SECTION 3

INDICATIVE APPROACH TO PREPARING AN OVER-CLADDING SCHEME COMPLIANT WITH BUILDING REGULATIONS AND APPROVED DOCUMENTS B AND L

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3.1 Introduction

3.1.1 In Section 4 of this report I consider whether various aspects of the over-cladding, as installed under the 2012-16 Works, complied with the Building Regulations and with guidance given within the Approved Documents. In this respect I have analysed Studio E's work, and that of Harley, and I report my findings in that Section of this report. In summary those findings are that the work of Studio E and Harley failed to comply with the Building Regulations and failed to follow the guidance given in ADB Volume 2 ('*ADB2*') in multiple areas of both design arrangement and material/product selection.

3.1.2 I believe that a failure of process was the cause of many of the problems. For example:

a) There does not appear to have been a proper review of code requirements in relation to fire safety with respect to the over-cladding.

b) There does not appear to have been an adequate investigation into the range of conditions within the external wall that had to be addressed in terms of developing a code compliant design with respect to fire safety.

c) There does not appear to have been a clear strategy in terms of developing the design for fire safety. This is particularly pertinent with respect to the proposed cavity barrier installation.

3.1.3 In order to assist the reader in following my commentary in Section 4 with respect to the above points, I have prepared a guide to the approach that I believe an architect should adopt for a project of this kind. I refer to this variously as an '*indicative approach'* and an '*indicative scheme'*. In this respect the RIBA produce a '*Plan of Work*'. First published in 1963, it has been very widely used in its various forms over the years. The indicative approach that I describe below has been informed by my experience of using the RIBA plan of work throughout my career.

3.1.4 The RIBA has recently (2013) introduced an amended Plan of Work in which the work stages have been redefined and described against numbers as opposed to letters which was the historically adopted method of describing work stages. I adopt, for the purposes of this report, the old '*letter based*' RIBA designations which prevailed when Studio E commenced this project, and which they used in defining their appointment to KCTMO and to describe their first report (Studio E Stage C Report). Appendix 2 to this report sets out an explanation of the RIBA Work Stages which will assist the Reader in understanding this system.

3.1.5 My indicative approach, which broadly reflects RIBA Stages D and E in the '*old*' Plan of Work, is based on an over-cladding arrangement that is as close as possible to the design brief and design proposal that Studio E adopted and developed for the project, taking into consideration the requirements and guidance of the Building Regulations and the then guidance contained within ADB2 and Approved Document L Part 1B ('ADL1B').

3.1.6 I make this qualification because since the Grenfell Tower fire the government has made various amendments to the guidance contained within the Approved Documents - particularly in relation to cladding materials. I have therefore applied the guidance given within those documents at the time that the design was developed for the 2012-16 Works.

3.1.7 For ease of reading, I have generally used the present tense when referring to the requirements of the Building Regulations and to the guidance given within the Approved Documents even though these might since have been amended.

3.1.8 I thus show and describe, through a combination of diagrams and specification notes, an outline of some of the key features of such an over-cladding scheme. These would form the basis for routine discussions with manufacturers, suppliers and the Building Regulations Officers in preparing a scheme that would satisfy the requirements of the Building Regulations and be compliant with the guidance in the Approved Documents. It is important to note that this kind of work cannot be fully developed without such discussions which, as I will show in Section 4, were not conducted with appropriate effect.

3.1.9 For a project of this scale an architect would normally work with a team of consultants including, insofar as the work relates to over-cladding, a services consultant, structural engineer and specialist fire engineer. The services consultant would assist in developing the response to Part L of the Building Regulations culminating in a thermal modelling report and SAP calculations (a measure of the energy efficiency of a building) together with external lighting design, and security such as CCTV. The structural engineer would deal with the principal issues relating to the secondary structure that supports the over-cladding, including justification of the capacity of the existing main structure to carry the additional loads involved. My experience is that for larger and more complex projects most of the Design and Build Contractors that my firm has worked for have insisted on the appointment of a specialist '*fire consultant*'. Where they have not appointed a fire consultant, we have provided strong recommendation that they do appoint such a specialist.

3.1.10 I understand that although Rydon chose not to appoint Exova under their Design and Build contract (during which time Studio E were novated to Rydon) Exova's appointment to KCTMO was maintained and they remained available to provide advice to Studio E on an '*as and when needed*' basis as evidenced, for example in the email exchange between Studio E and Exova requesting advice with respect to the confusion relating to terminology in connection with cavity barriers and fire stopping {EXO00001294}.

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3.1.11 In preparing the indicative approach I, and those colleagues within HKS who have assisted me, have worked without recourse to any such advice from other consultants, including fire specialists, or from Building Control, product manufacturers, specialist cladding sub-contractors or main contractors. That is why I use the term '*indicative*': this is not a worked-up design with the benefit of such collaboration, but is what I would expect a reasonably competent architect to prepare at my so-called '*indicative stage*', that is Stages D and E (Design Development and Technical Design).

3.1.12 The indicative scheme for the over-cladding shown herein is taken to the level appropriate for tendering a Design and Build project where the sub-contractor for cladding would thereafter assume responsibility for developing construction documentation following its appointment. However, I further qualify this comment below with respect to the appointment terms that were agreed between Studio E and KCTMO for the 2012-16 Works.

3.1.13 Despite those qualifications, I believe that the arrangements that I show herein are sufficiently developed to usefully demonstrate the basis of what I believe would have been a workable solution that would satisfy the requirements of the Building Regulations and guidance contained within ADB2 for the over-cladding of Grenfell Tower. By describing within this section the issues that must be addressed and the process involved in developing such a scheme, as well as showing an indicative arrangement for some of the key details, I thus provide a basis for the critical review that I offer in Section 4.

3.1.14 The process that I describe is restricted to the work of preparing a design for the over-cladding. For the purposes of this exercise I do not stray into discussing the wider range of an architect's typical activities and responsibilities for a project of this kind such as establishing and confirming terms of appointment / procurement and contract arrangements / structuring the teams and briefing other consultants / creating programmes and timetables for critical activities / preparing responsibility matrices etc. These issues are all important in terms of 'process' but are not dealt with here.

3.2 Carrying Out a Code Review

3.2.1 At the earliest possible opportunity, it is essential to arrange for a thorough code-evaluation to be carried out. This comprises an evaluation of all applicable Building Regulations and relevant guidance that will affect the question of compliance.

Larger architectural practices often have a person (or team) whose designated responsibilities include providing such support to the project architect/design team.

3.2.2 Through this exercise it is possible to establish a clear understanding of what codes and regulations, and which parts thereof, impact on the work that will be undertaken in preparing the indicative approach. This research should be well advanced before any serious design work starts.

3.2.3 Such research is best expressed in a series of memoranda, and in diagrammatic form with attached notes. This can then be used to brief all team members as they join the project. It will be developed further in terms of detail as the project progresses.

Upon completion of the project such information should be retained within the archived records, to be re-visited and reused as appropriate: for example, if subsequently instructed to carry out further work on that same project.

3.2.4 In this case a code review establishes that two key parts of the Building Regulations will require particularly careful attention:

- PART L: CONSERVATION OF FUEL AND POWER
- PART B: FIRE SAFETY

I will deal with the code guidance in this order because the project's primary purpose was to improve thermal performance. I will not address other parts of the Building Regulations as they are not relevant to this section of my report.

3.2.5 For the over-cladding work at Grenfell Tower guidance to meeting the requirements of the Building Regulations in respect of Part L and Part B is provided under Approved Document L1B (hereinafter referred to as '*ADL1B*') and Approved Document B Volume 2 (hereinafter referred to as '*ADB2*').

3.2.6 I am aware in this respect that it is not mandatory to comply with the guidance in the Approved Documents and that in terms of meeting the requirements of the Building Regulations other methods and solutions may be adopted provided that it can satisfactorily be demonstrated that they will achieve compliance with the requirements of the Building Regulations.

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In this respect I quote from ADB2 as follows:

'…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.'

3.2.7 However, in preparing the indicative approach, I see no need to depart from the guidance as given within the Approved Documents for a project that is:

a) Fairly routine in character; and

b) For which the construction and design budget constraints do not support any particularly adventurous design work that might otherwise prompt such a departure.

3.2.8 Furthermore, I have no evidence that Studio E sought any alternative guidance to that given within the Approved Documents, so it seems to be entirely reasonable to adopt the guidance given within ADL1B and ADB2 in terms of achieving compliance of the indicative approach with the requirements of Parts L and B of the Building Regulations.

3.3 Establishing an Appropriate U-value

3.3.1 The principal intent with respect to the over-cladding of Grenfell Tower was to upgrade the external envelope – walls and windows – in order to improve the building's thermal performance. This necessitates establishing, at the very outset of the process, a suitable target U-value which is a measure of thermal efficiency. Unless this figure is given within the Client's brief (which I understand was not the case here) the immediate question an architect would need to resolve is: what U-value *should* be targeted? In this respect the obvious starting point is to determine what is required under the Building Regulations.

3.3.2 A '*U-value*' is the measure of heat loss – in this case through a wall: the lower the U-value the better the wall's performance in terms of insulating against heat loss in winter and against heat gain in summer.

Summary of the Building Regulation requirements and the guidance given within Approved Document L1B

3.3.3 Regulation 23 of the Building Regulations states:

'*Requirements for the renovation or replacement of thermal elements*

(1) Where the renovation of an individual thermal element –

(a) constitutes a major renovation; or

(b) amounts to the renovation of more than 50% of the element's surface area;

the renovation must be carried out so as to ensure that the whole of the element complies with paragraph L1(a) (i) of Schedule 1, in so far that it is ***technically, functionally and economically feasible'*** (my emboldening).

(Note: the above quote is taken from ADL1B paragraph 5.1: October 2010 Edition incorporating 2010, 2011 and 2013 amendments. It differs slightly from the text within the 2010 Building Regulations which does not make reference to '*technical, functional and economic feasibility*').

3.3.4 Paragraph L1 of Schedule 1 of the Building Regulations (under PART L CONSERVATION OF FUEL AND POWER) states that:

'Reasonable provision shall be made for the conservation of fuel and power in buildings by:

(a) limiting heat gains and losses –

i) through thermal elements and other parts of the building fabric...;'

3.3.5 ADL1B provides guidance with respect to over-cladding work to existing buildings (as was the case at Grenfell Tower) under Section 5: '*Guidance on thermal elements*' (sub-heading: '*THE PROVISION OF THERMAL ELEMENTS*') wherein paragraph 5.6A states:

'***Major renovation*** *means the renovation of a building where more than 25% of the surface area of the building envelope undergoes renovation'.*

On this basis the over-cladding of Grenfell Tower clearly constitutes a '*major renovation'*.

3.3.6 Paragraph 5.7 under the sub-heading '*RENOVATION OF THERMAL ELEMENTS*' states that:

'*...For the purposes of this Approved Document* ***renovation*** *of a* ***thermal element*** *through:*

(a) The provision of a new layer means either of the following activities:

i) Cladding or rendering the external surface of the ***thermal element****; or*
ii) Dry-lining the internal surface of a ***thermal element****.'*

3.3.7 Key to interpreting these requirements is defining the meaning of *'thermal element'*. In this respect it is surprising that ADL1B does not have an appendix that provides definitions, but Building Control Guidance Note 24 issued on 15 July 2011 helpfully defines a Thermal Element as:

'... a wall, floor or roof, excluding windows or doors... which separates part of a building that is thermally conditioned... from... the external environment...'

The external walls of Grenfell Tower, in their entirety, meet this definition.

3.3.8 When designing the new insulation at Grenfell Tower, the logical position on the building for any new thermal insulation is to apply it to the exterior face of the external walls. If adopting that design strategy (as applied by Studio E for Grenfell Tower and adopted for the indicative approach developed herein) ADL1B paragraph 5.7(a)(i) would apply i.e. this would constitute applying the insulation to the outside surface of the external surface of the thermal element, namely the wall.

3.3.9 The advantages of this approach (as opposed to adding insulation to the inside of the external walls, guidance for which is provided for under ADL1B paragraph 5.7(a)(ii)) is that:

a) Disruption to existing decorations, finishes, kitchen fittings etc. is kept to a minimum and, despite the acknowledged inconvenience, it is feasible for residents to remain in occupation during the construction period.

b) There is no loss of internal floor area which would be difficult to accommodate, especially in areas such as the kitchen.

c) There is no risk of interstitial condensation and cold bridging which is otherwise the case where the outside face of elements such as structural floor slabs and columns are not incorporated within the newly created thermal envelope. This avoids a situation in which there is a conduction path by which cold external temperatures can travel deep within the structure.

d) The existing external walls and structure are, by virtue of the new insulation being placed on their external surfaces, effectively transformed into thermal storage '*facilities*'. They thus retain heat in winter and cool in the summer which greatly improves the building's comfort and thermal efficiency: less heating and less cooling is required.

e) The heat gain during summer would be reduced because the sun's penetration into the flats would be reduced. (Max Fordham's Stage C report referred to '*chronic overheating in the summer*': page 5) {MAX00001683}.

3.3.10 However, under this arrangement the external wall inevitably becomes thicker as a result of the addition of the insulation and rainscreen over-cladding. Most occupants would require any increase to the thickness to be kept to a minimum as the greater the depth the more restrictive are the views through the windows from within – particularly views to the extreme left and right – and the greater the reduction in natural daylight. This therefore forms part of the design challenge: the overall increase to the wall's thickness should be minimised as far as possible. Paragraph 5.8 provides further guidance as follows:

*'Where the **thermal element** is subject to a **renovation** through undertaking an activity listed in 5.7a or 5.7b, the performance of **the whole of the thermal element** should be improved to achieve or better the relevant U-value set out in column (b) of Table 3…'*

In this context I interpret *'the whole of the thermal element'* to mean the combined performance of the original (retained) external wall together with the newly added over-cladding.

3.3.11 Table 3, as referred to in paragraph 5.8, ultimately provides the guidance required for this project under column (b) where it states that the external walls should be upgraded under the over-cladding work to achieve a U-value performance of 0.30 W/m2K *or better* (my italics).

Applying the Building Regulation requirements and the guidance given within Approved Document L1B to my Indicative Approach

3.3.12 As stated above, a '*U-value*' describes the rate at which heat is transmitted through a building element such as a wall, window or roof. The overall '*U*' value of the external walls is a very important consideration. High levels of heat loss will lead to discomfort: cold/condensation and/or increased heating bills. High levels of heat gain in summer will also lead to discomfort and/or increased energy bills where air-conditioning is adopted.

3.3.13 The original external walls at Grenfell Tower comprise a combination of solid reinforced concrete spandrel panels under the windows and solid reinforced concrete columns, both with low grade insulation and plaster to the inside face. According to Max Fordham's Stage C report page 5 / item 1.5 {MAX00001683} these elements were achieving U-values of the order of 1.5 W/m2K which is around 5 times the figure given as guidance under the relevant Approved Document for a new flat (i.e. they were considerably less efficient). Upgrading these two categories of thermal element (the concrete spandrel panels and concrete columns) to achieve the recommended U-value performance of 0.30 W/m2K does not represent any particular difficulty: 0.30 W/m2K is a very low standard requiring minimal insulation. (Current residential new-build standards are set at 0.16 W/m2K).

3.3.14 Even so, if any properly demonstrable difficulty does arise in terms of the technical, functional or economic feasibility of achieving this performance, it is possible under the Building Regulations to apply a lesser standard: ADL1B paragraph 5.12 states that:

'...Where the standard given in column (b) is not technically, functionally or economically feasible, then the thermal element should be upgraded to the best standard that is technically and functionally feasible and delivers a simple payback period of 15 years or less'.

In terms of the guidance given in ADL1B it is therefore evident that there is some considerable latitude in setting the U-value when embarking on the indicative approach.

3.3.15 Max Fordham's 'Stage C' report {MAX00001683}, prepared early on in the design process for the 2012-16 Works, recommended that the U-value for the external wall/thermal element should be set at 0.15 W/m2K. The background issues that informed the Max Fordham Stage C report are commonly understood by architects and routinely inform their design work. To assist the reader, I will summarise them here.

3.3.16 The heating and cooling of a building requires a very large proportion of the overall energy demands during its 'life'. Other energy demands include power for artificial lighting, mechanical ventilation and lifts. Traditionally, the supply of energy in the UK has been predominantly based on fossil fuels. These produce high levels of carbon emissions (CO2) which are increasingly seen as significant contributors to global warming, climate change, and decreasing air quality – especially within our cities.

3.3.17 Accordingly, recent years have seen significant efforts within the UK to reduce CO2 emissions associated with buildings. These efforts have included upgrading building envelope thermal performance in order to reduce heat loss through external walls and windows, the roof, and the ground slab, and reducing air-leakage through poorly fitting windows and doors (draughts etc.) This reduces energy demands for heating in winter and cooling in summer.

3.3.18 It is against this background that I consider that Max Fordham's recommendation of the 0.15 W/m2K U-value (much in excess of the ADL1B (minimum) guidance of 0.30 W/m2K) set a laudable objective for the project W/m2K. The U-value recommendation of 0.15 W/m2K is therefore the target performance standard which I shall adopt in the preparation of my indicative approach.

Testing the viability of the target U-value

3.3.19 Having established the minimum standard required under Building Regulations and ADL1B guidance, and the target U-value performance of 0.15 W/m2K, the next step is to test this target figure to establish whether it would be feasible *'technically, functionally and economically'* (as per the reference in ADL1B paragraph 5.12). This involves developing a design strategy and concept in terms of choice of materials and their arrangement that will:

a) Be economically viable within the constraints of the project's construction budget; and

b) Be capable of satisfying user requirements, planning requirements and technical issues relating to buildability and code compliance.

Economic viability

3.3.20 I acknowledge that value-engineering exercises took place during preparation for the 2012-16 Works. That is quite normal: design and specification changes routinely occur on most projects throughout the design process. For the purposes of this report I will therefore not discuss economic viability any further. The 0.15 W/m2K figure as recommended by Max Fordham was adopted for the 2012-16 Works and to the best of my knowledge it was not challenged as being economically non-feasible.

3.3.21 Whilst it is normal and routine for value engineering exercises to be carried out in order to improve the economic efficiency of delivering a design, or simply to reduce standards and scope of a project in order to reduce construction costs, it is never permissible during value-engineering to breach the requirements of the Building Regulations or basic standards of safety. In this context value engineering can be defined as:

'a systematic and organised approach to provide the necessary functions in a project at the lowest cost. Value engineering promotes the substitution of materials and methods with less expensive alternatives without sacrificing functionality' (RIBA Stage Guide 2015).

Town Planning etc.

3.3.22 I shall also set aside the matter of Town Planning. Again, I acknowledge that some difficulties arose for Studio E in this respect and again this is not unusual. Planning consent for the over-cladding was ultimately secured and so for the purposes of this report I will therefore not discuss matters of consent under Town Planning any further.

Functionality

3.3.23 As stated earlier the logical and sensible position for any such thermal upgrading is to the outside of the existing structure and construction. This was the position adopted by Studio E and the design team and this is the position that I shall adopt.

3.3.24 In summary, I do not anticipate that any functional or economic issues would render the 0.15 W/m2K as a non-viable target figure, albeit I am immediately aware of the importance, from both a functional and a cost perspective, of ensuring that any overall increase to the thickness of the external walls as a result of the additional over-cladding should be kept to a minimum.

3.3.25 In reaching that conclusion I am nevertheless aware that in meeting the requirements of Part L of the Building Regulations and adopting the guidance given under ADL1B, there is considerable latitude in terms of the U-value that I will adopt. Accordingly, I know that if I cannot achieve the 0.15W/m2K target figure recommended by Max Fordham I can recommend that a less demanding figure should be set.

3.4 Establishing a Fire Safety Strategy for the External Wall

3.4.1 Unsurprisingly, the code review that I routinely carry out reveals that Part B of Schedule 1 of the Building Regulations (Fire Safety) will be of paramount importance.

3.4.2 I discuss the requirements of the Building Regulations and the guidance given within ADB2 in relation to fire safety for the over-cladding design extensively elsewhere in this report. For the purposes of this section it is sufficient for me to simply state that meeting the requirements of Part B of the Building Regulations is one of the most important aspects of any design because, as with Part A that deals with structure, issues of health and safety lie at the heart of the Fire Safety legislation.

3.4.3 In developing my indicative approach for this over-cladding project, I am therefore particularly mindful of the need to take careful account of the guidance given within ADB2 especially with respect to Section 8: *Compartmentation*, Section 9: *Concealed spaces (cavities),* and Section 12: *Construction of external walls*.

3.4.4 Essentially, these require that I take care to understand and maintain the existing compartmentation provisions within the building, and that I take due care to ensure that, in terms of combustibility, all materials selected are in compliance with guidance given, and that appropriate care is taken to inhibit the passage of fire into, and thereafter within, any new cavities formed within the external wall construction.

3.4.5 I conclude that in meeting Part B of the Building Regulations and adopting the guidance given under ADB2, I have no latitude whatsoever. In particular:

a) The insulation to the new cavity that will be formed by the rainscreen system must be of '*limited combustibility*' as stated in paragraph 12.7.

b) The rainscreen cladding material must meet the requirements for external surfaces as set out under paragraph 12.6 and Diagram 40 (that is, it must provide a '*Class 0 (national class)* ***or*** *class B-s3, d2 or better (European class))*' (my emboldening).

c) Any other insulation product or filler material incorporated anywhere else within the external wall must be of '*limited combustibility*' as per paragraph 12.7.

d) The cavities formed by the new rainscreen system must be protected at their edges (which is particularly relevant to the surrounds to the ribbon fenestration) in order to inhibit that passage of fire into those newly formed cavities as per paragraph 9.3 and Diagram 33.

e) The cavities formed by the new rainscreen system must be sub-divided by cavity barriers vertically and horizontally so as to maintain continuity within the new cavities of the compartmentation arrangements between flats at the point that aligns with the junction of the compartment walls and floors with the external walls as per paragraph 9.3a.

3.5 Determining the Insulation Type, Thickness and the Key Dimensional Requirements

3.5.1 Thermal performance in relation to thickness is a key issue in terms of the selection of the principal insulation material that would be affixed to the outside of an existing building. In this respect different types of insulating materials offer different levels of performance, or efficiency as insulants: Polyisocyanurate (PIR – e.g. Celotex) for example is '*thermally*' more efficient than mineral wool. Therefore, as I will show in the tables below, the thickness of mineral wool required to achieve a '*U*' value of 0.15 W/m2K to the spandrel panels at Grenfell Tower is greater than that of Celotex by some 90mm.

Applying the guidance provided by my code review in terms of insulation material

3.5.2 My code review established at the outset that guidance within ADB2 under Section 12: '*Construction of external walls*' paragraph 12.7 recommends that '*any insulation product*' used in the external wall construction '*should be of limited combustibility*'.

3.5.3 I deal with this issue in much greater detail in Section 4 of this report, but at this stage it is sufficient for me to state that although (as set out above) PIR products are more efficient in terms of insulation performance than mineral wool, and although minimising the increase to the overall external wall thickness is important, I know of no PIR product that meets the criteria of '*Limited Combustibility*' as defined in ADB2. Indeed, I know of only one generic product other than mineral wool that meets this criterion and that is so certified which is '*cellular glass*' insulation of which the proprietary product Foamglas is one such example. (I define the standards of performance as required to achieve compliance with the term '*limited combustibility*' as used in ADB2 within Section 4 of this report).

3.5.4 From the outset, my approach, in terms of specification, wall thickness and technical detailing, will therefore be based on the incorporation of mineral wool as the insulation material within the cavity created by the rainscreen system. PIR products and any other product that fails to meet the definition of '*Limited Combustibility*' as set out in ADB2 are rejected from the outset as an insulation material suitable for use within the cavity created by the rainscreen cladding.

3.5.5 This approach extends – that is the rejection of any form of insulation material that fails to meet the definition of '*Limited Combustibility*' as set out in ADB2 - to all circumstances where insulation is required within the external wall including within any proprietary product or component which is assembled off-site such as the window infill panels and the gaps behind the window inner reveal linings.

Determining the external wall thickness

3.5.6 The next step is to determine the necessary thickness of mineral wool as required to achieve the 0.15 W/m2K target U-value.

3.5.7 I would obtain initial calculations to give the approximate dimensional requirements in terms of thickness of the insulation required at the spandrel/slab and column positions.

3.5.8 Such calculations are shown below. Essentially they demonstrate that with mineral wool it is possible for the spandrel/slab condition to produce a 0.142 W/m2K performance (an improvement on the 0.15 W/m2K target) against a 250 mm mineral wool installation, and for the column condition to produce a 0.170 W/m2K performance (slightly outside the U-value target) against a 180 mm mineral wool installation.

Assembly no.	Building assembly description	Interior insulation?
Test 4	**Grenfell External Wall with Mineral Wool - Column**	**no**

Heat transfer resistance [m²K/W]	
interior R_{si} :	**0.13**
exterior R_{se} :	**0.04**

	Area section 1	[W/(mK)]	Area section 2 (optional)	[W/(mK)]	Area section 3 (optional)	[W/(mK)]	Thickness [mm]	
1.	**Plasterboard**	**0.160**					**12**	
2.	**Insulation - existing**	**0.035**					**10**	
3.	**Concrete**	**1.400**					**1000**	**
4.	**180mm Mineral Wool**	**0.035**	**Brackets thermal break**	**0.230**	*		**180**	
5.								
6.								
7.								
8.								
		Percentage of sec. 1		Percentage of sec. 2		Percentage of sec. 3	Total	
		97%		**2.7%**			**120.2**	cm

U-value supplement		W/(m²K)	**U-Value:**	**0.170**	W/(m²K)

* Thermally broken brackets are based upon 100mm square brackets at 600mm centres vertically and horizontally.

** This is notional in order to get near a 0.180 U-Value.

Figure 3.1: U-Value Calculation – Column Locations with Mineral Wool Insulation

Assembly no.	Building assembly description	Interior insulation?
Test 2	**Grenfell External Wall with Mineral Wool - Spandrel Panel**	**no**

Heat transfer resistance [m²K/W]	
interior R_{si} :	**0.13**
exterior R_{se} :	**0.04**

	Area section 1	[W/(mK)]	Area section 2 (optional)	[W/(mK)]	Area section 3 (optional)	[W/(mK)]	Thickness [mm]
1.	**Plasterboard**	**0.160**					**12**
2.	**Insulation - existing**	**0.035**					**10**
3.	**Concrete**	**1.400**					**250**
4.	**250mm Mineral Wool**	**0.035**	**Brackets thermal break**	**0.230**	*		**250**
5.							
6.							
7.							
8.							
		Percentage of sec. 1		Percentage of sec. 2		Percentage of sec. 3	Total
		97%		**2.7%**			**52.2** cm

U-value supplement		W/(m²K)	**U-Value:**	**0.142**	W/(m²K)

* Thermally broken brackets are based upon 100mm square brackets at 600mm centres vertically and horizontally.

Figure 3.2: U-Value Calculation - Spandrel Panel Locations with Mineral Wool Insulation

3.5.9 In each case, for comparison, I show the same calculations applied to the Celotex PIR product:

Assembly no.	Building assembly description	Interior insulation?
Test 3	Grenfell External Wall with Celotex - Column	no

Heat transfer resistance [m²K/W]	
interior R_{si}:	0.13
exterior R_{se}:	0.04

	Area section 1	[W/(mK)]	Area section 2 (optional)	[W/(mK)]	Area section 3 (optional)	[W/(mK)]	Thickness [mm]	
1.	**Plasterboard**	0.160					12	
2.	**Insulation - existing**	0.035					10	
3.	**concrete**	1.400					1000	**
4.	**100mm Celotex**	0.021	**Brackets thermal break**	0.230	*		100	
5.								
6.								
7.								
8.								
		Percentage of sec. 1		Percentage of sec. 2		Percentage of sec. 3	Total	
		97%		2.7%			112.2	cm

U-value supplement		W/(m²K)	U-Value:	0.188	W/(m²K)

* Thermally broken brackets are based upon 100mm square brackets at 600mm centres vertically and horizontally.

** This is notional in order to get near a 0.180 U-Value.

Figure 3.3: U-Value Calculation – Column Locations with Celotex PIR Insulation

Assembly no.	Building assembly description	Interior insulation?
Test 1	**Grenfell External Wall with Celotex - Spandrel Panel**	no

Heat transfer resistance [m²K/W]	
interior R_{si} :	0.13
exterior R_{se} :	0.04

	Area section 1	[W/(mK)]	Area section 2 (optional)	[W/(mK)]	Area section 3 (optional)	[W/(mK)]	Thickness [mm]
1.	**Plasterboard**	0.160					12
2.	**Insulation - existing**	0.035					10
3.	**Concrete**	1.400					250
4.	**160mm Celotex**	0.021	**Brackets thermal break**	0.230	*		160
5.							
6.							
7.							
8.							
		Percentage of sec. 1		Percentage of sec. 2		Percentage of sec. 3	Total
		97%		2.7%			43.2 cm

U-value supplement		W/(m²K)	**U-Value:**	0.142	W/(m²K)

*Thermally broken brackets are based upon 100mm square brackets at 600mm centres vertically and horizontally.

Figure 3.4: U-Value Calculation – Spandrel Panel Locations with Celotex PIR Insulation

3.5.10 The above calculations are of critical importance in developing the design.

3.5.11 They show that *if* the target 0.15 W/m2K figure is to be adopted, the thickness of mineral wool that must be allowed for is 250mm to the spandrel and slab edges of the external walls, and 180mm to the columns. So a decision has to be taken before any further progress can be made: can such dimensions be accommodated in pursuit of a target U-value that is much in excess of the guidance offered within ADL1B, and more akin to the requirements for new-build residential, *or* should a dialogue be opened with the other consultants and client in order to determine whether the U-value performance target should be '*relaxed*' in order to avoid what might be considered an excessive '*build up*' of the overall wall thickness?

3.5.12 My judgement is that the somewhat greater 250mm/180mm dimensions required for mineral wool (PIR/Celotex requires 160mm and 100 mm respectively for the spandrel panels/slap edge and columns) can be accommodated without undue technical difficulty (structural supports etc. can be arranged to project further as will be required to support the rainscreen system) or any necessary serious compromise on the part of residents with respect to amenity (oblique views from windows further restricted).

3.5.13 I therefore consider those mineral wool thicknesses as acceptable and the target 0.15 W/m2K performance as a sound basis on which to proceed. I will thus only re-visit the question of U value/thickness of insulation if further unforeseen problems arise in the development of the indicative approach as based on the 250mm/180mm dimensional requirements consequent on the use of mineral wool.

3.5.14 I note in this context that Mr Sounes states at paragraph 43.7 of his statement {SEA00014273} that on the basis of product literature produced by Rockwool, who manufacture mineral wool thermal insulation, and the company's response to an enquiry in this respect, Studio E had concluded that a U-value of 0.15W/m2K '*might be aspirational*'.

3.5.15 Furthermore, I note that at paragraph 100.3 that Mr Sounes states that Max Fordham had advised '*that a 45 cm depth of Rockwool seemed "a bit high"*'. He further added that Max Fordham '*expected to achieve a U-value of 0.15 with approx. 180mm of insulation and "a phenolic foam insulation would give a greater insulation for the depth"*'.

3.5.16 I do not know in this respect whether Max Fordham in referring to 45cm as seeming '*a bit high*', was suggesting that the assessment of a need for '*45cms depth of Rockwool*' was excessive or whether he was suggesting that 45cms was too deep a dimension to be easily accommodated within the design.

3.5.17 Interpretation aside, based on the calculations carried out by my office I am confident that a U-value of 0.15W/m2K was achievable with a mineral wool depth of 250 mm to the spandrel panels and that in this respect Studio E had been misadvised or alternatively had mis-interpreted the advice given.

3.6 Selecting the Rainscreen Cladding

3.6.1 There are many ways in which the performance of external walls can be upgraded to improve thermal efficiency. One such way is by over-cladding using a rainscreen cladding system.

3.6.2 Rainscreen cladding systems are available in three principal different types: Vented Systems, Drained and Vented Systems, and Pressure Equalised (Moderated) Systems.

3.6.3 The type selected for the 2012-16 Works was a Drained and Vented System. This is a common system that has been in use for some considerable time (I was first involved in designing and specifying a rainscreen cladding system back in the 1980s).

3.6.4 I note that Studio E adopted a zinc panelling Drained and Vented system for the outer *'skin'* at concept stage {SEA00006429} and this was later changed to an ACP (Aluminium Composite Product) system. I will therefore base my indicative approach on the product selected for the 2012-16 Works: that is the Reynobond Architectural Wall Cladding (Cassette) Panels as incorporated into the Harley drawings and installed on the building.

3.6.5 Because of the Grenfell Fire the use of certain materials in external walls (i.e. lower than Euro class A2-s1, d0) have been banned for use on new buildings within a range of new building typologies including residential towers over 18 metres high. (In this respect government guidance refers to ACM products as opposed to ACP). I will therefore outline how I interpret the guidance given within ADB2 with respect to the use of ACP products at the time that the over-cladding design for the 2012-16 Works was being developed.

3.6.6 Paragraph 12.5 of ADB2 states:

'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'.

3.6.7 Paragraph 12.6 states, *'The external surfaces of walls should meet the provisions in Diagram 40'* which is titled *'Provisions for external surfaces or walls'*. An architect should conclude from illustration 'e' within Diagram 40 that the guidance in terms of fire safety for the performance of rainscreen panels for any building over 18 metres high would, for all those parts above 18 metres, be: *'Class 0 (national class)* ***or*** *class B-s3, d2 or better (European class)'* (my emboldening). This is clearly stipulated under the heading: *'KEY TO THE EXTERNAL WALL SURFACE CLASSIFICATION'*.

3.6.8 I have emboldened *'or'* because I interpret it to mean that an architect can choose a cladding material that meets **either** Class 0 **or** class B-s3, d2 or better. In this respect I point out that in the European classification the numbers relate to smoke production and/or flaming droplets/particles, as described in the note at the bottom of Diagram 40. The smaller the numbers, the better the performance.

3.6.9 Turning to BBA Certificate No. 08/4510 dated 14 January 2008 {BBA00000047} which refers to the Reynobond panels used for the 2012-16 Works, I note that on page 1 it states under 'Behaviour in relation to fire' that *'in relation to the Building Regulations for reaction to fire, the panels may be regarded as having a Class 0 surface in England…'*.

3.6.10 I particularly note in this respect the words *'in relation to the Building Regulations'*. On the basis that page 1 of the certificate states that the panels *'may be regarded as having a Class 0 surface in England'* and that they appear to meet the guidance given under Diagram 40, I consider this to be a satisfactory basis upon which an architect could have accepted and specified the product to which this Certificate of Confirmation relates, that is: *'Reynobond Architecture Wall Cladding Panels, aluminium /polyethylene composite panels used to provide a decorative/protective façade over the external walls of buildings'* (see top of page 1 of certificate).

3.6.11 It is therefore my opinion that the guidance within ADB2 (at that time) endorsed, in principle at least, the use of the Reynobond Aluminium Composite Panels for use on a project such as Grenfell Tower. It is my further opinion that most architects would have considered that such endorsement indicated that, in principle, the panels also met the requirements of the Building Regulations. That would certainly have been my conclusion. (I do however make further comments and qualifications on this point at the end of this section and within section 4).

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3.7 Establishing the Range of Detailed Conditions that Must be Dealt with in Order to Comply with the Guidance of ADB2

3.7.1 An architect should next turn to investigating the variety of window/wall conditions that the design would have to cater for: we call these '*details*' because they show very detailed design arrangements at the micro level – for example a staircase handrail – as opposed to very macro level information such as the overall elevation of a building. Preparing '*details*' is an essential part of an architect's work. Most details will repeat regularly throughout the building: these are commonly referred to as '*standard*' or '*typical*' details. Others will deal with less common situations: they are often referred to as '*specials*' or in cases where they are unique, '*one-off details*'.

3.7.2 Each detail is normally given a reference code. Identifying and coding all the typical details and all the special details is again an essential part of our work. Architects typically prepare a list of such details through careful examination of their larger scale drawings: plans, elevations and sections.

3.7.3 This is often called a schedule of details. With this task completed an architect will ensure that a detailed and code compliant design solution is prepared for every single case. In preparing the indicative approach I will show below how this is typically done. In doing so I will focus exclusively on Floors 4 to 23, which is the part of the building to which this section of my report applies.

3.7.4 In order to do this, I will prepare a series of basic diagrams which will show:

a) A typical overall floor plan with columns referenced and north sign noted for orientation purposes;

b) The range of window conditions to be found on each floor; and

c) The complete elevations for each of the four facades.

3.7.5 The floor plans throughout floors 4 to 23 repeat for every one of those floors. The typical plan arrangement is shown in the diagram below. (For convenience and consistency, I have adopted the same orientation as used generally within Dr Lane's Phase 1 report and I have adopted the same column referencing).

3.7.6 Each floor contains six flats, as shown at Figure 3.5 below:

- 4 x two-bedroom flats

- 2 x one-bedroom flats

Except for *'handing'* the 4 two-bedroom flats and the 2 one-bedroom flats are in each case identical.

(Note: *'handing'* means that a flat is identical albeit a *'mirror'* image).

Determining how many window details will be required: assessing the range of window conditions to be found on each floor and across the building and identifying the need for cavity barriers around window openings

3.7.7 The windows within the flats comprise a *'Ribbon Fenestration'* arrangement whereby a series of window frames are connected to form a continuous line. In the case of Grenfell Tower these run continuously between the main columns, albeit some frames were infilled with window infill/insulated panels as opposed to double glazing. This occurred where the Ribbon Fenestration passes across internal partitions and within the kitchens where the extract fans were located.

3.7.8 At Figure 11.8 on page 11-35 of her report Dr Lane shows 3 separate examples of what she describes as *'typical bays'* {BLAS0000011}. A *'bay'* in this context is a continuous series of aluminium window frames (some with window infill/insulated panels) which are connected together to run between two columns.

3.7.9 Using a similar approach, I consider below the range of different bay types that an architect would need to consider in terms of preparing details for the over-cladding with respect to each of floors 4 to 23. As Dr Lane reports, there are three basic bay types which she denotes as Type A, B and C. I have adopted these designations but, as shown on the plan below I have added a fourth designation: Type D. Taking any floor these are shown and described in the illustrations below:

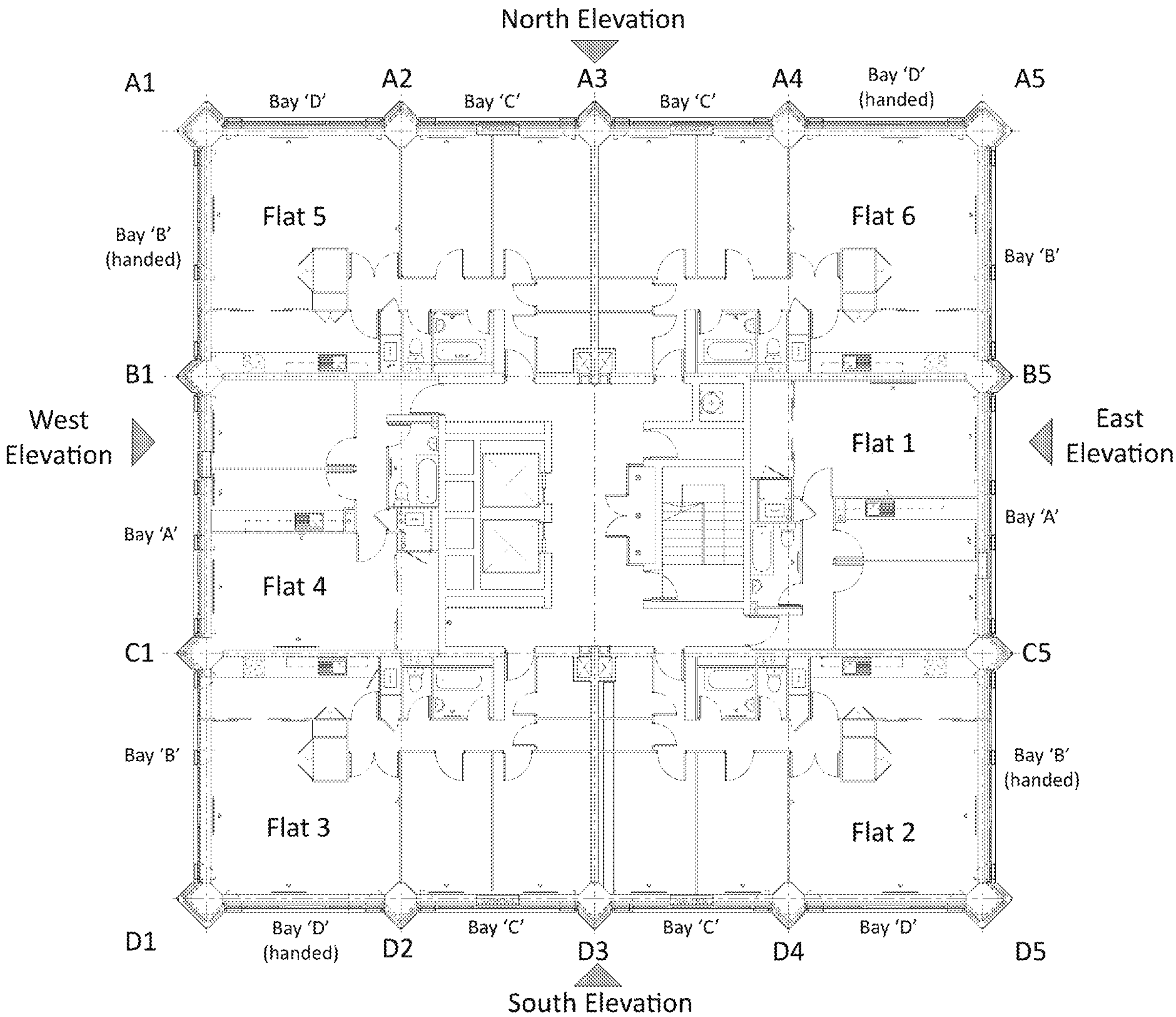

Figure 3.5: General arrangement plan of residential floor

(Diagram produced using Studio E drawing 1279 (04) 105 00) {SEA00010474}

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3.7.10 **Bay Type A:**

- 2 No (identical but handed):
- 1 bay west elevation between columns B1/C1; 1 bay east elevation between columns C5/B5
- TOTAL NUMBER: 2 x 20 floors = 40

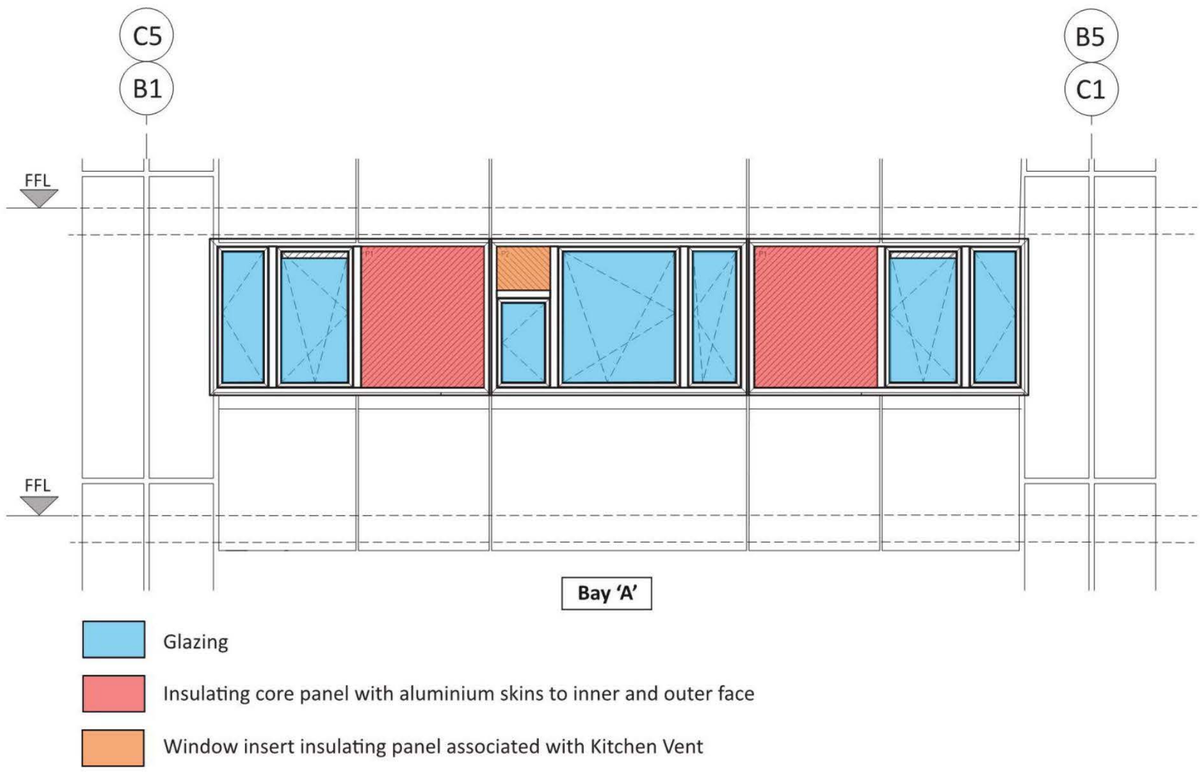

Figure 3.6: Typical elevation bay '*A*'.
(Diagram produced using Harley Drawing C1059-200-I) {HAR00008581}

(Note: these equate to '*Typical Bay East and West Elevations (1/2)*' on Figure 11.8 of Dr Lane's report) {BLAS0000011}

3.7.11 **Bay Type B:**

- 4 No (identical but handed):
- 2 bays west elevation between columns A1/B1 and C1/D1; 2 bays west elevation between columns D5/C5 and B5/A5
- TOTAL NUMBER: 4 x 20 floors = 80

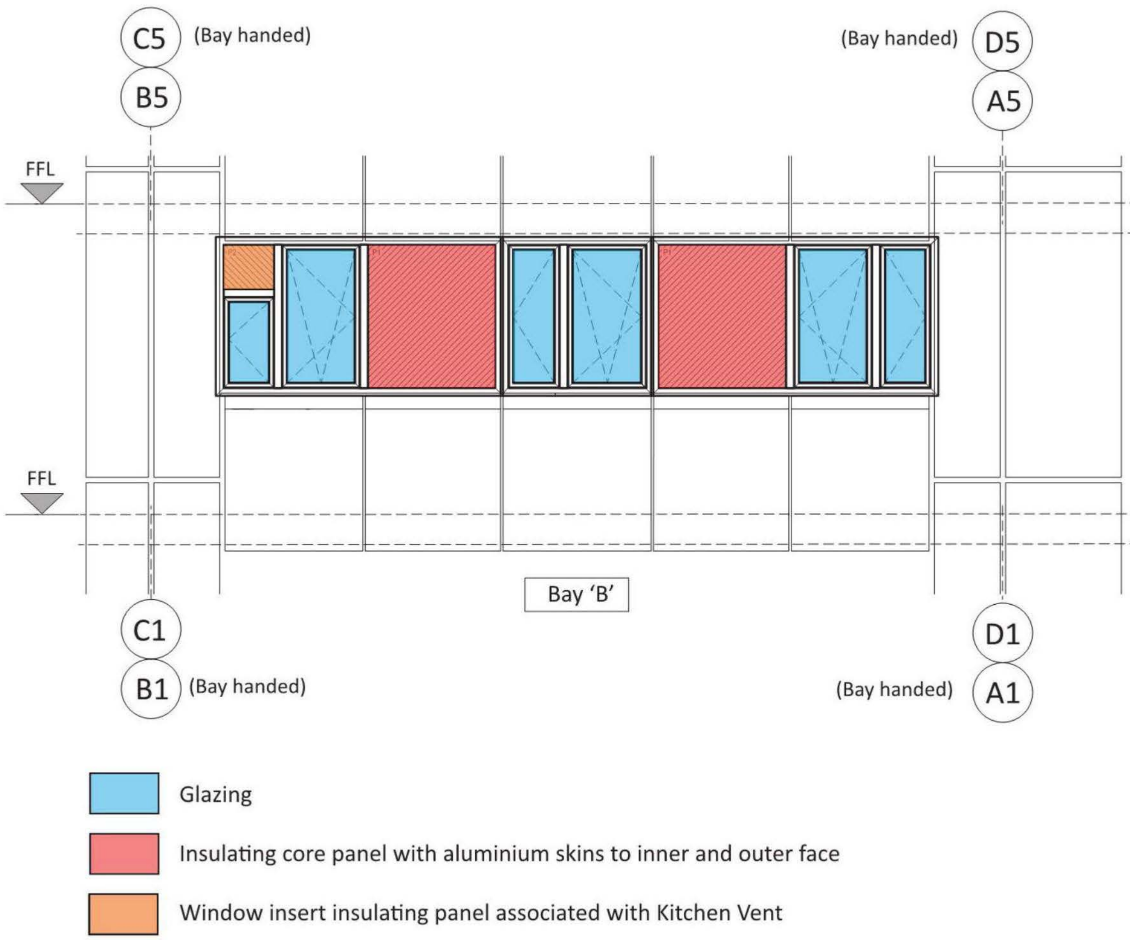

Figure 3.7: Typical elevation bay '*B*'
(Diagram produced using Harley Drawing C1059-201-D) {HAR00008886}

(Note: these equate to '*Typical Bay East and West Elevations (2/2)*' on Figure 11.8 of Dr Lane's report) {BLAS0000011}

3.7.12 **Bay Type C:**

a) 4 No (identical but handed):

- 2 bays north elevation between columns, A2/A3 and A3/A4 ; 2 bays south elevation between columns , D2/D3 and D3/D4

b) TOTAL NUMBER: 4 x 20 floors = 80

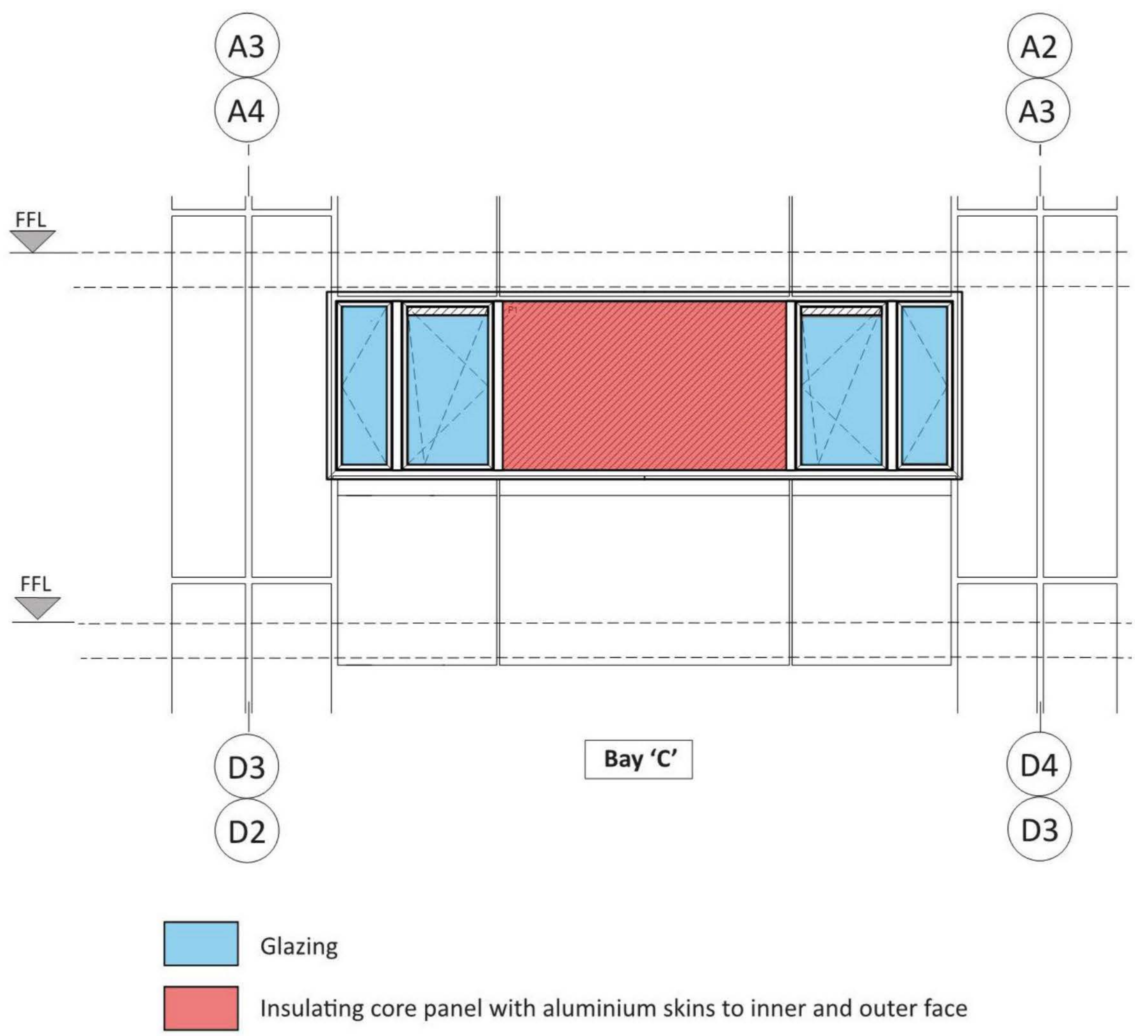

Figure 3.8: Typical elevation bay *'C'*
(Diagram produced using Harley Drawing C1059-202-C) {HAR00009729}

(Note: these equate to '*Typical Bay South Elevation*' on Figure 11.8 of Dr Lane's report albeit I believe this also applies to the North Elevation) {BLAS0000011}.

3.7.13 **Bay Type D:**

a) 4 No (identical but handed):

- 2 bays north elevation between columns, A1/ A2 and A4/A5 ; 2 bays south elevation between columns , D1/D2 and D4/D5

b) TOTAL NUMBER: 4 x 20 floors = 80

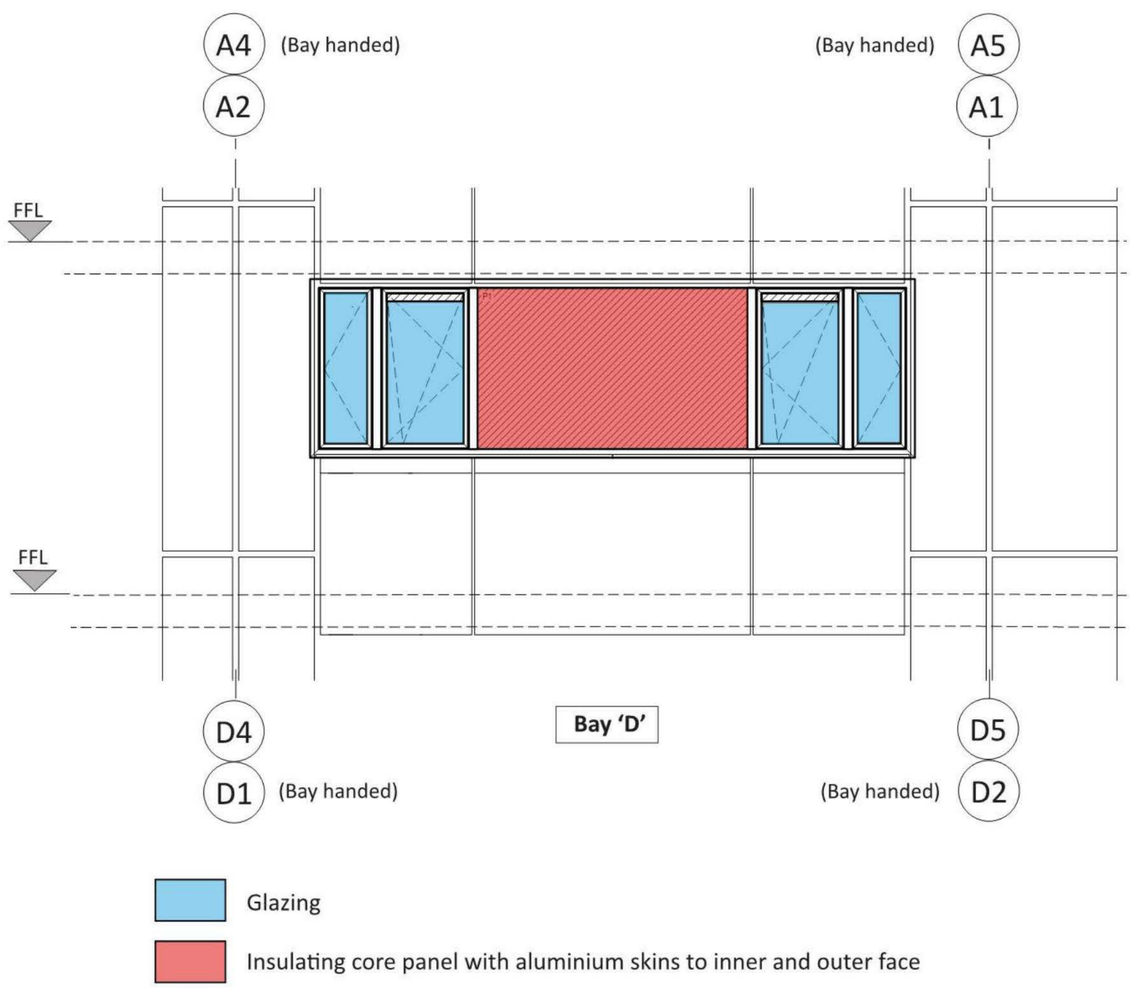

Figure 3.9: Typical elevation bay '*D*'
(Diagram produced using Harley Drawing C1059-202-C) {HAR00009729}

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3.7.14 The four diagrams below show these bays incorporated into the north, west, east and south elevations for a typical floor, coded to show in each case the bay type (that is *'Type A'*, *'Type B'*, *'Type C'* and *'Type D'*).

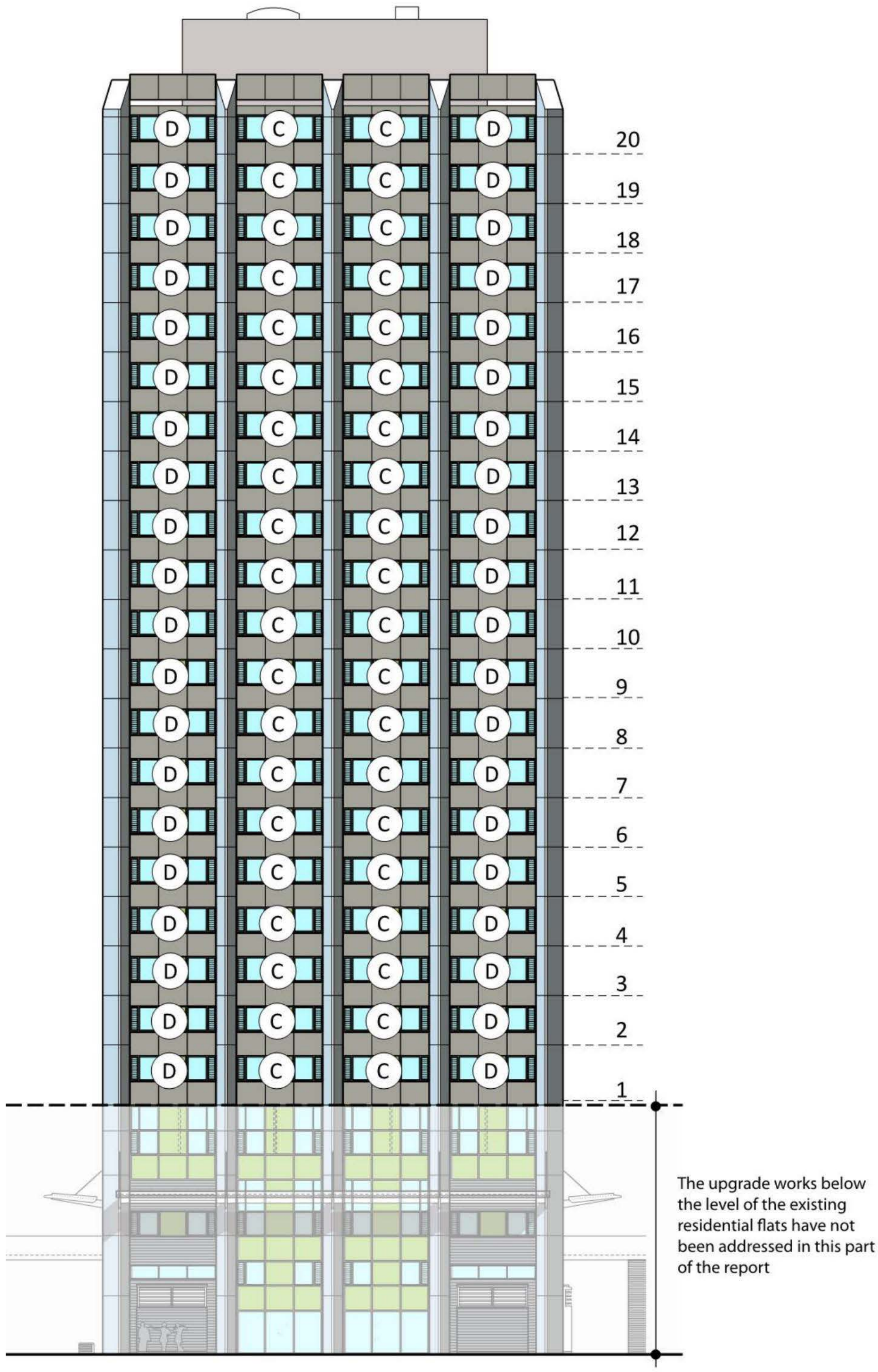


Figure 3.10: North elevation with bay types

(Diagram produced using Studio E Drawing 1279-RE300 Rev 01) {SEA00001647}

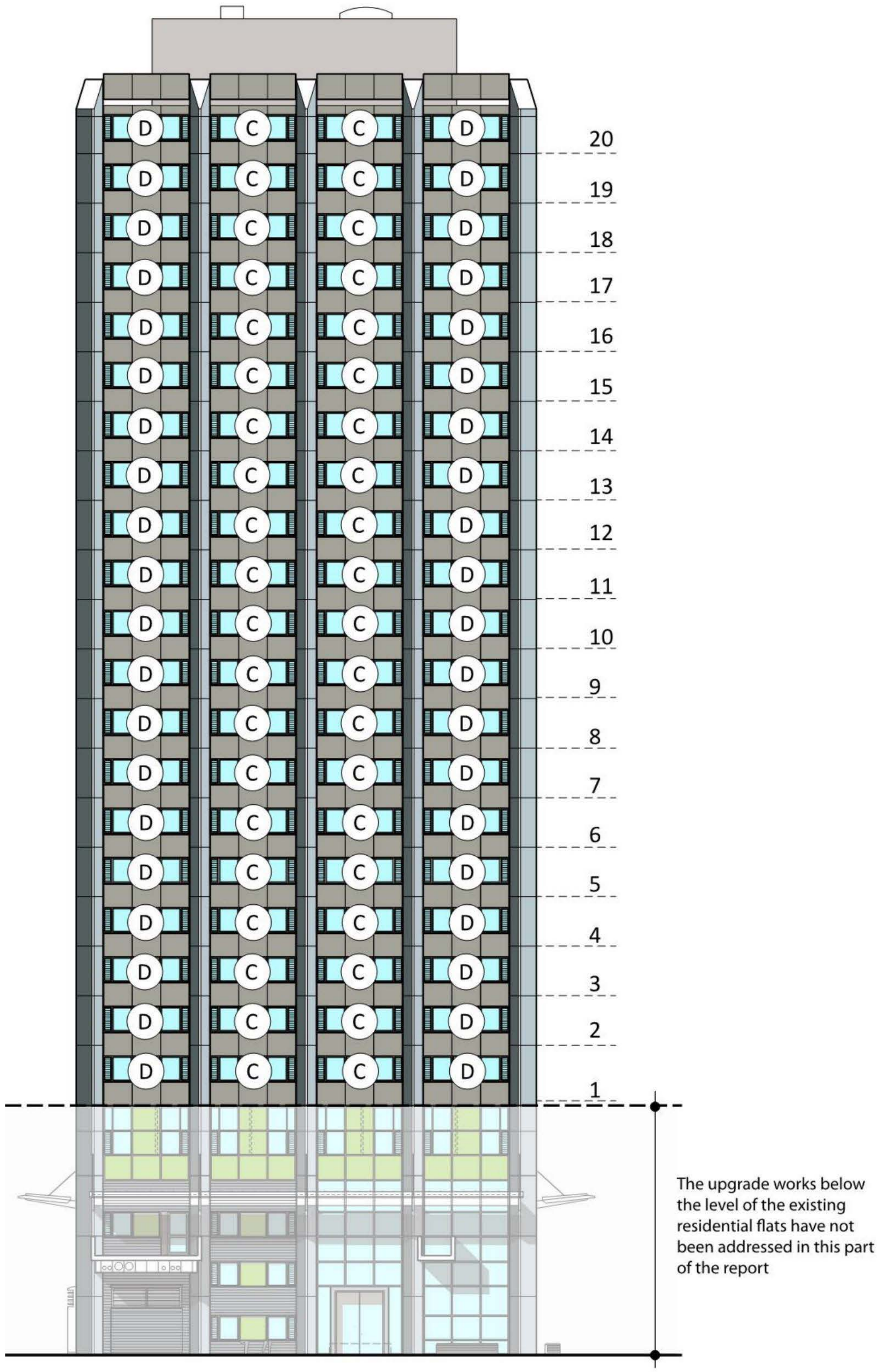


Figure 3.11: South elevation with bay types

(Diagram produced using Studio E Drawing 1279-RE300 Rev 01) {SEA00001647}

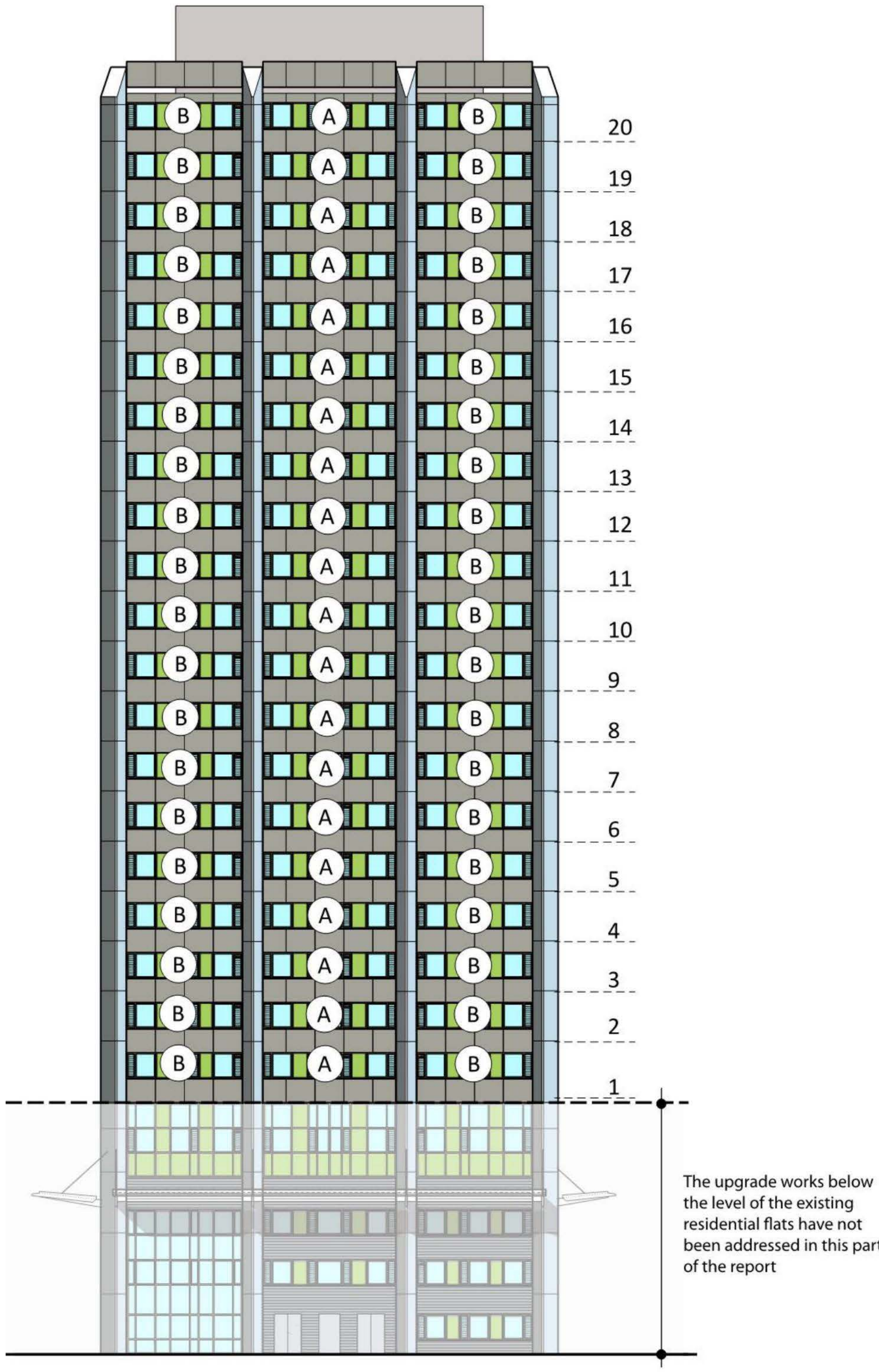


Figure 3.12: East elevation with bay types
(Diagram produced using Studio E Drawing 1279-RE300 Rev 01) {SEA00001647}

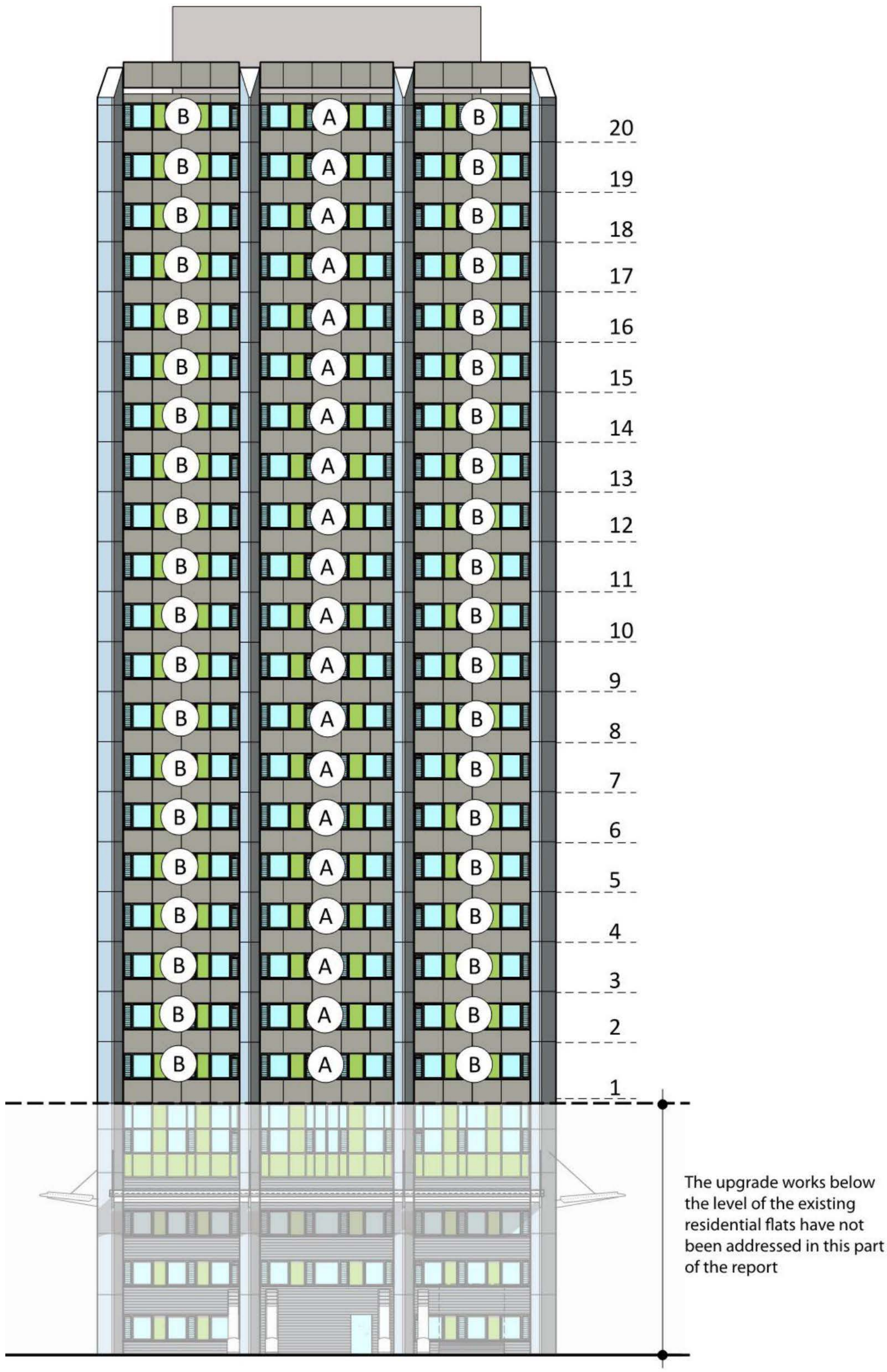


Figure 3.13: West elevation with bay types

(Diagram produced using Studio E Drawing 1279-RE300 Rev 01) {SEA00001647}

3.7.15 My analysis confirms that, in terms of details to the window cladding interface (and indeed to the interface of the windows with the original building), only three separate conditions exist: they are, as previously identified, the detail at the window side at the interface with columns (jamb detail in '*plan*') which I shall call Detail 1; the detail at the window top (head detail in section at the interface with the floor slabs above) which I shall call Detail 3; and the junction at the window sill at the interface with the concrete spandrel panels below (sill detail in '*section*') which I shall call Detail 2. These three positions are shown below using Bay Type A as the example albeit the details also apply in exactly the same way on all of floors 4 to 23 to Bay Type B, Bay Type C and Bay Type D.

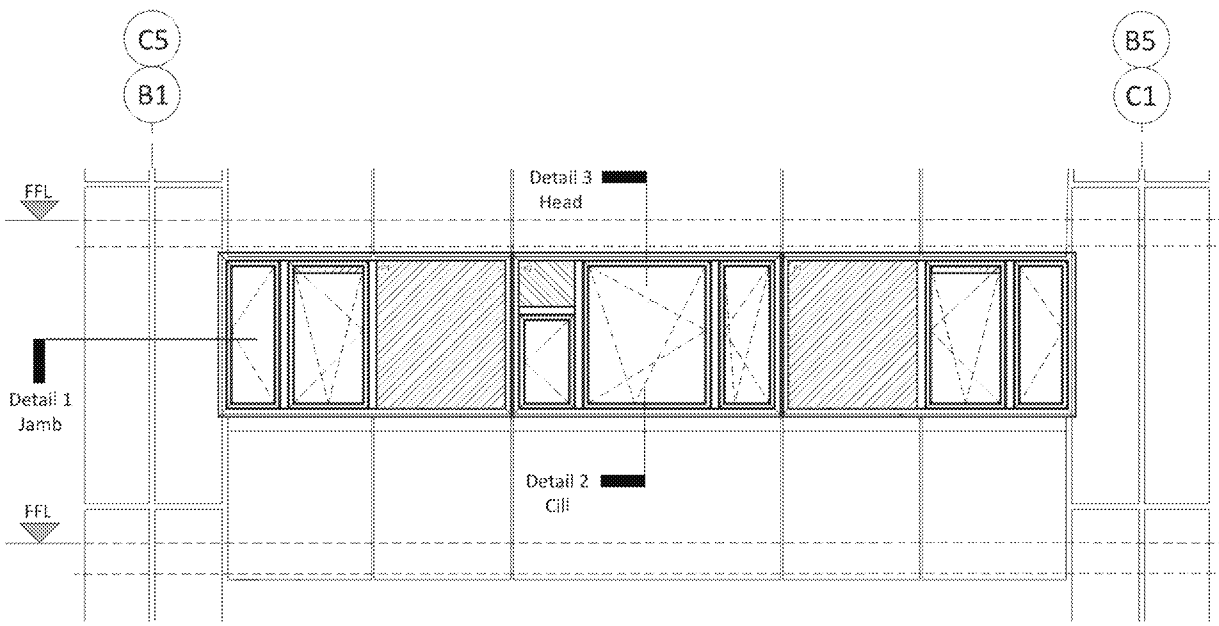


Figure 3.14: Typical elevation 'bay' with key detail locations
(Diagram produced using Harley Drawing C1059-200-I) {HAR00008581}

3.7.16 As noted above, we call these '*typical details*' and an architect normally describes the construction of a building design through a series of '*typical*' details that show repeating arrangements and '*special*' details that show infrequent or non-repeating conditions. These are shown in terms of location on elevations and plans.

3.7.17 Below is an elevation of Grenfell Tower marked up randomly to show typical positions for each of the three different details that must be designed for the jamb, head and sill conditions. The point is that once the principles for each of these details (Detail 1, Detail 2 and Detail 3) is resolved, that detail can be applied in all similar cases across all four façades. In this case, there appear to be no '*special details*'. Accordingly, what may at first appear to be a huge and complex task is, in architectural terms, quite simple. Three standard details will resolve the window/cladding/original structure relationship for all four facades of the entire over-cladding between Floor 4 and Floor 23.

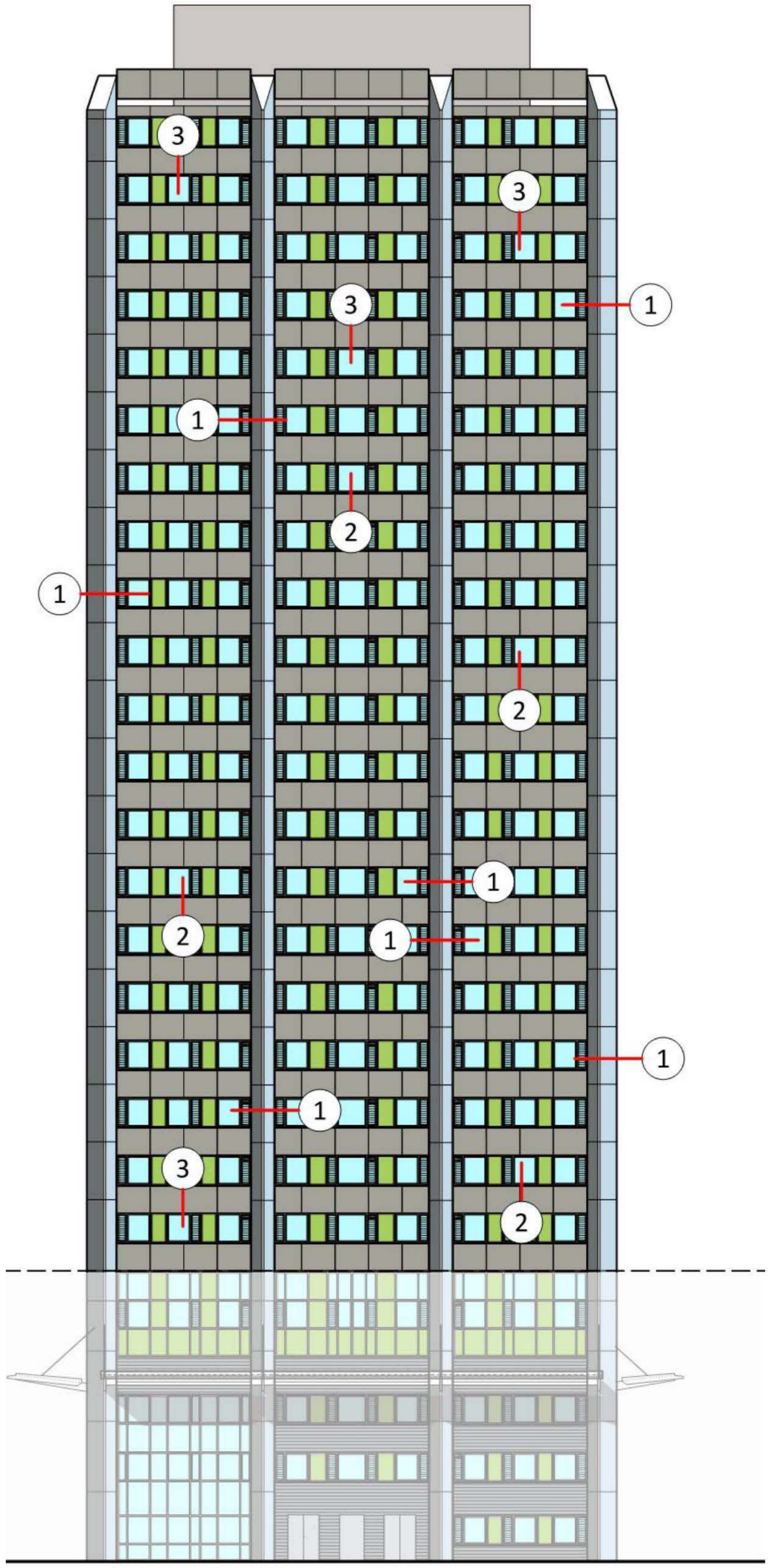


Figure 3.15: Typical elevation with examples of typical detail 1, 2 and 3 locations indicated
(Diagram produced using Studio E Drawing 1279-RE300 Rev 01) {SEA00001647}

3.7.18 The above referenced drawings (i.e. the typical floor plan; the four Bay Types (A, B C and D), and the north, west, east and south elevations for a typical floor) would be supplemented by elevations at 1:200 scale representing the entire façade on all four elevations. These would together be used as a basic '*platform*' from which an architect would typically operate in planning the detailed investigation that I next undertake into how the indicative approach can be developed in a way that meets the requirements of the Building Regulations and the guidance in ADB.

3.7.19 As a result of this investigation I am confident that the essential window jamb/column, head/slab and sill/spandrel arrangements will be consistent throughout: that is, the same three details will suffice for all conditions to floors 4 to 23 across all four facades. When resolved, these details should meet the guidance given under ADB2 paragraph 9.3: *'Cavity barriers should be provided to close the edges of cavities, including around openings.'* This then will deal with the requirements that the passage of fire *into* the cavity formed by the new rainscreen is inhibited. (Under Table A1 of Appendix A (Item 15) ADB2 offers guidance for all cavity barriers to be provided with a 30/15 rating (integrity /insulation). Manufacturers offer better performance ratings commonly in excess of this minimum performance: 30/30 and 60/30 are commonly available).

3.7.20 On the following four diagrams (Bay A, Bay B, Bay C and Bay D) I therefore next indicate (in yellow) where cavity barriers should be positioned *'close to the edges of cavities including around windows'* in order to meet the guidance of ADB2 paragraph 9.3.

3.7.21 Next, on the same four diagrams, I show (in red) where vertical cavity barriers are required to meet the guidance of paragraph 9.3a with respect to compartment wall/external wall junctions.

3.7.22 Finally, on the same four diagrams, I show (in green) where horizontal cavity barriers are required to meet the guidance of paragraph 9.3a with respect to compartment floor /external wall junctions.

3.7.23 The latter two cavity barriers (that is to align with compartment floors and walls) are intended to inhibit the passage of fire *within* each cavity zone (that is to inhibit the passage of any fire within one cavity zone passing into the next cavity zone) as opposed to cavity barriers 'close to the edges' around window openings that are intended to inhibit the passage of fire *into* a cavity.

3.7.24 This distinction is important and a clear understanding of the way they will work together – that is the inter-relationship of cavity barriers which inhibit the ingress of fire *into* cavities and cavity barriers that inhibit the progress of fire *within* cavities – is essential in designing the cavity barrier strategy that will meet the guidance given under ADB2.

3.7.25 It is notable in this respect that '*flats*' are exempt from the requirements of Table 13 as referred to under paragraphs 9.8 and 9.9 of ADB2. (See Table D1 of ADB2 Appendix D). In my view that is a shortfall of the ADB2 guidance as I believe that flats should not be exempt from the 20 metre rule in terms of the maximum permissible horizontal distance between vertical cavity barriers. I have, however, applied the guidance as given in ADB2 in this respect because in my view it would have been reasonable for Studio E to rely on ADB2.

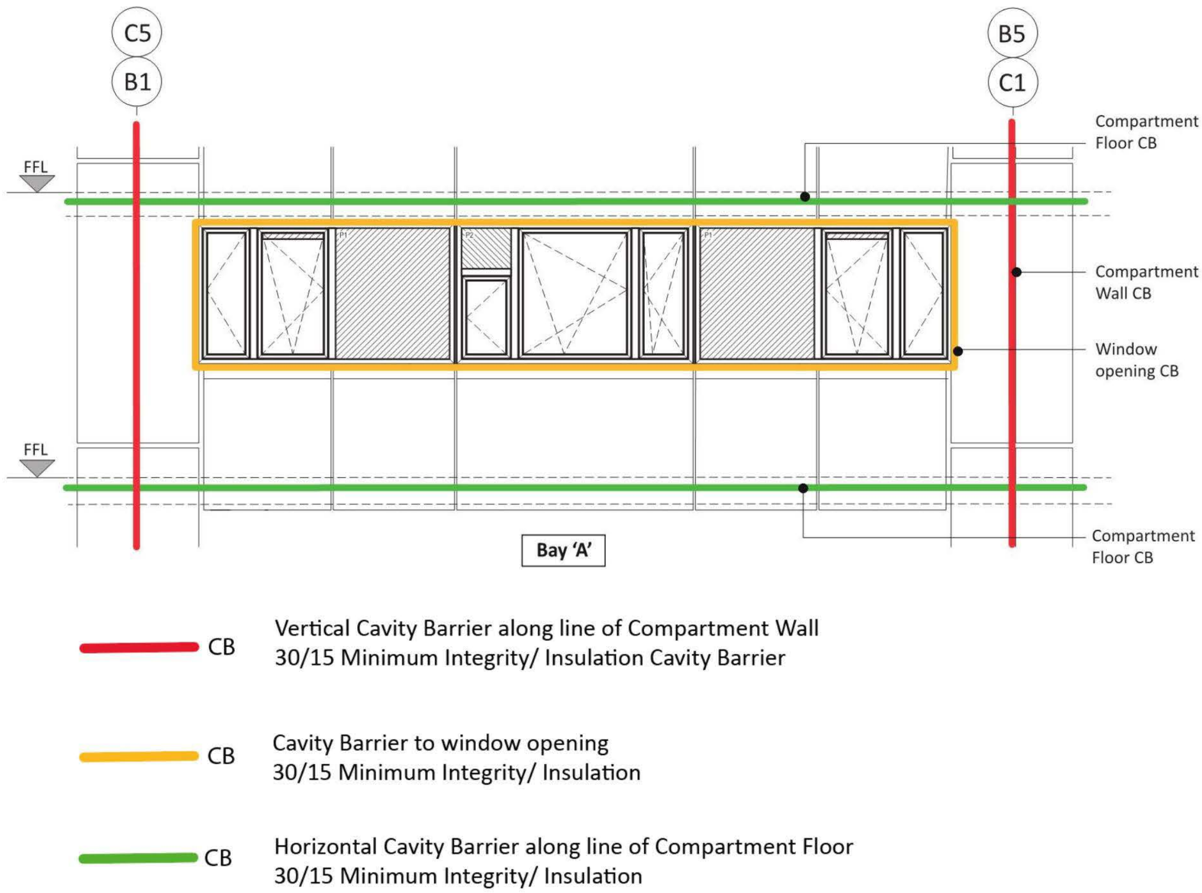


Figure 3.16: Typical elevation bay '*A*' with cavity barriers

(Diagram produced using Harley Drawing C1059-200-I) {HAR00008581}

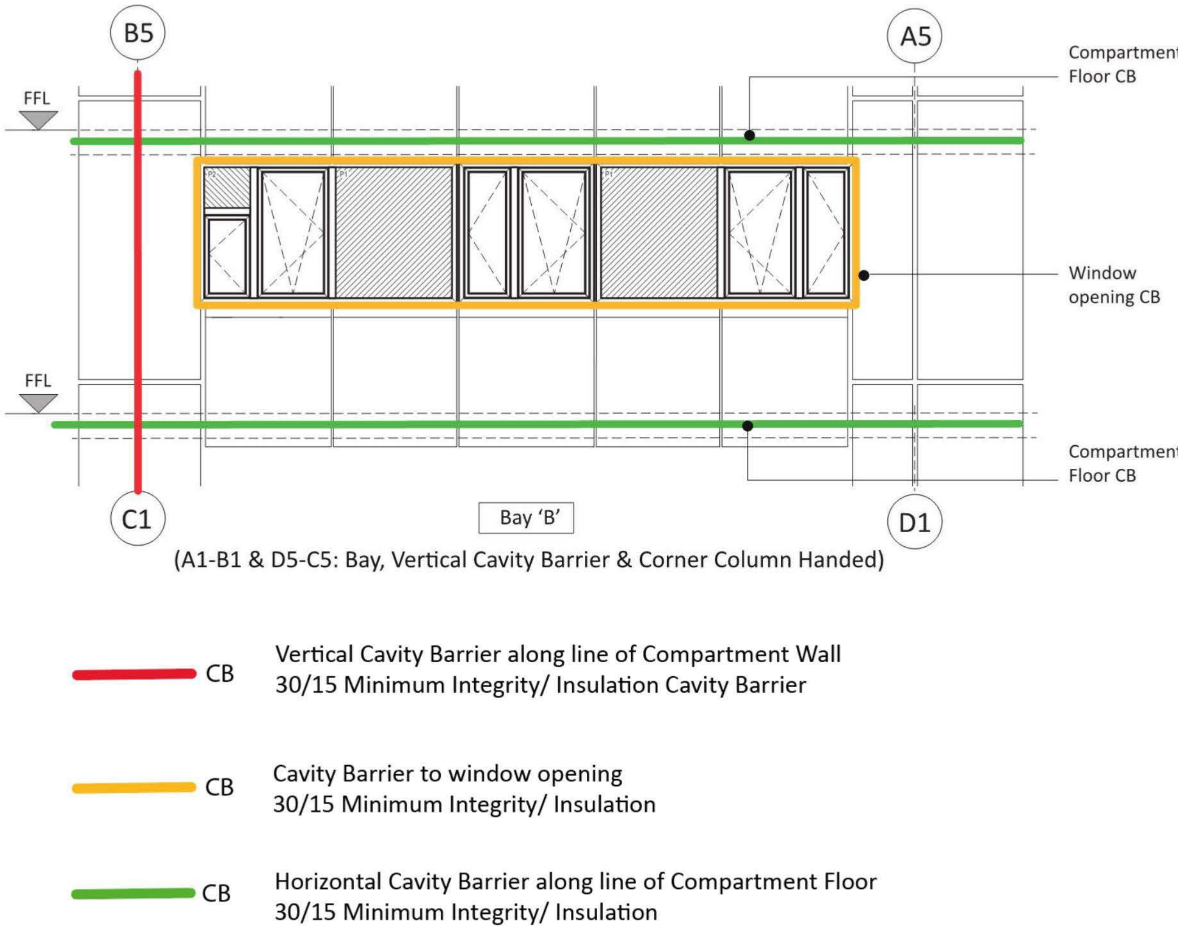
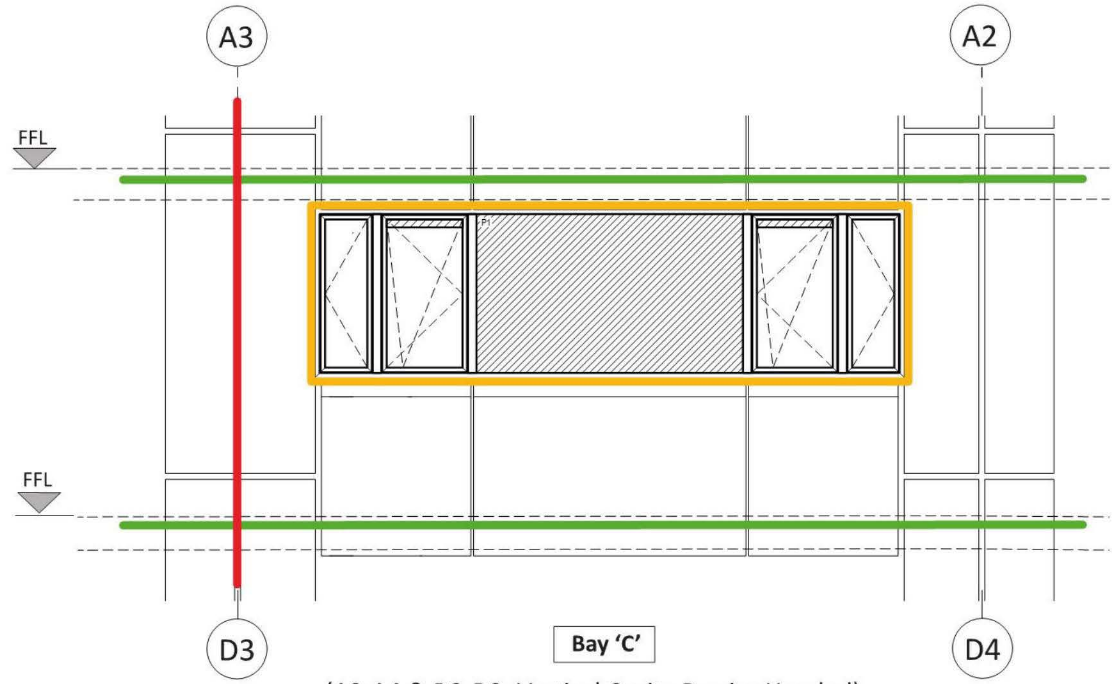


Figure 3.17: Typical elevation bay '*B*' with cavity barriers

(Diagram produced using Harley Drawing C1059-201-D) {HAR00008886}



(A3-A4 & D2-D3: Vertical Cavity Barrier Handed)

CB — Vertical Cavity Barrier along line of Compartment Wall
30/15 Minimum Integrity/ Insulation Cavity Barrier

CB — Cavity Barrier to window opening
30/15 Minimum Integrity/ Insulation

CB — Horizontal Cavity Barrier along line of Compartment Floor
30/15 Minimum Integrity/ Insulation

Figure 3.18: Typical elevation bay '*C*' with cavity barriers

(Diagram produced using Harley Drawing C1059-202-C) {HAR00009729}

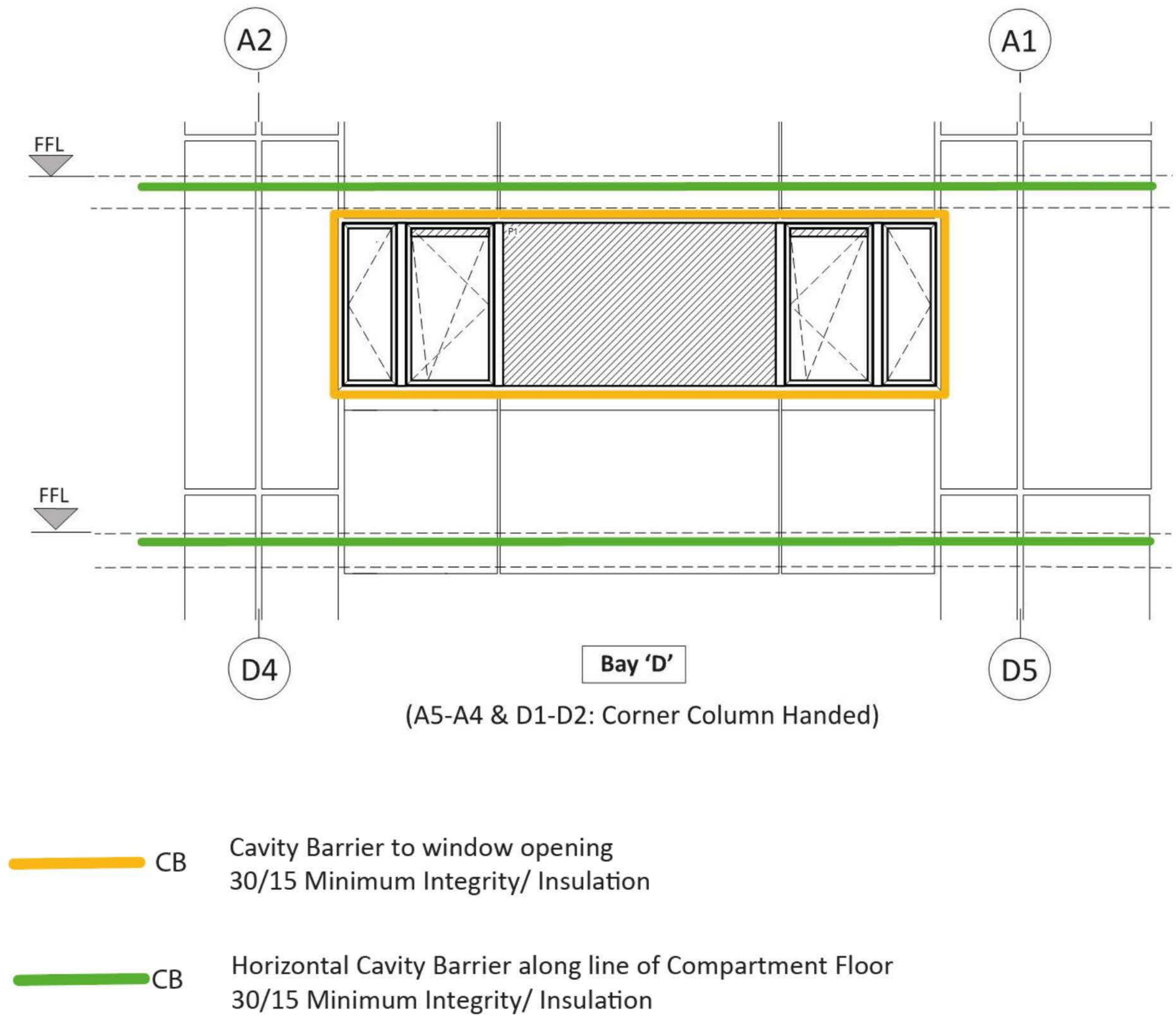


Figure 3.19: Typical elevation bay '*D*' with cavity barriers

(Diagram produced using Harley Drawing C1059-202-C) {HAR00009729}

Identifying where other cavity barriers will be required

3.7.26 The cavity barrier at the head/Crown has a unique and important function in maintaining compartmentation between vertical cavity barriers as they reach the top of the building. I have also been advised that its purpose is also intended to seal the top of the cavity in the event of fire to mitigate against, or inhibit the tendency of the cavity to produce a vertical venting or '*chimney*' effect which would otherwise intensify the fire.

3.7.27 The diagrams below show these provisions relating to cavity barriers applied to the top two floors of the building thus also meeting the guidance under ADB2 Diagram 33 for the closing of the cavity at the head of the building immediately below the Crown.

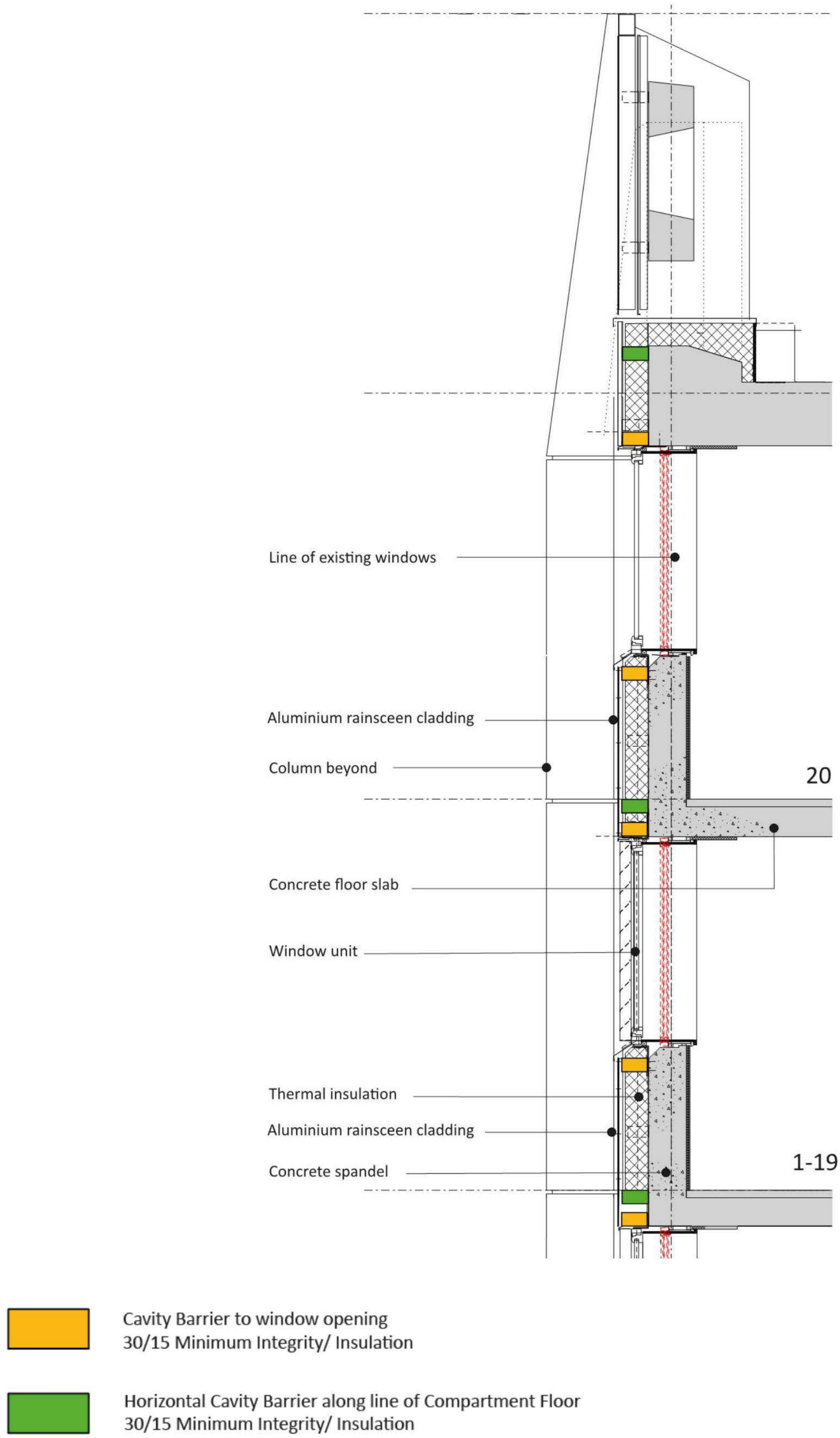
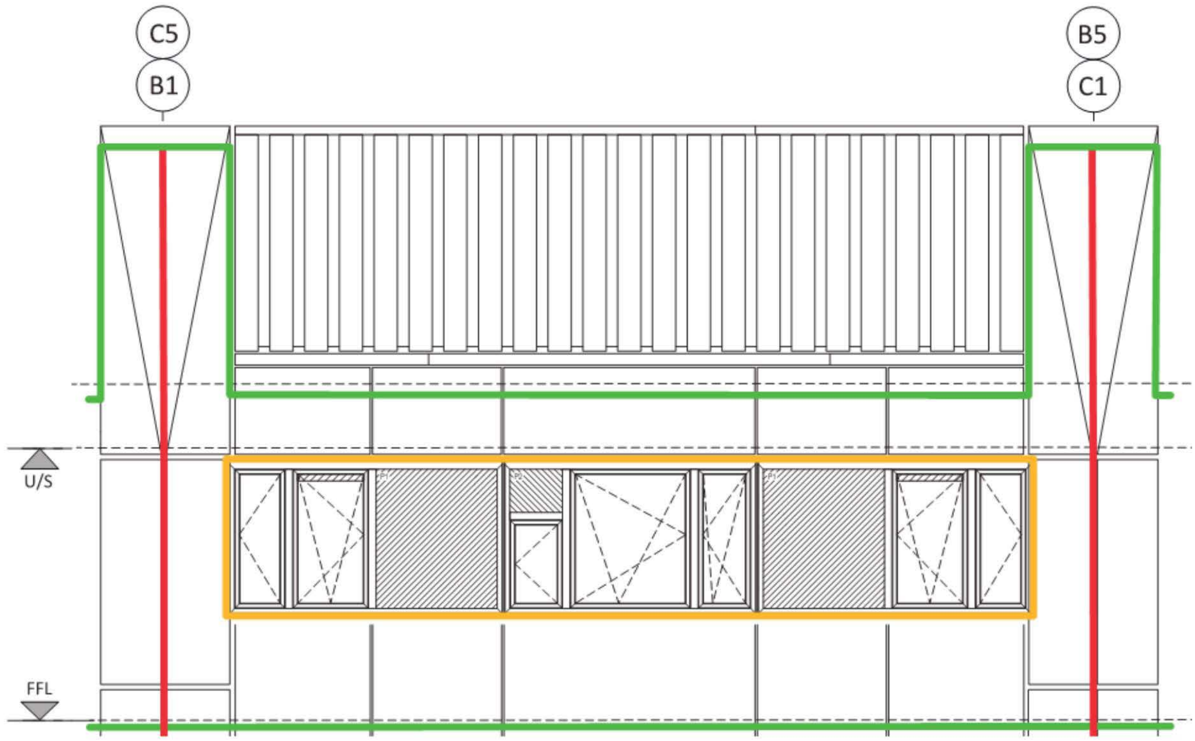


Figure 3.20: Typical section through part of envelope including the Crown

(Diagram produced using Studio E Drawing 1279 (06) 120 00) {SEA00002551}



CB Vertical Cavity Barrier along line of Compartment Wall
30/15 Minimum Integrity/ Insulation Cavity Barrier

CB Cavity Barrier to window opening
30/15 Minimum Integrity/ Insulation

CB Cavity Barrier along line of Compartment Floor & at head / edge of cladding
30/15 Minimum Integrity/ Insulation

Figure 3.21: Typical bay elevation at the Crown

(Diagram produced using Harley Drawing C1059-216) {HAR00008910}

Developing and illustrating a strategy for positioning cavity barriers

3.7.28 Having determined what is required in terms of cavity barriers at each bay, (that is at the mid-scale of consideration, the '*details*' referred to earlier in this section being at the micro scale) and at the Crown, I next consider the macro scale: that is the entire elevation. In this way an architect would routinely establish a cavity barrier strategy for the entire building which will inform the detailed design work and '*quantities*' in terms of specification that is a key factor in tendering.

3.7.29 First, I give further consideration to those vertical cavity barriers that will be required to align with compartment walls in order to comply with the guidance under ADB2 paragraph 9.3a which calls for cavity barriers *'at the junction between an internal cavity wall… and every compartment wall…'.* As stated, there are six Grid positions (A3, B1, B5, C1, C5 and D3) to which this applies. These will connect with the horizontal (compartment) cavity barriers which will run continuously around the perimeter of each floor and align with the floor-slabs. Care will be required in determining the optimum position on the columns for each these vertical cavity barriers. The following elevations show these cavity barriers in provisional position. I qualify it as '*provisional*' because final determination of the exact position to each column will require further study and consideration.

Figure 3.22: North and South Elevation with Vertical Cavity Barriers along line of Compartment Walls
(Diagram produced using Studio E Drawing 1279 RE300 Rev 01) {SEA00001647}

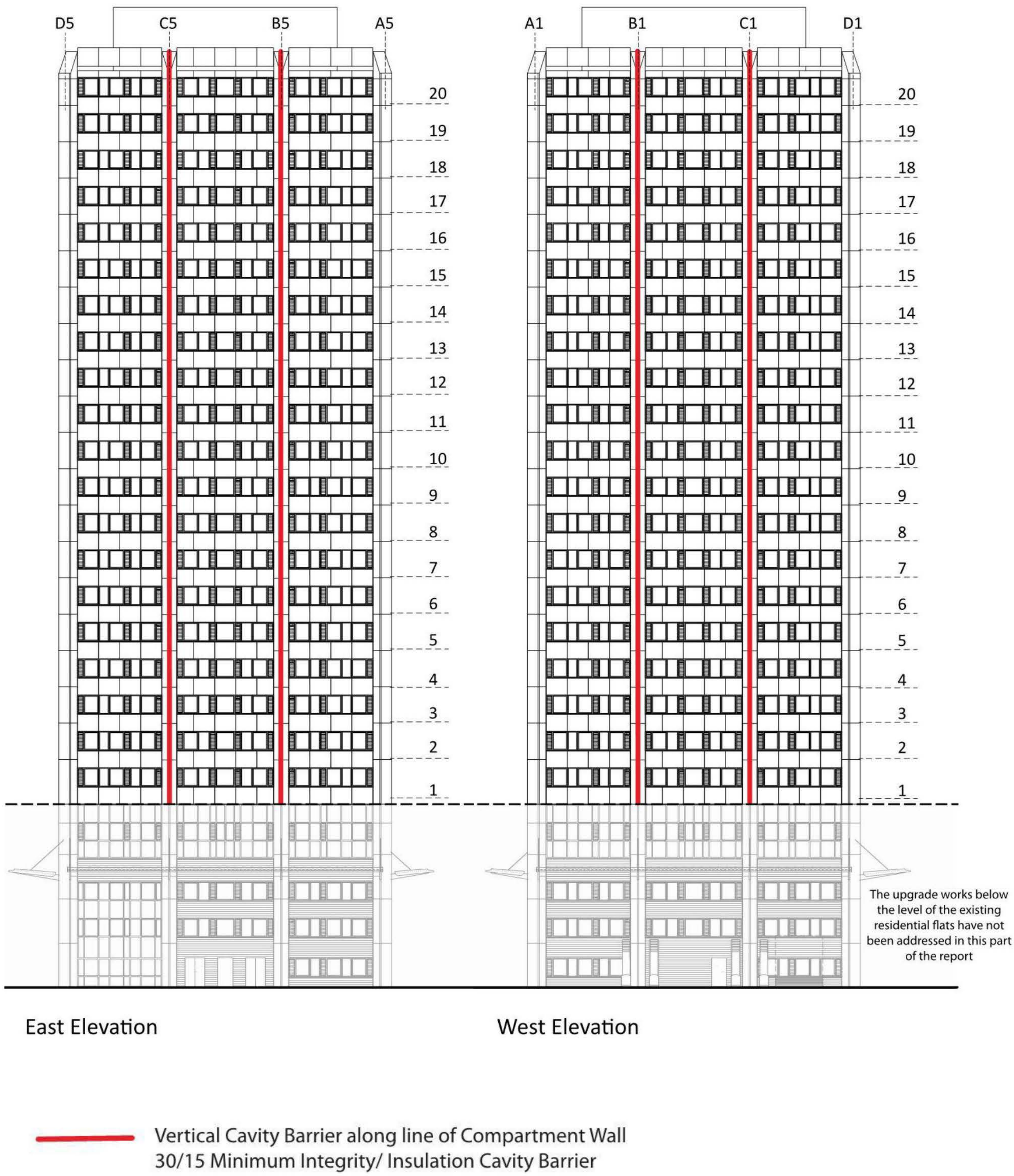


Figure 3.23: East and West Elevation with Vertical Cavity Barriers along line of Compartment Walls
(Diagram produced using Studio E Drawing 1279 RE300 Rev 01) {SEA00001647}

3.7.30 Next, I give further detailed consideration to the horizontal cavity barriers that will be required to align with compartment floors. These are required at every floor level. They will be installed on site **after** the vertical cavity barriers have been securely fitted. They must be '*squarely*' cut to fit very tightly / align closely with the vertical barriers: special tape must be cut and applied at all joints and junctions to maintain the seal that is necessary to inhibit the spread of fire outside any individual cavity and onwards into its '*neighbour*' either to the side or above: there must be no gaps. Special care will be required at the interface with the vertical channels that will support the rainscreen cladding both across spandrel panels and to the column structures.

3.7.31 I have seen no such detailed drawings by Studio E that show details at plan or section with such arrangements resolved and shown, although I acknowledge that their tender specification did describe a requirement that cavity barriers should achieve a continuous and tight fit. I would prefer to see such detailed drawings done pre-novation as part of the tender documentation, but either way Studio E were required to show such information post novation under the terms of their appointment with Rydon.

'*Schedule of Architectural Services*' of the Deed of Appointment {RYD00094228} item 31 required Studio E to: '*...provide further drawings to show sufficient information to construct the project to completion... a) External wall... construction details*'. On that basis Studio E should certainly have developed such details following novation, or, at the very least, ensured that such details were properly shown in a fully resolved form by Harley. Again I have seen no evidence that Studio E addressed this issue following their novation to Rydon.

3.7.32 Harley did do some detailed drawings but appear to have completely failed to understand the complexity of the geometries involved and the implications in compromising the integrity of the horizontal cavity barriers, for example around the columns. This failing is evident on a detail of Harley drawing C1059 - 304 Rev D {HAR00008902} as exhibited below which shows in plan a detail of the cavity barriers meeting at the '*open*' nose of the column. I deal with this in detail in Sections 4 and 5 of my report. Such a failing is surprising in a company that professes specialist knowledge and experience in cladding work.

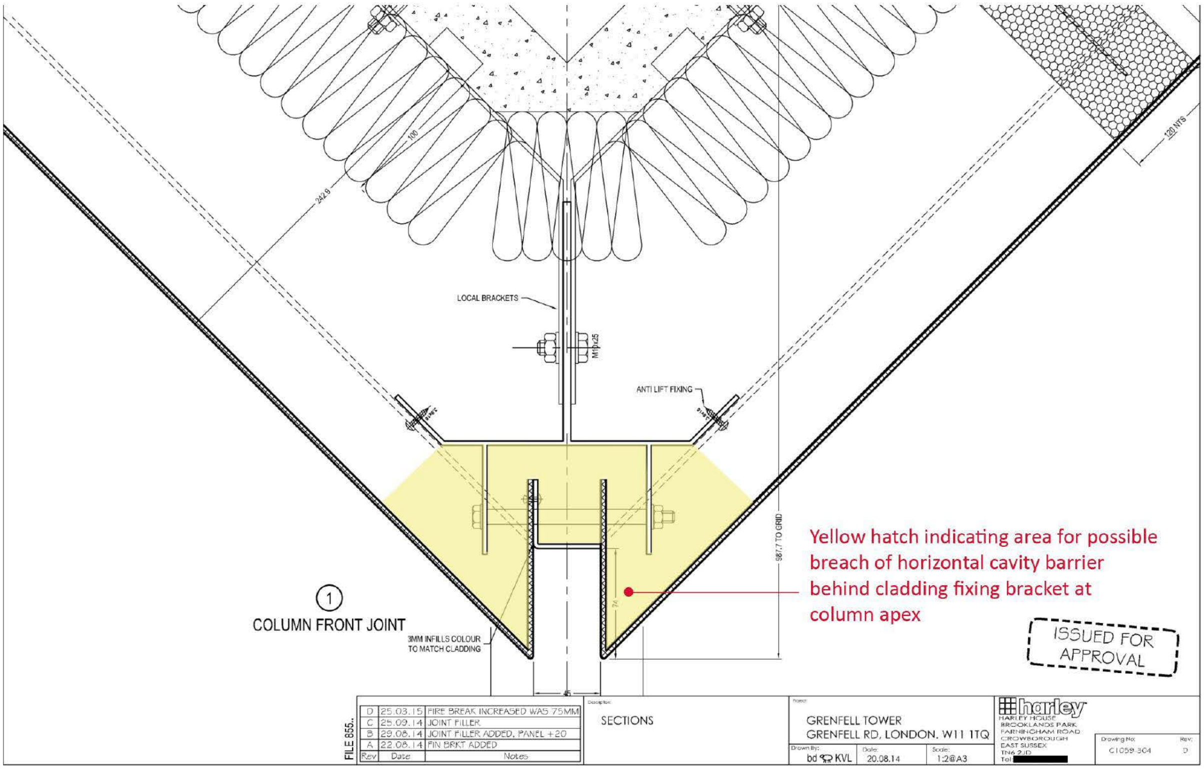


Figure 3.24: Harley Plan Detail at Column Nose C1059-304-D {HAR00008902}

3.7.33 In this respect a comment within Harley's brochure dated September 2013 indicates that Harley claimed to provide an expert service in terms of resolving such issues. I quote from that document below:

'…Harley offer a complete envelope solution. All elements of the façade are designed and installed by Harley with certain specialist services sub-contracted out. This provides clients with a one-stop-shop solution eliminating clashes on site, and takes responsibility for ensuring interface details are properly executed'.

Clearly in this respect, despite such claims, Harley's service was wanting.

3.7.34 I attach herewith a link to a video provided by the manufacturer of the cavity barriers specified for Grenfell Tower. It shows an installation 'step by step' and should assist the reader in understanding the process involved in typical installation of cavity barriers. https://youtu.be/E4fc2OnulD8

3.7.35 All this is *'brought together'* and illustrated at macro scale in the drawings of the kind shown below for both the four elevations and the plan of one complete typical floor (I use the term '*macro*' because I do not with these general arrangement elevations for cavity barrier strategy show the cavity barriers around window openings or to the Crown):

Figure 3.25: North and South Elevations with Vertical Cavity Barriers along the line of Compartment Walls and with Horizontal Cavity Barriers along the line of Compartment Floors

(Diagram produced using Studio E Drawing 1279 RE300 Rev 01) {SEA00001647}

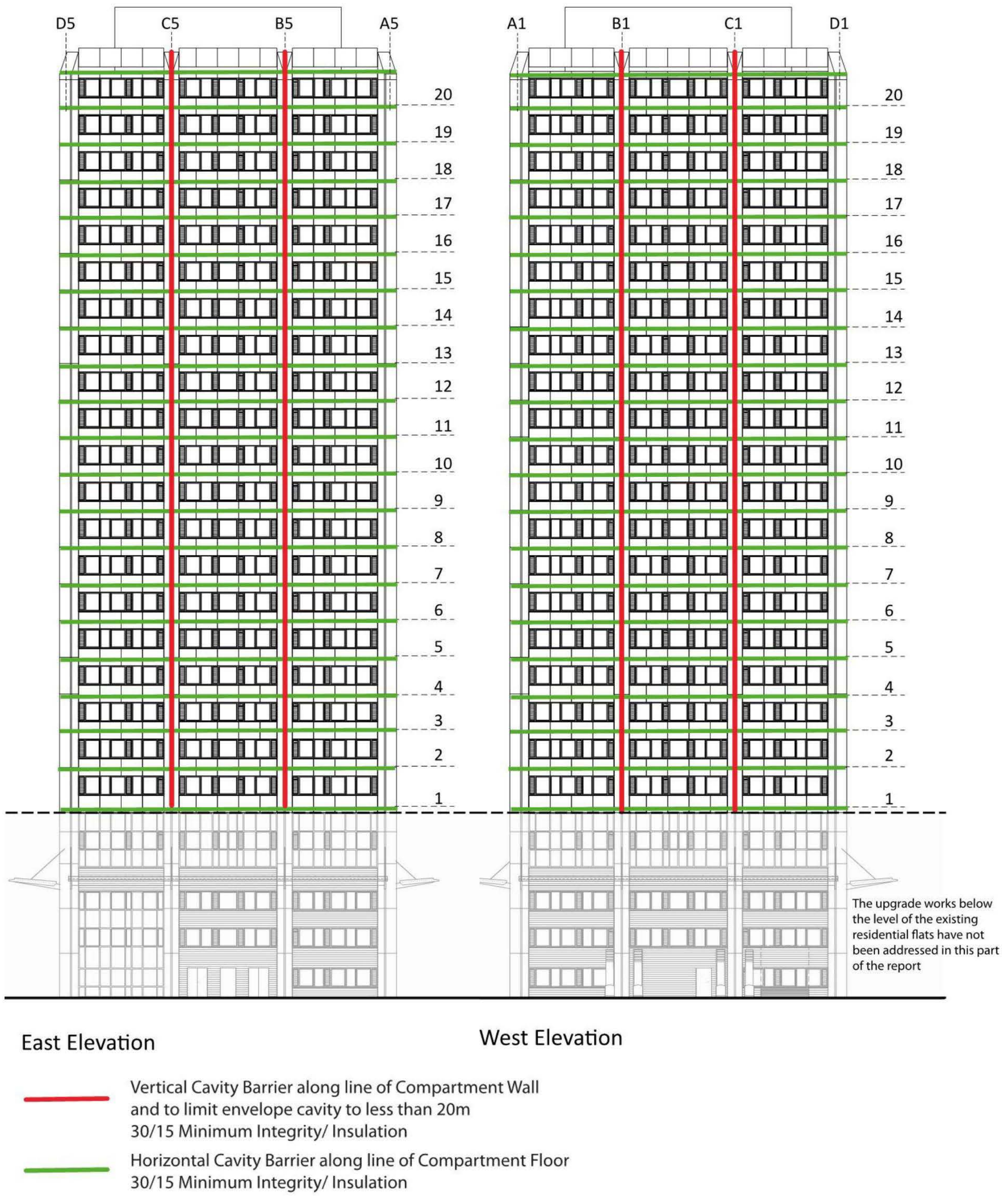
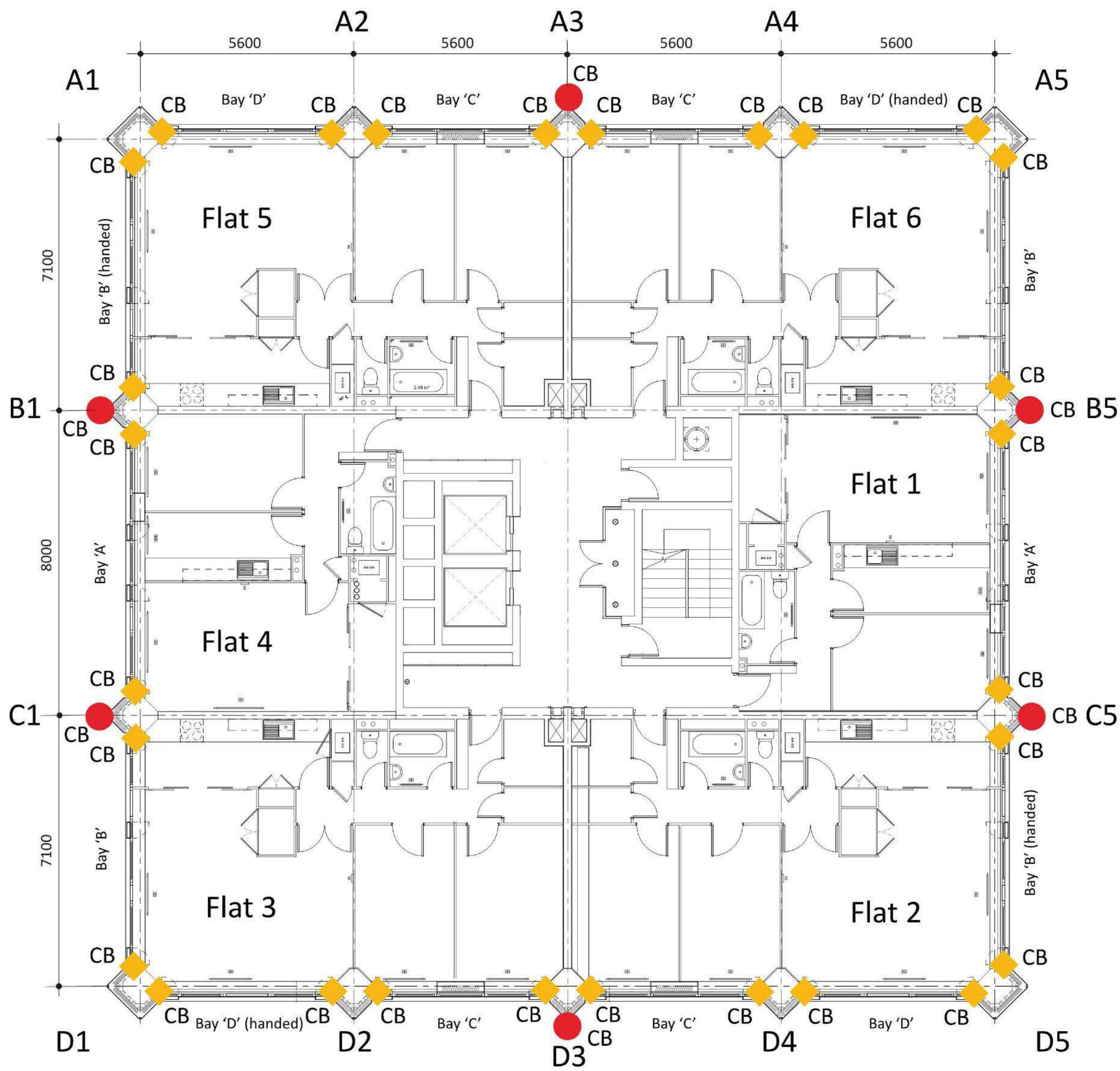


Figure 3.26: East and West Elevations with Vertical Cavity Barriers along the line of Compartment Walls and with Horizontal Cavity Barriers along the line of Compartment Floors

(Diagram produced using Studio E Drawing 1279 RE300 Rev 01) {SEA00001647}



CB Vertical rainscreen cavity barrier along line of internal compartment walls

CB Vertical cavity barrier at the window jamb

Figure 3.27: General arrangement plan of residential floor with vertical cavity barriers noted

(Diagram produced using Studio E drawing 1279 (04) 105 00) {SEA00010474}

3.7.36 This completes a process through which, as the drawings progressively show, all four facades have been divided into a series of '*zones*', each zone comprising one or three window bays (between columns that align with compartment walls) and one complete storey between floor slabs. The window bays are classed as '*openings*' within the '*zones*' around which is provided a continuous cavity barrier, the purpose of which, I repeat, is to inhibit the passage of fire (most probably from within the flat, but possibly from outside) into that cavity (as described at paragraph 9.3 of ADB2) . Each zone is thus '*contained*' within a perimeter of continuous cavity barriers the purpose of which is to inhibit the passage of any fire *out of that cavity zone*, or *into it* from an adjoining zone. I embolden '*continuous*' in each case because it is critical that no gaps occur in terms of the continuity of the cavity barriers. In this respect the SideRise video referred to above shows the joints/junctions (for example between consecutive cavity barriers, horizontal and vertical cavity barriers, and cavity barriers and adjoining elements such as the vertical cladding rails) being cut and formed tightly and then sealed with tape.

3.7.37 This then completes the review and development of a cavity barrier strategy for each façade at the '*macro*' and midi-scale. The next stage in the process that an architect would typically undertake is to prepare indicative '*details*' showing the cavity barriers which must be developed in compliance with the guidance of ADB2.

3.8 Addressing the Principal Design Challenges

3.8.1 Having established the range of conditions that must be dealt with in terms of detailed design, I therefore next turn my attention principally to technical issues in terms of both buildability and code compliance.

3.8.2 This essentially involves an iterative process in which an architect leads the consultant design team through a series of repeating cycles of '*proposing, testing and revising*' all of which are illustrated through design sketches, diagrams and notes. This process routinely considers a wide range of issues that include construction costs, buildability, Building Regulations, Planning Law, maintenance and running costs, and functionality in terms of user requirements and aesthetics.

3.8.3 Through this process, design and specification constraints and requirements are identified and possible solutions are reviewed and refined in the preparation of a coordinated design solution.

3.8.4 With the type and thickness of insulation required within the cavity created by the proposed new rainscreen already determined, having selected the product to be utilised as the outer '*skin*' of the rainscreen cladding system, and having determined the strategy with respect to positioning the cavity barriers, I will now set out the next steps that an architect would typically take in terms of:

a) Selecting / specifying the remainder of the materials and components that will be required to complete the installation; and

b) Showing in detail the way in which these materials and components would be incorporated into the design.

Selecting the materials required to complete the rainscreen over-cladding installation

3.8.5 Those materials and components (which in each case should comply with the guidance given within ADB2) comprise the following:

a) The support system for the rainscreen cladding with all associated fixings;

b) The framing within which will be incorporated the various glazed window arrangements, together with the various window infill/insulated panels;

c) All cavity barriers as required to comply with the requirements of Building Regulations; and

d) Any other components and materials such as vapour barriers/ damp proof membranes / sealants / filler materials / additional insulation to fill any gaps and ensure the completeness of the thermal '*wrap*' / inner linings to the heads, reveals and sills of the window arrangements.

3.8.6 I appreciate that under the contract procurement arrangements for this project, the detailed final design of most of these items was carried out by the selected specialist sub-contractor appointed by the successful Design and Build tenderer. In developing an indicative approach, I am therefore carrying out an exercise not dissimilar to the preparation of a suitable Design and Build tender package (albeit a Design and Build tender package should, in my opinion, carry more detail than I will be showing for my indicative scheme). As will be seen in the context of the indicative approach that I have developed, I believe that it is important that the principles of the design arrangements and materials specification in terms of assembly and code compliance are properly worked out for incorporation within the Employer's Requirements. Any subsequent scheme offered by specialist sub-contractors as an alternative will have to achieve code compliance, so the design arrangements should be worked through pre-tender stage in a manner that appropriately informs that process and meets the requirements of the Building Regulations and, as was clearly intended in the case of the 2012-16 Works, the guidance contained within ADB2. This effectively therefore provides both a design brief for the sub-contractor as well as a basis for subsequently assessing their proposals when commenting on fabrication/construction information. In the case of the Employer's Requirements that Studio E prepared, I accept that the documentation would have been based on the Proteus HR (honeycomb) rainscreen panel system. However, I have based my indicative approach on the ACP Reynobond system because that is what was ultimately adopted. The principles for the work involved in either case remain basically the same. Nevertheless, I accept that the process of document preparation for the over-cladding to the 2012-16 Works would have involved initially preparing Employer's Requirements based upon the incorporation of the Proteus HR system and thereafter, following the appointment of Rydon as the Design and Build contractor and the novation of Studio E, the amendment and further development of the scheme based on the substitution of the ACP Reynobond system.

Detailing of cavity barriers

3.8.7 It is of paramount importance to resolve the principles of the design in connection with the detailing and specification challenges relating to the cavity barriers in order to meet the guidance provided under ADB2 Section 9. As stated earlier, these relate to:

a) Sealing concealed spaces (cavities) around windows at the head, jambs and sills as recommended under paragraph 9.3. An architect would routinely deal with this during the development of the standard details (Details 1, 2 and 3) for the windows that I have referred to above.

b) Extending the internal compartmentation arrangements at floor and tenancy wall separation positions (that effectively isolate the flats one from another) into the newly formed cavities behind the rainscreen cladding as recommended under paragraph 9.3a. As I have stated earlier, whilst the elevations that I have shown above indicate the approximate positions, the exact positioning of the cavity barriers that align with compartment walls and floors will have to be determined and clearly shown in detail drawings.

c) Sealing the upper part of the external wall cavity below the Crown. Again, the exact positioning of these will have to be clearly shown.

Detailing the cavity barriers around the windows that will inhibit the spread of fire *into* the new cavities formed by the rainscreen cladding at the window openings

3.8.8 It becomes quickly apparent that whilst items b) and c) above are relatively easy to resolve in terms of meeting the guidelines contained within ADB2 Section 9 (although sadly, neither Studio E nor Harley managed to produce details in either case that met the guidance of ADB2 or the requirements of the Building Regulations), item a) produces some significant challenges for an architect. The reasons for this arise because the new window system should be located *'further out'* than the windows it replaces. This is necessary in order to maintain the continuity of the new thermal insulation and avoid situations of '*cold bridging*'. (This occurs when the insulation is interrupted, or its performance is compromised and can lead to condensation, mould and damage to decorations).

3.8.9 As I have stated, Diagram 33 and paragraph 9.3 ADB2 clearly recommend that cavities should be closed at their edges around openings. Paragraph 9.2a states that the purpose of closing cavities at their edges is to reduce *'the potential for unseen fire spread'.* Cavity barriers around openings are therefore, in my opinion, the_first line of defence in terms of preventing cavity fires.

3.8.10 The following diagrams show the arrangements of the column (plan) and top of spandrel panel (section) that forms respectively the side arrangement (jamb) and sill of all windows on floors 4 to 23 for which an architect would need to develop a detail design solution. Onto these diagrams I have marked the ideal position of the new windows in order to maintain the thermal line – it is as per that adopted by Studio E and Harley.

3.8.11 It is immediately evident that the geometries to the window jambs and sills are not orthogonal (i.e. do not involve right-angles) and that challenges exist in terms of positioning the cavity barriers at the very edge of the cavities at the window jamb/column junction and the window sill/spandrel junction. Superimposed on each diagram is a '*dashed*' red line which shows where the cavity barrier *should* be placed in order to comply with the guidance given under ADB2 Section 9. For convenience, I have also shown a continuous red line which indicates the position that was shown on the Harley drawings and installed. (As can be seen, the cavity was not closed at its edges under the 2012-16 Works at the jamb condition: the Harley vertical cavity barrier is too far from the window jamb. Likewise the Studio E vertical barriers were positioned too far from the window jambs to meet the guidance of ADB2 at paragraph 9.3. With respect to the sill/spandrel condition, neither Studio E nor Harley showed any cavity barrier at all. (I discuss this in much more detail in Section 4).

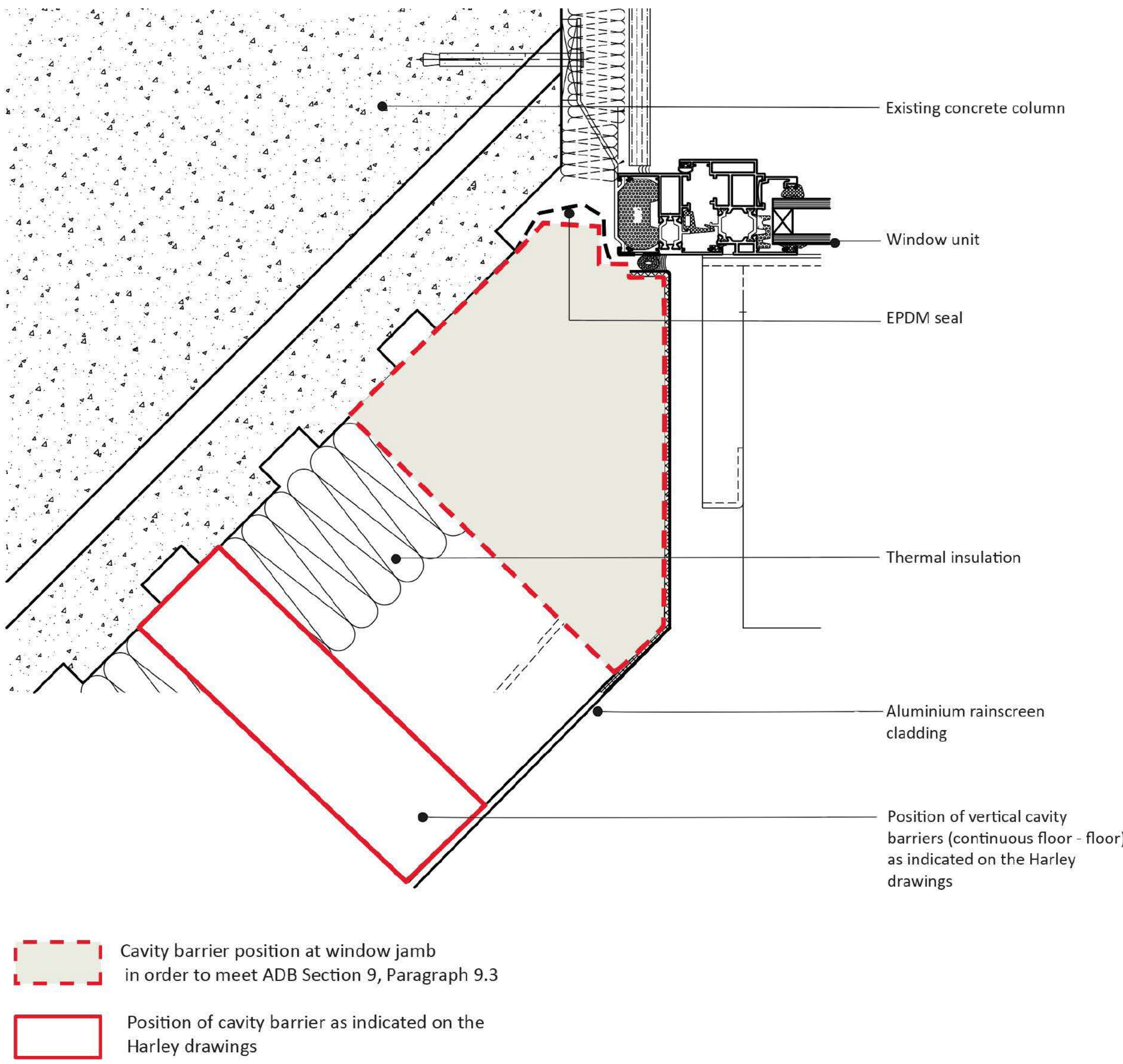


Figure 3.28: Detail 1 – Typical jamb/column interface with location of cavity barrier at window opening noted as per the guidance of ADB2

(Diagram produced using Harley Drawing C1059-302-D) {HAR00008880}

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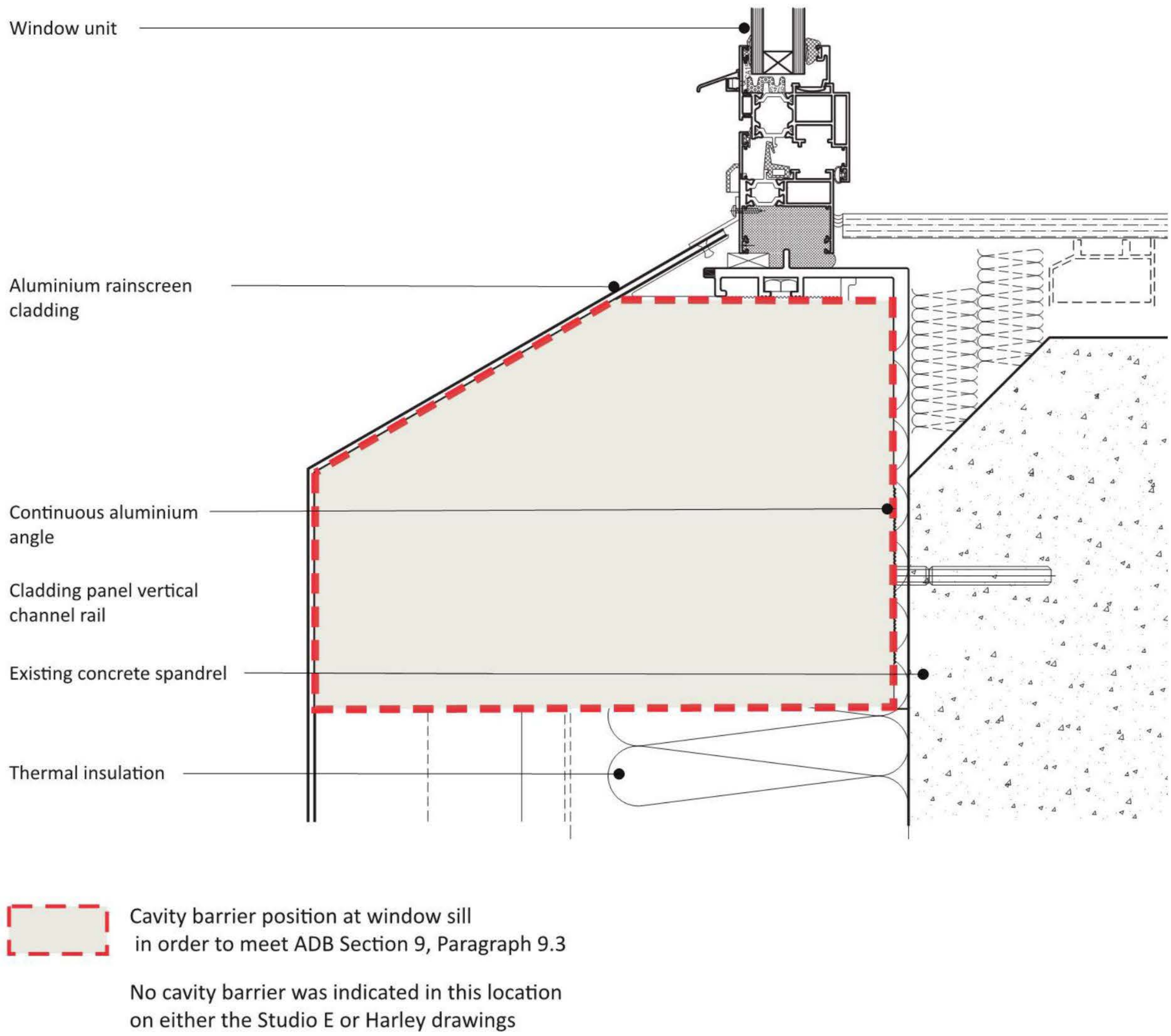

Figure 3.29: Detail 2 – Typical window sill/ spandrel with location of cavity barrier at window opening noted as per the guidance of ADB2

(Diagram produced using Harley Drawing C1059-300-E) {HAR00008469}

3.8.12 The window head/concrete floor slab edge relationship is orthogonal and therefore the detail is easier, as the following diagram shows. However, and for the same reasons, it is imperative that the cavity barrier is located at the very extreme edge of the cavity so as to inhibit the entry of fire into the cavity. Superimposed on the diagram is a '*dotted*' red line which shows where the cavity barrier should be placed in order to comply with the guidance given under ADB2 Section 9. (Again, I have also shown a continuous red line which indicates the position that was shown on the Harley drawings and installed).

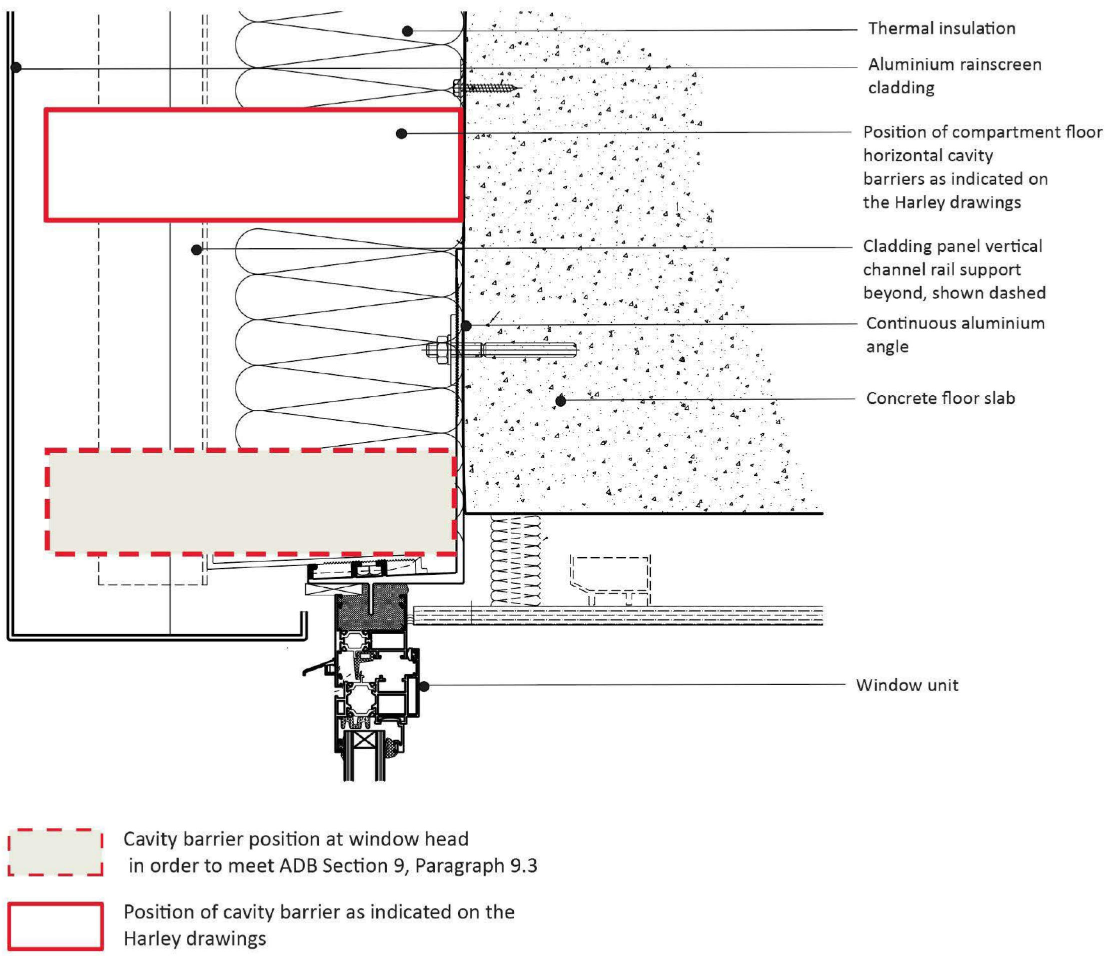

Figure 3.30: Detail 3– Typical window head with location of cavity barrier at window opening noted as per the guidance of ADB2

(Diagram produced using Harley Drawing C1059-301-E) {HAR00003958}

3.8.13 It is for these reasons that an architect should take great care in developing the details for such a project. It is very important to fully explore and in principle resolve the issue of closing the cavity around the window openings. This is not, in my opinion, a matter that can be left for later resolution by the cladding sub-contractor. Workable arrangements must be shown as part of the Building Regulations submission, and the Design and Build tender documentation should clearly show provisions in this respect; that is the type of cavity barriers proposed, their positions and detailed arrangements, and their extent. This necessitates, as demonstrated above, a fully worked out strategy with respect to cavity barriers being developed early in the design process in order that the details subsequently produced at this stage are properly informed.

3.8.14 An architect should routinely develop and show a cavity barrier strategy by preparing large scale – minimum 1: 5 – drawings and diagrams which will deal with Details 1, 2 and 3 identified above and shown on the elevation drawings as the three '*typical*' conditions that need to be resolved in terms of detailing the over-cladding at its interface with the window openings. An architect would routinely discuss all this with the appointed fire consultant (where one is appointed), manufacturers and suppliers of the principal components (that is the rainscreen cladding and the cavity barriers) and with the Building Control officer.

Detailing the cavity barriers that will inhibit the spread of fire *within* the new cavity created by the rainscreen system

3.8.15 Essentially, the principles for cavity barriers within a ventilated rainscreen system utilising a cassette system of ACP panels are as follows:

a) Cavities should permit vertical ventilation and drainage so horizontal cavity barriers with an appropriate fire rating should be affixed to leave a 25mm gap at the inside return edge of the ACP cassette.

b) The specified horizontal cavity barriers should contain an intumescent strip so that in the event of fire that strip will expand fully against the inside face of the ACP cassette in order to seal the gap and thus inhibit the spread of fire up and down the cavity.

c) Vertical cavity barriers do not require the 25 mm gap so are sized to fully fit the cavity.

3.8.16 As stated above an architect must take particular care to ensure that, in terms of the details, the horizontal cavity barriers are continuous with no gaps or interruptions so as to maintain the integrity of each zone. Particular attention is required where the barriers pass around the columns in order to maintain the horizontal compartmentation to all floors.

3.8.17 The detailing of the horizontal barriers thus ensures a tight fit and absolute continuity at the junctions with the (vertical) secondary structure that supports the rainscreen cladding, at the junction with vertical cavity barriers, and around the columns, especially at the '*internal*' corners where spandrel panel meets column, and at the external corners of the columns. This is all as indicated at ADB2 paragraph 9.2, and also implicitly under paragraph 8.6 from which I quote, respectively, as follows:

Paragraph 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 edge of cavities; therefore reducing the potential for unseen fire spread; and…'*

Paragraph 8.6: *'For the compartmentation to be effective, there should be continuity at the junctions of the fire-resisting elements enclosing a compartment and any openings from one compartment to another should not present a weakness'.*

3.8.18 In order to maintain the functional integrity of the horizontal cavity barriers, the cladding panels have been designed in a way that allows the vertical joints to be closed and/or sealed so as to inhibit the passage of any fire within the cavity '*around*' the horizontal barriers (that is outside the cladding line) and into the compartment above.

3.9 Indicative Diagrams

3.9.1 Through a series of diagrams and notes I now indicate the sort of provisions and arrangements that, if applied to the scheme developed by Studio E, and ultimately implemented at Grenfell Tower, would, in my opinion, have formed the basis for a code compliant outcome.

3.9.2 Together with the outline given above, which offers a clear indication principally of the macro and midscale aspects of the design process that appears to have been so lacking in the project execution by Studio E, I hope to provide the reader with further insight into what processes were absent, what types of drawings and sketches were missed, and why this was so critical to the failings of the envelope design. Whilst each exploratory sketch or drawing indicates a solution or starting point to the problem they respectively highlight, my main intention is to demonstrate why this part of the process, which Studio E appear to have so substantially neglected, is so critical to an architect in identifying the project's unique challenges that must be solved by a design team at the right stage of the process.

3.9.3 The elevation below again highlights the same three typical details as shown earlier. However, on exploring these interfaces through sketches at 1:5 (which Studio E appear not to have done) it is apparent that further typical repeating details are required to consider how the cavity barrier arrangements should work at other key interfaces. These are noted as typical details 4, 5 and 6 and are taken at plan view through the spandrel and column interface, the sill horizontal cavity barrier and through the column nose. I have seen no drawings that suggest Studio E addressed these 3 further conditions in detail.

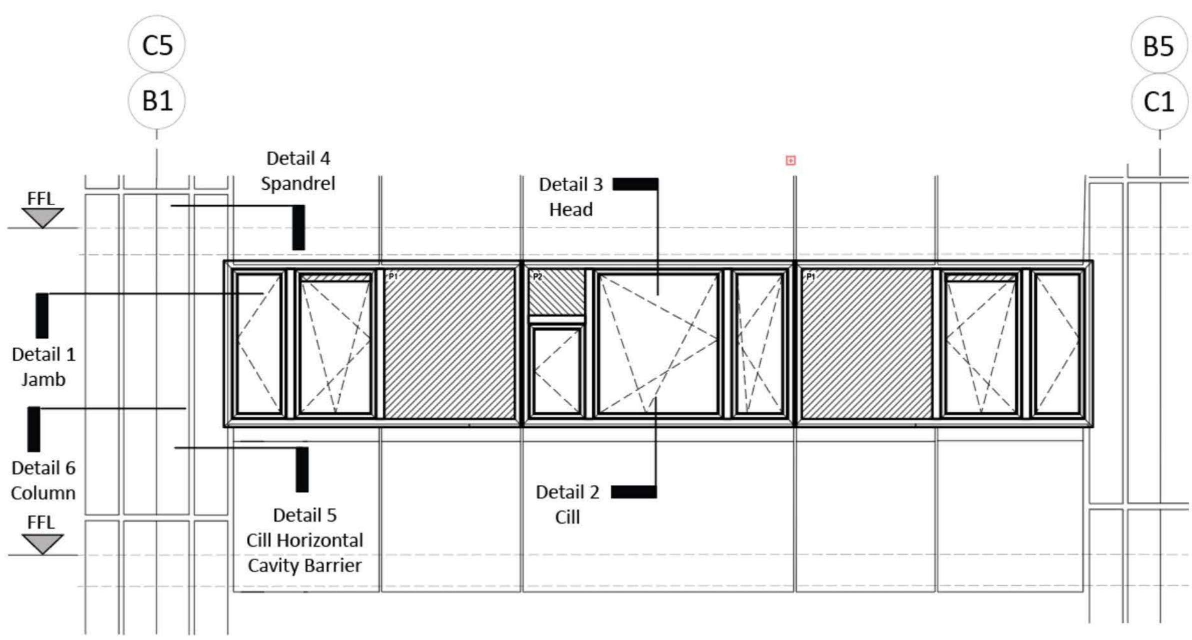

Figure 3.31: Typical bay with additional detail references
(Diagram produced using Harley Drawing C1059-200-I) {HAR00008581}

3.9.4 I therefore show again the complete façade elevation which I used earlier to randomly indicate the locations of details 1, 2 and 3 but now amended to incorporate random indications of the locations of additional details 4, 5 and 6 which will also require further study in pursuit of indicative approach to their resolution.

Figure 3.32: Typical elevation with examples of locations for typical details 1 to 6 indicated

(Diagram produced using Studio E Drawing 1279 RE300 Rev 01) {SEA00001647}

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Development of Typical Details

Development of Typical Detail 1

3.9.5 I begin by re-visiting Detail 1 shown below – that is the jamb detail. First I provide a basic arrangement sketch upon which I comment and then I provide a more refined sketch which has been developed for this condition. Note that in this case, and in all other typical details that I offer herein, the examples are exploratory sketches typical of those that an architect would develop as a basis for enabling development of the façade design through discussion with the wider design team including, where appointed, the fire consultant, manufactures, sub-contractors and Building Control. This is not to be interpreted as a finished design: as stated earlier it is '*indicative*' only.

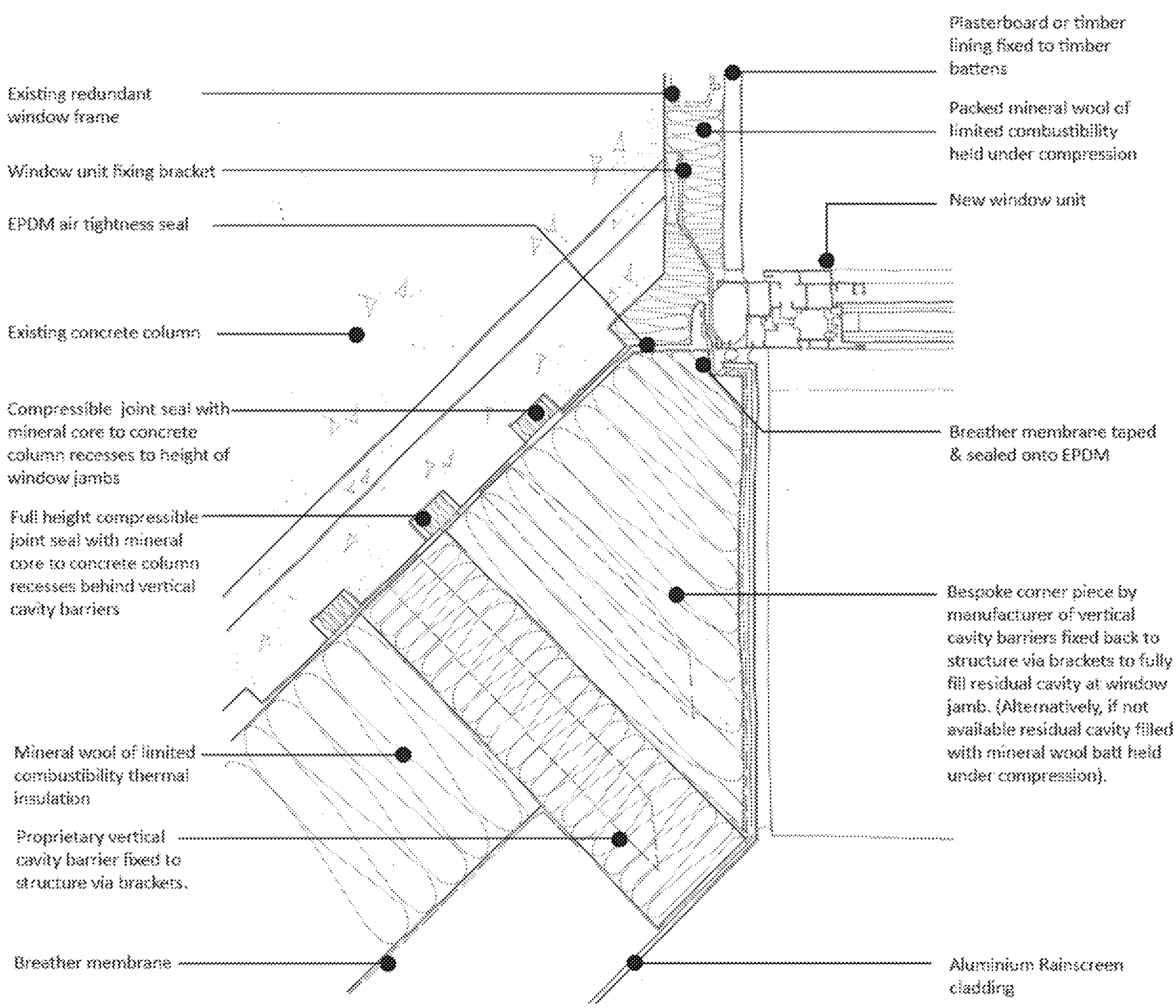

Figure 3.33: Typical Detail 1 – Jamb/column interface

a) Due to column and jamb geometry, the proprietary vertical cavity barrier that must run along the line of the compartment wall has been moved as close to the jamb as possible. The residual cavity at the polygon shaped reveal will then be fully filled by a bespoke (almost) trapezoid shaped factory-made cavity barrier by the same manufacturer as the vertical barrier, which can then be fixed in the same manner onto brackets fixed back to the structure. If, through dialogue with manufacturers, this is deemed unachievable the residual cavity would be filled with mineral wool insulation held under compression.

b) The trapezoid shaped vertical cavity barrier to each jamb condition would run only the height of the window opening and seal against the horizontal barriers at the head and sill – '*under*' the head and '*onto*' the sill as shown in the SideRise video the link for which is listed earlier.

c) Adjoining the trapezoid vertical barrier at the immediate jamb position, the rectangular vertical cavity barrier that runs the entire height of the column is located. The rectangular vertical barrier, which is installed before the horizontal barriers, is detailed to provide a robust connection with the cavity barrier along the line of the compartment floor.

d) (PARAGRAPH DELETED)

e) The recesses of the existing column are infilled using proprietary products that are suitable for firestopping joints and gaps in concrete construction. Such products are available with a mineral wool core, oversized and held under compression. This compressible infill would be installed to the recesses behind the vertical cavity barrier, and the trapezoid window cavity barrier. These types of products are generally used to seal gaps within concrete surfaces and as such their suitability would be explored further with the manufacturer to ensure they could be used in the proposed manner and meet the required performance as their test data.

f) Following the change to mineral wool thermal insulation and with the drained and vented rainscreen assembly a breather membrane would be considered.

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g) As to why a breather membrane would be considered, the thermal insulation that has been specified as mineral wool to meet the minimum requirement of limited combustibility is specifically for a rainscreen cladding arrangement. Whilst the mineral wool insulation is manufactured with a water repelling agent within the fibres and is designed to prevent water transmission, the vapour permeable breather membrane provides additional protection from any moisture tracking through the insulation to the inside face of the concrete structure. It provides a level of air permeability such that any moisture in the insulation due to any interstitial condensation or water ingress can dry to the outside air through the breather membrane. The breather membrane also provides a weathertight face to the mineral wool and prevents any cold air ingress into the insulation that may arise up the drained and ventilated cavity and adversely affect the thermal performance of the envelope. The breather membrane would also provide weather protection to the insulation and façade during the construction phase prior to the cladding being installed. (Note that I have not, within the indicative approach, offered any qualification with respect to the fire performance of the breather membrane. ADB2 was hitherto silent on the matter, and I think it unlikely that I would have given the issue any consideration. Since the Grenfell Fire ADB2 has been amended to provide guidance with respect to breather membranes used in such circumstances as Grenfell Tower. Under paragraph 12.16a '*Membranes used as part of the external wall construction above ground level should achieve a minimum of class B – s3, d0*').

h) An internal lining of either plasterboard or timber would be proposed and fixed to timber battens with the gap between the concrete column tightly packed with mineral wool of limited combustibility.

i) The proposed arrangement would be discussed with the different manufacturers of the specified products to ensure that they could be used in the proposed manner and meet the required performance in accordance with any relevant test data.

j) Following confirmation from the various manufacturers and perhaps after exploring other iterations of the arrangement, the detail would be circulated for comment to the wider design team including the Fire Engineer and Building Control.

3.9.6 A simplified diagram to show the main principles of this arrangement for Detail 1 is shown below:

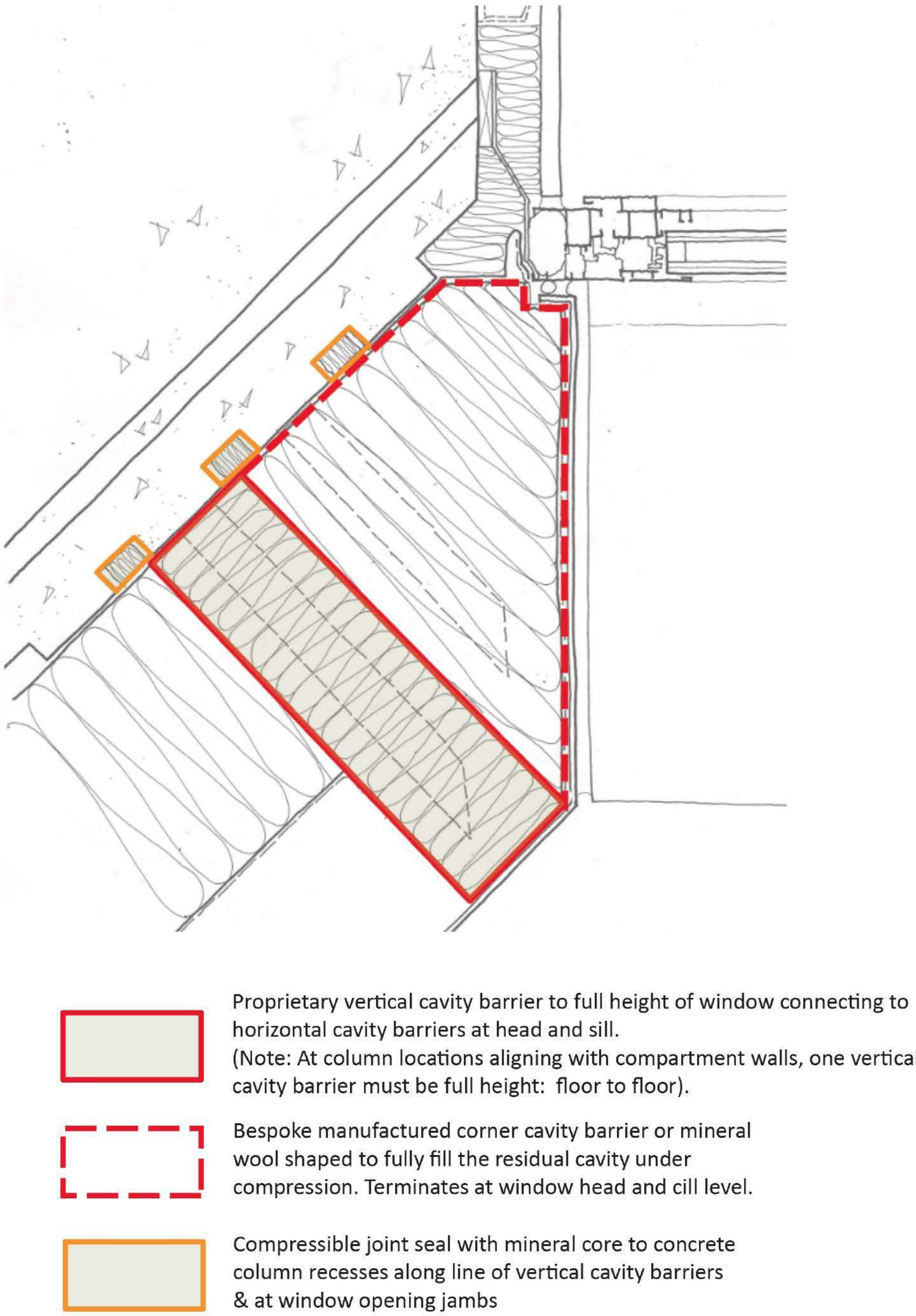

Figure 3.34: Typical Detail 1 – Jamb/ Column Interface with Cavity Barrier Arrangement Highlighted

a) The detail shown above indicates the use of the proprietary vertical cavity barrier, positioned as close to the window as possible and the adjoining bespoke trapezoid shaped cavity barrier or mineral wool shaped to fully fill the residual cavity at the window jamb.

b) The diagram also highlights the compressible joint seals required to the column recesses to avoid by-pass of the cavity barrier through these gaps. (Studio E made no such provision in this respect which meant that fire in the cavity could travel vertically both behind the vertical and the horizontal cavity barriers as they passed around the columns).

c) The proprietary vertical cavity barrier would be fixed back to the structure. In cases where the column aligns with a compartment wall the proprietary cavity barrier to one of the windows adjoining the column would run full height from compartment floor to compartment floor. This arrangement has the advantage of both '*bolstering*' the performance of the trapezoid cavity barrier at the window jamb and meeting the requirement under ADB2 paragraph 9.3a for a vertical cavity barrier to align with the compartment wall. Due to this dual functionality (compartment wall and window jambs) the performance of the barrier would need to achieve a minimum performance of 60/30 Integrity/Insulation to provide the same performance of two separate barriers each of 30/15 Integrity/Insulation as would be required were these to be separated installations. I would however seek guidance on this point from a specialist fire consultant (if appointed), from Building Control and from the fire authority.

Development of Typical Detail 2

3.9.7 I next re-visit Detail 2, that is: the sill detail. Again, I begin by providing a basic arrangement sketch upon which I offer a brief commentary and then I provide a more refined sketch which has been developed for this condition:

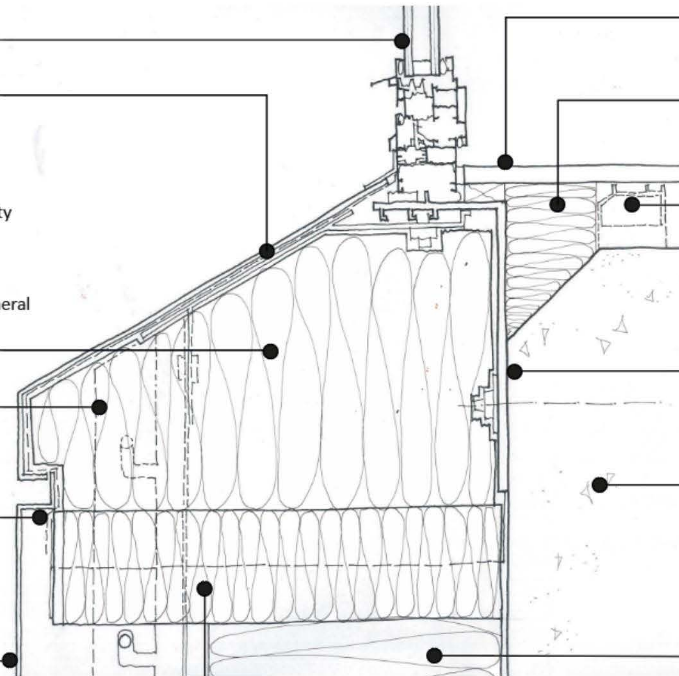

Figure 3.35: Typical Detail 2 – Sill detail

a) A proprietary '*open state*' horizontal cavity barrier has been located as close to the sill as practically possible. Due to the chamfer of the concrete column and the sill profile this leaves a residual cavity above.

b) Through dialogue with the product manufacturer a bespoke made sill element would be sought to fill this residual cavity. Alternatively, if this were unachievable, the cavity would be filled using a mineral wool batt held under compression.

c) To enable the sill profile cavity barrier to be installed a separate ACP cladding cassette has been introduced, with a joint directly above the cavity barrier.

d) Following the change to mineral wool thermal insulation with the drained and vented rainscreen assembly a breather membrane would be considered.

e) A lining to the window sills of some kind of timber or plywood would be proposed and fixed to timber battens with the gap between the concrete soffit tightly packed with mineral wool of limited combustibility.

f) To enable the cavity barrier bracket to be fixed direct to the concrete structure, the continuous aluminium channel that supports and restrains the base of the window frame would have slots cut out to facilitate this arrangement. Fixings of the cavity barrier bracket and the aluminium channel would be intermittent to avoid clashes. The diagram below illustrates the principles of this arrangement.

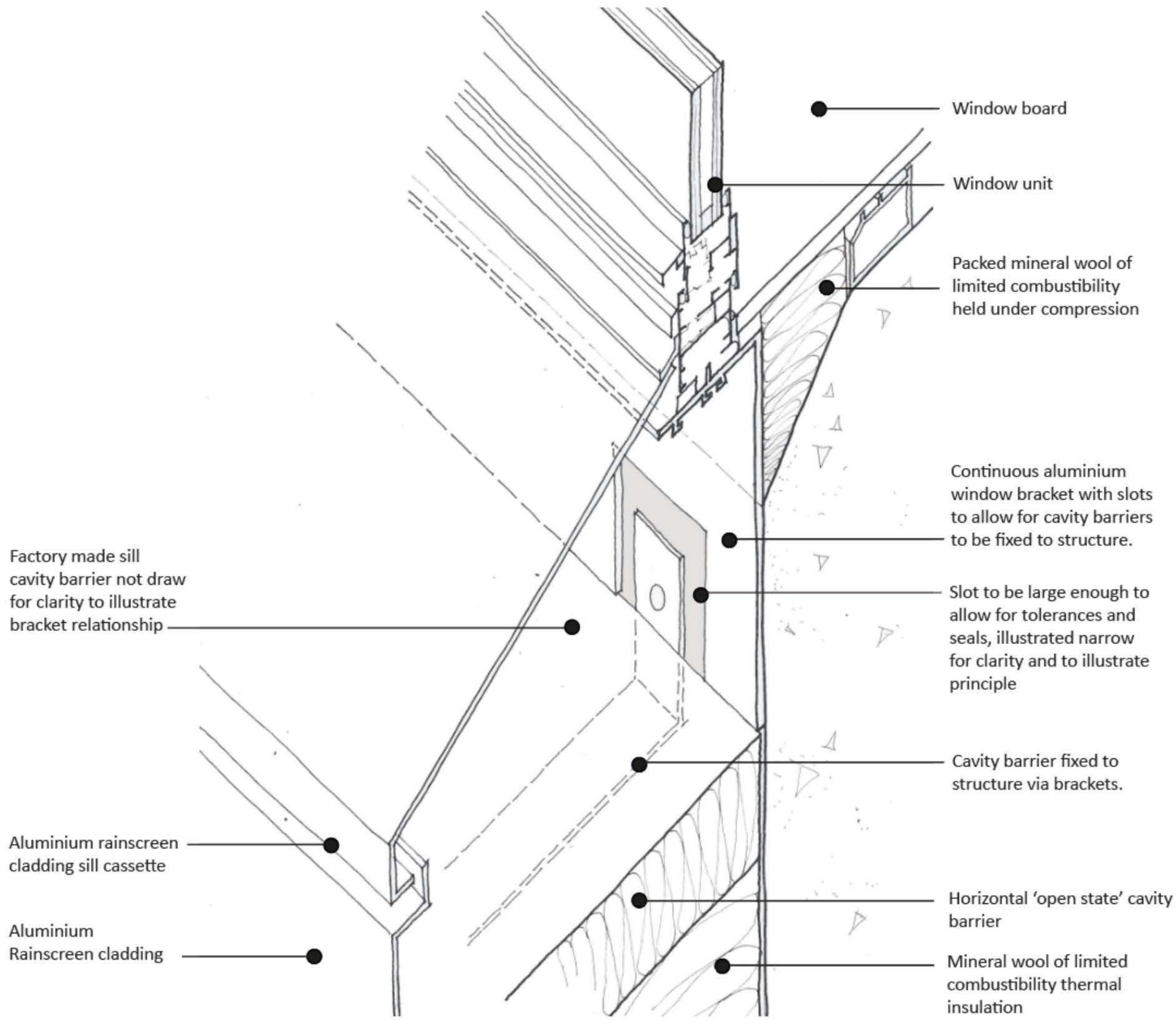

Figure 3.36: Sill detail to show continuous window bracket modified to accommodate cavity barrier supports

(Note that this drawing, and similar 3-dimensional images as contained herein, would not typically be included within a Design and Build tender pack – they have been produced and incorporated herein to assist the Reader)

g) The proposed arrangement would be discussed with the different manufacturers of the specified products to ensure that they could be used in the proposed manner and meet the required performance stipulated under any relevant test data criteria.

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h) Following confirmation from the various manufacturers and perhaps other iterations of the arrangement, the detail would be circulated for comment to the wider design team including the fire engineer and Building Control

3.9.8 A simplified diagram to show the main principles of this arrangement for Detail 2 is shown below:

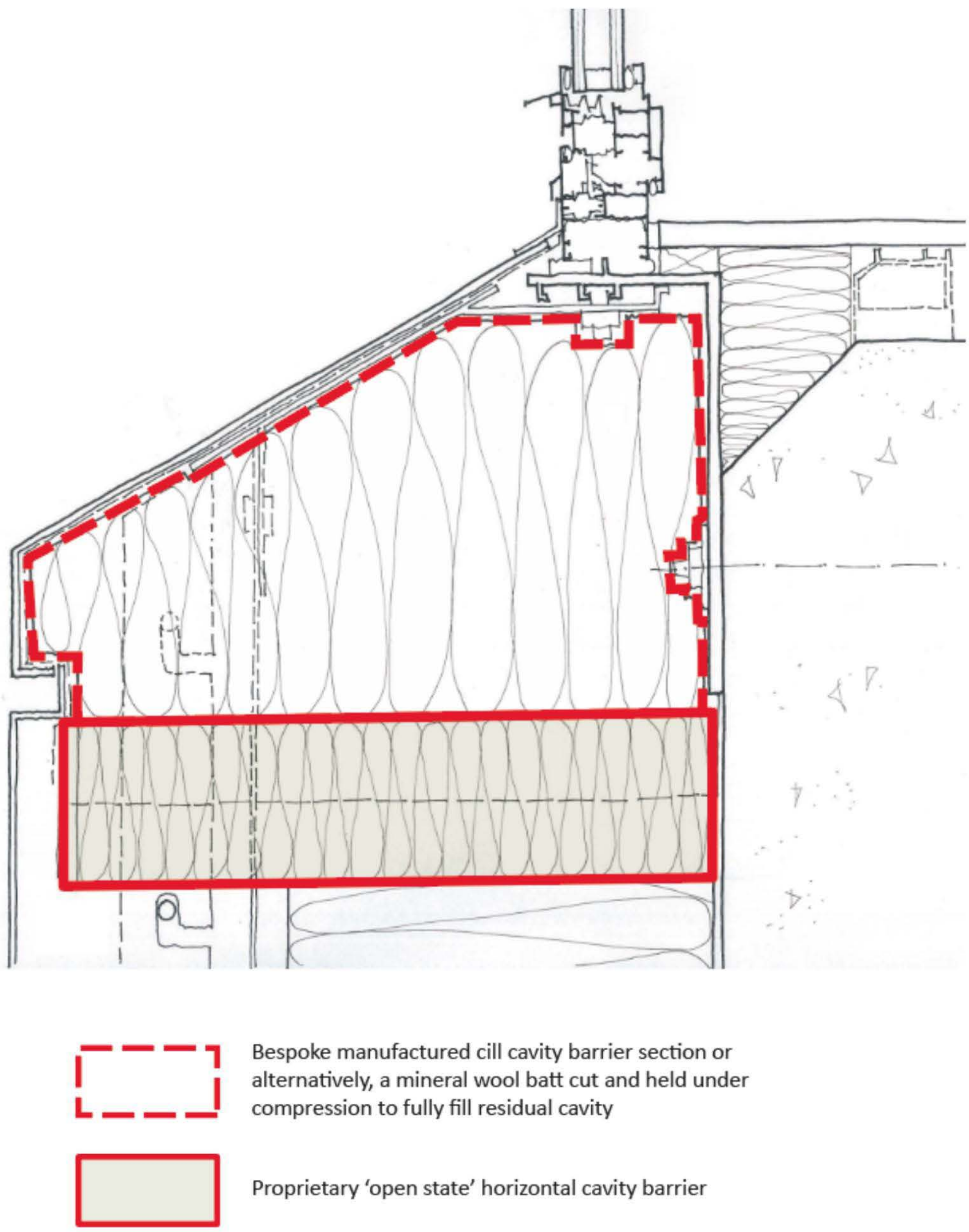


Figure 3.37: Typical Detail 2 – Sill detail with cavity barrier arrangement highlighted

a) This detail indicates the use of the proprietary cavity barrier, positioned as close to the window sill as possible and then the factory-made bespoke profile or mineral wool to fully fill the residual cavity above.

b) The proprietary horizontal cavity barrier would need to meet a minimum performance of 30/15 Integrity/Insulation.

Development of Typical Detail 3

3.9.9 I next re-visit Detail 3, the head detail. Again, I begin by providing a basic arrangement sketch upon which I offer a brief commentary and then I provide a more refined sketch which has been developed for this condition:

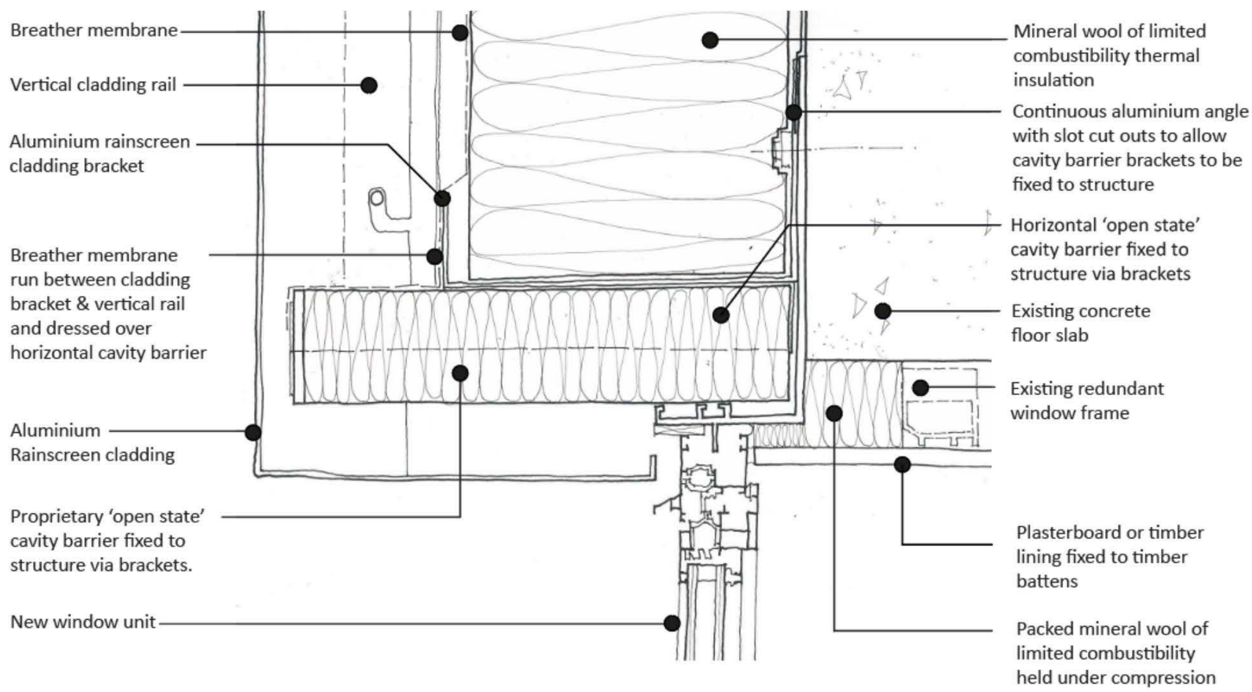


Figure 3.38: Typical Detail 3 – Head detail

a) The proprietary '*open state*' horizontal cavity barrier has been located directly above the window head.

b) To facilitate the position of the horizontal cavity barrier the last cladding bracket fixing would be moved above this and fixed back to the structure. The fixing of the bracket through the continuous angle would require early engagement with the Specialist Sub-Contractor to develop an appropriate arrangement. This is shown below:

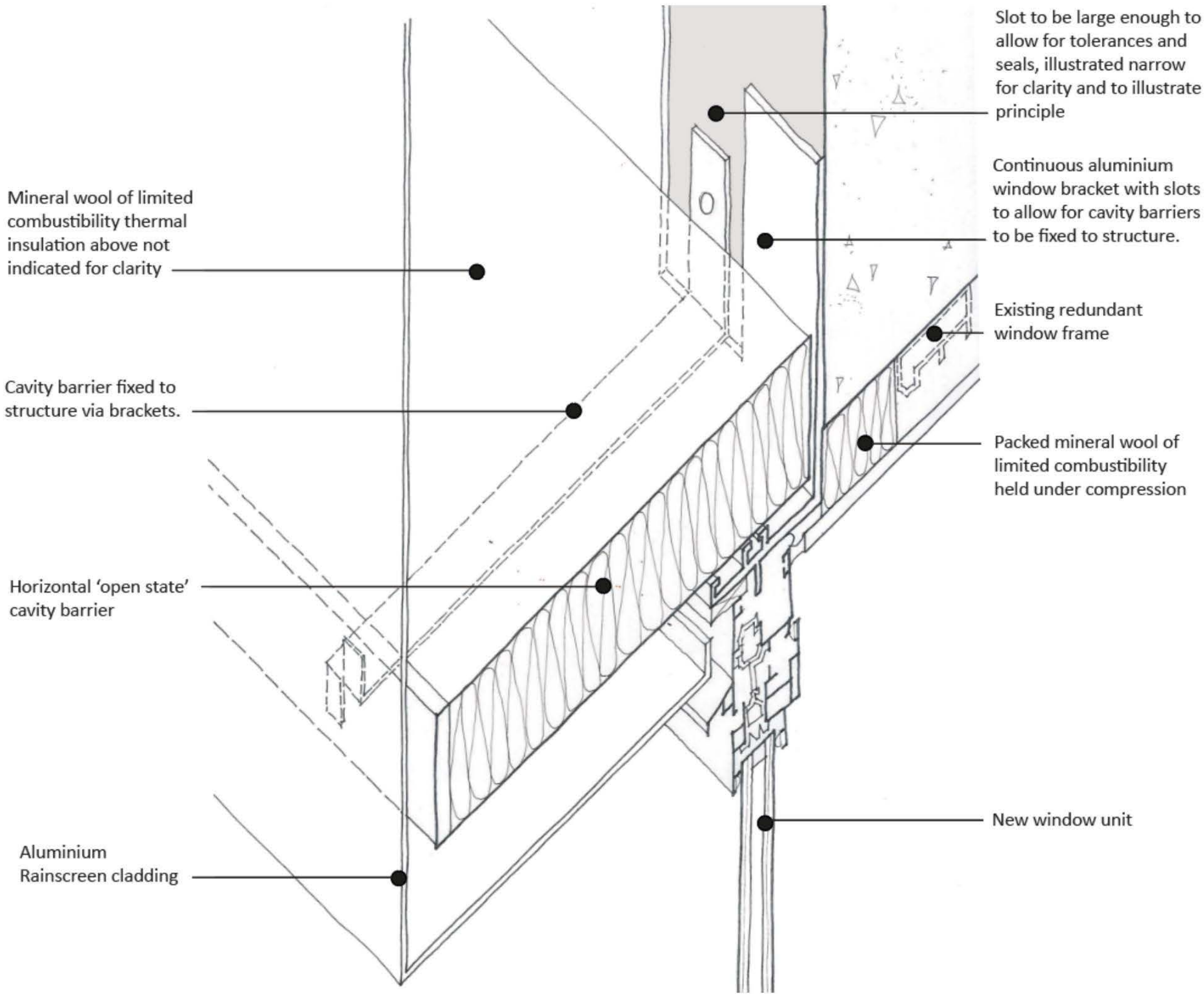


Figure 3.39: Head detail to show continuous window bracket modified to accommodate cavity barrier supports

c) To enable the cavity barrier bracket to be fixed direct to the structure, the continuous aluminium channel would, as shown on the drawing above, have slots cut out to facilitate this arrangement. Fixings of the cavity barrier bracket and the aluminium channel would be intermittent to avoid clashes.

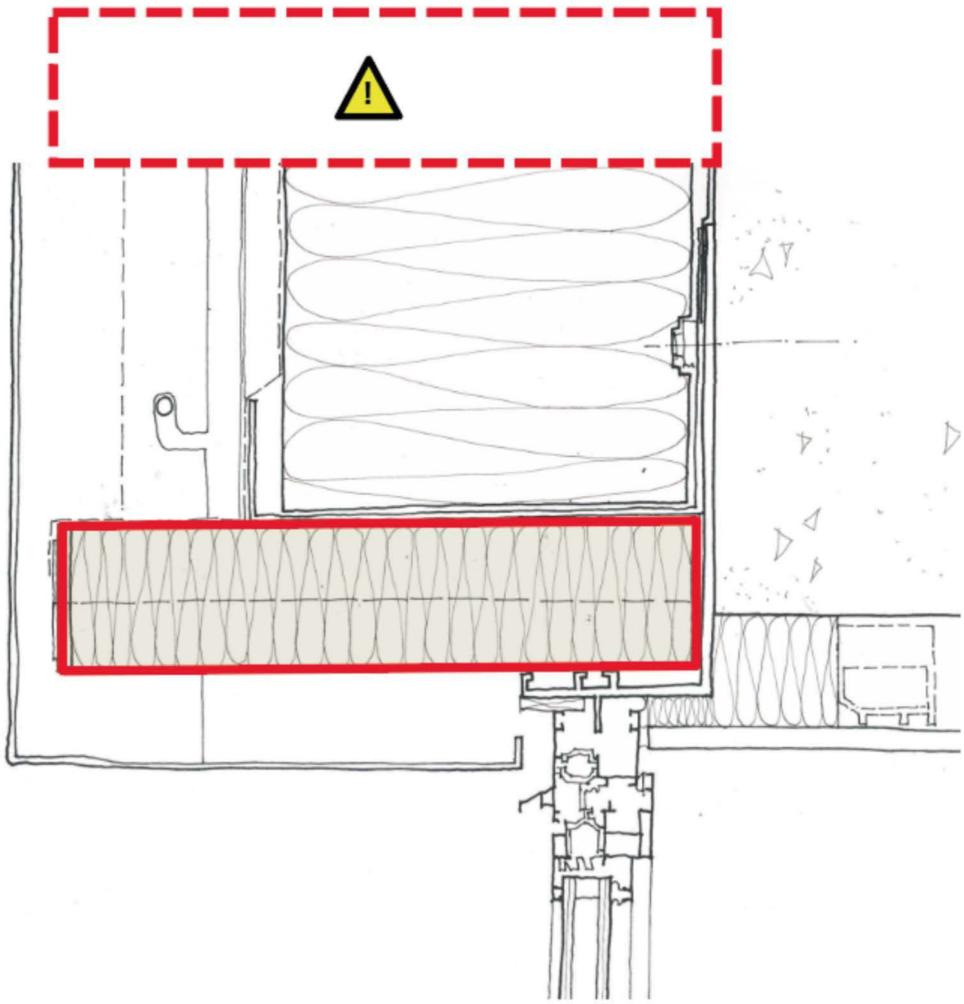
d) A lining to the window head reveals of either plasterboard or timber would be proposed and fixed to timber battens with the gap between the concrete soffit tightly packed with mineral wool of limited combustibility.

e) Following the change to mineral wool thermal insulation with the drained and vented rainscreen assembly, a breather membrane would be considered.

f) The proposed arrangement would be discussed with the different manufacturers of the specified products to ensure that they could be used in the proposed manner and meet the required performance stipulated under their respective test data criteria.

g) Following confirmation from the various manufactures and perhaps after exploring other iterations of the arrangement, the detail would be circulated for comment to the wider design team including the Fire Engineer and Building Control.

3.9.10 A simplified diagram to show the main principles of this arrangement for Detail 3 is shown below:



Continuous proprietary 'open state' horizontal cavity barrier positioned in order to meet ADB Section 9 for both provisions of cavity barriers at the window opening & along the line of compartment floors

The suitability of the single cavity barrier to provide dual functionality with respect to cavity barriers at the window head and compartment floor would be discussed with the wider team including the Fire Engineer & Building Control. Following which, either it would remain as illustrated or an additional barrier would be introduced and aligned with the top of the floor slab for the separate cavity barrier along the line of the compartment floor. Likewise, the suitability of the back of the barrier positioned against the aluminium angle would also be discussed and either would remain as illustrated or an additional barrier would be introduced and aligned with the top of the floor slab for the separate cavity barrier along the line of the compartment floor.

Figure 3.40: Typical Detail 3 – Head detail with cavity barrier arrangement highlighted

a) The diagram above indicates the use of the proprietary cavity barrier to the window head providing a dual role, at the cavity barrier of the window head and along the line of the compartment floor.

b) This use of a cavity barrier to perform two functions is due to the position of the window head in relation to the compartment floor.

c) Due to this dual functionality, the performance of the barrier should be reviewed to determine whether there is a need to increase the performance to 60/30 minimum integrity/insulation to provide the same performance of two separate barriers, each of 30/15 Integrity/Insulation as would be required were these to be separated installations. As with the jamb detail described above, I would however seek guidance on this point from a specialist fire consultant (if appointed), from Building Control and from the fire authority.

d) To limit any reduction in the thermal performance at this interface, the cavity barrier has been located as close to the window frame as possible. However, this only achieves a partial overlap with the compartment floor. This, and the proposal for the cavity barrier to provide a dual function, would be discussed early in the design process with the wider team before tender, including the fire engineer with early consultation also arranged with Building Control. Depending on the outcome of these discussions this would remain as the proposal or an additional horizontal cavity barrier would be positioned at the top of the floor slab, each to provide a minimum performance of 30/15 integrity/insulation in line with the guidelines contained within ADB2 at Table A1.

Development of Typical Detail 4

3.9.11 I will now explore Detail 4 that I have identified as an additional (non-window) condition needing study and resolution in relation to the cavity barrier strategy and installation. Again, I begin by providing a basic arrangement sketch upon which I offer a brief commentary and then I provide a sketch which has been developed for this condition:

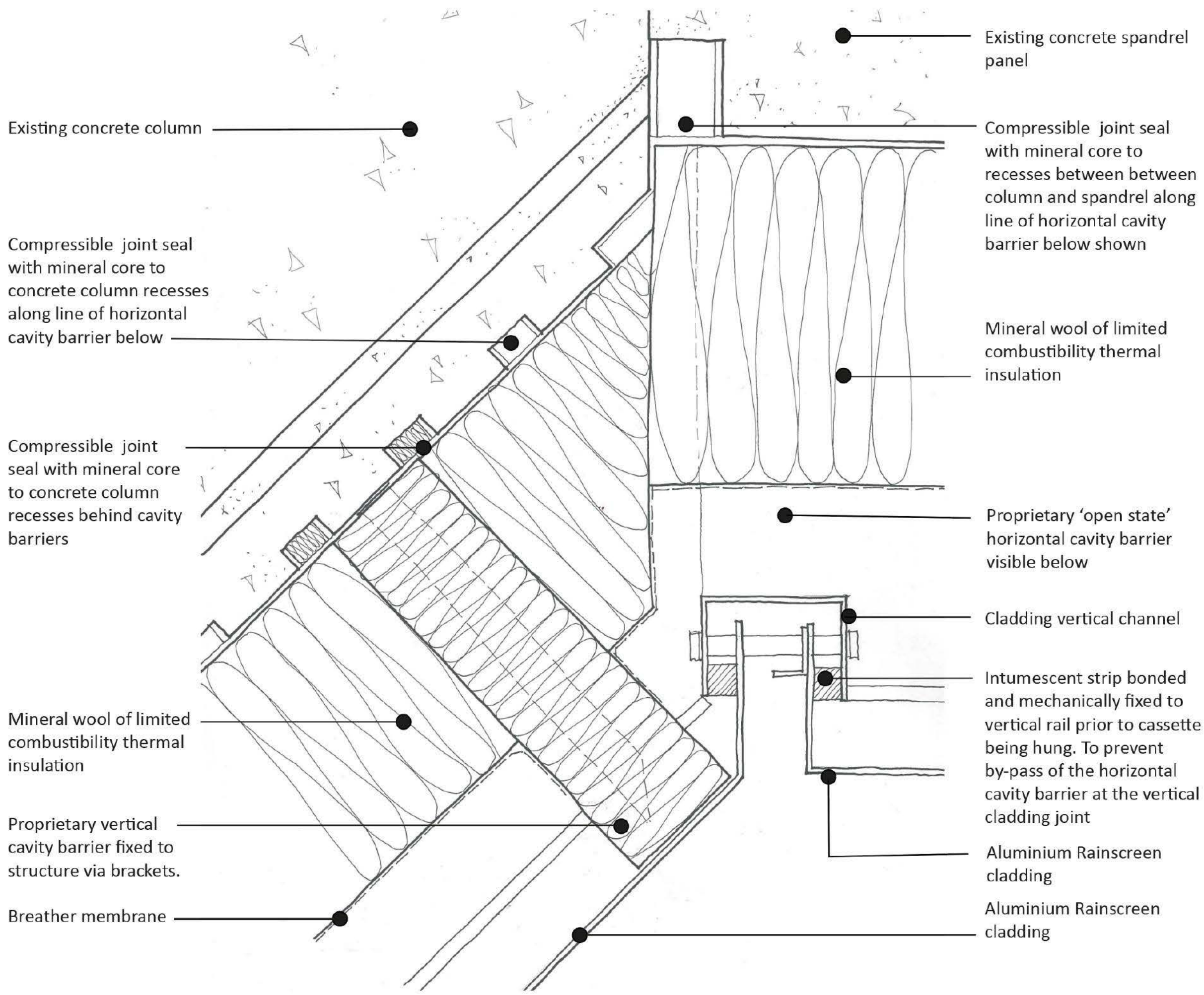


Figure 3.41: Typical Detail 4–Plan detail through: spandrel / column interface where column aligns with compartment wall

(Note this only occurs to one jamb in each such condition)

a) In this detail the proprietary vertical cavity barrier located at the window jamb opening continues through the spandrel zone on one side of the column to provide the cavity barrier along the line of the compartment wall. To avoid any by-passing of the vertical barrier via the column, recesses are again infilled with a compressible joint seal with a mineral wool core.

b) The existing spandrel panel has a rebate at the column interface that would lead to a by-pass of the horizontal cavity barrier if left as a void. A compressible joint seal with mineral wool would also be required here. These products are specified oversized and compressed on installation to form a tight seal when fitted.

c) These compressible joint seals would be specified to meet the same performance as the cavity barriers that they sit behind.

d) Where the horizontal cavity barrier interfaces with the vertical channel support of the cladding, a seal will be required to prevent any by-pass of the barrier via the gaps between the cladding cassette and the channel, which is inherent in the channel and cassette system to provide buildability tolerances. (The internal dimension of the spandrel cassettes is greater than the length of the vertical supporting rails to enable installation and therefore gaps are inevitable. These must be sealed). The drawings below illustrate this condition. They can be read with the '*physical*' model provided for this condition.

e) The sketch details below (respectively a 'plan' view, a '*sectional*' view and a view from below) indicates a compressible seal that would be bonded to the vertical channel prior to the cassette being installed and held under compression thereafter. This exploratory sketch detail highlights key issues with the envelope design. Early engagement would be arranged with the specialist sub-contractor to develop an appropriate arrangement to avoid this type of potential flaw with the rainscreen cladding system.

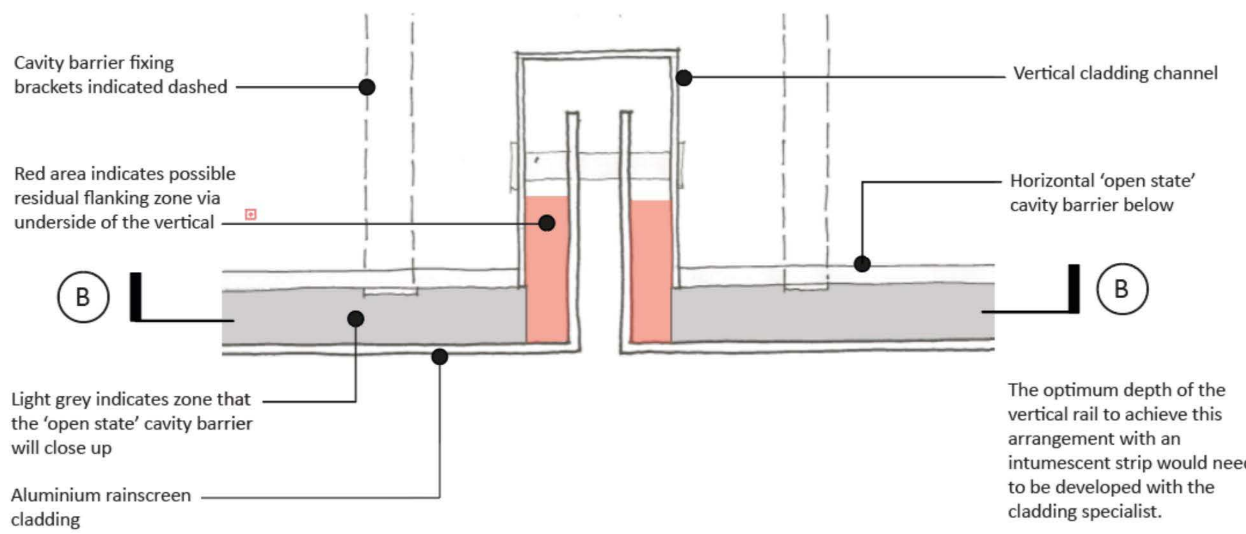


Figure 3.42: Plan Detail A- A Through Typical Cladding Joint at Spandrel

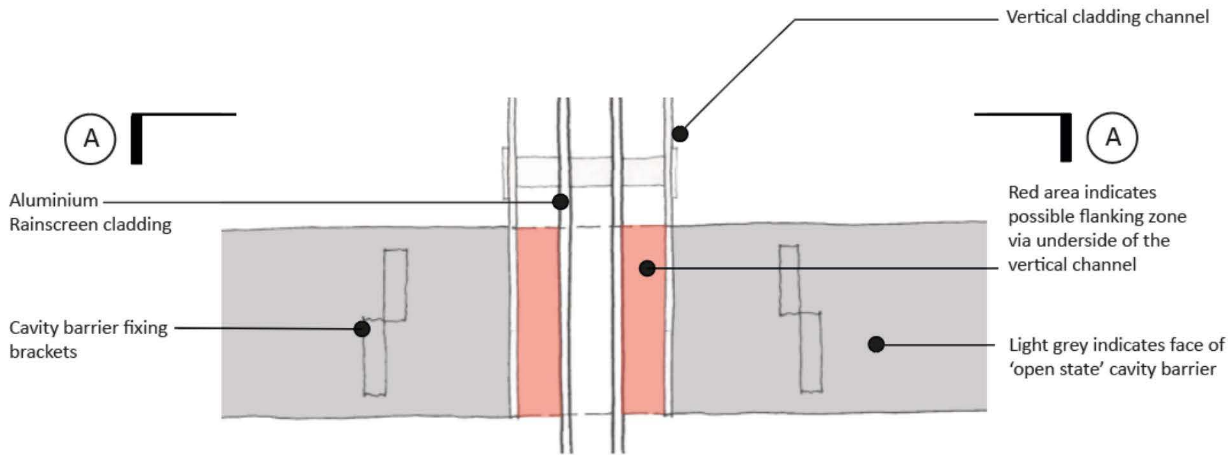


Figure 3.43: Sectional Elevation B-B Through Vertical Rail at Spandrel

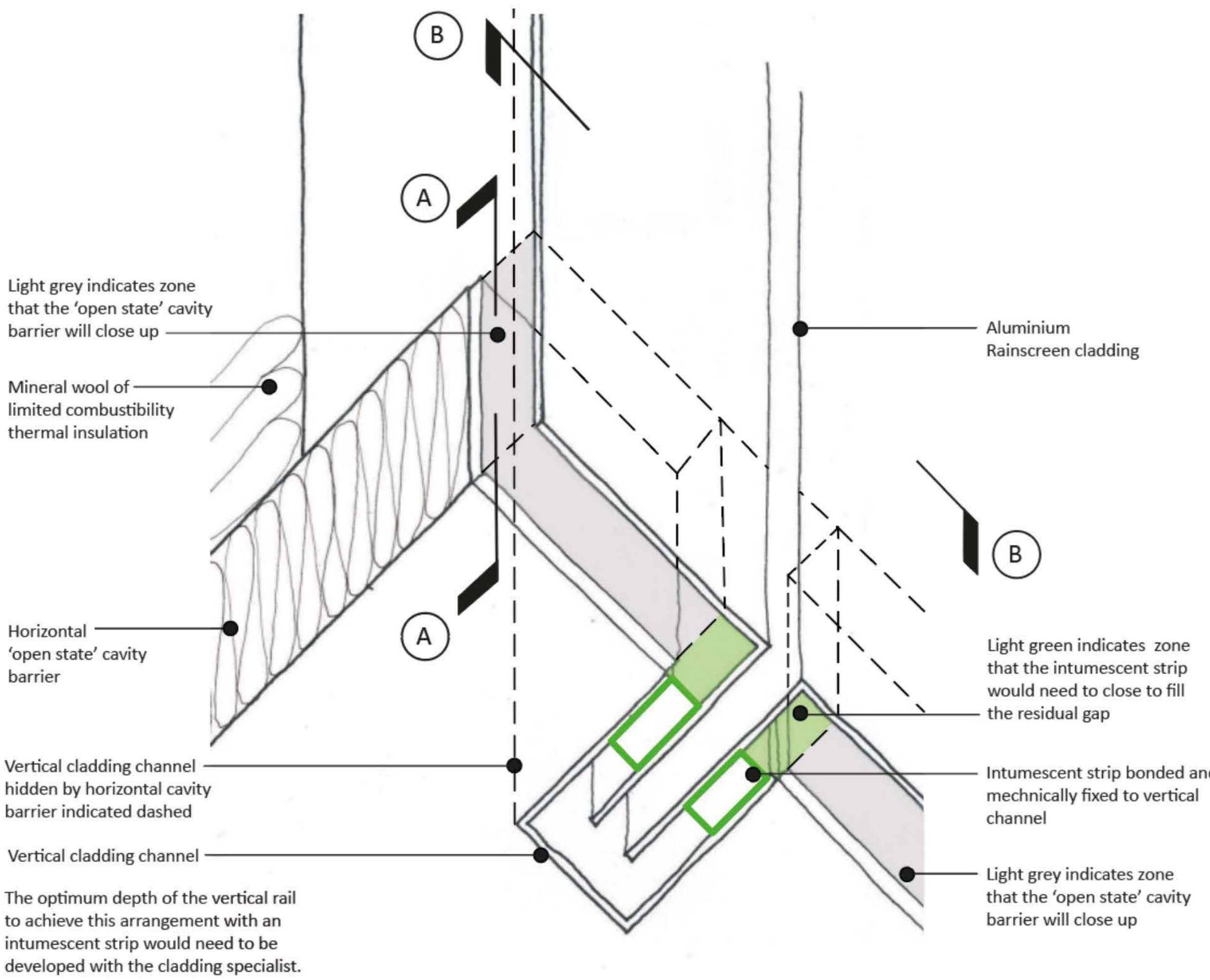


Figure 3.44: 'Worm's eye view' looking up at cladding and vertical rail interface above window head

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f) The specification of the proprietary seal to prevent this by-pass described above would also require early research into suitable products to ensure that they could be used in the proposed manner and meet the required performance.

g) The intumescent joint seal to the vertical cladding channel would be specified to meet the same performance as the cavity barriers they sit behind.

h) The proposed arrangement would be discussed with the different manufacturers of the specified products to ensure that they could all be used in the proposed manner and meet the required performance stipulated under their respective test data criteria.

i) Following confirmation from the various manufacturers and perhaps other iterations of the arrangement, the detail would be circulated for comment to the wider design team including the Fire Engineer and Building Control.

3.9.12 A simplified diagram to show the main principles of this arrangement for Detail 4 is shown below:

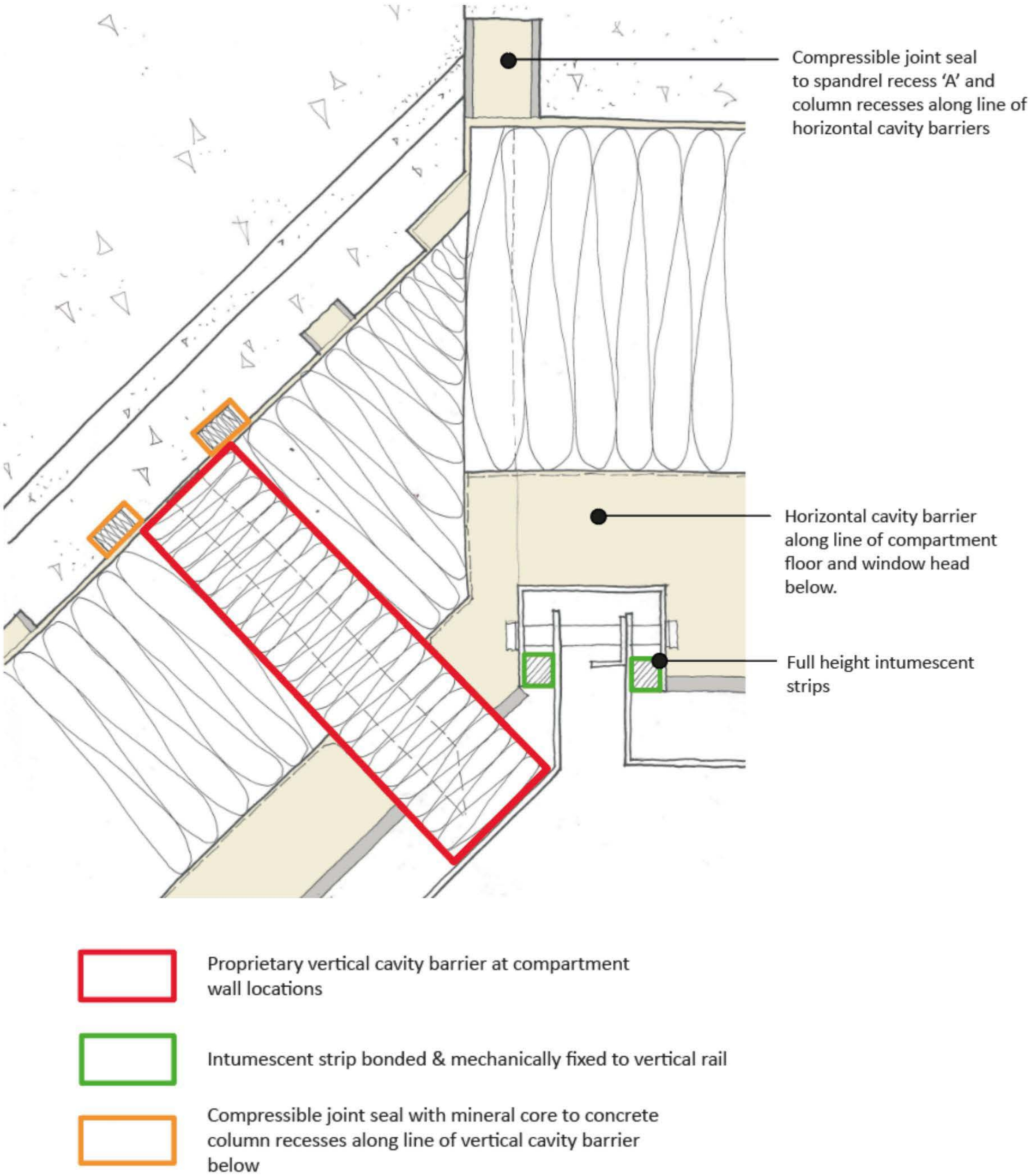

Figure 3.45: Typical detail 4–Plan detail through spandrel / column with cavity barrier arrangement highlighted

a) The diagram indicates the use of the proprietary horizontal and vertical cavity barriers. In addition, the compressible seals are incorporated to inhibit the fire from bypassing the horizontal cavity barriers via the channels within the concrete columns.

b) The diagram also shows the intumescent seals to the vertical channel supporting the rainscreen cassettes to the vertical channel at concrete column and spandrel recesses (marked '*A*' on drawing above) again to inhibit the fire from by-passing the horizontal cavity barriers via those channels.

c) The continuous vertical cavity barrier would be specified to meet a minimum performance of 30/15 Integrity Insulation.

d) The joint seal behind the continuous vertical cavity barrier would be specified to meet a minimum performance of 30/15 Integrity Insulation.

e) Due to the dual role of the proprietary horizontal cavity barrier (window and compartment floor) the joint seal behind this would be specified to meet a minimum performance of 60/30 Integrity Insulation.

Development of Typical Detail 5

3.9.13 I will now explore Detail 5 that I have also identified as an additional (non-window) condition needing study and resolution in relation to the cavity barrier strategy and installation. Again, I begin by providing a basic arrangement sketch upon which I offer a brief commentary below and then I provide a sketch which has been developed for this condition:

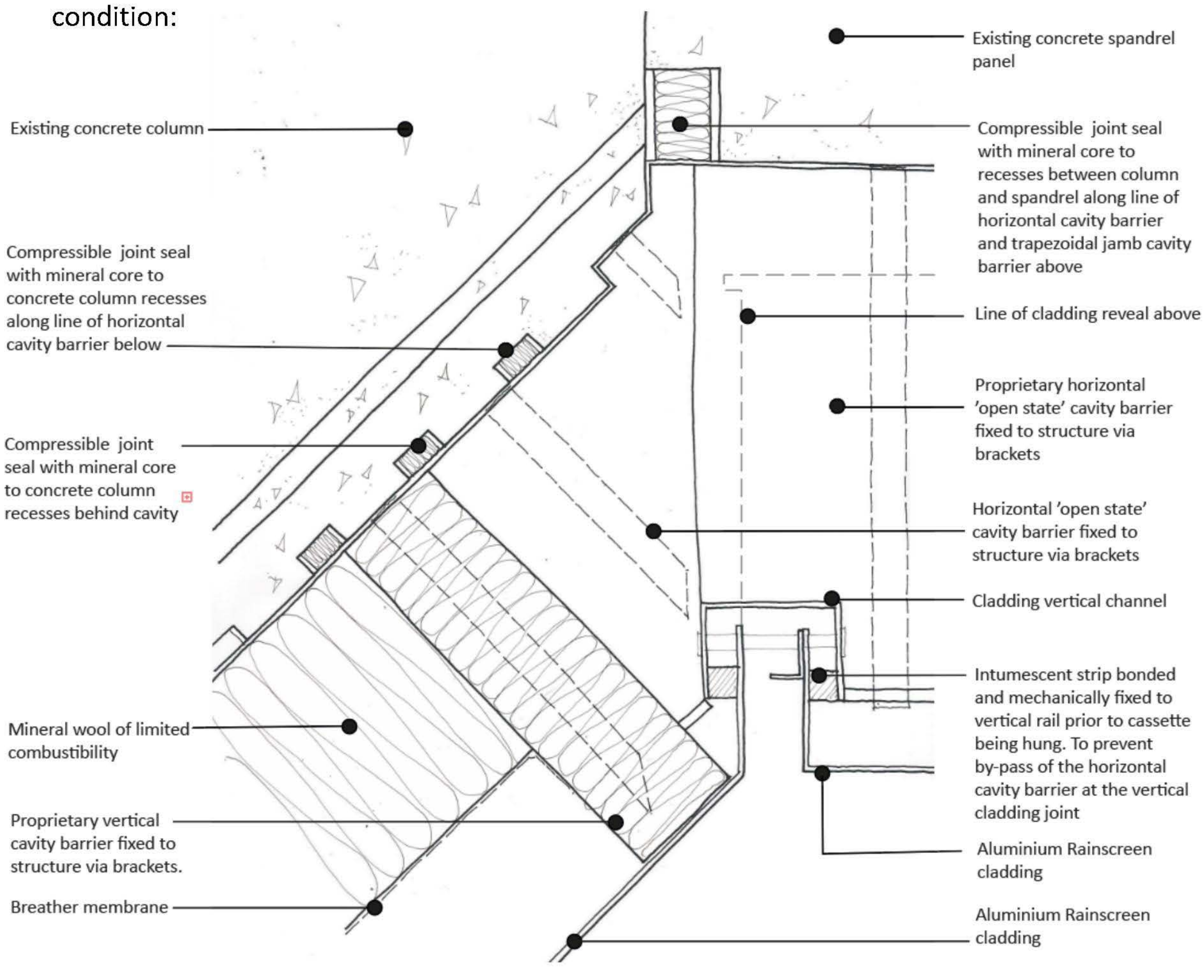

Figure 3.46: Typical Detail 5 –Plan detail through sill horizontal cavity barrier

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a) The sketch detail indicates the interface of the proprietary vertical cavity barrier adjacent to the window jamb and the horizontal cavity barrier at sill level.

b) To ensure a robust seal the sill cavity barrier has been extended '*right through*' to seal against the proprietary vertical cavity barrier rather than to the trapezoid shape of the window jamb cavity barrier. The drawing below illustrates this:

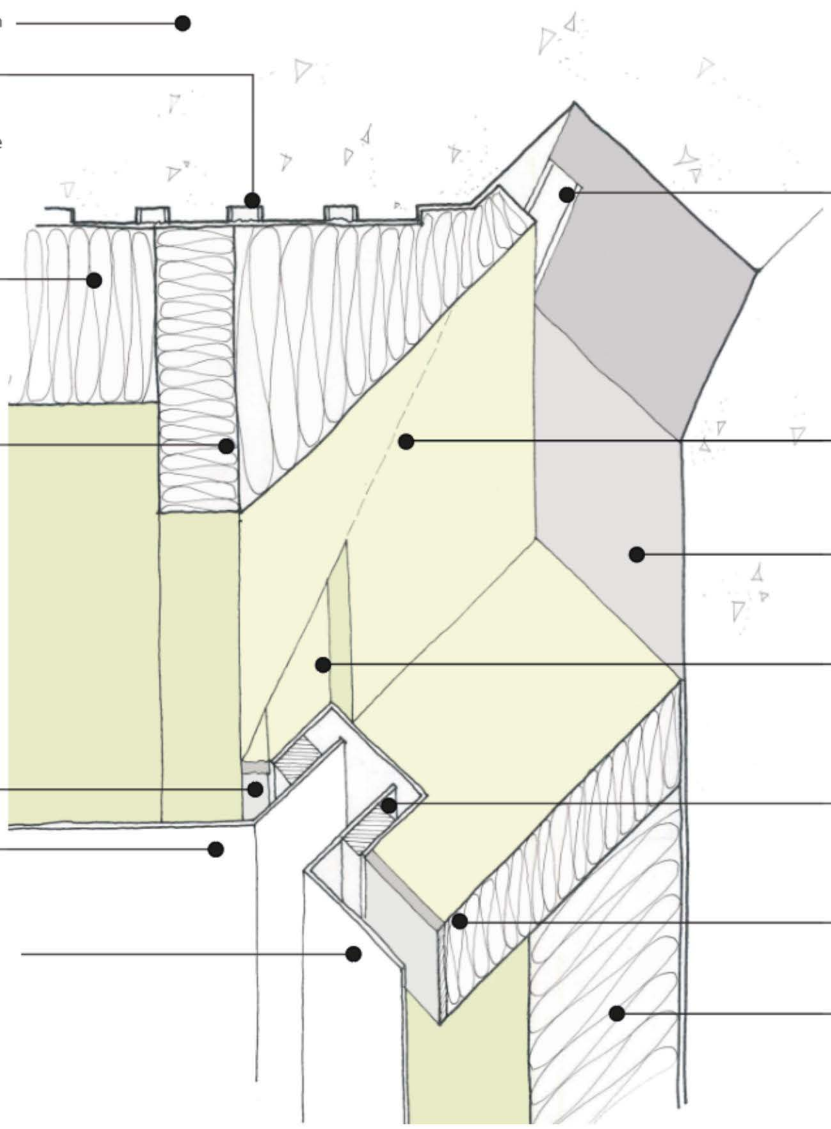


Figure 3.47: View from above of window sill horizontal proprietary cavity barrier/ window jamb cavity barrier

c) The horizontal cavity barrier would seal against the vertical cavity barrier in accordance with the standard installation recommendations and test data.

d) The detail indicates the same compressible joint seal arrangement to the concrete recess and gap between the cladding panel and vertical rail.

e) The horizontal cavity barrier at sill level (and at window head level) will need to be site cut or preferably factory made to '*negotiate*' the column and spandrel geometry.

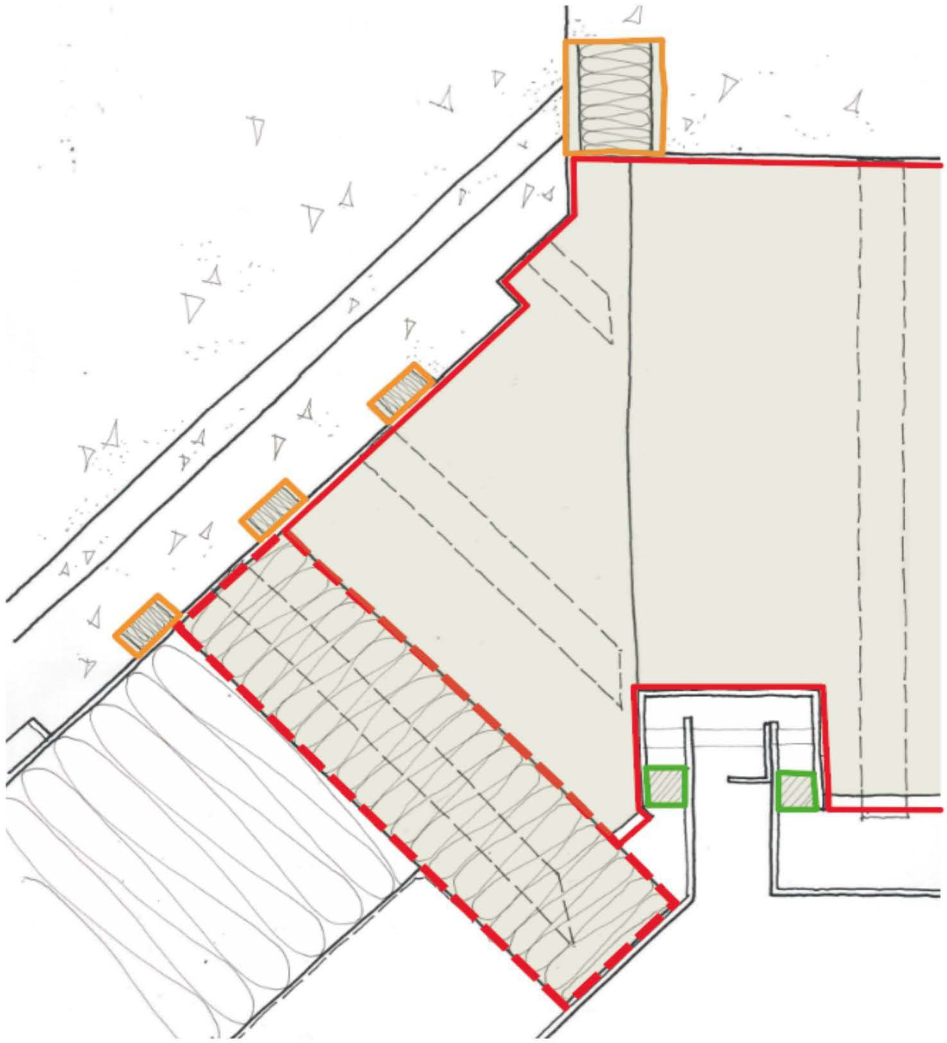
f) As at other locations, the barrier would be impaled on spiked brackets fixed back to the structure and the corner piece either provided as a bespoke factory element or cut on site prior to installation.

g) Due to the unique nature of the existing building these early detailed sketches are essential to identify problems and enable discussions with the product manufacturers and the wider design team including the Fire Engineer.

h) Following confirmation from the various manufacturers and perhaps after exploring other iterations of the arrangement, the detail would be circulated for comment to the wider design team including the Fire Engineer and Building Control.

Typical Detail 5 –Plan detail through sill horizontal cavity barrier

3.9.14 Again, I provide below a simplified diagram to show the main principles of this arrangement:



Proprietary horizontal 'open state' cavity barrier at cill level

Full height Intumescent strip bonded & mechanically fixed to vertical rail

Compressible joint seal with mineral core to recesses between column and spandrel along line of horizontal cavity barrier and trapezoidal jamb cavity barrier above

Proprietary vertical Cavity Barrier at cill level and floor to floor at compartment wall locations

Figure 3.48: Typical Detail 5 – Plan detail through sill with cavity barrier arrangement highlighted

Development of Typical Detail 6

3.9.15 Finally, I explore Detail 6 that I have identified as the last additional (non-window) condition needing study and resolution in relation to the cavity barrier strategy and installation. Again, I begin by providing a basic arrangement sketch upon which I offer a brief commentary below and then I provide a sketch which has been developed for this condition:

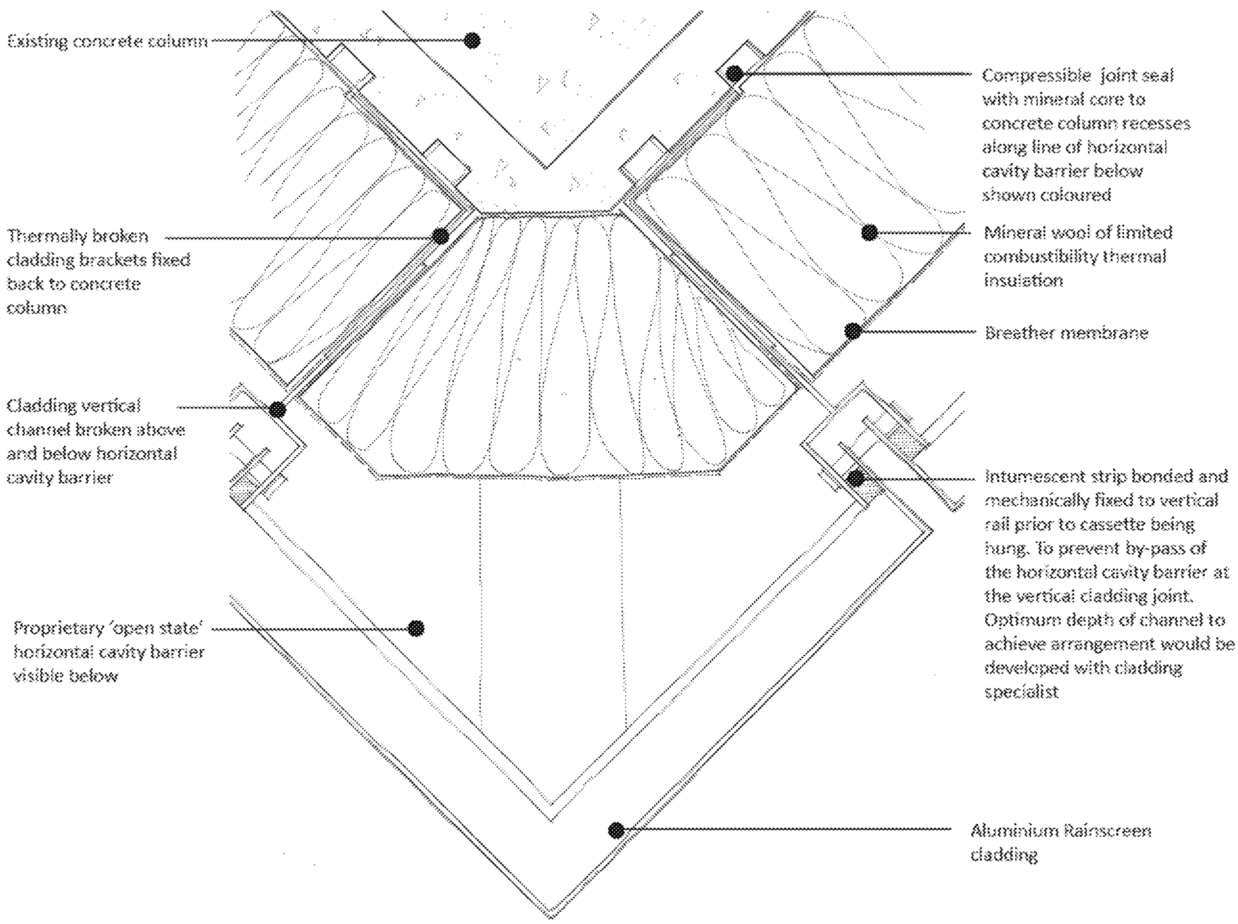


Figure 3.49: Typical Detail 6 – Plan detail through column 'nose'

a) To facilitate a continuous horizontal cavity barrier at the column '*nose*' (not provided under the Harley construction details and not addressed by the Studio E tender information) the proposal above indicates a one piece '*nose*' cladding panel with joints to the adjacent cassettes introduced at the side. (The Bay Elevations of the indicative scheme show these revised joint arrangements).

b) This has the benefit of eliminating routes for by-pass behind the cladding bracket and at the cladding rail that occur when the joint is located at the apex.

c) Compressible seals would be required at the concrete column recesses to prevent by-pass of the continuous horizontal cavity barrier. These would be sized to the same depth as the barrier and meet the same performance as the horizontal barrier.

d) Compressible seals would also be required to the gap between the vertical rail and the cladding panel cassette and would be full height and meet the same performance as the horizontal barrier.

e) The proposed arrangement would be discussed with the different manufacturers of the specified products to ensure that they could be used in the proposed manner and meet the required performance as their test date.

f) Following confirmation from the various manufactures and perhaps after exploring other iterations of the arrangement, the detail would be circulated for comment to the wider design team including the Fire Engineer and Building Control.

3.9.16 Again, simplified diagram to show the main principles of this arrangement for Detail 6 is shown below:

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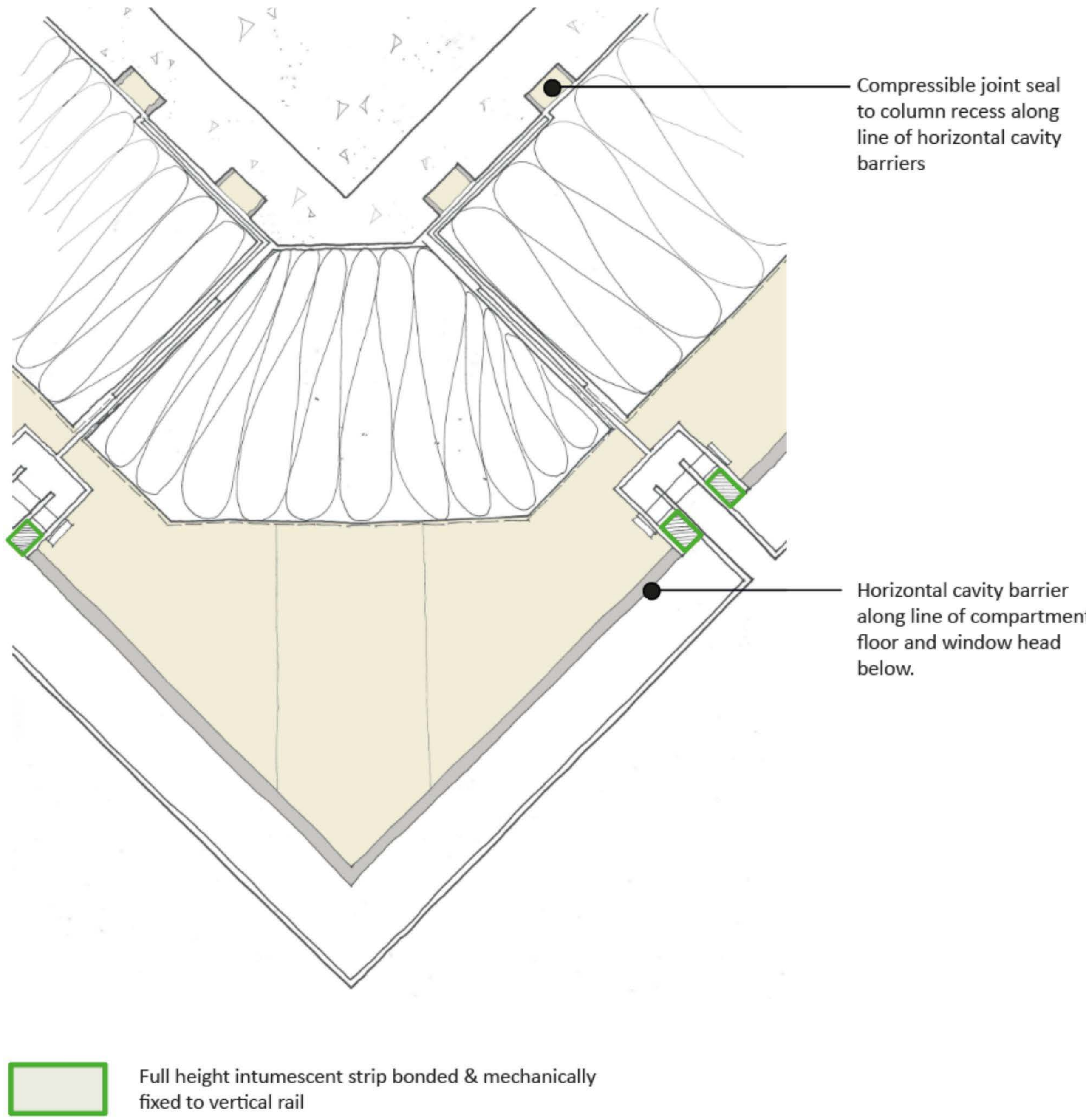


Figure 3.50: Detail 6 – Plan detail through column 'nose' with cavity barrier arrangement highlighted

a) The diagram indicates the use of the proprietary horizontal barrier in addition to the compressible seals to prevent by-pass to the vertical channel and concrete column and spandrel recesses.

b) Whilst in this location the horizontal cavity barrier is not performing the dual role of protection along the line of compartment floor and at the window opening, to facilitate an easier installation and reduce the installation of the wrong barrier in the wrong location, these would also be specified to meet a minimum performance of 60/30 Integrity/Insulation. In this way the simple principal of ALL horizontal cavity barriers to all horizontal compartmentation positions (that is along slab edges whether over windows or around columns) would be 60/30.

Summary to this Section

3.9.17 This combination of:

a) **Compartmentation Strategy:** whereby i) the incorporation of continuous cavity barriers around window openings at head, jambs and sills in order to inhibit the passage of fire (from window openings) ***into*** cavity zones and ii) the overall gridding of the building into cavity zones, which, due to the continuity of the cavity barriers which define those zones and the tightly formed seals at all junctions, inhibits the further spread of any fire from within any particular cavity zone to an adjoining cavity zone.

b) **Compartmentation Detailing:** with respect to junctions between cavity barriers where vertical and horizontal barriers meet at the corners of window openings and of cavity zones, and where cavity barriers interface with vertical cladding rails.

mean that the façades are examined holistically in terms of applying the guidance in ADB2 to the indicative scheme. This strategic and holistic approach is essential to the application of ADB2 guidance (or indeed any other approach so adopted) to an effective design solution on any project of this size and complexity.

3.9.18 This can be brought together, with the relevant details all indicated in the following mid-scale '*study*' of the four typical window bays and the section through the upper two floors, as follows:

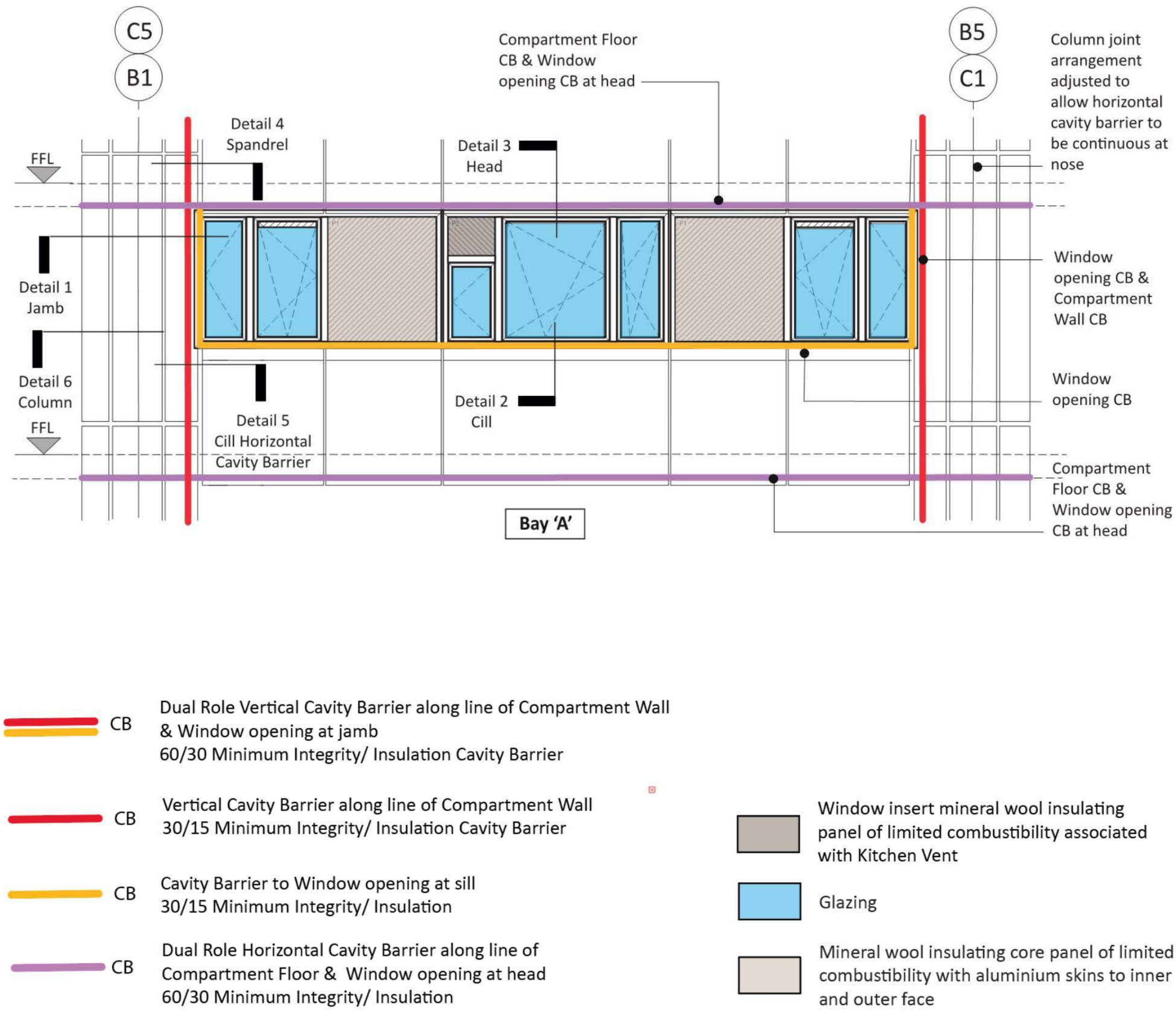


Figure 3.51: Typical elevation Bay '*A*' with cavity barriers arrangement

(Diagram produced using Harley Drawing C1059-200-I) {HAR00008581}

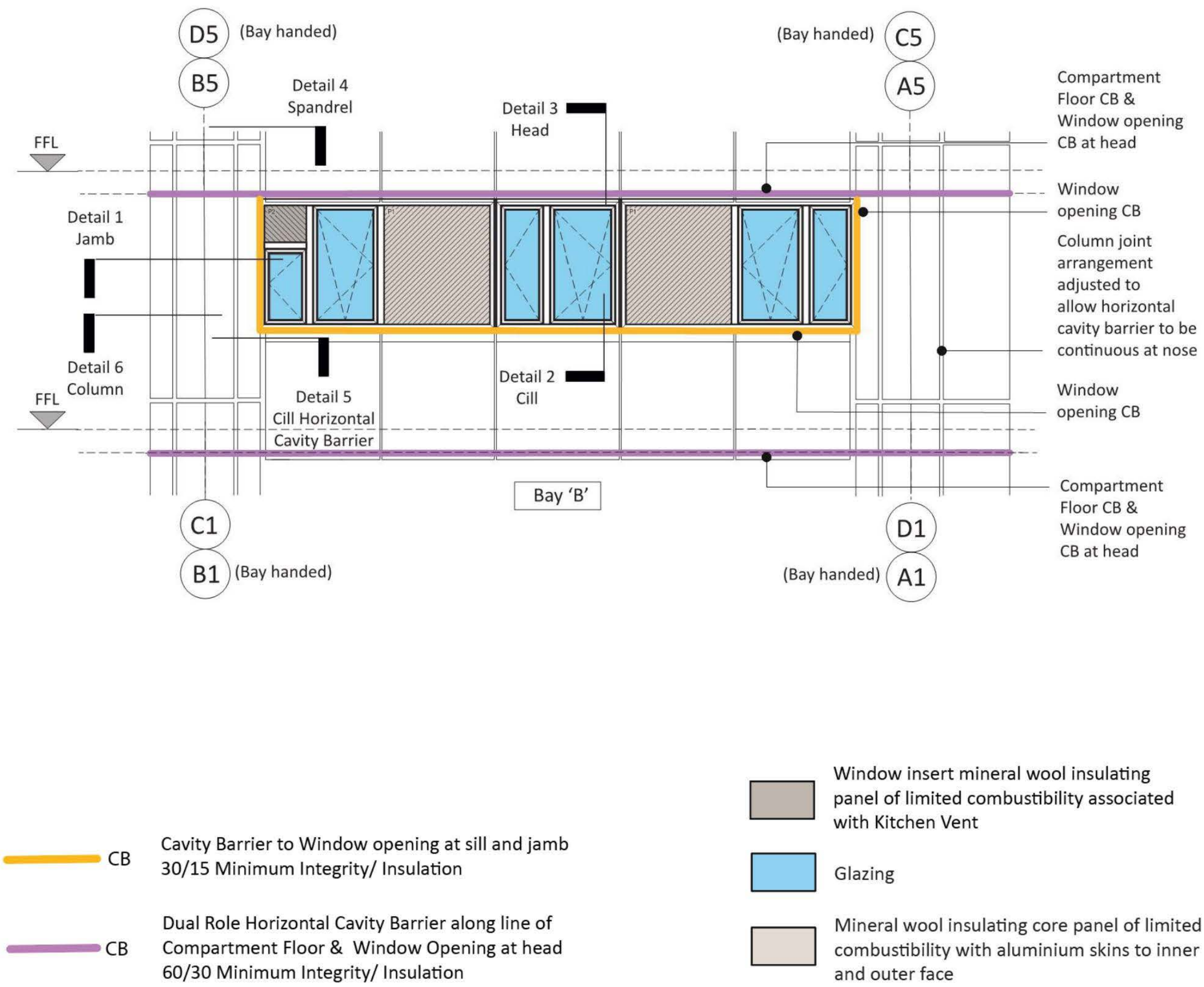
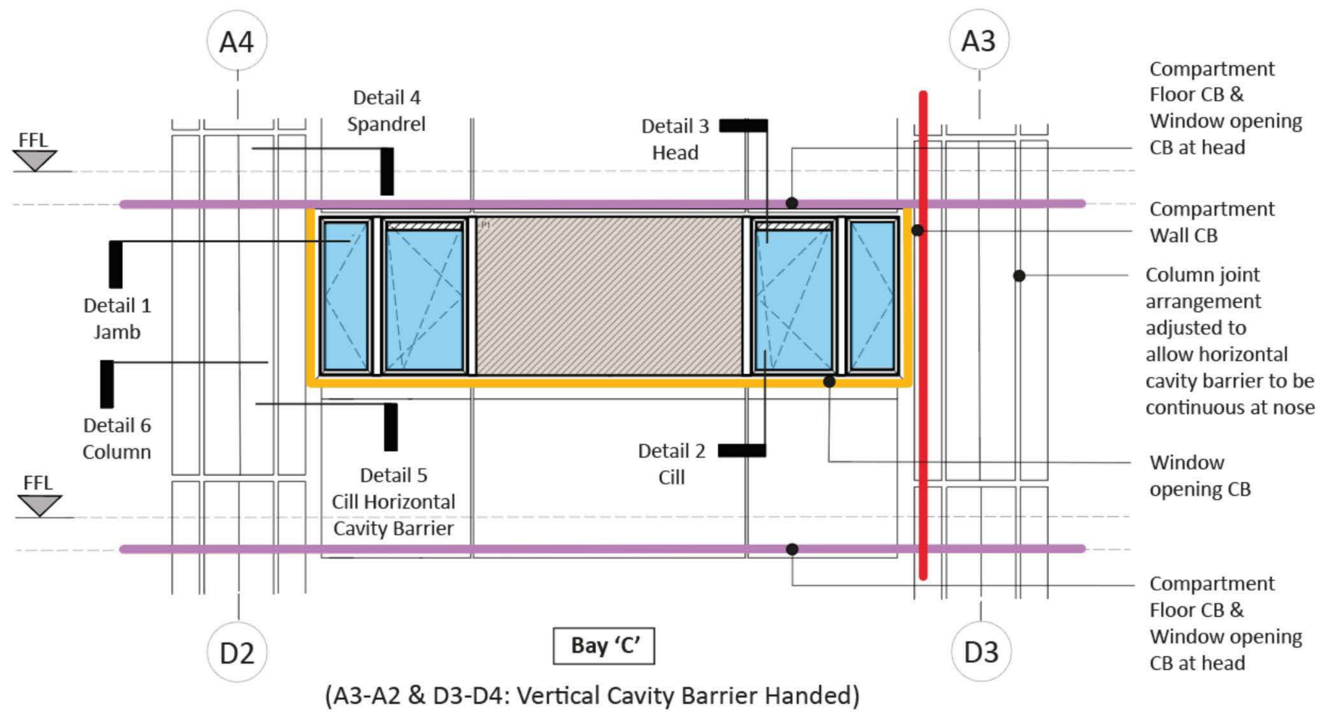


Figure 3.52: Typical elevation bay '*B*' with cavity barriers arrangement

(Diagram produced using Harley Drawing C1059-201-D) {HAR00008886}



CB — Dual Role Vertical Cavity Barrier along line of Compartment Wall and to window opening at jamb
60/30 Minimum Integrity/ Insulation Cavity Barrier

CB — Vertical Cavity Barrier along line of Compartment Wall
30/15 Minimum Integrity/ Insulation Cavity Barrier

CB — Cavity Barrier to Window opening at sill and jamb
30/15 Minimum Integrity/ Insulation

CB — Dual Role Cavity Barrier along line of Compartment Floor & Window Opening at head
60/30 Minimum Integrity/ Insulation

Glazing

Mineral wool insulating core panel of limited conbustibility with aluminium skins to inner and outer face

Figure 3.53: Typical elevation bay '*C*' with cavity barrier arrangement
(Diagram produced using Harley Drawing C1059-202-C) {HAR00009729}

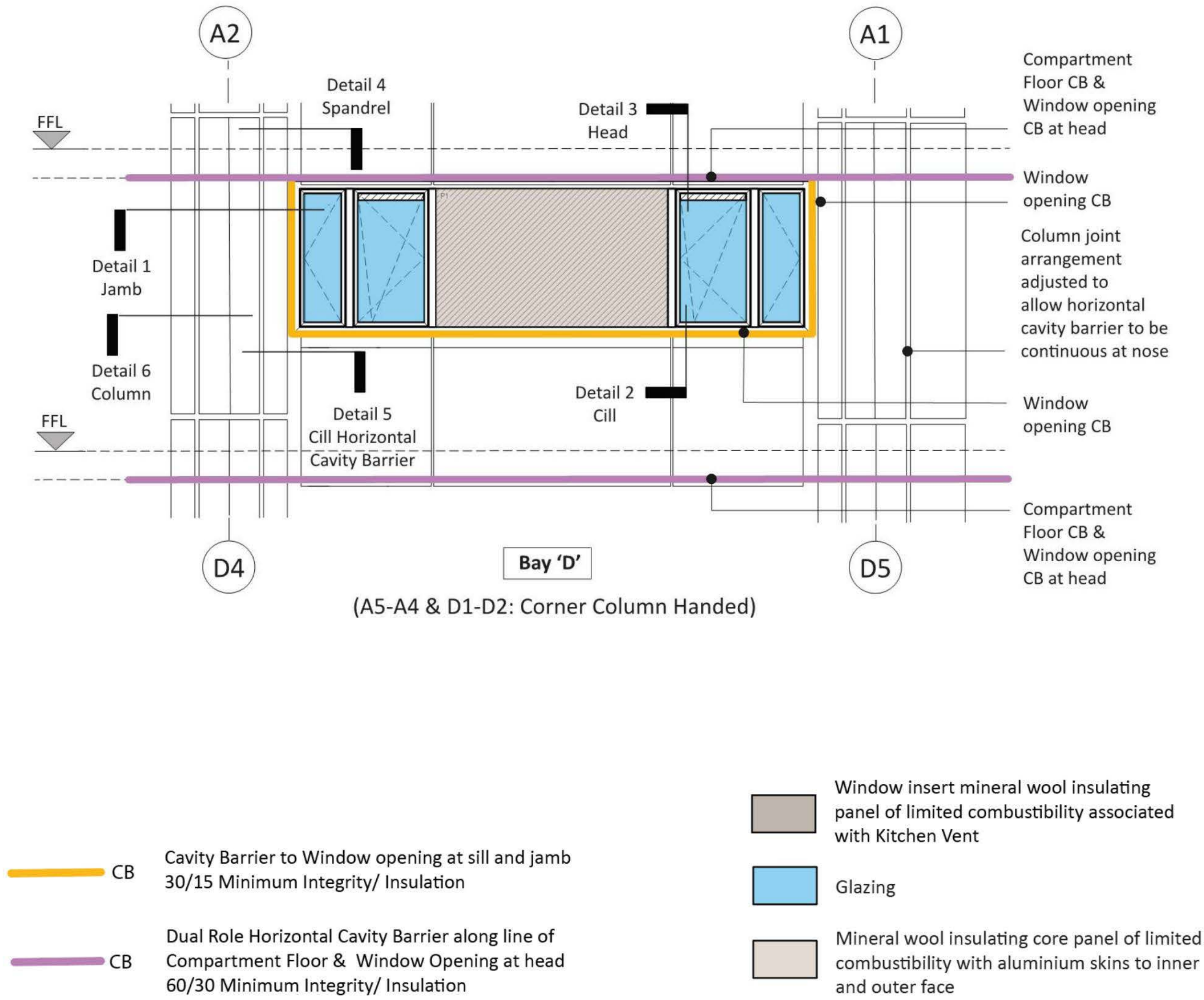


Figure 3.54: Typical elevation bay '*D*' with cavity barrier arrangement
(Diagram produced using Harley Drawing C1059-202-C) {HAR00009729}

3.9.19 Shown below are a series of diagrams which illustrate in section where the horizontal cavity barriers are located. The position selected is for the upper two flats and the Crown. An elevation and 3-dimensional drawings illustrate proposed arrangements under the indicative scheme for the Crown.

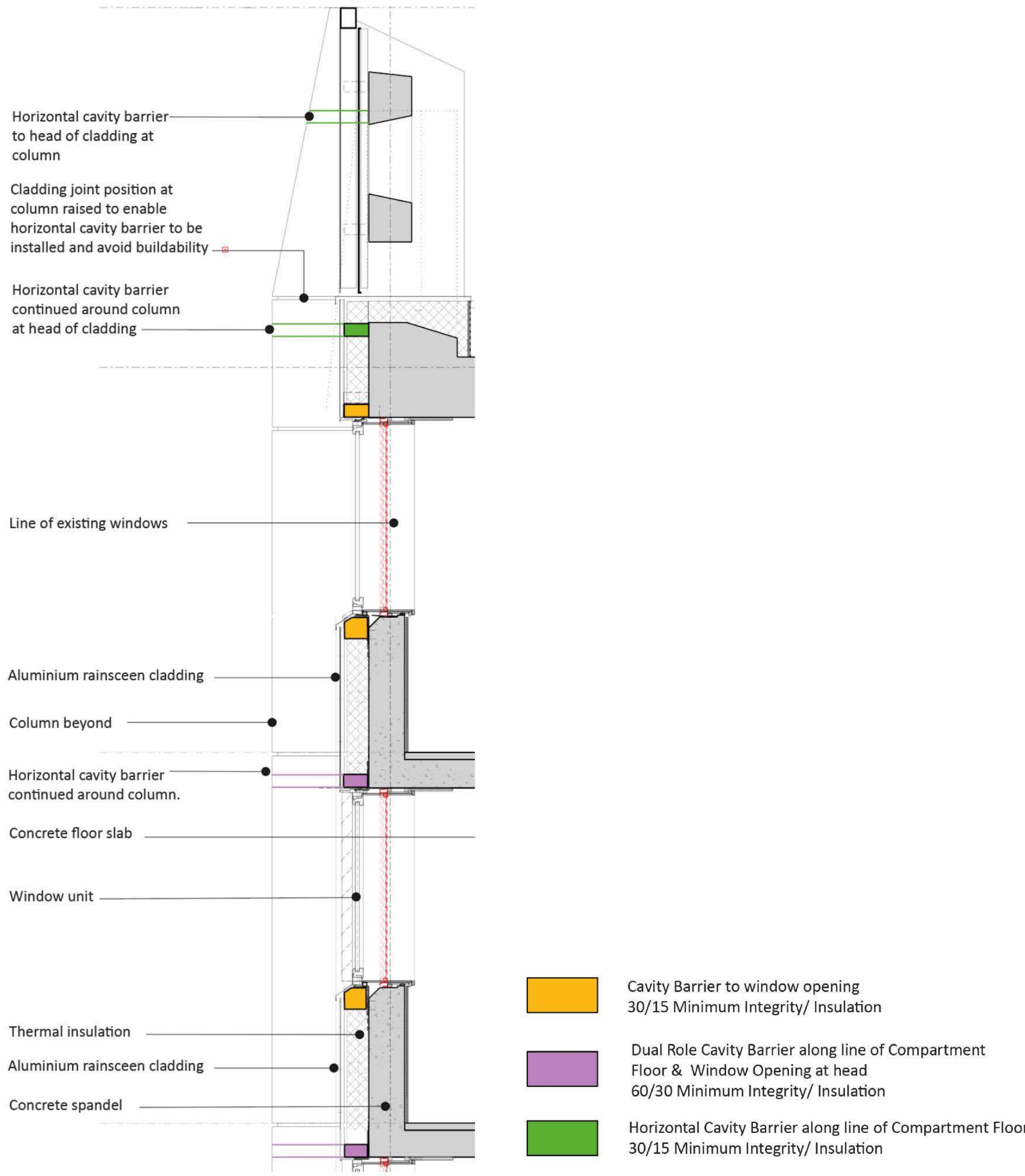


Figure 3.55: Typical section through envelope of residential floors

(Diagram produced using Studio E Drawing 1279 (06) 120 00) {SEA00002551}

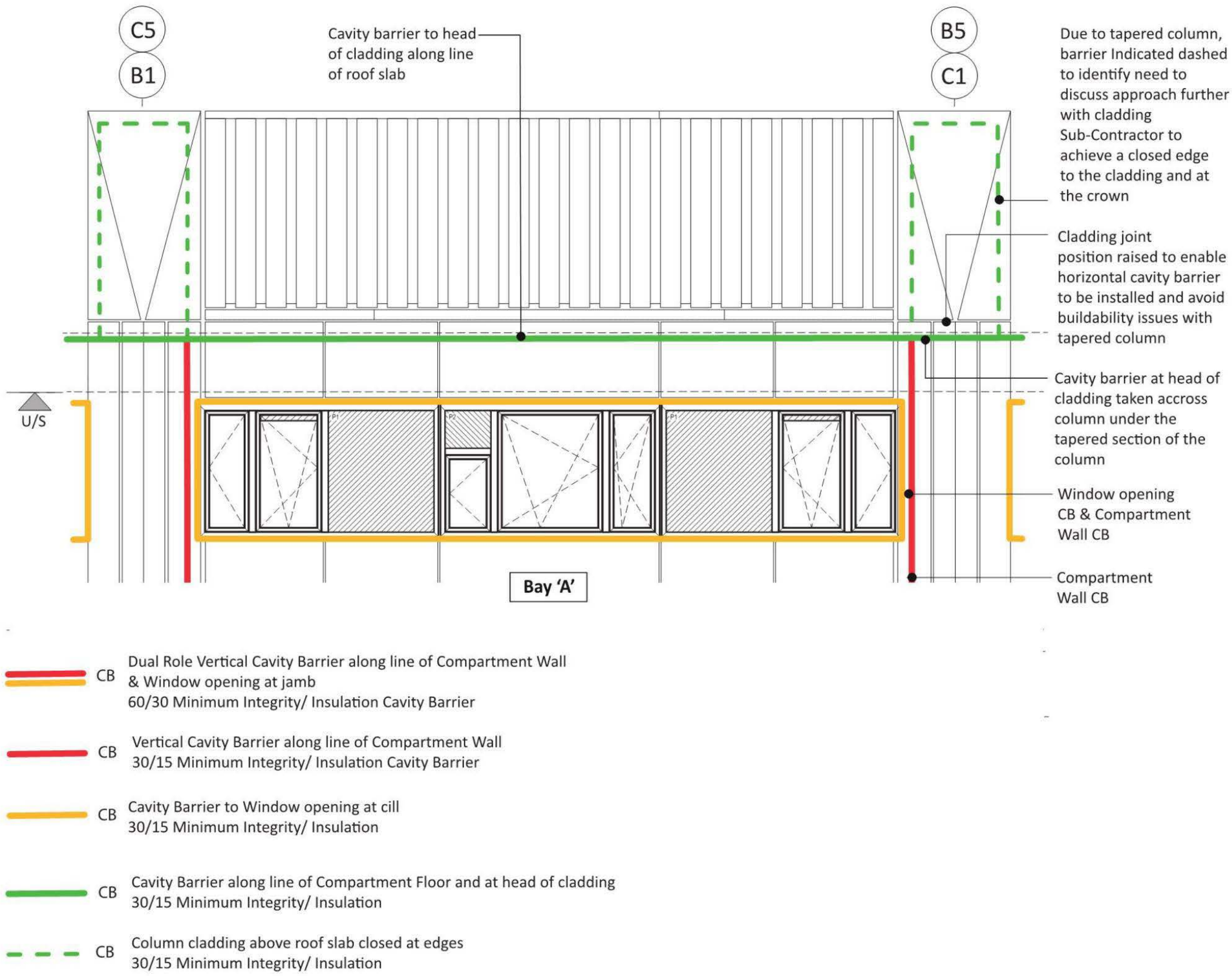


Figure 3.56: Typical bay elevation at the Crown

(Diagram produced using Harley Drawing C1059-216) {HAR00008910}

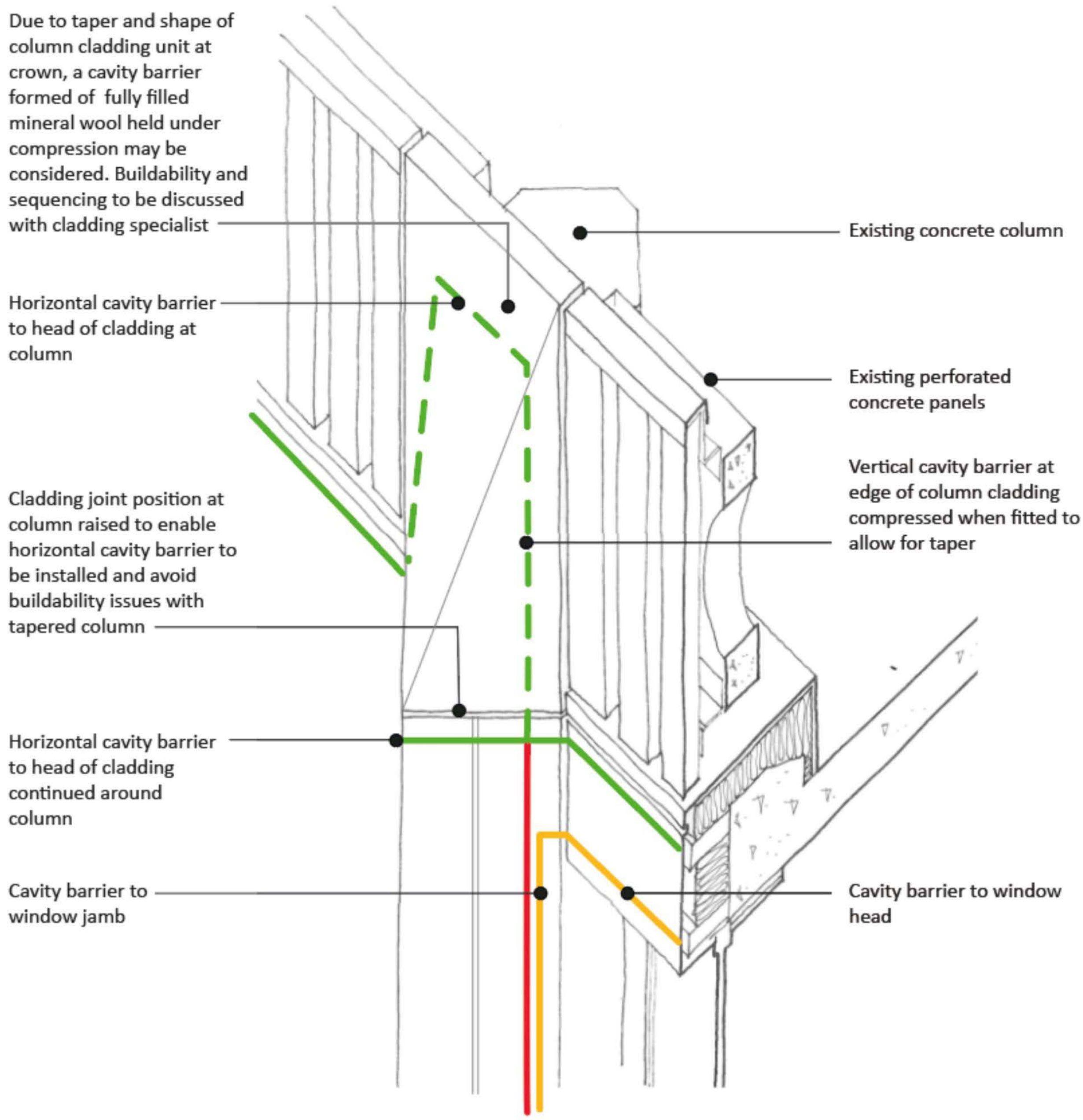


Figure 3.57: Typical view at the Crown with Cavity Barrier Requirements indicated

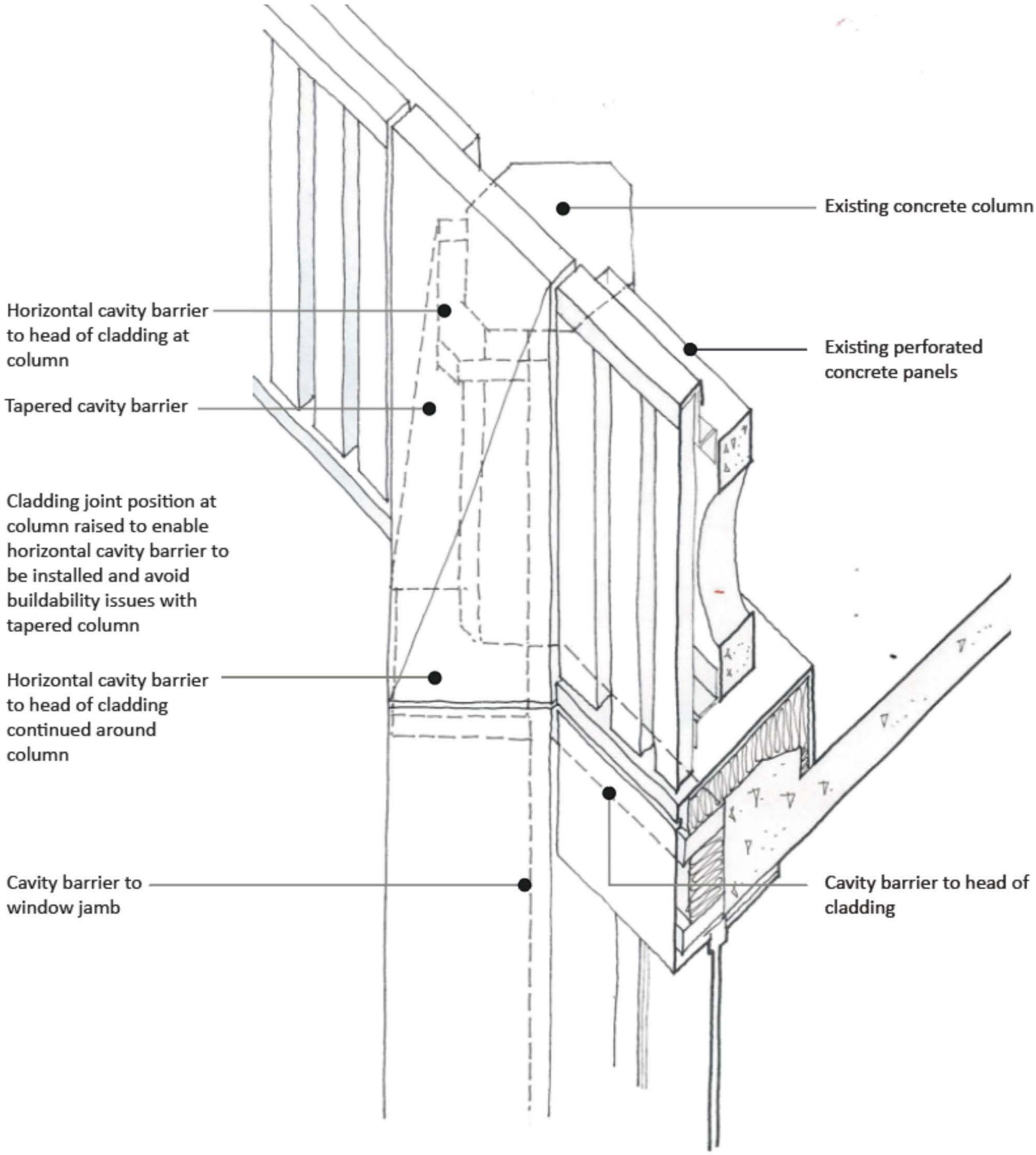


Figure 3.58: Typical view at the Crown with Hidden Detail of Cavity Barriers shown

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3.10 Discussion and Conclusions

3.10.1 Within this section I have explained the *process* that an architect would routinely go through in preparing a design for an over-cladding scheme. That process can be summed up under the following principles which are key to achieving compliance with the Guidelines of ADB2. In each case I summarise Studio E's failing in italics and indicate whether this was a failure of design, a failure of specification, a failure through omission or a combination of any or all of the three:

a) **Indicative Approach:** The insulation to the cavity behind the new rainscreen cladding is specified as mineral wool in order to comply with the requirements of limited combustibility – as indicated at ADB2 paragraph 12.7.

Studio E: From their Stage C Report {SEA00006429} onwards Studio E incorporated a PIR product which did not comply with the guidance in ADB2 that the insulation should be of 'limited combustibility'.

Opinion: Studio E specification error.

b) **Indicative Approach:** Cavity barriers are incorporated at the (extreme) edge of cavities (that is: around window openings) in order to close cavities at their immediate interface with window openings at head, jamb and sill positions, thereby to inhibit the passage of fire *into* the cavities – as indicated at ADB2 paragraph 9.3 and Diagram 33.

Studio E: Although horizontal and vertical cavity barriers were included in the tender stage specification, the drawn tender stage information that Studio E produced did not show/incorporate cavity barriers at the edge of cavities to the jambs and sill of window openings e.g. 1279 (06) 110 -00 {SEA00002499}. The head arrangement, as shown on the same drawing, albeit closer to the cavity edge was not effective so the passage of fire into the cavities at the jamb, sill and head positions was therefore not inhibited as per the guidance in ADB2.

Opinion: Studio E design error.

c) **Indicative Approach:** Tightly fitting horizontal cavity barriers are incorporated to the edge of the slabs to run continuously over (immediately above) windows and around all columns in order to maintain the horizontal compartmentation to all floors. The detailing of these ensures a tight fit and absolute continuity. This is particularly important at the junctions with the (vertical) secondary structure that supports the rainscreen cladding, at the junction with vertical cavity barriers (as indicated at ADB2 paragraph 9.2a, and implicitly under paragraph 8.6), and around the columns especially at the '*internal*' corners where spandrel panel meets column, and at the external corners of the columns (the '*nose*').

Studio E: The tender stage information that Studio E produced did not demonstrate these provisions. Although horizontal cavity barriers were included in the tender stage specification, horizontal cavity barriers were not illustrated to slab edges other than over windows, and then the drawing was at too small a scale to show the arrangements with sufficient clarity, e.g. drawing 1279 (06) 110 -00 – {SEA00002499}. The 2012-16 Works as built did not provide continuity at the interface with the secondary structure, around the columns especially at the '*internal*' corners where spandrel panel meets column, and at the external corners of the columns (the nose) and across the vertical '*grooves*' to the columns. The vertical passage of fire was therefore not inhibited at these points.

Opinion: Studio E design error/omission.

d) **Indicative Approach:** Tightly fitting vertical cavity barriers are incorporated to one side of those columns which align with compartment walls (immediately adjacent to trapezoid shaped jamb cavity barriers where they bi-pass windows). These vertical cavity barriers run continuously over the full height of the building. The detailing of these ensures a tight fit and absolute continuity both vertically and with those cavity barriers around the window openings and other horizontal barriers. (Note: On the other side of those columns, and to both sides of columns that do not align with compartment walls, the proprietary vertical cavity barriers are run adjacent to the trapezoid cavity barriers at the window jambs for only the height of the windows).

Studio E: The tender stage drawn information that Studio E produced did not demonstrate these provisions: although vertical cavity barriers were included in the tender stage specification, and some vertical cavity barriers were illustrated in plan on some Studio E details e.g. drawing 1279 (06) 110 -00 {SEA00002499}, vertical cavity barriers were omitted (not shown) at compartment wall positions on Studio E general arrangement plan drawing no. 1279 (04) 105-00 {SEA00010474}, and on Studio E's typical bay elevation within drawing no. 1279 (06) 110 -00 {SEA00002499}.

Opinion: Studio E design error/omission – whilst I would not expect all conditions to have been shown / resolved the fact that Studio E appear to have not explored any cavity barrier condition in detail is cause for serious concern and criticism. An indication of the essential principles through selected detail studies would have been undertaken by any architect applying due care and diligence at this stage.

***NOTE**: the consistent failing with respect to b) c) and d) above was that Studio E did not show clear and comprehensive arrangements which indicated a strategy by which the cavity barrier installation would comply with the guidance of ADB2 at either the macro or the micro scale.*

e) **Indicative Approach:** The cladding panels have been proposed in a way that allows the vertical joints to be closed and/or sealed so as to inhibit the passage of fire within the cavity '*around*' the horizontal barriers and into the compartment above - as indicated at ADB2 paragraph 9.2a, and implicitly under paragraph 8.6.

Studio E: The tender stage drawn information that Studio E produced did not demonstrate these provisions. The 2012-16 Works as built did not protect against the passage of fire across the horizontal cavity barrier at the junction of panels.

Opinion: Studio E design error/ omission.

f) **Indicative Approach:** The window infill panels incorporated within the Ribbon Window System are specified with a mineral wool insulation. This is necessary in order to meet the recommendations for insulation material used within the external wall to be of limited combustibility – ADB paragraph 12.7.

Studio E: The 2012-16 Works incorporated plastic surrounds and sills which created voids. These voids incorporated a PIR product which did not comply with the requirements for certification as being of '*limited combustibility*'.

Opinion: Studio E design omission

3.10.2 The above account reveals widespread failure on the part of the Studio E work (in terms of both specification and design) to meet the guidance provided within ADB2 (I provide a detailed analysis in this respect within Section 4). It is important to note that Studio E do not appear to have conducted a proper process of design development in support of the Design and Build tender process, for example I have seen no 1:5 detailed drawings for that stage within the information provided to me on my Relativity platform. It seems that Studio E placed an inappropriately high level of expectation that such work would be carried out by the appointed cladding sub-contractor. In this context I am mindful that in placing such reliance elsewhere Studio E breached the terms of their appointment with Rydon which clearly sets out the basis upon which such work was required of Studio E {RYD00094228}.

3.10.3 Much in the way of necessary detailed design work was indeed ultimately carried out by Harley but it was, in many important respects, fundamentally flawed. Had Studio E's work been properly carried out earlier as it should have been, and as shown within the guide to process set out within this section, then a) it is more likely that Harley would have subsequently got their detailed design work right and b) in checking Harley's sub-contractor drawings, as was Studio E's duty, Studio E would have had a clear basis for spotting the errors, having worked out the design principles themselves in the first instance.

3.10.4 In failing to comply with such guidance the 2012-16 Works also failed to meet the requirements of the Building Regulations in all aspects of design and specification.

3.10.5 The Studio E failings occurred at a variety of stages within the design and construction process. As examples:

a) The offending insulation was specified by Studio E at a very early stage: Studio E Stage C Report of October 2012 {SEA00006429} whilst not directly referring to Celotex does incorporate Max Fordham's Stage C Report which denotes Celotex FR5000 as the insulation material. The error was never corrected.

b) Studio E did not, at tender stage, specify the type of insulation to be incorporated into the window infill panels. Harley specified a Styrofoam (XPS) core as part of their construction documentation and Studio E appear not to have raised this matter when commenting on their drawings {HAR00004309}.

c) Whilst Studio E did specify compressible mineral wool to '*gaps*' at tender stage {SEA00010008} they did not produce any detailed drawings showing its location. Harley stipulated insulation '*by others*' behind head, jamb and sill internal linings as part of their construction documentation without naming a product {HAR00008469} {HAR00008470} and {HAR00008471}.

3.10.6 The important point in terms of each of these failings is that whilst it may be reasonable for items of lesser importance to be finalised in terms of detailed design and specification at later stages of a project, the main principles relating to the design in terms of the detailed arrangements and materials specification should be resolved by the time the project is put out to tender at least to the stage shown within the indicative approach that is illustrated above. The issues of insulation, cavity barriers, general arrangement rainscreen details and window infill panels certainly, in my view, all fell under the heading of '*main principles*'.

3.10.7 Following the appointment of the main Design and Build Contractor, and thereafter the various sub-contractors and suppliers, requests for changes to design and specification may of course be made and accepted but this often leads to very substantial variations.

3.10.8 A design for over-cladding that is prepared in compliance with the guidance given within the Approved Documents, and which is taken to the stage illustrated within the above indicative approach, should form a reliable platform for the assessment of any such proposed changes. The principles in terms of code compliance have been resolved and these should inform each subsequent stage of design and construction activity. This requires that the design must be thoroughly and properly worked out through the proper development of all necessary detailed drawings.

3.10.9 In the next section (Section 4) I will show how the design and specification developed through examination of three key stages which I call Snap-Shots:

a) Stage D Report: Aug 2013 (Snap-Shot 1)

b) Tender Documentation Nov 13-Jan 2014 (Snap-Shot 2)

c) Construction Documentation April 14-2016 (Snap-Shot 3)

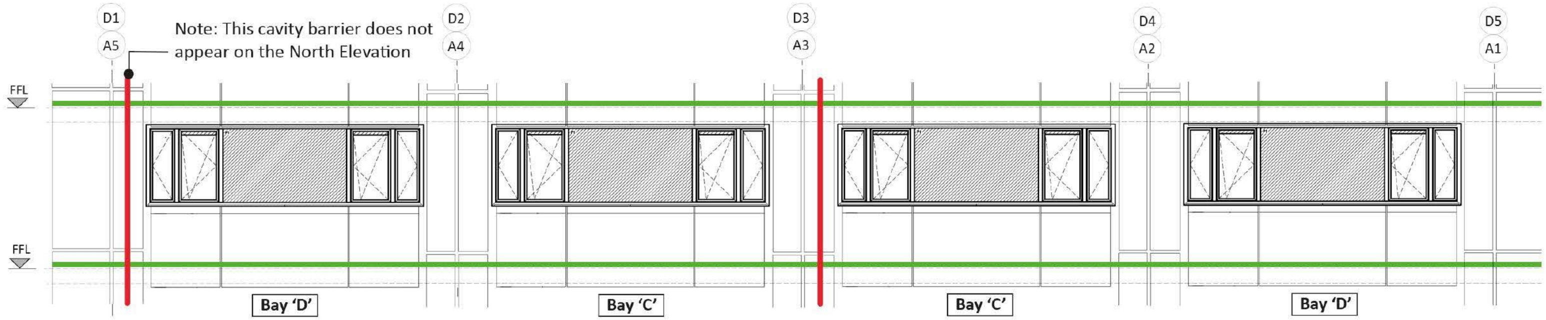
I then, under Snap-Shot 4, comment on the As-Built record drawings of May 2016

3.10.10 As a conclusion to this section I show, in landscape format, two elevations of a typical floor to the north and south façade. On the upper of these two elevations I have shown the arrangements with respect to cavity barriers as proposed by Harley and effectively endorsed by Studio E. Comparison with the drawing below, which represents the arrangements as developed for my '*indicative approach*', shows the extent to which the Harley proposal fails to meet the guidance of ADB2 with respect to cavity barriers. Of particular note is the failure of the Harley offering to provide any cavity barriers to the window surrounds. This, in consequence, meant that there was no inhibition whatsoever at head, jamb or sill to the fire passing from the openings into the cavity zones.

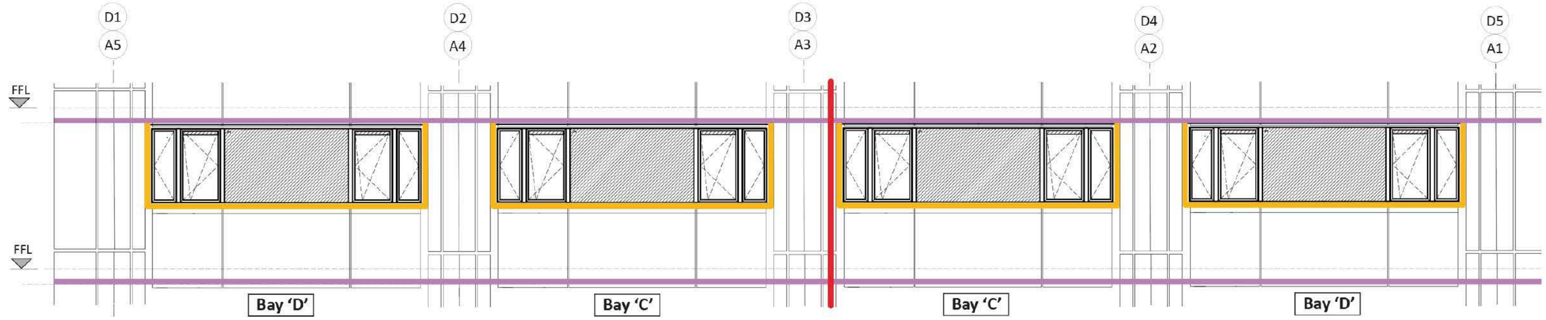
3.10.11 The next landscape drawing shows the same two elevations repeated albeit with the Harley elevation colour washed to show the extent of uninhibited fire passage from the opening into the cavity zone.

3.10.12 The small plan of a typical floor at the base of each elevation gives column references and assists with location and orientation.

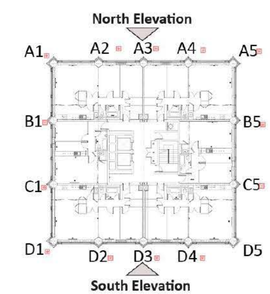
Figure 3.59: Typical Residential Floor North & South Elevations Comparing the Cavity Barrier Approach of Harley Documentation & Indicative Approach



North & South Elevations Through Typical Floor (Harley)
Marked up elevations of Harley Drawings, Bay C & Bay D {HAR00009729}



North & South Elevations Through Typical Floor (Indicative Approach based on requirements of ADB)
Marked up elevations of Harley Drawings, Bay C & Bay D {HAR00009729}



- CB Vertical Cavity Barrier along line of Compartment Wall
- CB Cavity Barrier to Window opening at sill and jamb
- CB Cavity Barrier along line of Compartment Floor
- CB Dual Role Cavity Barrier along line of Compartment Floor & Window Opening at head

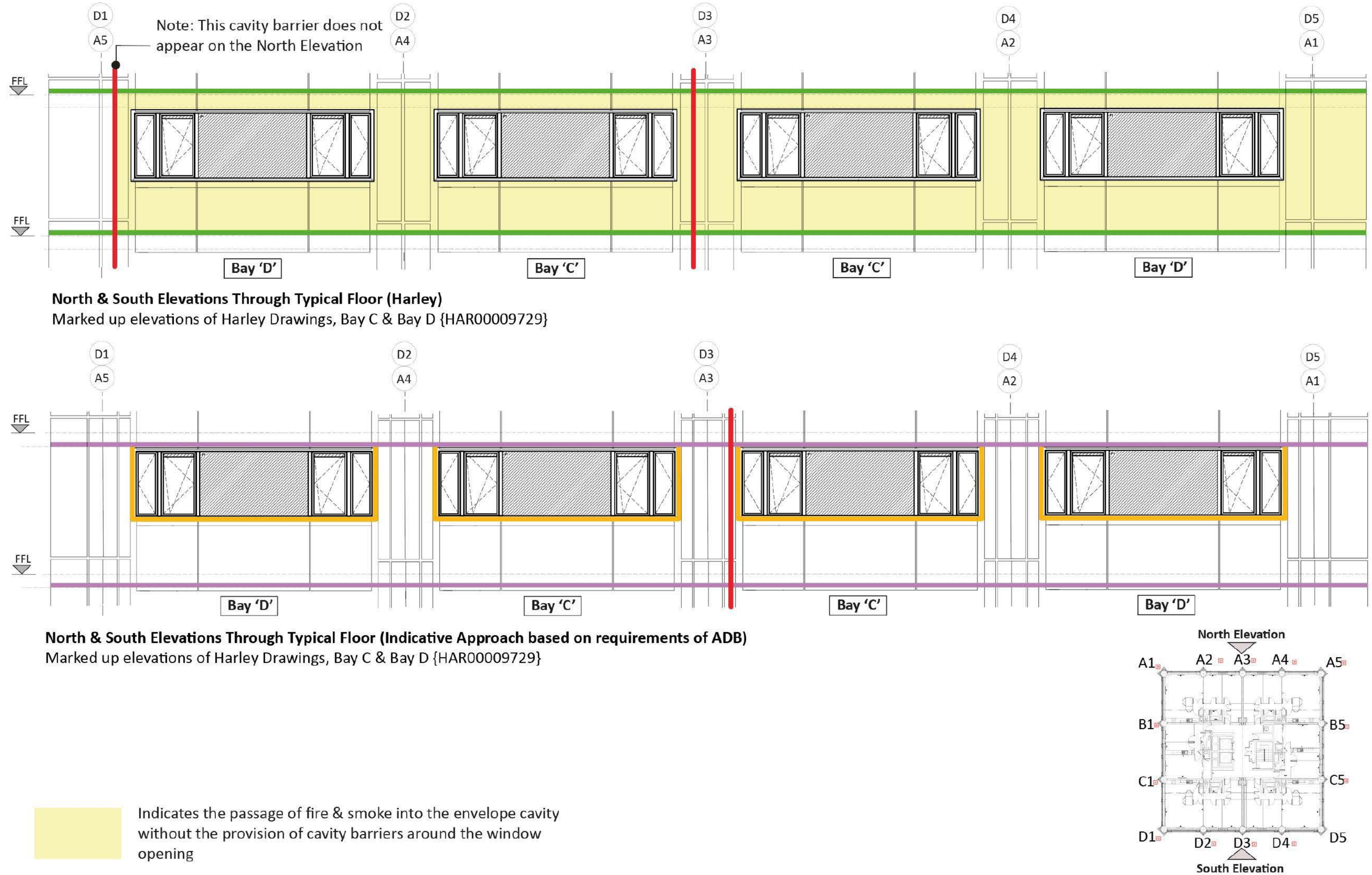


Figure 3.60: Typical Residential Floor, North & South Elevations Showing the Passage of Fire & Smoke into the Envelope Cavity Without the Provision of Window Cavity Barriers

3.10.13 I repeat the process for the East and West elevations in the landscape elevations shown below. The same consequences and commentary as applied to the North and South elevations also apply to this situation.

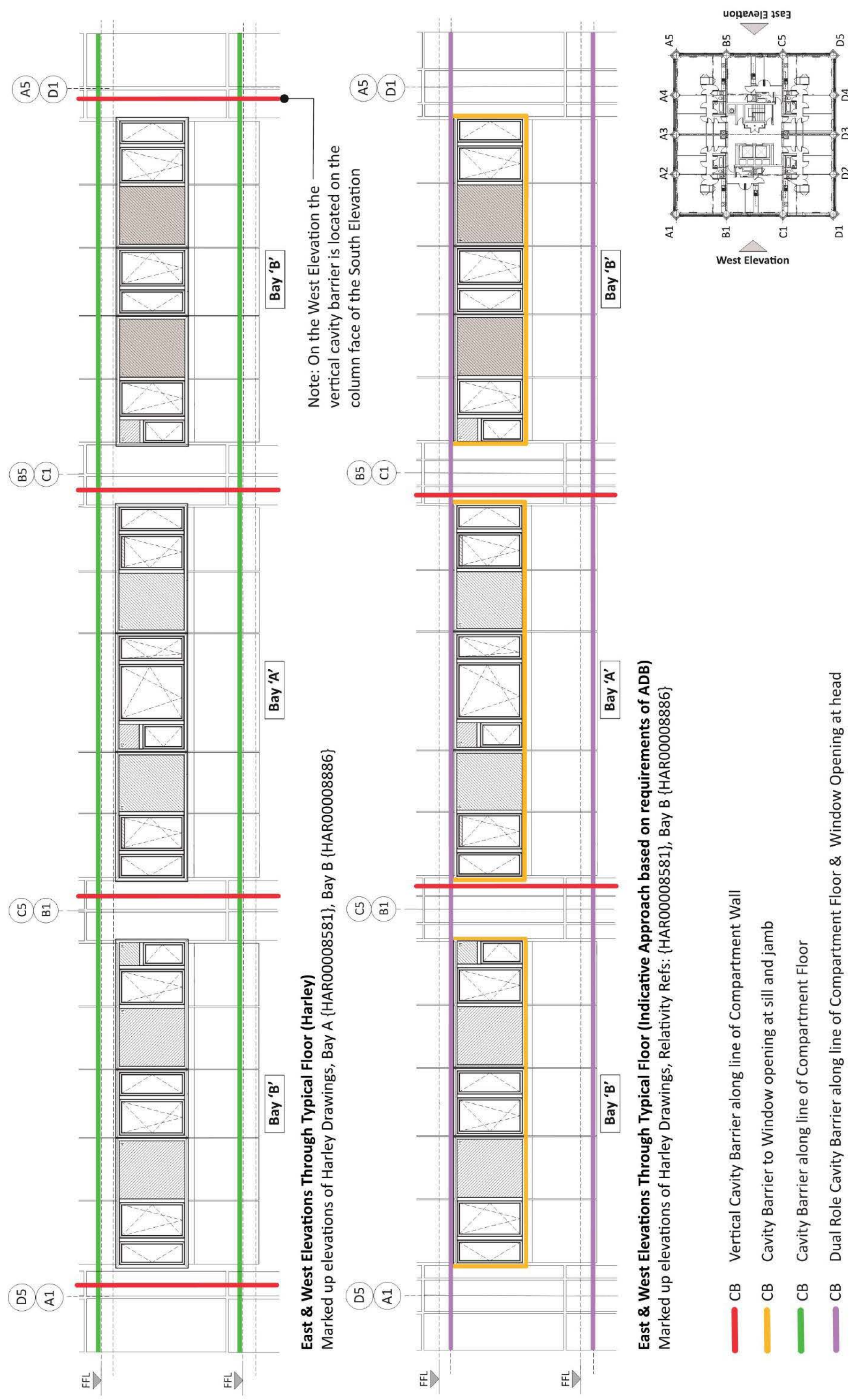


Figure 3.61: Typical Residential Floor East & West Elevations Comparing the Cavity Barrier Approach of Harley Documentation & Indicative Approach

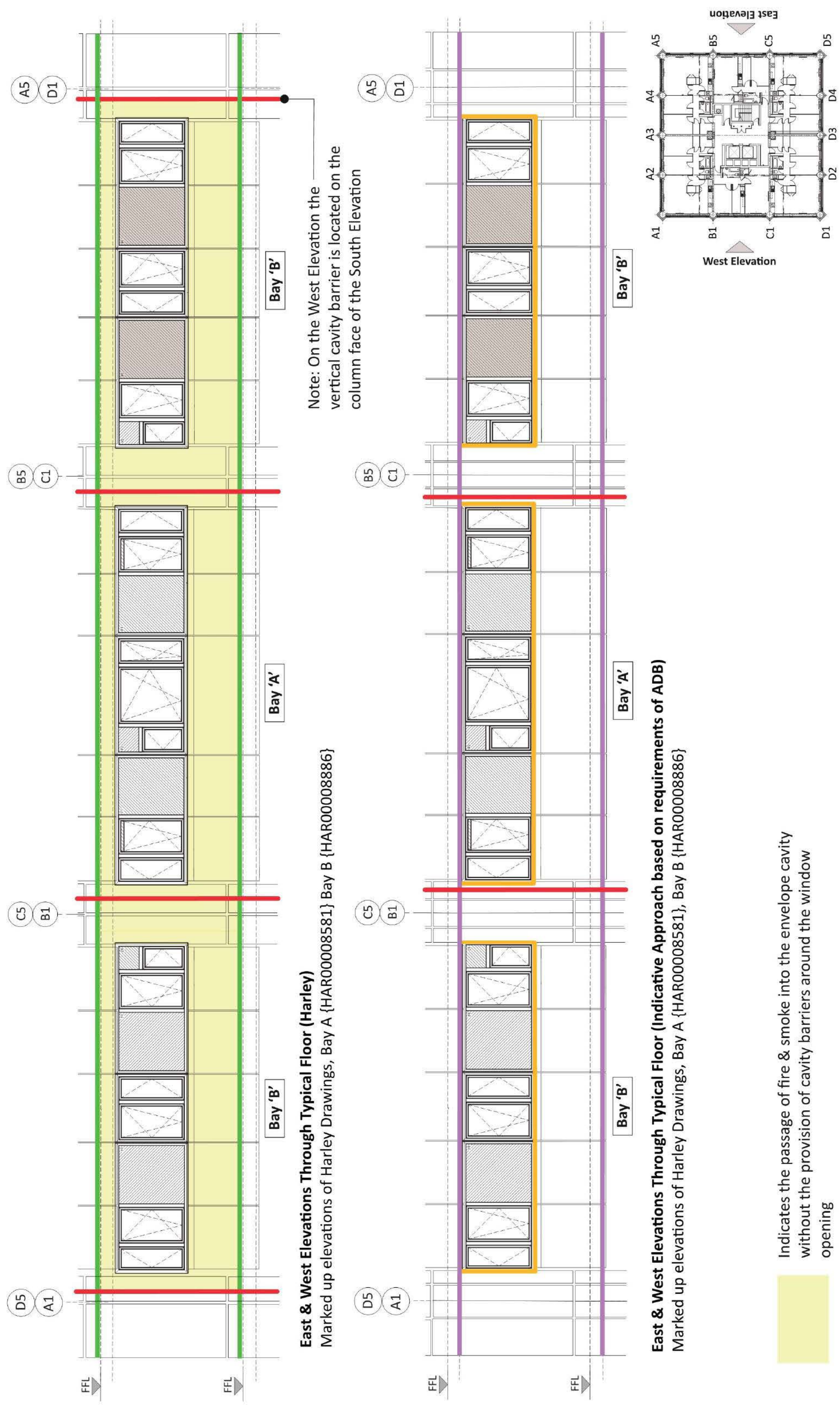


Figure 3.62: Typical Residential Floor, East & West Elevations Showing the Passage of Fire & Smoke into the Envelope Cavity Without the Provision of Window Cavity Barriers

Elevational diagrams above produced using Harley Drawing C1059-200-I {HAR00008581}, C1059-201-D {HAR00008886} and C1059-202-C {HAR00009729}

3.11 Qualification

3.11.1 This indicative approach has been developed to assist the Inquiry in its deliberations with respect to Grenfell Tower. I have sought to demonstrate how an architect would address a problem of this kind (that is over-cladding of an existing high-rise apartment tower with an original structure and construction as that at Grenfell Tower). In that process I have adopted the design approach of Studio E amended only as far as necessary to achieve what I consider to be the basis of a proposal that would meet the Building Regulations and compliance with the guidance of ADB2 as written at the time of the 2012-16 Works.

3.11.2 This work is only in outline form and would require considerable further input following dialogue with other specialist consultants and a Building Control Department in order to be developed into a robust scheme.

3.11.3 For the avoidance of doubt this should not be taken as a design that HKS Architects would adopt.

3.11.4 This work is offered only for the purposes of the Inquiry and is not to be taken as advisory in any other context.

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