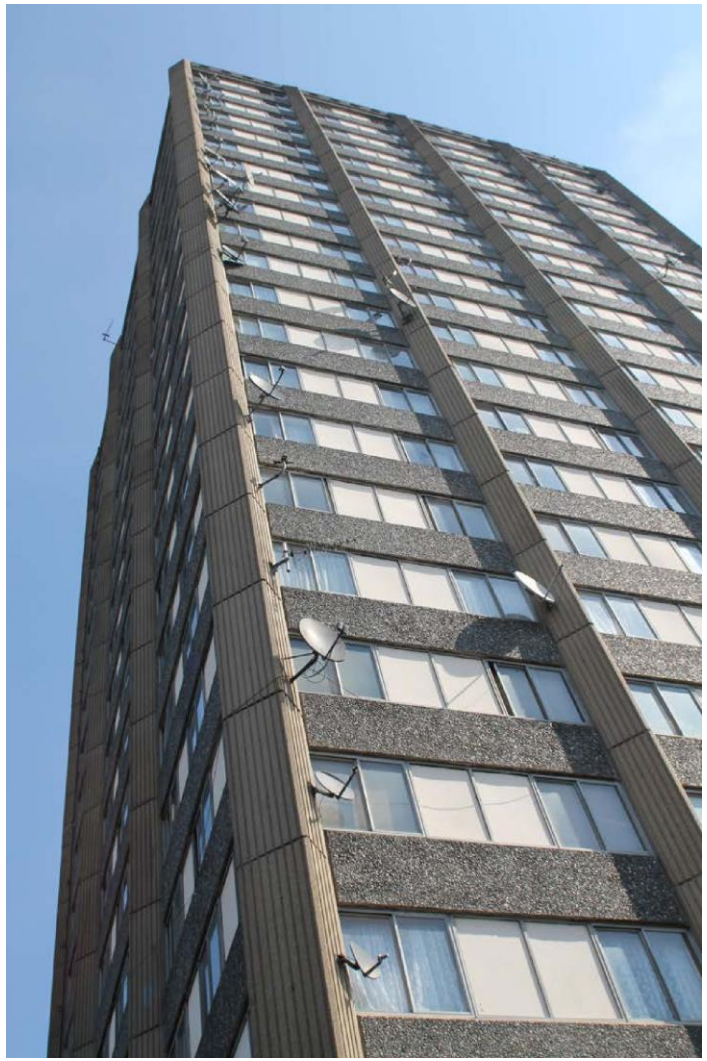
On 14th June 2017, there were three gas supplies in Grenfell Tower

A Landlord gas supply	serving boilers in the basement	• no impact to compartmentation at Grenfell Tower
Original residential gas supply	penetrates every compartment floor	• The condition of the remaining 5 supply routes is currently being investigated by the Inquiry appointed Expert
A single new residential gas supply	following replacement works in 2016/2017 – routed through the protected stair and penetrating the stair compartment wall and flat '2' compartment wall on 13 floors of the Tower	• Incomplete work regarding compartmentation • Incomplete work regarding the required ventilation

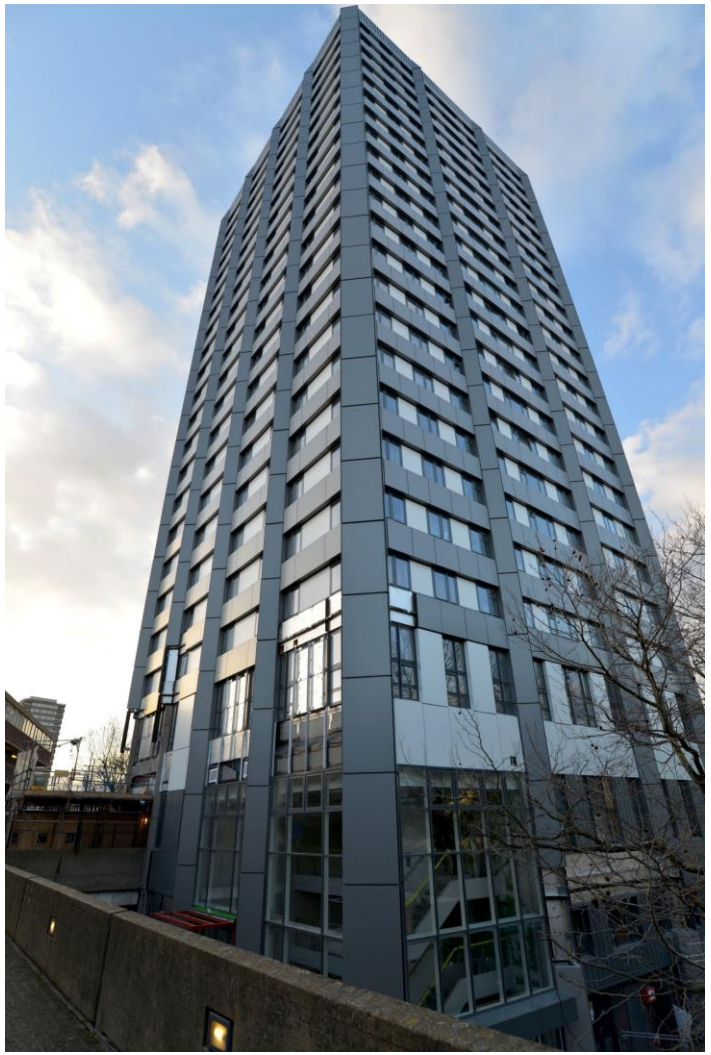
Grenfell Tower
Primary Refurbishment 2012-2016:
Overview

ARUP

Refurbishment of Grenfell Tower 2012 - 2016



Grenfell Tower 2012



Grenfell Tower 2016

External works during the primary refurbishment

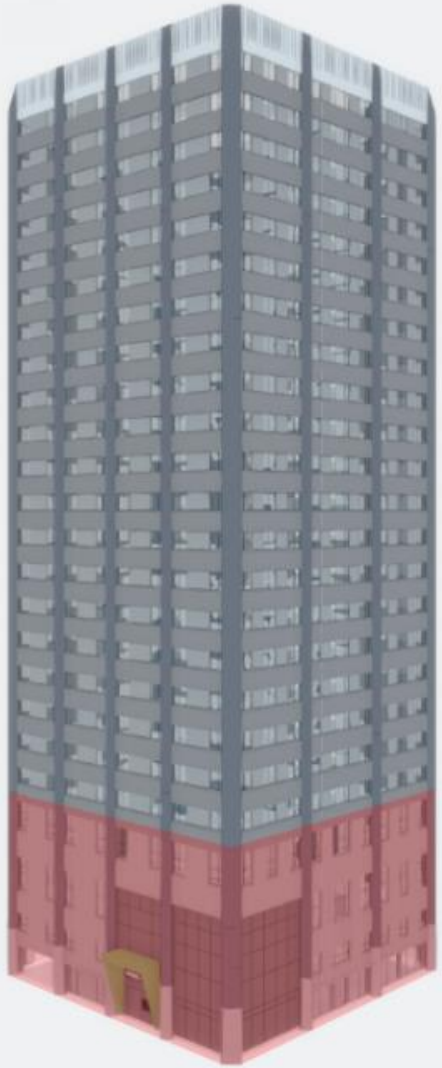
Contract boundary for Grenfell Tower primary refurbishment

Primary refurbishment: Overview of internal reconfiguration, Ground – Level 3

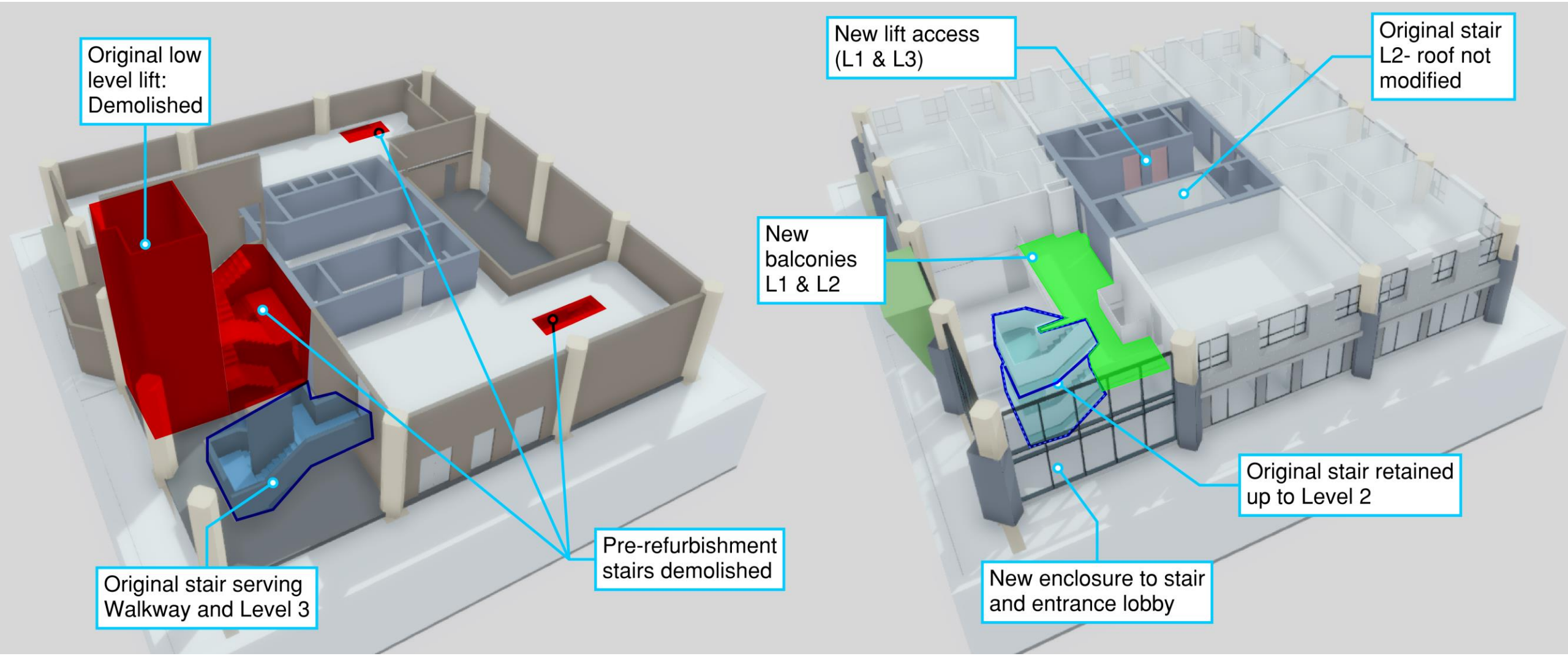
Before primary refurbishment

Substantial reconfiguration of the internal layouts on Ground Level to Level 3 to create 9 new residential apartments, nursery, two community rooms, and a boxing gym

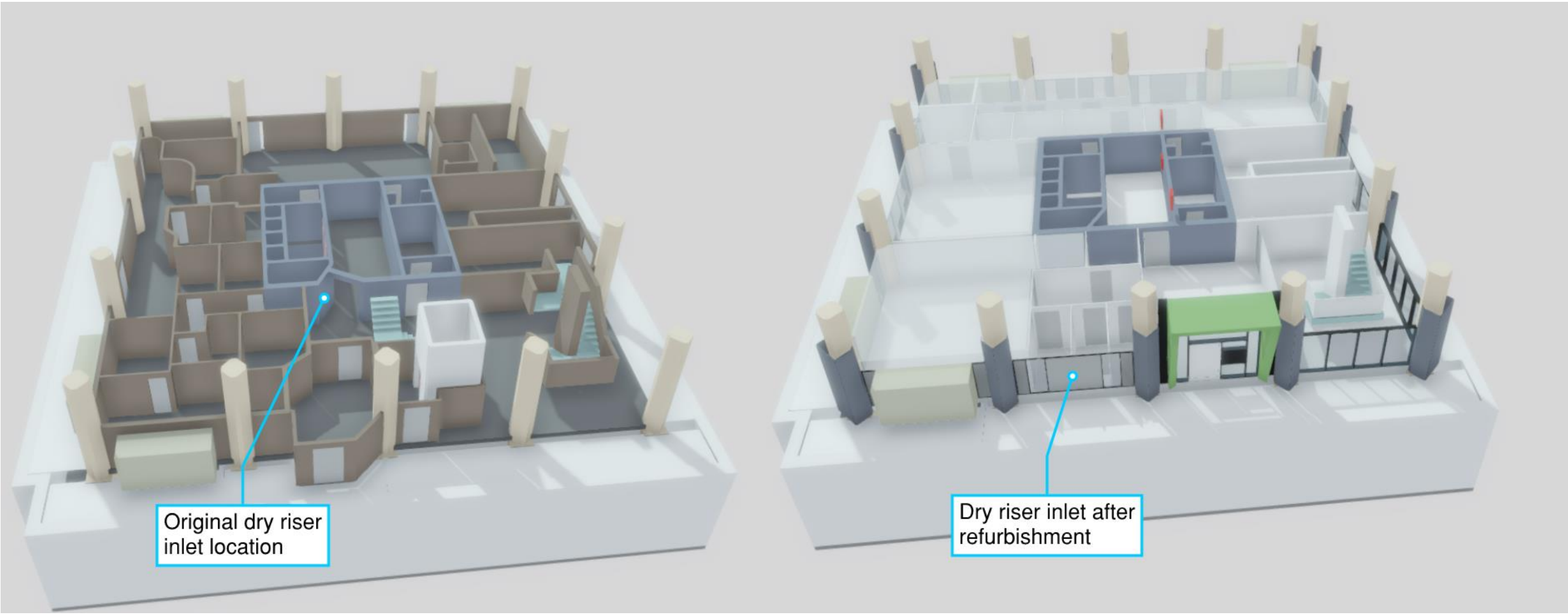
After primary refurbishment



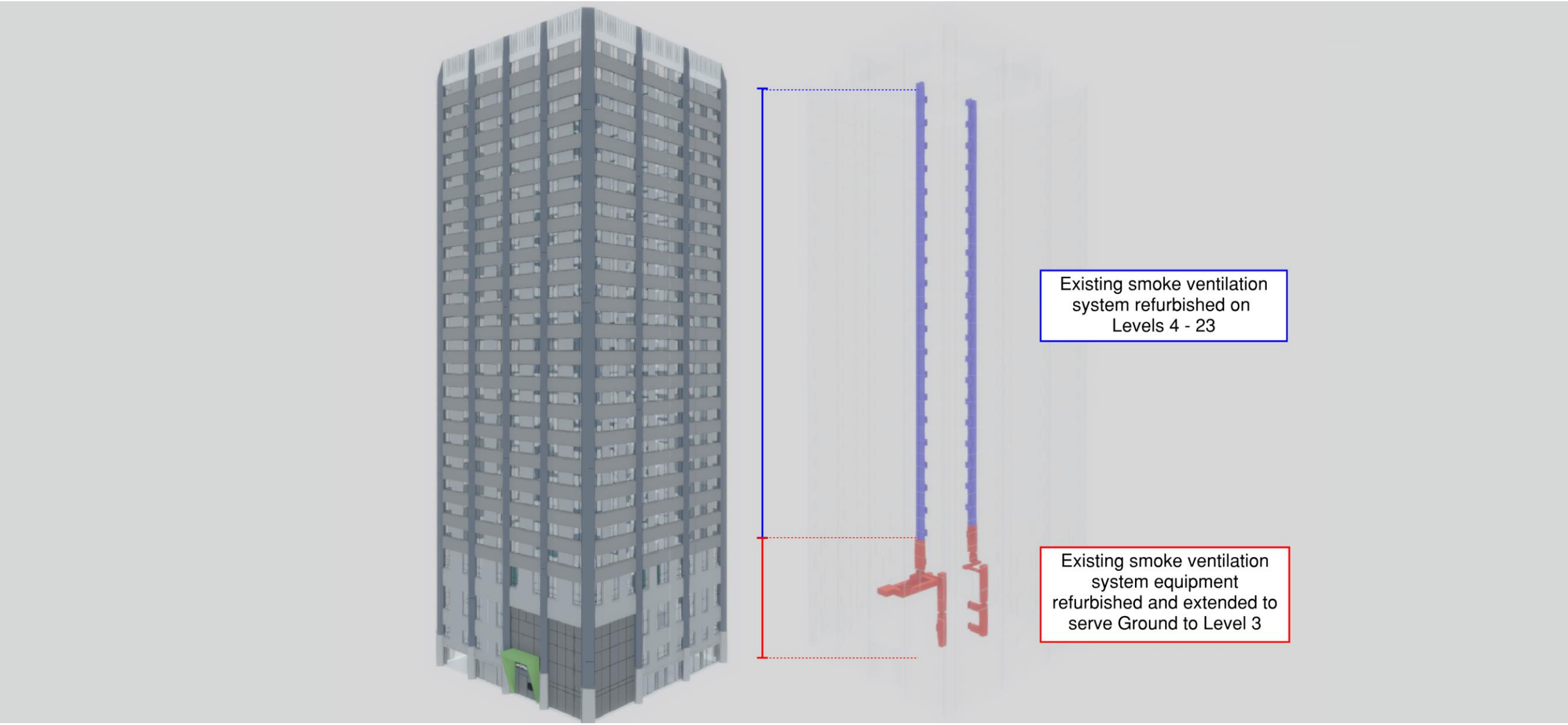
Primary refurbishment: Overview of works, stairs and lifts



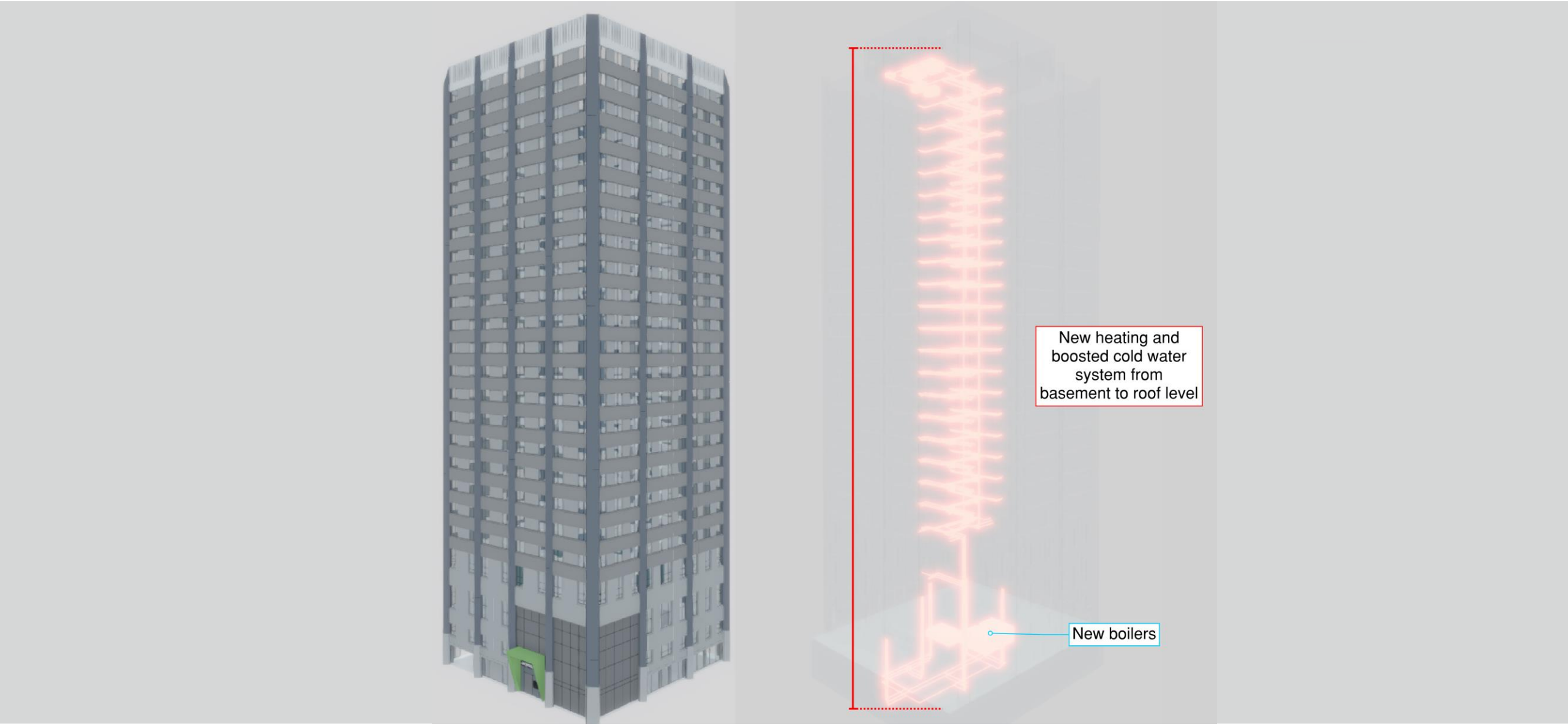
Primary refurbishment: Overview of works to fire fighting main



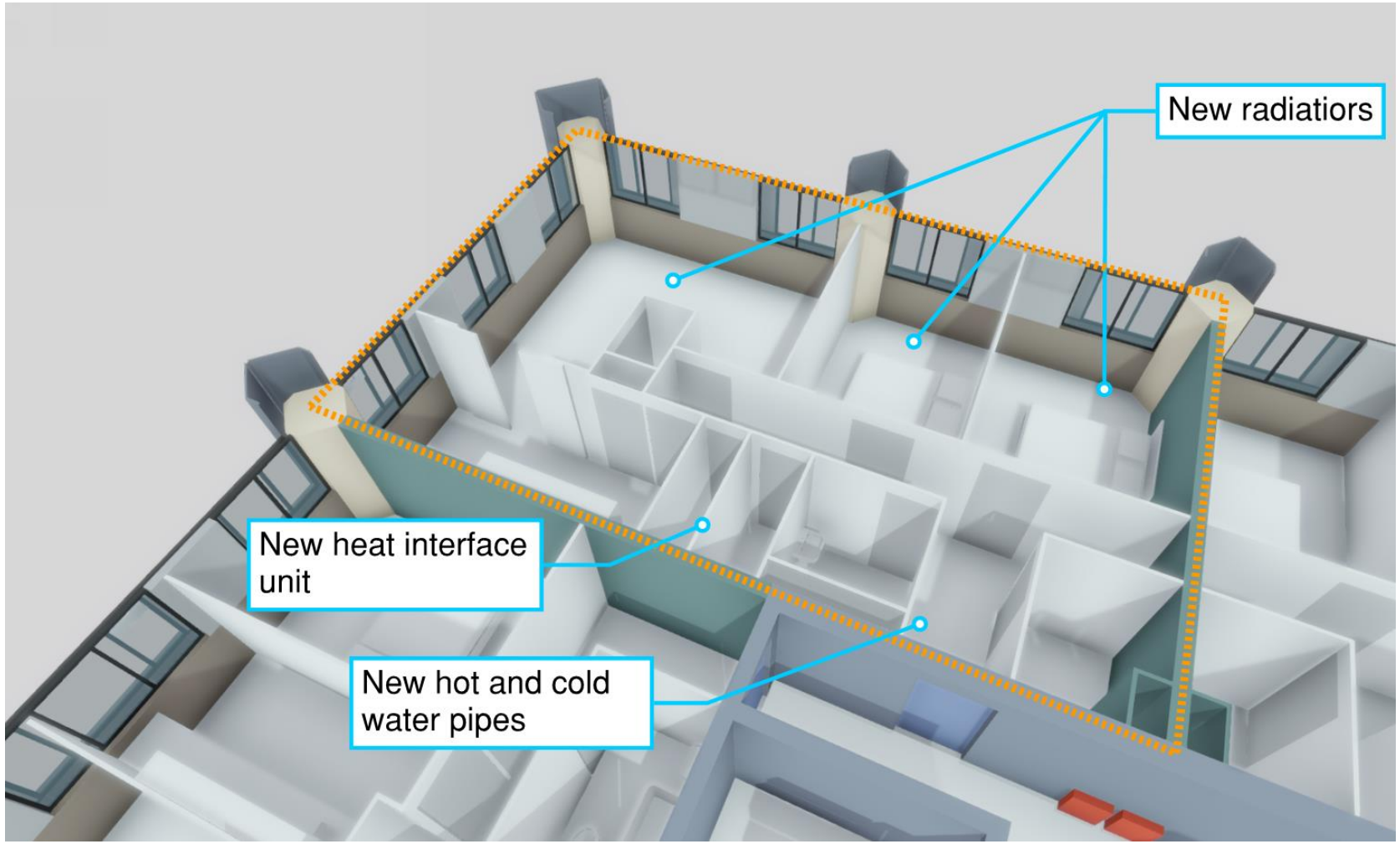
Primary refurbishment: Overview of works to lobby smoke control



Heating/hot water and cold water – works within common areas

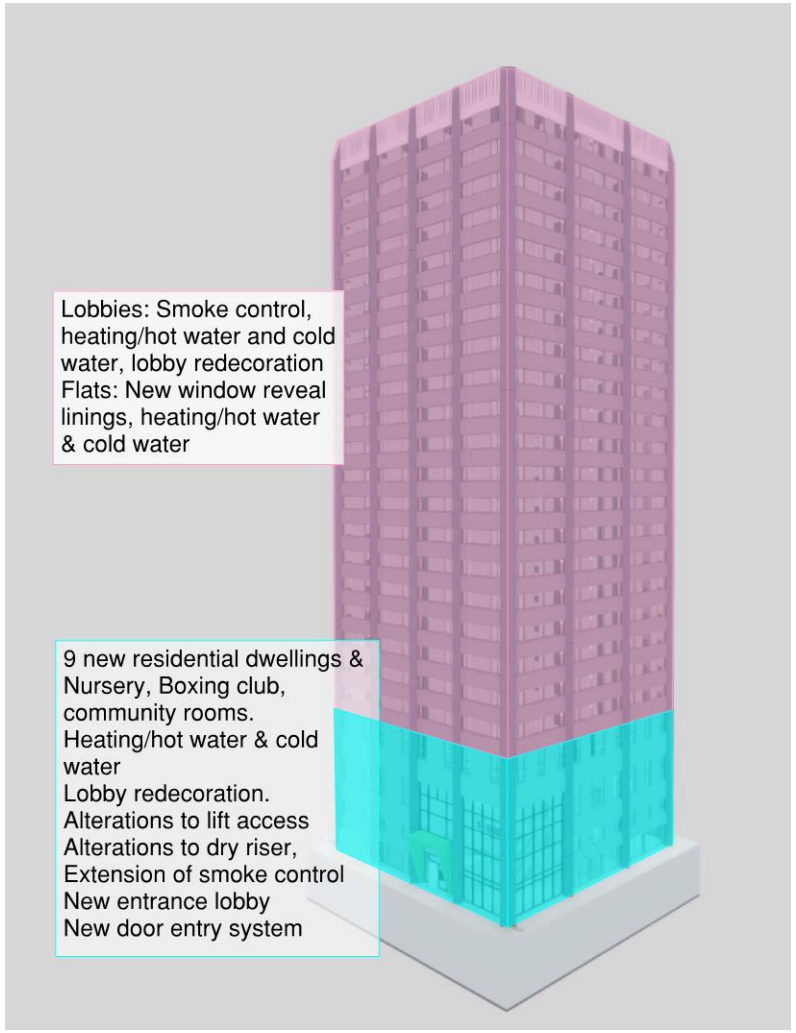


Heating/hot water and cold water – works within dwellings

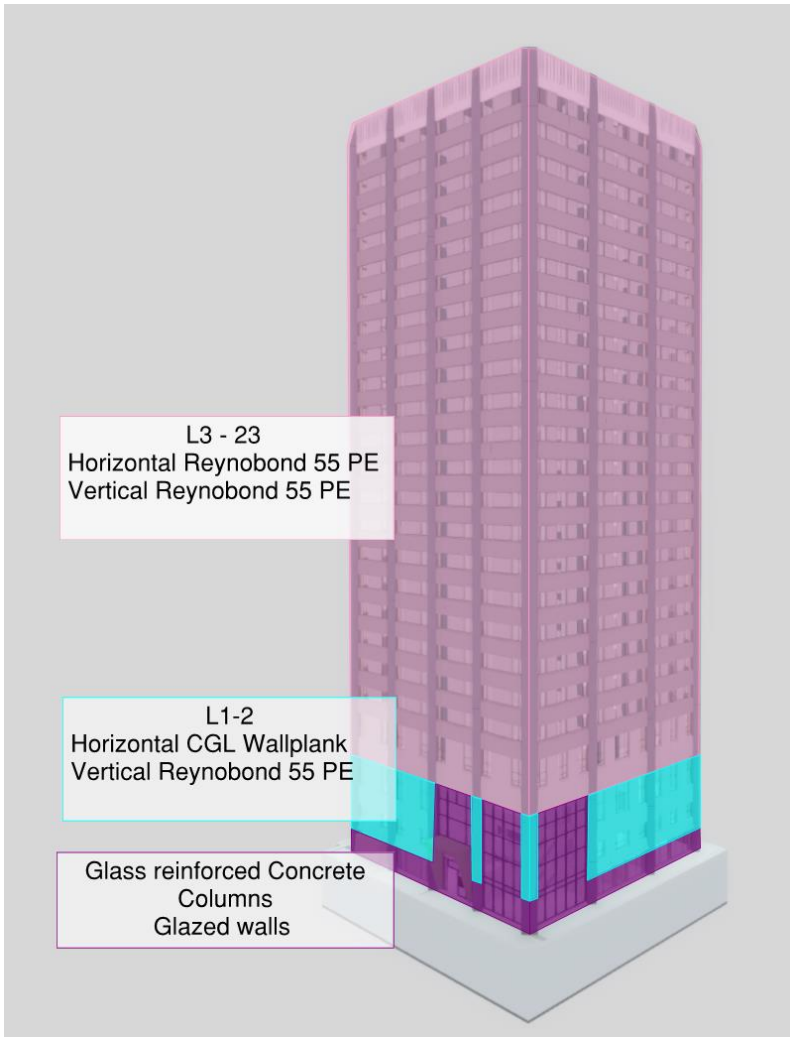


Existing dwelling

Primary refurbishment: Overview of works over all levels



Internal works



External cladding works

External works to land surrounding the building

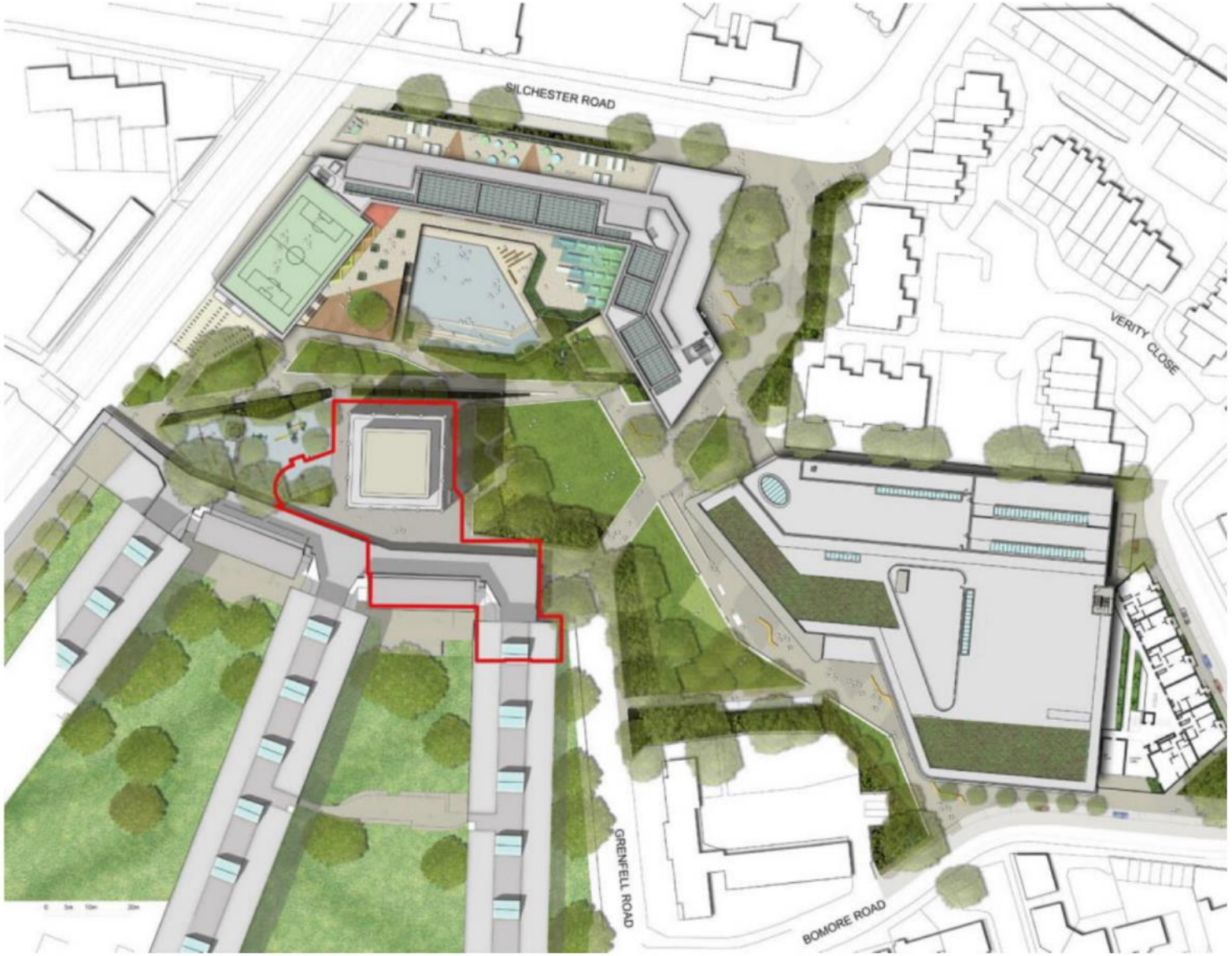
Grenfell Tower
Primary Refurbishment 2012-2016:
Other works

ARUP

External works

Changes to immediate surroundings of Grenfell Tower

Contract boundary for primary refurbishment outlined in red

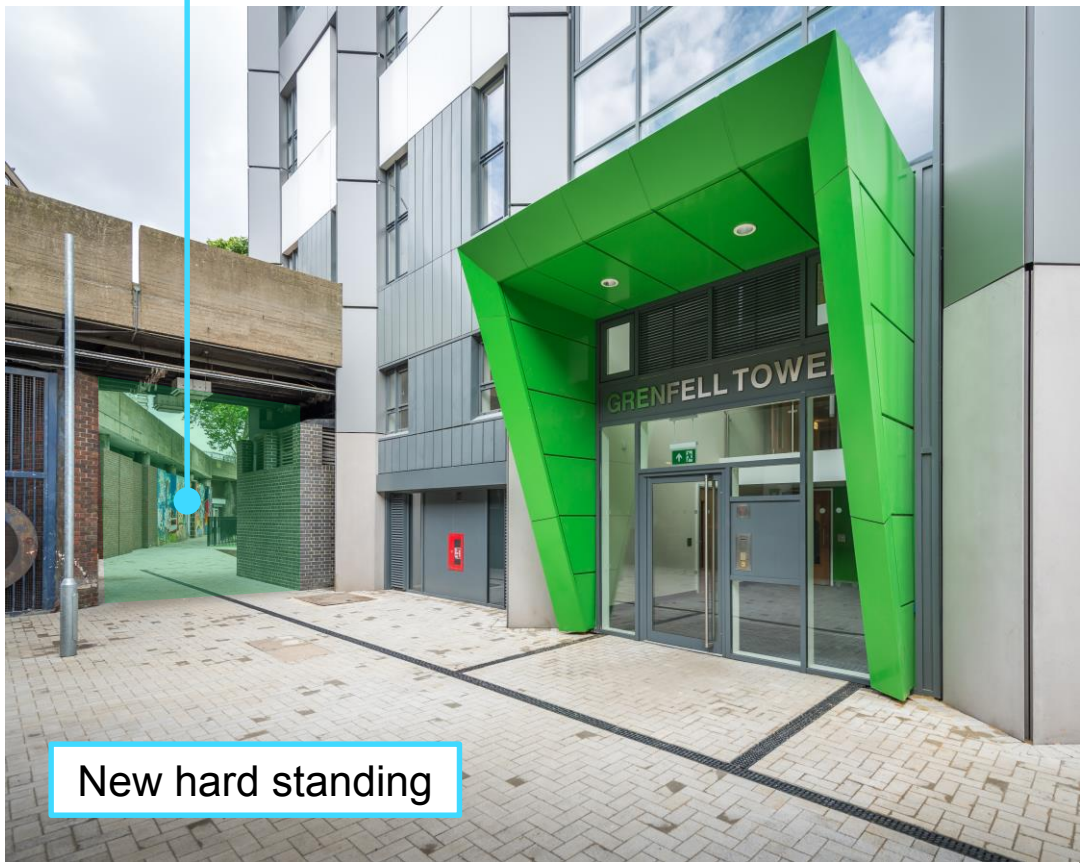


External works impact on immediate area surrounding Grenfell Tower

Pedestrian access to area west of Grenfell Tower (playground) via stairs

Before primary refurbishment:
Main entrance at South elevation of Grenfell Tower

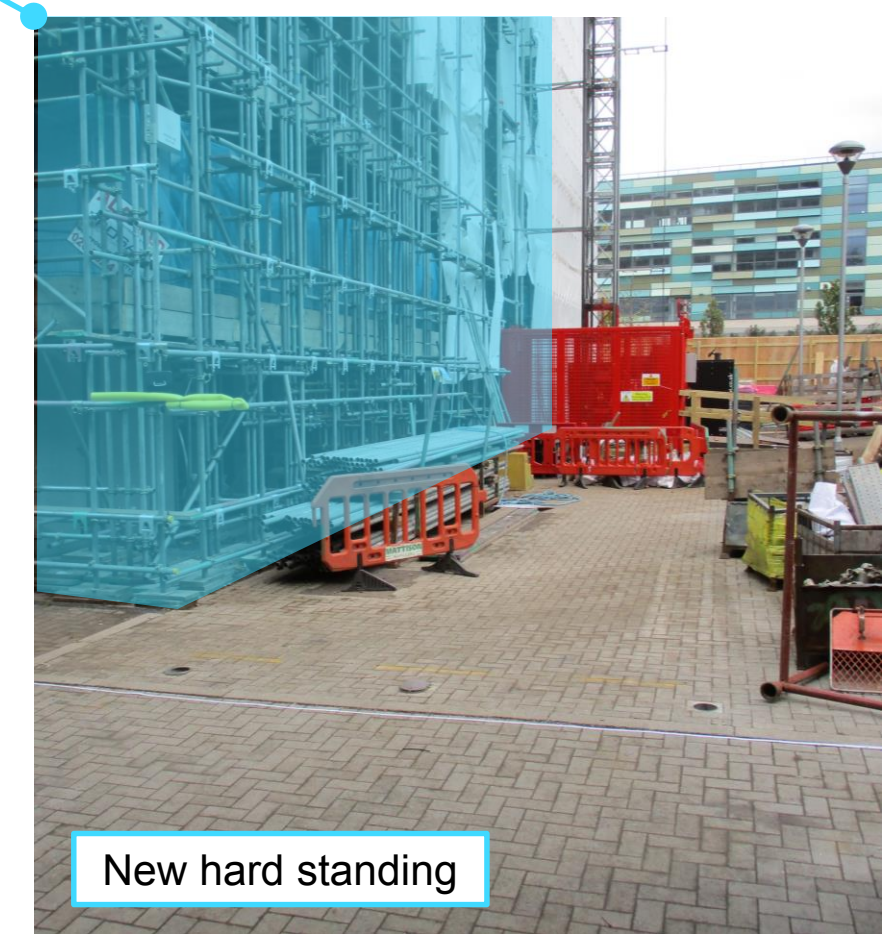
Level pedestrian access to area west of Grenfell Tower (playground)



After primary refurbishment:
Main entrance at South elevation of Grenfell Tower

Fire vehicle access after primary refurbishment

Fire vehicle access

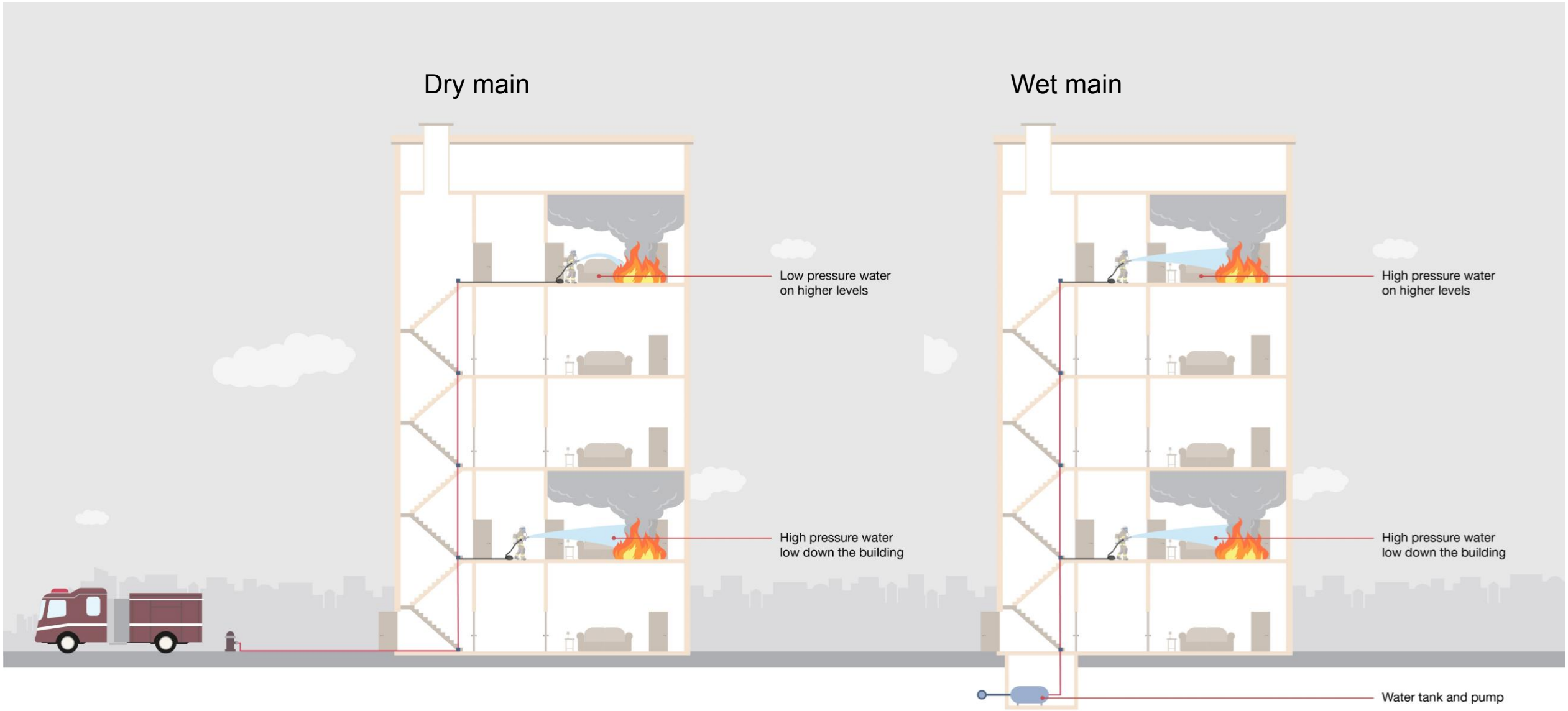


After primary refurbishment:

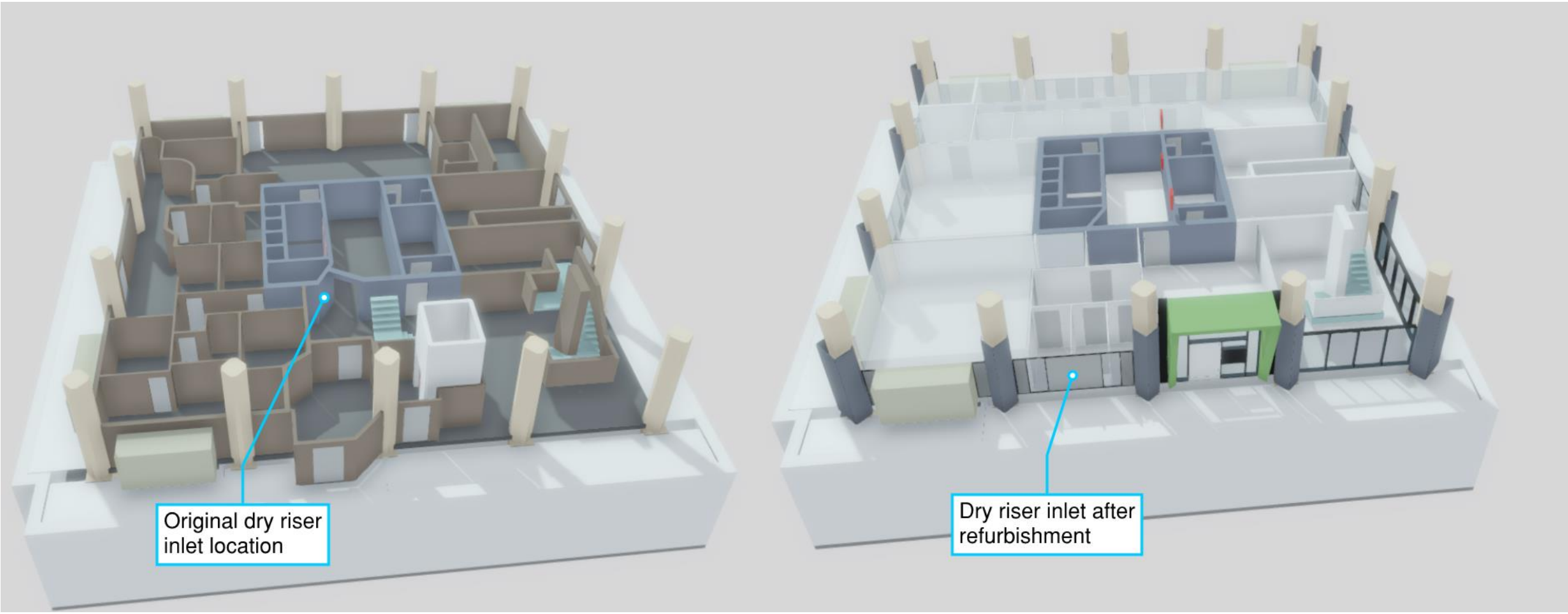
Reconfiguration of Ground Level to Level 3

Internal fire fighting main

Fire Protection Measure: Fire mains

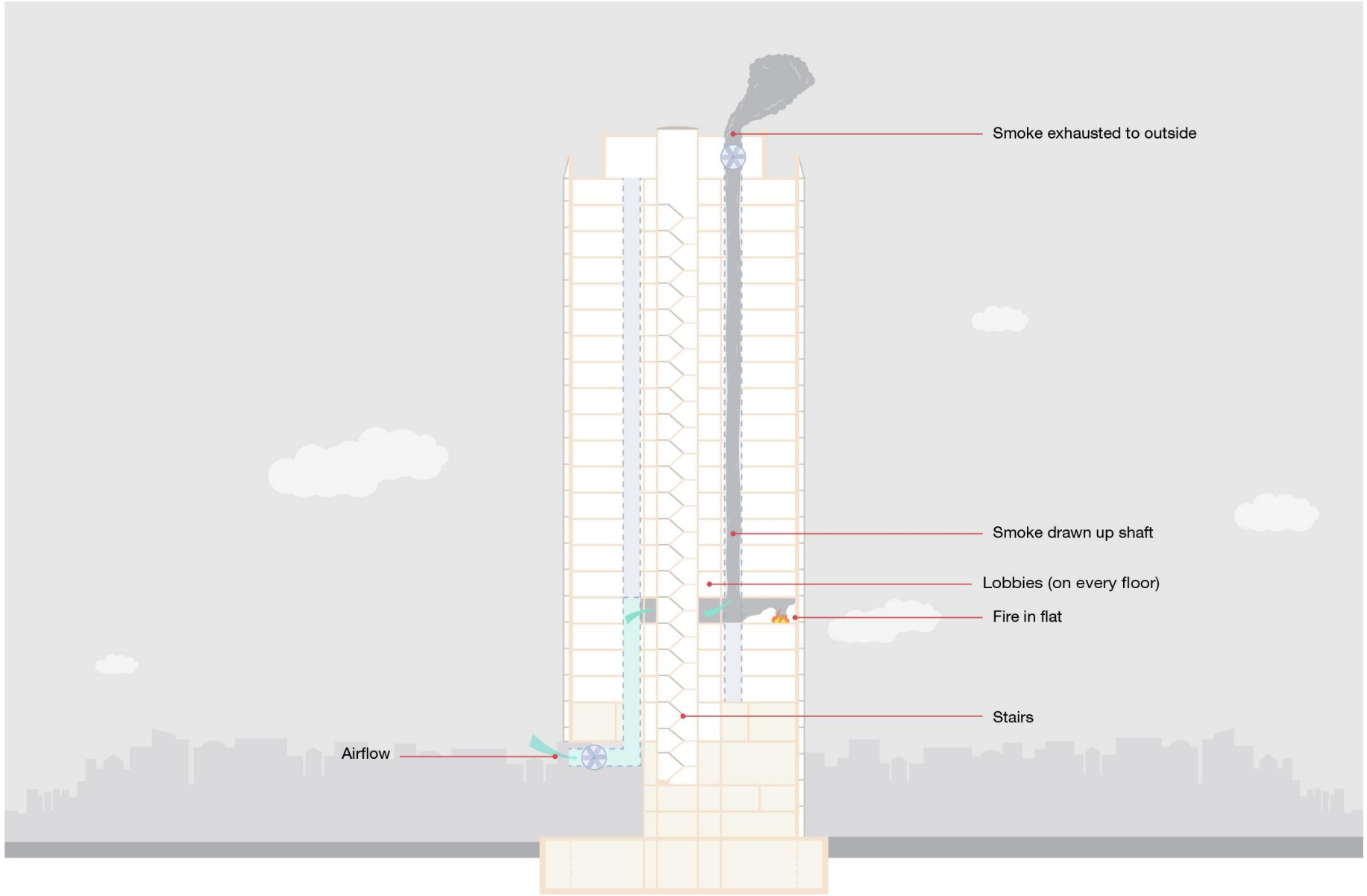


Works to dry rising main

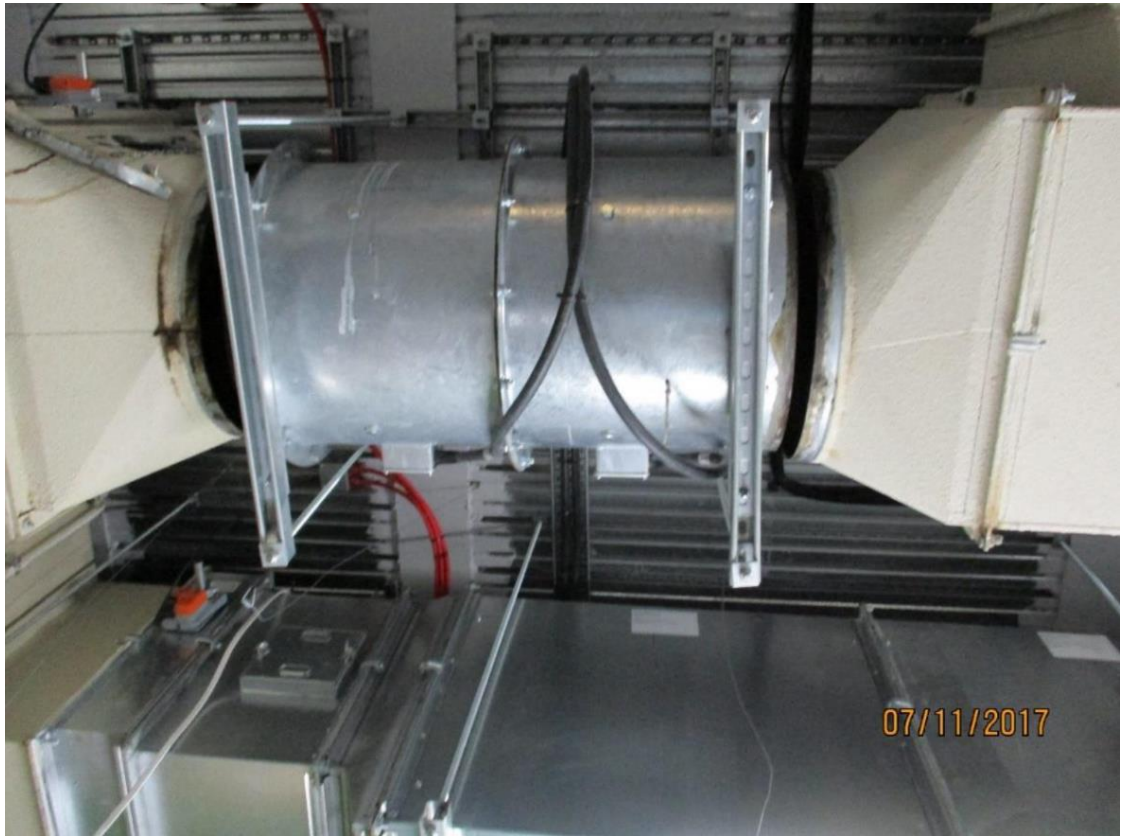


Smoke control system

Operation of original smoke control system



South Shafts – Level 2 smoke exhaust fan and vent



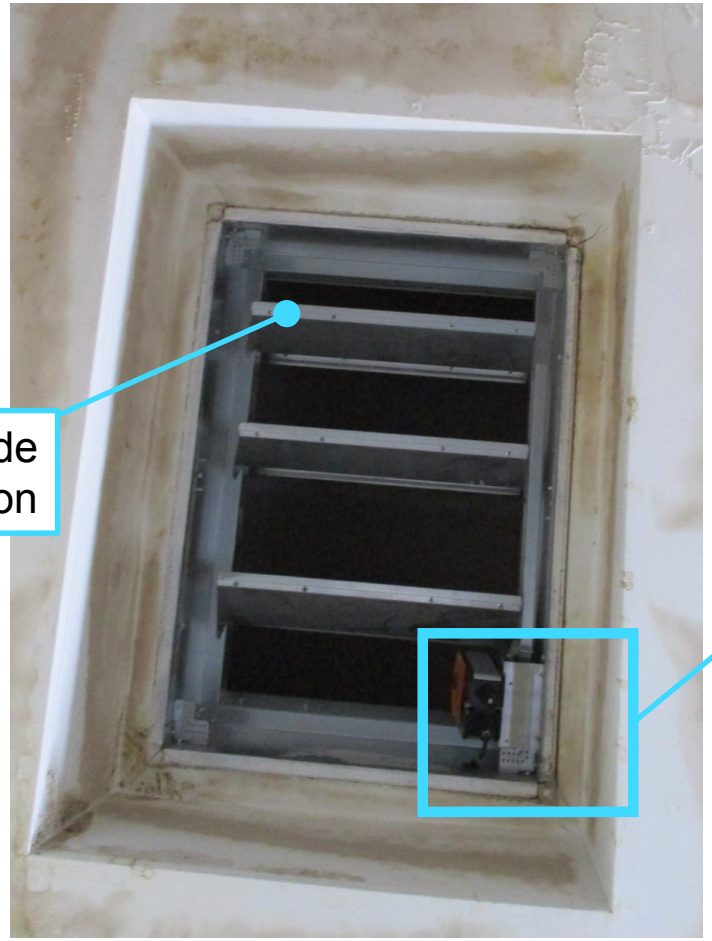
Smoke exhaust fans at Level 2

Vent on Level 2 for south smoke shaft

South Shafts – Level 2 smoke exhaust fan and vent

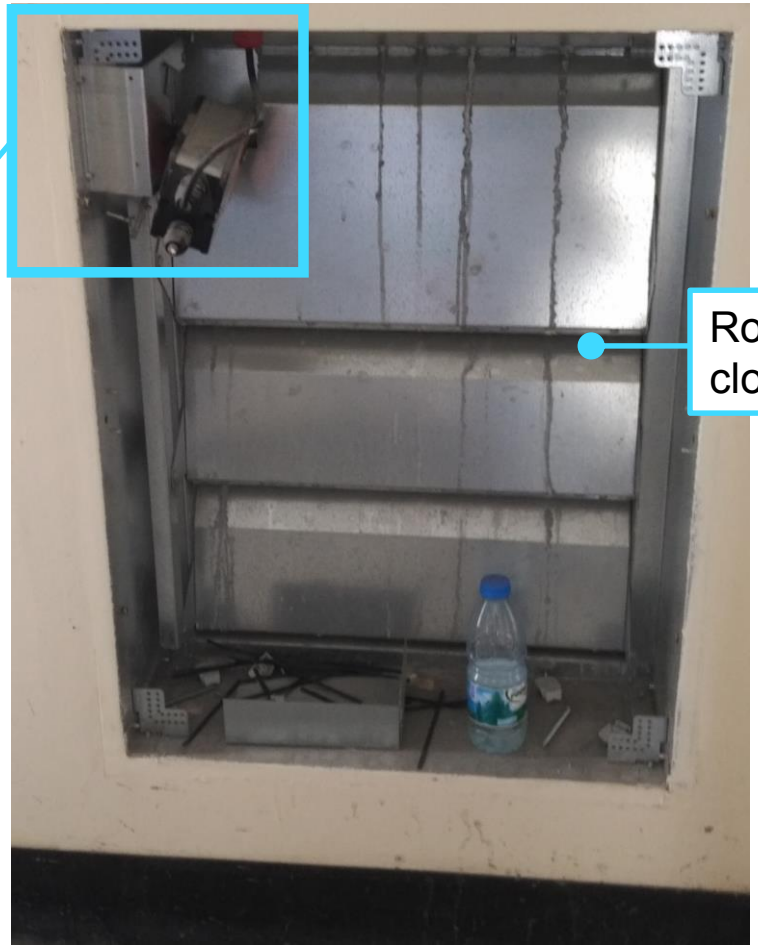
Ductwork at Level 2 for south smoke shaft

Automatic opening vents within the lobbies



Rotating blade in open position

Motor to open and close vent



Rotating blade in closed position

Rotating blade in open position

Rotating blade in closed position

North Shafts – Roof Level extract fan and vent

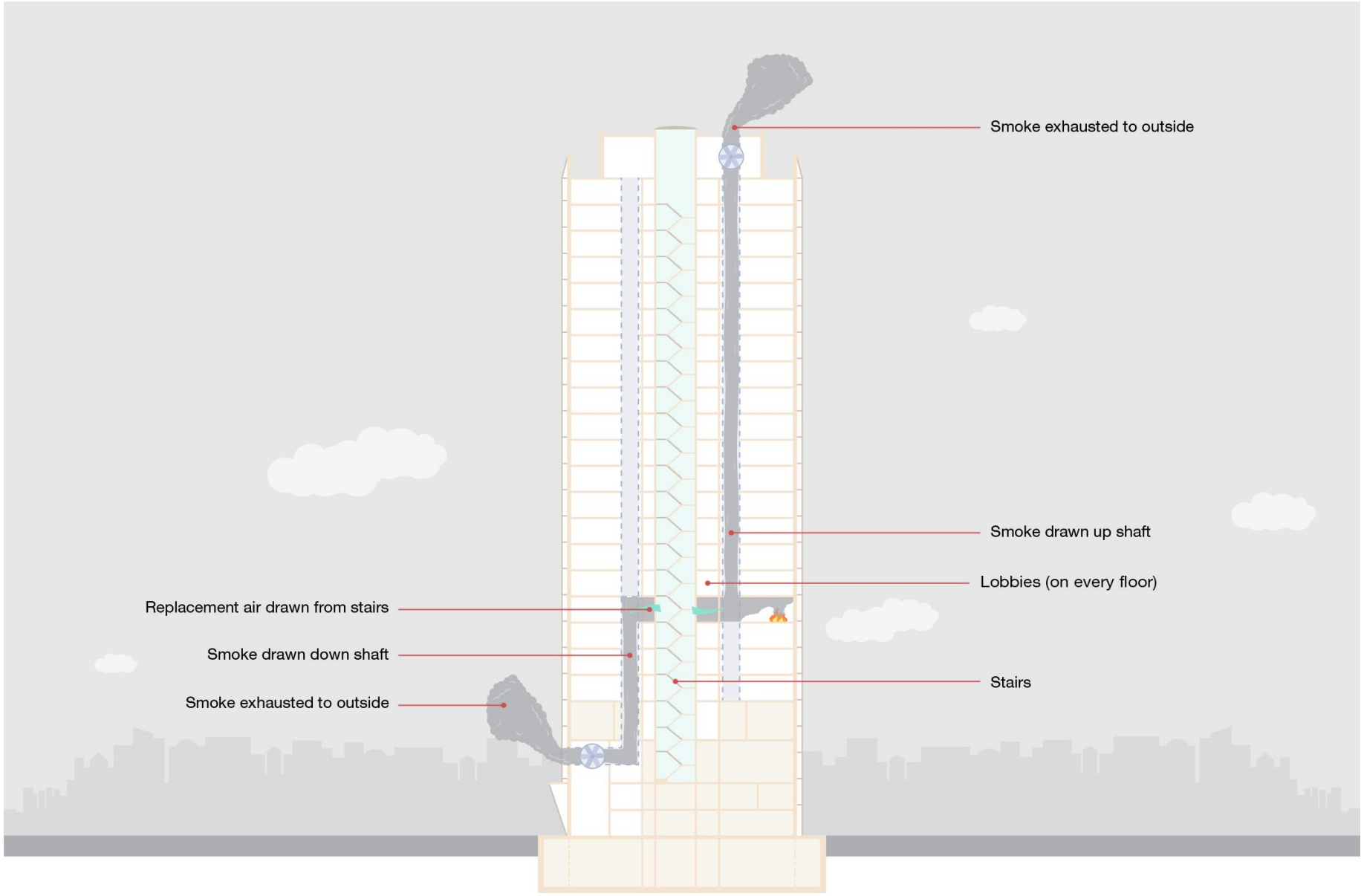
Environmental fan and smoke extraction fan in Rooftop Plant Level

Weatherproof housing/roof vent on Roof above north smoke shaft

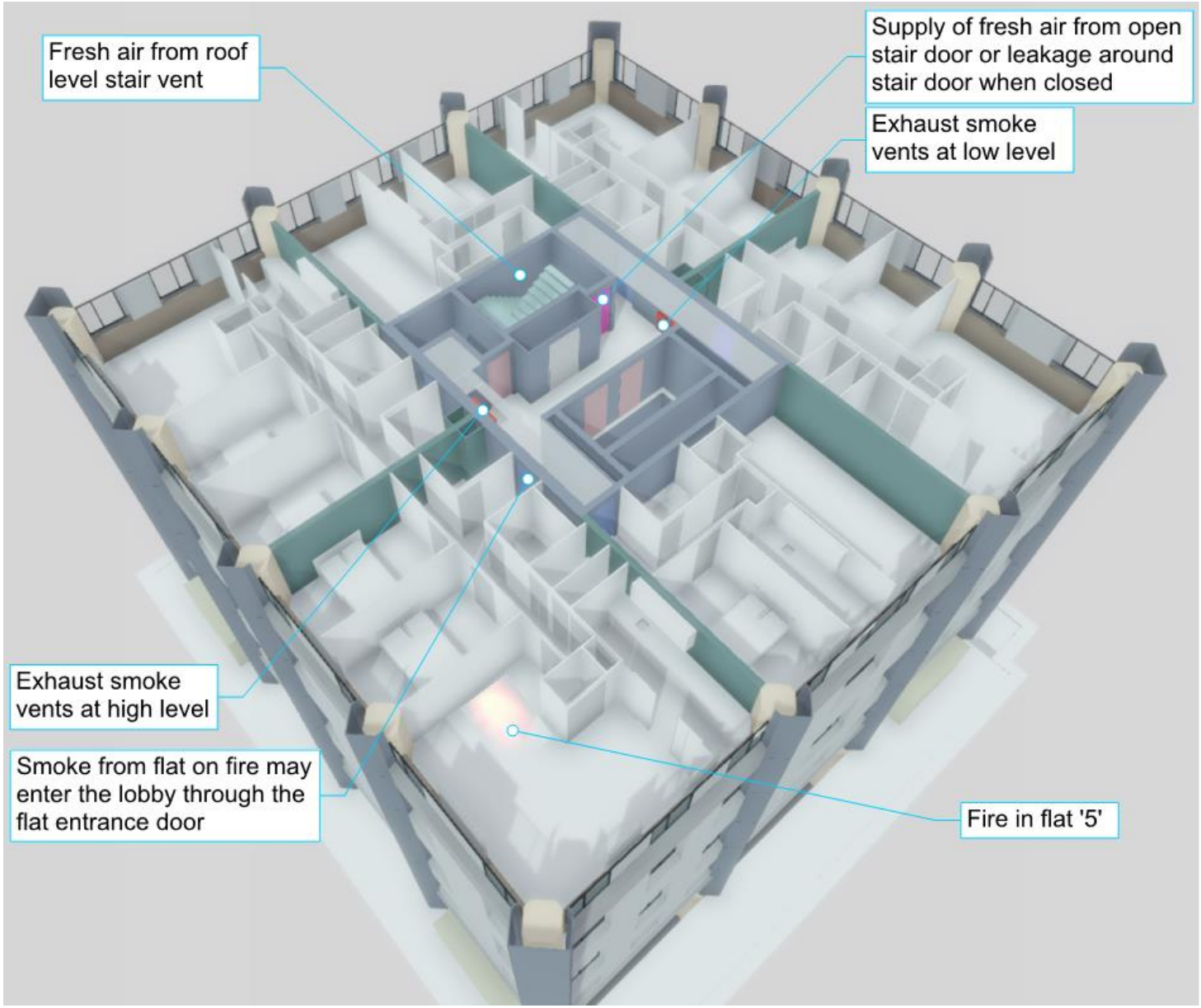
Operation of the combined lobby environmental and smoke control system

Lobby smoke detector

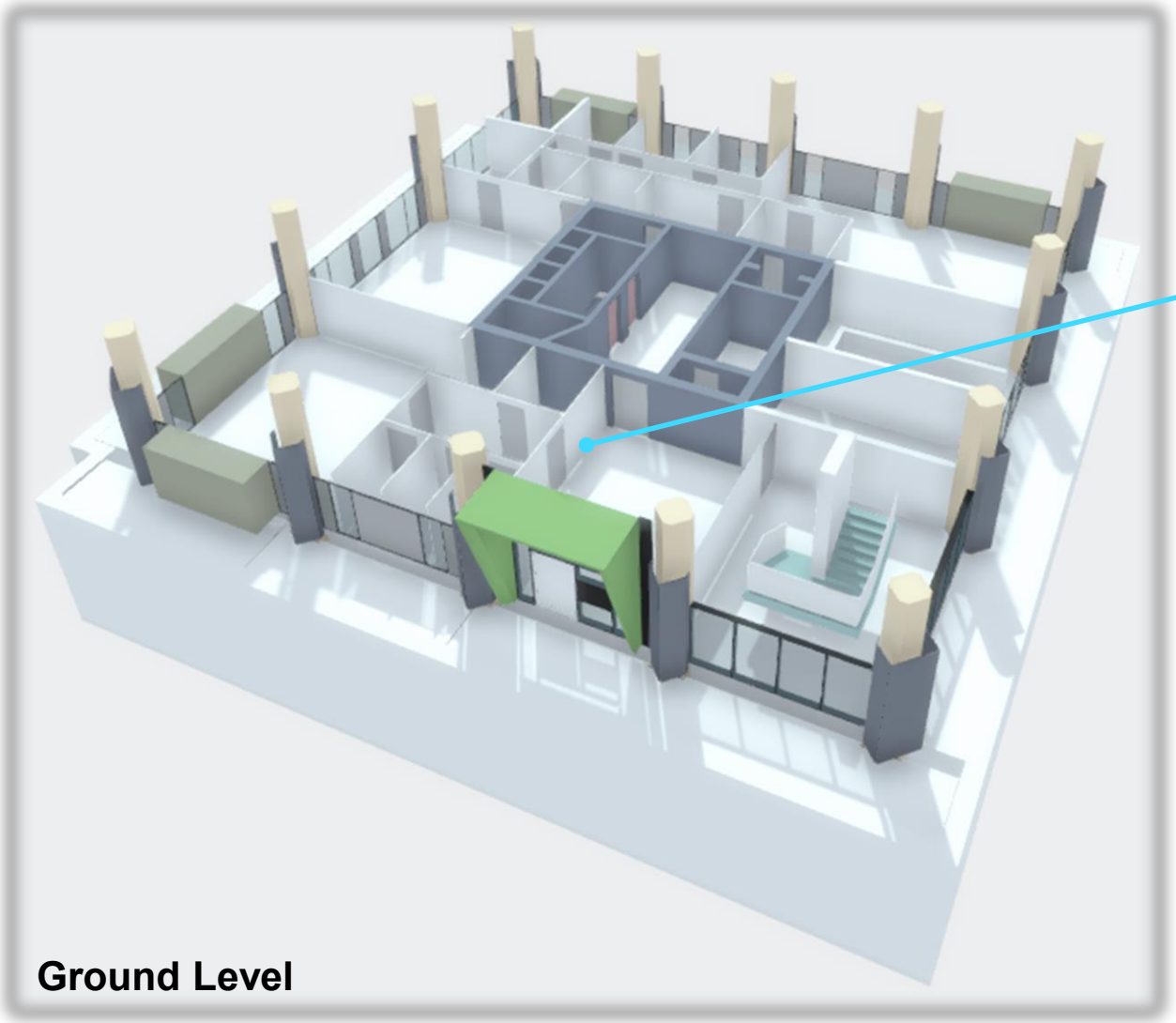
Operation of the combined lobby environmental and smoke control system



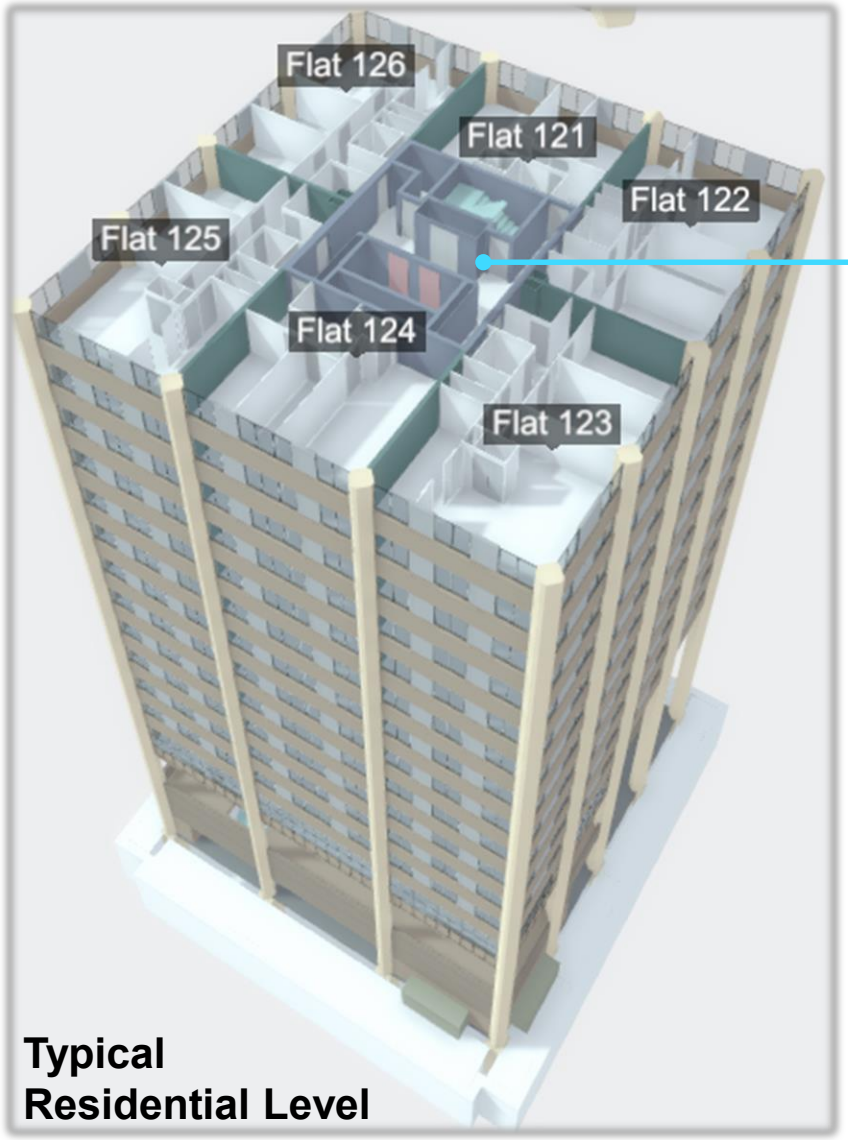
Operation of the combined lobby environmental and smoke control system



Smoke Control System – Fire fighter controls



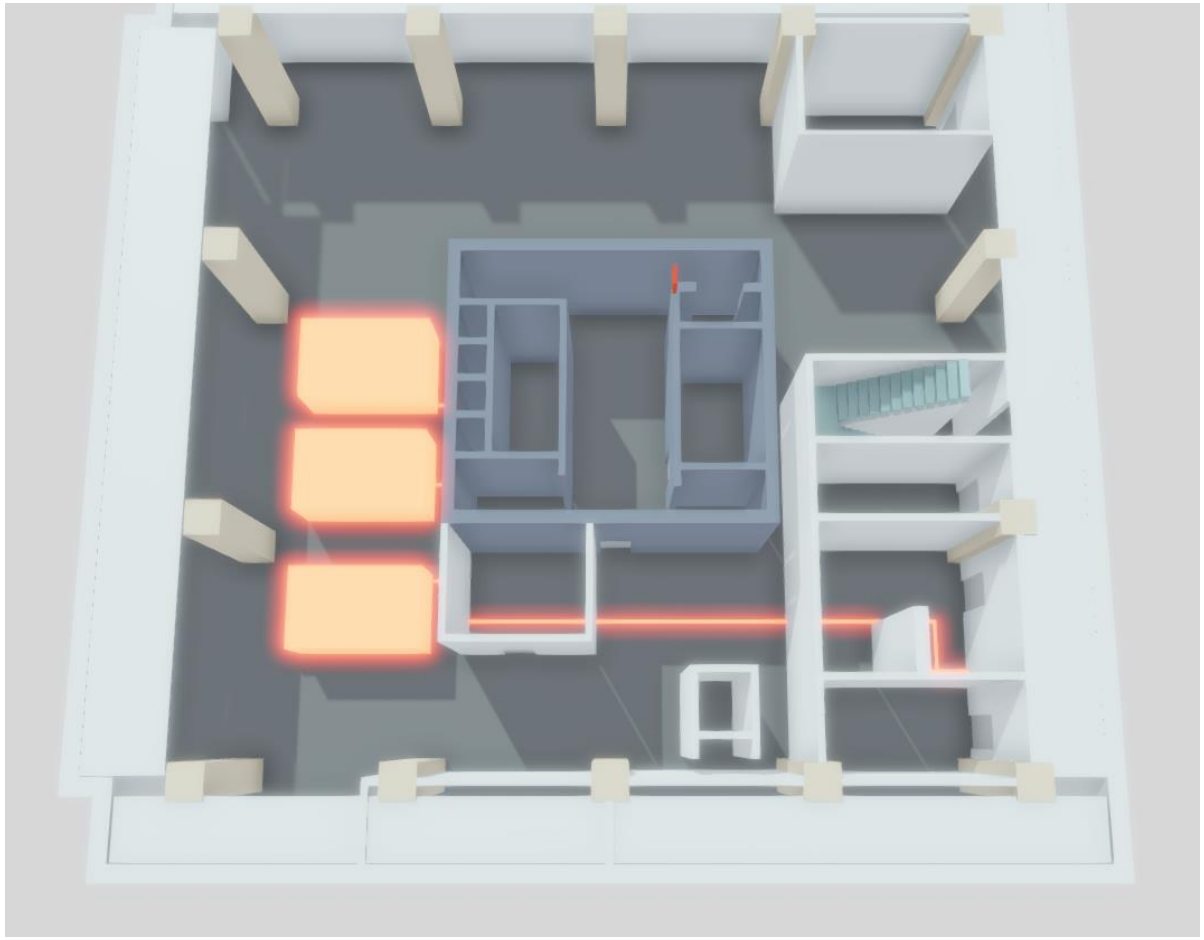
Fire Service operation



Smoke control override switch

Heating/hot water & cold water systems

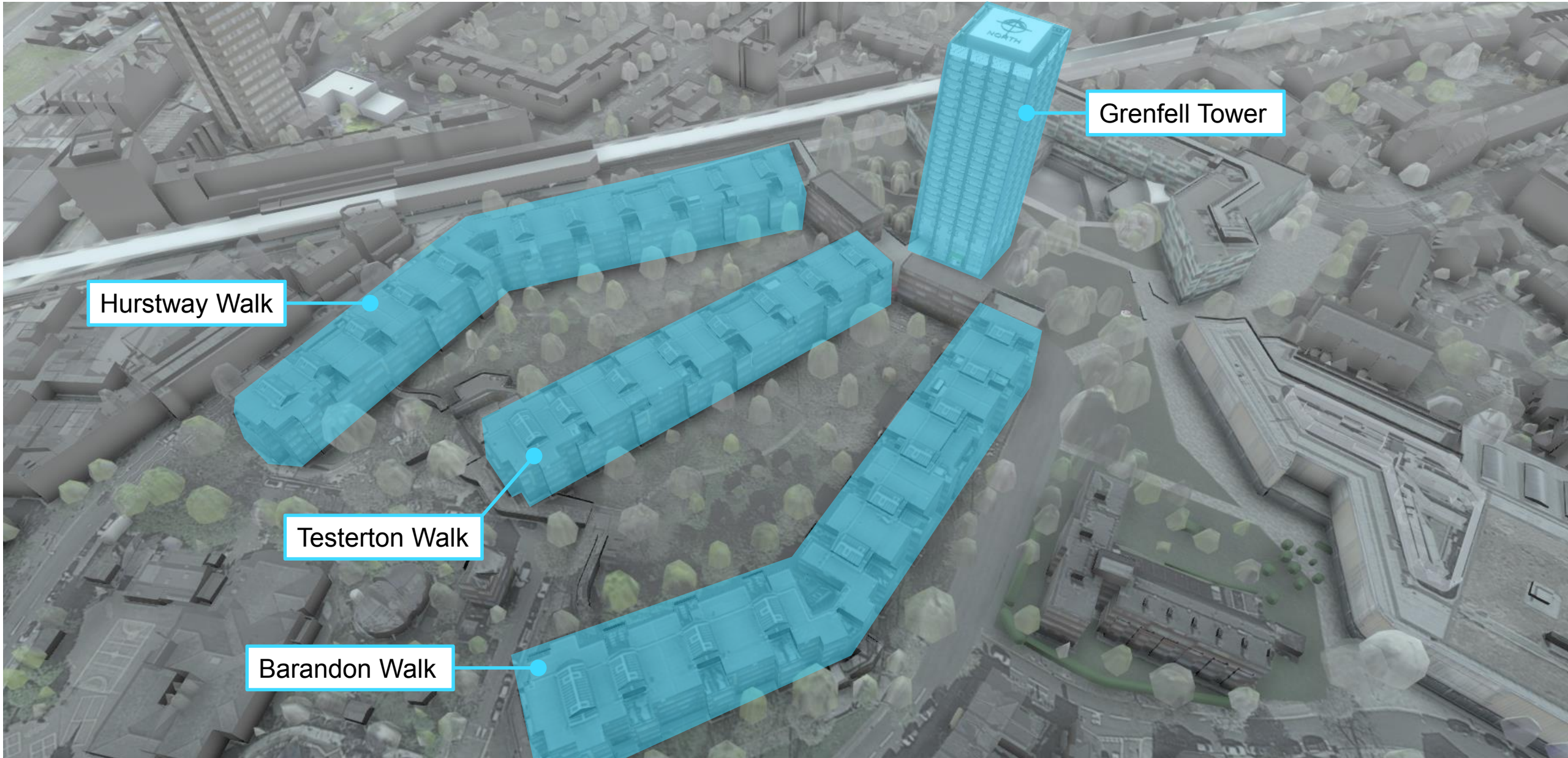
New boilers



Original boilers
and gas line

New boiler

Original boilers retained to continue serving finger flats



Cupboard in common lobbies, Levels 4 – 23

Cupboard in Level 6 lobby

New ceilings in common lobbies, Level 4 – 23

False ceilings in Level 6 lobby

Summary

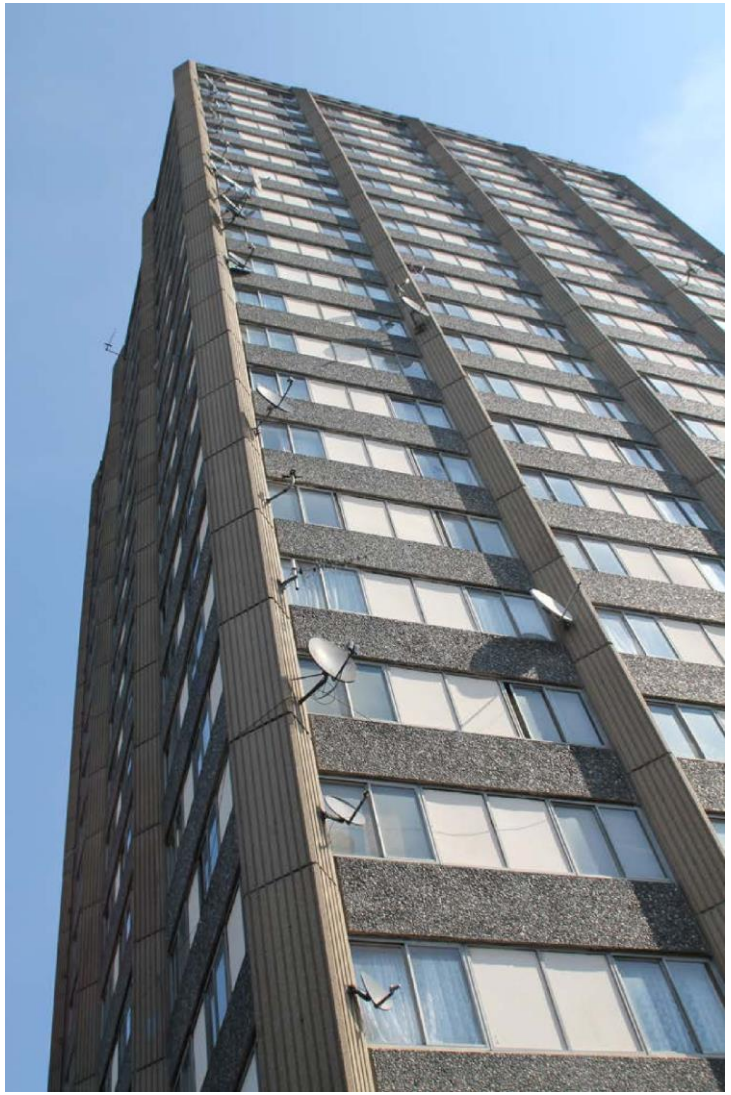
“The general scope of the project is:

- *Adaption of 2 lifts to include 2 x new doors*
- *Recladding of the façade*
- *Reconfiguration of the podium levels to provide additional residential accommodation (9 no. new flats)*
- *Relocation and refurbishment of the nursery*
- *Relocation and refurbishment of the boxing club*
- *Provision of new community room*
- *Decorations to the existing lobbies*
- *Construction of a new entrance lobby (previously an undercroft)*
- *Modifications to the MEP systems as follows:*
- *New heating system to all areas*
- *New boosted cold water distribution system to all areas*
- *Refurbishment and extension of the smoke/environmental ventilation systems*
- *Alterations to the dry riser system*
- *Alterations to the door entry system*
- *External hard & soft landscaping”*

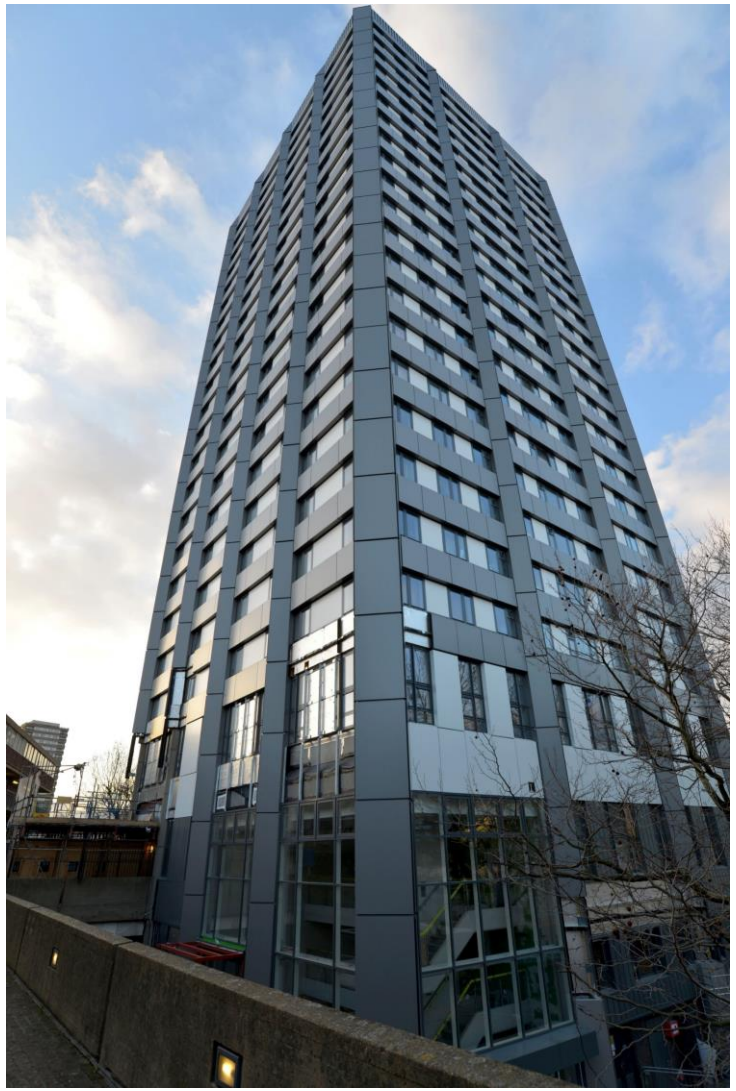
Grenfell Tower
External Wall Primary Refurbishment
2012-2016

ARUP

Recladding of the external wall during the 2012-2016 refurbishment



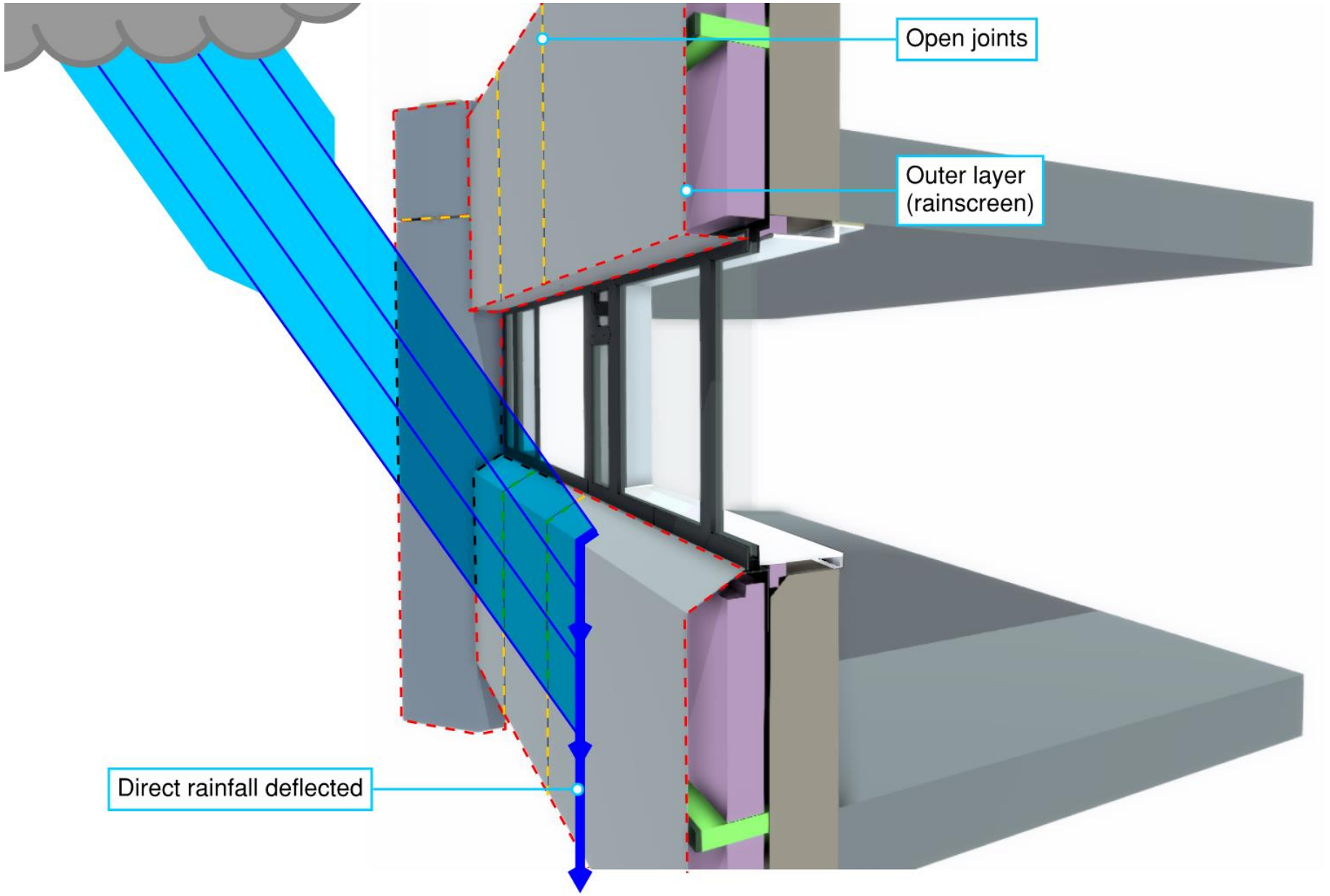
Grenfell Tower 2012



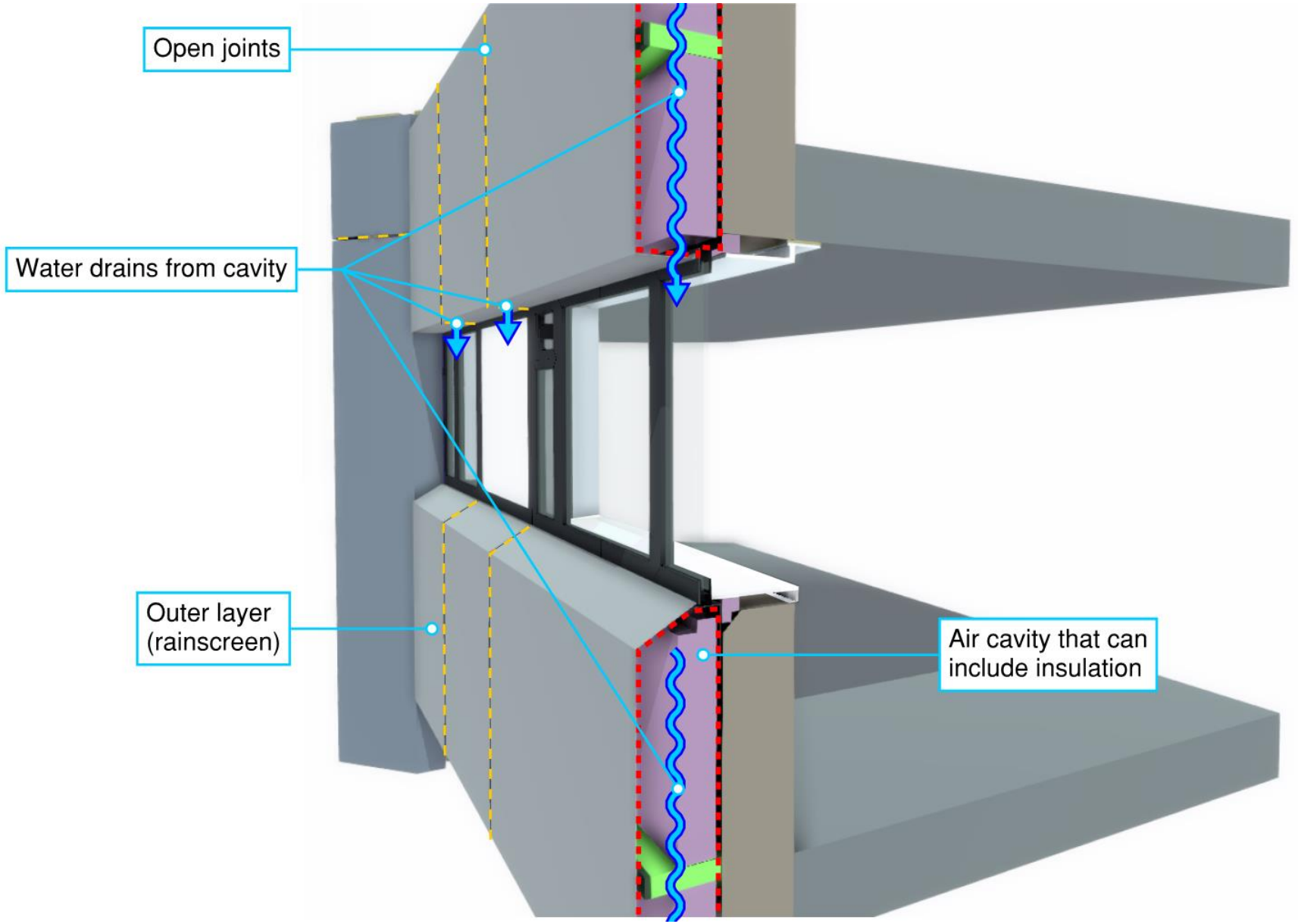
Grenfell Tower 2016

Ventilated rainscreen cladding systems

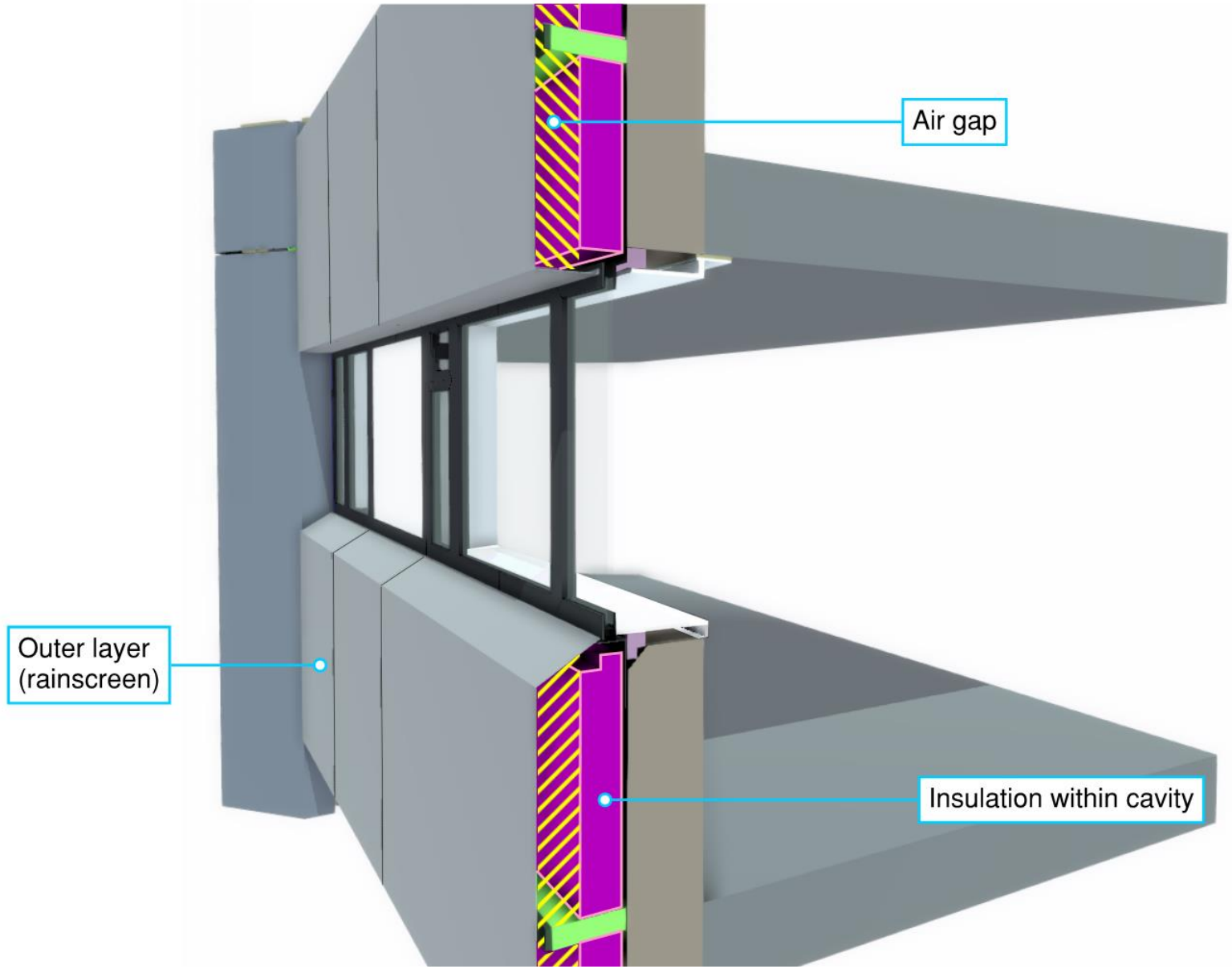
Rainscreen system: Outer layer



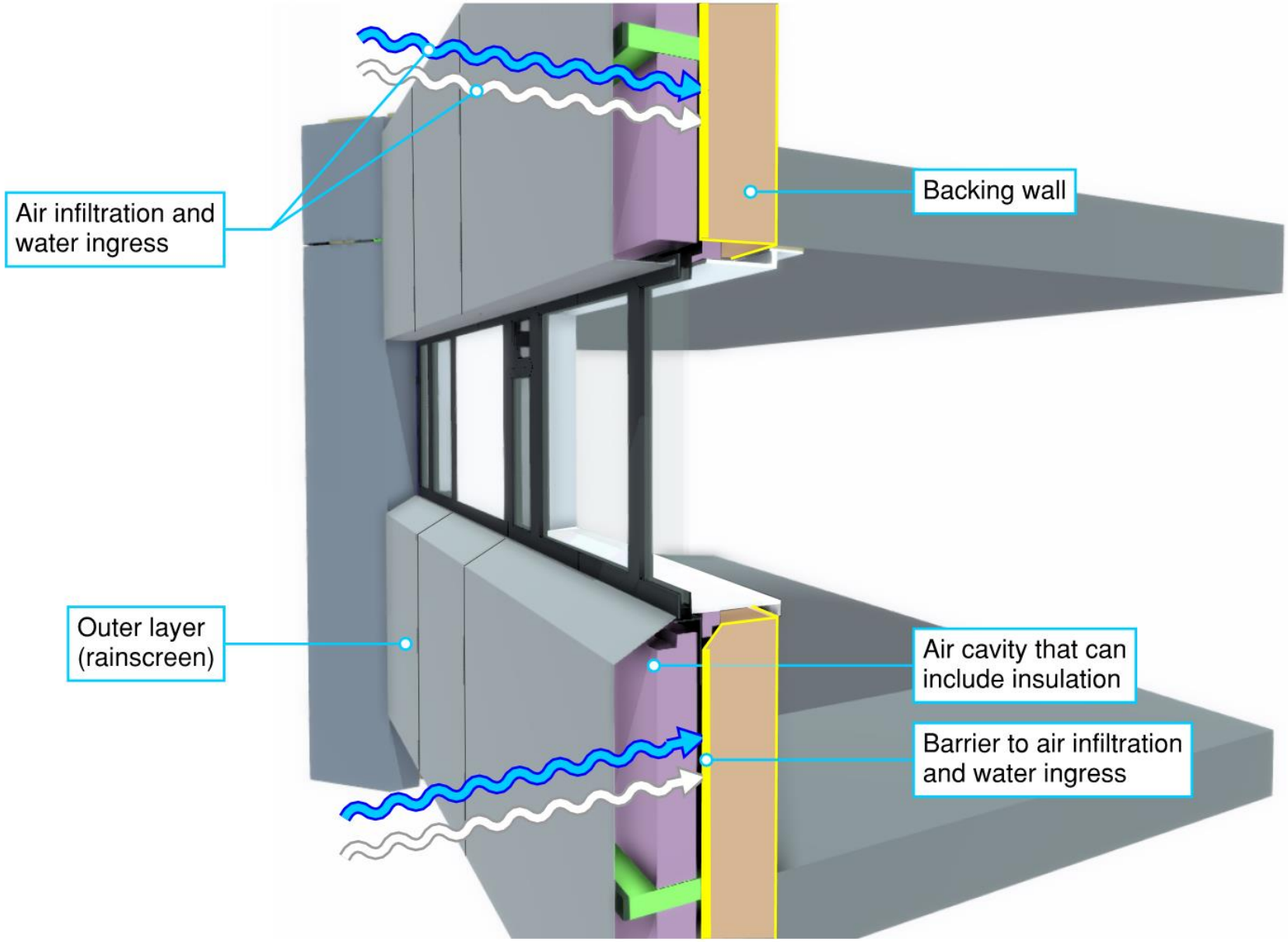
Rainscreen system: cavity



Rainscreen system: cavity insulation



Rainscreen system: backing wall



The Requirements
Regulation B4: External Fire Spread

Regulation B4 external Fire Spread

External Fire Spread

B4.—(1) 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.

(2) The roof of the building shall adequately resist the spread of fire over the roof and from one building to another, having regard to the use and position of the building.

ADB 2013 Section 12 Construction of external walls

B4.ii Provisions are made in Section 12 for the fire resistance of external walls and to limit the susceptibility of the external surface of walls to ignition and to fire spread.

ADB 2013 Section 12.5 External Wall Construction

External wall construction

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.

Externall walls should either meet the guidance given in paragraphs 12.6 to 12.9 or meet the performance criteria given in the BRE Report *Fire performance of external thermal insulation for walls of multi storey buildings* (BR 135) for cladding systems using full scale test data from BS 8414-1:2002 or BS 8414-2:2005.

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).

ADB 2013 Section 12.5 External wall construction

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ADB 2013 Section 12.5 External wall construction

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also be limited in practice by the provisions for space separation in Section 13 (see paragraph 13.7 onwards).

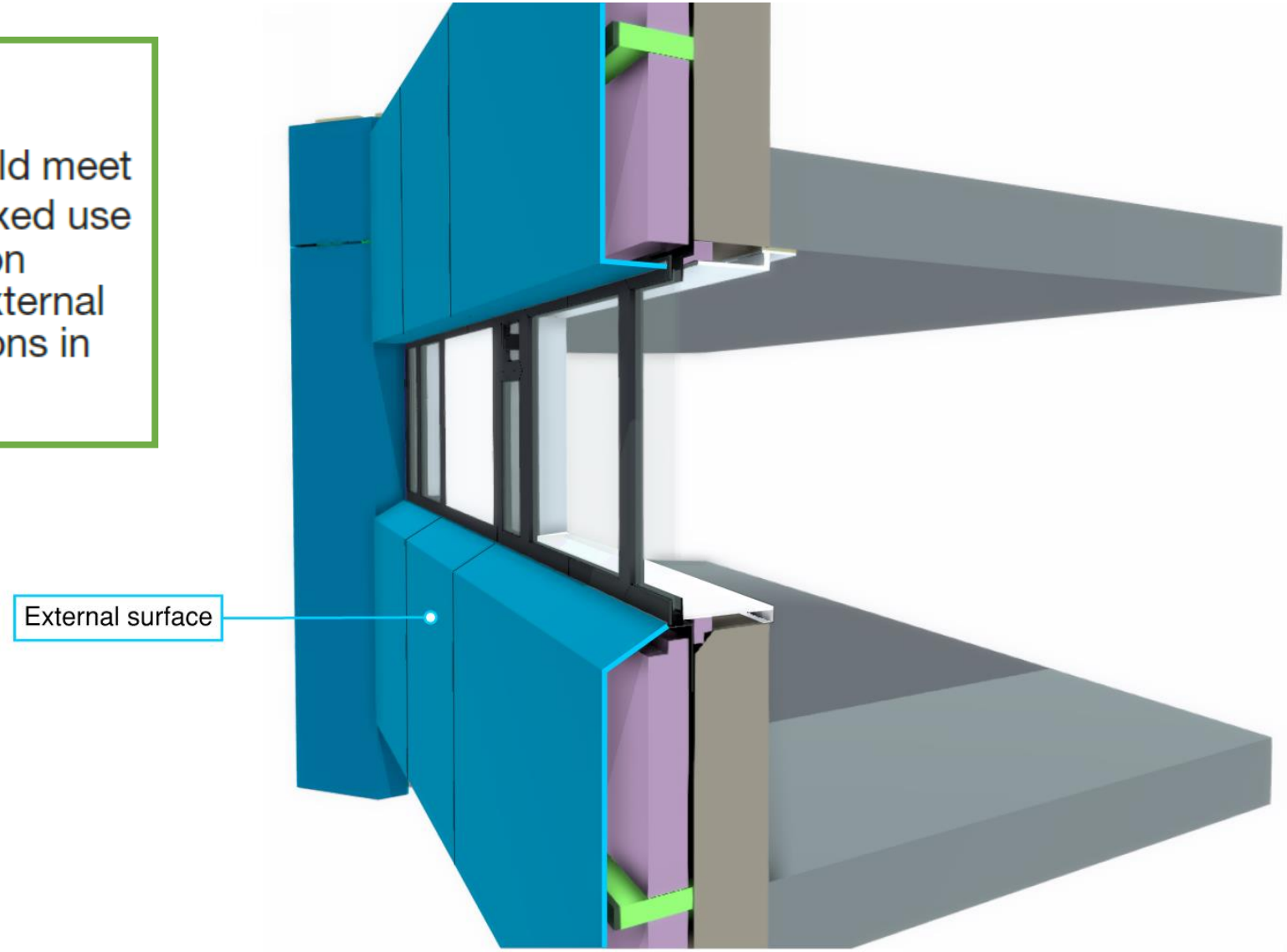
Provisions for external wall construction

ADB 12.6 -12.9

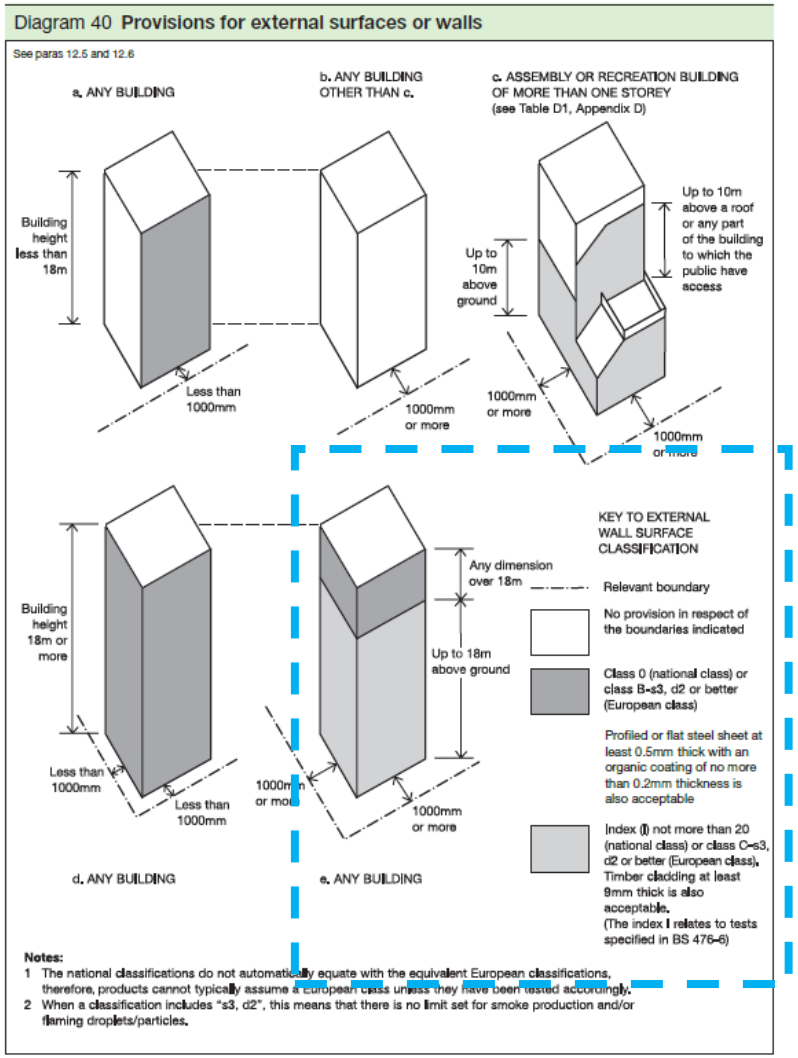
ADB 2013 Paragraph 12.6 External Surfaces

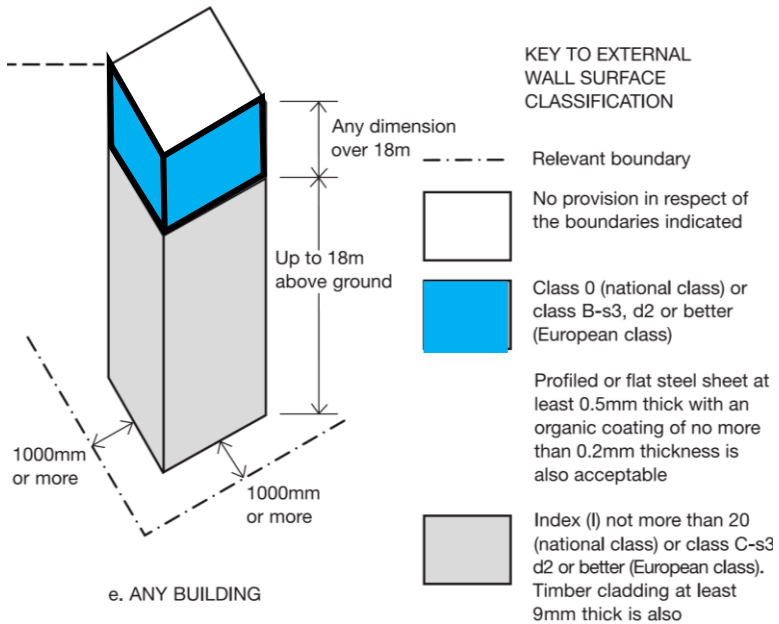
External surfaces

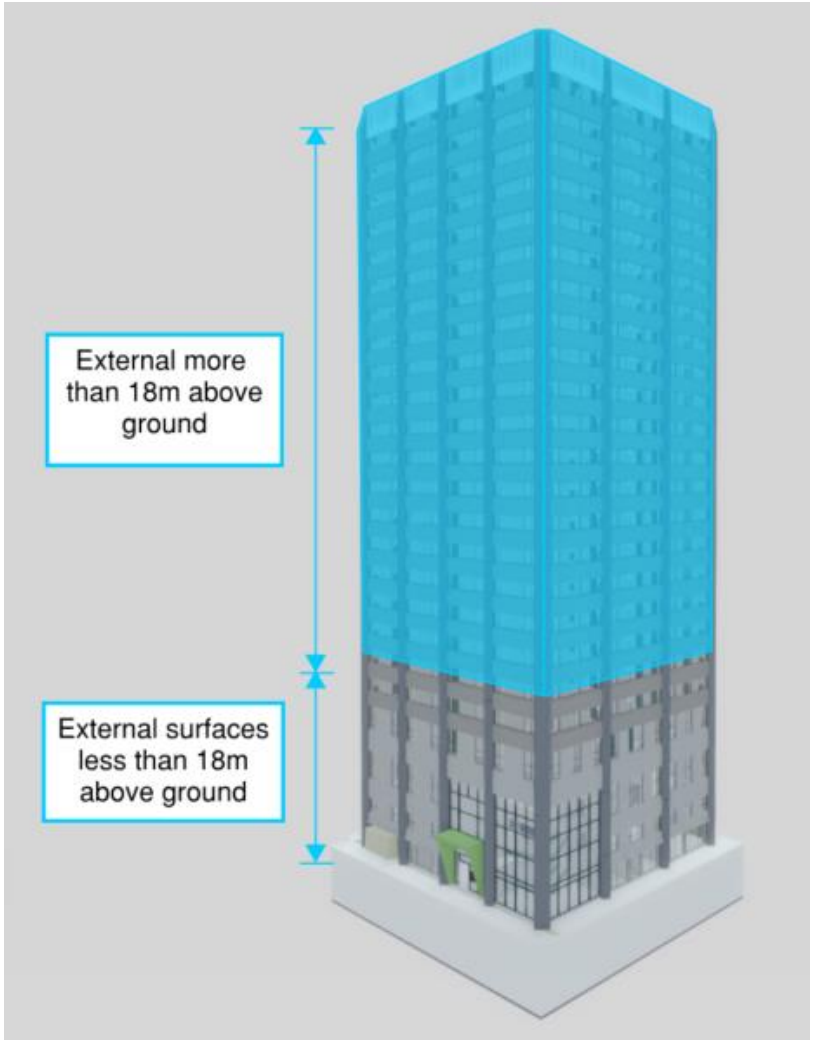
12.6 The external surfaces of walls should meet the provisions in Diagram 40. Where a mixed use building includes Assembly and Recreation Purpose Group(s) accommodation, the external surfaces of walls should meet the provisions in Diagram 40c.



ADB 2013 Paragraph 12.6 External surfaces and Diagram 40



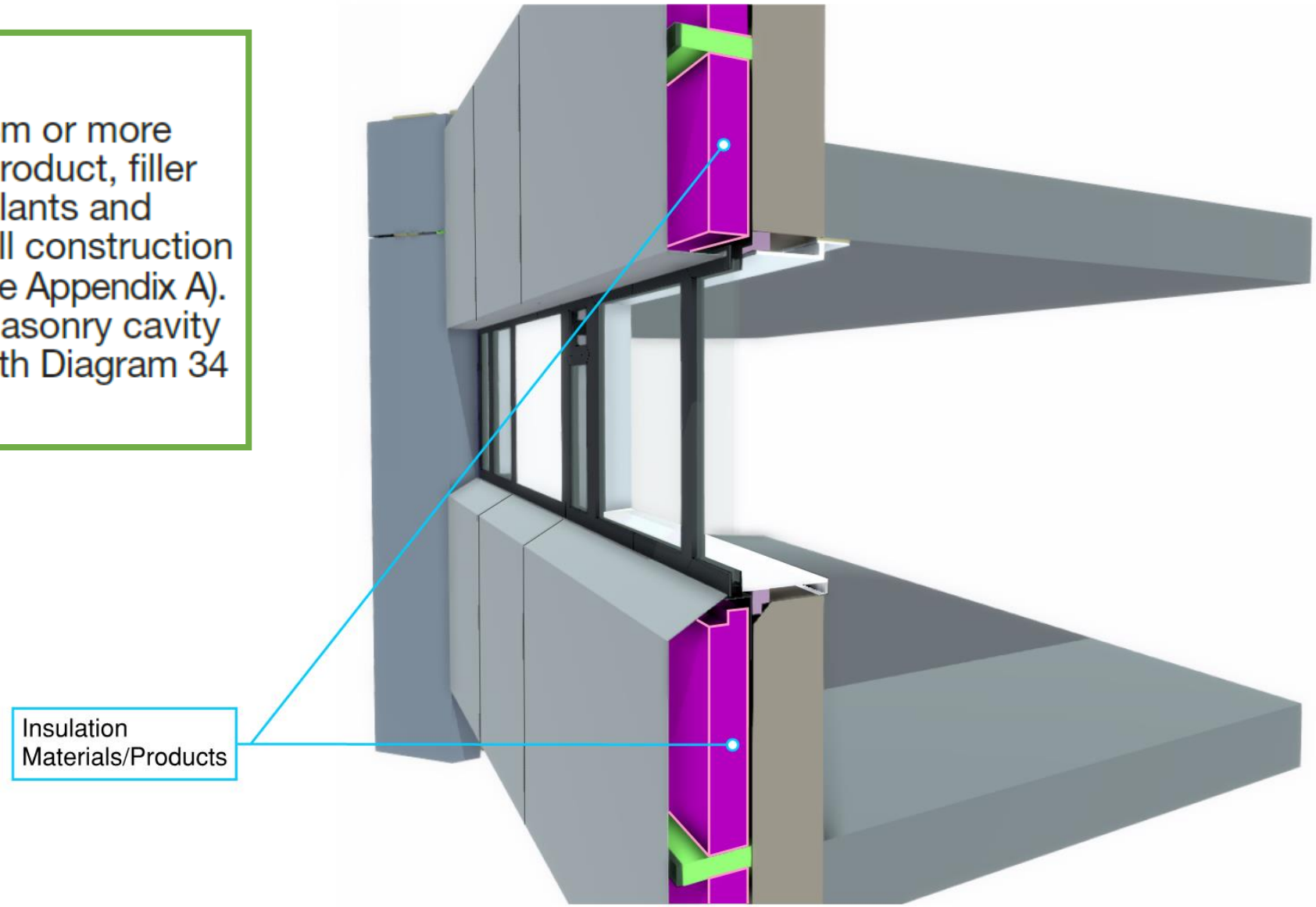




ADB 2013 Paragraph 12.7 Insulation Materials/Products

Insulation Materials/Products

12.7 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.

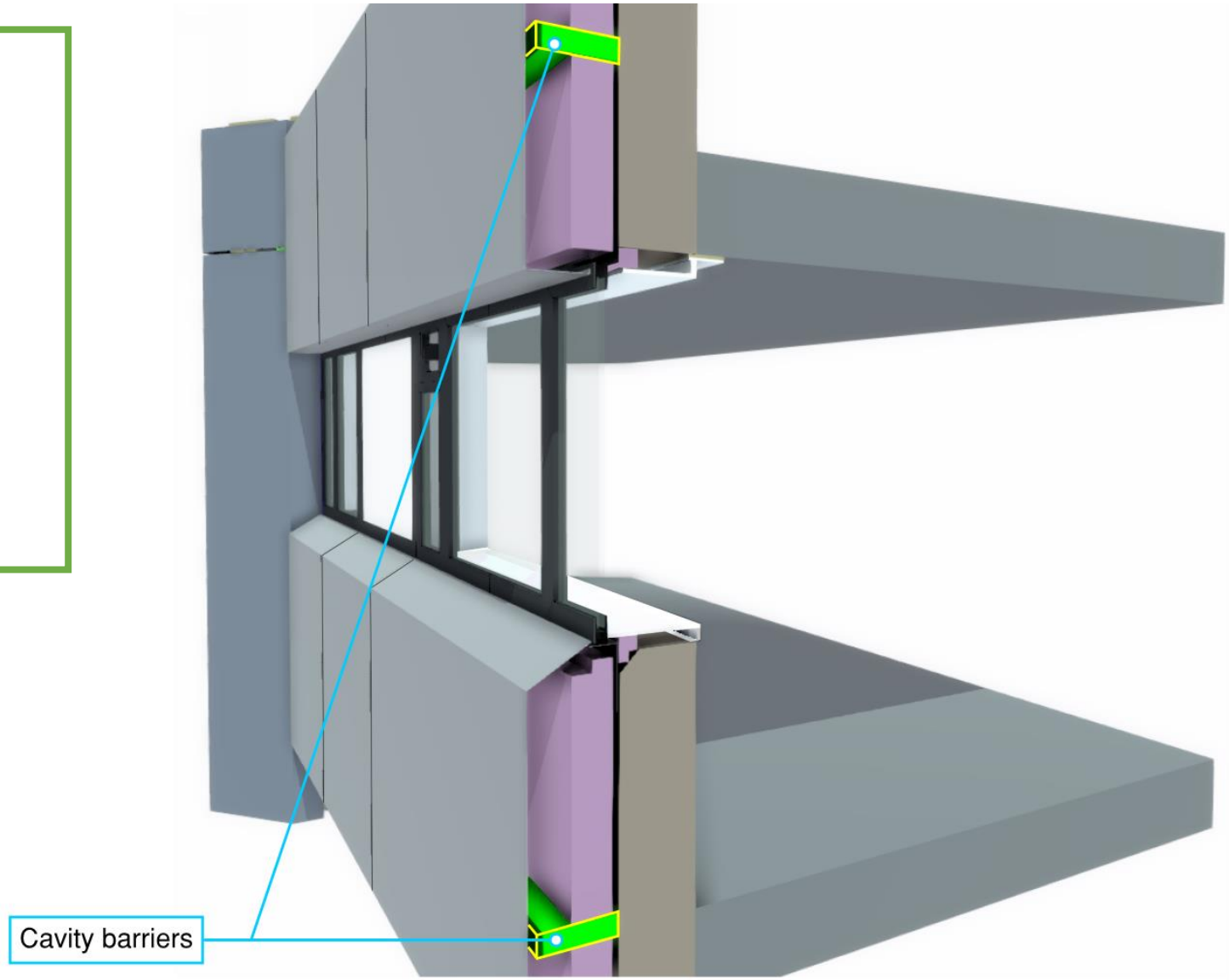


ADB 2013 Paragraph 12.8 and 12.9 Cavity Barriers

Cavity barriers

12.8 Cavity barriers should be provided in accordance with Section 9.

12.9 In the case of a 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.



ADB 2013 The rules for cavity barriers in external walls (residential)

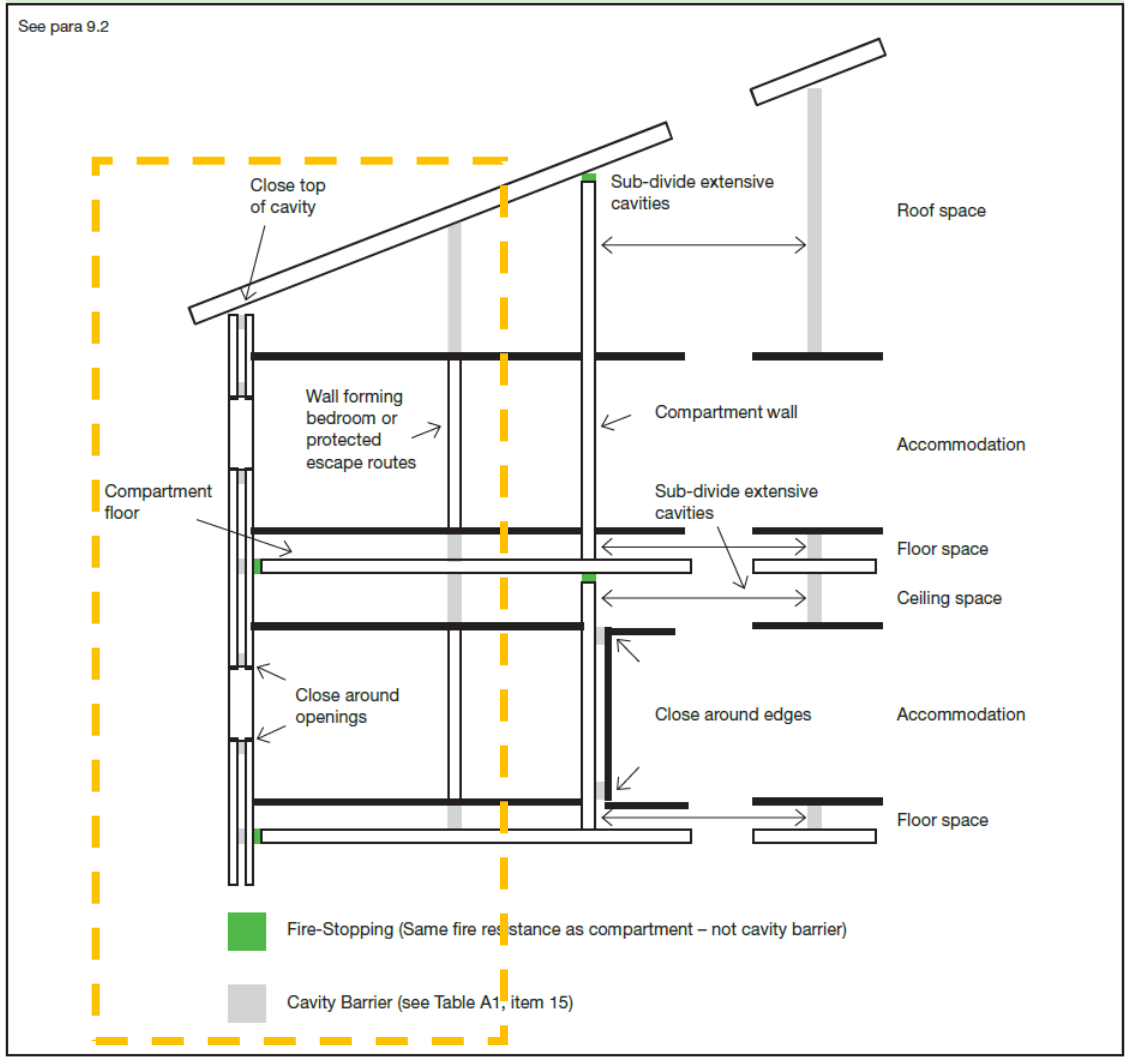
Provision of cavity barriers

9.2 Provisions for cavity barriers are given below for specified locations. The provisions necessary to restrict the spread of smoke and flames through cavities are broadly for the purpose of sub-dividing:

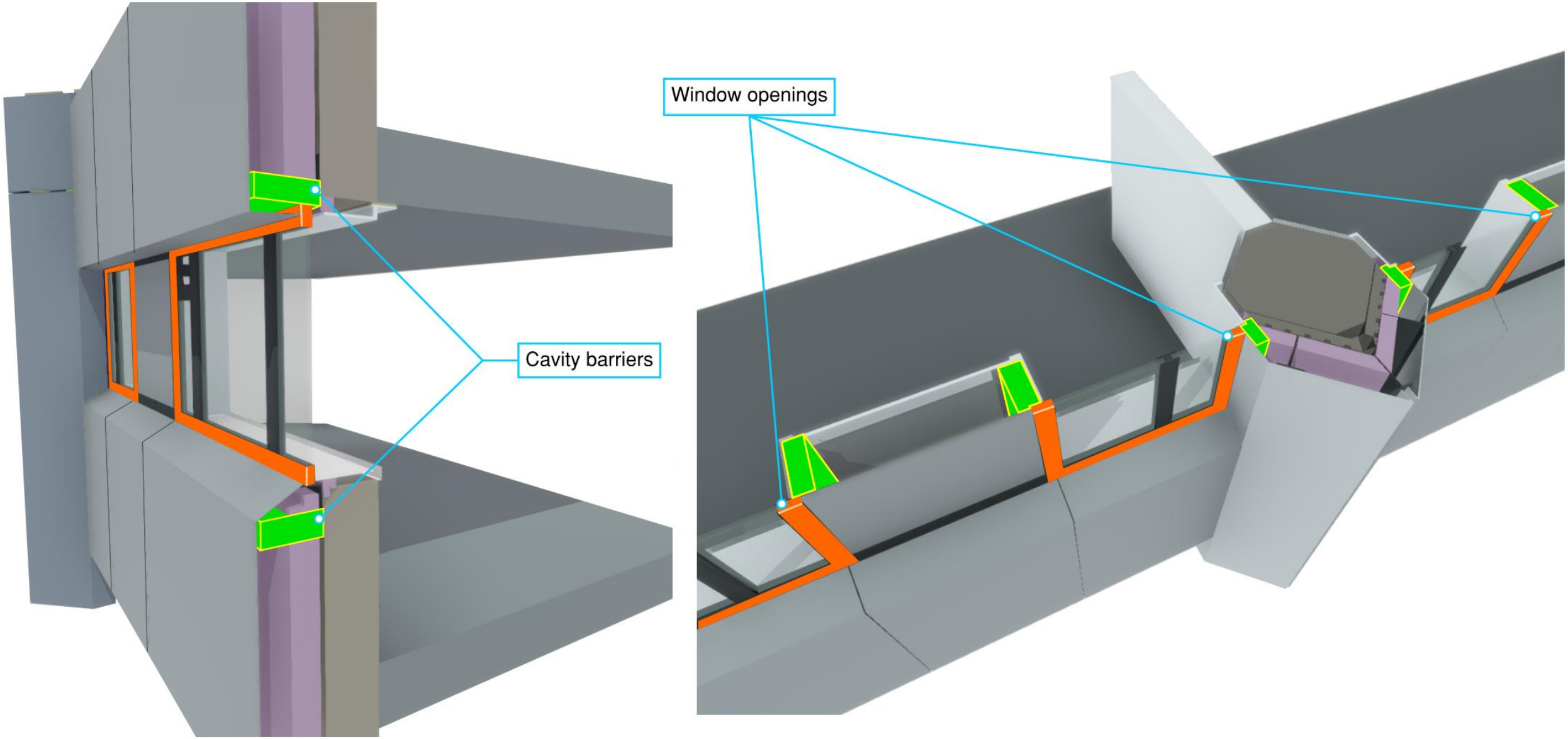
a. cavities, which could otherwise form a pathway around a fire-separating element and closing the edges of cavities; therefore reducing the potential for unseen fire spread; and

Note: These should not be confused with fire-stopping details, see Section 10 and Diagram 33 (see also paragraphs 9.3 to 9.7).

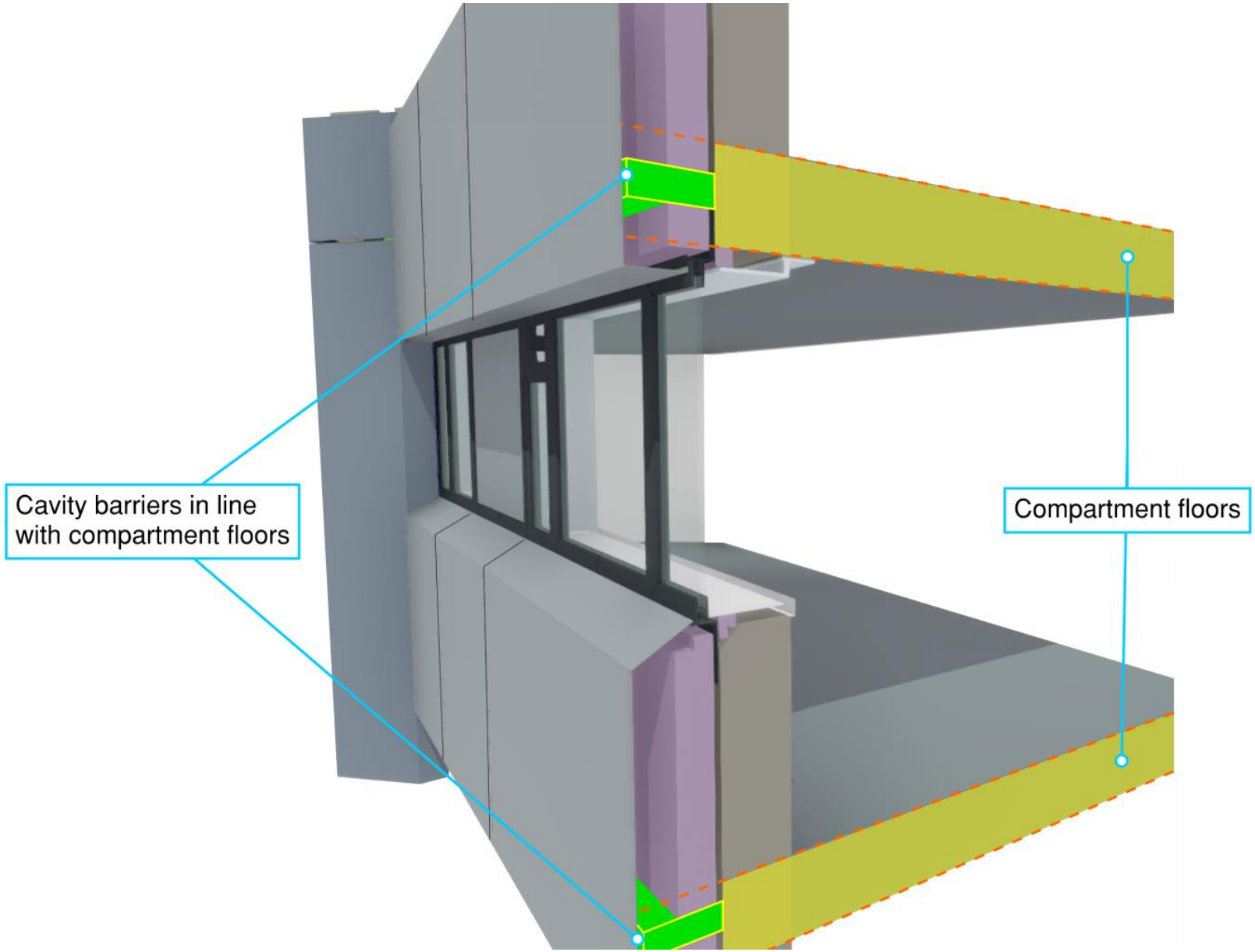
Diagram 33 **Provisions for cavity barriers**



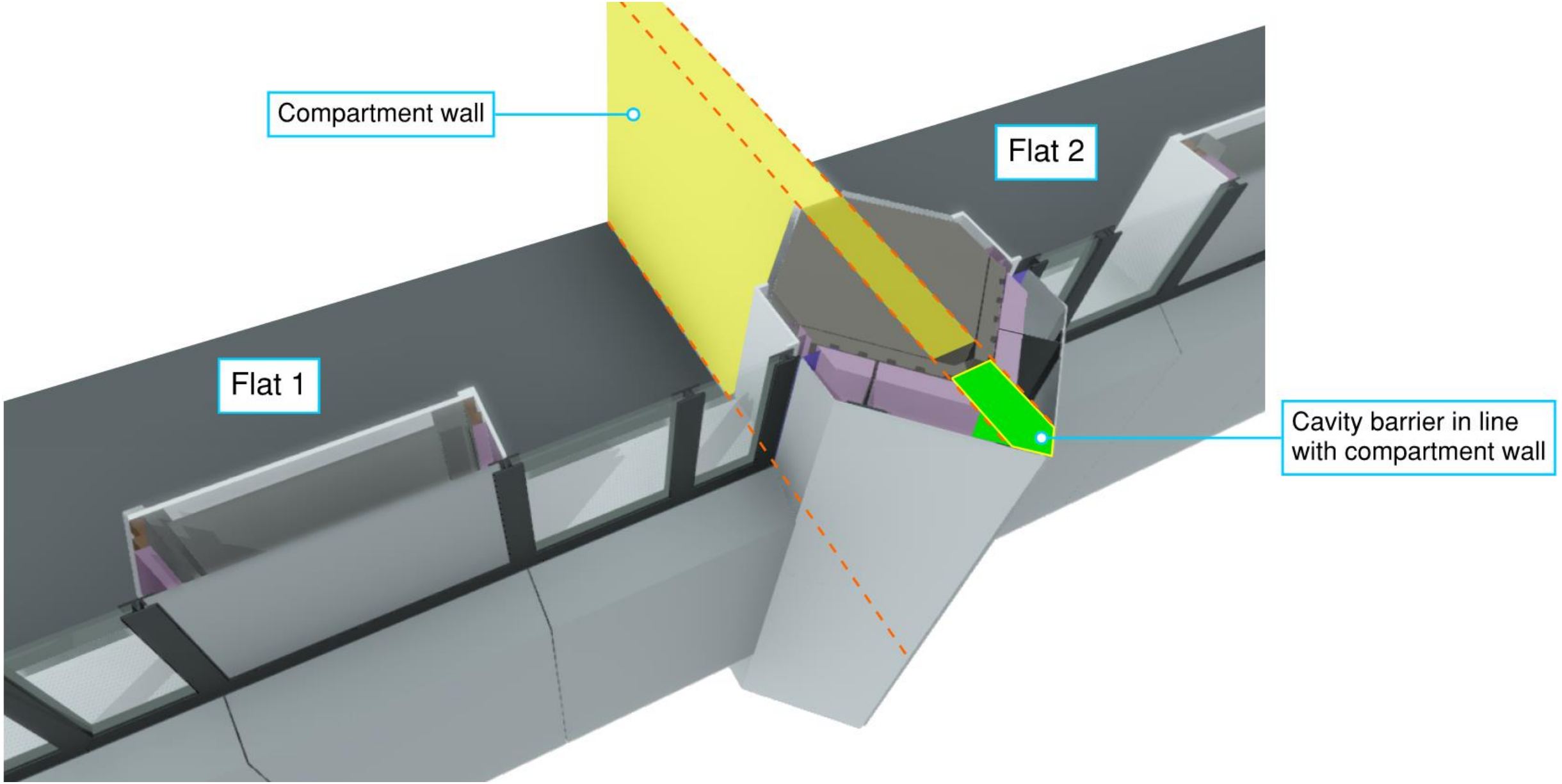
ADB 2013 Cavity barriers to close openings



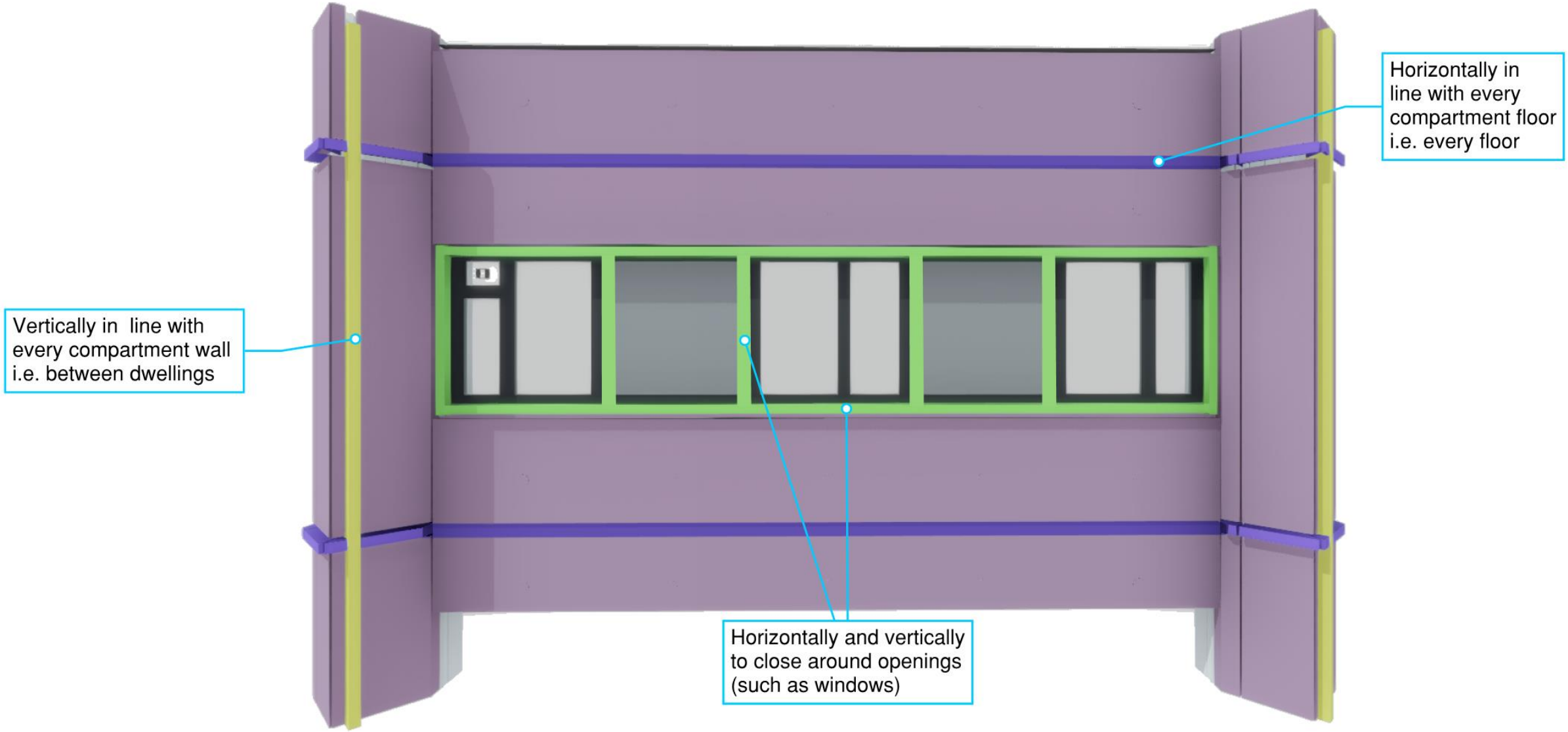
ADB 2013 Cavity barriers at compartment floors



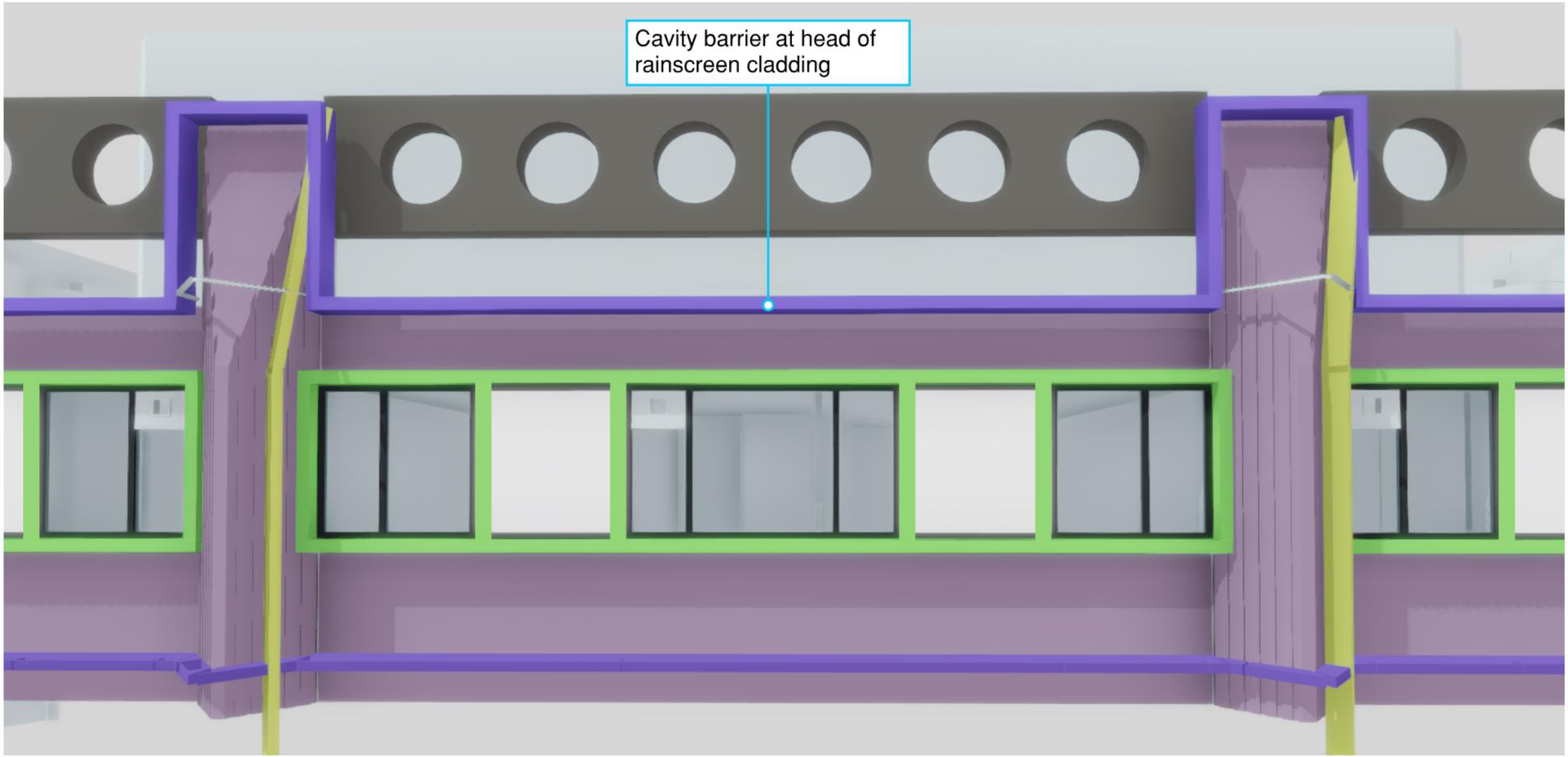
ADB 2013 Cavity barriers at compartment walls



ADB 2013 Cavity barrier provisions (summary)



ADB 2013 cavity barriers to close the top of the cavity



ADB 2013 Section 9 Construction and fixings for cavity barriers

Construction and fixings for cavity barriers

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 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.

Note: Cavity barriers provided around openings may be formed by the window or door frame if the frame is constructed of steel or timber of the minimum thickness in a) or b) above as appropriate.

9.14 A cavity barrier should, wherever possible, be tightly fitted to a rigid construction and mechanically fixed in position. Where this is not possible (for example, in the case of a junction with slates, tiles, corrugated sheeting or similar materials) the junction should be fire-stopped. Provisions for fire-stopping are set out in Section 10.

ADB 2013 Section 10 Protection of openings and fire stopping

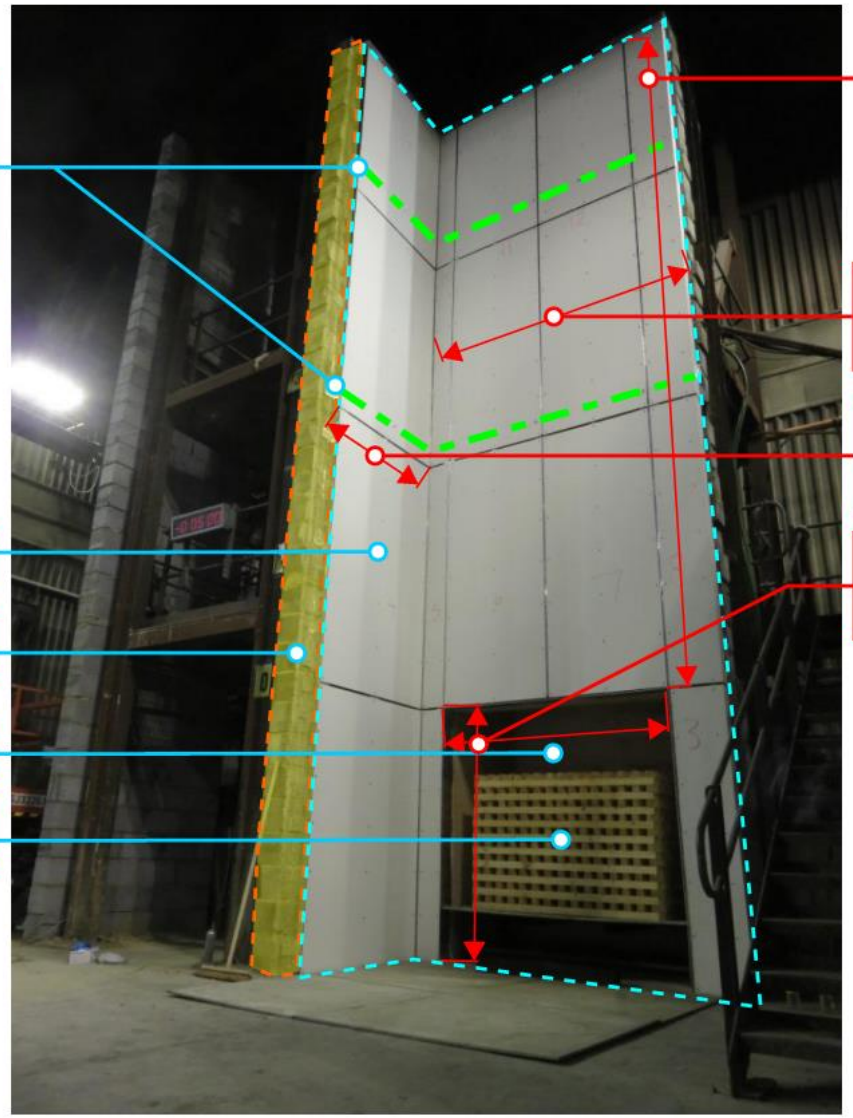
10.2 If a fire-separating element is to be effective, every joint or imperfection of fit, or opening to allow services to pass through the element, should be adequately protected by sealing or fire-stopping so that the fire resistance of the element is not impaired.

Provisions for external wall construction

ADB 12.5: BR 135 & BS 8414

BS 8414 Method of test for non load bearing cladding systems

BS 8414-1 Large scale test



Temperature measurements taken at 2.5m and 5m above opening

Test specimen

Test apparatus

Combustion chamber

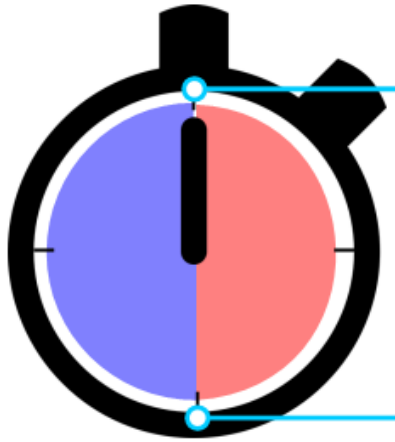
Timber crib heat source

Test specimen height: >6m above the opening

Test specimen width: >2.6m

Test specimen 'wing wall' width: >1.5m

Combustion chamber opening: 2m x 2m



Test ends at 60 mins

30 mins until extinguishment

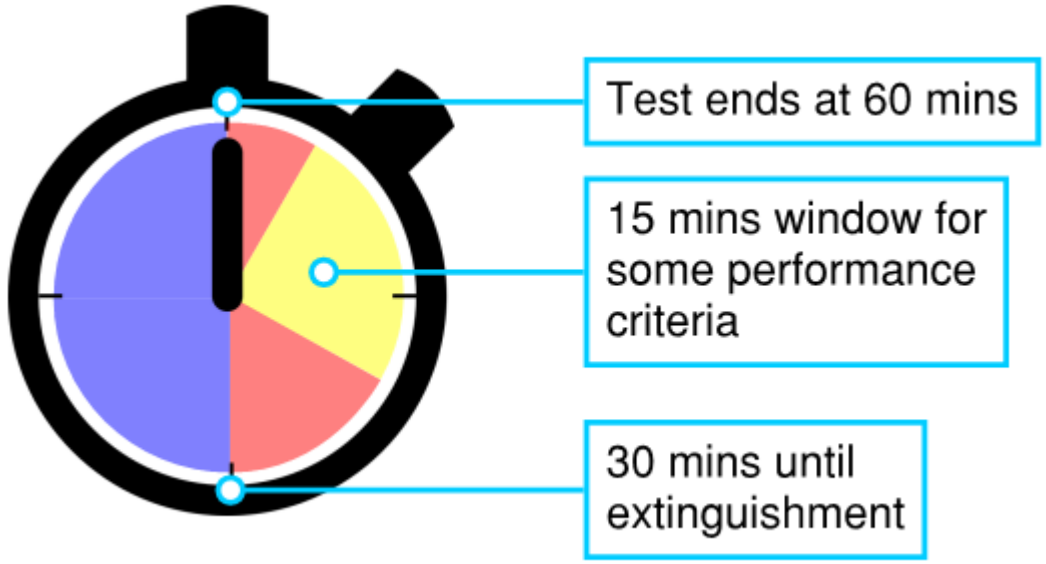
BR135 Annex A Performance criteria and classification method for BS 8414-1

A2.2 External fire spread

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 30 s, within 15 min of the start time, *ts*. An example graph is shown in Figure A6.

A2.3 Internal fire spread

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 30 s, within 15 min of the start time, t_s. An example graph is shown in Figure A6.



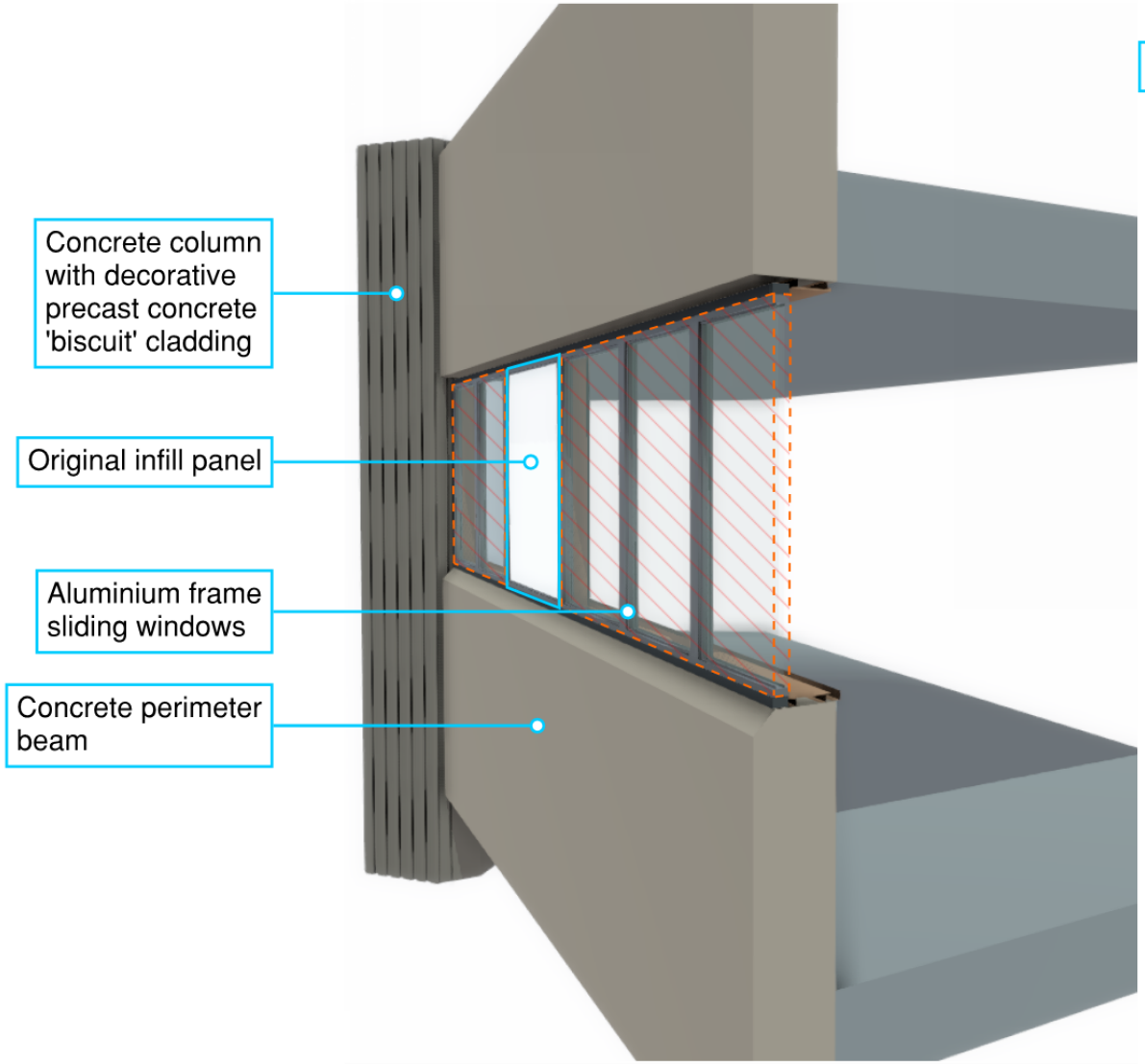
A2.4 Mechanical performance

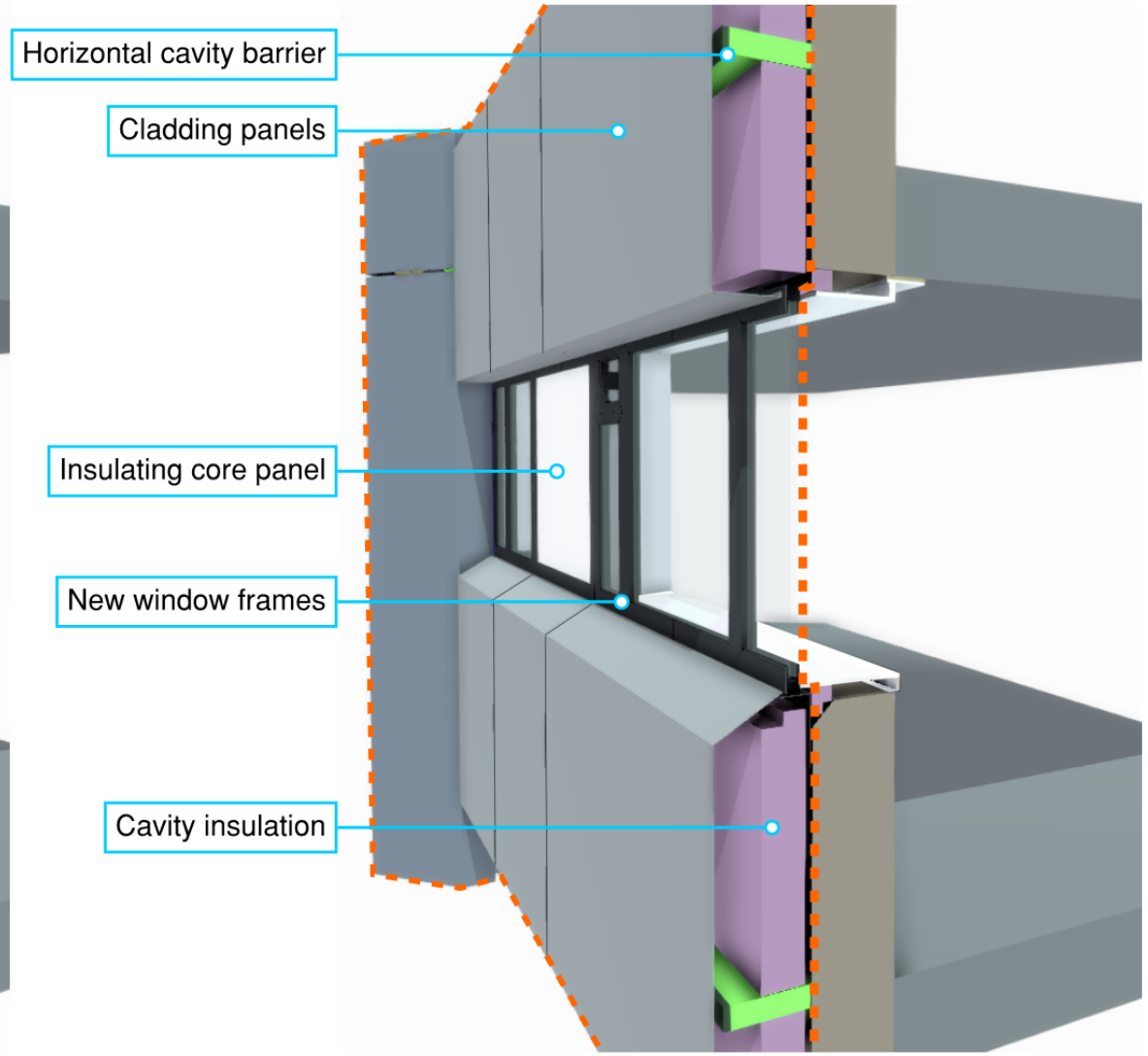
No failure criteria have been set for mechanical performance. However, ongoing system combustion following extinguishing of the ignition source shall be included in the test and classification reports, together with details of any system collapse, spalling, delamination, flaming debris or pool fires. The nature of the mechanical performance should be considered as part of the overall risk assessment when specifying the system (eg Figure A7).

No criteria set

The materials applied externally to the external wall of Grenfell Tower

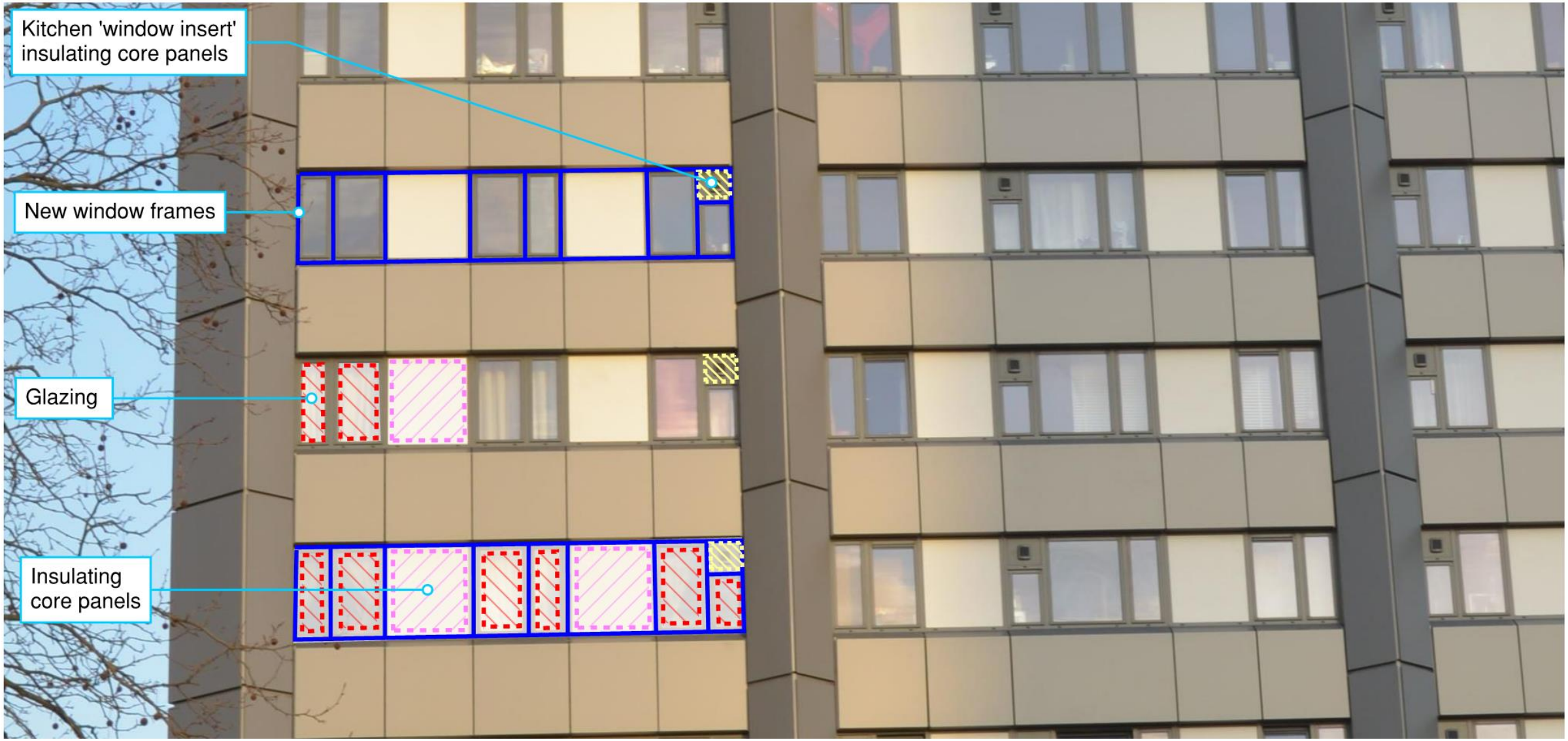
The external over cladding of Grenfell Tower – the materials applied





The new window frames, glazing and insulating core panels

The new window frames, glazing and insulating core panels - materials

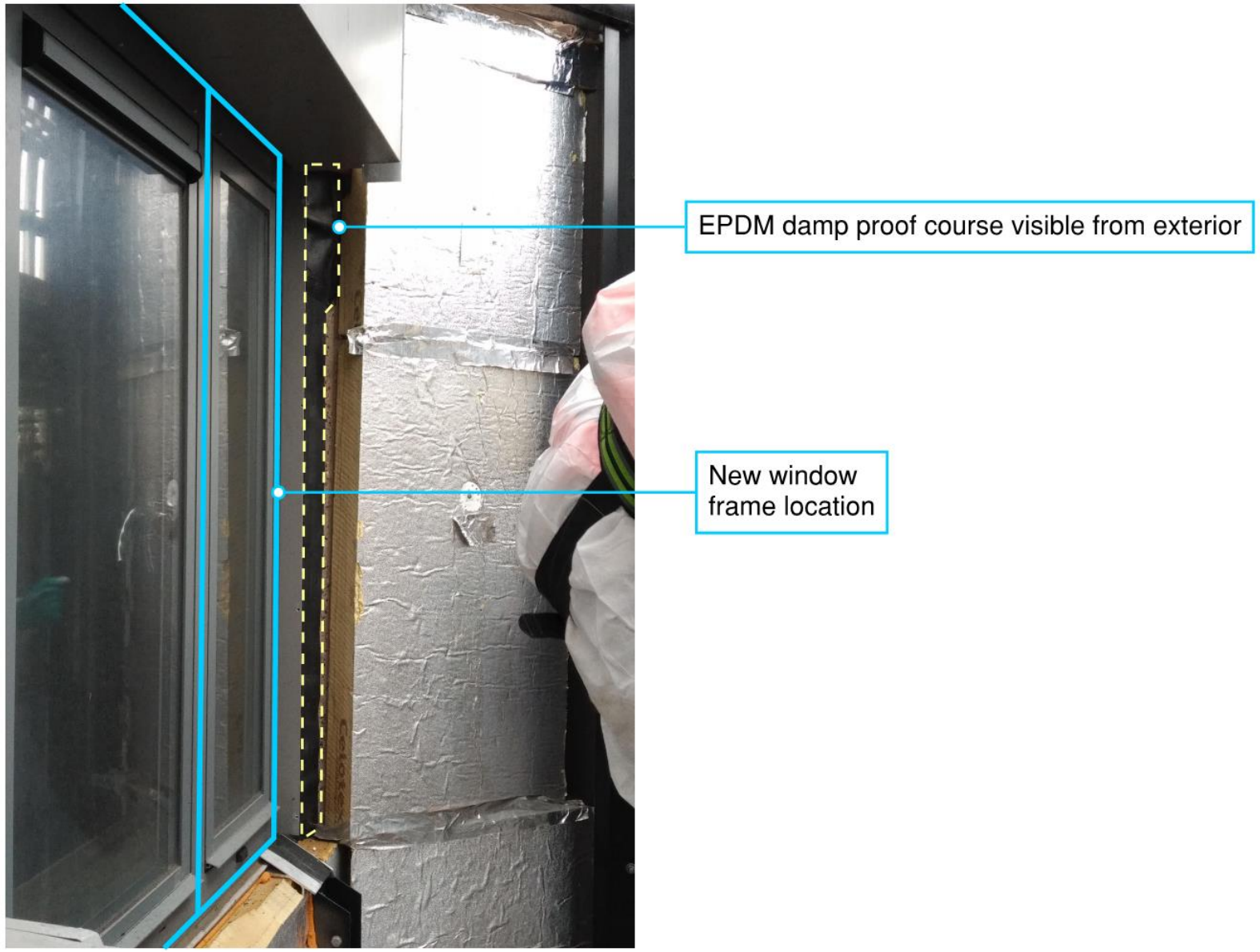


Kitchen window inserts – observed materials

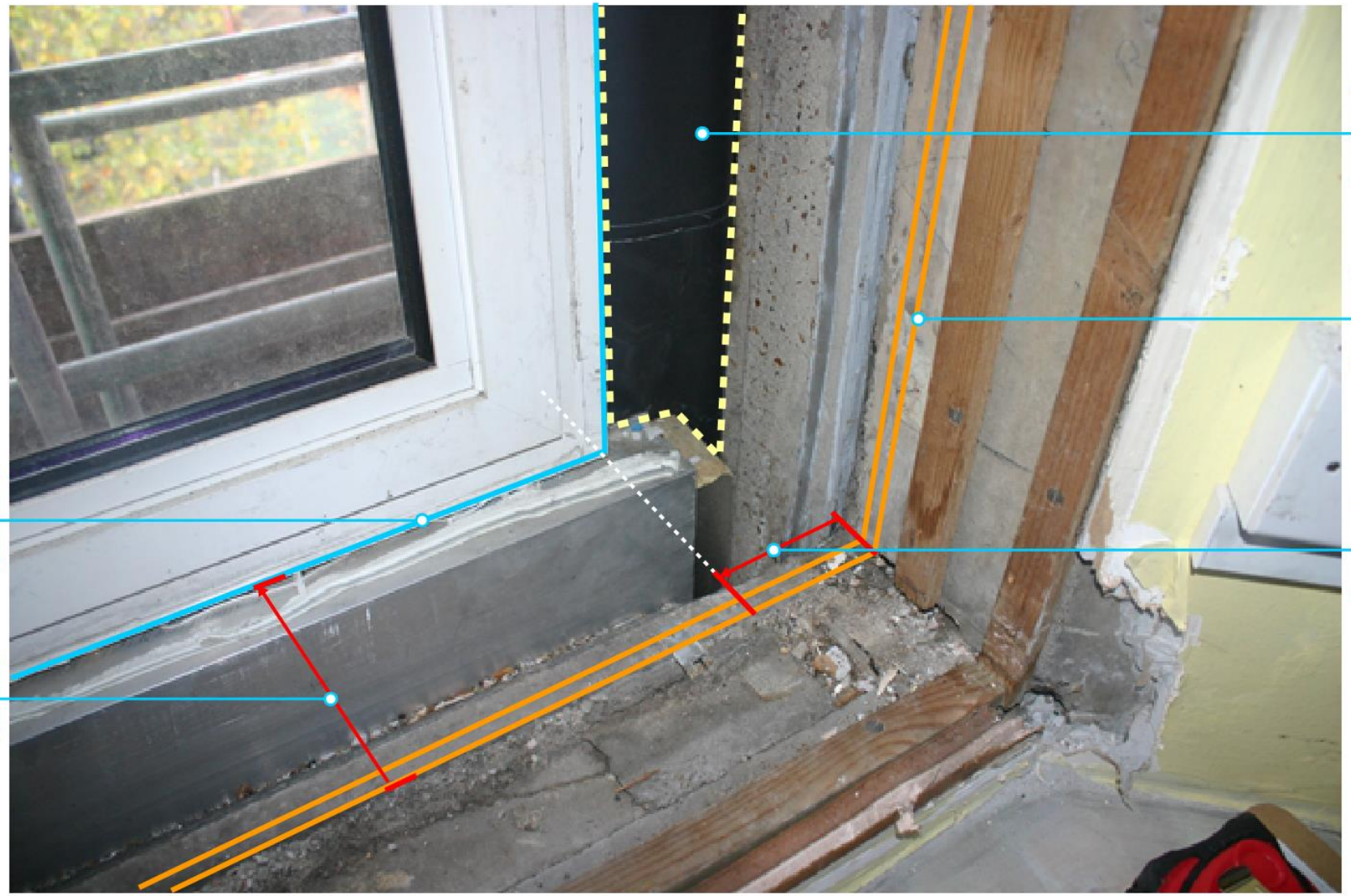
The position of the new window frames relative to the old windows

The installed EPDM Damp proof course

EPDM Damp proof course observed from the exterior of the building



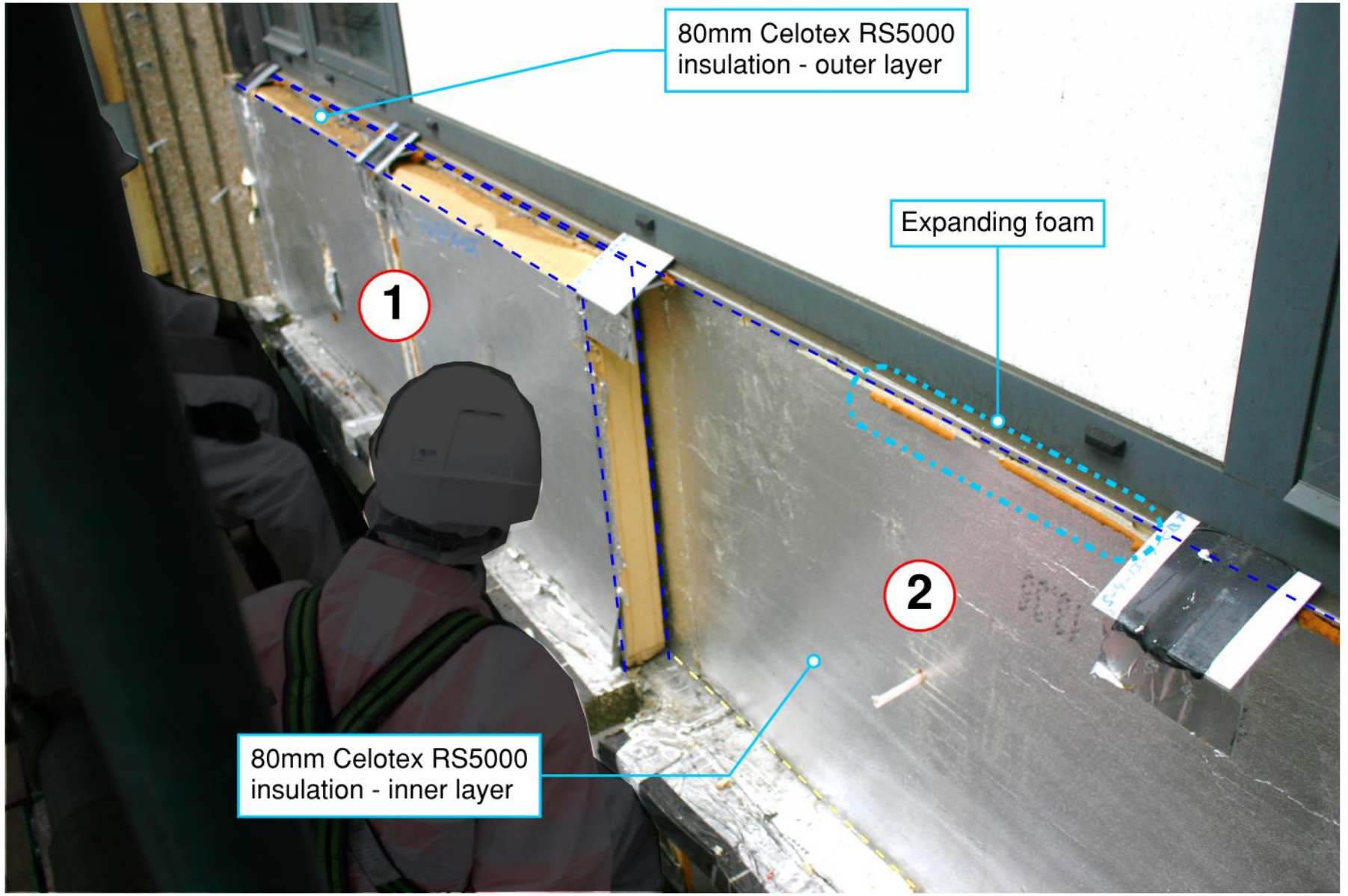
Original vs. new windows



The installed cavity thermal insulation

Rainscreen thermal insulation applied to columns

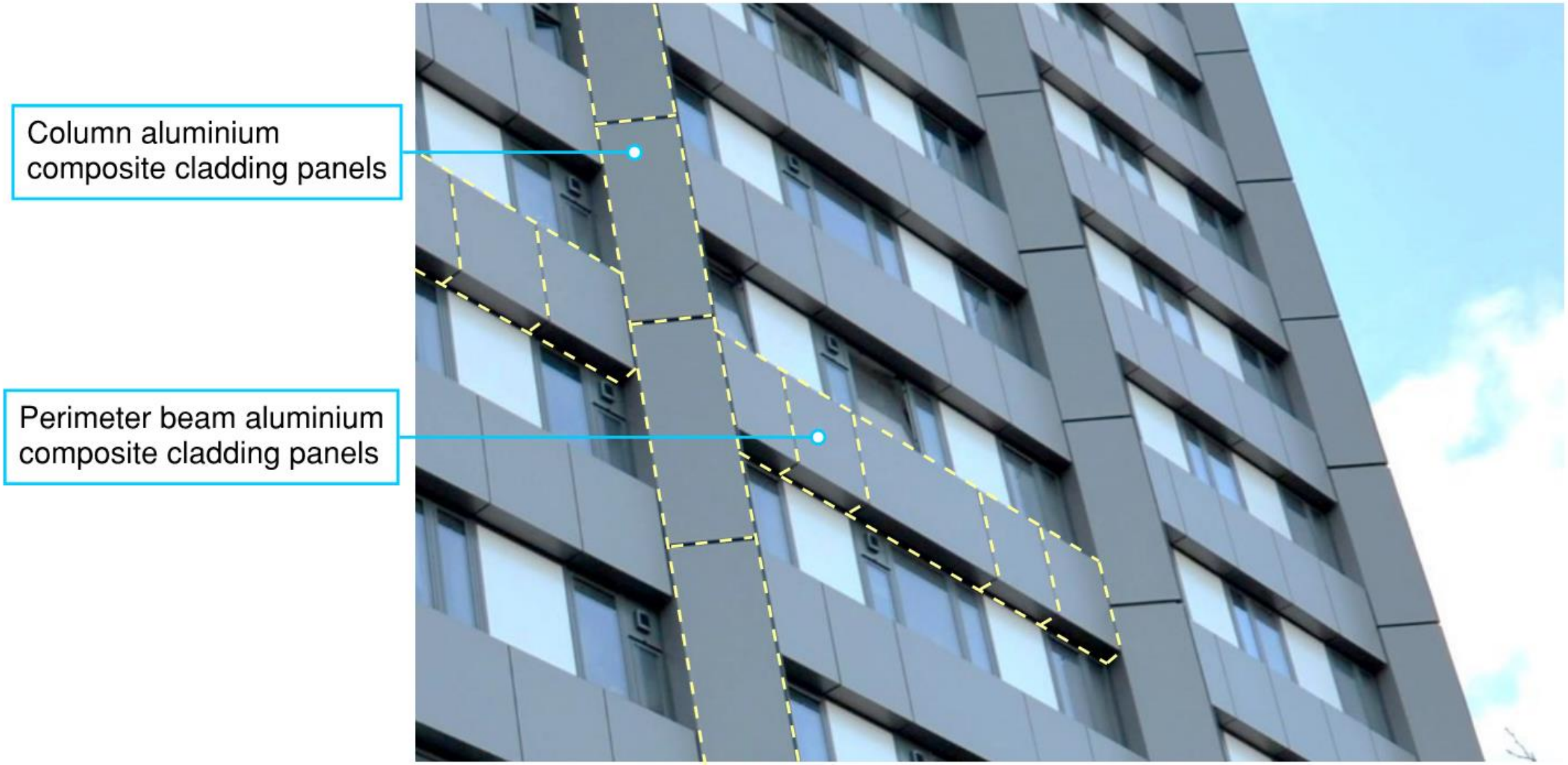
Rainscreen insulation applied to perimeter beam above and below windows



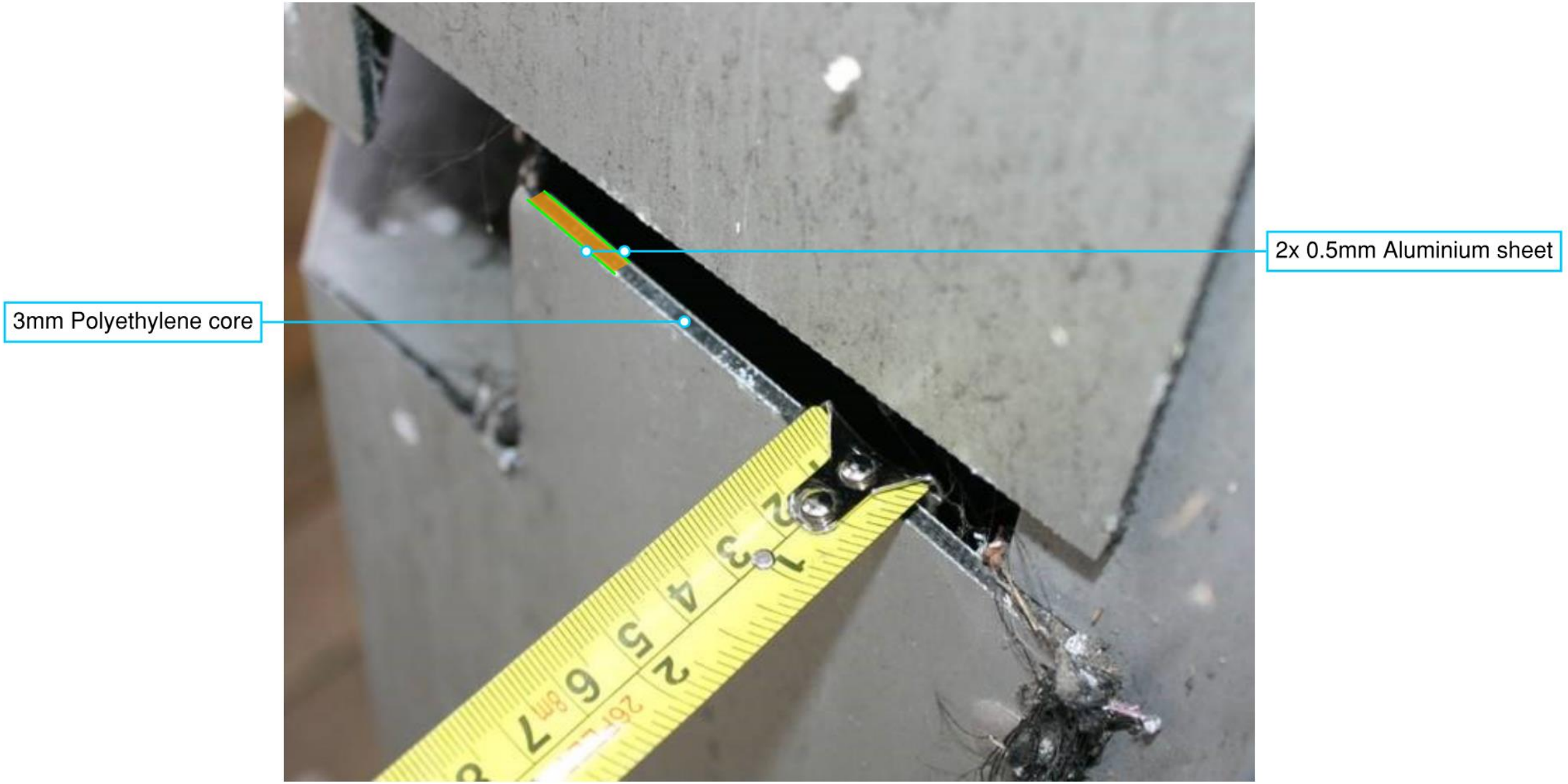
Kingspan Kooltherm K15 Rainscreen board

The installed rainscreen outer layer

Rainscreen outer layer – Aluminium composite panels

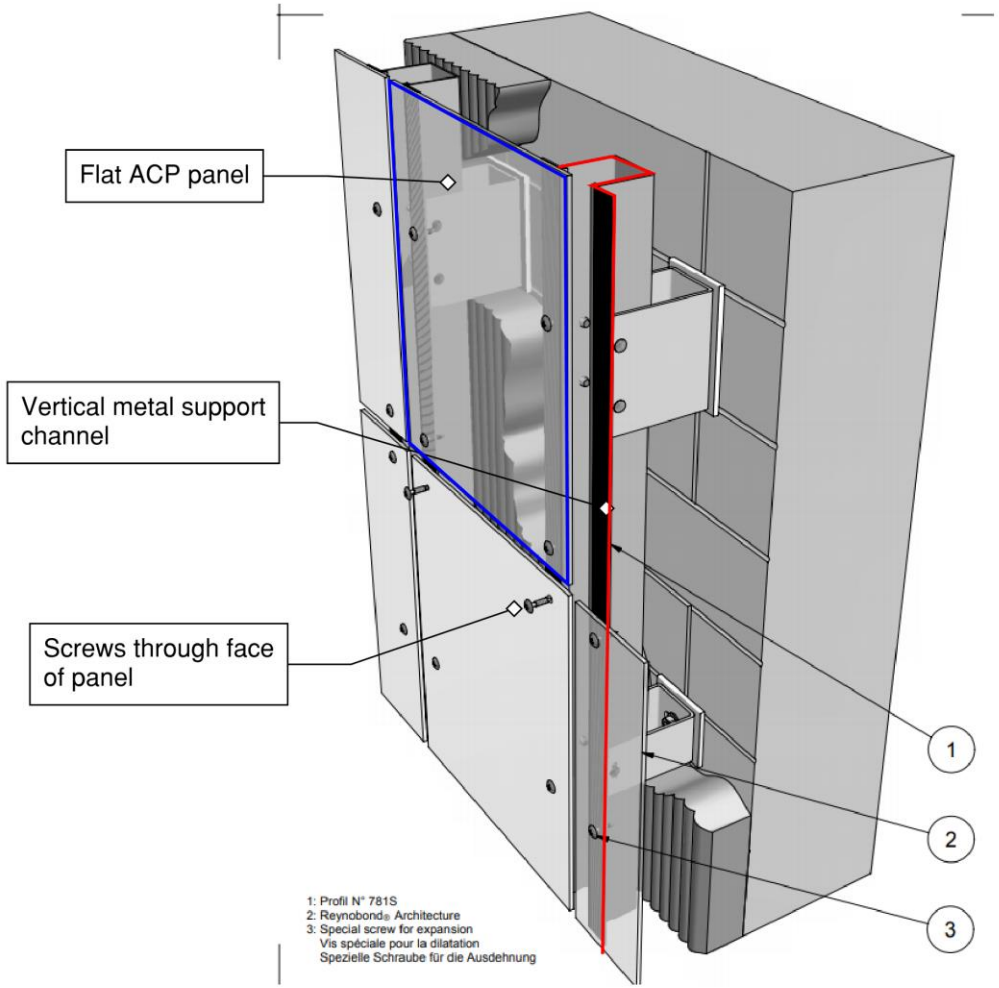


Reynobond 55 PE aluminium composite panels

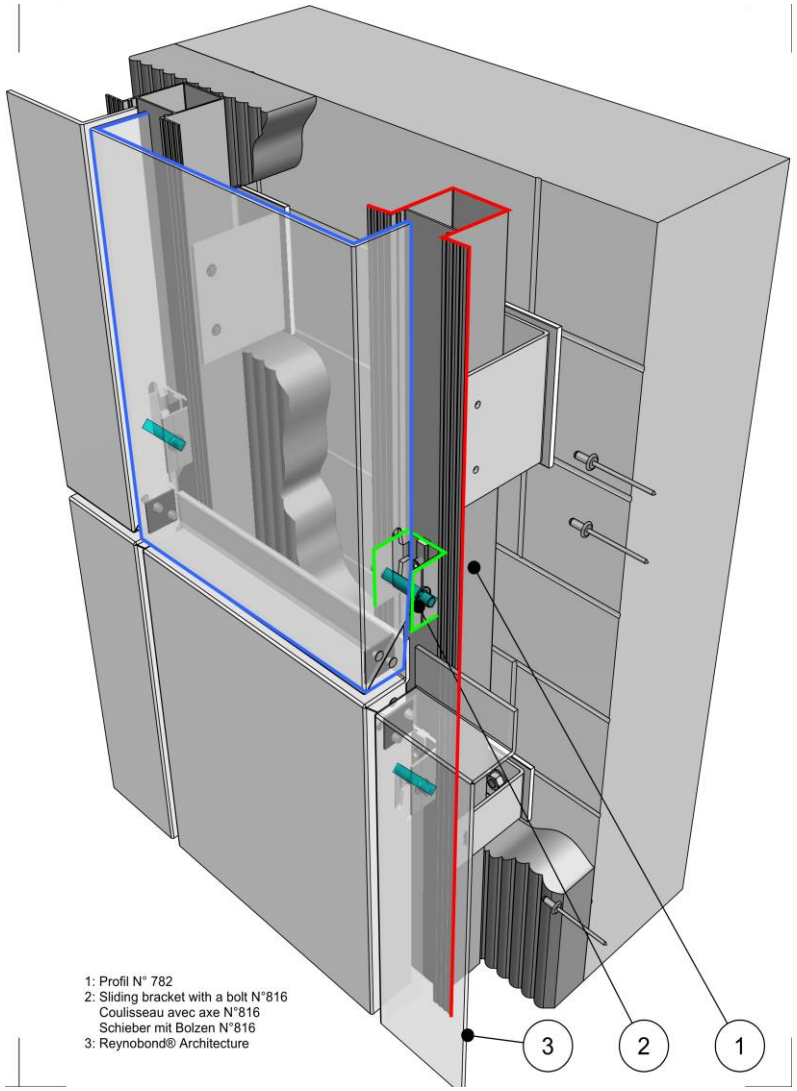


Methods of supporting Reynobond 55 PE ACPs

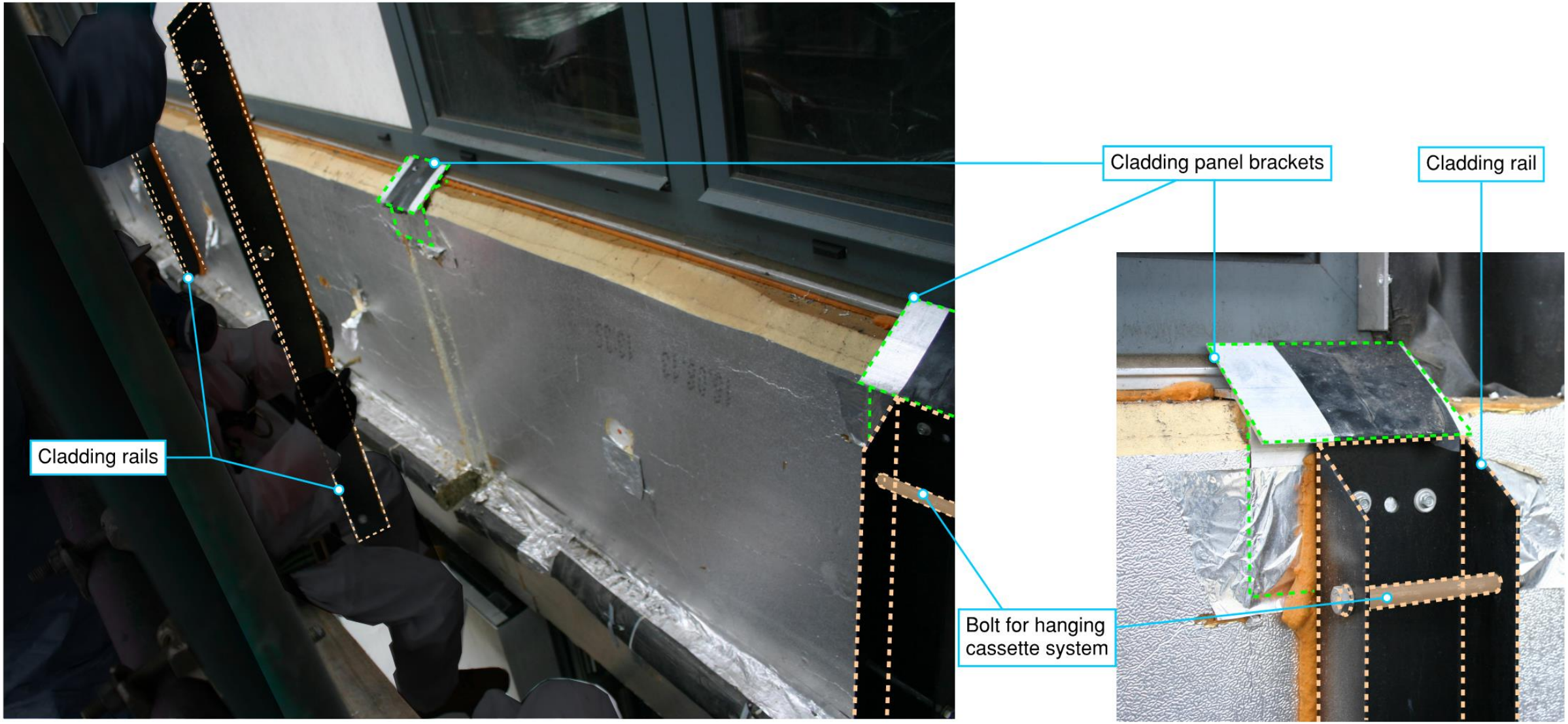
Flat Panel screw fixed in place



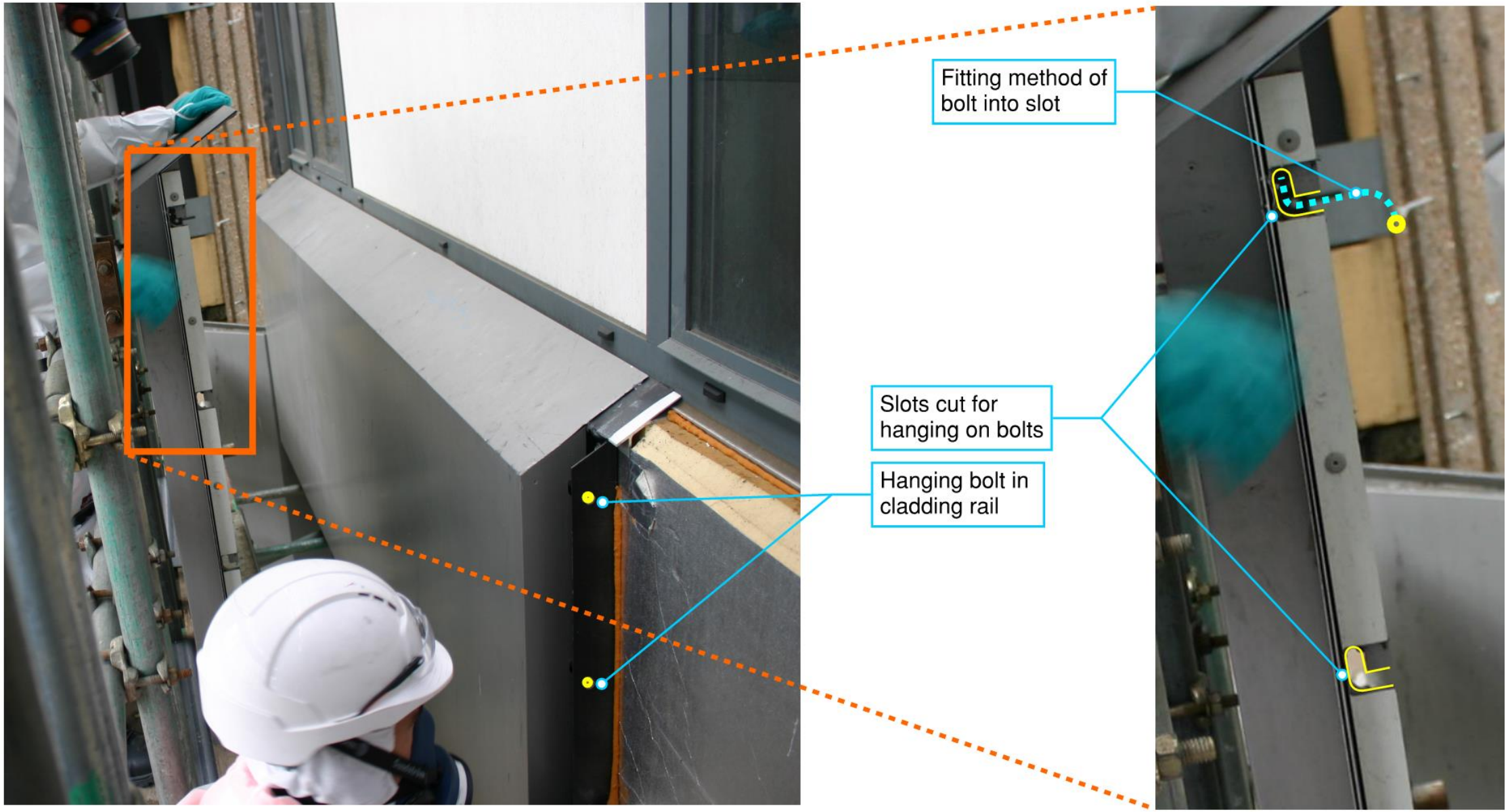
Modular cassette system hung on bolts



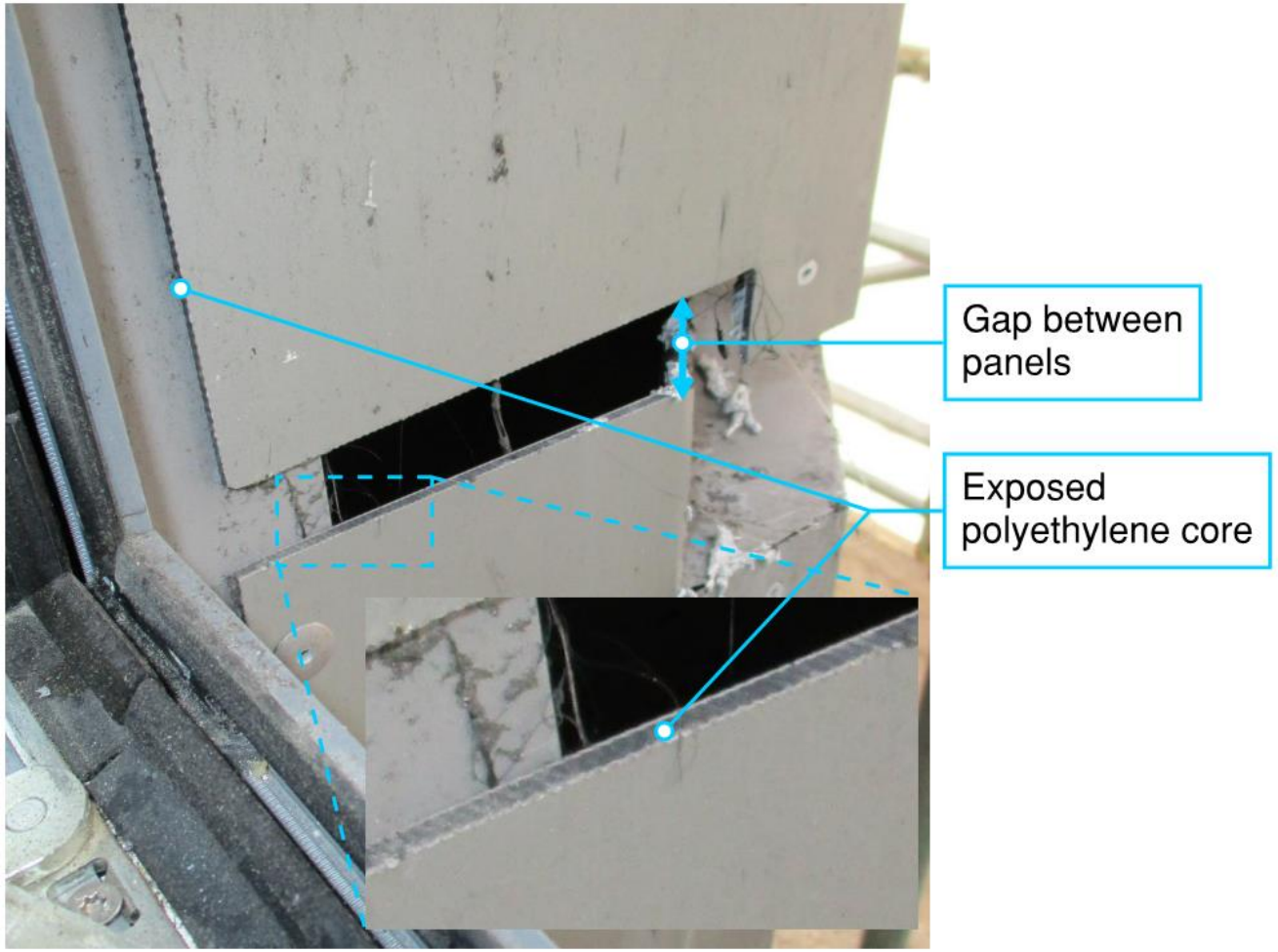
Cladding rails for the Reynobond 55 PE ACPs



Hanging of the Reynobond 55 PE ACPs

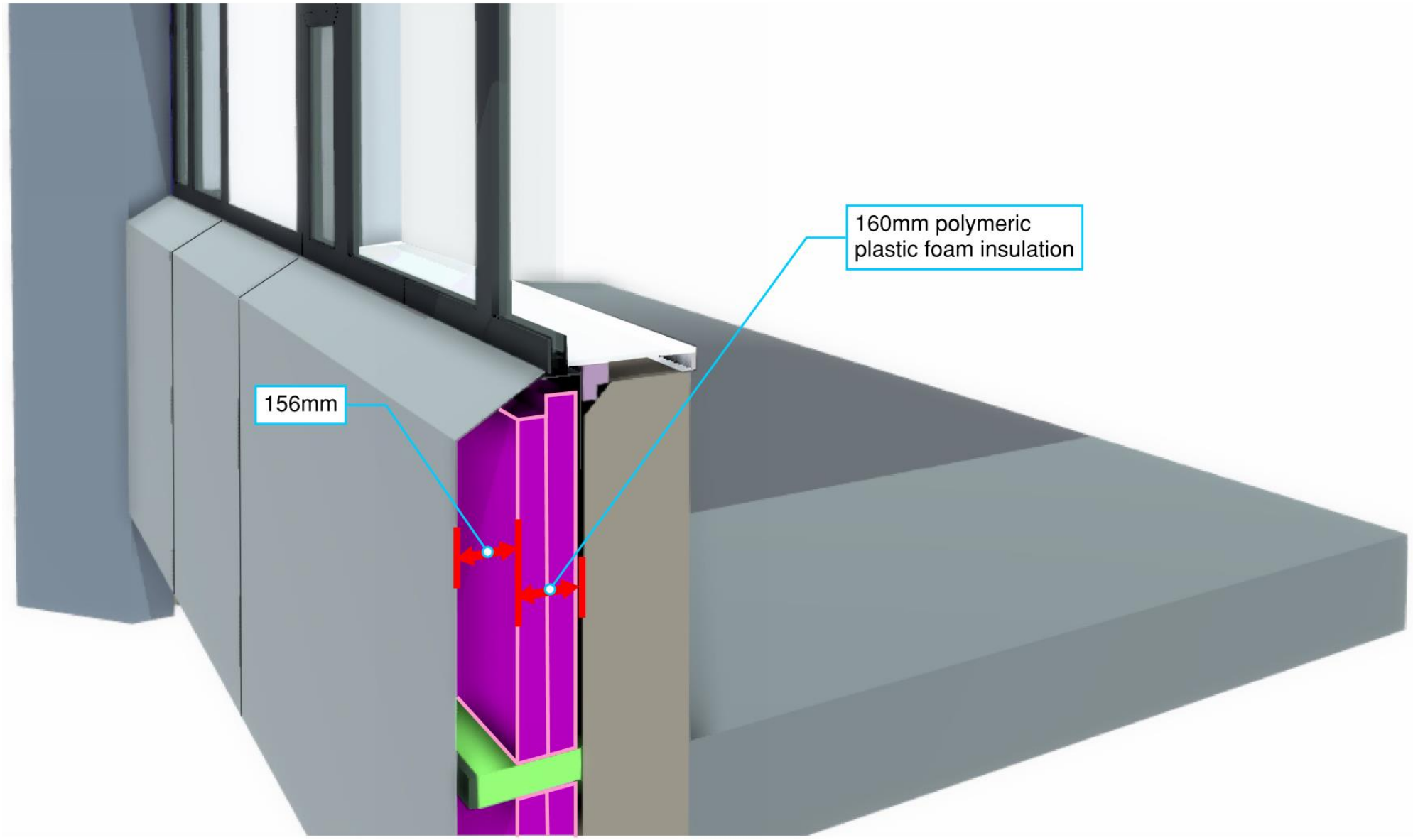


The gaps between installed ACP cladding panels

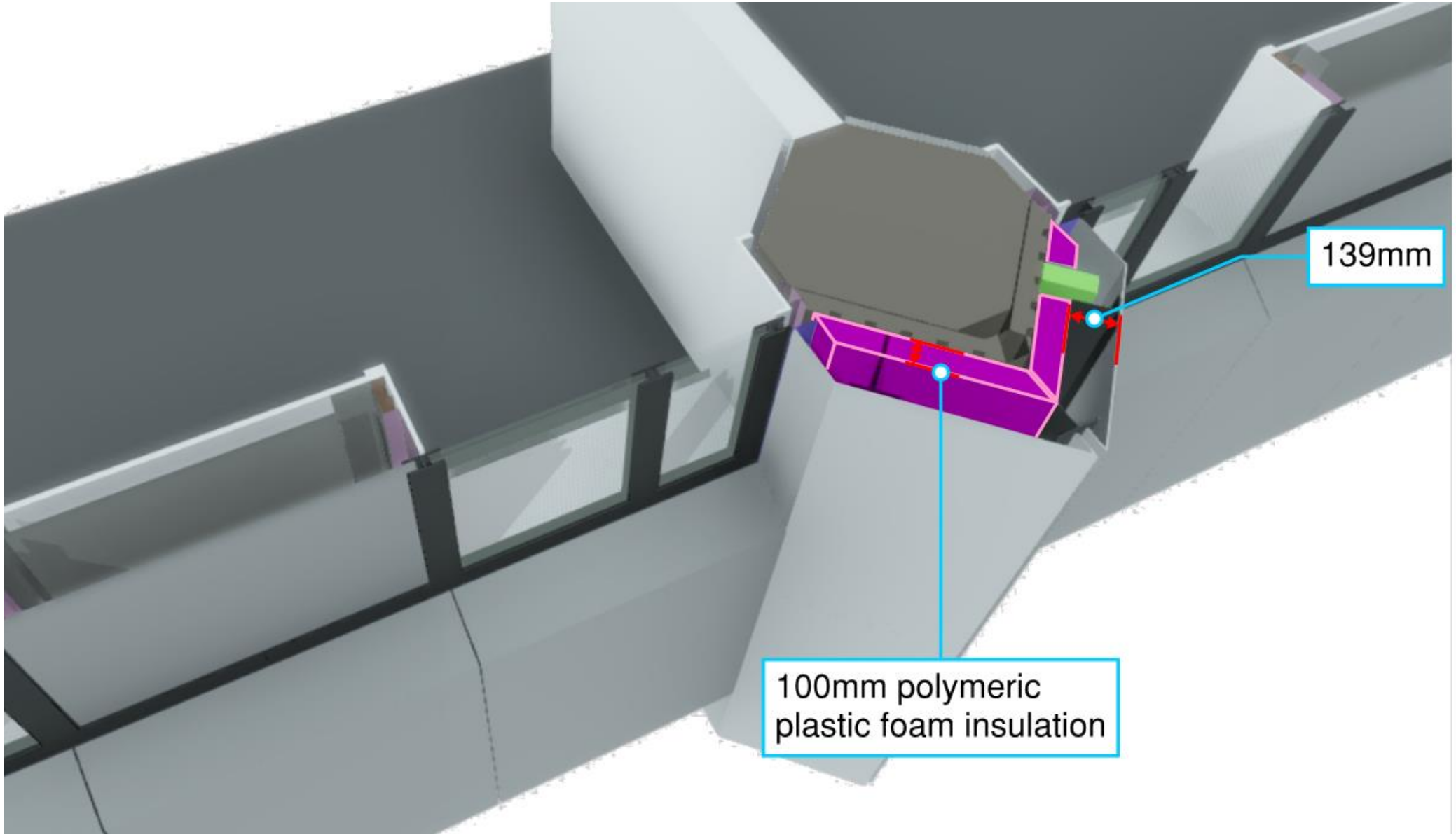


The cavities created by the over-cladding

New external wall cavities – Perimeter beam cavity

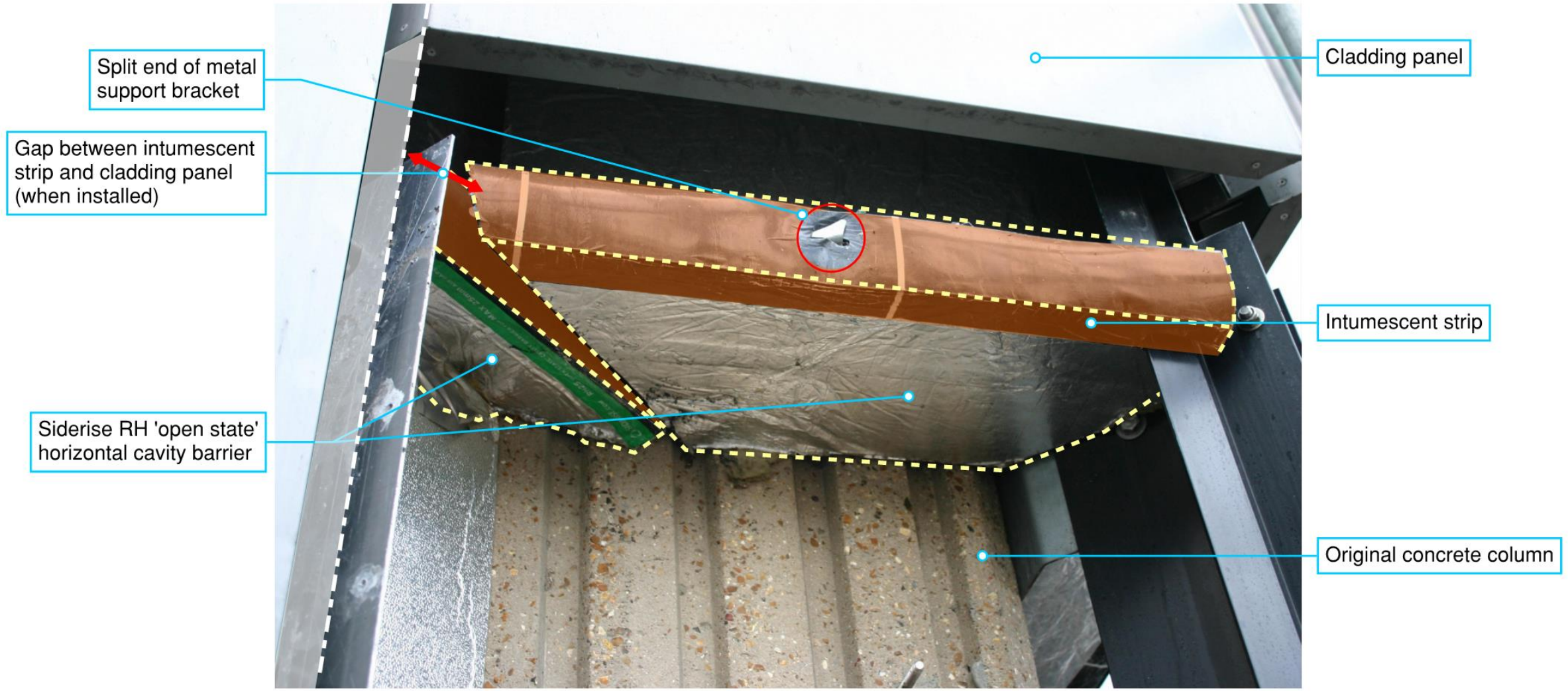


New external wall cavities: Column Cavity

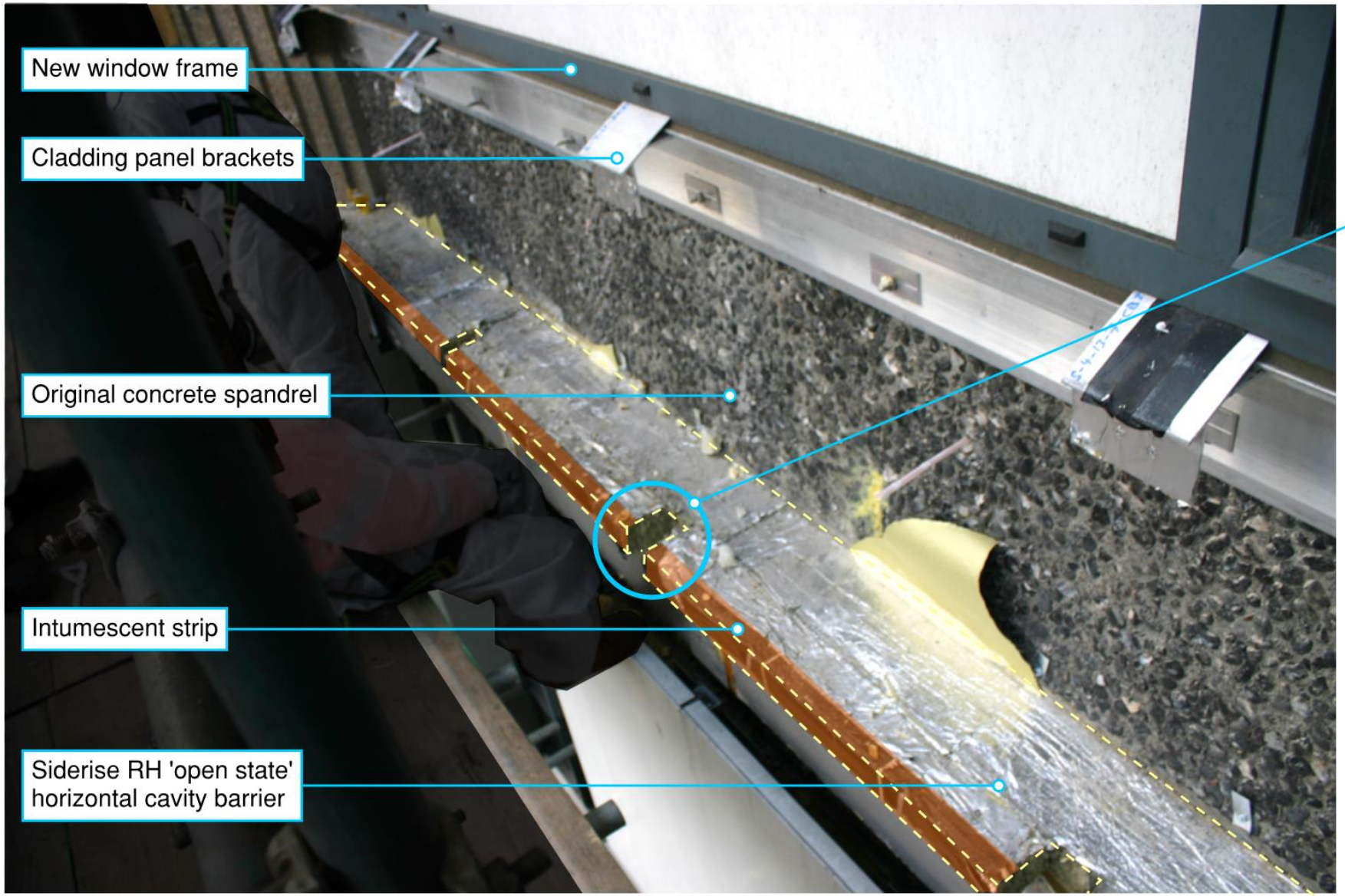


The installed cavity barriers

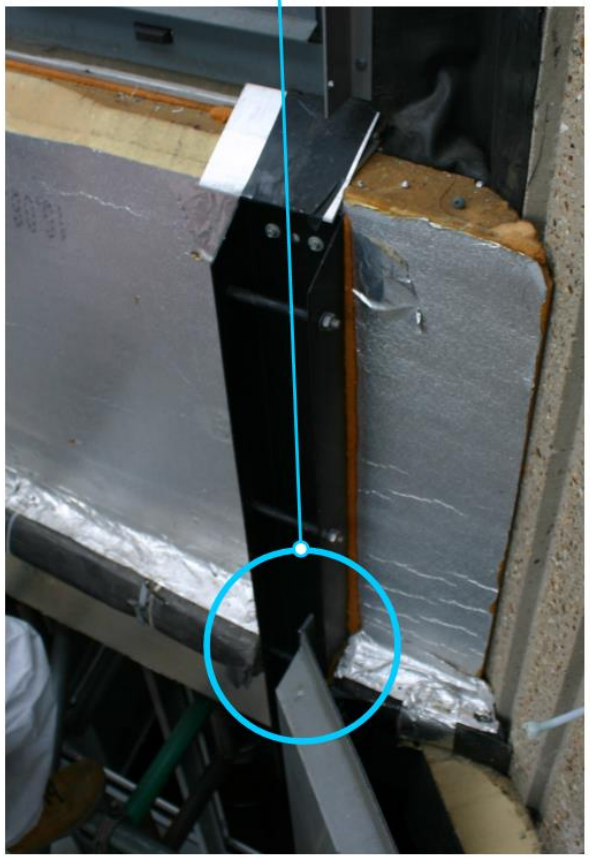
Horizontal cavity barriers at junction with the compartment floors



Horizontal cavity barriers – junction with the cladding rails

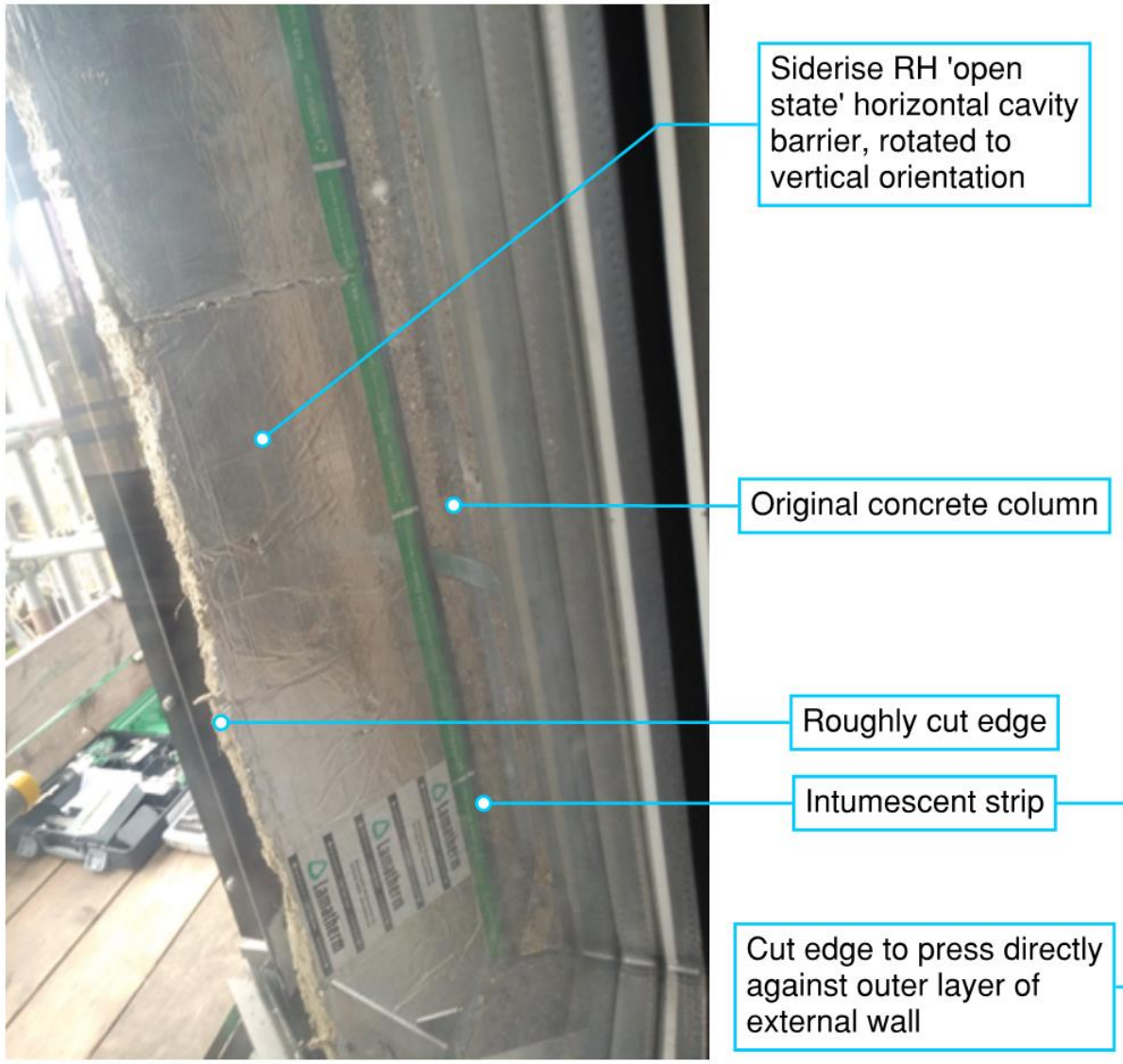


'Notches' cut into horizontal cavity barrier to incorporate cladding rails

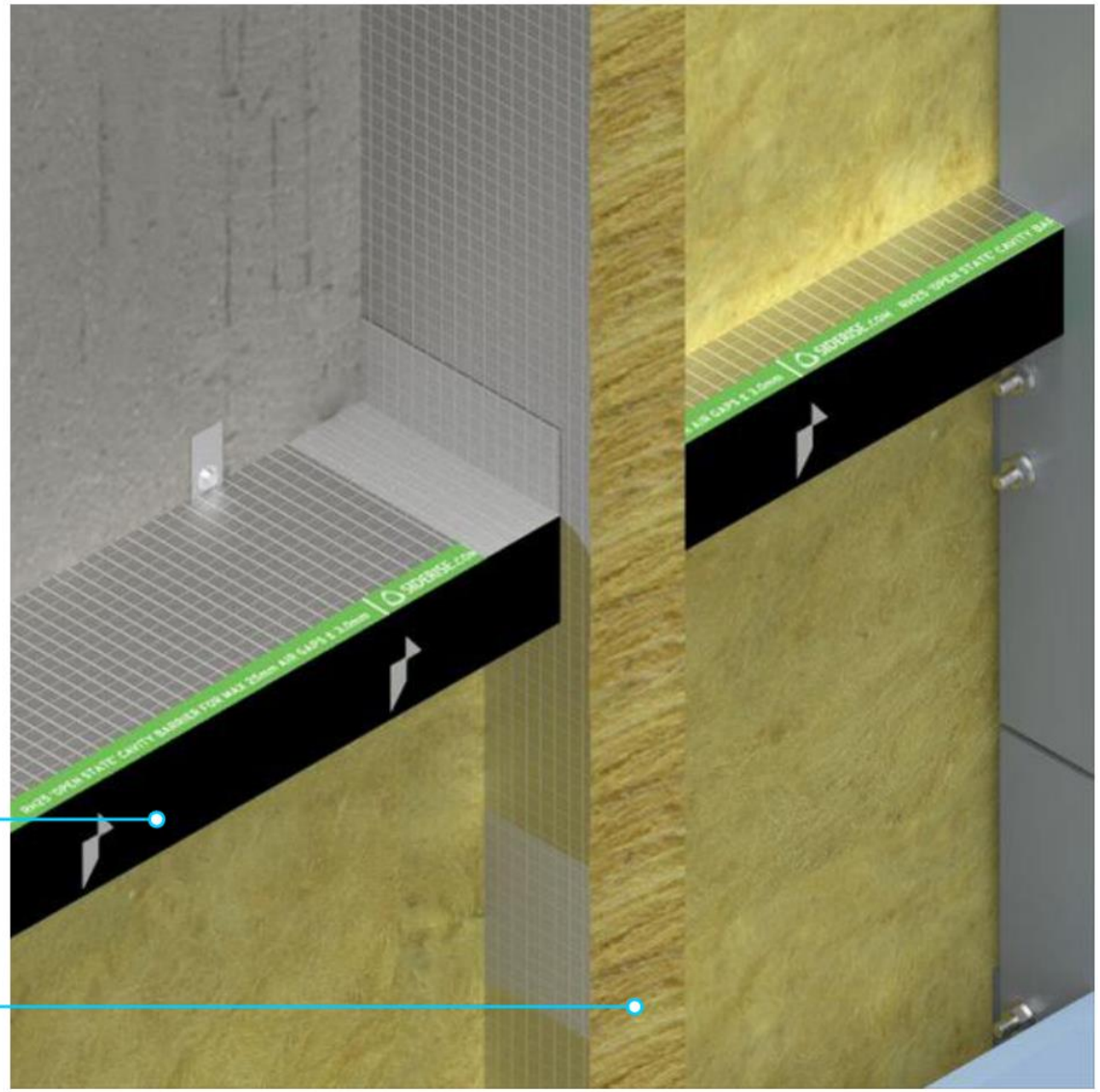


Vertical cavity barriers – junction with the compartment walls

Grenfell Tower

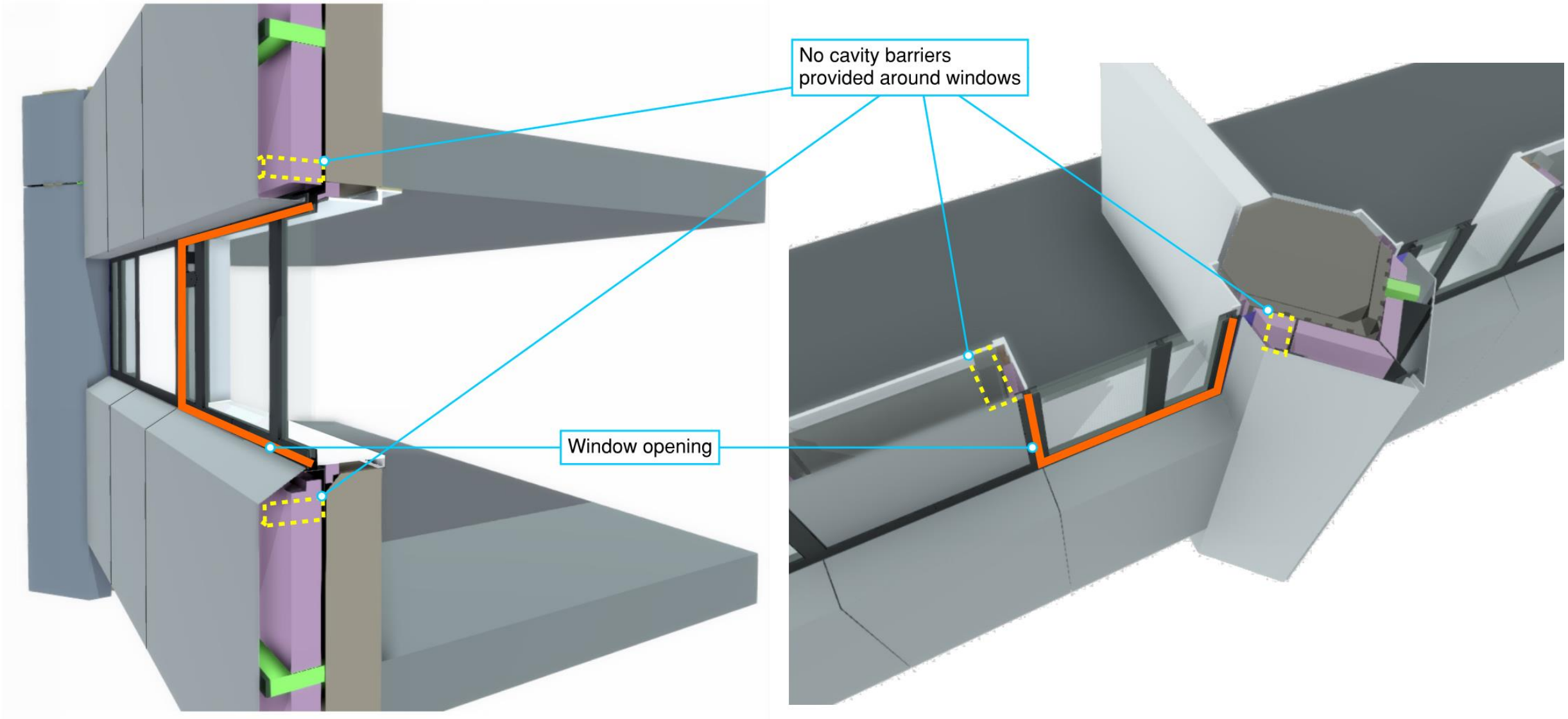


Manufacturer's marketing materials

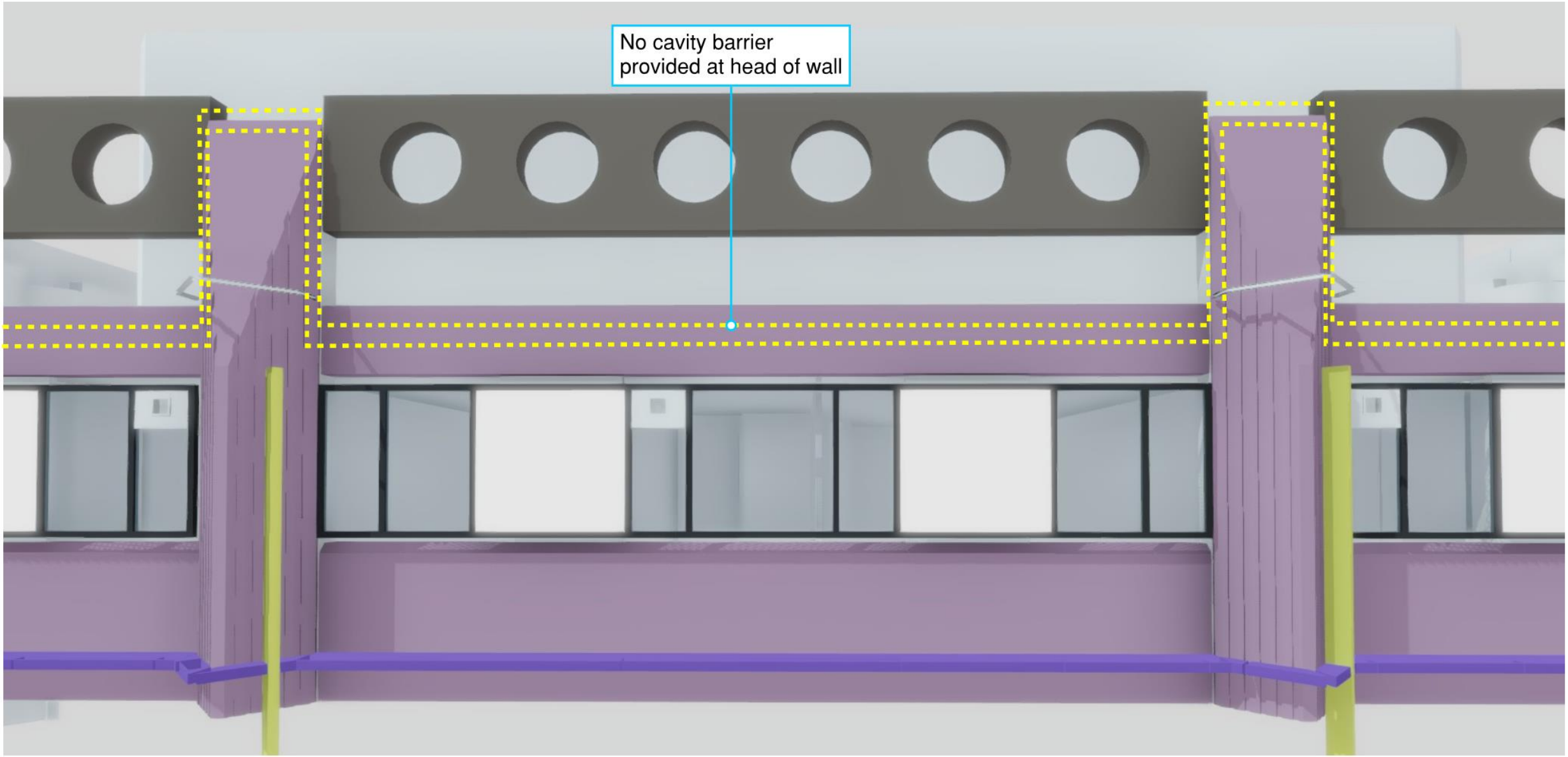


Cavity barriers omitted
from the new cavities

Cavity barriers omitted - Around window openings



Cavity barriers omitted – At the head of the wall

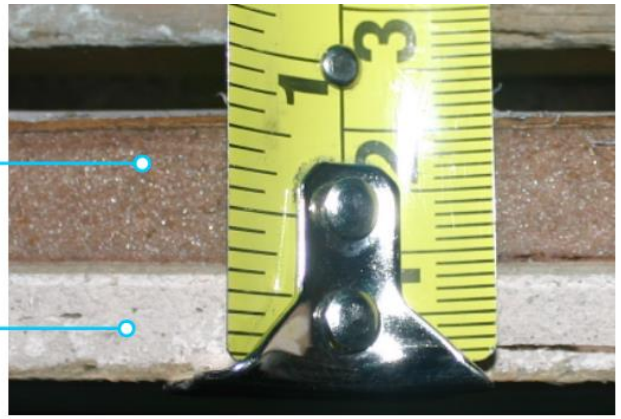


The materials applied internally to the external wall of Grenfell Tower

Purlboard – existing material retained at window head

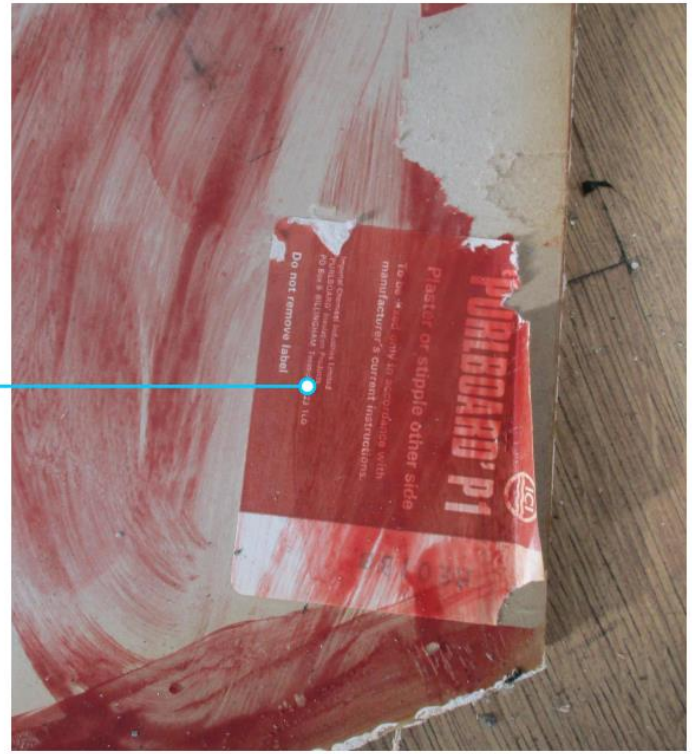
Approximately 12mm polyurethane foam

Approximately 8mm Hardboard

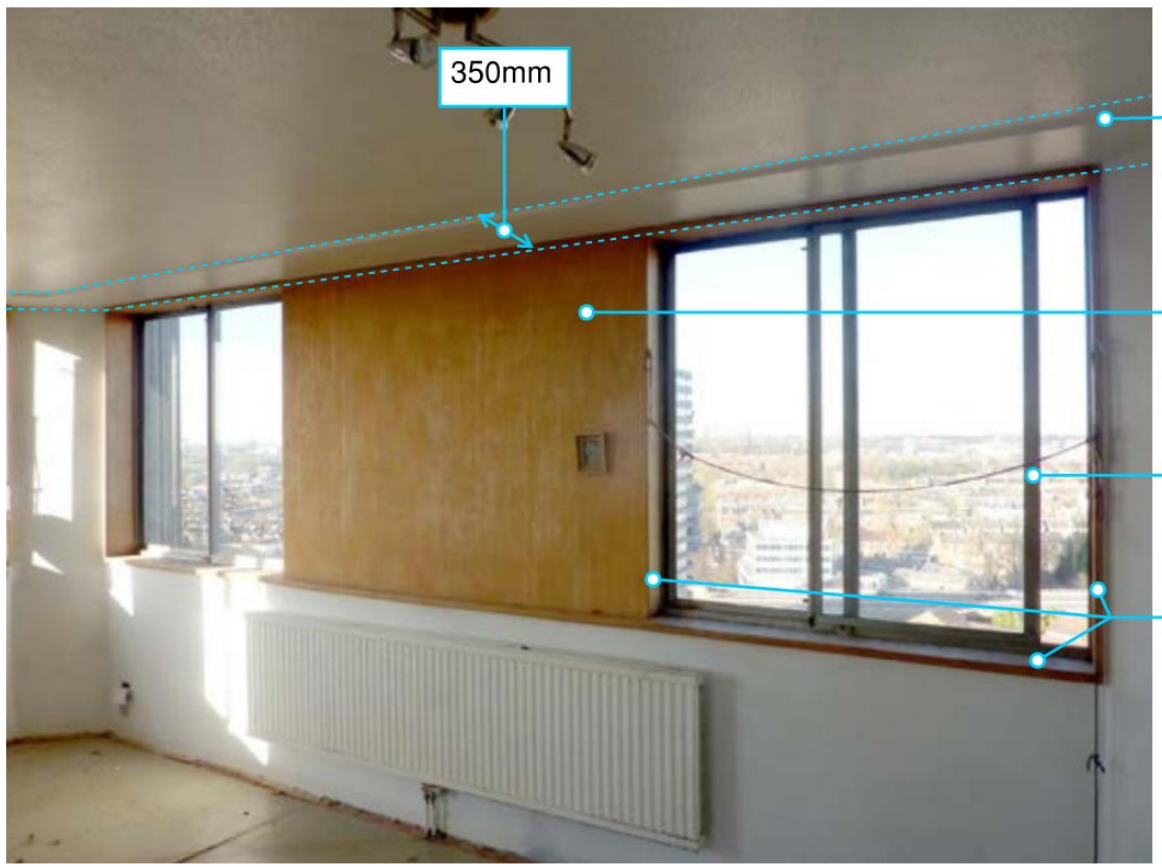


Purlboard situated on ceiling around perimeter of rooms

Insulated board labelled 'Purlboard' P1 with ICI manufacturer logo. Observed on the floor next to ceiling with missing board



Internal works to the external wall of Grenfell Tower



Grenfell Tower pre-refurbishment

20mm x 350mm Purlboard

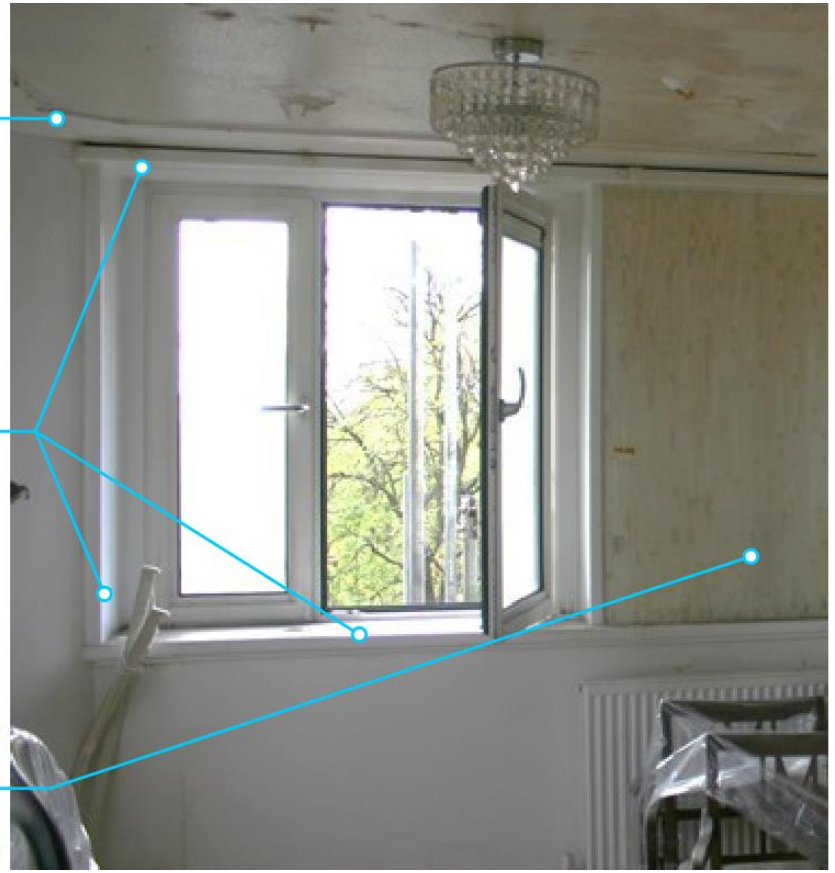
Timber lining to infill panel

Original window frames

Timber window reveal linings

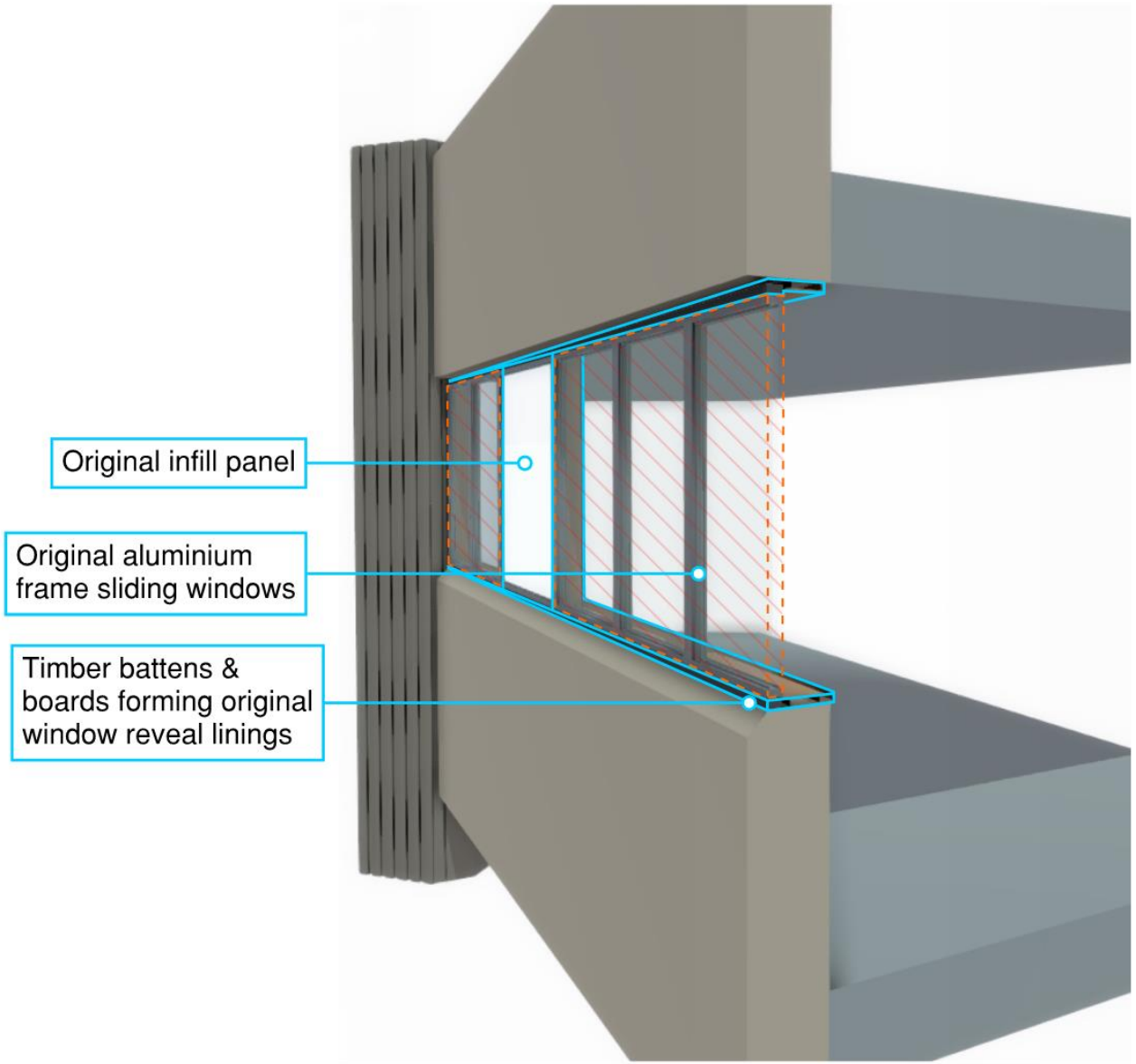
uPVC window reveal linings

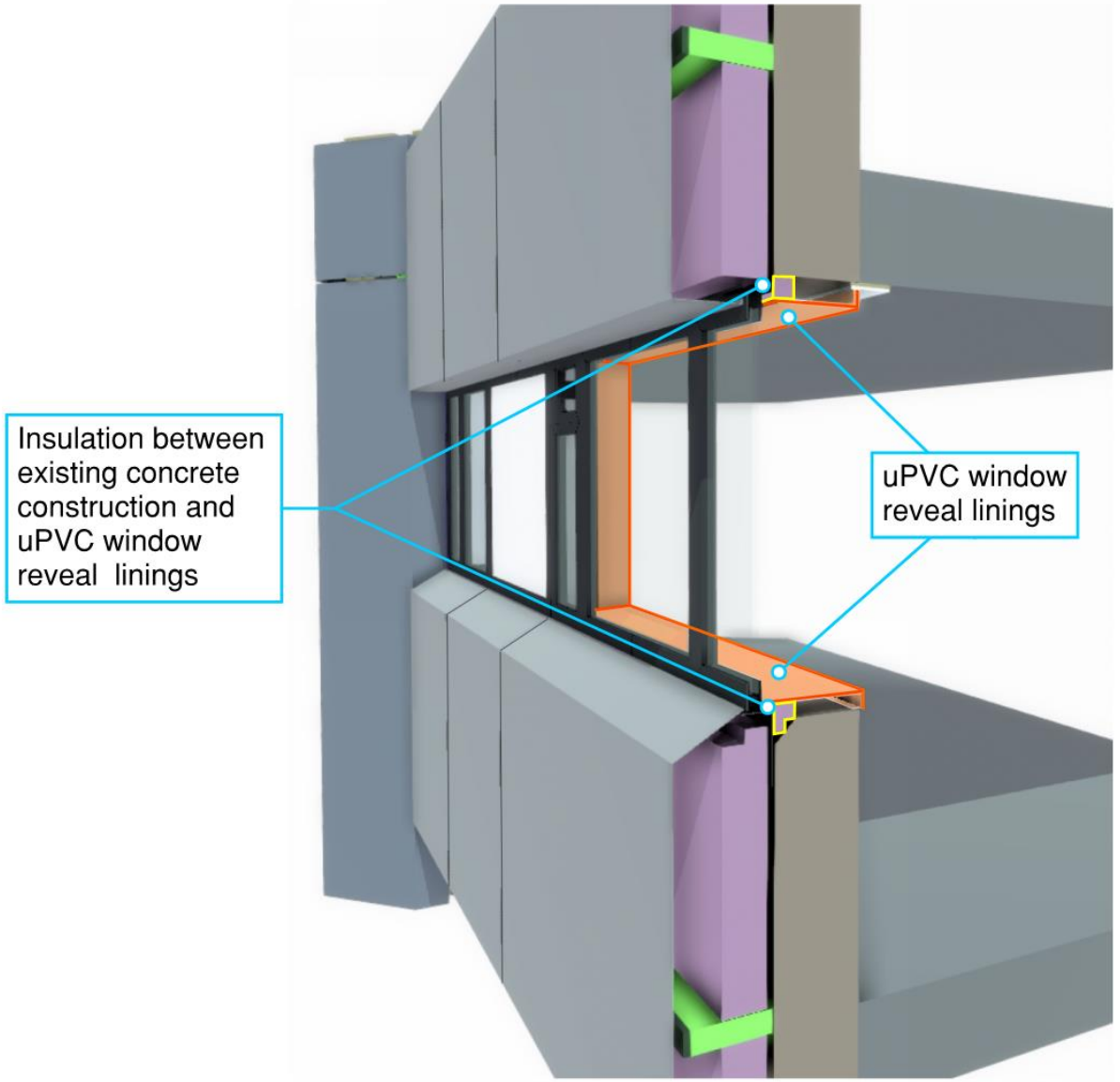
Original infill panel in front of insulating core panel



Grenfell Tower post-refurbishment

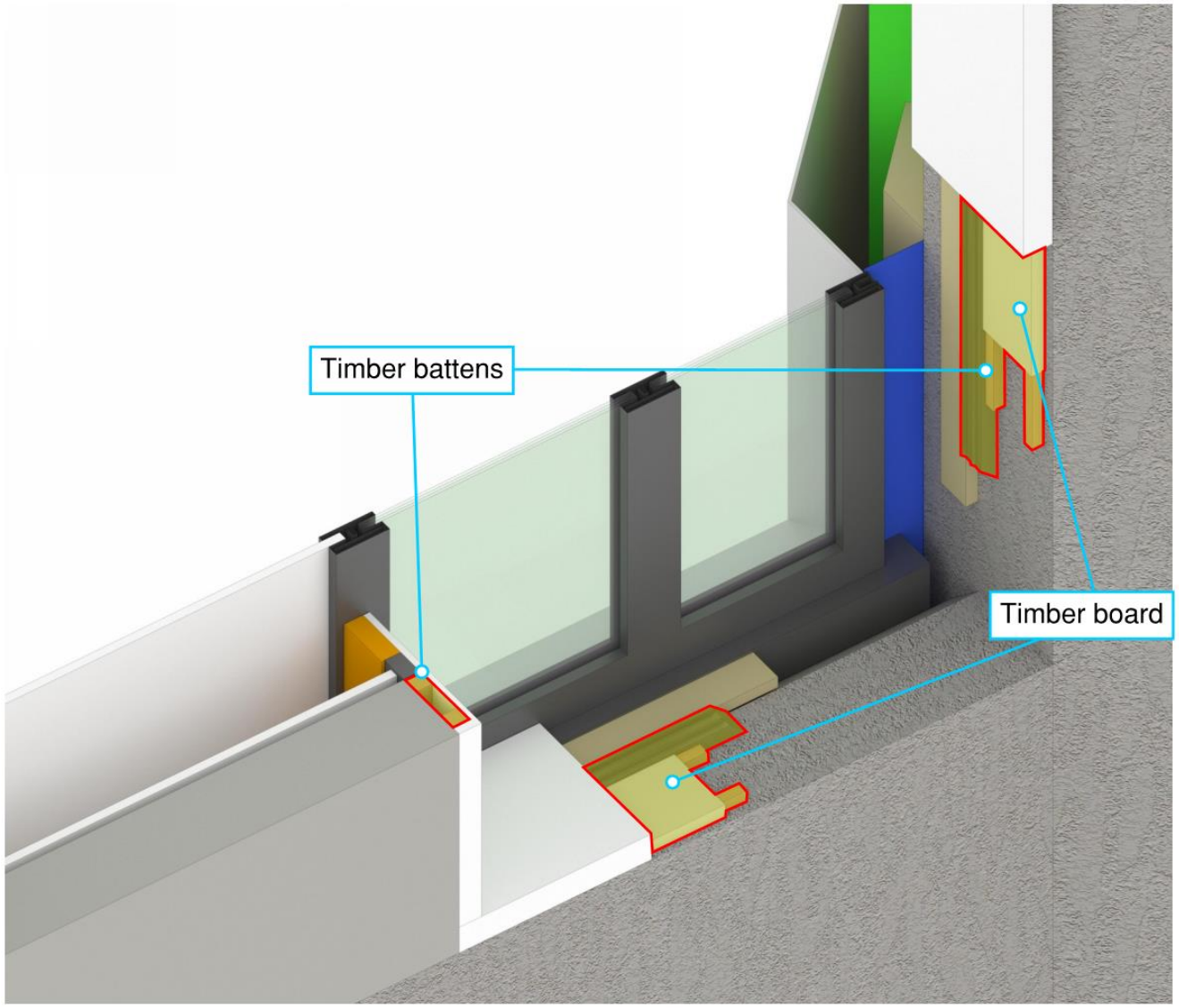
New reveals for the replacement windows – the materials applied

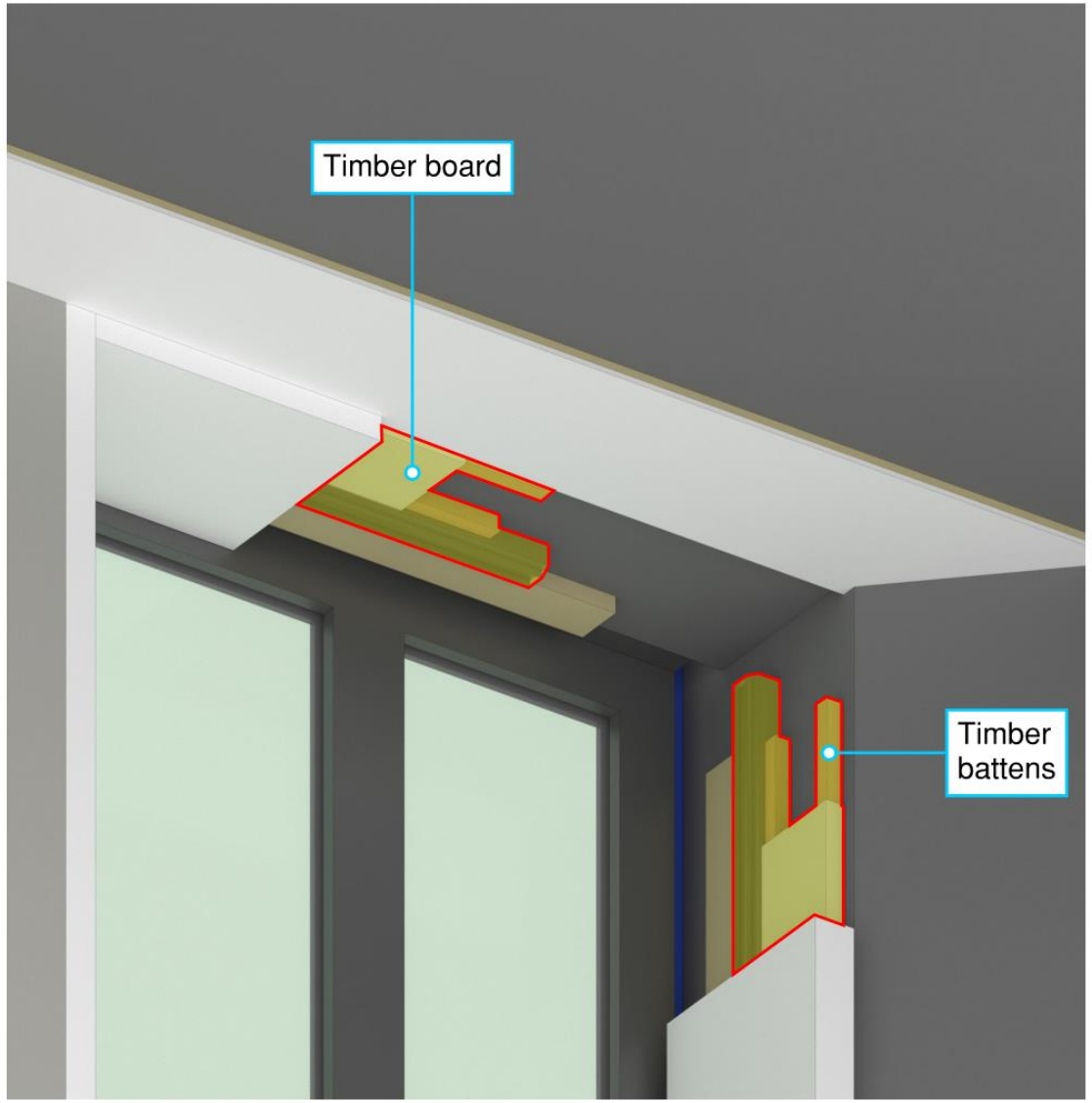




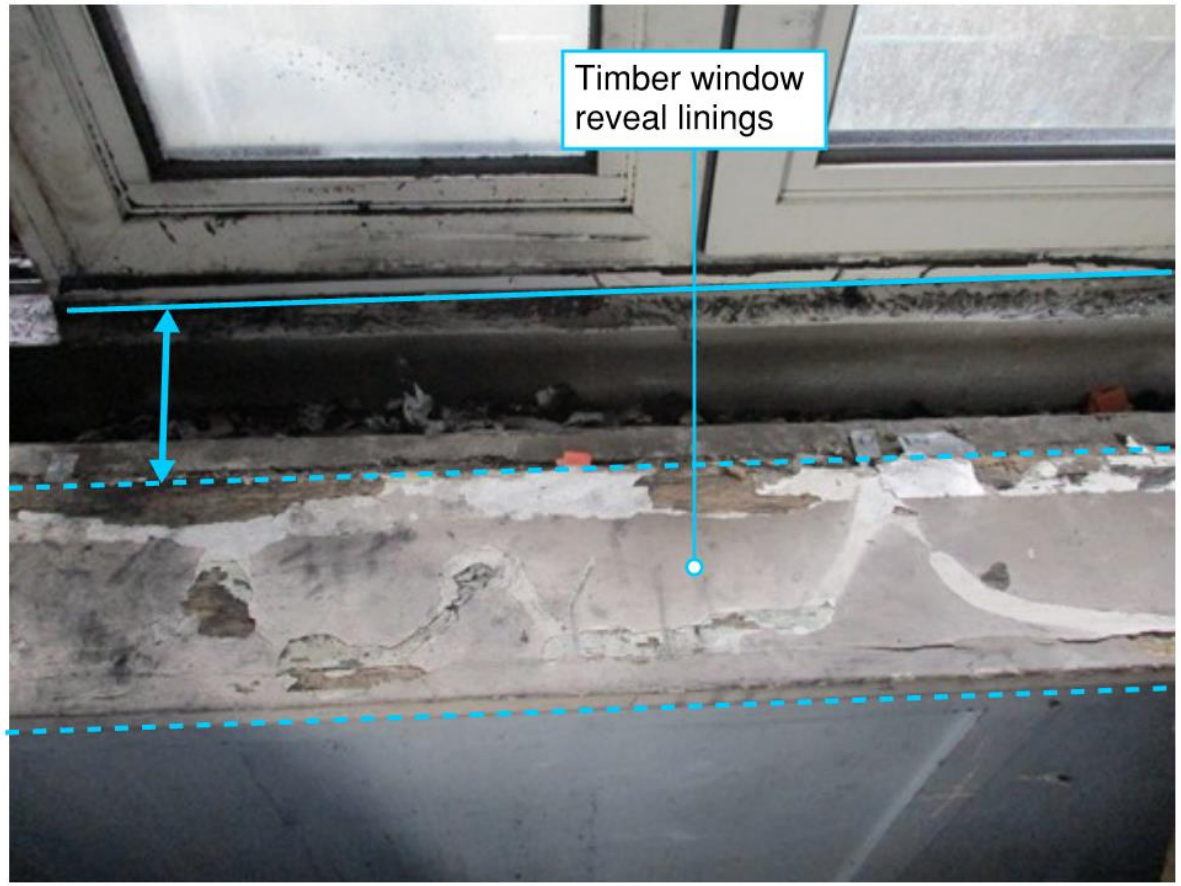
Original window reveal timber lining

Position of the retained timber from the original window linings





Materials lining the window openings internally – original timber elements

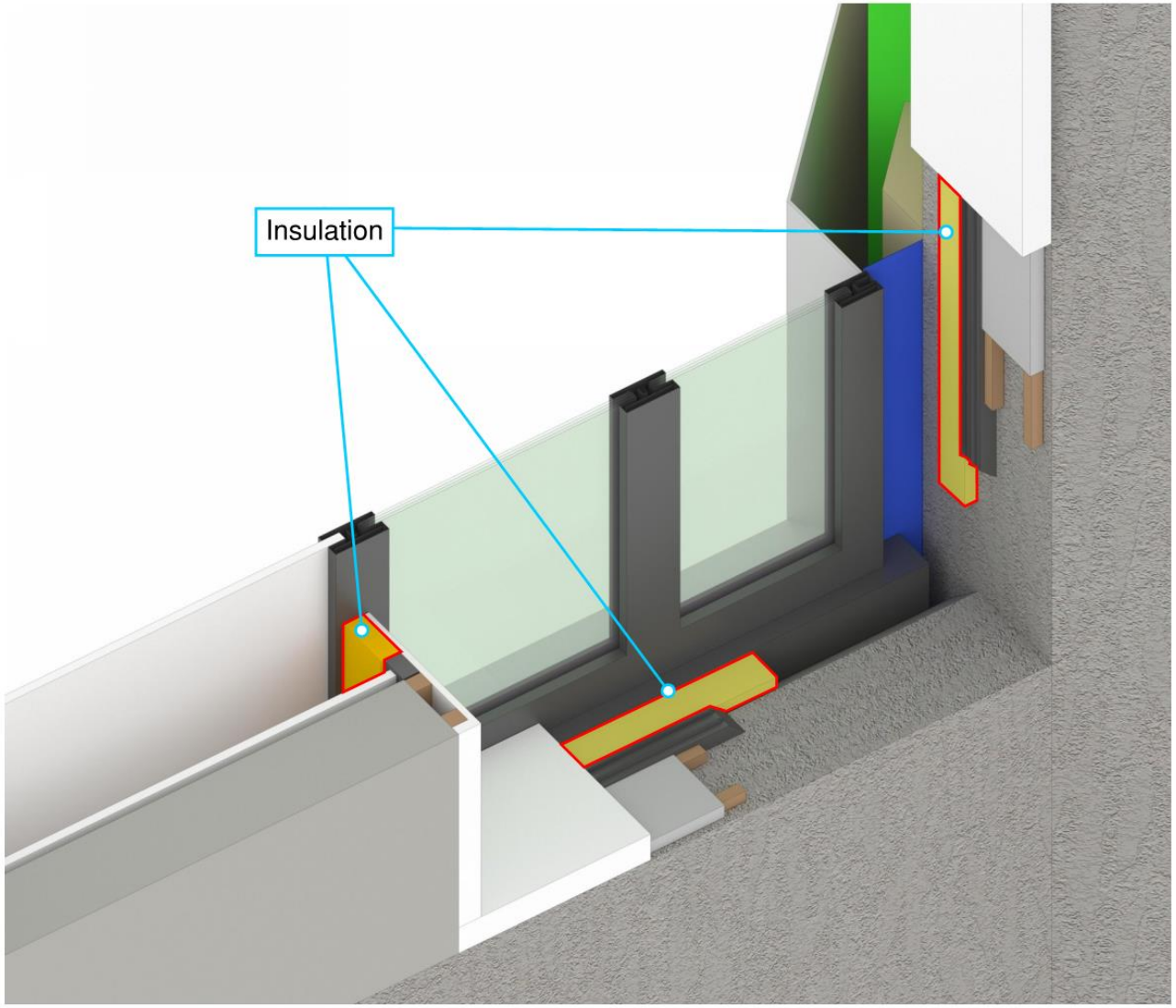


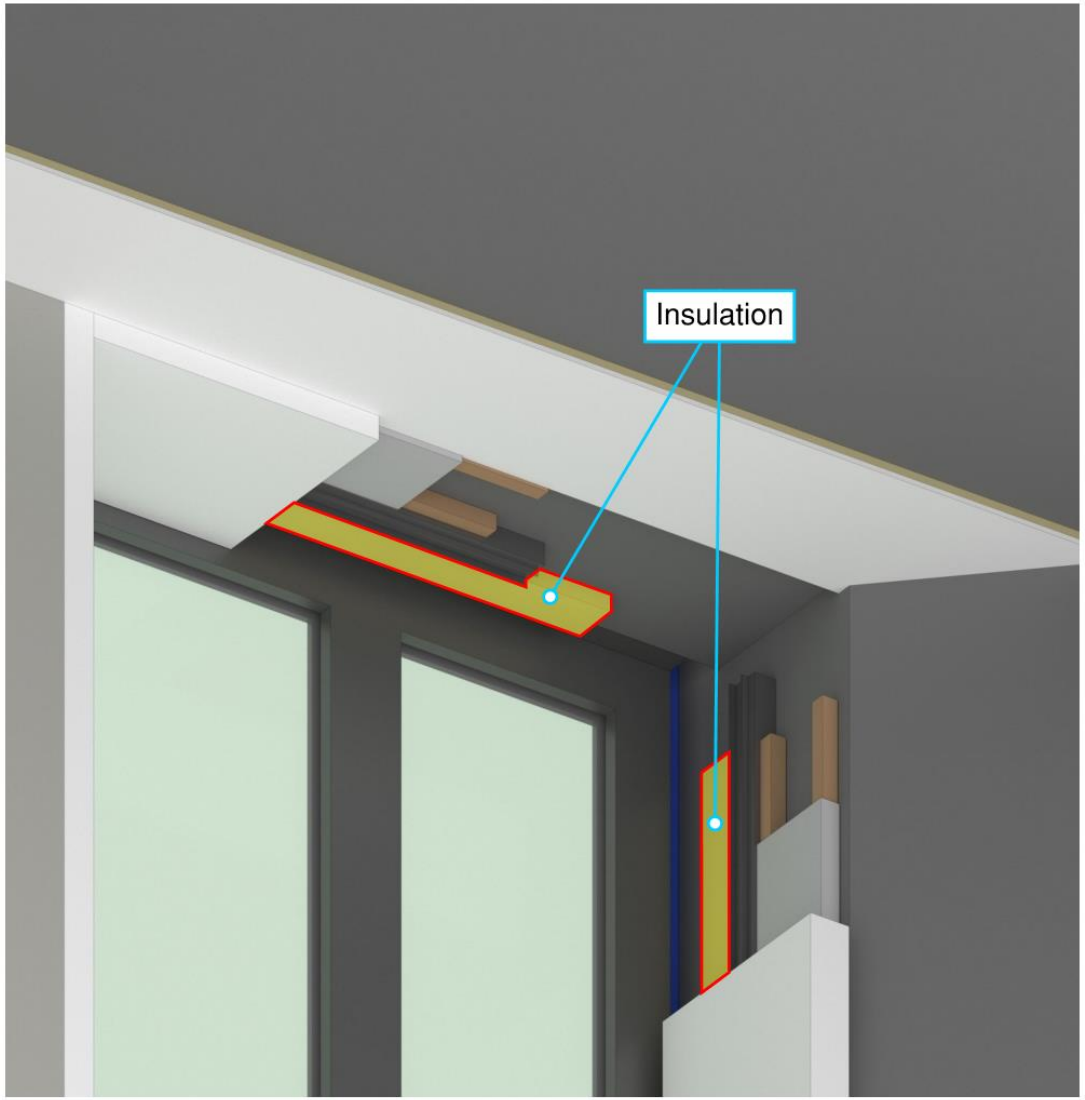
Foam filler

Top of window opening – Plastic foam filler material

Insulation beneath the uPVC window reveal lining

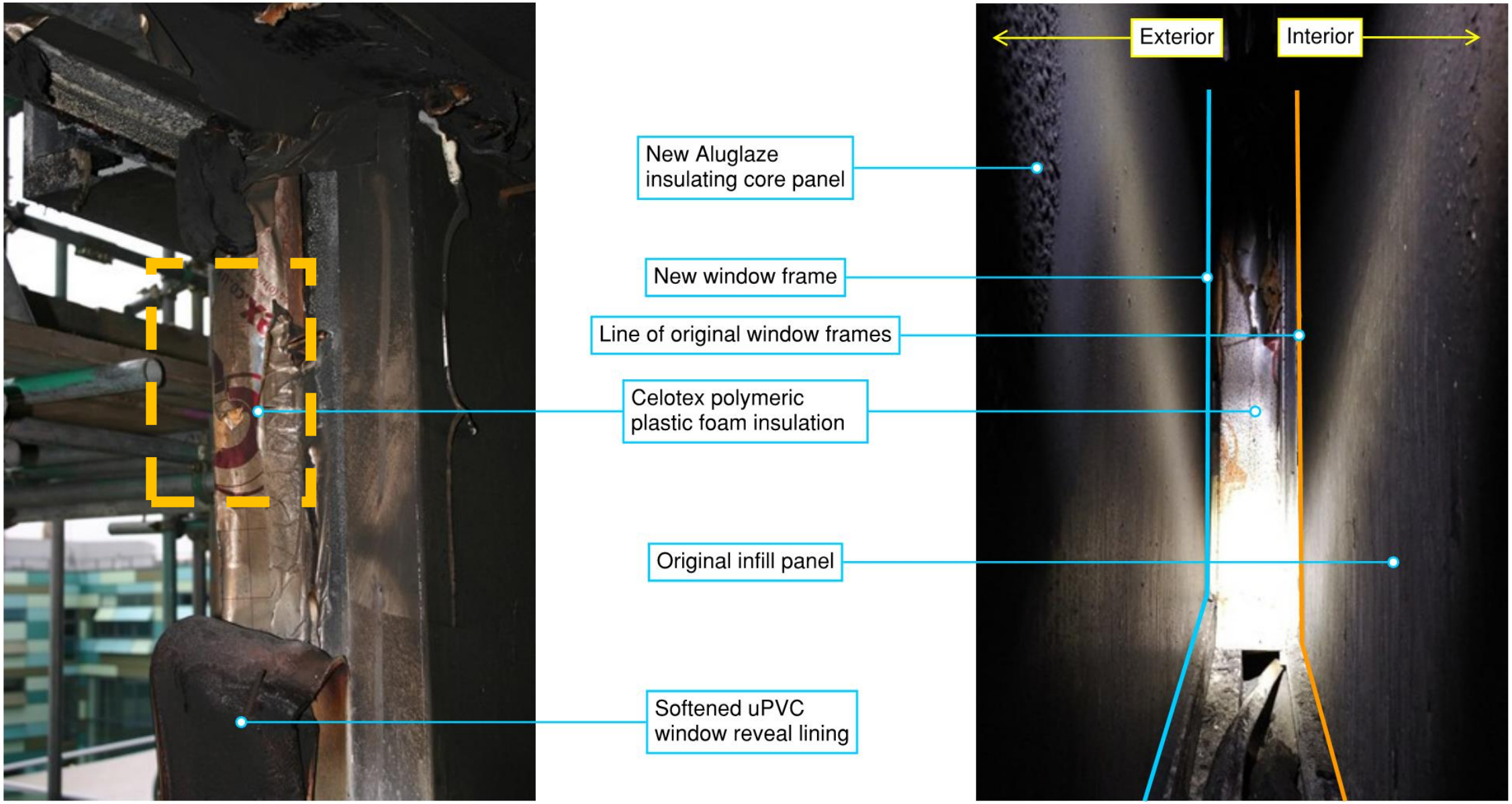
The location of insulation beneath the uPVC window linings





Thermal insulation observed at the top of the windows

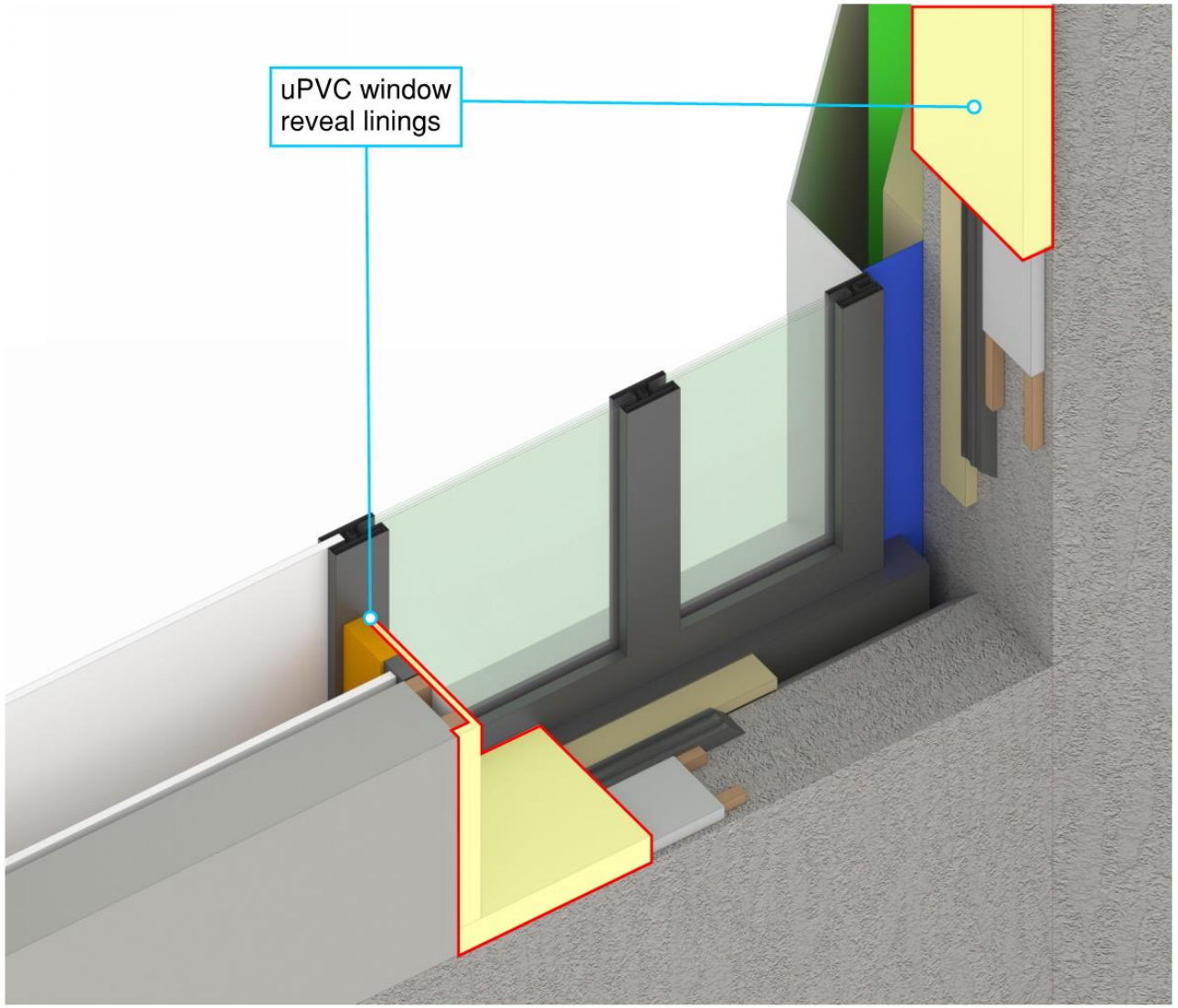
Thermal insulation observed at the window sides

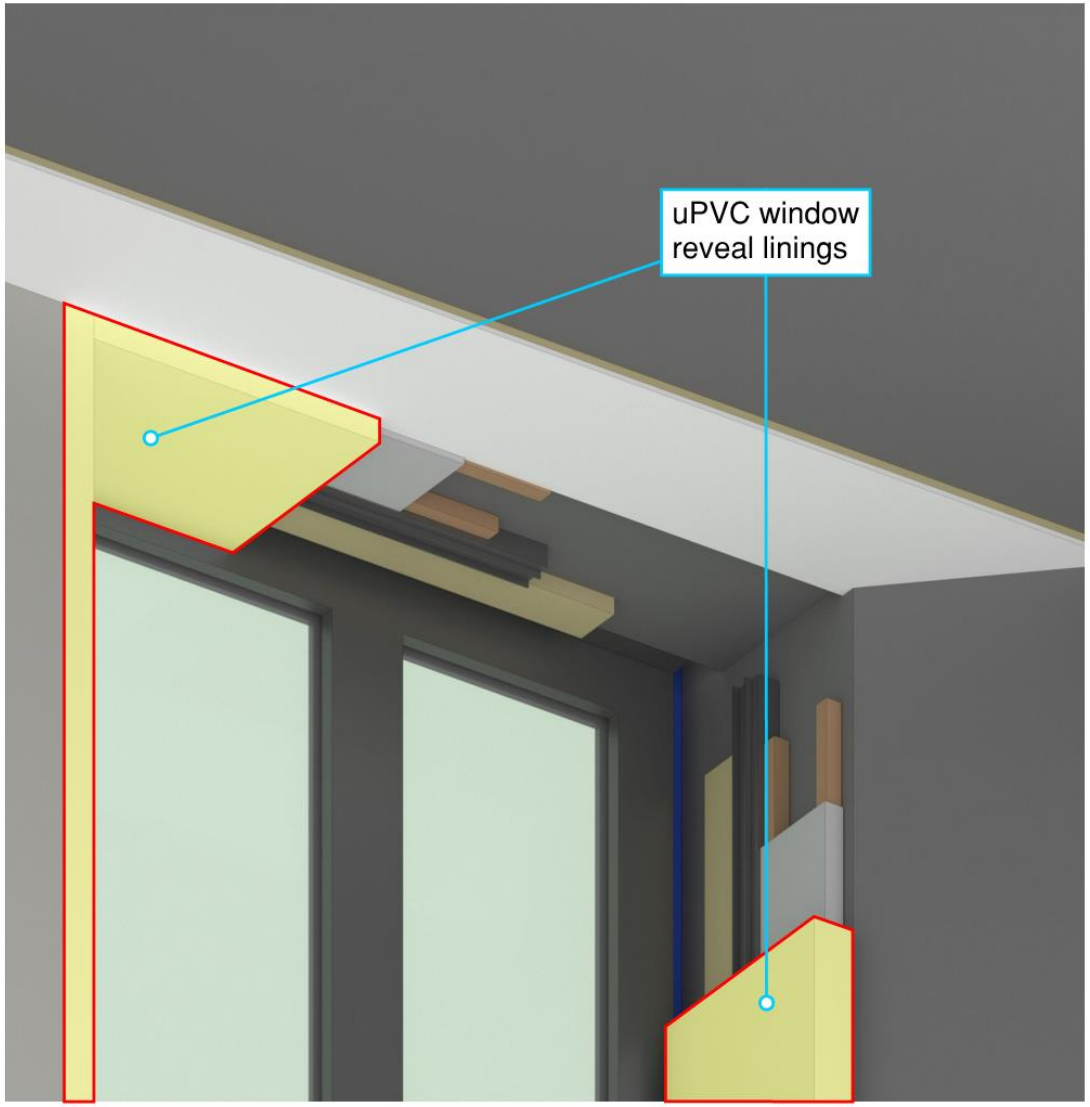


Thermal insulation overserved affixed to the underside of removed uPVC

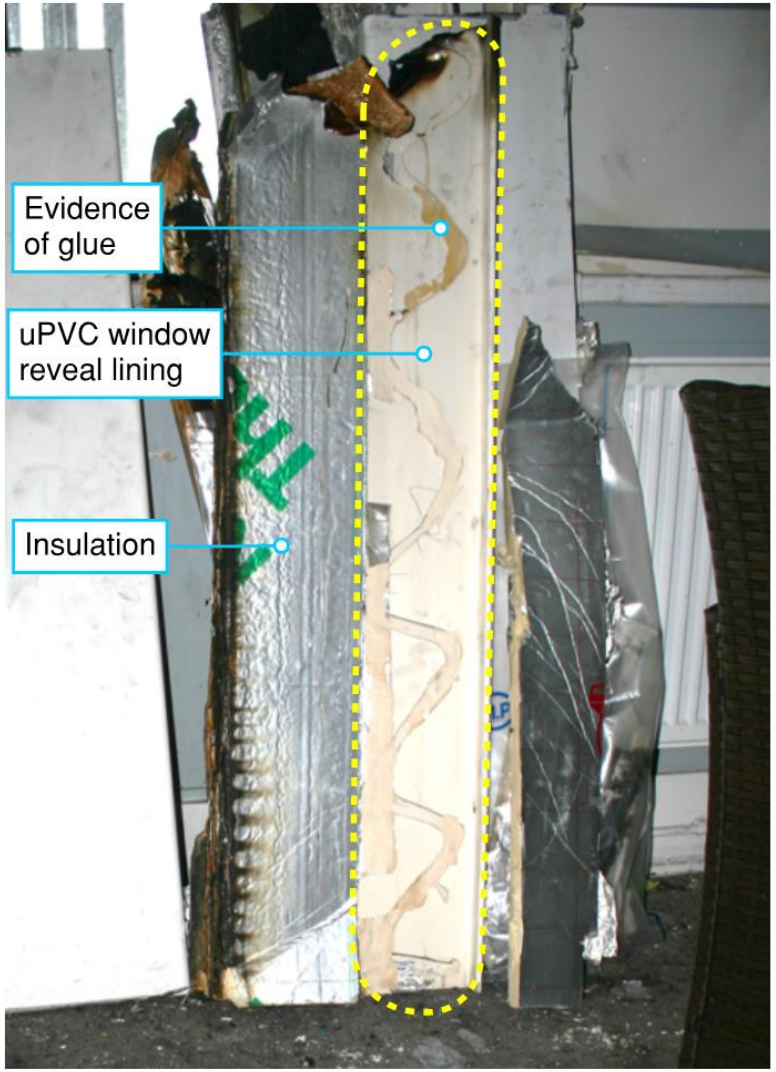
uPVC New window reveals: uPVC lining

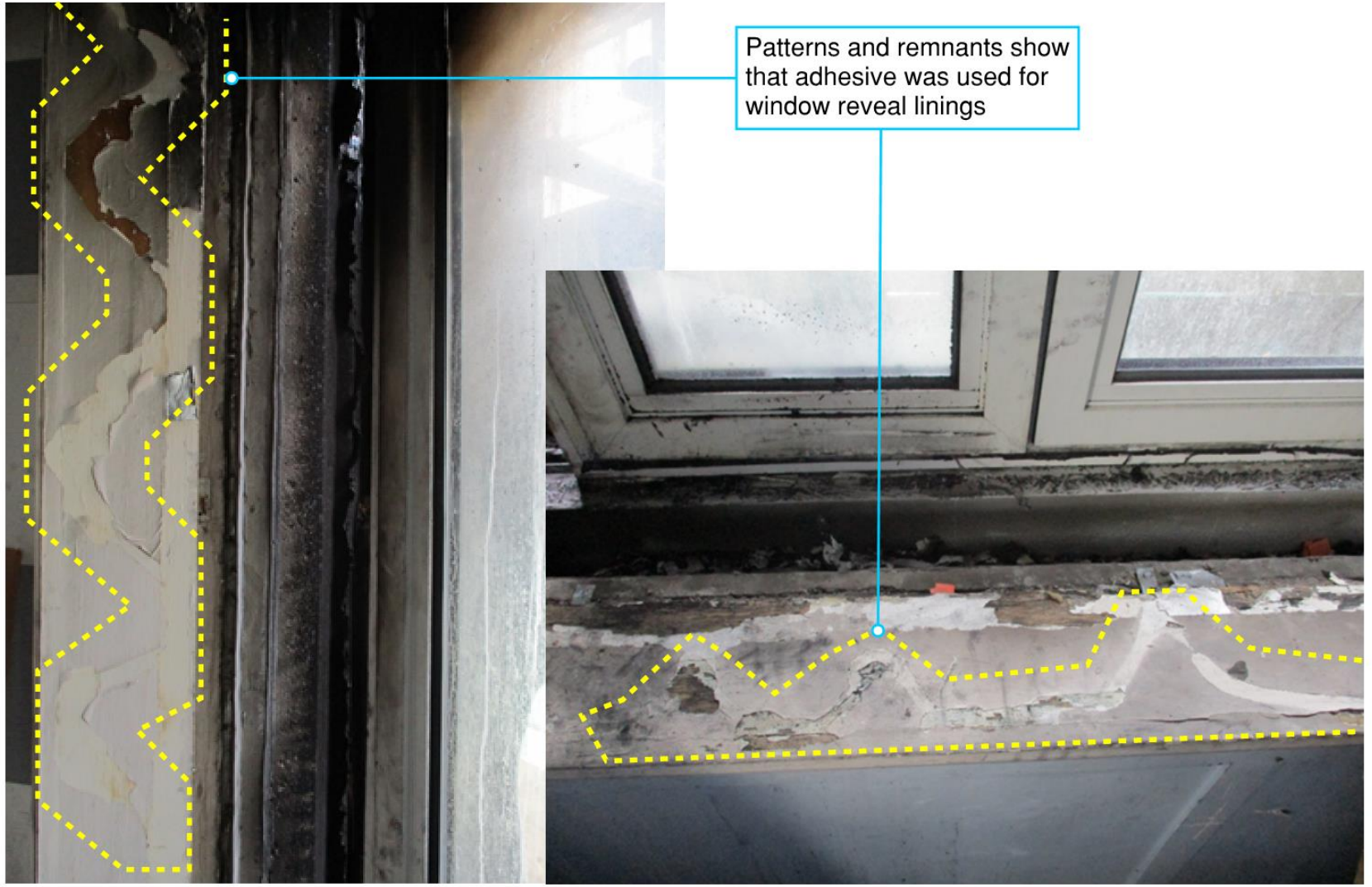
Internal uPVC window linings



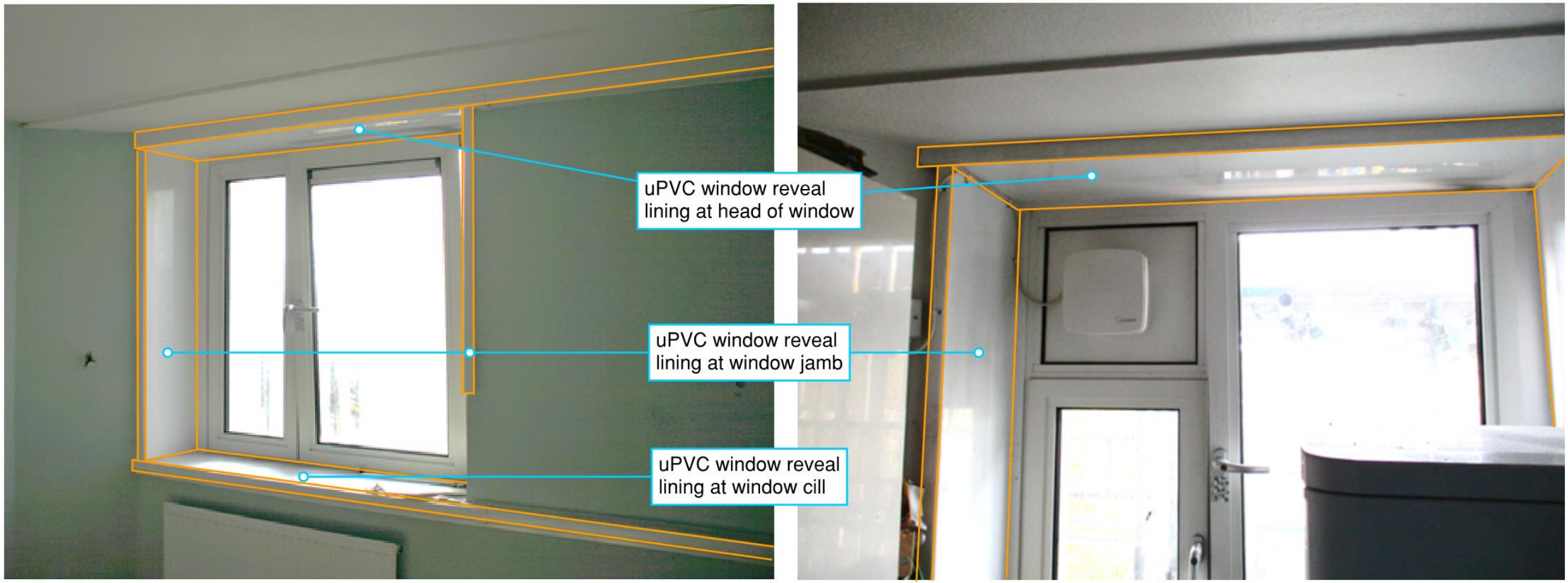


Method of fixing the uPVC window linings





Finished surface of the internal linings to the windows



Performance of the materials installed internally as cavity barriers