

**Grenfell Tower – fire safety investigation:**  
**The fire protection measures in place on the night of the fire, and conclusions as to:**

**The extent to which they failed to control the spread of fire and smoke;**  
**The extent to which they contributed to the speed at which the fire spread.**

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**Phase 1 Report – Section 8**

**The external wall – materials and construction**

**REPORT OF**

**Dr Barbara Lane FREng FRSE CEng**

**Fire Safety Engineering**

**24<sup>th</sup> October 2018**

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<b>Specialist Field</b>	:	Fire Safety Engineering
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<b>On behalf of</b>	:	Grenfell Tower Inquiry
<b>On instructions of</b>	:	Cathy Kennedy, Solicitor, Grenfell Tower Inquiry
<b>Subject Matter</b>	:	To examine the circumstances surrounding the fire at Grenfell Tower on 14 <sup>th</sup> June 2017
<b>Inspection Date(s)</b>	:	6 <sup>th</sup> October, 1 <sup>st</sup> November, 7-9 <sup>th</sup> November 2017

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## **8 The external wall – materials and construction**

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### **8.1 The purpose of Section 8**

- 8.1.1** In this Section 8, I describe the results of my investigation into the construction materials, and their arrangement, to form the external wall on Grenfell Tower, as a result of the refurbishment works in 2012-2016.
- 8.1.2** I provide an explanation of what materials I found and where I found them, during my post-fire site investigations.
- 8.1.3** I provide measurements of the external wall construction taken during my site inspections and from design and construction drawings. Where further evidence of measurements becomes available, I may be required to revise my report.
- 8.1.4** It should be noted that on many of the top floors of Grenfell Tower there are no construction materials left to inspect. As a result, I focused my attention on Level 3 and Level 4, where the construction materials were largely intact. However, I did inspect all floors in Grenfell Tower, for various technical reasons, between 1<sup>st</sup> October and the 9<sup>th</sup> November 2017.
- 8.1.5** I am also aware that BRE have removed a large quantity of material from Grenfell Tower and are carrying out a series of fire tests on those materials. And that Professor Luke Bisby will carry out his own fire tests on sample materials from Grenfell Tower also. In the event any evidence is provided to me regarding the identification of additional materials to those reported here, I will update my report.

### **8.2 Definition of an external wall**

- 8.2.1** For the purposes of my expert report, I am going to refer to the external wall at Grenfell Tower, with the following materials and systems incorporated in that definition, as follows.
- 8.2.2** The refurbishment works included the creation of a new external wall which was a ventilated rainscreen cladding system.
- 8.2.3** It contained:
- a) The original building external wall as the backing wall;
  - b) A new weatherproof membrane between the new windows and the existing concrete structure;
  - c) New windows and window frames;
  - d) New insulating core panels as infill between certain windows;
  - e) New small window inserts formed with insulating core panel to accommodate the kitchen extract fan;



- f) New thermal insulation applied directly to the backing wall;
- g) New thermal insulation applied around every window under the internal finishes;
- h) A rainscreen cavity (drained to the exterior);
- i) Multiple other cavities I explain herein;
- j) Rainscreen cladding panel as the external surface;
- k) Fixings and supporting structure outlined in Section 8.9 of my report.

**8.2.4** The purpose of a rainscreen is defined in the British Standard code of practice for stone based rainscreen cladding (BS 8298-4):

*“A ventilated rainscreen should have the following key elements:*

- a) An outer layer (the rainscreen), intended to shelter the building from the majority of direct rainfall. Some joints between panels or at the edges of the rainscreen should be left open.*
- b) A cavity, which can include insulation, intended to collect any water which passes through the joints in the rainscreen layer, and to permit such water to flow down to a point where it is collected and drained from the cavity. The insulation layer should not completely fill the cavity.*
- c) A backing wall, intended to provide a barrier to air infiltration and water ingress into the building.*

*NOTE 4 A ventilated rainscreen cladding system is either pressure-equalized or drained-and-ventilated. The system at Grenfell was a drained and ventilated system”*

**8.2.5** Studio E, the architects of the refurbishment work, defined the external wall works as rainscreen cladding in the Studio E NBS specification section H92 ‘Rainscreen Cladding’ (SEA00000169).

**8.2.6** Please also note that in Section 3 of my report I have set out the definitions of combustible, burning, smouldering, and other combustion process related terminology, upon which I intend to rely when explaining my analysis and opinions in this Section 8 and all parts of my Expert Report.

**8.2.7** I have provided a detailed description of the reaction to fire tests in Appendix F, as these form the statutory means of classifying materials of limited combustibility, non-combustible materials, etc., as defined in the Approved Document B 2013 (ADB).

**8.2.8** To assist the reader, where I have referred to a material as “combustible” herein, I mean “A material that will ignite and burn when sufficient heat is applied and when an appropriate oxidiser is present” (Dehann, 2007).



**8.2.9** In Section 11 of my report I analyse the compliance of the materials used to form the rainscreen cladding system on Grenfell Tower, and whether they complied with the ADB 2013 requirements for Limited Combustibility and other required fire performances. These issues are not addressed in this Section 8.

## **8.3 Methodology to confirm the materials and their arrangement at Grenfell Tower**

**8.3.1** I have taken two main actions to confirm the materials, and their arrangement as external wall construction, at Grenfell Tower:

- a) A detailed onsite inspection as explained in Section 6 of my report.
- b) A detailed review of documentation provided to me which is relevant to this issue and which I have referred to throughout this Section.

**8.3.2** The following sections are the outcome of that analysis. I have focused my analysis on the external wall construction of the original residential floors (levels 4-23) only. The cladding on the lower floors was constructed from different materials and was not involved in the fire on 14<sup>th</sup> June 2017.

## **8.4 Original form of the external wall**

**8.4.1** The building is approximately 70m tall and 22m by 22m on plan. There is a central reinforced concrete (RC) core with perimeter RC columns. The RC columns have a pre-cast “biscuit” (right-angled slab) to the outer surfaces. This was used as permanent formwork to cast the columns. Spanning between the concrete columns are solid concrete structural spandrels (Figure 8.1).

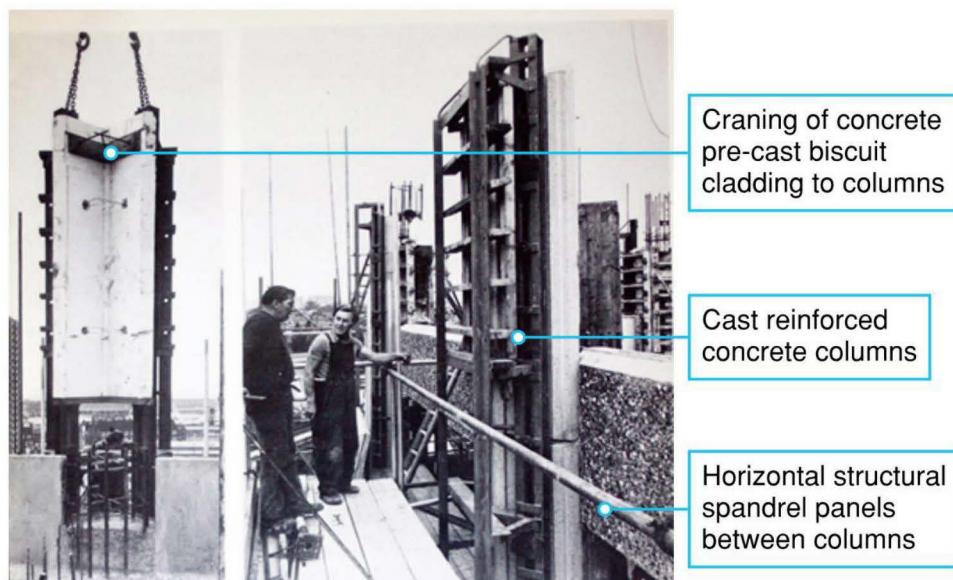


Figure 8.1: Construction of original Grenfell Tower external wall – horizontal spandrels and vertical column cladding. (from <https://www.grasart.com/blog/lancaster-west-estate-an-ideal-for-living> accessed 12/02/2018)

- 8.4.2 The floor slabs were 20cm thick (8 inches).
- 8.4.3 The walls enclosing the protected lobbies, stairs and lift shafts on every level are collectively referred to as the core walls. The thickness of the core walls varies between 20cm and 30cm (8 to 12 inches).
- 8.4.4 The perimeter beams are approximately 25cm thick (10 inches).
- 8.4.5 The perimeter columns are approximately 70cm square (27 inches). This does not include the precast ridged facing that was used as sacrificial formwork. This ridged facing as visible today on the Tower, was permanently connected to the columns through the provision of metal wires embedded in the concrete of the columns.
- 8.4.6 The structural walls between flats were 20cm thick (8 inches).
- 8.4.7 The pre-cast concrete cladding to the columns and the horizontal spandrel form part of the external wall of the building. As indicated in Figure 8.2 to Figure 8.4 and summarised in Figure 8.6, the spandrels were solid concrete with no cavities. The opening between the horizontal spandrels was filled with a combination of sliding windows held in aluminium frames and non-structural, non-combustible infill panels (material currently unknown but understood to consist of asbestos-bearing cementitious materials).

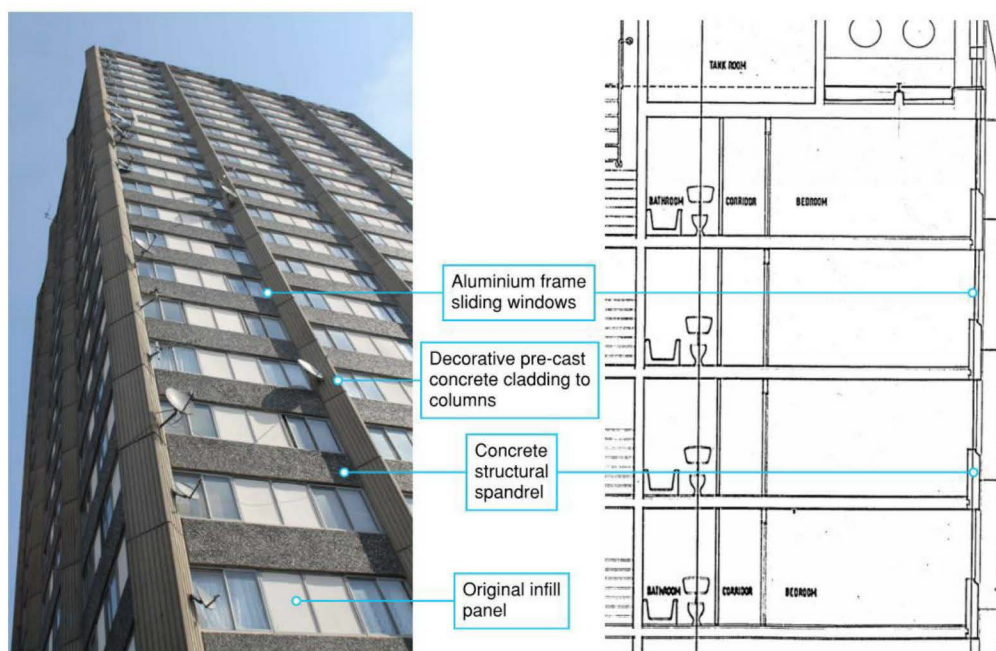


Figure 8.2: Original form of the external wall of Grenfell Tower (Image Grenfell Tower refurbishment Stage D Design Report – CCL00000028; RBK00018840)



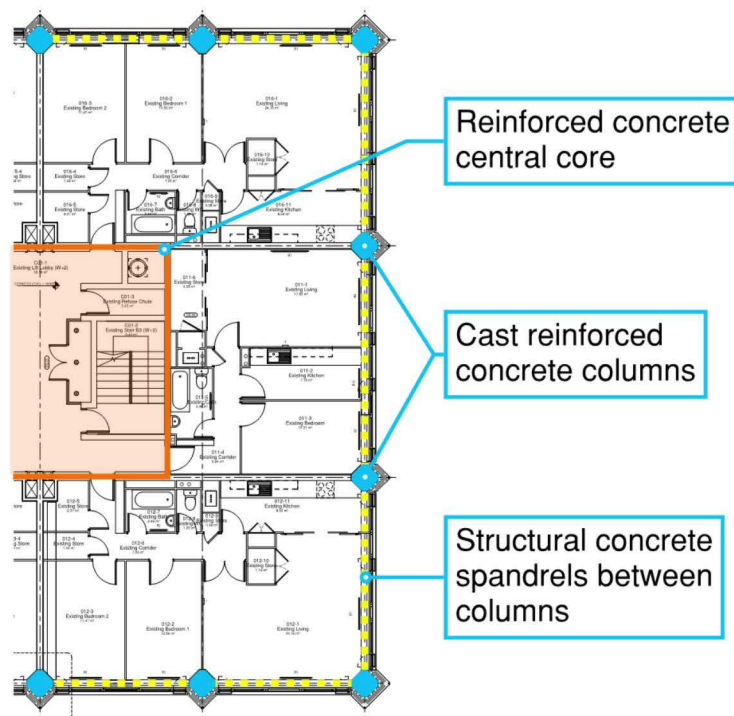


Figure 8.3: Plan view of original form of the concrete structure (Based on SEA00010474)

#### 8.4.8

The original form of the interior window finishes and the windows themselves is shown in Figure 8.4. The window cills, jambs and heads appear to be lined in timber.

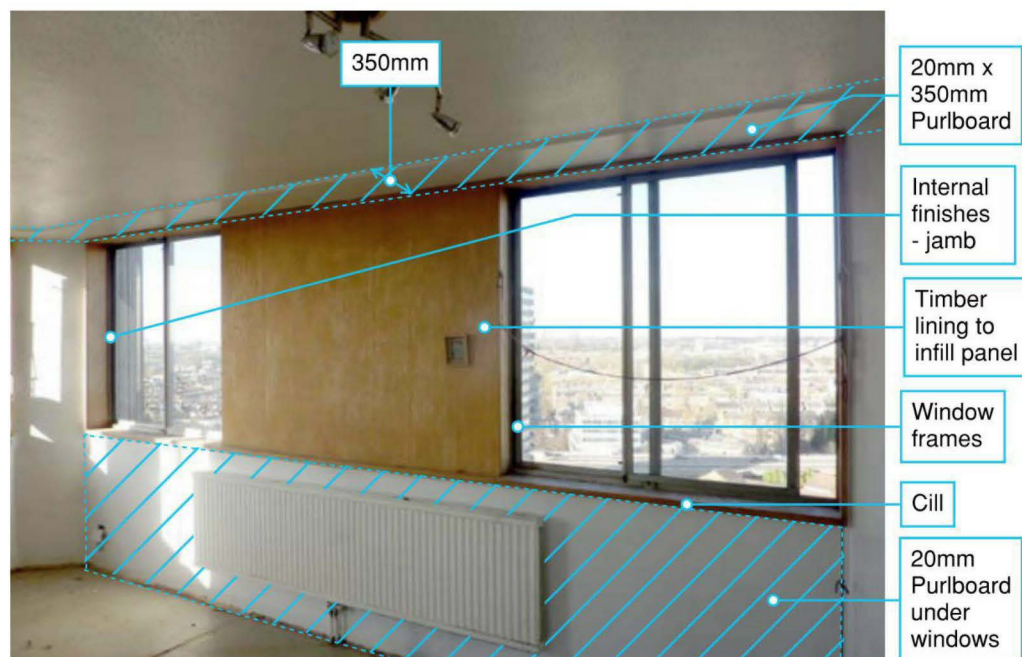


Figure 8.4: Original form of the internal window finishes (Image Grenfell Tower refurbishment Stage D Design Report - CCL0000028)



- 8.4.9** A protruding strip of material adjacent to the head of the window was observed during my site inspections to be labelled ICI Purlboard, an approximately 20mm thick product, comprising an 8mm thickness plasterboard layer with 12mm of combustible polyurethane foam insulation bonded to the rear - as shown in Figure 8.5.

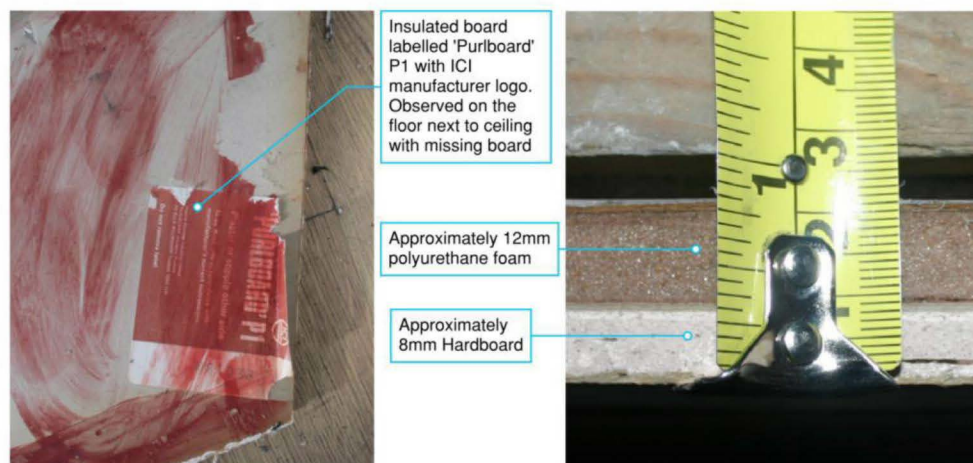


Figure 8.5: Insulation board details (Left: product name and manufacturer visible on section of board observed on the floor of Flat 23, Level 5. Right: Thickness of layers in insulated board affixed to external wall as my team observed in Flat 13, Level 4)

- 8.4.10** My team observed a product label on a piece of this board in Flat 23, Level 5 where a portion of the board was detached from the ceiling and located on the ground.
- 8.4.11** Polyurethane is a combustible plastic used for a variety of construction applications. The SFPE Handbook<sup>1</sup> lists polyurethane as combustible and Table A.36 of the Handbook lists the ignition temperature for polyurethane as 271°C.
- 8.4.12** This material was used in the original building to close the gap between the window head reveal and the concrete soffit above as shown in Figure 8.6. The width of this strip was measured on site (see Appendix C) as 350mm and lines the ceiling adjacent to the full perimeter of the external wall in each flat.
- 8.4.13** As highlighted in Figure 8.4 and Figure 8.6, a larger panel of Purlboard was also present underneath the windows from floor to cill level, between every column.

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<sup>1</sup> The SFPE (Society of Fire Protection Engineers) Handbook 5<sup>th</sup> Edition is the most extensive single reference handbook for fire science and engineering. Over 130 fire engineers and researchers contributed chapters to the book, representing universities and professional organizations around the world. The Handbook was first published in 1998 and the 5<sup>th</sup> edition of the Handbook was published in 2016, as it is regularly updated and revised with new research and information.

## 8.5 Overview of existing, proposed and observed external wall

8.5.1 Figure 8.6 and Figure 8.7 show the extent of the changes brought about by the window opening refurbishment works, in comparison to the previously installed windows. This is to identify which parts of the window openings were original and removed, which parts were original and retained, and which parts were then added as part of the refurbishment works.

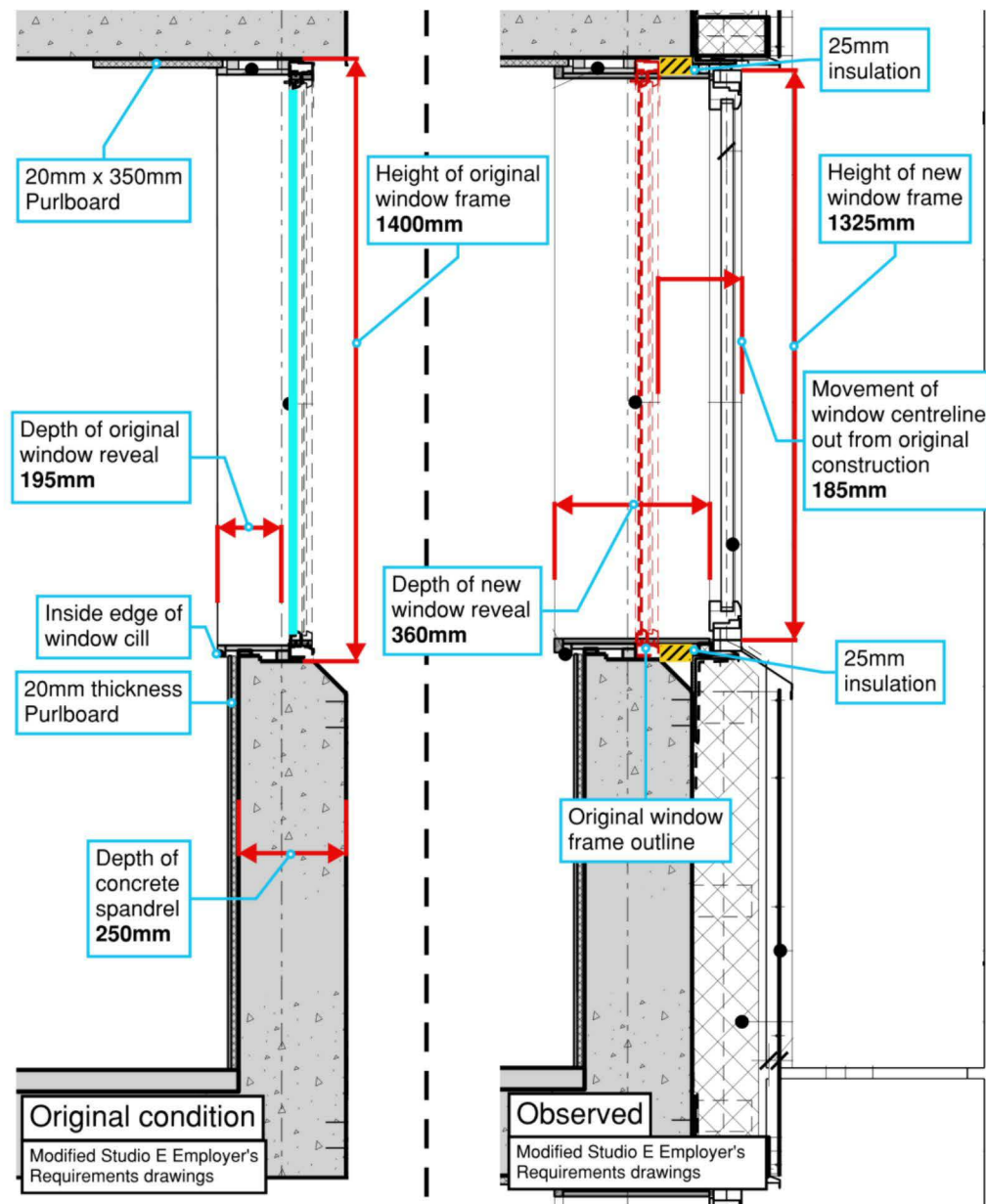


Figure 8.6: Section view of original (left) and refurbished/observed (right) window openings (adapted from SEA00013045). See Section 8.7 for further details of the combustible insulation indicated. .



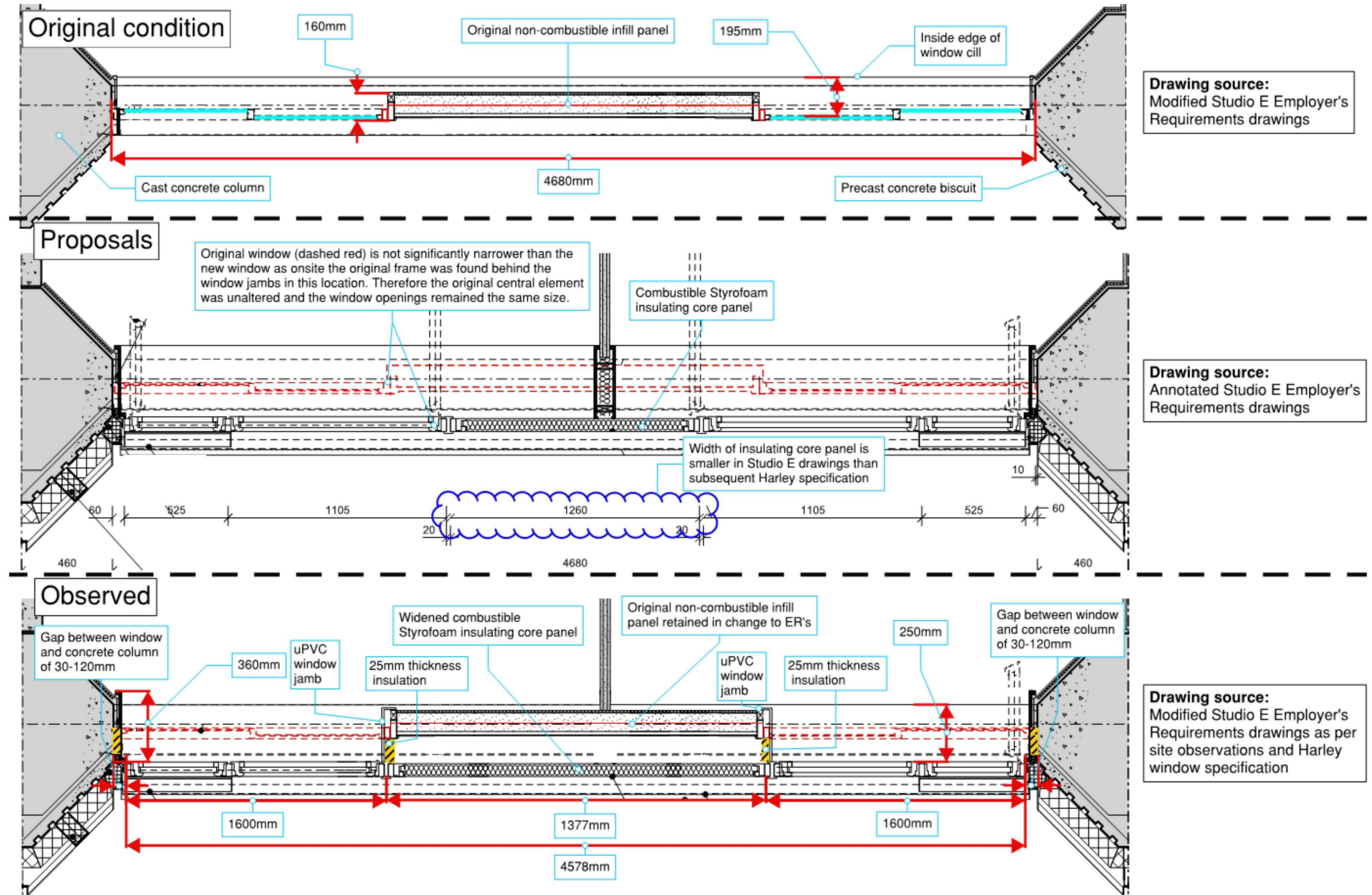


Figure 8.7: Plan view of original, proposed and observed window opening based on (SEA00013045). Details of original non-combustible infill panel taken from (HAR00003765). See section 8.10 for further details of the combustible insulating core panels indicated (Aluglaze)



## **8.6 Overview of refurbishment works to the external wall**

- 8.6.1** Figure 8.8, Figure 8.9, Figure 8.10 and Figure 8.11 present the proposed facade build-up as part of the refurbishment design as taken from Harley drawings (HAR00008879, HAR00008880, HAR00008901). These drawings provide an overview of all of the major components of the external wall build-up.
- 8.6.2** Specifically, Figure 8.8 provides an overview of the external wall construction. This is a rendered image built up using information from the original design drawings and observations from site.
- 8.6.3** Figure 8.9 gives a vertical section through the wall build up at the floor slab to external wall interface. Figure 8.10 presents the same information, but specifically looking through a section at window level.
- 8.6.4** Figure 8.11 presents a horizontal section through the window at the jamb interface on the column side of the window. Harley did not issue a drawing of the jamb at the in-fill side of the window as this did not appear to be in their scope of works. I will investigate these matters further in my Phase 2 report.
- 8.6.5** These Figures, and the Figures presented throughout the following subsections (based upon them), feature dimensions that are derived from the design drawings, unless stated otherwise.
- 8.6.6** In the following Sections I will describe each part of the external wall build up from the inside of the building to the outside.
- 8.6.7** I will identify the materials used and how each material was positioned in relation to the surrounding materials, as well as details of fixing and jointing of these materials.
- 8.6.8** These Figures have been produced using my observations on site (see Appendix C) and my review of documentation made available to me (references provided throughout).
- 8.6.9** Unless stated otherwise, I have observed each of the materials and components of construction outlined in the following Sections of my report, in more than one location. I am therefore confident that they are representative of the construction over the whole building. I will revisit this issue and update my analysis where necessary when additional evidence is provided to me.

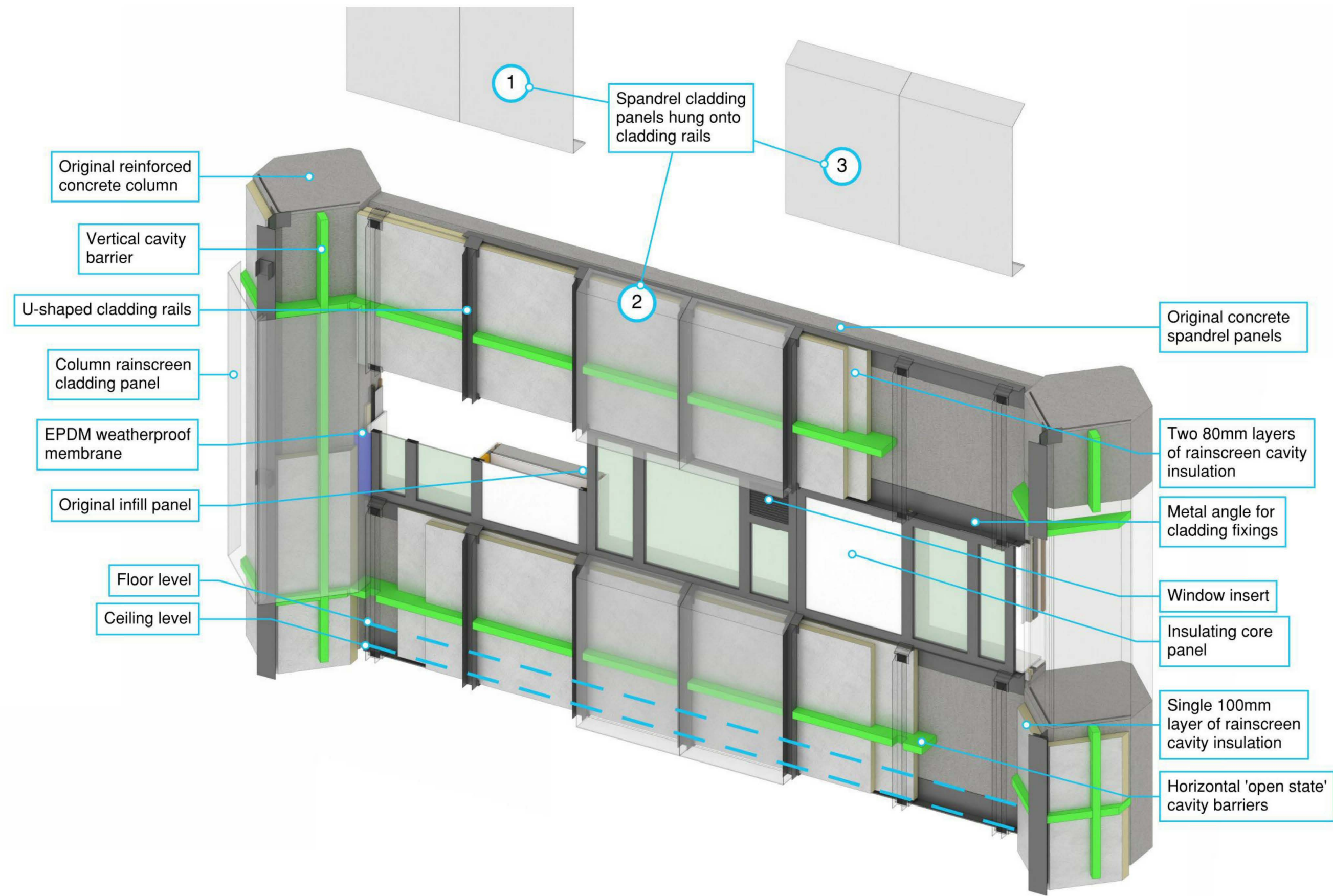


Figure 8.8: Render of external wall construction after completion of the refurbishment works



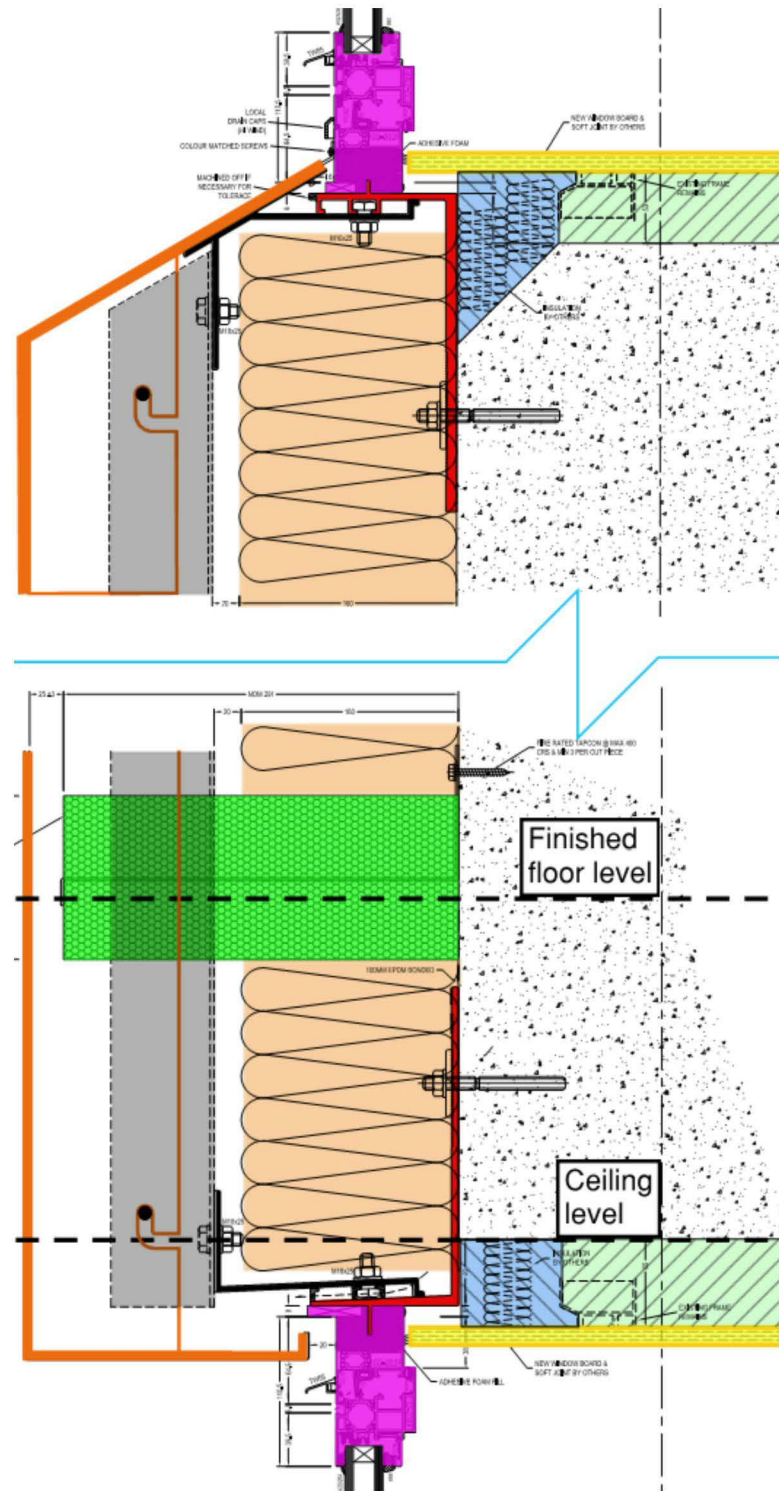


Figure 8.9: Section view of spandrel (HAR00008879 & HAR00008901)

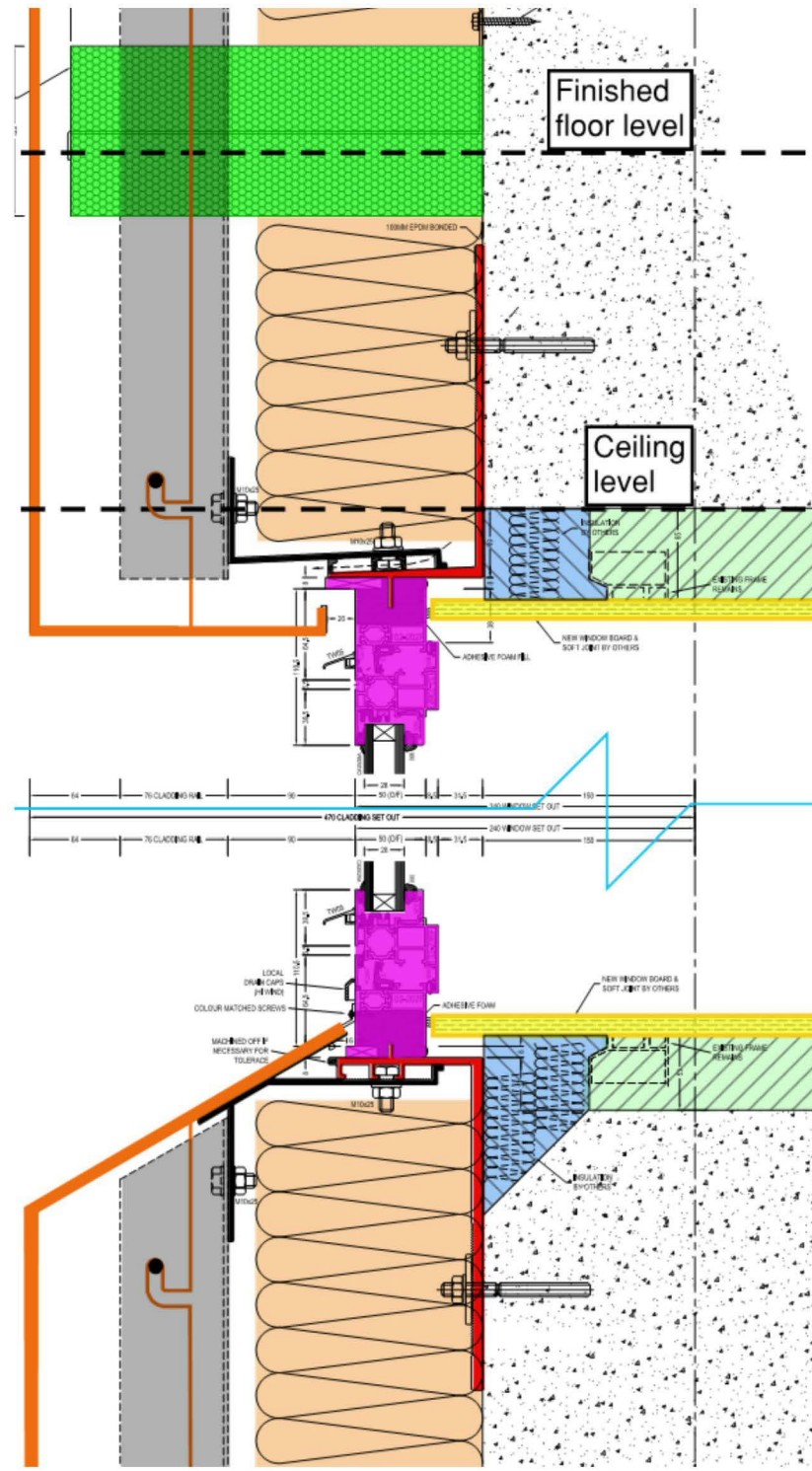


Figure 8.10: Section view of window (HAR00008879 & HAR00008901)

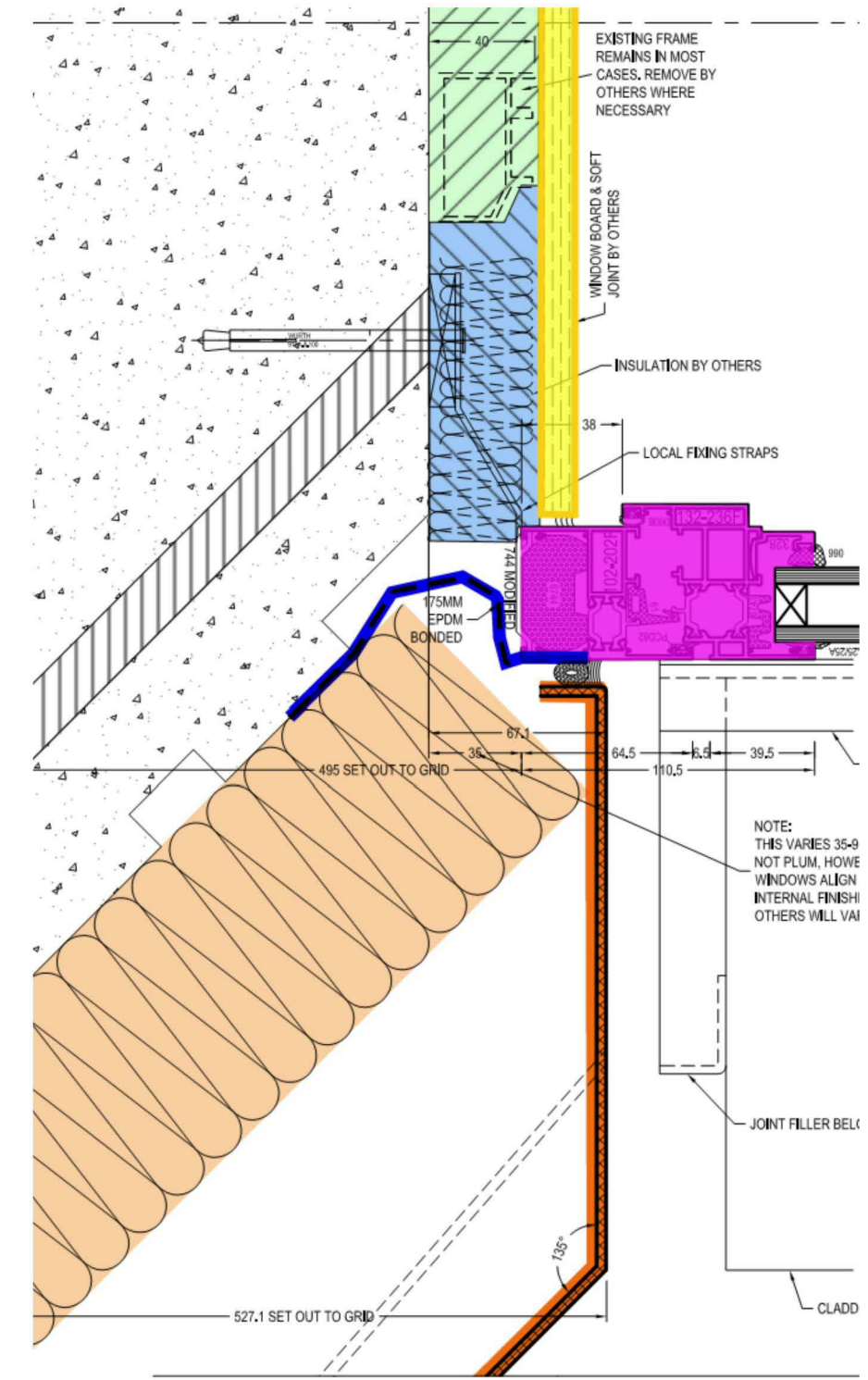


Figure 8.11: Plan view of window jamb at column (HAR00008902)

- |   |   |  |                           |   |                               |                            |
|---|---|--|---------------------------|---|-------------------------------|----------------------------|
| Aluminium window frame                      | uPVC internal finishes                          | Rainscreen cavity insulation                 | Cavity barrier            | Internal cavity partially filled with 25mm insulation       | Original timber window reveal | EPDM weatherproof membrane |
| Continuous metal angle attached to spandrel | Brackets attaching cladding rail to metal angle | Cladding rail with bolts for cassette 'hook' | Rainscreen cladding panel | Outline of metal plate affixed to rainscreen cladding panel |                               |                            |



## **8.7 Internal finishes, cavities and insulation**

- 8.7.1** The design drawings show the location and dimensions of the uPVC finishes and cavities within the window reveals, as shown in Figure 8.12 & Figure 8.13 below. The Harley and Studio E drawings indicate the presence of insulation within each of these cavities but do not specify the type, size or thickness.
- 8.7.2** The Studio E NBS specification (SEA00000169) does not include this insulation.
- 8.7.3** As shown in the locations described by Figure 8.6 and Figure 8.7, I observed on site that the cavities in the cill and head reveals (Figure 8.12) were fitted with 25mm thick pieces of combustible insulation glued to the rear face of the uPVC.

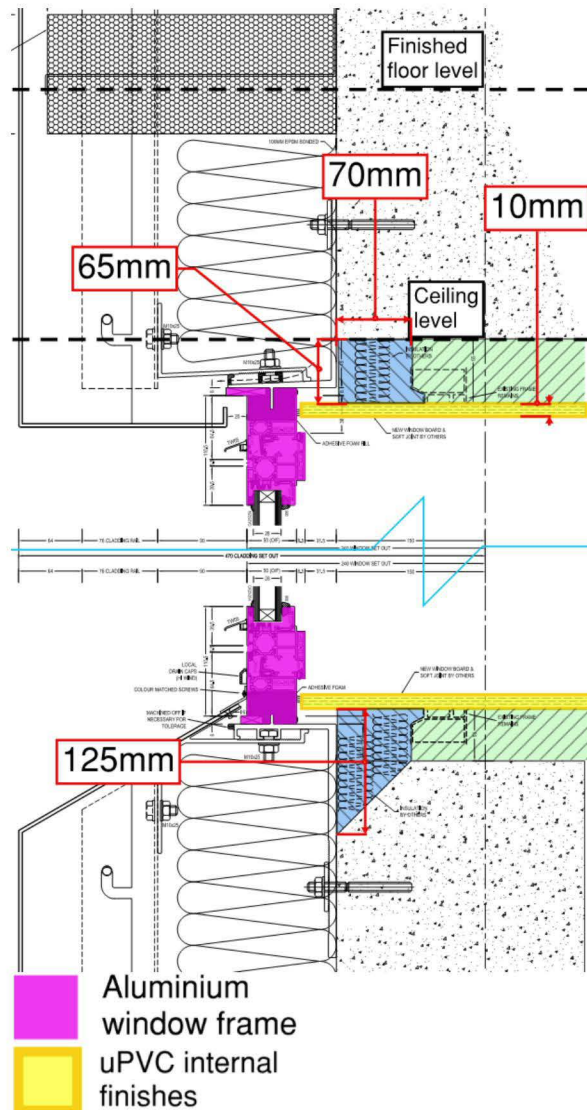


Figure 8.12: Window section highlighting uPVC finishes and internal cavity formed (10mm uPVC dimension measured on site)

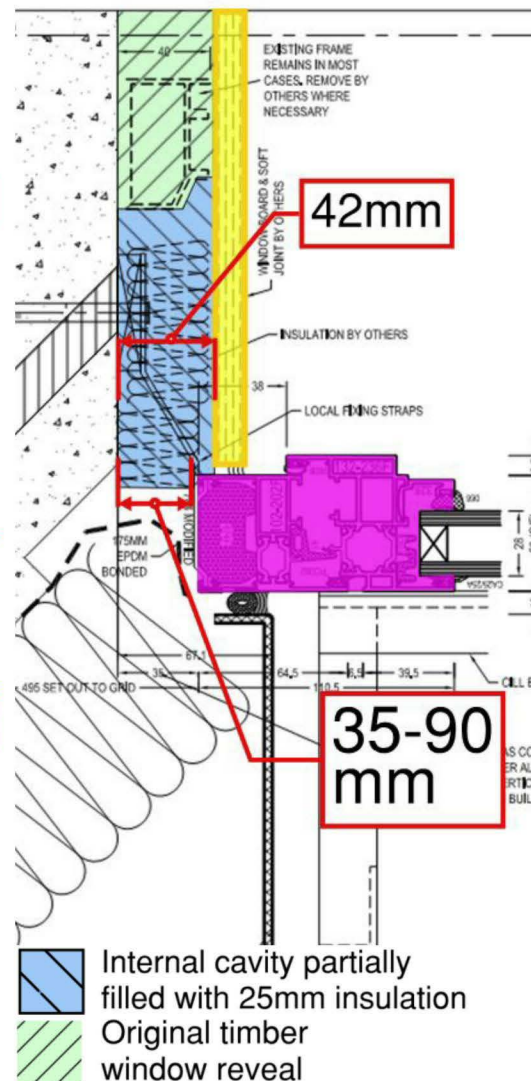


Figure 8.13: Window jamb and column plan detail highlighting uPVC finishes and internal cavity formed

- 8.7.4 I confirmed the position of the uPVC and the existing timber window reveals indicated on Studio E and Harley drawings, that were retained beneath the new uPVC surfaces, during site visits on the 7<sup>th</sup>, 8<sup>th</sup> and 9<sup>th</sup> November 2017 (visible in Figure 8.15).
- 8.7.5 The design drawings show that the new windows were reduced in size and fitted in a new position compared to the original installation and I confirmed this on site (see Figure 8.15, original installation marked in black).
- 8.7.6 Note that the original Purlboard combustible lining was not removed in the refurbishment works (Figure 8.4 & Figure 8.14).
- 8.7.7 The following materials were therefore present in the window reveals:
- New uPVC reveals –solid plastic material (combustible)

- b) Original timber reveals –solid wood material (combustible)
- c) New cavity insulation –plastic insulation foam manufactured by Celotex and Kingspan (combustible) (Figure 8.16 & Figure 8.18)

**8.7.8** uPVC is an acronym for “unplasticised polyvinyl chloride”. This material is a rigid combustible plastic used for a variety of construction items.

**8.7.9** In Grenfell Tower uPVC was used as the coverings (or “reveals”) to the sides of the hole through the façade in which the windows were fitted.

**8.7.10** The SFPE Handbook provides the following material properties for uPVC:

- a) Glass Transition temperature – 80°C. This is the temperature beyond which plastics soften significantly, leading to deformation and “drooping”.
- b) Melting point – 75-100°C. When the plastic becomes a liquid.
- c) Ignition temperature – 395°C. When the plastic starts to burn.

**8.7.11** When heated above 100°C uPVC releases Hydrogen Chloride gas. This gas is toxic and an irritant.



Figure 8.14: Internal linings as seen on my site inspection within Flat 22 living room.



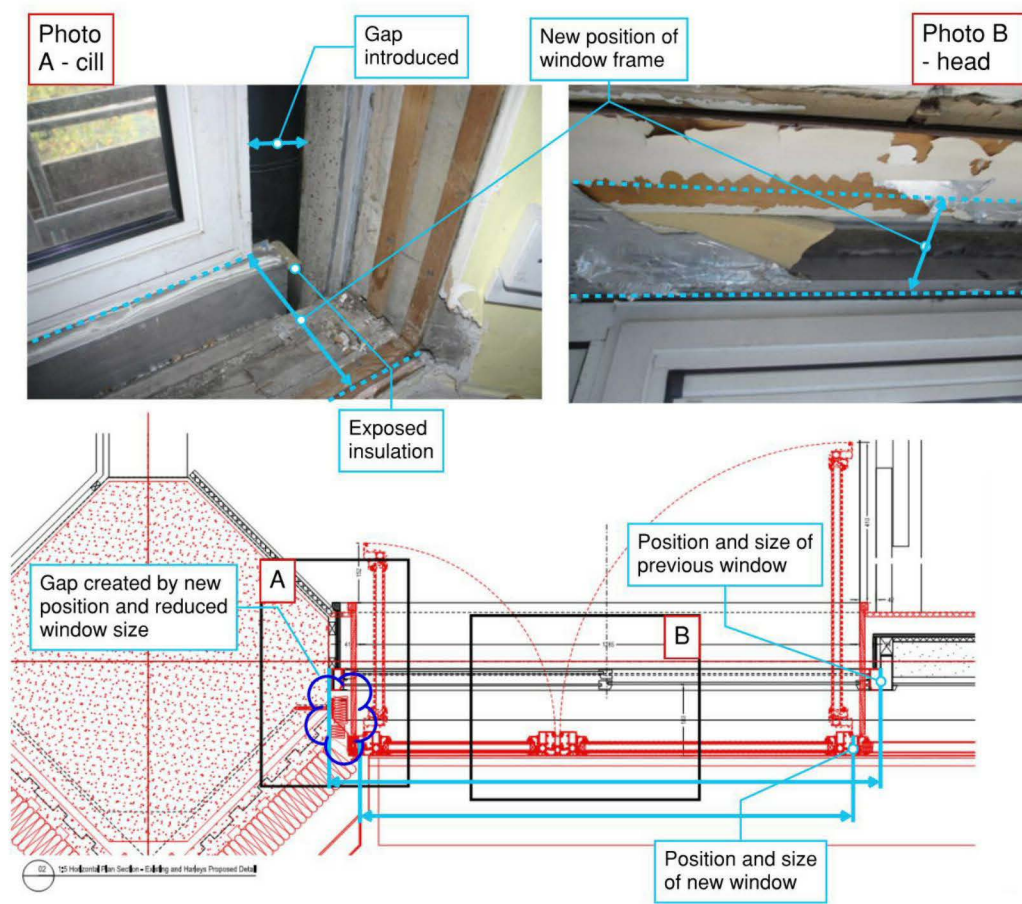


Figure 8.15: Evidence of repositioning and reduction of size of new windows (HAR00003765). Photos from Flat 13 Kitchen

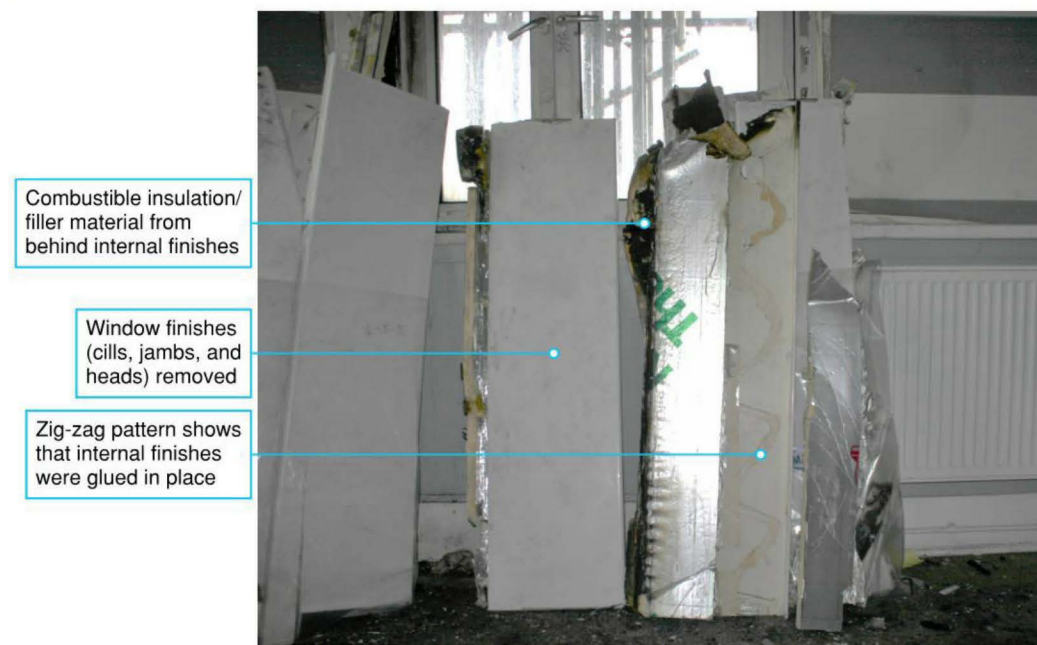


Figure 8.16: Combustible insulation materials (identified in section 8.7.12) from underside of internal finishes. Flat 15 living room.

- 8.7.12** Figure 8.16 provides evidence from site that insulation taken out of the cavities created behind the new uPVC window reveals was combustible. It pictures the reveals and insulation after removal, with the remnants of glue on the underside of the reveals apparently demonstrating that the new uPVC fittings were glued into place, rather than being mechanically fixed.
- 8.7.13** Design drawings did not specify the materials to be used in these locations, but site inspection confirmed at least two different materials:
- Celotex PIR insulation (combustible)
  - Kingspan ‘Therma’ range PIR insulation (combustible)
- 8.7.14** PIR is an acronym for ‘polyisocyanurate’ and is a rigid plastic foam. The SFPE Handbook lists PIR foams as a combustible material and Table A.36 of the Handbook lists the ignition temperature of PIR foams as 378°C.
- 8.7.15** In this case, the insulation was fitted to enclose the new cavity created between the new and existing in-fill panels (excerpt of Figure 8.7 enlarged and annotated below):

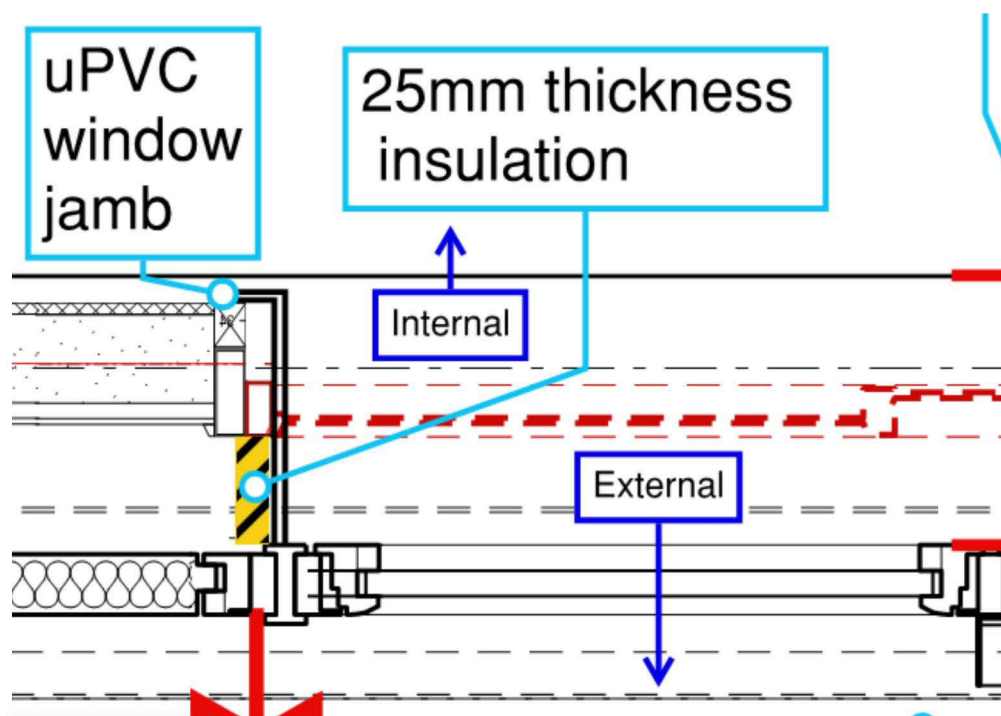


Figure 8.17: Enlarged plan of window jamb detail in centre of window opening  
(Based on HAR00003765, onsite measurement of 25mm insulation)

- 8.7.16** In design drawings there was no evidence that this cavity was intended to have any intermediate barriers or insulation installed. Figure 8.19 identifies that the cavity between the new insulating core panel (Aluglaze) and original non-combustible infill panel was unbroken over the full length to the adjacent window reveal.



- 8.7.17** Figure 8.18 presents further evidence that combustible insulation was fitted behind the combustible uPVC as it shows a combustible Celotex material installed behind the uPVC. This image was taken in Flat 16 where the fire softened the uPVC revealing the combustible insulation fitted behind. The photograph is of the window jamb as shown in the drawing in Figure 8.17. This material closes the gap between the old infill panel and the new Aluglaze insulating core panel.
- 8.7.18** The insulation in this location is not the insulation that was affixed to the original backing wall as part of the rainscreen cladding (referred to later in section 8.9 of this report as ‘rainscreen cavity insulation’). It is Celotex insulation of another thickness, fitted on the room side of the new windows. I have provided an inset into the photograph in Figure 8.18 of the Celotex logo as it appears on their products.
- 8.7.19** From my site inspections, it was not possible to tell whether the insulation in this specific location was always Celotex, or if other products, for example Kingspan insulation, was also used. Further investigation is required before I can reach a definitive conclusion as to the insulation materials used in this location throughout the building.
- 8.7.20** Please refer to Section 8.5 for more information on the placement of the internal cavity insulation.

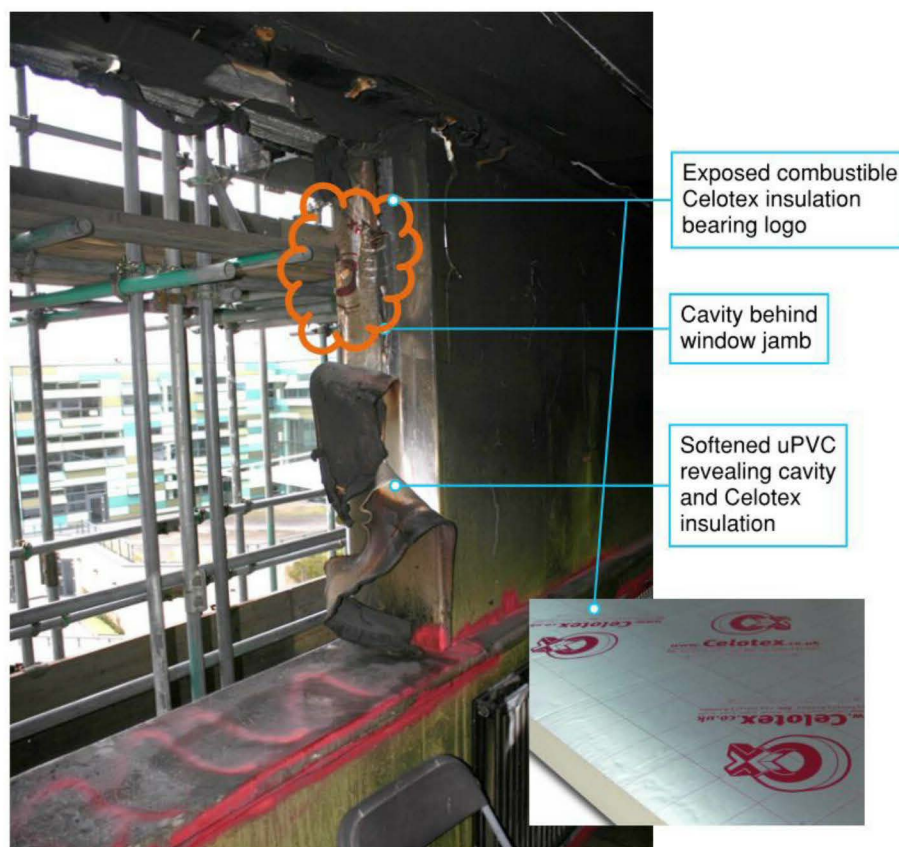


Figure 8.18: Softened uPVC finish revealing cavity and combustible insulation board within. Flat 16 Living room.



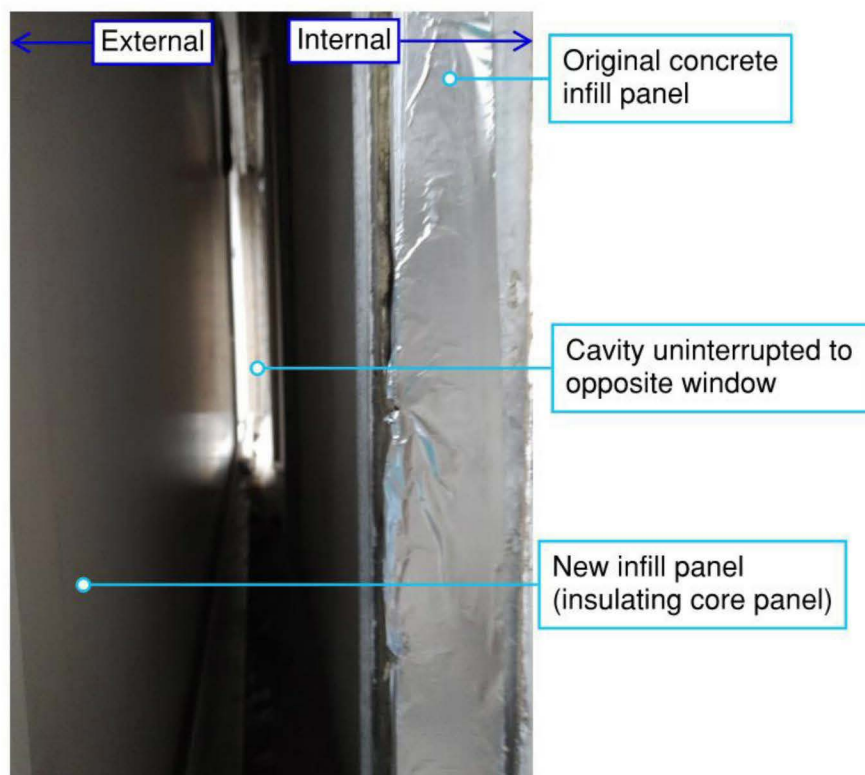


Figure 8.19: Cavity formed between original concrete infill panel and new insulating core panel (Aluglaze). These cavities were located between window sets. This image is from Flat 13.

## 8.8 Window frame & EPDM weatherproof membrane

8.8.1 To close the gap introduced by the alterations to the windows as shown in Figure 8.15, a weatherproof membrane of Ethylene Propylene Diene Monomer (EPDM) rubber was used as a seal, in the location shown in Figure 8.20:

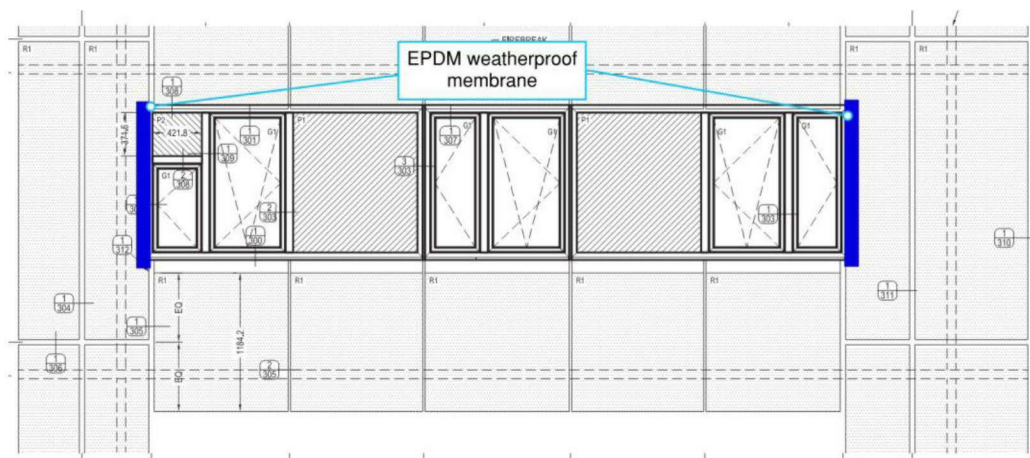


Figure 8.20: Location of EPDM weatherproof membrane (underneath insulation and rainscreen) (Based on HAR00008581)

**8.8.3** The Harley design drawings show a location and dimensions for the EPDM and window frames as shown in Figure 8.21.

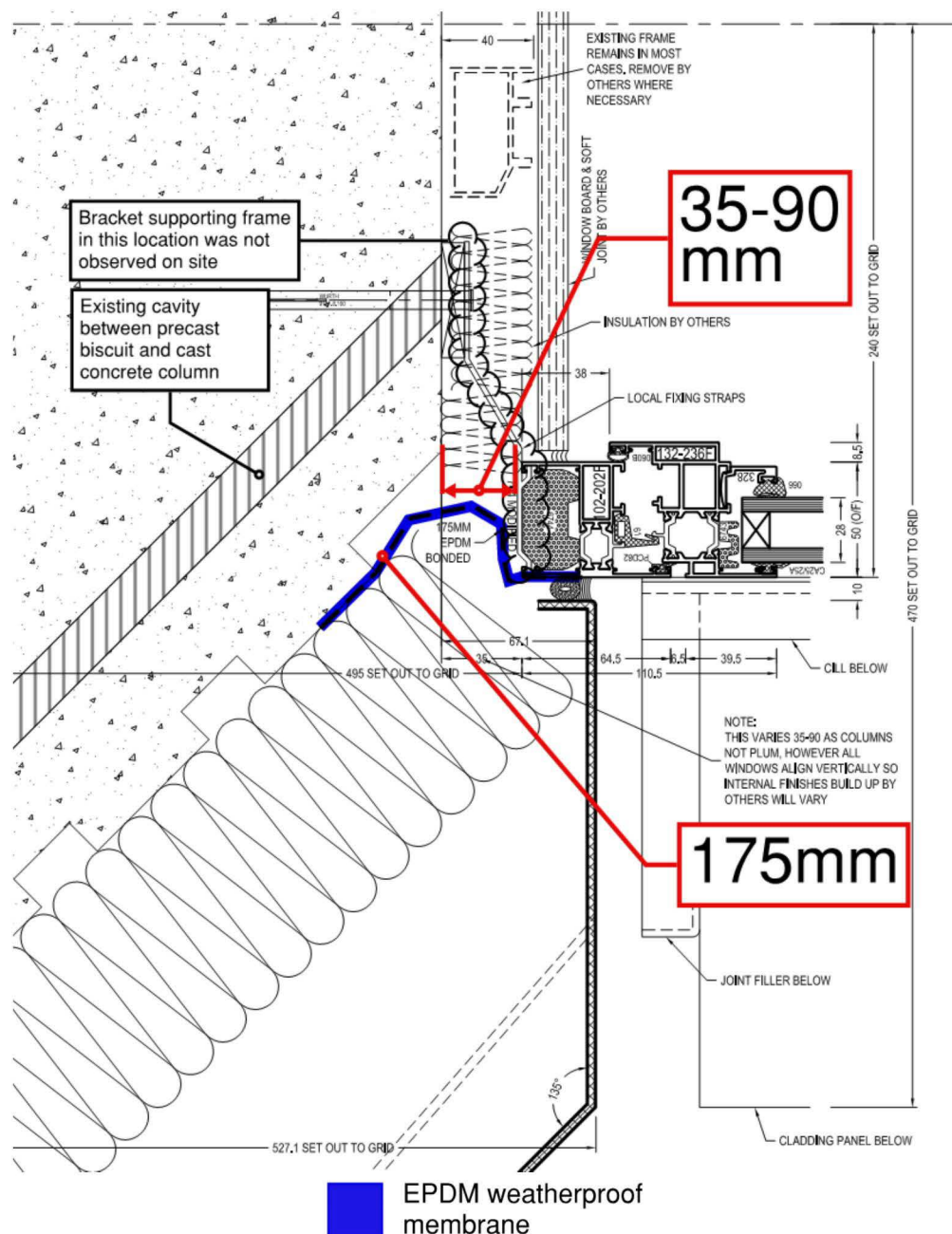


Figure 8.21: Harley design drawings/dimensions showing EPDM weatherproof membrane

<sup>2</sup> Co-published by the Society of Fire Protection Engineers

**8.8.4** The following materials were present in the window frame and the weatherproof membrane:

- a) Window frame –powder coated aluminium (non-combustible)
- b) Weatherproof membrane –EPDM rubber (combustible)
- c) Glazing –glass (non-combustible)

**8.8.5** The EPDM was bonded to the window frame and the face of the concrete column on site - onsite photographs are presented in Figure 8.22 & Figure 8.23.

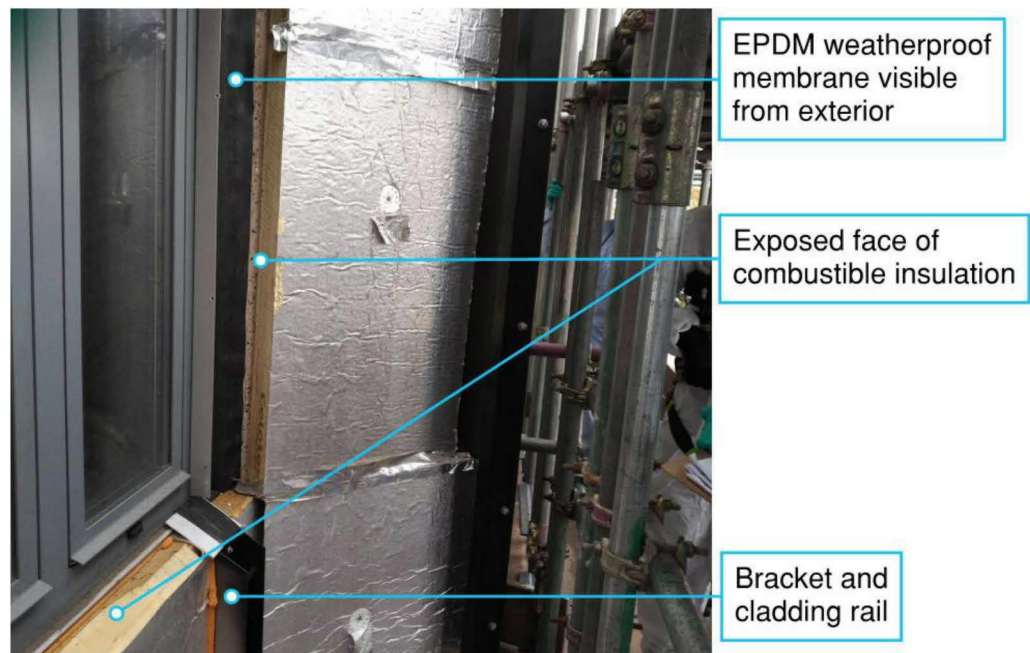


Figure 8.22: Exterior view of window/column junction with exposed EPDM weatherproof membrane



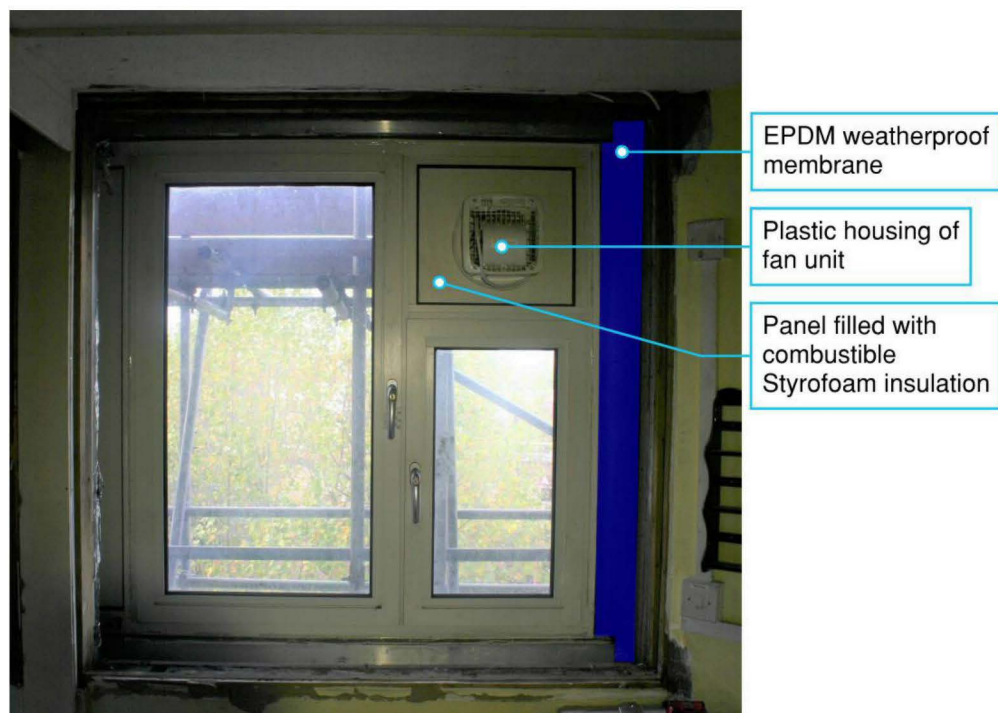


Figure 8.23: Interior view of window/column junction with exposed EPDM weatherproof membrane. Flat 13 Kitchen (see section 8.9 for further details of window insert panel)

- 8.8.6** The thickness of the EPDM was not measured onsite and I have not been able to confirm the thickness from any of the Harley information reviewed to date. However, this type of material is commercially available in products from 1-3mm in thickness. This is consistent with the approximate thickness seen onsite.
- 8.8.7** As identified in Figure 8.21 and Figure 8.24, the Harley design drawings showed the gap introduced by the alterations to the windows as part of the refurbishment to be 30-95mm. But the gap between the window frames and the face of the columns observed on site varied between 30-120mm.



Figure 8.24: Photograph showing changes and how they introduced gaps around the window frames (Flat 13)

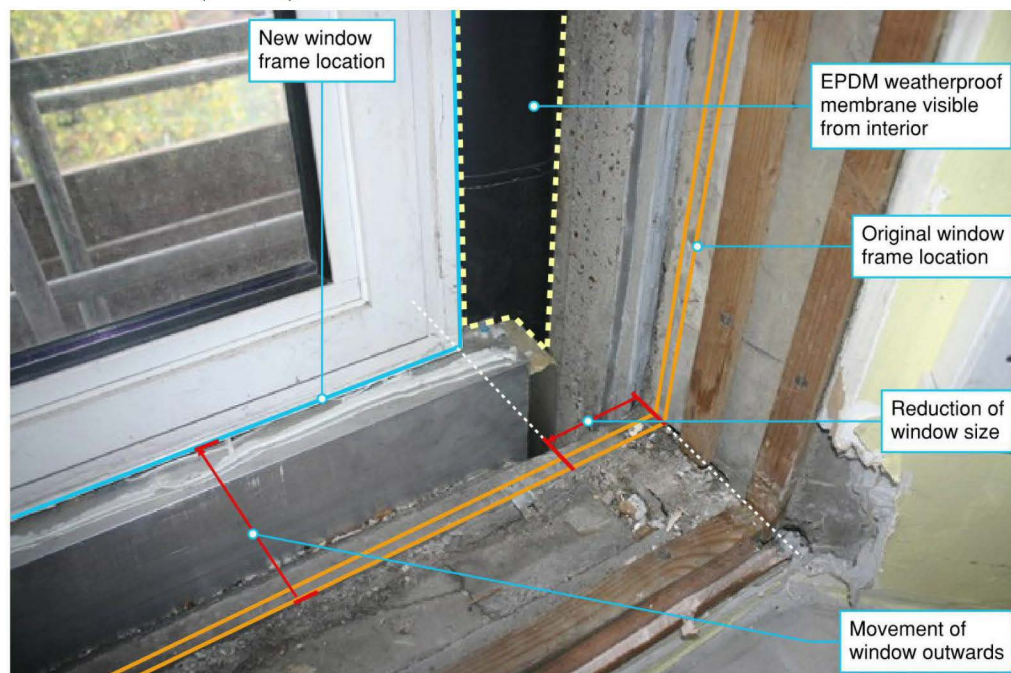


Figure 8.25: Detailed view of flat 13 window frame

- 8.8.8** The total construction tolerance recommended for aluminium window frames is 20mm in the relevant standard “BS 8213-4:2007 Windows, doors and rooflights – Part 4: Code of practice for the survey and installation of windows and external doorsets”. My site observations show this value was exceeded.
- 8.8.9** The above information shows that the alterations of the window frame size and the window location, introduced a gap visible from both the inside and the outside of the flat, and in which the combustible EPDM weatherproof membrane was visible (in cases where the uPVC reveals provided in the



refurbishment had been removed). This is summarised in the detailed window render in Figure 8.26.

**8.8.10** Figure 8.26 below is a 3D render of the window opening by Arup, summarising the materials and construction outlined in this section of the report, as viewed from the inside and outside of a typical room in Grenfell Tower.

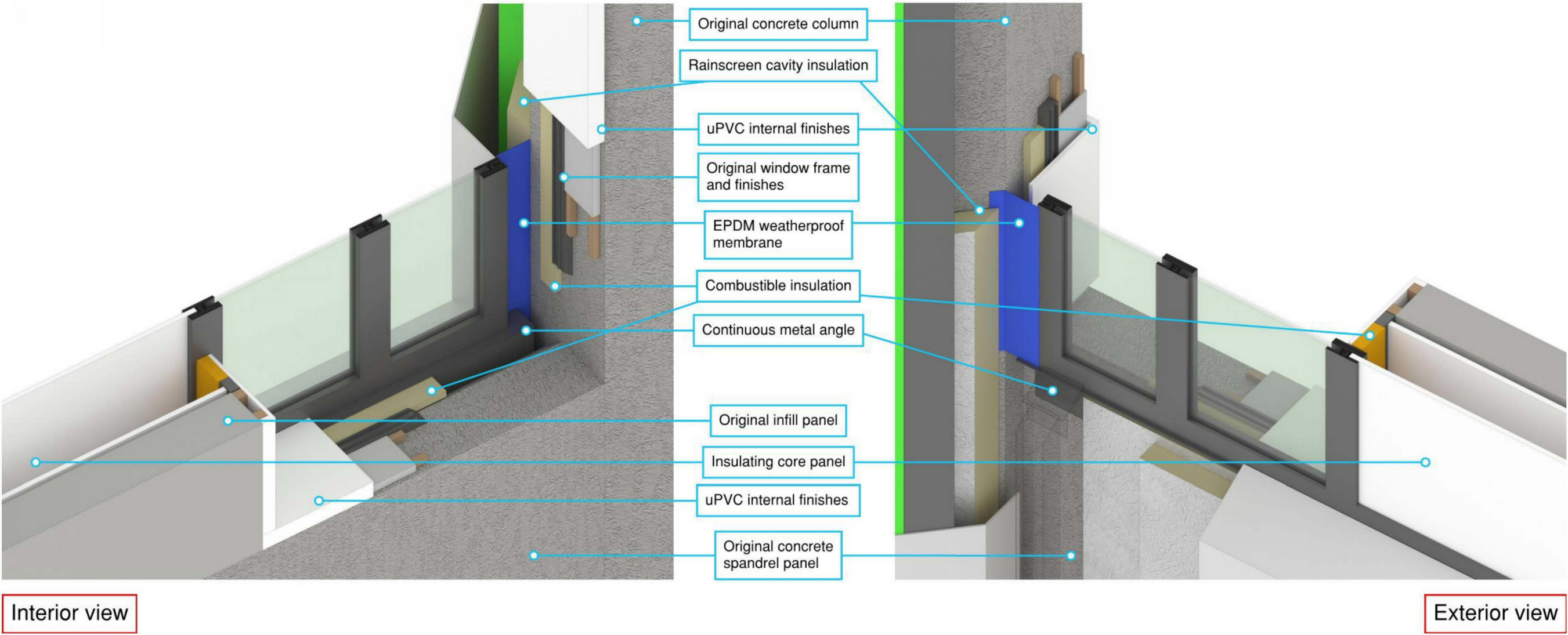


Figure 8.26: Annotated window detail render, as viewed from interior (left) and exterior (right)



## 8.9 Rainscreen cavity insulation & cavity barriers

8.9.1 The Harley design drawings show the location and dimensions of the rainscreen cavity insulation and cavity barriers as shown in Figure 8.27 & Figure 8.28:

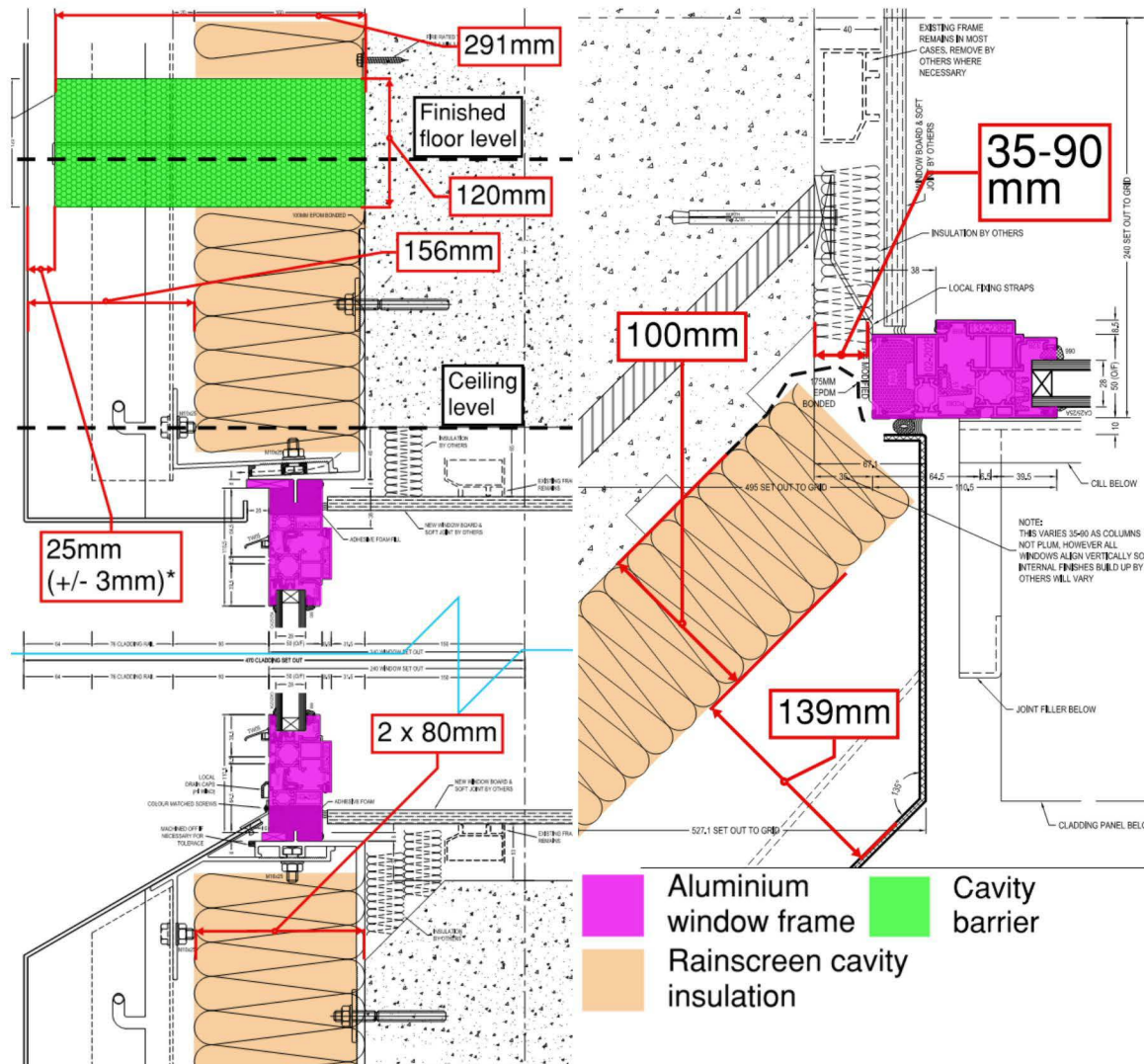


Figure 8.27: Window section highlighting rainscreen cavity insulation and cavity barriers  
\* In this instance construction tolerance was shown on design drawings

Figure 8.28: Window jamb and column plan detail highlighting rainscreen cavity insulation (cavity insulation dimension from HAR00008902)

### 8.9.2 Insulation to spandrel panels

8.9.3 Two layers of 80mm combustible insulation (refer to section 8.9.16 for specific details of material used) was affixed to the external face of the existing concrete spandrel panels between the window openings. This is in agreement with purchase orders for 80mm insulation (SIG00000010, SIG00000012).

- 8.9.4** The insulation was affixed by a 180mm stake screwed into the face of the existing concrete spandrel or column (Figure 8.29 & Figure 8.33). The 180mm stakes pierced the insulation, therefore mechanically fixing it to the existing structure. Foil tape was applied to seal the insulation where it was pierced by the stakes.
- 8.9.5** Over the spandrels, this formed a ventilated cavity of 156mm in depth between the inside face of the Reynobond rainscreen cladding panels and the outer face of the rainscreen insulation. I have verified the size of the cavity by taking measurements onsite (Flat 16).
- 8.9.6** As indicated in Figure 8.29, an expanding foam was used as joint filler to partly fill joint gaps associated with the insulation, throughout the rainscreen system. The Harley material data sheets (HAR00001323) show that this was a polyurethane foam, which is a combustible material (see Section 8.4.10 above).

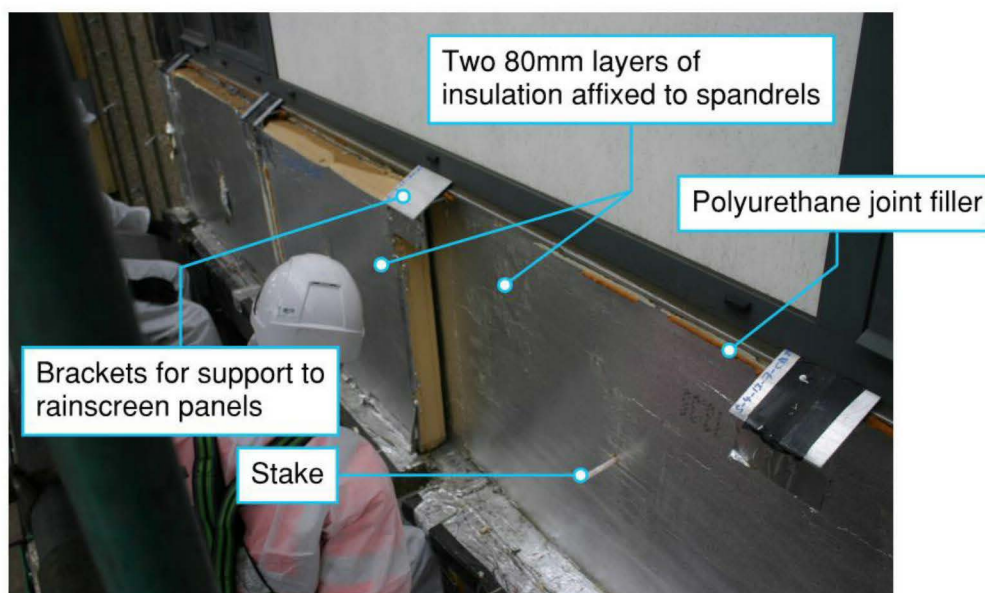


Figure 8.29: Two layers of insulation with exposed edges visible on spandrel, along with stakes for fixing (outside Flat 12).

- 8.9.7** Figure 8.31 identifies a condition observed on site where the rainscreen cavity insulation was exposed on the “room side” in front of the EPDM weatherproof membrane. In this case, the EPDM weatherproof membrane has been sealed between the interface of the two layers of the rainscreen cavity insulation. The inner layer is fully exposed on the inside of the room (noting window and frame removed in this photo).
- 8.9.8** In Figure 8.32 I present one of my photos showing sun light through a post-fire damaged window reveal – to emphasise how little a barrier this posed to the detailing shown in Figure 8.31.



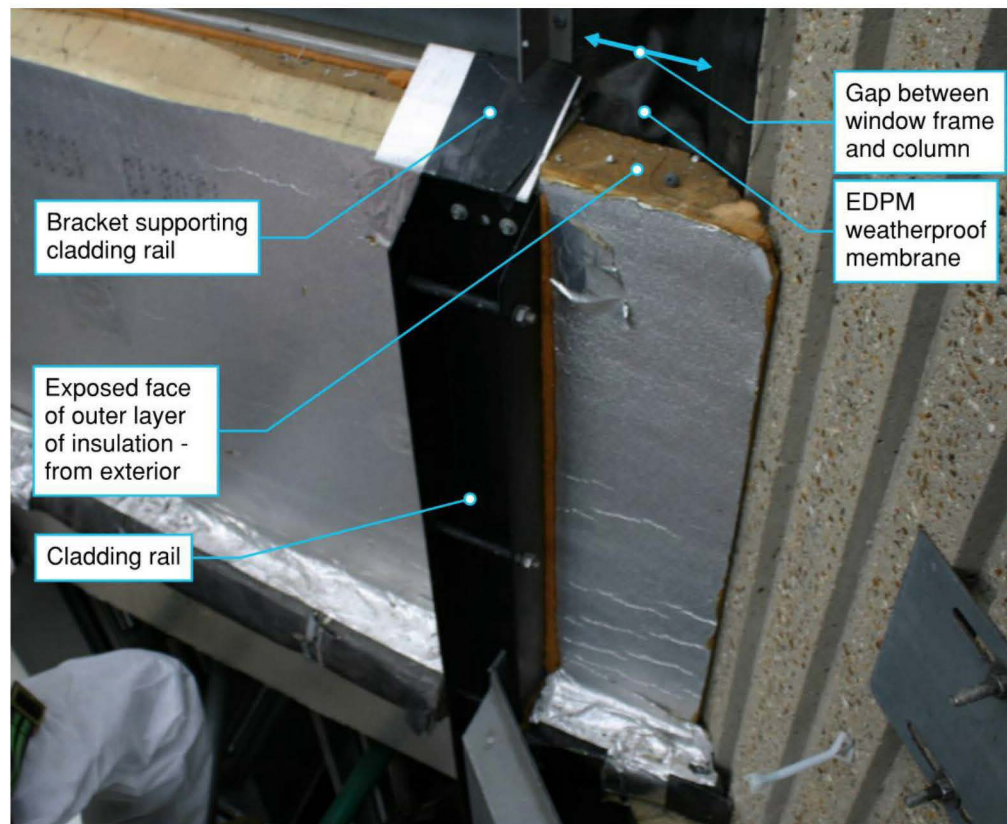


Figure 8.30: Cladding rail that supports panel cassettes shown attached to bracket. Exposed face of the insulation in close proximity to gap and EPDM weatherproof membrane (Outside Flat 12)



Figure 8.31: Rainscreen cavity insulation visible from interior due to EPDM weatherproof membrane bonded between insulation layers, in close proximity to gap and EPDM weatherproof membrane (Flat 13)



Figure 8.32: Post-fire condition of window finishes in fire damaged flat (METS00017068) (Flat 93, Level 12)

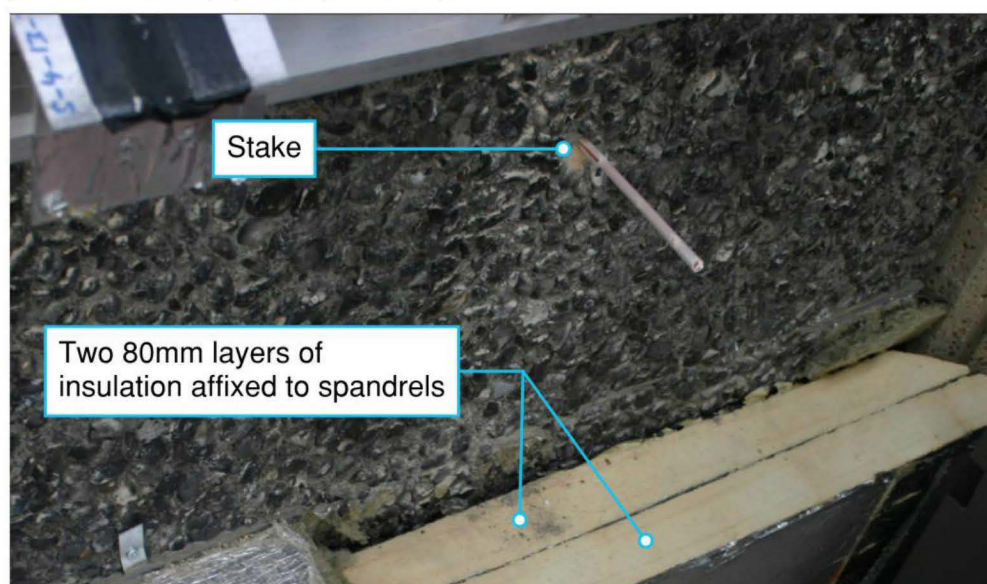


Figure 8.33: Further detail of two layered spandrel insulation fixing





Figure 8.34: Grenfell Tower before (left – CCL00000028) and after (SEA00000371) refurbishment works

#### **8.9.9      Insulation to columns**

**8.9.10**      The drawings set out a thickness of 100mm for the rainscreen cavity insulation over the columns.

**8.9.11**      This is in agreement with purchase orders for 100mm thickness Celotex RS5000 (SIG00000010, HAR00000583 and HAR00000781), as well as onsite measurements. The insulation was affixed using the same method (pushed onto metal stakes) as the insulation applied to the spandrels.

**8.9.12**      Over the columns, this formed a ventilated cavity of 139mm in depth between the inside face of the Reynobond rainscreen cladding panels and the outer face of the rainscreen insulation.

**8.9.13**      Cavities were also created by the ridged form of the precast concrete biscuit (slabs affixed to the outside face of the cast concrete column, see Figure 34 below) and the application of the rainscreen cavity insulation and cavity barriers. I have not seen any evidence either in the Harley construction drawings or from onsite observations of an attempt to seal these cavities:

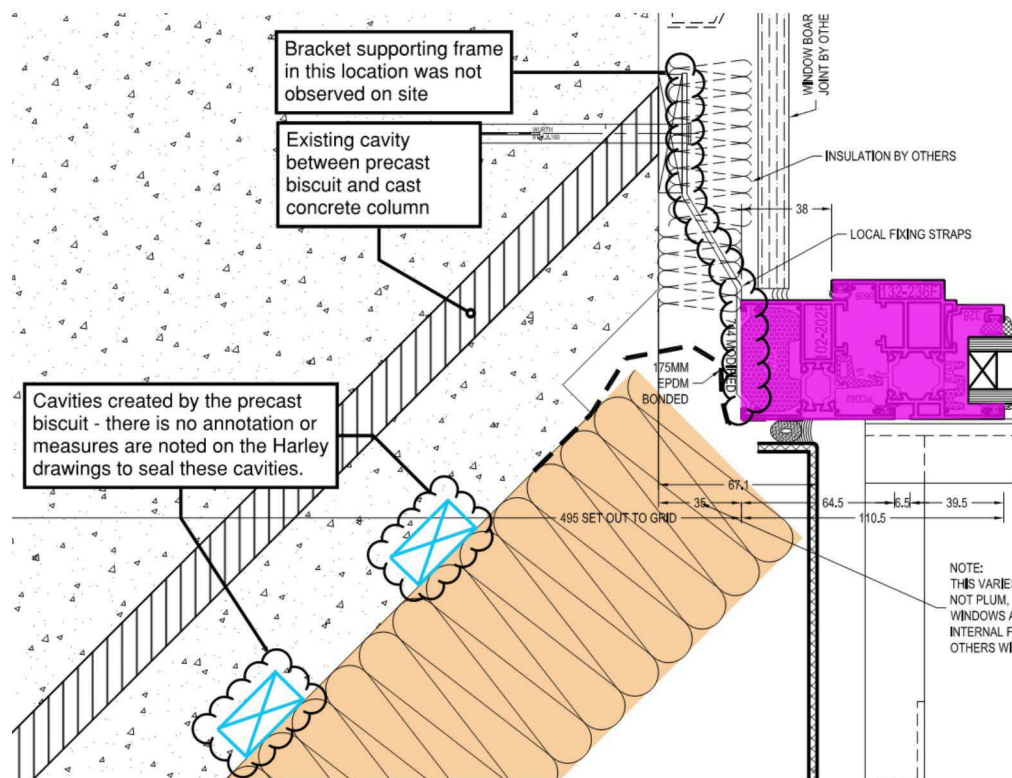


Figure 8.35: Precast biscuit cavities formed by the application of the rainscreen cavity insulation

#### 8.9.14

The visible brackets in Figure 8.36 were for the support of the rainscreen cladding system only and provide no structural support to the insulation.



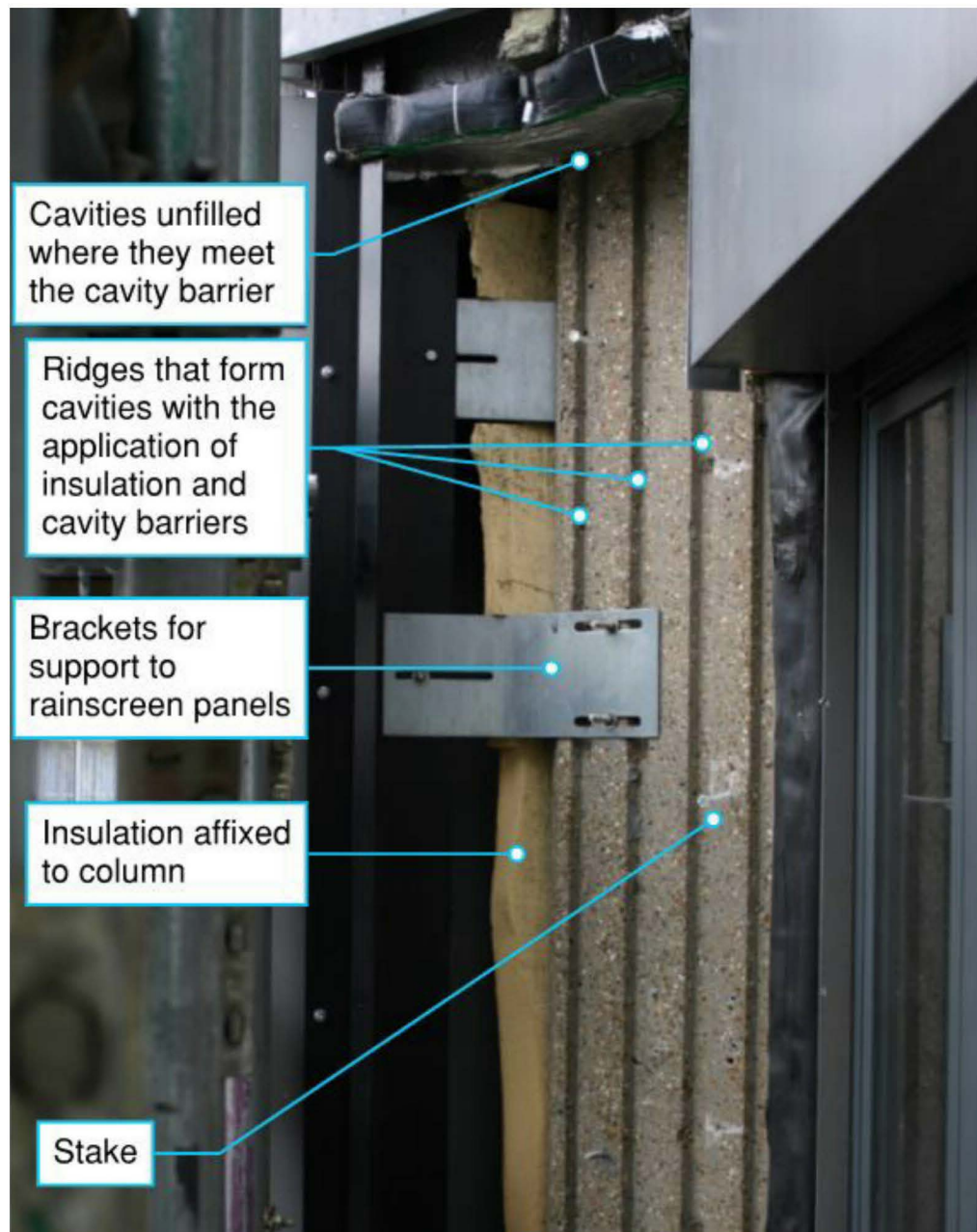


Figure 8.36: Photograph showing insulation affixed to column and rainscreen cladding brackets

#### 8.9.15 **Evidence of the form of Insulation installed at Grenfell Tower**

8.9.16 The insulation I observed was a rigid foam. From observations made on site and purchase orders from Harley to SIG (SIG00000010, SIG00000012) the insulation purchased for installation on Grenfell Tower was Celotex 'RS5000' and Kingspan 'Kooltherm K15'. Figure 8.37 provides evidence from site that Celotex was used on the façade. See Figure 8.38 for evidence that a Kingspan Kooltherm insulation board was used on the spandrel panels.

- 8.9.17** Kingspan Kooltherm is a product range containing multiple different types of insulation. ‘K15’ is the only product in that range listed<sup>3</sup> by Kingspan as for use in a rainscreen cladding system. Therefore, specific testing of Kingspan Kooltherm products retrieved from Grenfell Tower is required to confirm the specific product installed.
- 8.9.18** I have not yet seen any evidence on site or any purchase orders to suggest that Kingspan Kooltherm K15 was also used on the columns. This is due to the thickness of the product in the purchase order was in agreement with only the spandrel insulation.
- 8.9.19** The Studio E NBS specification provides for: *“Not less than 150mm for spandrel panels and 80mm for columns”* of Celotex PIR insulation (SEA00000169 dated 30<sup>th</sup> January 2014). Celotex RS5000 is a polyisocyanurate (PIR) thermal insulation board which is combustible (Table A31, SFPE Handbook 5<sup>th</sup> edition).
- 8.9.20** Kingspan K15 is a phenolic foam board which is combustible (Table A31, SFPE Handbook 5<sup>th</sup> edition). Purchase orders show that due to production issues disrupting the supply of Celotex 276m<sup>2</sup> of Kingspan K15 in 80mm was ordered as a substitute (SIG00000013). Kingspan boards were applied to the spandrel panels, as can be seen in Figure 8.38.
- 8.9.21** The classification of these products, and their required installation details, are discussed further in Section 11 and Appendix E of my report.
- 8.9.22** The front and rear face of these products are provided with factory applied aluminium foil facing. The Rainscreen Cladding Specification Guide (CEL00000013) issued by Celotex for use with the RS5000 series published in August 2014 states within the installation guidelines that:
- “In all cases, the joints of the insulation boards should be taped with a self-adhesive aluminium rainscreen foil tape with a minimum width of 75mm.”*
- 8.9.23** Foil tape was not included in the Studio E NBS Specification (SEA00000169) and did not appear on the Harley or Studio E design drawings. However, in Figure 8.37, aluminium foil tape is visible on joints between insulation boards affixed to the column.
- 8.9.24** The edges of these insulation boards were observed to be exposed, i.e. neither foil nor foil tape was affixed to the edges of the insulation. In Figure 8.37, it can be seen that these exposed edges were visible in close proximity to the new window frames and the gap introduced by the window alterations. The Rainscreen Cladding Specification Guide does not expressly advise the edges of insulation boards to be taped.

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<sup>3</sup> <https://www.kingspan.com/gb/en-gb/products/search?n=11261> [ Accessed 06/04/2018]





Figure 8.37: Evidence of Celotex in place as part of the external wall

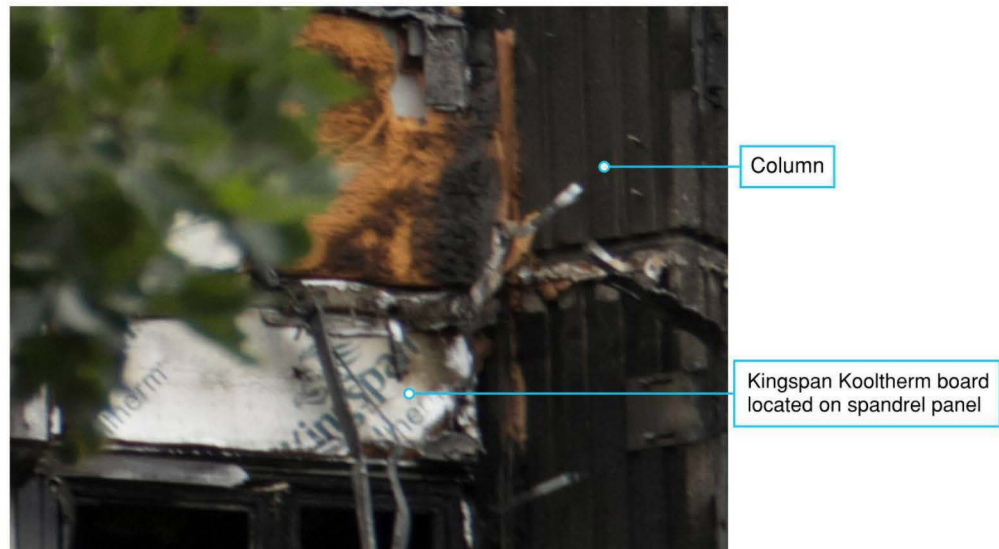
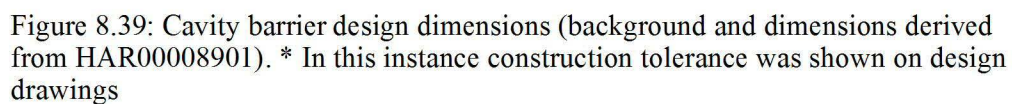


Figure 8.38: Photograph showing Kingspan Kooltherm board on spandrel panel (KIN00000015)

8.9.25 **Cavity barriers**

8.9.26 The requirements for cavity barriers and fire stopping are dealt with in Section 11 of my report.





During my site inspections, I observed that the product installed was the SIDERISE RH ‘Open State’ Horizontal Cavity Barrier. Figure 8.40 presents a typical installation detail as observed on site. I observed this installed in the horizontal direction and vertical direction. (Figure 8.52).

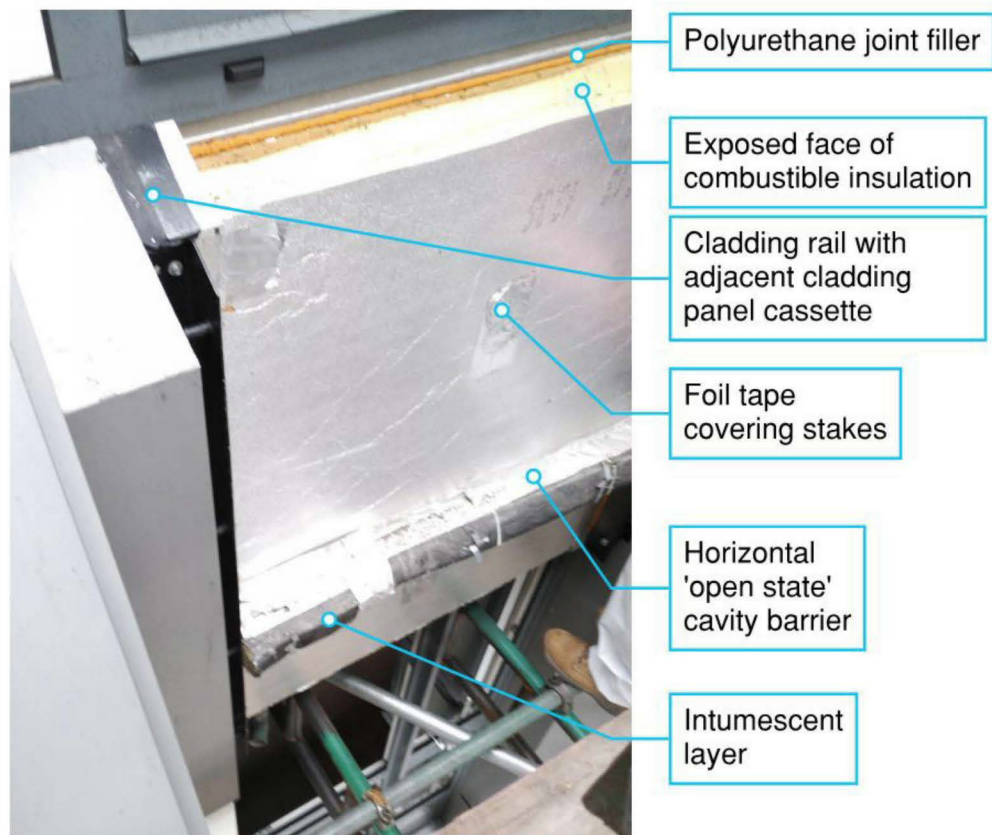


Figure 8.40: Horizontal cavity barriers on spandrel as observed on site

- 8.9.28** SIDERISE RH 'Open State' horizontal cavity barriers are sold for use in drained and ventilated facades, allowing drainage of any moisture within the façade construction, whilst maintaining airflow.
- 8.9.29** The SIDERISE RH 'Open State' horizontal cavity barriers were installed approximately 700mm down from window cill level. The barriers were mechanically fixed to the spandrels and column face using metal support brackets which pierce the full depth of the cavity barrier at 400mm centres. The split protruding ends of the bracket was counter folded to retain the cavity barrier (Figure 8.43).
- 8.9.30** The O&M manual construction drawings (C1059-100 Rev I [HAR00008991]) specify the following products for horizontal 'fire breaks'.

*"Fire Breaks – New Build Zones*

*Horizontal – Siderise Lamatherm RH25G-120/60 Ventilated breaks for 120 min integrity & 60 min insulation.*

*And*

*Fire breaks Refurb zones*

*Horizontal – Siderise Lamatherm RH25G-90/30 Ventilated breaks for 90 min integrity & 30 min insulation."*



**8.9.31** The O&M manual construction drawings (C1059-100 Rev I [HAR00008991]) specifies the following products for vertical ‘fire breaks’:

*“Fire Breaks – New Build Zones*

*Vertical – Siderise lamatherm RVG-120/60 full fill (non- ventilated) breaks for 120 min integrity and 60 mins insulation*

*And Fire breaks Refurb zones*

*Vertical – Siderise lamatherm RVG-90/30 full fill (non- ventilated) breaks for 90 min integrity and 30 mins insulation”*

**8.9.32** The “refurb zones” refers to Levels 04 -23 and the new build zones Ground – 03 where new flats were created.

**8.9.33** As indicated in Figure 8.41 and Figure 8.42, the position of the horizontal cavity barriers differed between the design information and the location measured on site. This difference means that combustible insulation was installed directly above the head of the window, where the Studio E design would have positioned the cavity barrier in this location (which is formed of non-combustible material).

**8.9.34** Annotations on the Studio E drawings associated with the cavity barriers do not refer to provision of cavity barriers around the window opening. They state: “Cavity fire barrier in line with compartment floor structure.” only.

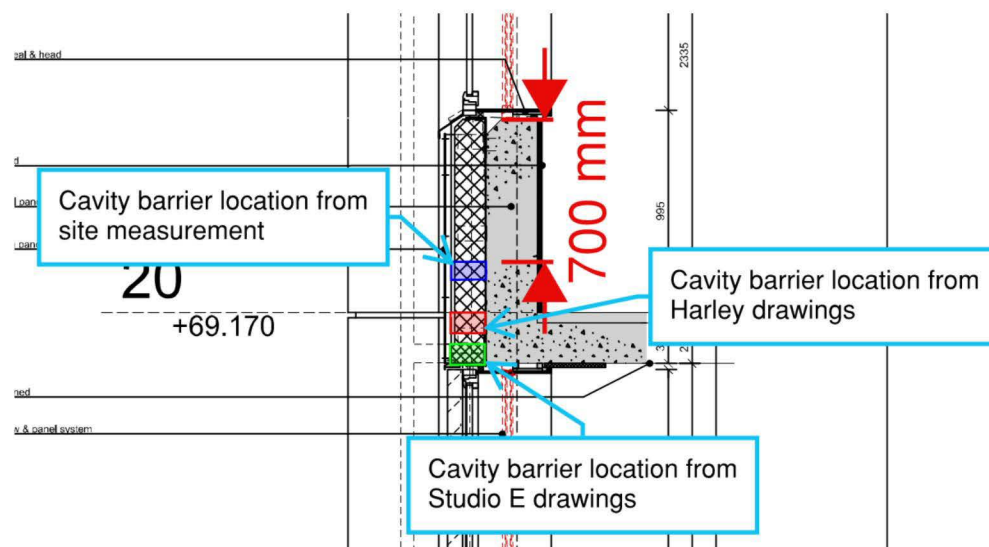


Figure 8.41: Horizontal cavity barrier locations (onsite measurement of 700mm and annotations based on SEA00002551)



Figure 8.42: Evidence from site of position of cavity barrier (Flat 16, Bedroom 2)

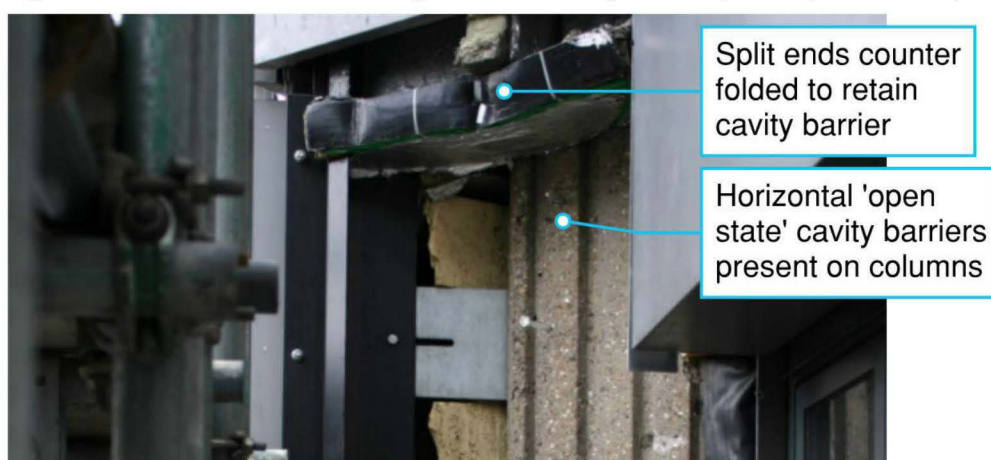


Figure 8.43: Horizontal cavity barriers on column, showing fixing method.

**8.9.35** According to the Siderise data sheet *SIDERISE RH and RV cavity barriers for use in the external envelope or fabric of buildings* (SIL00000230), the brackets are drilled on site and should be secured to the inner structural wall using non-combustible steel anchors or screws. The outer fixing method was observed to be a metal strip split into two and folded back against the cavity barrier in each direction. I have not been able to confirm the types of fixings used on site and therefore I have not determined the compliance of the installation and spacing of the mechanical fixings for the cavity barriers.

**8.9.36** I will revisit this issue and update my analysis where necessary when additional evidence is provided to me.





Figure 8.44: Junction of column and spandrel horizontal cavity barrier. External of Flat 12.

**8.9.37** The product literature also states:

*“SIDERISE RH ‘Open State’ horizontal cavity barriers incorporate a continuous high performance reactive intumescent strip which is bonded to the leading edge. The intumescent material has a reaction to fire performance to Class ‘E’. In the event of exposure to fire, the intumescent rapidly expands and fully seals the purposely designed ventilation gap, formed at the time of installation, between barrier and the rear of the cladding...*

*The leading edge of the horizontal cavity barriers is encapsulated in a weather resistant polymer film. As standard, the film is black so as to register as a ‘shadow-line’ behind open joints in the cladding...*

*For product identification purposes, the top edges of the film used on the RH25 and RH50 systems are colour-coded green and red respectively...*

*Both options are available with either galvanised mild steel (G) or stainless steel (S) fixing brackets as part of the system.*

*The specific horizontal cavity barrier system is then referred to as either RH25G, RH25S, RH50G or RH50S accordingly. The choice of bracket is usually determined by the rainscreen system designer according to project exposure and/or location.*

**8.9.38** I have over marked the position of the intumescent strip and weather resistant polymer film referenced in the product literature in Figure 8.45 below.



Figure 8.45 Position of black weather resistant polymer film and continuous high performance intumescent strip

8.9.39 One example is illustrated in Figure 8.46:

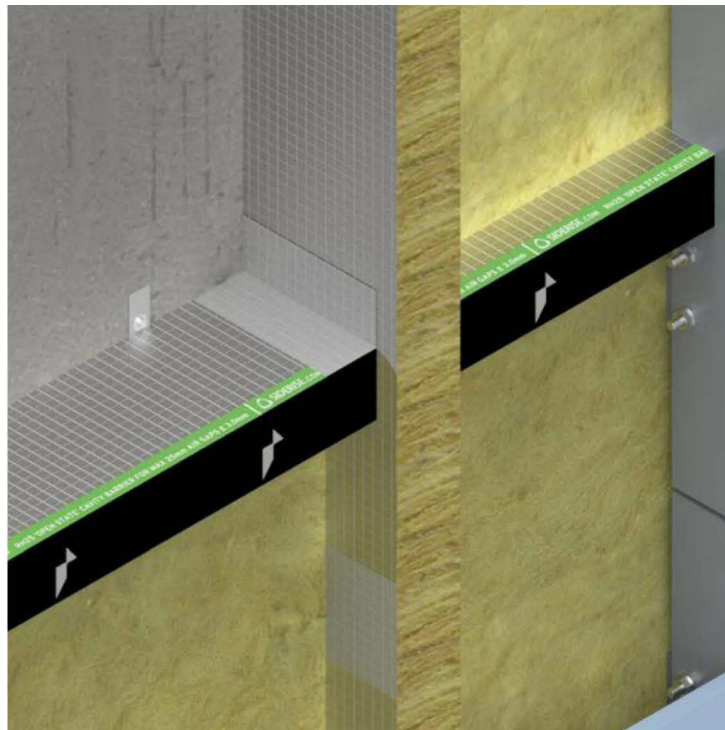


Figure 8.46: Diagram from product literature showing the RH25 (green) product as installed

8.9.40 The brochure then goes on to state the following:

*“SIDERISE RH50(G/S) - 30/30 must be installed with product logo tape on the top face, this is to ensure that the intumescent is located at the bottom of the barrier, thus closest to fire.”*



- 8.9.41** I now note that this statement about the position of the product logo tape only applies to the RH50 variant of the product in the Siderise online technical guidance, and not to any of the RH25 versions.
- 8.9.42** The test evidence provided to the Public Inquiry (full reference list in Appendix E), such as SIL00000223, shows: first a Class 0 foil tape capping to the vertical face of the exposed mineral wool which forms the cavity barrier, then a graphite intumescent strip applied to this foil face and finally a horizontal rainscreen logo tape.
- 8.9.43** The intumescent strips are 75mm deep, in all the open state cavity barrier tests I have been provided with.
- 8.9.44** The relative location of the 75mm deep graphite intumescent, on any of the mineral wool cavity barriers at the deeper size of 90mm or 120mm are not shown in the test reports.
- 8.9.44.1** Interestingly, RH50G and RH50S are both 75mm in depth i.e. the same depth as the applied intumescent. So it is very unclear why it is only those products which must be installed with the product logo tape on the top face, in circumstances where both the cavity barrier and its intumescent are the exact same depth.
- 8.9.45** It would make sense if any cavity barrier greater in height than 75mm had a second orientation rule (rainscreen logo tape on the up side) which matched the fire test condition of that deeper cavity barrier. By this I mean that when the intumescent strip is smaller in depth than the cavity barrier depth itself, it would make sense to require the barrier to be fixed in a particular orientation (e.g. with the intumescent strip at the bottom) in order that the installation properly reflected what had been tested.
- 8.9.46** This would presumably become even more important in circumstances where the gap to fill by the intumescent, increases from 25mm to 50mm as is the purpose for the RH50 (G/S). Unfortunately, I am not aware of the reasons why this is the position and further information may, in due course, be necessary.
- 8.9.47** I noted on site at Grenfell Tower that the orientation of the product RH25G-120/60, which is 120mm deep, was installed such that the manufacturer's logo and data on the green tape was facing downwards in certain locations, as can be seen in Figure 8.47 & Figure 8.48. I have no test evidence available to me which shows that this orientation has been tested. As the intumescent strip behind the black polymeric seal is smaller than the depth of the cavity barrier (i.e. the strip is 75mm compared to the depth of the barrier at 120mm), evidence that this orientation provides the necessary protection is required



Figure 8.47: Cavity barriers installed onsite with green stripe on the bottom face of the cavity barrier, as well damage leading to the intumescent strip separating from the cavity barrier. External of Flat 12.

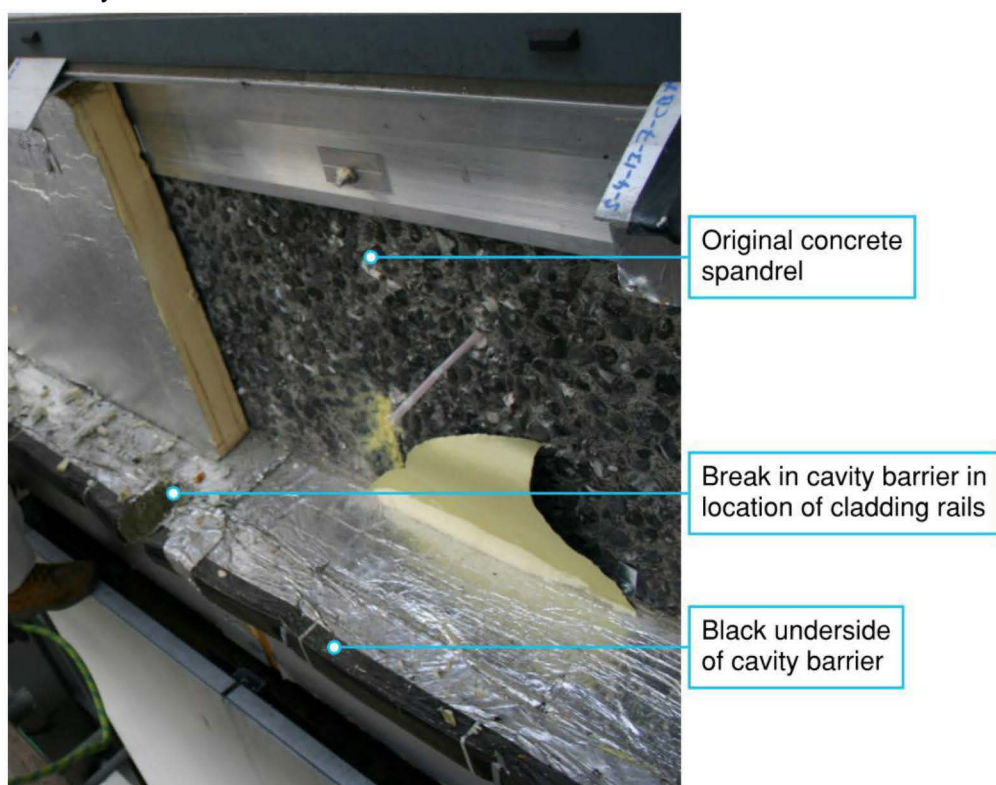


Figure 8.48: Horizontal cavity barrier without green strip visible on top of product. External of Flat 12.

#### 8.9.48

Additionally, as shown in Figure 8.30 and Figure 8.48, the U-shaped cladding rail supporting the cladding panel cassettes breaks the continuity of the horizontal cavity barrier at least every 1100mm. Note this spacing would



vary where any panel sizes vary - See Section 11 of my report for further information. This means that the cavity barrier was regularly interrupted over the length of the spandrel on every level.

**8.9.49** Furthermore, it was noted onsite that the cut edges of the cavity barriers were of poor quality leading to a imperfect fit with the column or spandrel (Figure 8.49), as well as a poor fit where adjoining other cavity barriers.

**8.9.50** The Siderise cavity barriers are cut to length on site using a saw or similar tool, as advised on the Siderise installation literature. The cavity barrier product data sheet advises that: “*Adjacent lengths of the horizontal cavity barrier should be tightly abutted to prevent gaps. The top surface of the joint should be sealed with **SIDERISE foil tape RFT 120/45**.*” It was apparent during my site inspection that gaps were present in the cavity barriers, with rough non-linear edges exposed.

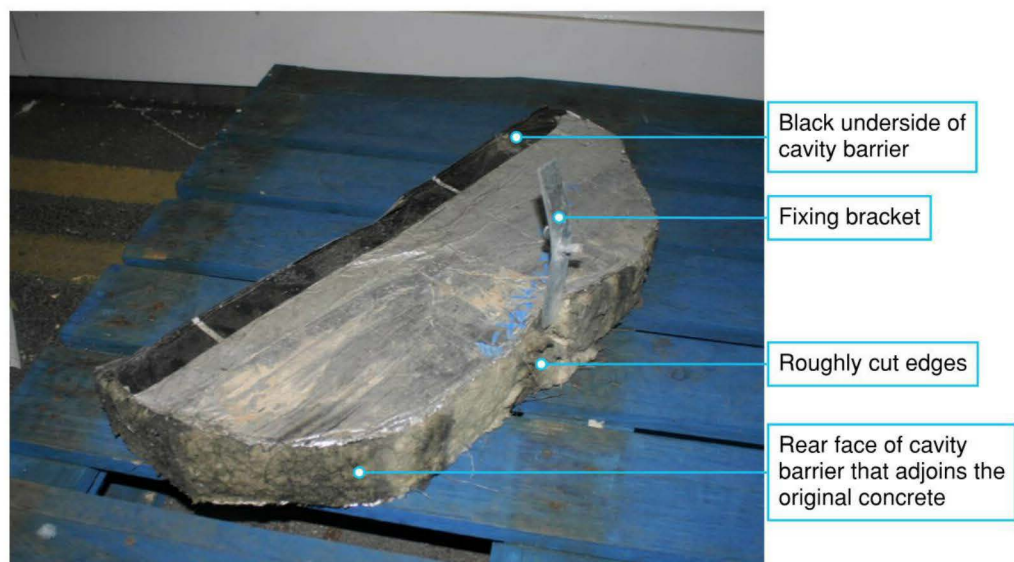


Figure 8.49: Horizontal column cavity barrier showing roughly cut rear faces

**8.9.51** This quality of preparation led to a poor fit when installed, as shown in Figure 8.50:

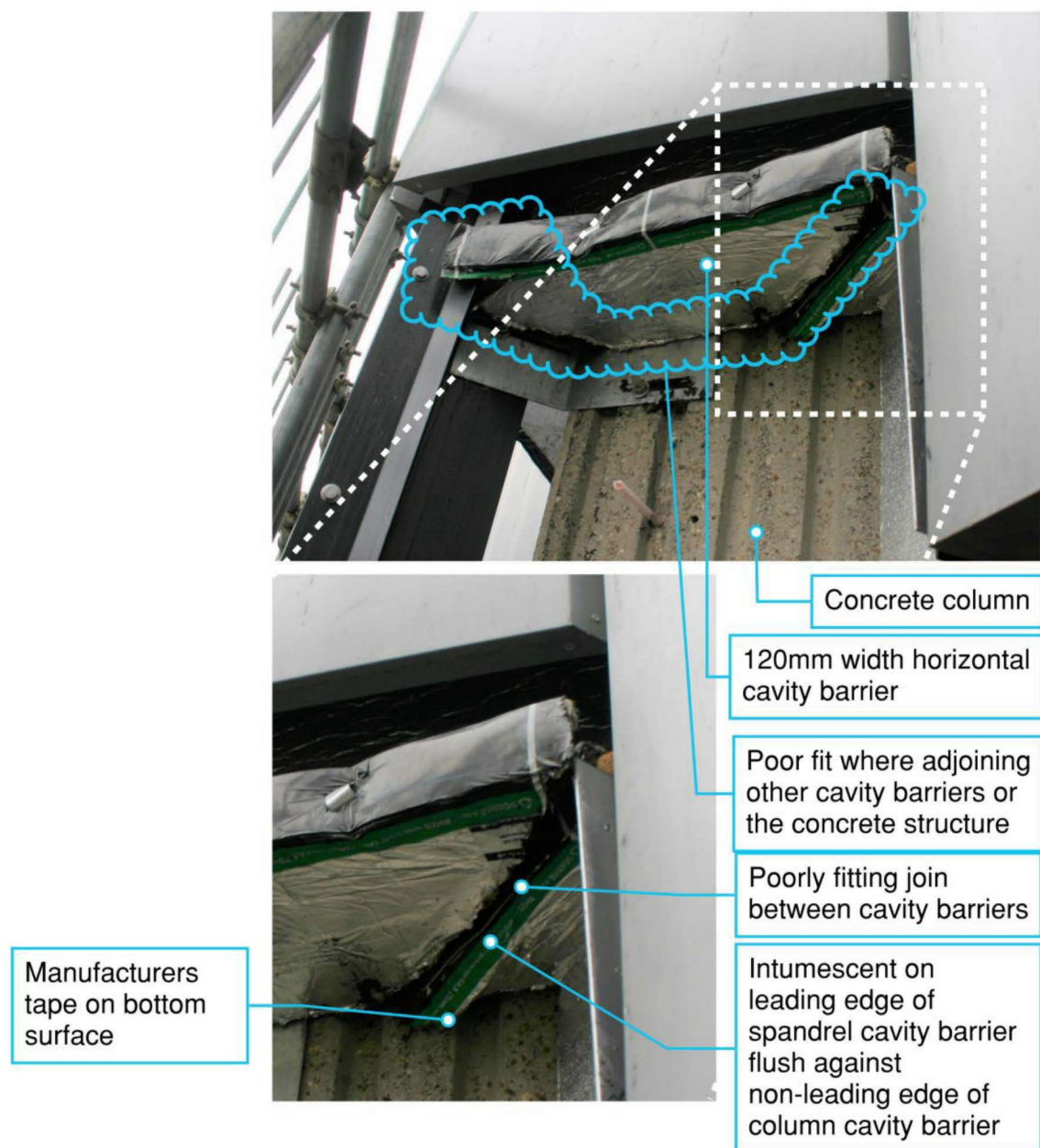


Figure 8.50: Poorly fitting horizontal cavity barrier. (Flat 12).

- 8.9.52** I was only able to determine the cavity barrier product type installed on Grenfell Tower in one location of the external façade on level 4 (column D1 – exterior of flat 13) as the cladding was still in place in all other locations.
- 8.9.53** The vertical cavity barriers observed on site were not the Siderise Lamatherm RVG-120/60 Full Fill (non-ventilated) breaks as prescribed in the Harley specifications (HAR00008991), but appeared to be the same RH25G-120/60 product (intended for horizontal installation) rotated and installed in the vertical position (Figure 8.52). The leading edge (with the intumescent strip behind the polymeric seal) was located flush to the column surface, with the rough cut edge facing the rainscreen cladding panel. The RH25G-120/60



product has not been tested in this orientation (as shown in Figure 8.52) and is hence noncompliant as I discuss further in Section 11.

**8.9.54** Cavity barriers were not provided on all columns. The Harley construction elevation drawing (HAR00008582) states:

*"VERTICAL FIREBREAKS NOT REQD ON 4 COLUMNS, IE GRIDS 2 & 4 (NORTH & SOUTH)"*

**8.9.55** This is in agreement with my site observations (Figure 8.51), which were collated both from inspection through the panel gaps on Level 3 of the building and from the evidence of vertical cavity barriers remaining on Levels 16-23.

**8.9.56** It should be noted that due to restricted access I was not able to inspect for the presence of vertical cavity barriers on a fifth column, column B1 (West façade).

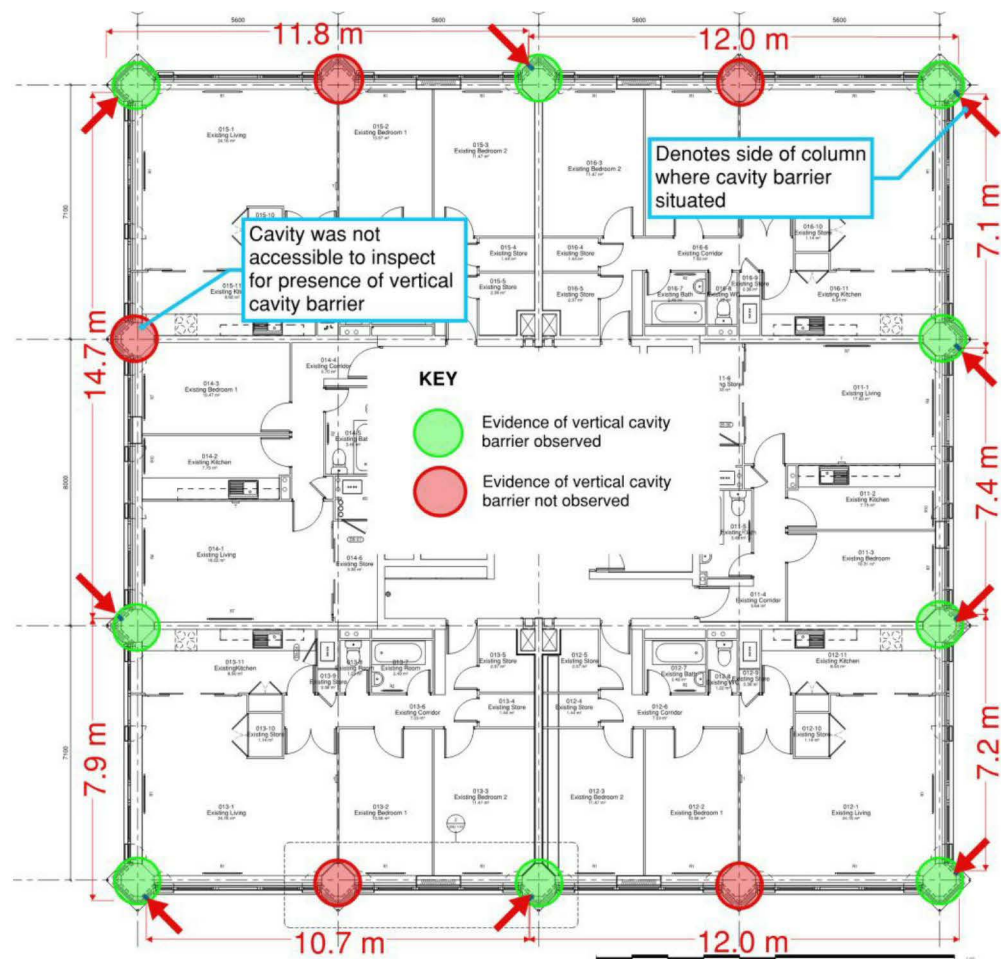


Figure 8.51: Site observations for locations of vertical cavity barriers

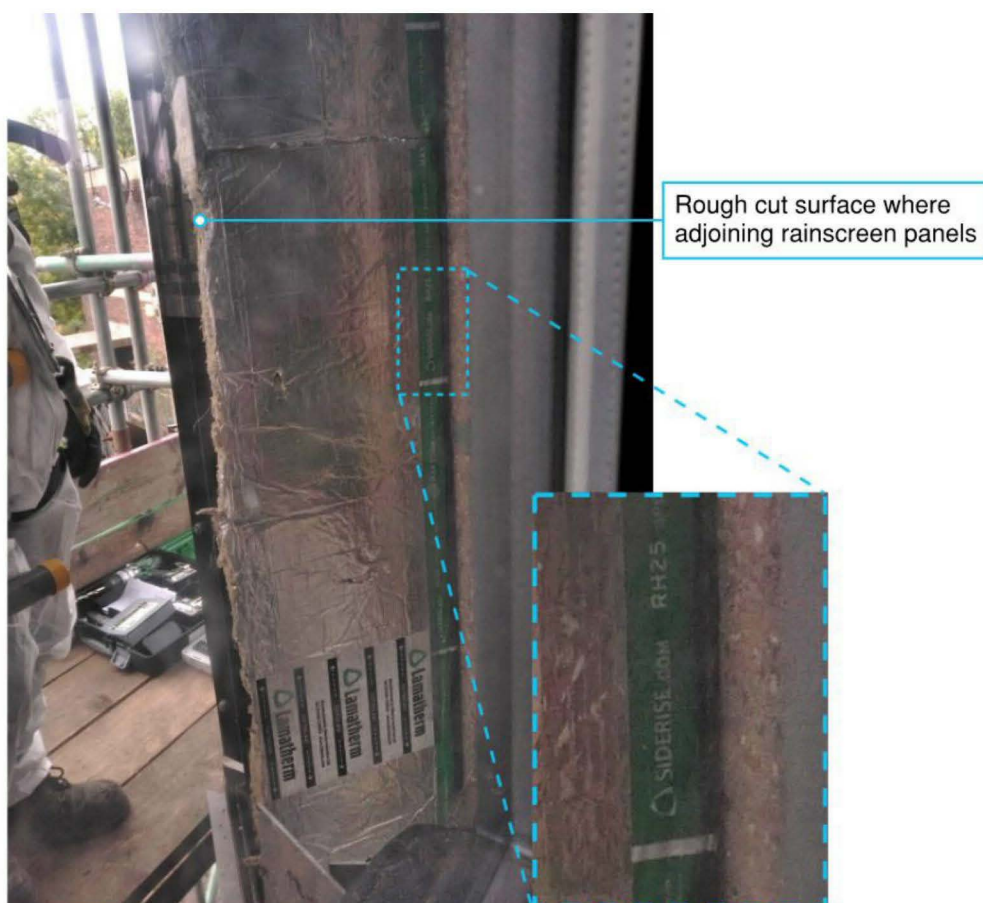


Figure 8.52: Siderise RH25 installed in vertical orientation. External of Flat 13, column D1.



## 8.10 Window inserts, insulating core panels & rainscreen cladding panels

### 8.10.1 Rainscreen cladding panels

8.10.2 The design drawings show the location and dimensions of the rainscreen cavity insulation and cavity barriers as shown in Figure 8.53 & Figure 8.54:

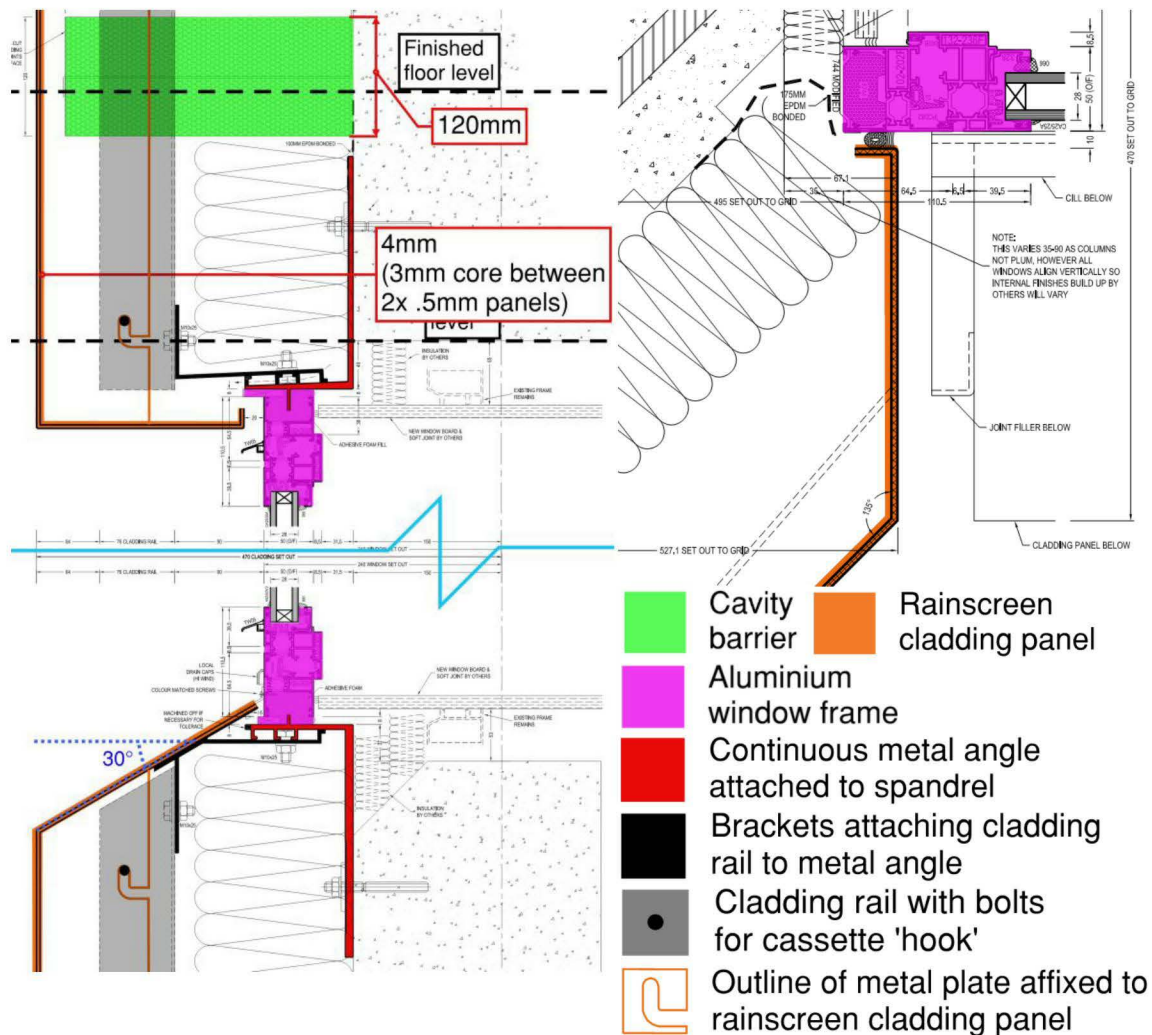


Figure 8.53: Window section highlighting rainscreen cladding panels

Figure 8.54: Window jamb and column plan detail highlighting rainscreen cladding panels

8.10.3 During site inspection I inspected the rainscreen cladding panels, which form part of the outer surface of the refurbished external wall.

8.10.4 The panels forming this external surface were an aluminium composite panel with a black plastic core (I did not observe any panels with a different coloured core). The Arconic order acknowledgments (ARC00000012; ARC00000027; ARC00000043; ARC000000215) show that the panels purchased by Harley for installation at Grenfell Tower were Reynobond 55 PE. The external surface was 0.5mm thick aluminium and the 3mm core was

polyethylene. These measurements are consistent with observations on site (see Appendix C).

**8.10.5** Reynobond 55 PE aluminium composite panels are available with either a black coloured or a translucent core, as outlined in the test reports presented in Section 11. Whilst I observed the black core variant only during my site investigations, the Arconic Inc. order acknowledgements (ARC00000012; ARC00000027; ARC00000043; ARC00000215) I have seen did not specify any particular core colour. However, it is possible that Figure 8.65 may be a sample of a translucent core, and I note that the expert witness report of Prof. Bisby states that both the ‘black and clear’ PE core material were present on the Tower.

**8.10.6** According to the Harley design drawing (HAR00008879) the panels covering the spandrels were formed with a 30 degree from horizontal diagonal return to the bottom of the window, and a 90-degree horizontal return to the top of the window, as seen in section in Figure 8.53.

**8.10.7** At the head of the window, the design incorporated a 20mm gap between the panel and the window frame leading into the ventilated cavity (Figure 8.53).

**8.10.8** The panels were incorporated as part of an over cladding system and were therefore located above (Figure 8.66) and below (Figure 8.55) the window openings, across the spandrels and over all of the existing columns (Figure 8.56).

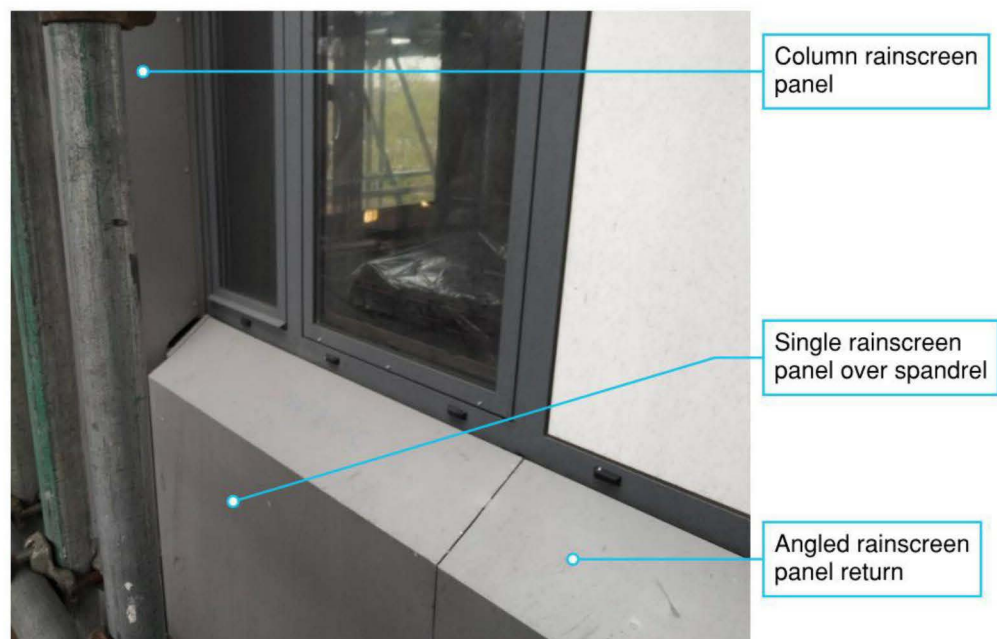


Figure 8.55: Spandrel rainscreen panel. External Flat 12.





Figure 8.56: Close-up photograph of cladding to residential floors.

- 8.10.9** The cladding composite panels to the spandrels were hung on vertical cladding rails at approximately 1150mm centres (as measured onsite). The rails were affixed to the building as follows (refer to Figure 8.29 & Figure 8.30):
- a) Steel angles were fixed to the window head and cill along the majority of the length of the window opening (a gap was present at either end as identified in Figure 8.15);
  - b) Brackets were then fixed to the steel angles (Figure 8.30);
  - c) Cladding rails were then fixed to the brackets;
  - d) The composite panels were 'hung' on the cladding rail ().
- 8.10.10** I observed that the cladding composite panels were fixed onto the columns Grenfell Tower as follows
- a) Steel angles were fixed to the face of the concrete columns (Figure 8.36);
  - b) Cladding rails were then fixed to the brackets;
  - c) The composite panels were 'hung' on bolts fixed into a continuous cladding rail
- 8.10.11** The spandrel rainscreen panels used were of various sizes. I measured panels 1100mm in width.
- 8.10.12** I note from the CEP purchase orders (ARC00000011, ARC00000024, ARC00000035) and Arconic order acknowledgements (ARC00000012; ARC00000027; ARC00000215) multiple widths (1250mm - 1750 mm) and lengths (2300 – 3000mm) of Reynobond 55 PE smoke silver panels, and one size of Reynobond 55 PE pure white (1500 x 2300 mm) were purchased.

- 8.10.13** I have reviewed the Arconic Inc. website <sup>4</sup> where they describe two types of Reynobond aluminium composite panel: flat panels, which can be screw fixed or riveted to supports or modular cassette systems which are hung from supports.
- 8.10.14** Arconic do not define on their website what material or construction differences exist between the flat panel and modular cassette systems.
- 8.10.15** The purchase orders for Grenfell Tower do not specify which of panels flat or modular cassette were purchased.
- 8.10.16** I have investigated whether the panels installed may have been Arconic's modular cassette panels by comparing my onsite observations and review of the construction drawings against Arconic's standard details for modular cassette panels. Specifically I have compared the following:

- a) How the panels were shaped; and
- b) How the panels were supported.

- 8.10.17** Figure 8.58, Figure 8.59, and Figure 8.60 I have included Arconic standard details for modular cassette panels and flat panels. It can be seen that in the modular cassette system, panels are formed into a 3d shape with the support (a horizontal bolt in the rail) hidden behind the panel, whereas for the other systems the panels are screwed or riveted through the face of the panel into the supporting bracket rail

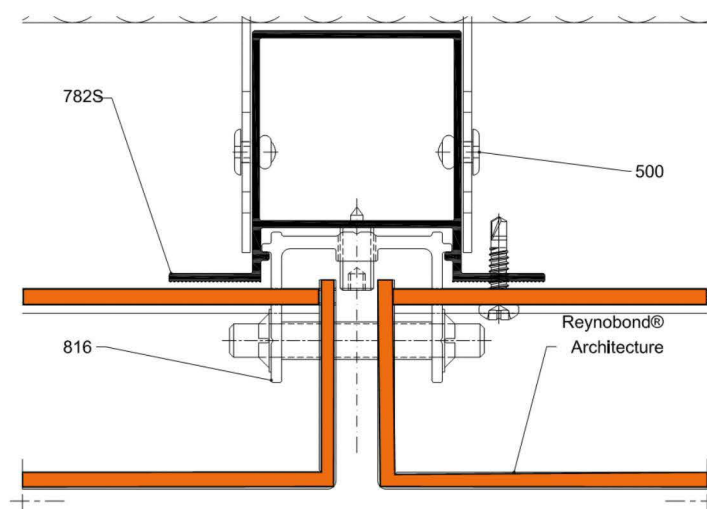


Figure 8.57 Arconic Modular cassette (riveted)<sup>4</sup> (Reynobond panel highlighted in orange)

<sup>4</sup> Arconic website standard details: [https://www.arconic.com/aap/europe/en/cad\\_files.asp?dir=010](https://www.arconic.com/aap/europe/en/cad_files.asp?dir=010) [accessed 10/04/2018]



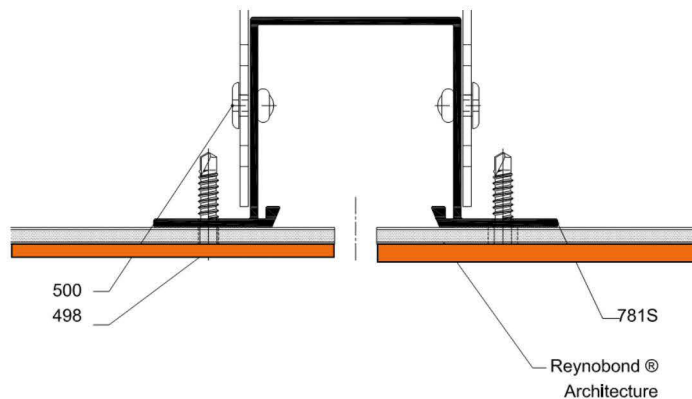


Figure 8.58 Flat panel (Screw fixed)<sup>4</sup> (Reynobond panel highlighted in orange)

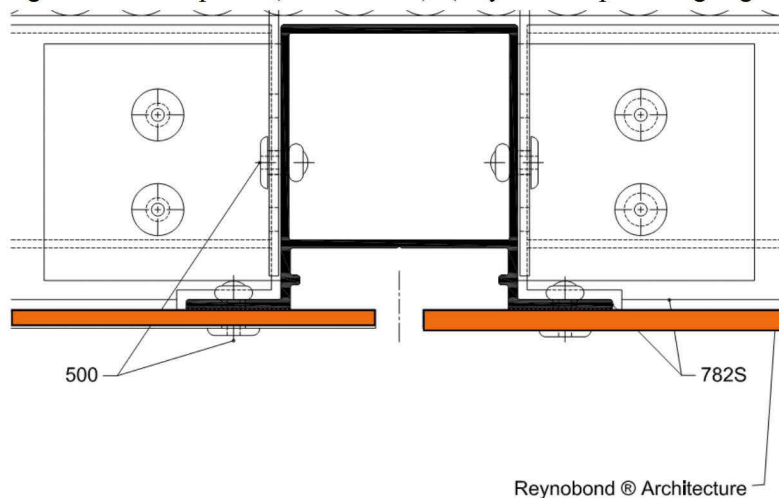


Figure 8.59 Arconic Flat panel (riveted)<sup>4</sup> (Reynobond panel highlighted in orange)

#### 8.10.18

On Grenfell Tower, I observed that the panels were formed into shapes as shown in Figure 8.60 and hung on bolts through a carrier rail. I have therefore, compared the system to Arconic's standard details for modular cassette systems.



Figure 8.60 ACM panels formed into 3D shape

**8.10.19** Based on review of the Arconic standard details for modular cassettes I have determined that these systems are designated by Arconic as either KU, KS, or KH-25/35/50 or VA or NVA, depending on the dimensions of the panel, how they are hung and how they are fixed. This is shown in Figure 8.61.

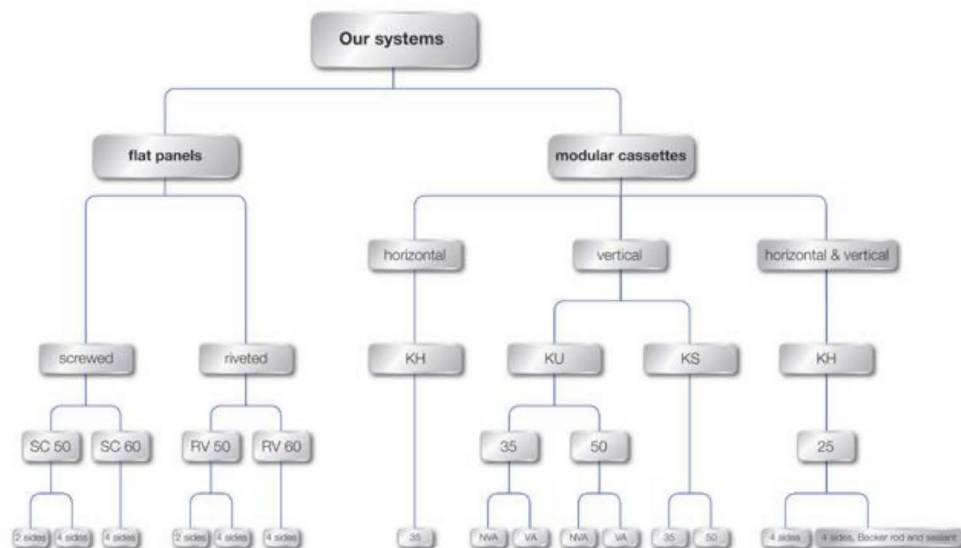


Figure 8.61 Arconic panel designations (adapted from Arconic website<sup>4</sup>)

**8.10.20** I noticed two differences on how panels were shaped at Grenfell Tower compared to the Arconic standard details for modular cassette systems.

**8.10.21** Firstly, the cassette panel designation from Arconic of 25, 35, or 50 appears to relate to the depth of the return of the panel (i.e. the depth of sides of the



panel). In Figure 8.62 I have compared the Arconic KU50 panel which shows a panel return depth of 50mm (the largest described by the Arconic standard details) to the detail specified for Grenfell Tower, which I also observed onsite. It shows an equivalent panel return dimension of 117mm.

**8.10.22** The returns of the cladding panels at Grenfell Tower were also fitted with a metal sheet at the edge where it hangs on the bolts and carrier rail Figure 8.63. Such a metal fitting is not featured in any of the Arconic standard details for modular cassettes.

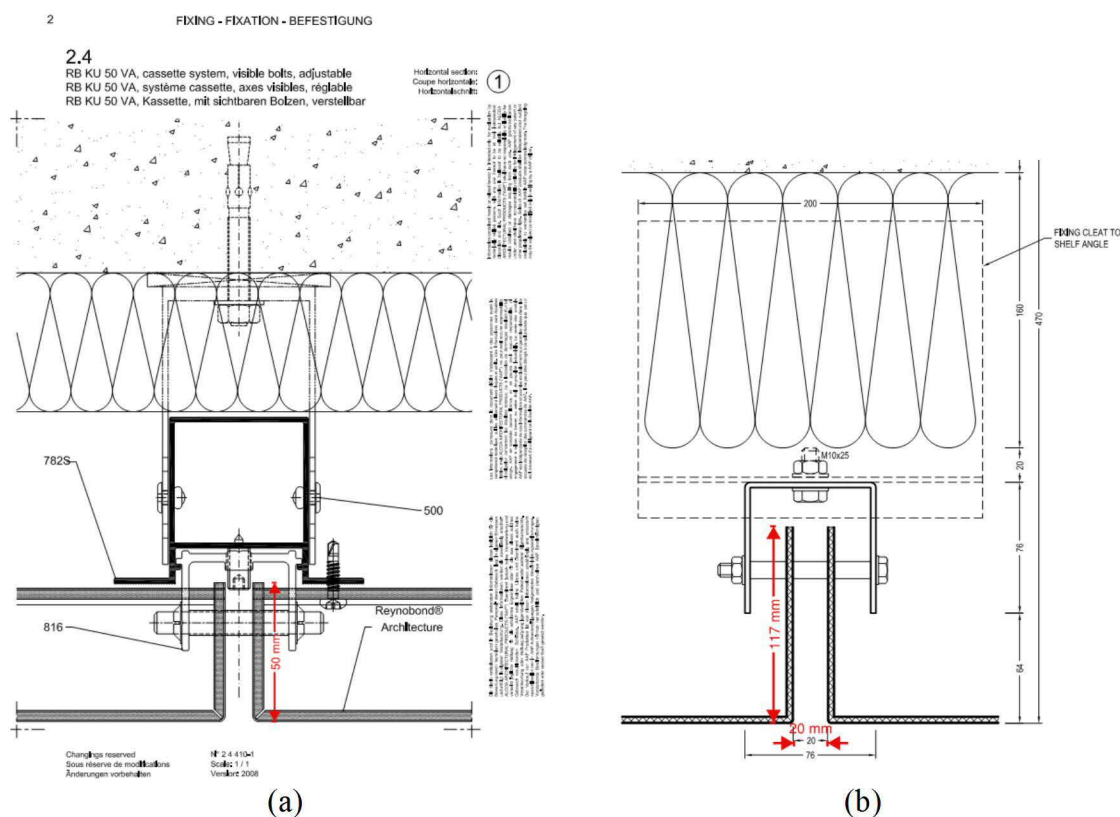


Figure 8.62 (a) Arconic Standard detail for KU50 (50mm return of ACP panel) (b) Depth of return of Grenfell Cladding panel (measured from C1059-305 Rev D [HAR00008903])

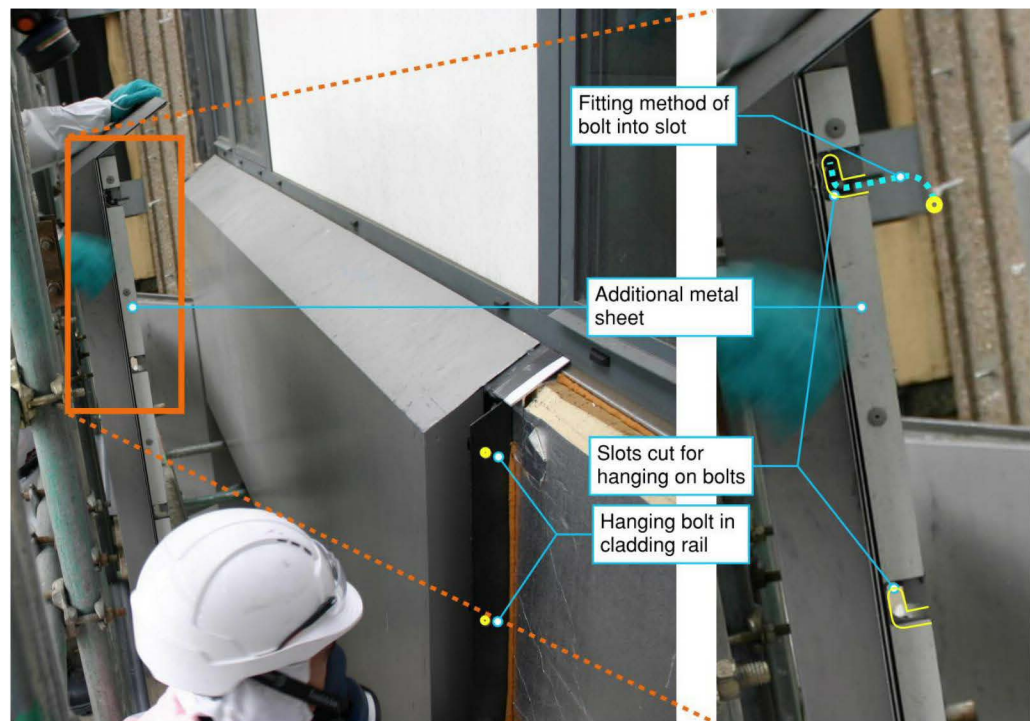
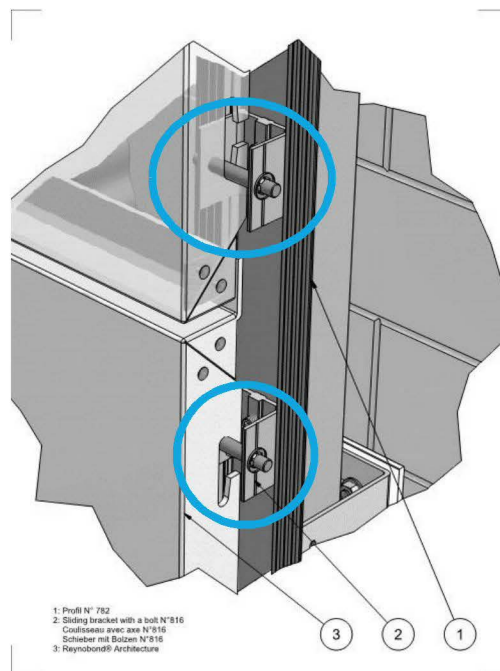
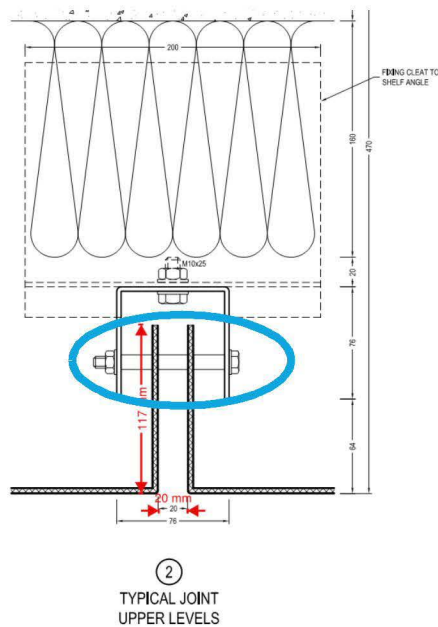


Figure 8.63: Additional metal sheet observed onsite attached to ACP panel on Grenfell Tower that was not shown on standard Arconic Drawings [photo taken on level 4 outside flat 13]

**8.10.23** Finally, in terms of how the Grenfell Tower composite panels are fixed onto the building, I have compared the Grenfell Tower façade fixing detail to the Standard Arconic detail for cassette system hung on bolts in Figure 8.64.





a) Grenfell Tower Cladding detail (Adapted from C1059-305 Rev D [HAR00008903]) and site photo (note bolts circled in blue fixed into a continuous rail not individual brackets)

b) Standard fixing detail for an Arconic Reynobond KU 50 VA (Modular cassette system hung on bolts) (note bolts circled in blue fixed into individual brackets)

Figure 8.64 Comparison of Grenfell Tower Cladding fixing detail to the Standards Arconic detail for an example KU 50 VA

**8.10.24** It can be seen that the Grenfell Tower cladding panels are hooked onto bolts attached to a continuous cladding rail (Figure 8.64 (a)) whereas in the Standard Arconic system (Figure 8.64 (b)) the bolt is fixed into individual brackets which are then attached to a cladding rail.

**8.10.25** As the dimensions of the panels observed on site, both in terms of their shape and fixing method, deviate from the standard Arconic details, I believe it is

likely that a bespoke system (using Reynobond 55 PE panels but not in accordance with the standard Arconic systems) was installed at Grenfell Tower.

- 8.10.26** CEP fabricators are listed in the Harley O and M manual (RYD00092657) as the Curtain Walling, windows and doors fabricator.
- 8.10.27** At this stage it appears likely that CEP received the ACM panels from Arconic and then formed them into a bespoke cassette shape with a bespoke fixing detail. It will be necessary to obtain evidence from CEP to explain their process and procedures, and I will address this in my Phase 2 report.
- 8.10.28** Therefore, in Section 11 of my Expert Report, I assess test evidence for the Reynobond 55 PE cassette systems (provided to the Public Inquiry by Arconic), recognising the differences I have found between the standard details and the on-site application. I will re visit this issue and update my analysis where necessary should further evidence regarding the specific type of Reynobond 55 PE panel supplied and installed at Grenfell Tower be confirmed. In Appendix O, I explain all the test evidence I have for Reynobond products, as received from the BBA and from Arconic Inc.
- 8.10.29** The columns were clad with 1 panel per face, that is 2 rainscreen panels on the intermediate columns and 3 rainscreen panels on the corner columns (Figure 8.56).
- 8.10.30** The rainscreen panel system incorporates gaps between each of the panel junctions for ventilation and rainwater drainage. On site in the areas I inspected, I noted that the panel gaps ranged between 15mm and 30mm.
- 8.10.31** The construction of the rainscreen cladding panels was such that the polyethylene core was exposed around the perimeter of the panel. Thus at each of these gaps the exposed PE core was in close proximity to the rainscreen cavity as shown in Figure 8.65, Figure 8.66 and Figure 8.67. Polyethylene is a combustible material.



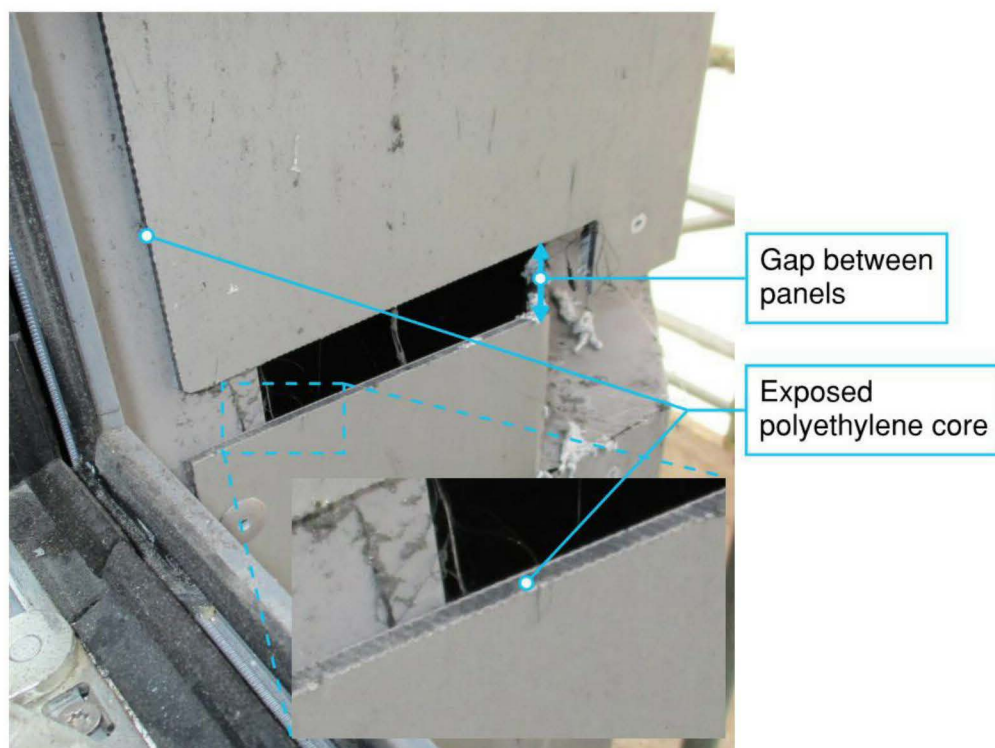


Figure 8.65: Column rainscreen panel gaps and exposed PE core. Flat 10.



Figure 8.66: Panel gap in spandrel rainscreen cladding panels at head of window. Flat 10.





### 8.10.32 **Insulating core panels – between windows**

8.10.33 Set into the windows themselves were two types of unglazed elements in various configurations. See Figure 8.69 and Figure 8.70 for the two typical arrangements as specified in Studio E and Harley design information. The insulating core panels were approximately 1318mm in height and vary from approximately 820mm to 1375mm in width.

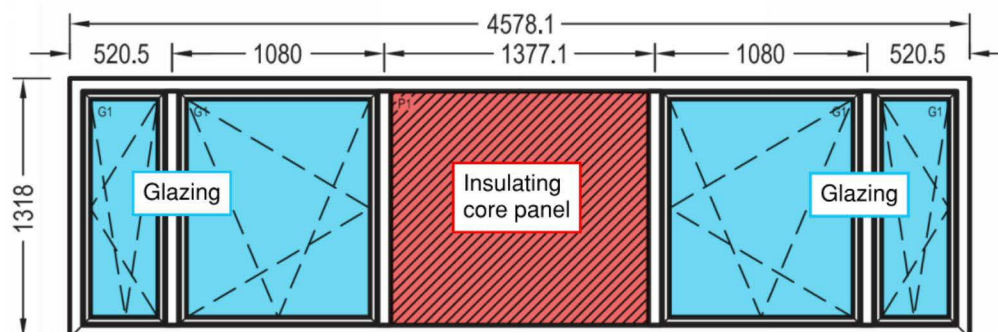


Figure 8.69: Typical elevation for two-window configuration (Based on HAR00008145)

8.10.34 For those elements marked as insulating core panels, the Harley specification (HAR00008991) lists the following construction:

- a) 1.5mm aluminium skin;
- b) a core of 25mm Styrofoam (extruded polystyrene – combustible);
- c) 1.5mm aluminium skin;
- d) Finished with PPC (polyester powder coating) on both outer surfaces.

8.10.35 The composition of the large insulating core panels was not examined as they were set into the window construction and not removed for inspection during my time on site.

8.10.36 Styrofoam is a trademarked brand of extruded polystyrene foam (XPS). produced by DOW chemicals. XPS is listed as a combustible material in the SFPE handbook and Table A.36 lists the ignition temperature as 356°C.

### 8.10.37 **Window insert insulating core panels**

8.10.38 The 'window insert' insulating core panel associated with a vent for the kitchen was approximately 530mm x 500 mm and varies in its location depending on the internal layout of the flat.

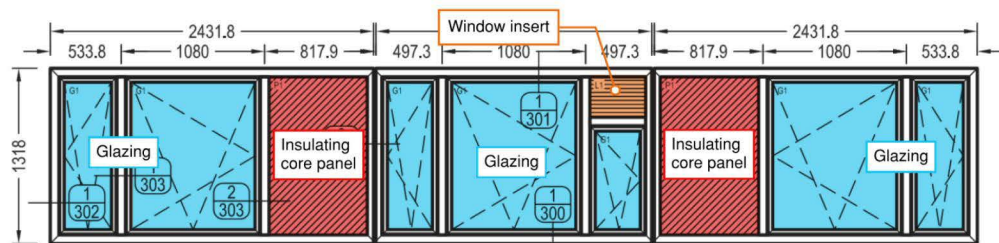


Figure 8.70: Typical elevation for three-window configuration (Based on HAR00008145)

**8.10.39** Within the kitchen window framing system, a vent was placed in the upper corner of the window, as shown in Figure 8.71. According to the Harley specification (HAR00008991) the construction of this element was to be as follows:

- 1.5mm aluminium skin;
- a core of 25mm Kingspan TP10 PIR insulation (combustible);
- 1.5mm aluminium skin;
- Finished with PPC (polyester powder coating) on both outer surfaces.

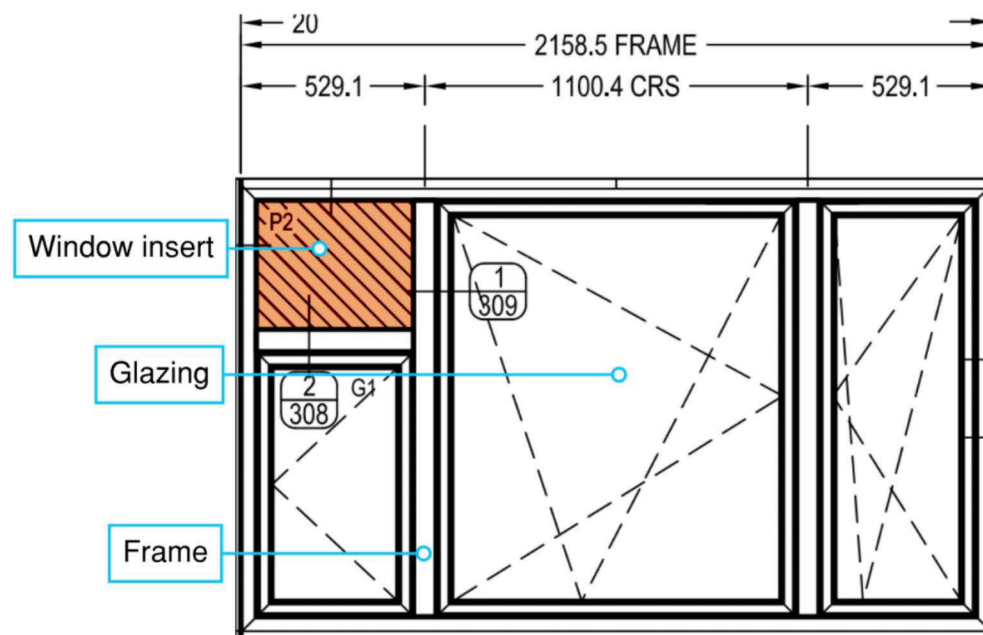


Figure 8.71: Typical kitchen window insert insulating core panel and vent location (Based on HAR00008145)

**8.10.40** Additionally, the fan unit was constructed with a combustible plastic housing (Figure 8.72).

**8.10.41** The core material in the specification is not consistent with my observations from site, as shown in Figure 8.73. Although the drawings and specification



indicate the material specified as Kingspan TP10 (PIR), the foam insulation observed on site was light blue which is consistent with the Styrofoam (extruded polystyrene) material as specified for the main infill panels (Aluglaze).

**8.10.42** As outlined in section 8.10.36, Styrofoam/Polystyrene is a combustible material.

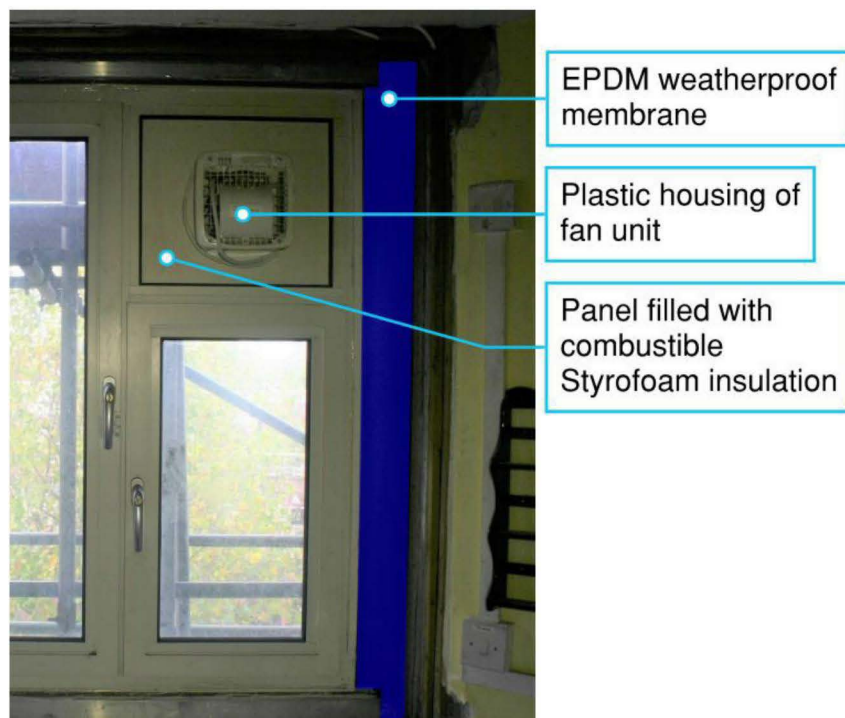


Figure 8.72: Window insert insulating core panel in place showing plastic housing for fan



Figure 8.73: Window insert insulating core panel removed from glazing system. Flat 10 Kitchen (however this window insert was present for every flat as per the Harley specification (HAR00008991)).

## **8.11 Conclusions**

- 8.11.1** In this section I have explained the outcome from my analysis of the materials I found on site, and of supporting documentation available to me. I have therefore set out my opinion on the materials and their arrangement as the external wall at Grenfell Tower.
- 8.11.2** In Section 9 I will use this information to identify the key routes for fire spread out, and back in, through the window construction.
- 8.11.3** In Section 10 I will use this information to identify the vertical and lateral fire spread routes throughout the external wall construction.
- 8.11.4** In the event that further evidence emerges in due course, which suggests that additional materials were present in the building envelope which I have not addressed in this chapter, I will update my analysis accordingly.