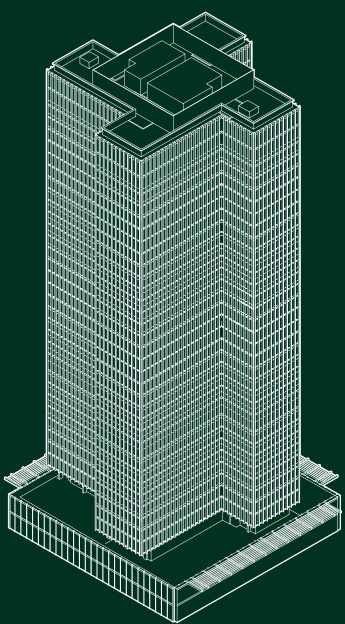

EUSTON TOWER

Feasibility Study Volume Three
Options for Retention and Extension

December 2024

British Land

Revision B | December 2024

This document supersedes Revision A submitted in December 2023. It was updated in December 2024 to reflect revisions to the proposed development, noting that the principles of the Feasibility Study are unchanged. Principally, these updates include:

- Massing updates to reflect the revised massing
- Rationalisation of the podium assumptions between options in the Feasibility Study
- Updates to the floor areas and facade areas for all options in the Feasibility Study
- Assumption of composite metal deck as the baseline floor system in the Feasibility Study
- The inclusion of detailed breakdowns and curves for WLCAs for the lab-enabled options
- Updates to all WLCAs in the Feasibility Study to reflect the changes above.

British Land
GT GARDINER &THEOBALD
3XN GXN
VELOCITY Transport Planning
SWECO
ARUP
GERALDEVE
POINT 2
Thornton Tomasetti
CBRE
DS2

Revision	Issued for	Date	Prepared by	Checked by
A	Planning Submission	06.12.2023	GXN	AOZ
B	Planning Revisions	11.12.2024	GXN	AOZ

Issue: 11 December 2024
Rev: B

Contents

Executive Summary - Volume Three

This study forms part of the design evolution and pre-application process to explore options for re-imagining Euston Tower. This document is Volume Three of a detailed, three-part feasibility study assessing, in detail and transparently, the opportunities for reuse, degrees of retention and refurbishment of the existing tower.

In Volume One the focus was on the condition of the existing tower. The study showed that significant intervention to key building elements is required to bring it up to the standard that is required by current Building Regulations and guidance, let alone the standards expected for a contemporary, high quality, flexible, and sustainable building. The resulting floorplates would be compromised and unsuitable for the Central London office market.

Notwithstanding the strong policy position against loss of commercial space, Volume Two expanded on Volume One to explore alternative uses for the tower: Office-only (continued use), Office and Laboratory, Residential and Office, Residential and Laboratory, Hotel-only, Hotel and Student Accommodation.

Regardless of use, the same primary issues identified in Volume One would need to be addressed before the building can be brought back to life. The extent of structural alterations necessary to deliver these upgrades is exacerbated in the residential (including student accommodation) mixed-use options, where each use requires two, independent escape cores. This also precludes the possibility of mixing more than two distinct use cases.

This Volume builds further on Volumes One and Two to explore solutions to make the tower work with an expanded floorplate. The extent of this floorplate is intended to be indicative, and it does not presuppose the outcome of any developments around massing.

A consolidated core layout is desirable to improve flexibility and connectivity of the floorplate. When coupled with the desire to maximise retention, this leads to a preference for a consolidated, central core. Substantial structural works would be necessary to deliver this core, including new lift shafts and new risers. Large portions of the existing floor slab would be impacted by these interventions leading to a reduction in the slab ultimately retained.

The existing floor to floor heights are challenging for delivering a high quality, flexible, and sustainable commercial building, especially one that offers the floor to ceiling heights sought by the market. By analysing 725 leasing deals conducted in Central London in the ten year period between 2012 and 2022, it was clear that occupiers lease spaces with clear ceiling heights of 2.6m or higher. Of these only five (<1%) had ceiling heights that could reasonably be achieved with the existing floor levels at Euston Tower. Resetting the floor to floor heights by strategically removing slabs is technically possible, but would bring with it significant construction complexity, temporary works, and health & safety risks, and result in disproportionately limited retention. It would result in an efficient use of the land.

Regardless of floor to floor heights, retaining significant portions of the floor slabs would constrain grid options to tie in with the existing building grid, and bake in many of the limitations of the existing structure. These limitations would inhibit floorplate flexibility and adaptability in-use, restricting options for future use and increasing the likelihood of significant further interventions (and associated carbon emissions) being required in the future.

Taking all these factors into account, this study concludes that an option that retains the substructure and core with new floor slabs is the most feasible to achieve the project vision and missions. Balancing structural retention with the constraints and construction complexity that comes with greater levels of retention, it would deliver flexible floorplates with clear spans, enabling the building to be more easily adapted to different users and uses over time, while mitigating where possible the short-term carbon impacts through deconstruction, reuse and recycling.

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Anti-freeze
LTZ 1113

13

Euston Tower

Introduction

13.1 Background

Standing as a forgotten landmark on the northern edge of central London, Euston Tower is the tallest and oldest building in the Regent's Place campus. Comprising 645,000ft^2, it was completed in 1970 as an office building to provide cellular office accommodation typical of the period, and formed part of a wider master plan known as Euston Centre.

The site falls within the London Borough of Camden, and is bounded by Euston Road to the south, Hampstead Road to the east, and the pedestrianised Regent's Place Plaza to the west. It now sits within the Knowledge Quarter Innovation District.

Since its completion in 1970, it has undergone a small refurbishment to add a secondary glazing system and perimeter fan coil system (ca. 1990), but beyond this its external form and façade remain largely as originally constructed. These elements of the building are in a generally poor condition, due to a combination of wear in use and the quality of the original detailing.

Gradually it has been vacated, and since 2021, with the exception of the retail at ground level, the building is entirely disused.

Accordingly, British Land is seeking to transform Euston Tower into a beautifully designed, sustainable, new building, delivering pioneering workspace, accessible and inclusive spaces for neighbouring communities, and support the development of the local economy. Their vision is to create a world leading science, technology and innovation building and public realm for Camden and the Knowledge Quarter that inspires, connects and creates opportunities for local people and businesses.

As a first step in the re-imagining of Euston Tower, British Land is assessing the opportunities for retention and refurbishment of the existing tower and its basement. At a high level this assessment considers the condition of the existing building and its fitness for purpose, the technical feasibility of upgrades where appropriate, alternative use cases, the economic viability of these scenarios, and options for retention and extension of the existing tower.

13.2 Revisions to the Application

There have been revisions made to the pending strategic application for full planning permission (ref. 23/5240/P), submitted in December 2023 for the proposed development.

The principal components of the 2024 revisions are detailed in the Planning Statement addendum. With respect to the Feasibility Study, the primary revision is an adjustment to the tower massing to create a simpler, rectangular form.

The Feasibility Study has been updated to reflect this revision to the proposed development, noting that the principles of the Feasibility Study are unchanged. Principally, these updates include:

- Massing updates to reflect the revised massing
- Rationalisation of the podium assumptions between options in the Feasibility Study
- Updates to the floor areas and facade areas for all options in the Feasibility Study
- Assumption of composite metal deck as the baseline floor system in the Feasibility Study
- The inclusion of detailed breakdowns and curves for WLCAs for the lab-enabled options
- Updates to all WLCAs in the Feasibility Study to reflect the changes above.

Where volumes are not impacted by the 2024 revisions, these have been left unchanged. Accordingly, the feasibility study comprises:

- Volume One - Assessing the Existing Building (unchanged from submission dated December 2023)
- Volume Two - Pathways for Alternative Uses (unchanged from submission dated December 2023)
- **Volume Three - Options for Retention and Extension (this document) (superseded by submission dated December 2024).**

13.3 Structure of this Study

This feasibility study is split into three volumes, which together form a detailed and transparent assessment of the opportunities for retention and refurbishment of the existing tower.

This document forms Volume Three of the study.

Volume One
(unchanged from submission dated December 2023)
Volume One explores, in detail, the condition of the existing tower. It considers the planning policy relating to the future use of Euston Tower, as well as market requirements for continued commercial use of the tower.

It presents an appraisal of the operation of the existing building, including an assessment of the building services.

Finally it sets out the upgrades required to comply with current legislation, based on a technical review looking at the condition of the architecture, structures, and facade.

Volume One concludes that the cost of upgrades for continued office use and the quality required would make viability challenging, and the resulting product would be compromised in the leasing market. Therefore alternative use cases should be explored.

Volume Two
(unchanged from submission dated December 2023)
Volume Two explores pathways for alternative uses within the existing tower. It studies a broad spectrum of realistic use cases, with both single- and mixed-use options, specifically:

- Office-only
- Office and lab
- Residential and office
- Residential and lab
- Residential and hotel
- Hotel-only
- Hotel and student accommodation.

It considers the policy position for each use case in turn, and how the specifics of the site and proposals are suited or unsuited thereto.

It presents stacking diagrams and test layouts, which are developed working through the implications on structures, MEP, fire, and vertical transportation.

As in Volume One, it sets out the upgrades required to comply with current legislation for each respective alternative use case.

Finally it considers the economic viability of the alternative use cases.

Volume Two concludes that only continued commercial use is appropriate, and that additional value is required to improve the viability. Therefore options that generate additional lettable area should be explored.

Volume Three (this document)
(superseded by submission dated 2024)
In response to the preceding two volumes, Volume Three explores options for retention and extension of the existing tower.

It considers commercial use only, and details several options for retaining portions of the existing tower while at the same time extending the floorplates. The options range from maximum retention and extension, through partial retention and extension retaining some floor slabs and/or the core, to new build.

The study shows how, due to the interventions required to comply with Building Regulations, there is no scenario that retains 100% of the existing structure within the existing envelope, and that accordingly the schemes should be measured against an upgraded tower.

Each option entails a different level of complexity. For each option the amount of structural salvage, the buildability and impact of temporary works is assessed. The resulting quality of space is considered looking at grid constraints and floor to ceiling heights. Finally, the impact on flexibility, adaptability, and potential to design for disassembly is studied. This is followed by a feasibility stage whole life-cycle carbon assessment of the options.

Figure 13.1 Three volumes of this feasibility study

13.4 Purpose of this Report

This study forms part of the design evolution and pre-application process to explore options for re-imagining Euston Tower. This document is Volume Three of a detailed, three-part feasibility study to assess, in detail and transparently, the opportunities for reuse, and degrees of retention and refurbishment of the existing tower.

This document is prepared in response to the requirements of the London Plan 2021, specifically policy SI 7 and its associated guidance on the circular economy, but also takes cognisance of policy D3 with regards to optimisation of site capacity. It is also aligned with the policies of the Camden Local Plan 2017 and its supplementary document: Camden Panning Guidance - Energy efficiency and adaptation which in clause 9.4 requires a condition and feasibility study, and an options appraisal for all major developments proposing substantial demolition.

This Volume builds on Volumes One and Two to explore solutions to make the tower work with an expanded floorplate. The options presented vary in degrees of structural retention (but also complexity). For each option in turn, the degree of retention is considered, as well as the level of future-proofing delivered by each option. The impact on buildability, driven by factors such as complexity of construction methodology, temporary works, and health & safety is assessed. Finally the efficiency of each option is also considered.

Section 14 explores and builds on the market commentary presented in Volume One. It shows how demand in the high-end office space is sensitive to clear floor to ceiling heights, especially for larger floorplates, and the impact of floorplate size on daylighting.

Section 15 presents a study that sets the baseline for maximum possible retention. Due to the upgrades required to comply with Building Regulations, it is not possible to retain 100% of the existing structure, and this new baseline should be used as the measure for comparisons with the options presented in later sections.

Sections 16 and 17 present the options study complete with feasibility level whole life-cycle carbon assessments. They set out the overarching considerations and parameters, and then step through each of the options in turn, Finally, they present a brief conclusion to this part of the study, showing that a solution that retains the core and foundation is the most suitable option. While subjective, this option offers the best balance of structural retention and buildability, and delivers floorplates that would be flexible and adaptable to future needs. It is acknowledged that more retention would result in lower upfront carbon emissions today, but to do so would bake in many of the adaptability limitations of the current structure, increasing the risk of further interventions (and their associated carbon emissions) being required in the medium-term future.

Section 18 outlines how resource efficiency will be addressed through the building's life-cycle, as well as the steps taken to future proof the building and reduce future waste.

The aim of this study is to outline and explore the various factors — technical, economic, policy-driven, market demand, etc. — that inform a re-imagining of Euston Tower. Together with London Borough of Camden and its stakeholders, this will allow for an informed, fact-based decision to be made for Euston Tower's future. A future which realises British Land's vision to create a world leading science, technology, and innovation building and public realm for Camden and the Knowledge Quarter that inspires, connects, and creates opportunities for local people and businesses.

13.5 Project Team

Client	British Land
Project Manager	Gardiner & Theobald
Cost Manager	Gardiner & Theobald
Architect	3XN Architects
Executive Architect	Adamson Associates
Planning Consultant	Gerald Eve
Structural Engineer	Arup
Services Engineer	Arup
Fire Engineer	Arup
Wind	Arup
Transport & Servicing	Velocity
Lifting Consultant	SWECO (with input from Arup)
Facade Consultant	Thornton Tomasetti (with input from Arup)
Sustainability Strategy	GXN
Sustainability Consultant	SWECO
Daylight	Point2
Market Analysis	CBRE
Financial Viability	DS2

14

Euston Tower

Lettability & Daylighting

14.1 Impact of Floor to Ceiling Heights

14.1.1 Feasibility Volume One Market Summary

In Feasibility Volume One, a thorough analysis of the market conditions was undertaken.

It showed that a "flight to quality" was evident in the market. Driven by more stringent corporate ESG requirements from tenants, there is an increased desire by large office occupiers to acquire high quality buildings, those that satisfy the latest guidance and achieve top certifications like BREEAM, WELL, and NABERS.

Floor to ceiling height plays an integral part in lettability, with occupiers displaying clear preference for BCO-compliant spaces.

14.1.2 Lettability

The floor to ceiling heights (and by implication floor to floor heights) are a critical factor in determining the feasibility of retaining elements of the existing structure. Indeed regardless of the intervention, it is crucial that the space delivered is attractive to the market, and eminently lettable.

In its Guide to Specification, The British Council for Offices (BCO) recommends floor to ceiling clear heights. For new-build it recommends 2.6 - 2.8m, while for refurbishment the recommendation is 2.45 - 2.8m.

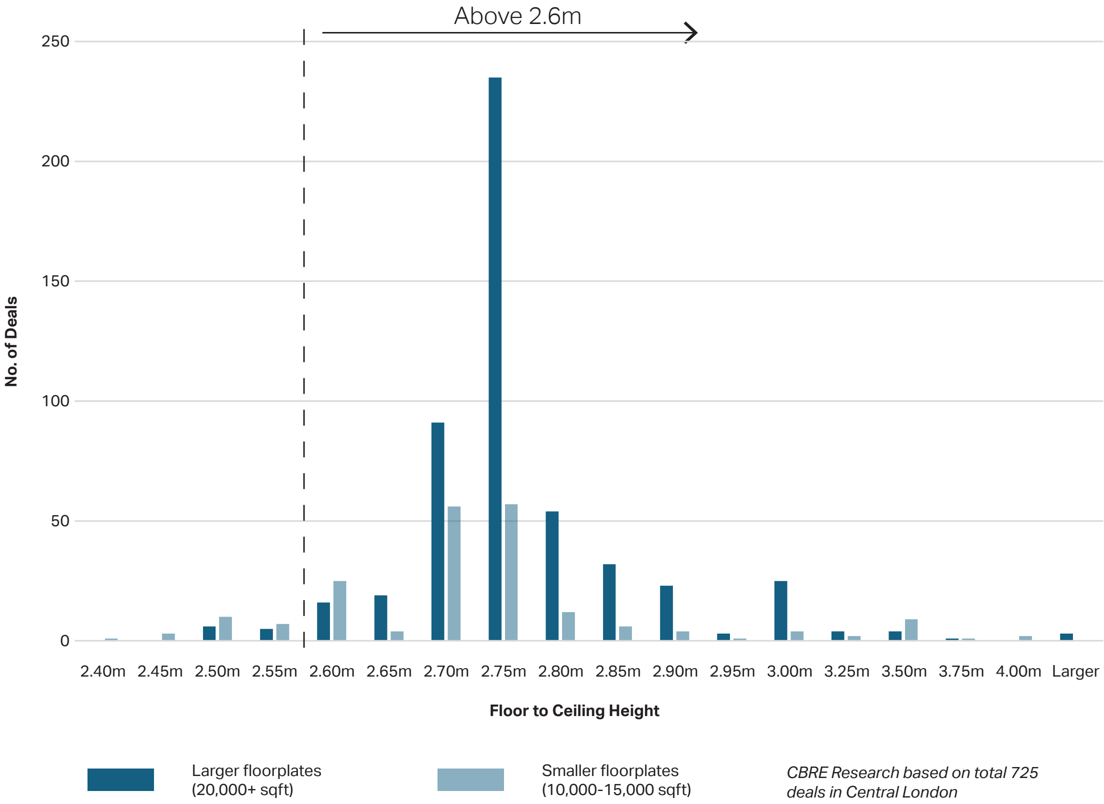
The existing floor to ceiling heights at Euston Tower sit outside of this range for new build (existing floor to ceiling is 2.5m).

For refurbishment, the existing clear height is already at the lower end, and would be reduced with the introduction of modern services which are required. Without a ceiling, it would be possible to achieve the lower range of the floor to ceiling heights in limited areas, noting that significant areas would be compromised and/or non-compliant. With a ceiling included, the floor to ceiling heights would fail to meet the recommendations of the BCO across extensive portions of the floorplate (the room sections are shown in Feasibility Volume One Section 6.4).

The evidence suggests that the market demands significantly taller floor to ceiling heights than currently exist at Euston Tower, especially for larger floorplates at the higher end of the market.

In the analysis in Volume One, 725 central London leasing deals were analysed for the ten year period between 2012 and 2022. The analysis considered both smaller floorplates (10,000-15,000 sqft) and larger floorplates (20,000+ sqft). Across all deals there are only five deals in this analysis for the floor to ceiling height that could reasonably be achieved with or without a ceiling zone within the existing structure at Euston Tower (0.5% of all deals analysed). Refer to the summary in Figure 14.1. The implication is that occupiers in Central London lease spaces with floor to ceiling heights of at least 2.6m, or preferably higher. The existing slab levels at Euston Tower do not allow this, and the risk is exacerbated due to the quantum of floor area at Euston Tower.

No. of Deals by Floor to Ceiling Height (Smaller and Larger Floorplates)



No. of Deals by Floor to Ceiling Height (Smaller and Larger Floorplates)

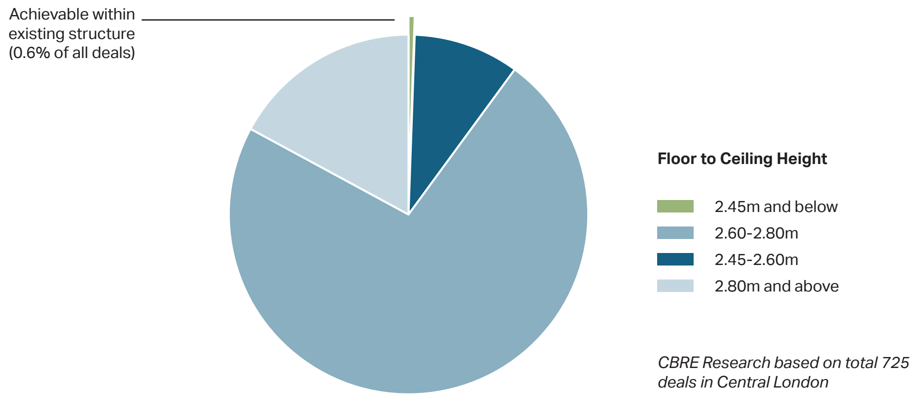


Figure 14.1 Summary of leasing data from Volume One

14.1.3 Daylighting

One of the drivers for the clear floor to ceiling heights recommended in the BCO guidance, is to help ensure good daylighting, which is important for the health and well-being of occupiers. Noting that floor to ceiling height is one of many parameters that affects daylight performance (others include: context, floorplate depth, facade design, etc.).

It is clear from the conclusions of Feasibility Volumes One and Two, that only continued commercial use is appropriate for the building, and that options that generate additional lettable area should be explored to improve viability.

A daylighting study was conducted to establish the impact of extending the floorplates on daylighting performance. The following options were assessed where in all cases the building is upgraded to meet current building regulations (i.e. additional ventilation, risers, firefighting lifts, etc.):

- Existing floorplate
- Existing floorplate with 1m extension
- Existing floorplate with 3m extension.

The methodology used was as per *BRE Site Layout Planning for Daylight and Sunlight: a guide to good practice (BRE209 2022).* Assumptions used in the assessments are as per Figure 14.2. The recommendation for daylight performance is F_{plane} 50% above E_T 300lux for 50% of daylight hours (BS EN 17037).

It was concluded in Feasibility Volume One that, regardless of the development option pursed, the existing facade requires replacing. Accordingly, all daylighting assessments assume the same, new facade with assumptions as per Figure 14.2, and internal ceiling heights as per the upgraded options in Volume One Section 7.4 (see Figure 14.3).

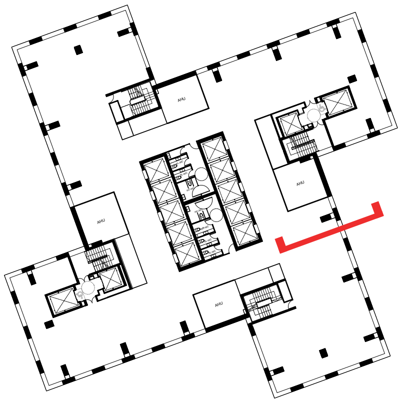
The results are shown in Figure 14.5. It is clear that the daylight performance drops off significantly, even with a 1m extension. Noting that this is unlikely to generate enough lettable area to significantly improve viability. This is because the "good" daylight zone* is typically limited to a relatively narrow band at the perimeter (see indicative section in Figure 14.4). One way to improve the daylight penetration of this "good" zone, is to increase the floor to ceiling height.

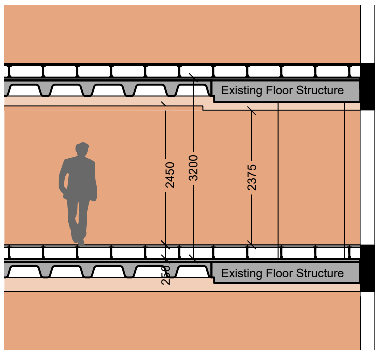
Software		SOL
Methodology		BRE Site Layout Planning for Daylight and Sunlight: a guide to good practice (BRE209 2022)
Assessment plane		850mm working plane
Grid size		500mm square grid
Weather data		CIBSE WCT16SET
Sky model		Perez
Method		2 phase at 60min intervals
Reflectances		
	Partitions	0.7
	Floors	0.4
	Ceilings	0.8
	Reveals (int)	0.7
	Reveals (ext)	0.2
Windows		
	VLT	60%
	Maintenance	8%
	Frame	8%
	Geometry	Floor to ceiling at 50% WWR

Figure 14.2 Assumptions used for daylighting studies

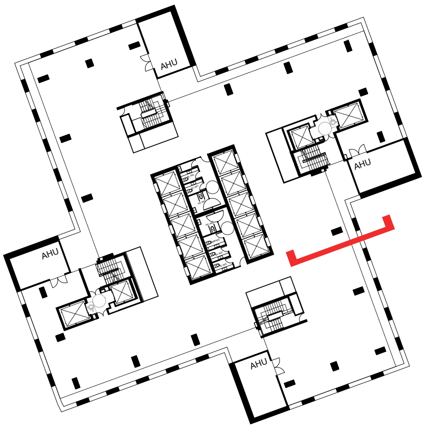
** "Good" daylight be considered approximately 300 lux illuminance at the working plane*

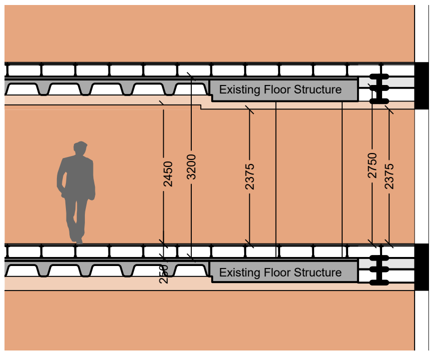
Existing floorplan



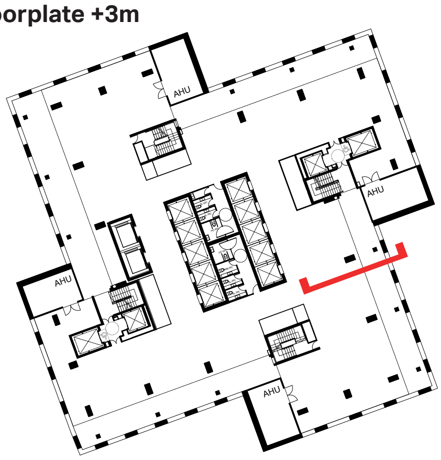


Existing floorplan +1m





Existing floorplan +3m



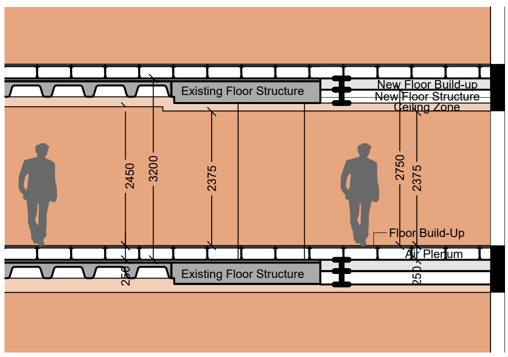


Figure 14.3 Floorplate layouts and sections assessed for daylighting studies

In the layouts in Figure 14.3, it is important that the AHU rooms are on the facade to eradicate the need for supply / extract ductwork across the floorplate.

The results are shown in Figure 14.5. It is clear that the daylight performance drops off significantly, even with a 1m extension. Noting that this is unlikely to generate enough lettable area to significantly improve viability. As stated above, this is because there are limits to the "good" daylight zone, and in this case it is exacerbated because of the bulkhead in the extensions that impinges on the daylight zone in the facade.

Increasing the glazing ratio would help to improve daylight performance, but this must be balanced with solar gains to avoid unnecessary cooling energy demand. The current WWR of 50% is on the upper end for a pragmatic low energy facade. Similarly, an increased visual light transmittance (VLT) would improve daylighting but comes with an increased g-value resulting in increased solar heat gains. Strategies like higher reflectances, light shelves, etc. are not considered feasible as they are thought to be too restrictive to potential occupiers.

One feasible way to improve the daylight penetration of the "good" daylighting zone, is to increase the floor to ceiling height.

As a means of testing this, two additional studies were conducted, where in all cases the building is upgraded to meet current building regulations (i.e. additional ventilation, risers, firefighting lifts, etc.):

- Expanded floorplate at 3.2m floor to floor height
- Expanded floorplate at 3.8m floor to floor height.

Apart from the increased floor to floor heights, everything else is identical between the two studies. All assumptions are as per those detailed in Figure 14.2.

The results, shown in Revision A of this document, showed clearly that the increase in floor to floor height from 3.2m to 3.8m increased the daylight penetration. With the extension there was also more useful floor area in the "good" daylight zone, as much of the core could be consolidated within the central area, and only the AHU rooms were needed at the facade.

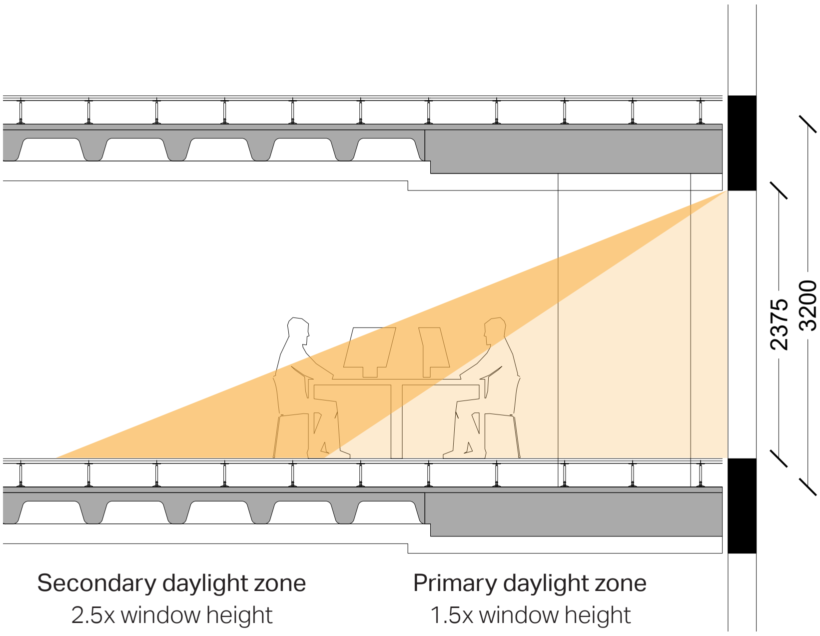
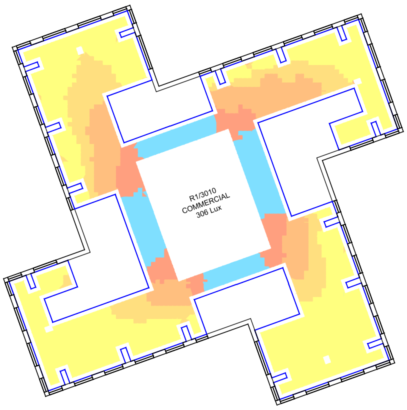


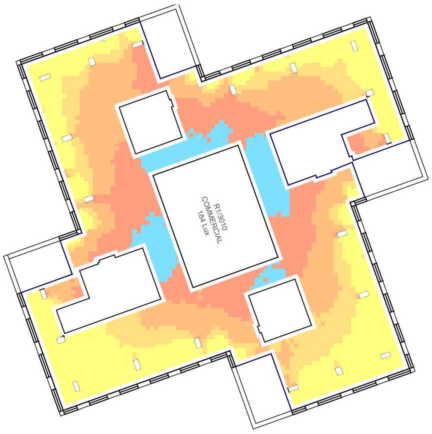
Figure 14.4 Indicative sketch showing good daylight zone (Schumann et al., 2013). For side lit spaces, this zone is limited to the perimeter as indicated

Existing floorplate



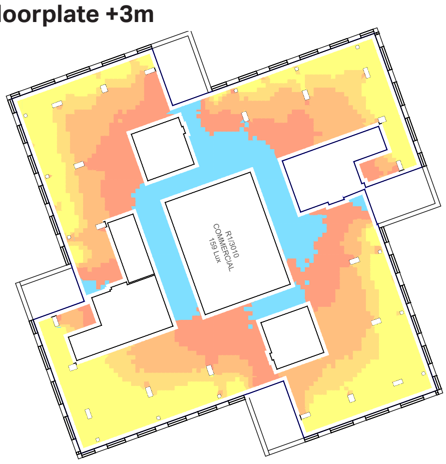
Floor to floor	3.2m
Floor to ceiling	2.375-2.450m
Facade	New with 50% WWR
E_T	300lux
F_{plane}	51%
Well daylit area	~341m^2

Existing floorplate +1m



Floor to floor	3.2m
Floor to ceiling	2.375-2.450m
Facade	New with 50% WWR
E_T	300lux
F_{plane}	32%
Well daylit area	~290m^2

Existing floorplate +3m



Floor to floor	3.2m
Floor to ceiling	2.375-2.450m
Facade	New with 50% WWR
E_T	300lux
F_{plane}	30%
Well daylit area	~313m^2

Figure 14.5 Results of daylighting studies

14.1.4 Benefits of Expanded Floorplates and Larger Floor to Ceiling Heights

Expanded floorplates and larger floor to ceiling heights are key to delivering a sustainable development that can adapt to changing demands, and one that will be attractive in the market and therefore well-used now and into the future.

They impact the following, all of which are important considerations overall:

- **Optimise site capacity**
  Expanded floorplates deliver more useful area on the same footprint, helping to optimise the site capacity in a well-connected and strategically important location. Refer to Volume One Section 5.4.
- **Lettability**
  It is imperative that the development attracts the right occupiers to ensure the building is well-utilised. The market demands floor to ceiling heights of 2.6m or larger. Refer to Section 14.1.2. This is a rather unique refurbishment project, and leasing it as a refurbishment project would be seen to be not viable for a building of this size. A refurbishment that results in a poorly-let / under-utilised building would be environmentally wasteful.
- **Daylighting**
  Allows for larger windows and more natural light to penetrate deeper into the office space. Natural light is known to improve mood, productivity, and overall well-being among employees. Refer to Section 14.1.3.
- **Adaptability and flexibility**
  Expanded floorplates with regular column grids and clear spans is required to deliver "flexible open space". This is the most in-demand feature for occupiers, refer to Volume One Section 4.1. Larger floor to ceiling heights allow room to grow services depth to flex to the changing demands of the future, mitigating premature obsolescence. It also allows for the installation of various internal layouts and furniture to meet future needs.
- **Views out**
  Added internal clear height enables improved views out from deeper on the floorplate, maximising the project's unique views and location. Views out are important for the health and well-being of occupiers.
- **Openness**
  Larger ceiling heights help to create a sense of spaciousness and openness, which can contribute to a more pleasant and inspiring work environment. This can also make offices feel less cramped and more visually appealing, which is important for the well-being of occupiers.
- **Impression and branding**
  For some occupiers, having an impressive office space is essential for creating a positive impression on clients, partners, and employees. A spacious, high-ceilinged office can reflect a company's success and values.

Figure 14.6 Daylight in existing Euston Tower 2022

15

Euston Tower

Establishing a New Baseline

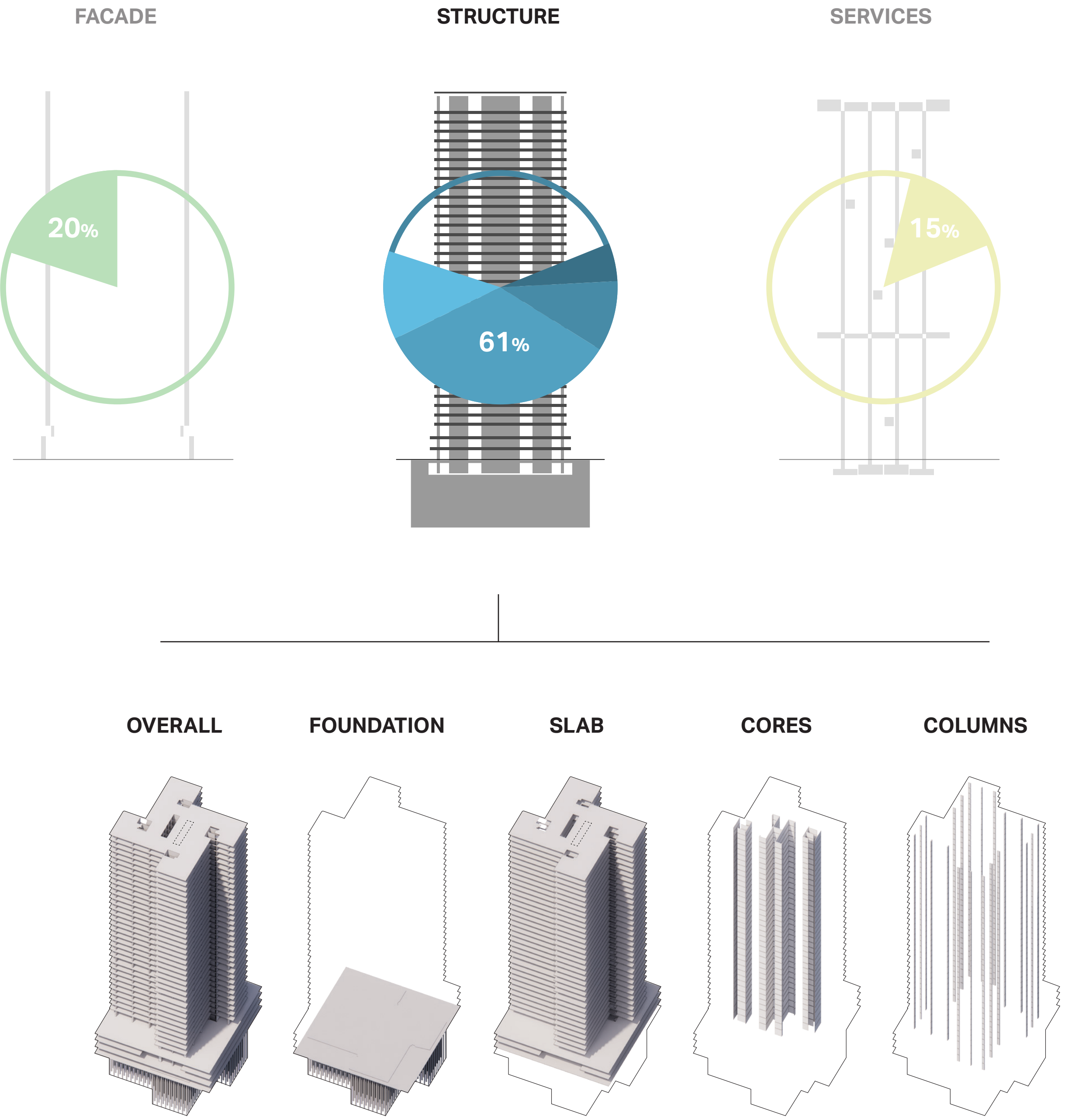
15.1 Carbon Distribution

In Volume One it was shown that the distribution of embodied carbon within the existing tower is primarily in the structure. With the façade needing replacement and the existing services already mostly stripped out, this makes the structure the key focus for retention.

However, it was shown that widespread upgrades are required to the existing building to bring it up to compliance with the current Building Regulations. Among other things, these upgrades result in new penetrations to the existing structure, eroding the total structure that can be retained.

The impact of said interventions means that 100% structural retention is not feasible within the current envelope. This section aims to re-establish the baseline for what is meant by maximum retention within the current envelope, based on the requirements for compliance with current Building Regulations. This is then used as a baseline against which the options for structural retention that follow in this study are compared.

As shown in Volume One, approximately 61% of the embodied carbon in the existing building is in the structures. This then breaks down into the constituent structural building elements, the distribution of which is shown in Figure 15.1. It is clear that the majority of the structural embodied carbon is in the foundation (19%), slabs (60%), and cores (14%), and these therefore present the biggest opportunities for retention.



	OVERALL	FOUNDATION	SLAB	CORES	COLUMNS
Embodied Carbon	**8,950** tCO_2e	**1,683** tCO_2e	**5,348** tCO_2e	**1,266** tCO_2e	**651** tCO_2e
Ratio of Carbon	**100** %	**19** %	**60** %	**14** %	**7** %

Figure 15.1 Embodied carbon of existing tower broken down by structural element

15.2 Minimum Upgrades Required

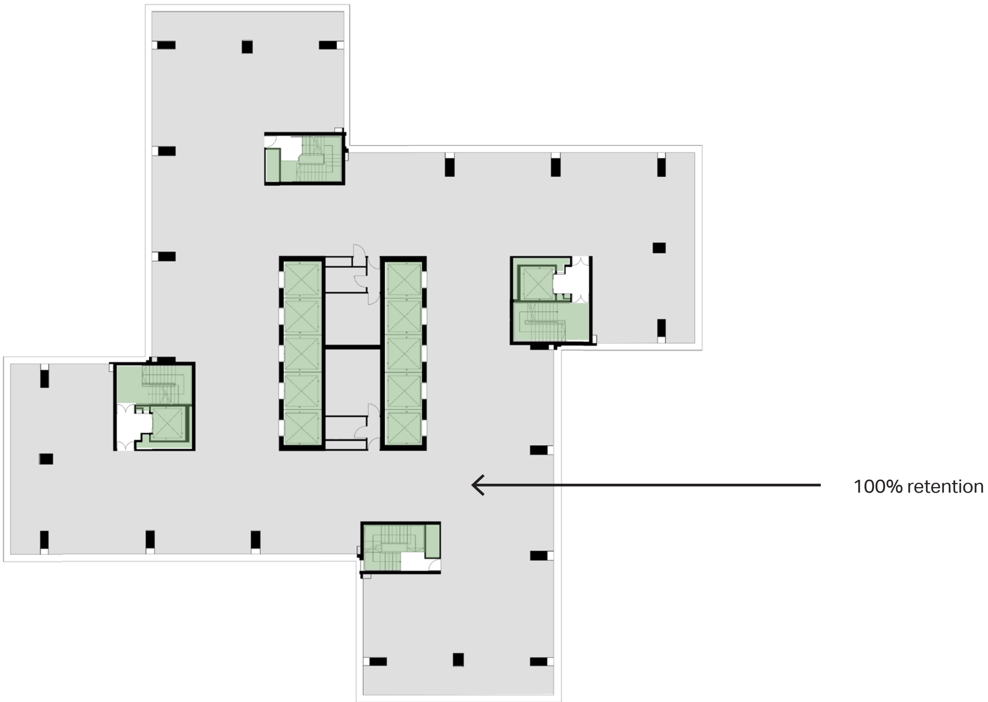
As shown in Volumes One and Two, the following minimum upgrades are required for compliance with current Building Regulations:

- Structural fire performance upgraded to 120 minutes
- Sprinkler provision added throughout
- Mechanical smoke ventilation added
- Dedicated fire fighting lifts required (not shared with goods lifts)
- Fire fighting lifts upgraded to current standards
- Fire compartmentation added to facade
- New air handling plant with higher fresh air rates to meet ADF, and heat recovery to meet ADL
- New central plant provisions with energy efficiency to meet ADL
- Facade thermal performance upgraded to meet energy efficiency requirements in ADL.

Working within the existing envelope (i.e. no floorplate extensions), the impact of these upgrades on the existing floorplate are shown in Figure 15.2. The penetrations required for new lifts and risers are shown in orange. However, wherever a portion of the ribbed slab is interrupted the entire ribbed structure must be removed in this location. This results in additional demolition shown in red.

If the existing floorplate is considered to be 100% retention, the resulting best-case maximum retention on the upgraded floorplate is 82% (by volume). This is considered the best-case estimate as the retention is likely to be lower in reality, as the slivers of retained floor slabs are unlikely to be maintained.

EXISTING FLOORPLATE



UPGRADED FLOORPLATE

Figure 15.2 Diagram showing erosion of floor slab due to upgrades to meet current Building Regulations

When this is scaled up to the full building, the 60% of embodied carbon in the slabs reduces to 49%.

Combining this with all the other structural elements, results in the maximum possible structural retention of the existing, when considering the upgrades required. Figure 15.3 shows that this maximum structural carbon retention is 89%.

The same can be done considering structural retention by volume. When considered by volume, maximum structural retention is 90%.

This is considered the baseline for maximum structural retention. The only way a larger degree of retention could therefore be achieved would be to expand the floorplate and introduce new core elements in areas of the expanded floorplate (as to minimise penetrations in the existing floorplate). It is acknowledged that greater structural salvage could be achieved by doing so. This is the starting point for the exploration in the next section.

** Assumes no floorplate extension (i.e. working within the existing envelope), meaning new risers need to be cut out of the existing floorplate. With extended floorplates, possibility exists to position risers outside of this existing footprint, resulting in potential higher degrees of retention.*

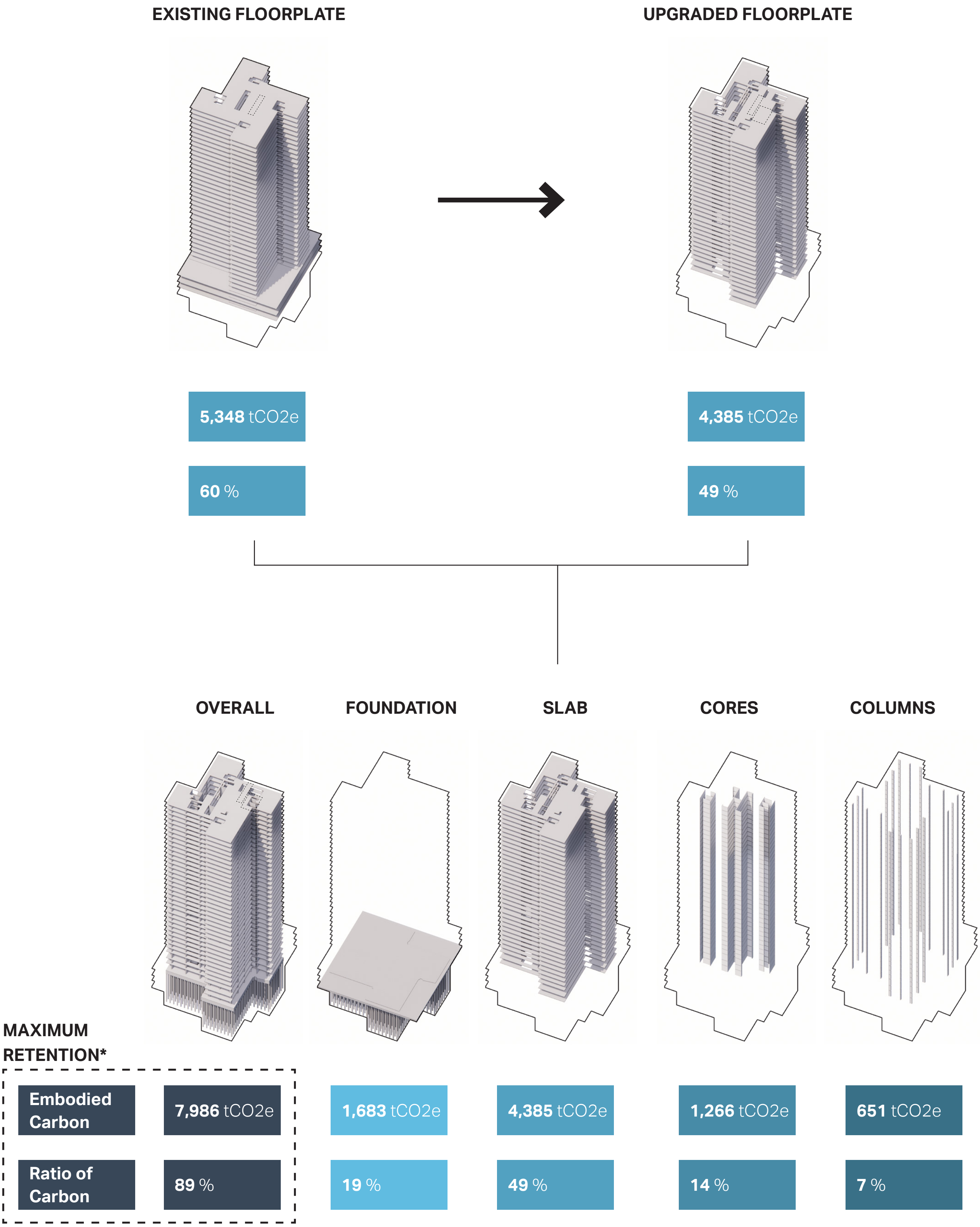


Figure 15.3 Embodied carbon of existing tower after upgrades, broken down by structural element

16

Euston Tower

Retention Options Appraisal

16.1 Aim and Approach

16.1.1 General

This Section of the Feasibility Study considers design solutions that find the best balance between retaining elements of the existing tower, and the opportunities enabled by new-build elements. Ultimately this is looking at the extent of retention and extension, and the opportunities, challenges, advantages, and disadvantages caused by these approaches.

It was shown in Volume One that there is little opportunity, nor merit, in retaining any elements of the existing tower beyond its structure. The other major elements — the facade and MEP systems — are too outdated and poorly performing to retain in-situ, and have already mostly been stripped out in the case of MEP. Accordingly, retention in this study focuses on the extent of the existing structural system that can be retained and incorporated into a new proposal.

16.1.2 Outline of this Section

The following describes the outline of this Section of the study:

- **Section 16.2** describes the key considerations and parameters for the appraisals
- **Section 16.3** presents a selection of assessments that form the appraisal, with options from across the retention spectrum. It is acknowledged that the options appraisal cannot be exhaustive, but it is intended to be illustrative of the general principles.

The aim is to systematically step through the interventions, and assess each intervention, transparently and objectively, against a set of overarching considerations. However, because the merits of a scheme are determined by multiple parameters, it is challenging to assess individual parameters (e.g. number of slabs retained, extent of core retained) in an isolated manner. Rather they need to be looked at in the context of an overall proposal. Therefore they are combined into a set of proposals with varying degrees of intervention. This is detailed in Section 16.3 where the proposals are assessed:

- **Major Refurbishment and Extension**
  Shown in Volume One not to be feasible
- **Retention and Partial Extension**
  Max Retention
- **Retention and Extension**
  "Full" Retention
- **Partial Retention and Extension and Disassemble and Reuse**
  Retain Consecutive Slabs (Office)
  Retain Consecutive Slabs (Office and Lab)
  Retain Interstitial Slabs (Office)
  Retain Interstitial Slabs (Office and Lab)
  Retain the Core
- **New Build**
  New Build.

Throughout this study, options are assessed using the same, typical extended floorplate. The extent of this floorplate is intended to be indicative of one plausible extension only, and it does not presuppose the outcome of any developments around massing. An exception is the Retention and Partial Extension option which uses a smaller extension.

Ultimately the conclusions are not sensitive to the shape or absolute dimensions of the extended floorplate. This to say that the outcome of this assessment would be the same regardless of the shape of the extension.

The options appraisal in this section are based on detailed, individual studies of core layouts, slab retention, and section retention. These detailed studies are included in the Appendices:

- **Appendix A** looks at core designs and floorplate layouts with differing degrees of retention. It looks at the plans in isolation and does not consider the impact of the stack.
- **Appendix B** studies options for retaining different proportions of the existing floor slab. Here each option is paired with a commensurate core layout, noting that others could be chosen though this would not affect the outcomes. It looks at the plans in isolation and does not consider the impact of the stack.
- **Appendix C** considers the vertical section looking at how many slabs could be retained. It looks at the sections in isolation, not considering the floorplate layouts.

Figure 16.1 View from the roof of Euston Tower 2022

16.2 Considerations and Parameters

16.2.1 Considerations

The brief for this Section can be summarised as follows:
- Retain as much of the existing structure as possible
- Design floorplates and a structural system that are future-proofed
- Prioritise health & safety, and buildability
- Ensure reasonable efficiencies and viability
- Consider potential to incorporate lab-enabled spaces.

Retain Structure
All options in this study are based on retaining as much as possible of the existing concrete structure. The various structural elements which make up the existing structure are: basement foundations, slabs, columns, central core, and satellite cores. The degree to which each of these elements is retained varies between the options studied.

Future-proofed
There are two time lenses associated with future-proofing. The in-use lens looks at flexibility and adaptability of the building during its lifetime. This considers the floorplate layout (core positioning, grids, circulation) and how it may influence future spatial flexibility. It also considers adaptability, which are more intrusive moves (e.g. creating a double height space) that would give the building added longevity by enabling it to flex to future demands.

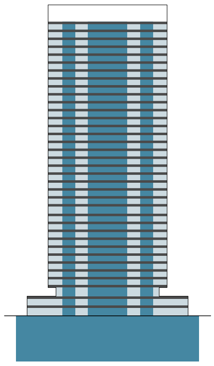
The end of life lens looks at design for disassembly. Here the aim is to design in methods of non-destructive disassembly where possible, to promote material reuse and reduce waste in the future. The degree to which the options could be future-proofed is contingent on any limitations carried over from the existing structure.

Health & Safety and Buildability
Demolishing and constructing within an existing building, often simultaneously, introduces different health & safety risks relative to typical blue sky construction. Similarly cutting and carving elements out of the existing structure generally changes its loading characteristics, and temporary stability works are often needed to support this.

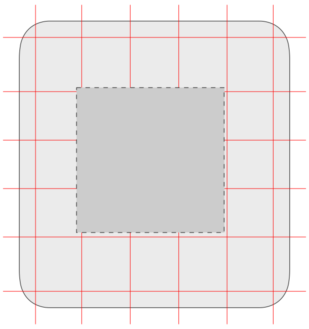
Each option presents a different degree of retention, upgrade, and extension of the existing structure, with a unique set of health & safety considerations and differing extent of temporary works required.

Efficiency and Viability
It is critical that the options could be plausibly delivered at reasonable viabilities and with reasonable Estimated Rental Values (ERVs). This means giving consideration to construction complexity (and therefore programme and cost), lettability, and also overall efficiency of the massing and floorplates.

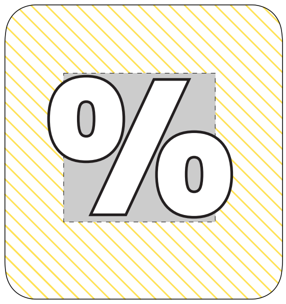
Lab-enabled
Flexibility to incorporate lab-enabled spaces is desirable to maximise future use options and contribute to the growth and success of the Knowledge Quarter. However, it is acknowledged that, while it remains a desire and a consideration, the ability to provide or not provide lab-enabled spaces should not dictate building use.



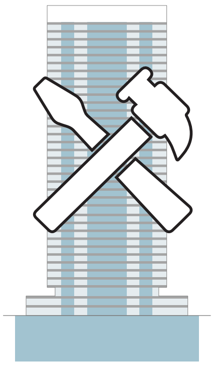
RETAIN STRUCTURE
Endeavour to retain as much structure as possible



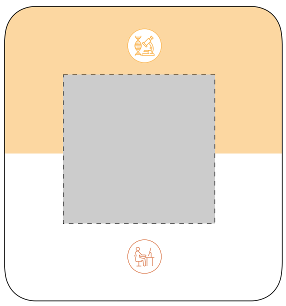
FUTURE-PROOFED
Ability to flex and adapt to changing trends and demands



EFFICIENCY AND VIABILITY
Deliver market-attractive floorplates with reasonable efficiencies



HEALTH & SAFETY AND BUILDABILITY
A construction methodology that is safe and practical



LAB-ENABLED
Provide spaces capable of being used as lab spaces

Figure 16.2 Key considerations for assessing the options in this study

16.2.2 Parameters

As a means of testing the extent of structural retention that could be achieved, the following parameters are investigated:

- Floorplate layout
- Extent of slab retained
- Extent of section retained.

Floorplate Layout

The floorplate layout must incorporate the design of a core or cores that maximises reuse of the existing structural elements, brings the building up to compliance with current Building Regulations (see Volume One and Section 15), and delivers an acceptable floorplate efficiency (net to gross).

The resulting layout, from a perspective of circulation and grid, should also be flexible to accommodate multiple configurations, and occupiers, both now and well into the future.

Extent of Slab Retained

It is not always possible, or desirable, to retain the full slab. This is partially owing to the upgrades required to bring the existing building up to compliance with current Building Regulations (see Volume One and Section 15), and partially owing to new elements dictated by the extended floorplates.

This parameter considers how much of the existing slab could be retained to produce a plausible and structurally sound proposal.

Extent of Section Retained

This parameter is evaluating how much of the existing building could be retained vertically, while achieving as many of the brief requirements as possible. There are multiple elements to consider within this parameter, specifically the central core, satellite cores, number of slabs retained, and combinations thereof.

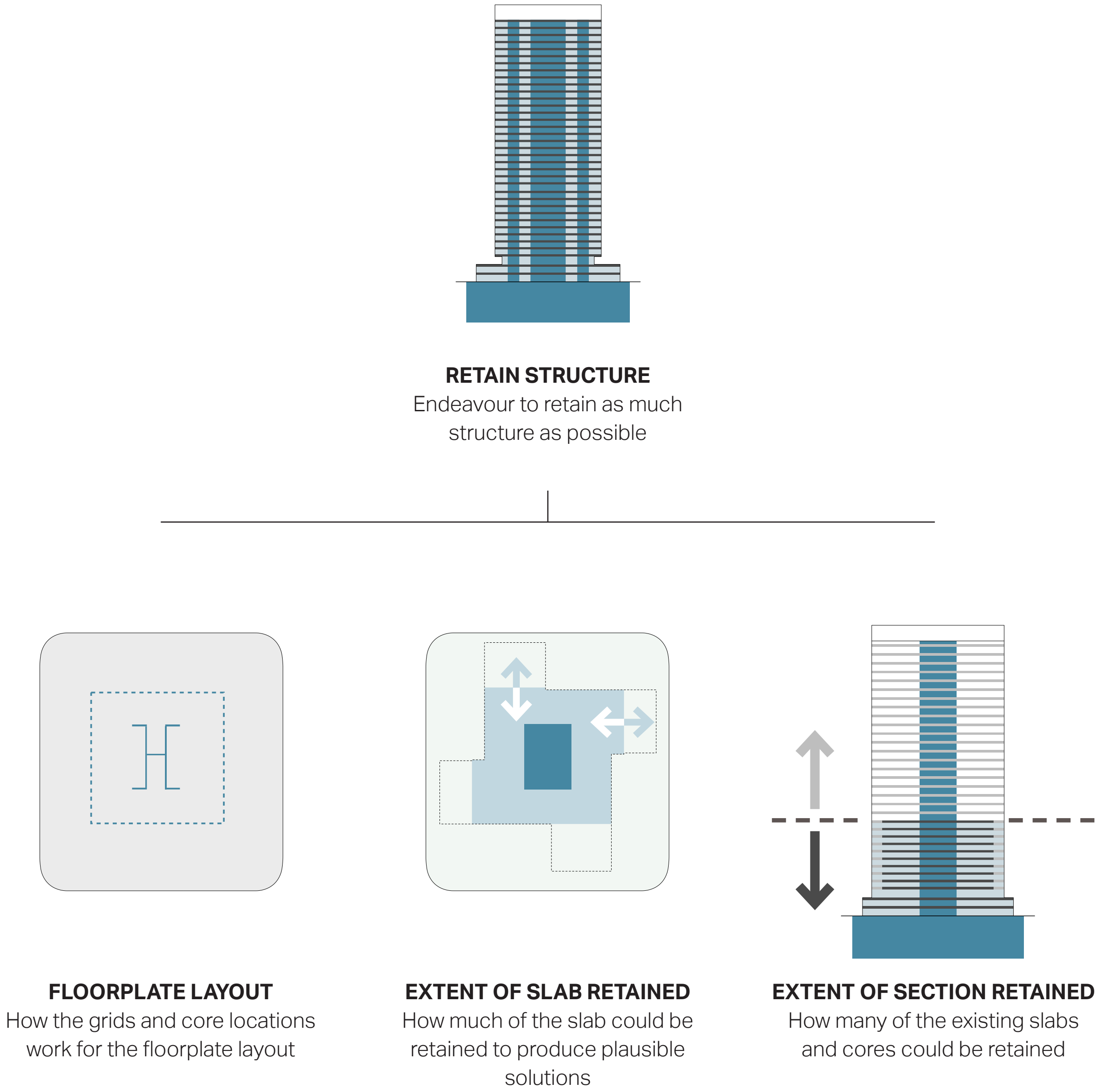


Figure 16.3 Key parameters for developing the options in this study

16.3 Options Appraisal

There are five approaches presented in this Section. The approaches are categorised under the following headings:

- Major Refurbishment
- Retention and Partial Extension
- Retention and Extension
- Partial Retention and Extension (Disassemble and Reuse)
- New Build.

In Volume One, it was shown that a major refurbishment option — working within the existing envelope — is not feasible. Of the remainder, there are plausible options that span the gamut from least deconstruction in the case of the retention and partial extension options, to most deconstruction in the case of the new build option. This is shown in Figure 16.4.

With the exception of the new build option, all options would retain the existing below ground substructure and foundations. The extent of existing structure above ground, and the way in which it would be maintained, is the main difference between the options.

Major Refurbishment

- Shown in Volume One not to be feasible. It is not considered further.

Retention and Partial Extension

- Max Retention option that maximises existing structure retention. It retains all existing floor slabs with new construction only for a small extension that is supported off of the existing structure, and the new cores which are located outside of the footprint of the existing building. It maintains the central core structure and the existing floor to floor height of 3,200mm.

Retention and Extension

- **"Full" Retention** option that retains all existing floor slabs with new construction for the extension only. It maintains the central core structure and two of the satellite cores. It maintains the existing floor to floor height of 3,200mm.

Partial Retention and Extension and Disassemble and Reuse

Five options are explored in this category:

- **Retain Consecutive Slabs (Office)** option that retains all existing floor slabs below Level 12, and builds new slabs above. It maintains the central core structure. Existing slabs maintain the existing floor to floor height of 3,200mm, while new slabs have a floor to floor height of 3,800mm suitable for office use.
- **Retain Consecutive Slabs (Office and Lab)** option that retains most existing floor slabs below Level 12, and builds new slabs above. It maintains the central core structure. Portions of the existing slabs are removed below Level 12, in order to provide double-height space suitable for lab use. Existing office areas maintain the existing floor to floor height of 3,200mm with 6,400mm for the lab spaces, while new slabs have a floor to floor height of 3,800mm suitable for office use.
- **Retain Interstitial Slabs (Office)** option that strategically retains interstitial (approximately every 6th) existing floor slabs, and builds new slabs in between. 6 slabs are retained above the podium. It maintains the central core structure. It delivers office storeys with three different floor to floor heights: 3,840mm in the lower portion of the stack, 3,980mm in the mid portion, 3,840mm in the upper portion, and 4,800mm for the uppermost two storeys.
- **Retain Interstitial Slabs (Office and Lab)** option that strategically retains interstitial existing floor slabs, and builds new slabs in between. 6 slabs are retained above the podium. It maintains the central core structure. It delivers lab-enabled storeys with floor to floor height 4,266mm in the lower portion of the stack and office storeys with floor to floor heights of 3,980mm and 3,840mm in the mid and upper portions of the stack respectively. The uppermost storey is 7,040mm.
- **Retain the Core** option that retains the central core and below ground foundations only. All slabs are built new. Office levels have a floor to floor height of 3,800mm, with the flexibility to include lab-enabled floors with higher floor to floor heights of 4,100mm.

New Build

- **New Build** option demolishes and recycles the full existing tower. No structure is retained (including foundation and substructure).It delivers office levels with a floor to floor height of 3,800mm, with the flexibility to include lab-enabled floors with higher floor to floor heights of 4,100mm.

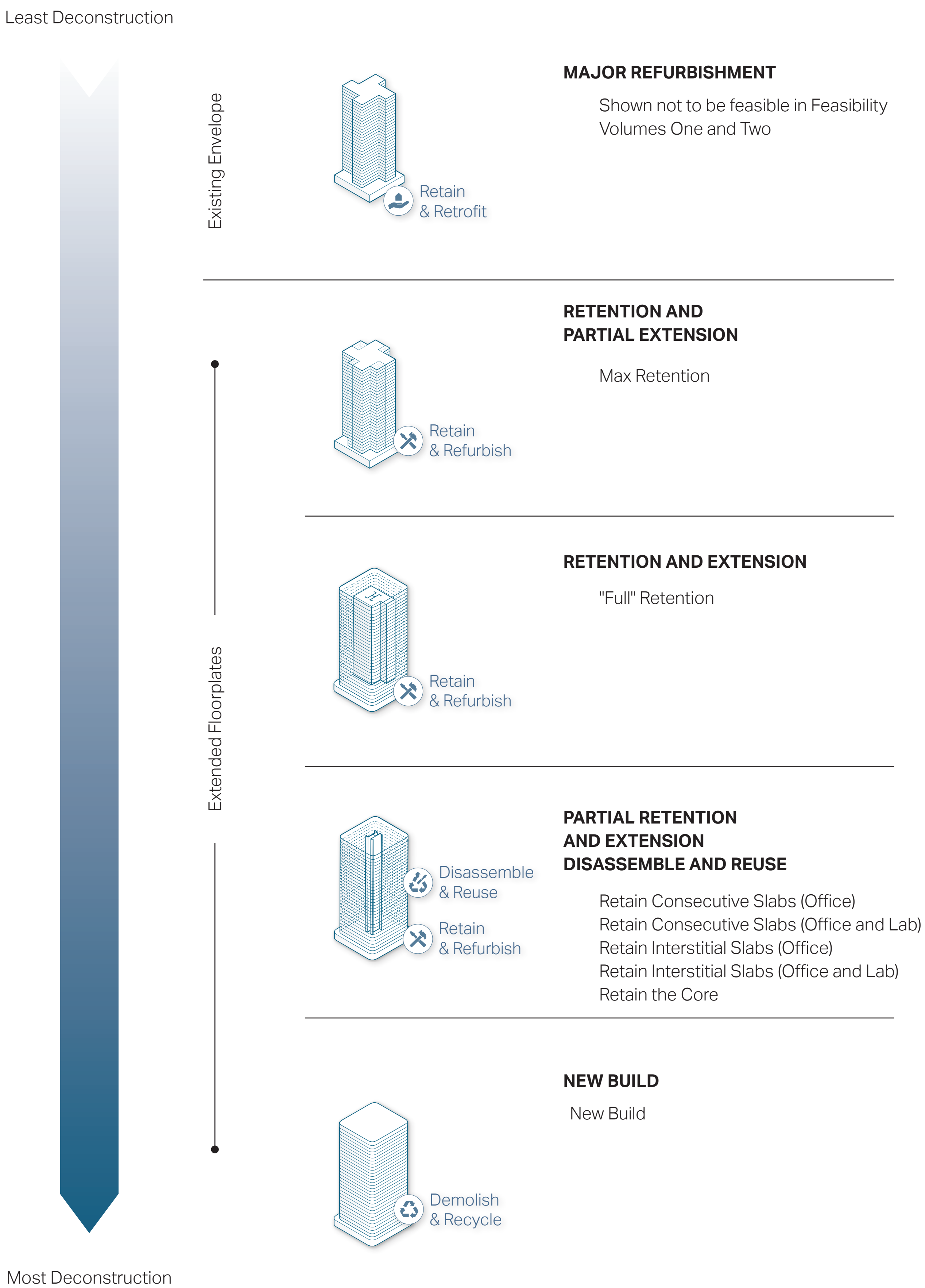


Figure 16.4 Overview of options

16.3.1 Retention and Partial Extension - Max Retention

Description

This option seeks to maximise retention, retaining all existing floor slabs. It would maintain the central core structure, but remove and infill all four satellite cores. New core areas would be added outside the footprint of the existing floorplate, and the floorplates extended by 900mm. Floors would maintain the existing floor to floor height of 3,200mm.

Structural retention would be at best 93% retention by carbon (or 92% by volume). See Figure 16.9 where the reduction from maximum is due primarily to the core layout which does not retain the satellite cores.

The section and floor slab retention diagrams are shown in Figure 16.8, with the structural retention diagrams shown in Figure 16.9.

The programme stack and room sections are shown in Figure 16.10 overleaf.

Ultimately the existing floor to floor height is challenging for delivering a modern office offering. While improved over the existing building, this option would create a larger quantum of compromised floor space, noting that the additional space at the perimeter is difficult to use effectively due to the existing column positions and proximities to the external cores. At the same time, it would carry the existing column grid, and retain the limitations of the existing structure, hindering flexibility and adaptability in-use, and potential for non-destructive disassembly at end of life. This option is not considered further because it does not solve these issues.

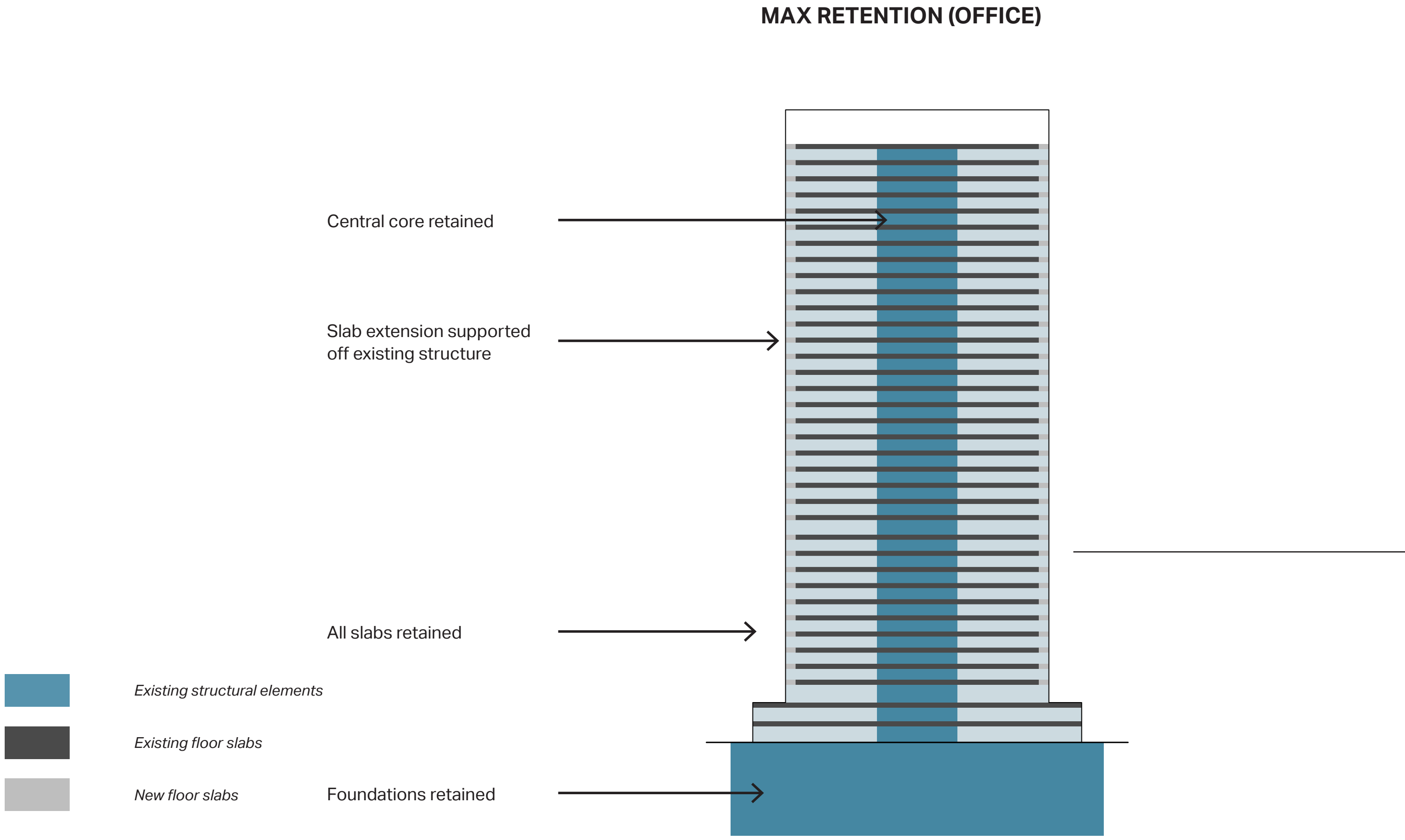
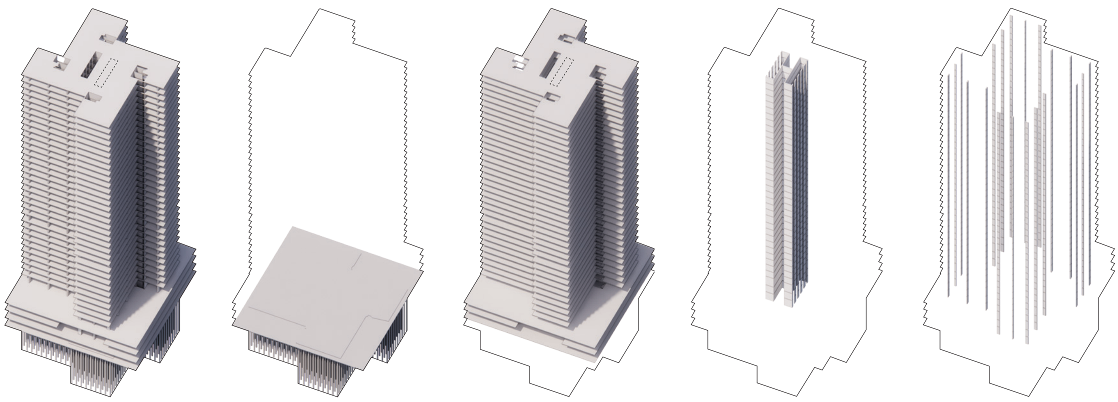


Figure 16.5 Diagram showing retained structural elements in this option (section above and slabs opposite)

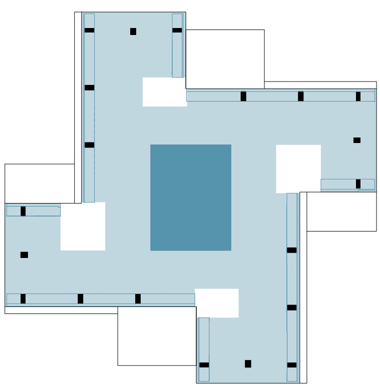


	OVERALL	FOUNDATION	SLAB	CORES	COLUMNS
	MAXIMUM POSSIBLE WITHOUT EXTENSION* 89 %				
Embodied Carbon	**8,361** tCO2e	**1,683** tCO2e	**5,348** tCO2e	**679** tCO2e	**651** tCO2e
Ratio of Carbon	**93** %	**19** %	**60**%	**8** %	**7** %

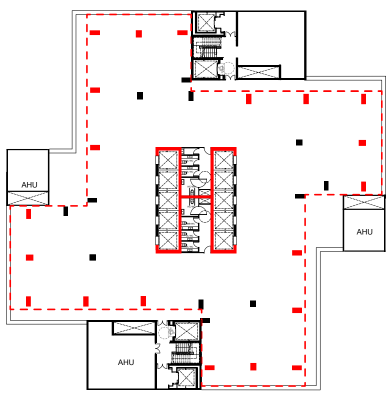
** Assumes no floorplate extension (i.e. working within the existing envelope), meaning new risers need to be cut out of the existing floorplate. Refer to Section 15. With extended floorplates, possibility exists to position risers outside of this existing footprint, resulting in potential higher degrees of retention.*

Figure 16.6 Embodied carbon and retention of structure broken down by structural element

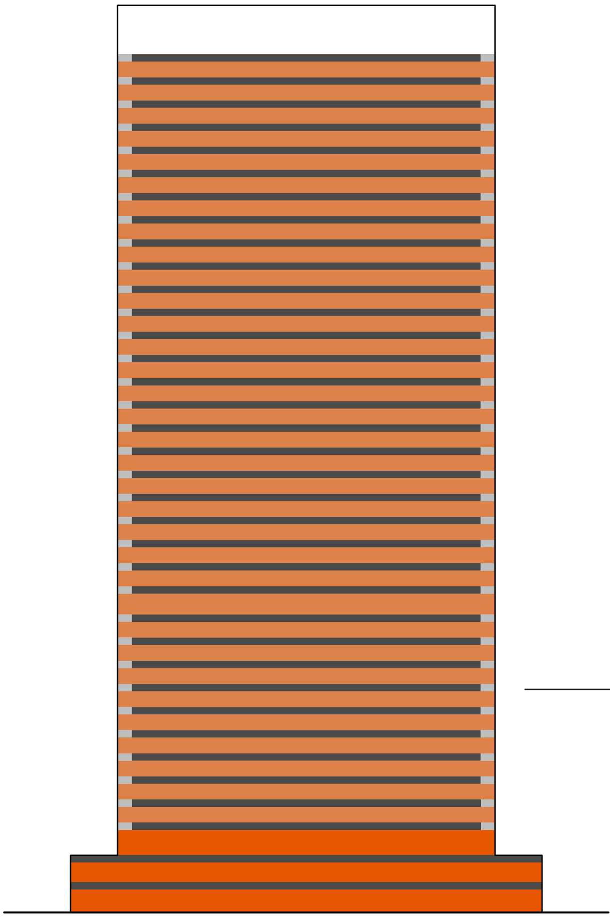
ALL LEVELS
Central core retained, full existing slab retained, all satellite cores removed



INDICATIVE CORE LAYOUT
Retain central core and append new core areas outside existing footprint



PROGRAMME AND SECTION STACK
Max Retention (Office)



3.2m floor to floor office space

Podium amenity

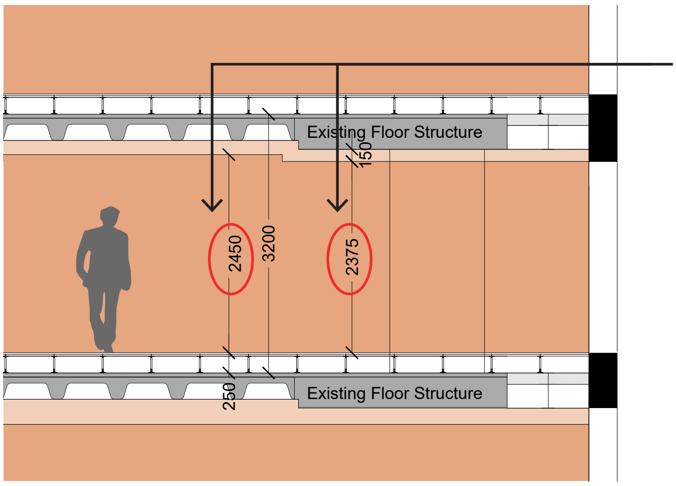
New-build floor slab

Retained floor slab

Figure 16.7 Programme stack diagram (above) and room section (opposite)

ALL LEVELS (DROPPED CEILING)

Floor to floor 3,200mm
Floor to ceiling 2,375mm (2,450mm achievable under areas of existing ribbed slab)



Floor to ceiling height of 2,375mm compromises quality of space. With the extension, there is even more quantum of compromised floor space. 2,450mm achievable only under areas of existing ribbed slab. These levels could be delivered without a dropped ceiling and achieve 2,425mm clear (refer to Section 16.3.2).

Structural Rationale for the Extension
This option would retain all existing floor slabs and extend the existing floorplate by 900mm as the maximum extension that can be cantilevered off of the existing structure. New core elements are added outside the footprint of the existing floorplate to reduce the need for any new major penetrations in the existing floor slabs.

To achieve this structurally, a new steel frame would be constructed in the new areas with the structural depth of the floorplate limited to the existing structural floor depth, i.e. 15 in. or ca. 380mm. It is most sensible for this extension to be supported off the existing structure. As such, a load balance approach is practical.

Removal of the satellite cores is not trivial. Modifications to the existing stability structure mean that new, supplementary stability structure is required. This would be achieved by using the new appended core elements as part of the global stability system.

A larger horizontal extension could be provided if the vertical structure and foundations are strengthened. This would require new vertical structure and substructure, making the marginal area gain carbon intensive.

Future-proofed
Flexibility of the floorplates would be inhibited by having to work within the constraints of the existing column grid due to retaining the existing slabs. Existing columns would be positioned with spans that are not ideal for a modern office layout, and would be irregular meaning they are difficult to subdivide rationally.

From an adaptability perspective, there is no opportunity to design in double-height amenity spaces, or additional soft spots. This would inhibit the building being able to change to suit future trends, increasing its risk of becoming obsolete prematurely. This limitation is extended to the ability to design the structural system for ease of disassembly, promoting material reuse and reducing potential waste in the future.

Health & Safety and Buildability
Buildability would be moderately complex. The risk of unknowns in the existing structure is increased with significant levels of retention, and the lack of consistency from level to level is likely to introduce further complexity at each of the interfaces between existing and new structure.

A large part of the construction complexity is driven by the temporary works requirements. In this case there would be moderate temporary works required where there would be unconstrained slab edges on every level. Where the existing satellite cores would be removed, the key is maintaining continuity of the perimeter ring beam to support the retained slab, meaning that new construction would be required prior to demolition of the satellite cores. This would introduce an additional health & safety risk by having demolition and construction activities happening simultaneously and in close proximity.

Efficiency and Viability
This option would be challenging from a viability perspective because, while it represents an improvement over the existing building, floor space is still compromised. All levels would retain the existing building floor to floor height of 3,200m, which was shown in Volume One (and Section 2 of this document), to be challenging for delivering a modern office offering, making leasing difficult on these floors, if not impossible. Additionally, significant works are required to deliver little additional net area, and the area that is delivered (the 900mm cantilever at the perimeter zone) is hindered by the existing column positions.

Lab-enabled
This option presents no opportunity for lab-enabled spaces due to floor to floor heights being too low for lab use.

Site Capacity
This option does not optimise site capacity, and public realm upgrades would be limited by the scale of the redevelopment. Refer to Volume One Section 5.4. It does not provide the in-demand lab-enabled space required in London.

16.3.2 Retention and Extension - "Full" Retention

Description

This option seeks to maximise retention, retaining all existing floor slabs. It would maintain the central core structure, as well as the west and east satellite cores. Floors would maintain the existing floor to floor height of 3,200mm. Floors would be extended to deliver an expanded floorplate.

Maximum structural retention would be at best 89% retention by carbon (or 90% by volume) once the slabs are upgraded to current regulations within the existing floorplate, as shown previously in Section 15. In this case 84% retention by carbon would be achieved (or 85 % by volume). See Figure 16.9 where the reduction from maximum is due primarily to the core layout which does not retain all the satellite cores.

The section and floor slab retention diagrams are shown in Figure 16.8, with the structural retention diagrams shown in Figure 16.9.

The programme stack and room sections are shown in Figure 16.10 overleaf.

Ultimately the existing floor to floor height is challenging for delivering a modern office offering. This option would only create a larger quantum of highly compromised floor space. At the same time, it would carry the existing column grid, and retain many of the limitations of the existing structure, hindering flexibility and adaptability in-use, and potential for non-destructive disassembly at end of life. This option is not considered further because it does not solve these issues.

"FULL" RETENTION

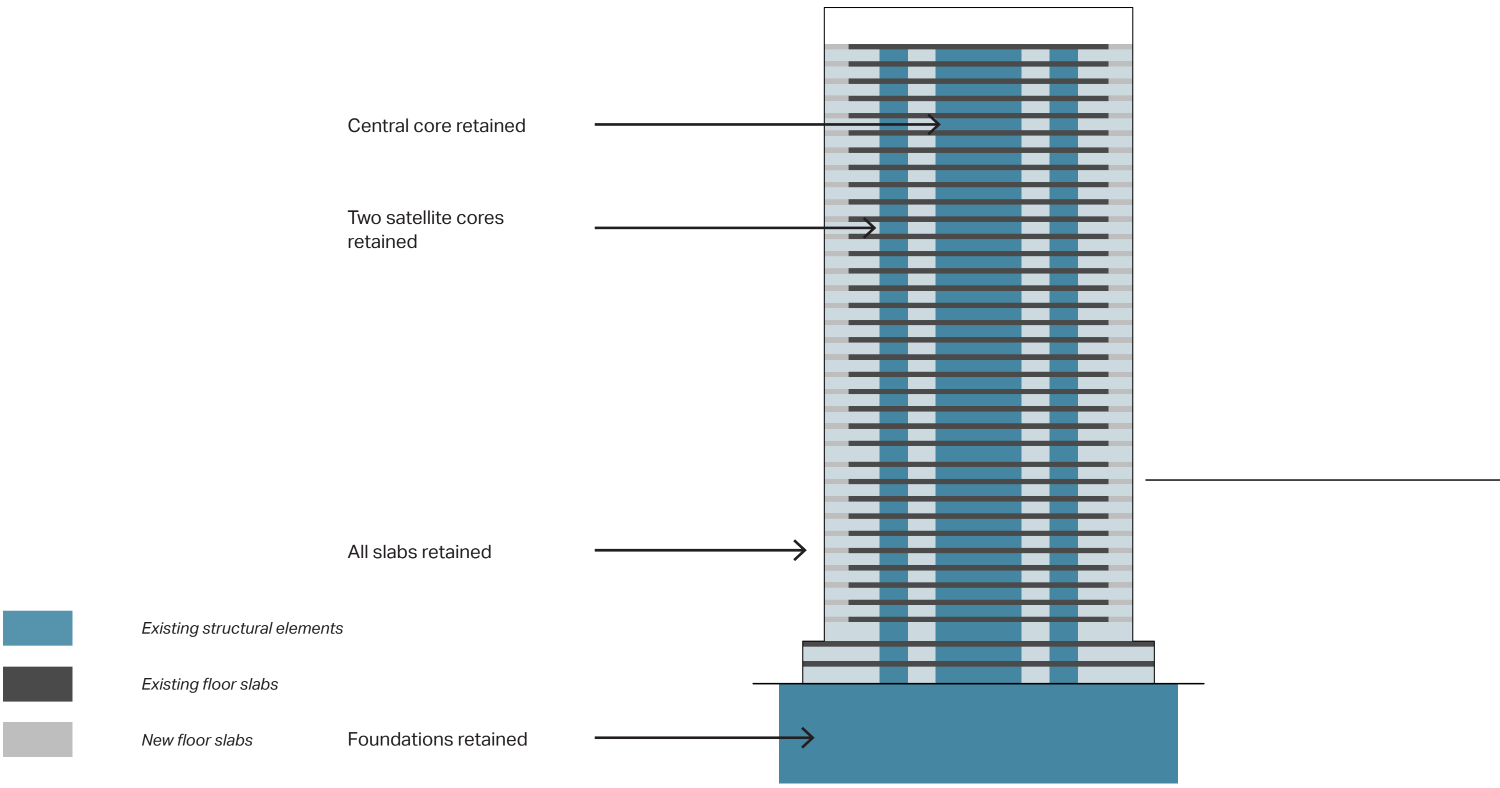
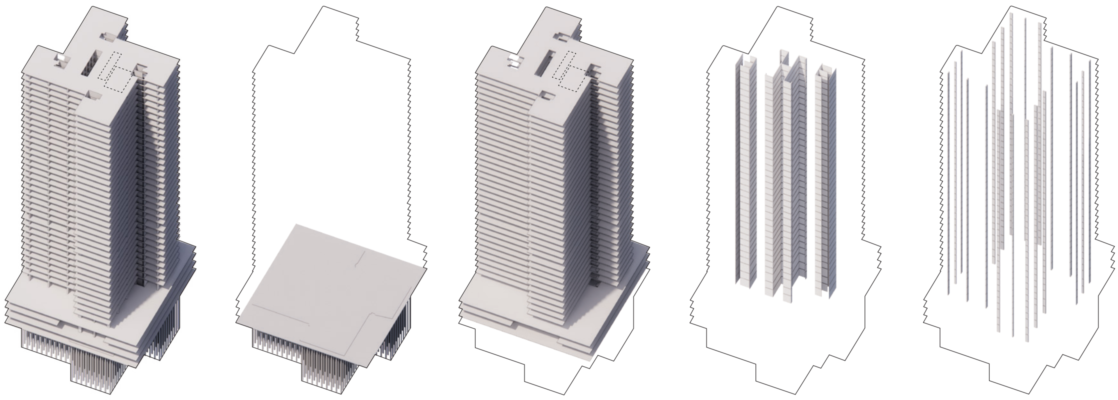


Figure 16.8 Diagram showing retained structural elements in this option (section above and slabs opposite)

OVERALL	FOUNDATION	SLAB	CORES	COLUMNS



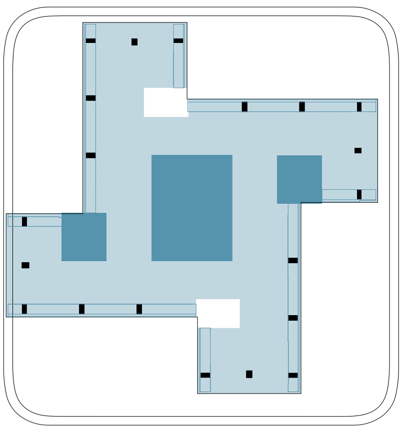
MAXIMUM POSSIBLE WITHOUT EXTENSION*
89 %

	OVERALL	FOUNDATION	SLAB	CORES	COLUMNS
Embodied Carbon	**7,525** tCO2e	**1,683** tCO2e	**4,278** tCO2e	**912** tCO2e	**651** tCO2e
Ratio of Carbon	**84** %	**19** %	**48**%	**10** %	**7** %

** Assumes no floorplate extension (i.e. working within the existing envelope), meaning new risers need to be cut out of the existing floorplate. Refer to Section 15. With extended floorplates, possibility exists to position risers outside of this existing footprint, resulting in potential higher degrees of retention.*

Figure 16.9 Embodied carbon and retention of structure broken down by structural element

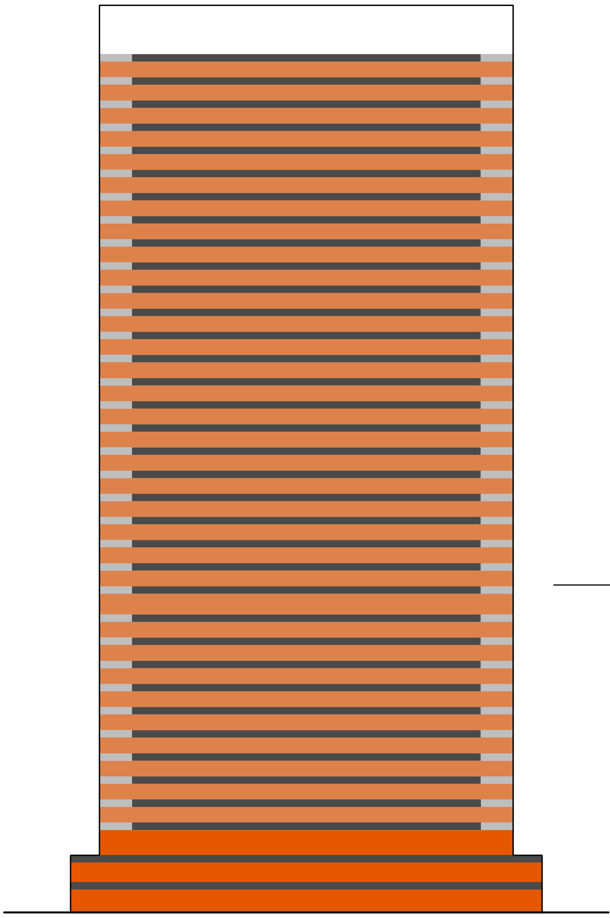
ALL LEVELS
Central and two satellite cores retained, full existing slab retained, north and south satellite cores removed



INDICATIVE CORE LAYOUT
Retain Central Core and Two Satellite Cores

PROGRAMME AND SECTION STACK

"Full" Retention



3.8m floor to floor office space

3.2m floor to floor office space

Podium amenity

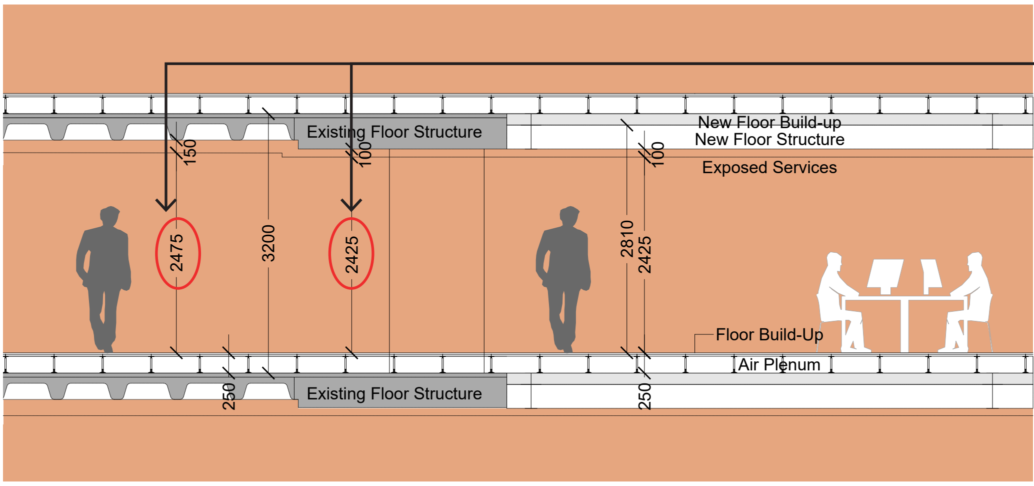
New-build floor slab

Retained floor slab

Figure 16.10 Programme stack diagram (above) and room sections (opposite)

ALL LEVELS (EXPOSED SERVICES)

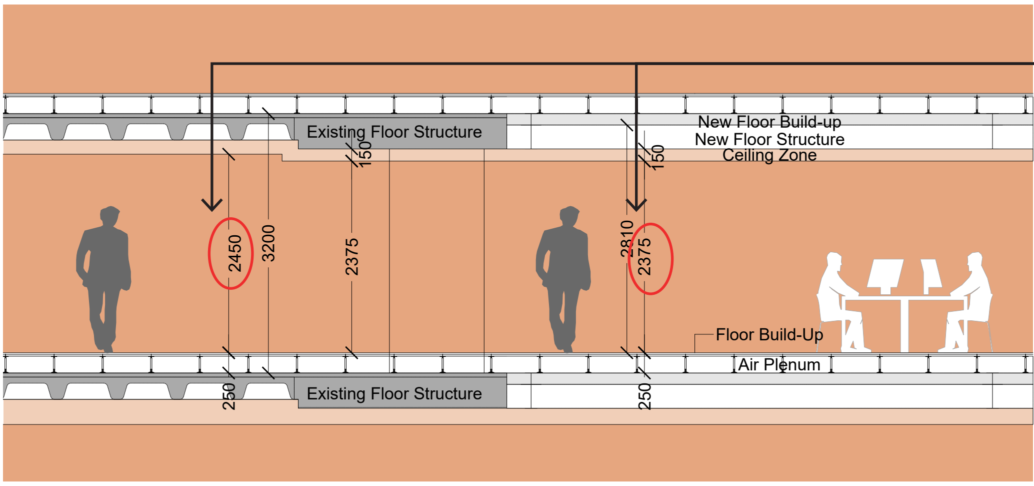
Floor to floor 3,200mm
Floor to ceiling 2,425mm (2,475mm achievable under areas of existing ribbed slab)



Floor to underside of services height of 2,475mm is achievable only under areas of existing ribbed slab. A clear height to the underside of services of 2,425mm is achievable across all other areas of the floorplate. Exposing the services may not be to every tenant's liking.

ALL LEVELS (DROPPED CEILING)

Floor to floor 3,200mm
Floor to ceiling 2,375mm (2,450mm achievable under areas of existing ribbed slab)



Floor to ceiling height of 2,375mm compromises quality of space. With the extension, there is even more quantum of compromised floor space. 2,450mm achievable only under areas of existing ribbed slab.

Floor to Ceiling Heights
In Figure 16.10, options are shown for the floor sections. One option has exposed services (to maximise floor to ceiling heights or perception of height), and one option has a dropped ceiling to maximise flexibility for tenants.

The exposed services option could achieve 2,475mm clear, which would be compliant with the BCO recommendation for floor to ceiling heights in refurbished buildings (2,450-2,800mm) only under areas of existing ribbed slab. There would be extensive areas of the floor slab that would not be compliant with the BCO recommendation.

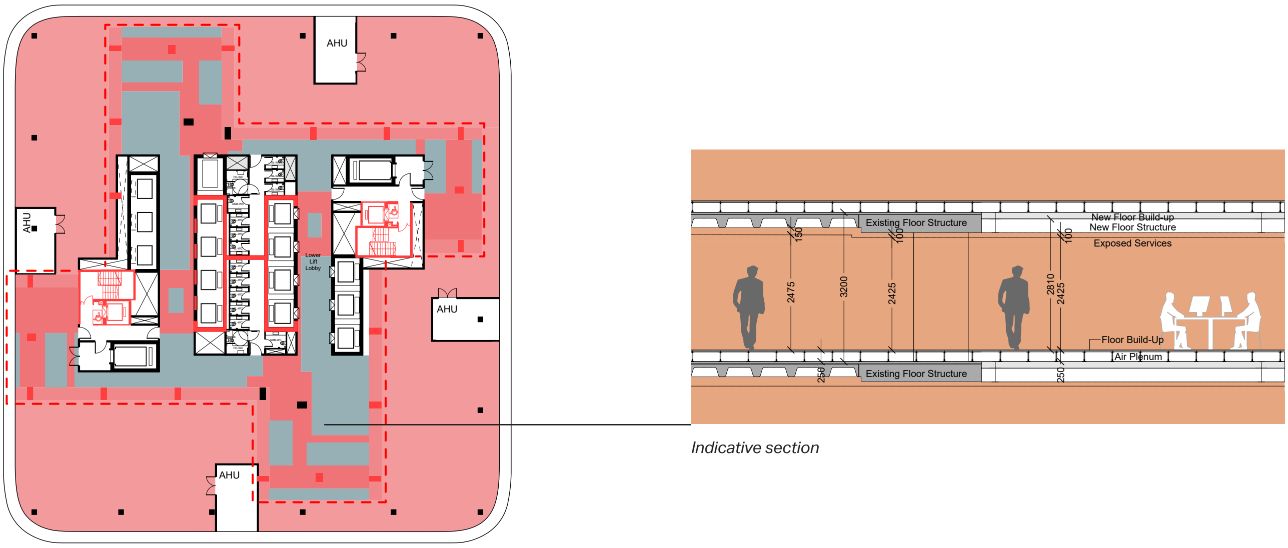
The dropped ceiling option could not achieve 2,450mm clear height, and would not comply with the BCO recommendation for floor to ceiling heights in refurbished buildings (2,450-2,800mm), save for under areas of existing ribbed slab. There would therefore be extensive areas of the floor slab that would not be compliant with the BCO recommendation.

In order to maximise clear height, services would be kept clear of the ring beam zone so far as possible because the ring beam is deeper than the rest of the floor system (see Figure 16.11). This would lead to restrictions on floor layout in these areas (e.g. no lighting fixtures would be placed below the ring beam), and crossovers, like sprinkler mains, would be rationalised to minimise the localised points where clear height would be below the BCO recommendation.

Ultimately this strategy would result in compromised floor space. The extent of this compromise is shown in the diagram in Figure 16.12.

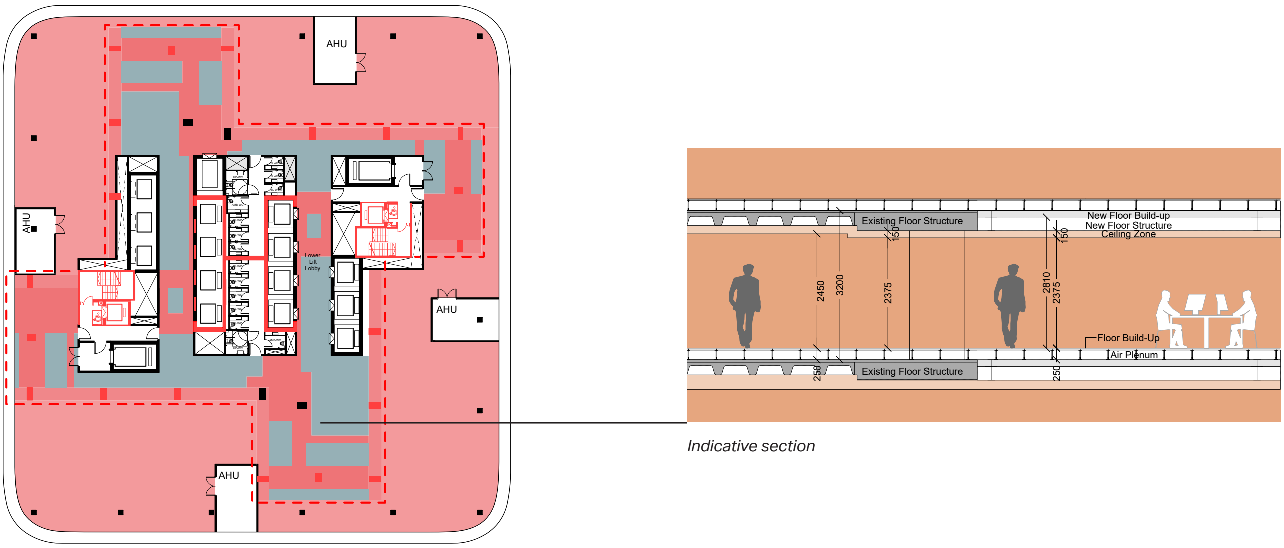
Figure 16.11 Existing ring beam is deeper than the rest of the structural floor system, creating a pinch point for clear floor to ceiling heights once new ceiling services are installed

EXPOSED SERVICES



Indicative section

DROPPED CEILING



Indicative section

Services below existing ribbed slab zone. BCO refurb compliant with clear height 2,450mm (dropped ceiling) or 2,475mm (exposed services)

Restricted services zone / non-compliant zone. If services drop into this area would not be BCO compliant

BCO guidelines for refurbishments

Floor to ceiling heights 2,450-2,800mm

Figure 16.12 Floor to ceiling heights compared to BCO recommendation for refurbishments

16.3.3 Partial Retention and Extension - Retain Consecutive Slabs (Office)

Description

This option would retain all existing floor slabs below Level 12, and build new slabs above. It would maintain the central core structure. Existing slabs would maintain the existing floor to floor height of 3,200mm, new slabs would have a floor to floor height of 3,800mm suitable for modern office use. Floors would be extended to deliver an expanded floorplate.

The section and floor slab retention diagrams are shown in Figure 16.5. The programme stack and room sections are shown in Figure 16.7 overleaf.

Level 12 is chosen as the split between the lower retained stack and the upper portion where new slabs would be built out. This is because the existing Level 12 is an MEP service level and has a larger floor to floor height (3.9m) than the typical existing office floors (3.2m). The vertical transport strategy would be reliant on using double decker lifts (reducing the footprint of lifts required and therefore resulting in improved floorplate efficiency), but these are contingent on a consistent inter-storey height. The alternatives are twin lifts (which can accommodate varying inter-storey heights) for which there is a single-source supply procurement risk, or using conventional single-decker lifts, but this would inflate the core and significantly erode the net to gross efficiency. Respectively, these two alternatives result in a level of risk that is unacceptable to the development (if the twin lifts cannot be procured the development cannot go ahead as planned), and a net to gross efficiency that will be not be viable to deliver. Accordingly, within the constraints of the vertical transport strategy, it would not be possible to retain a single level with an odd floor to floor height.

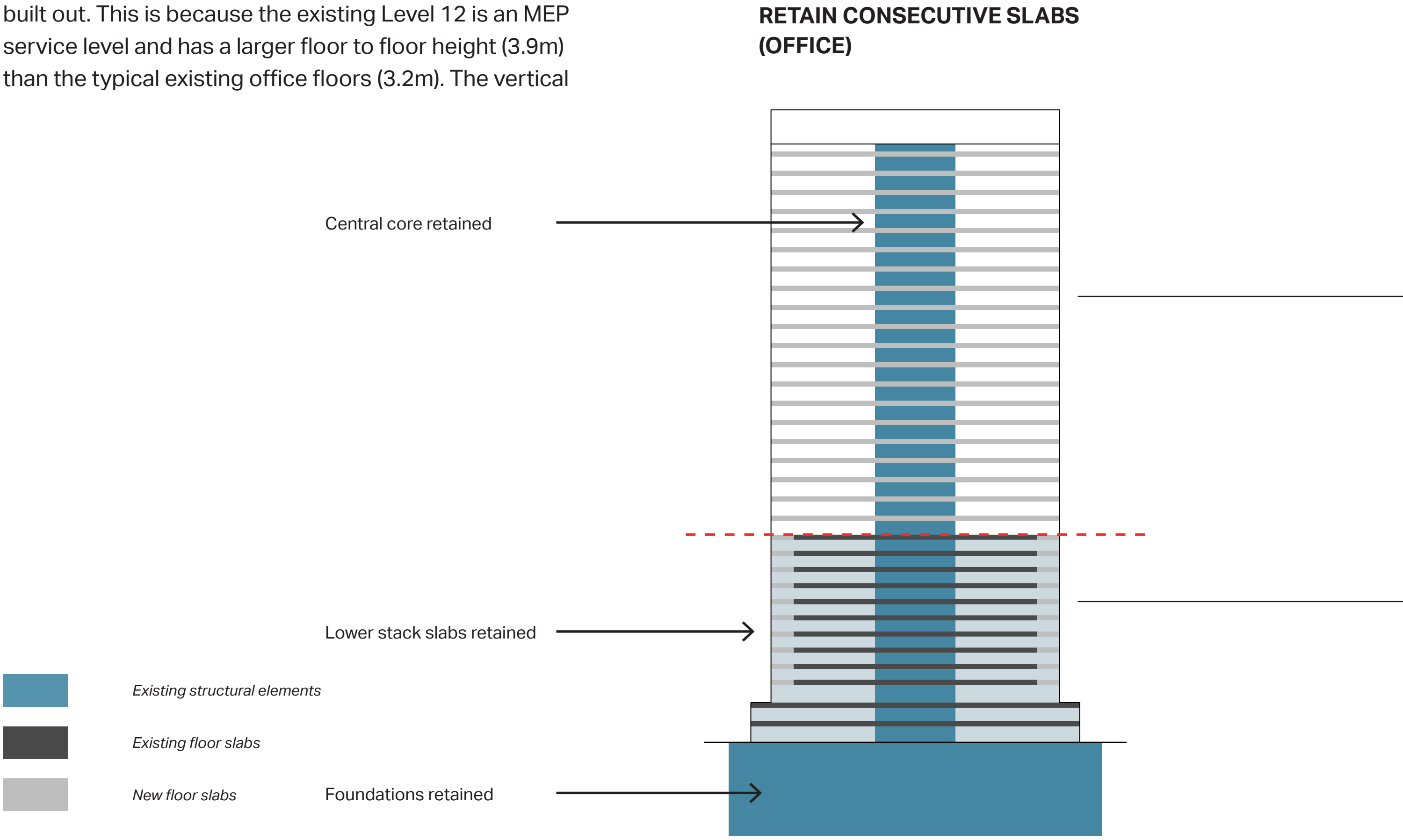
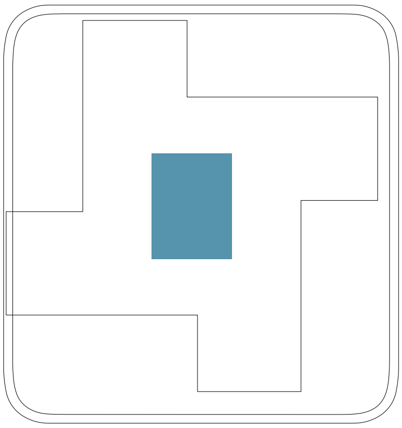
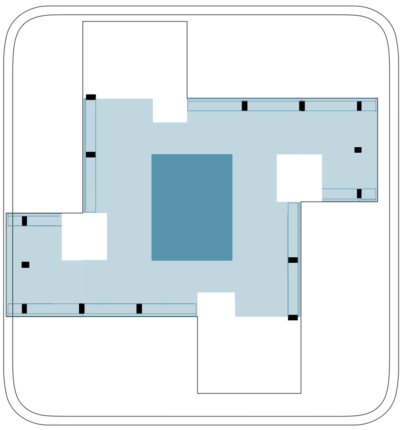


Figure 16.13 Diagram showing retained structural elements in this option (section above and slabs opposite)

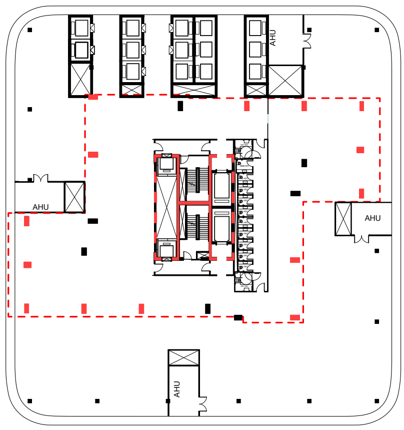
UPPER STACK
Core retained, floorplates removed



LOWER STACK
Core retained, central square and east and west pinwheel arms retained



INDICATIVE CORE LAYOUT
Retain Central Core with Centralised North Core



PROGRAMME AND SECTION STACK

Retain Consecutive Slabs (Office)

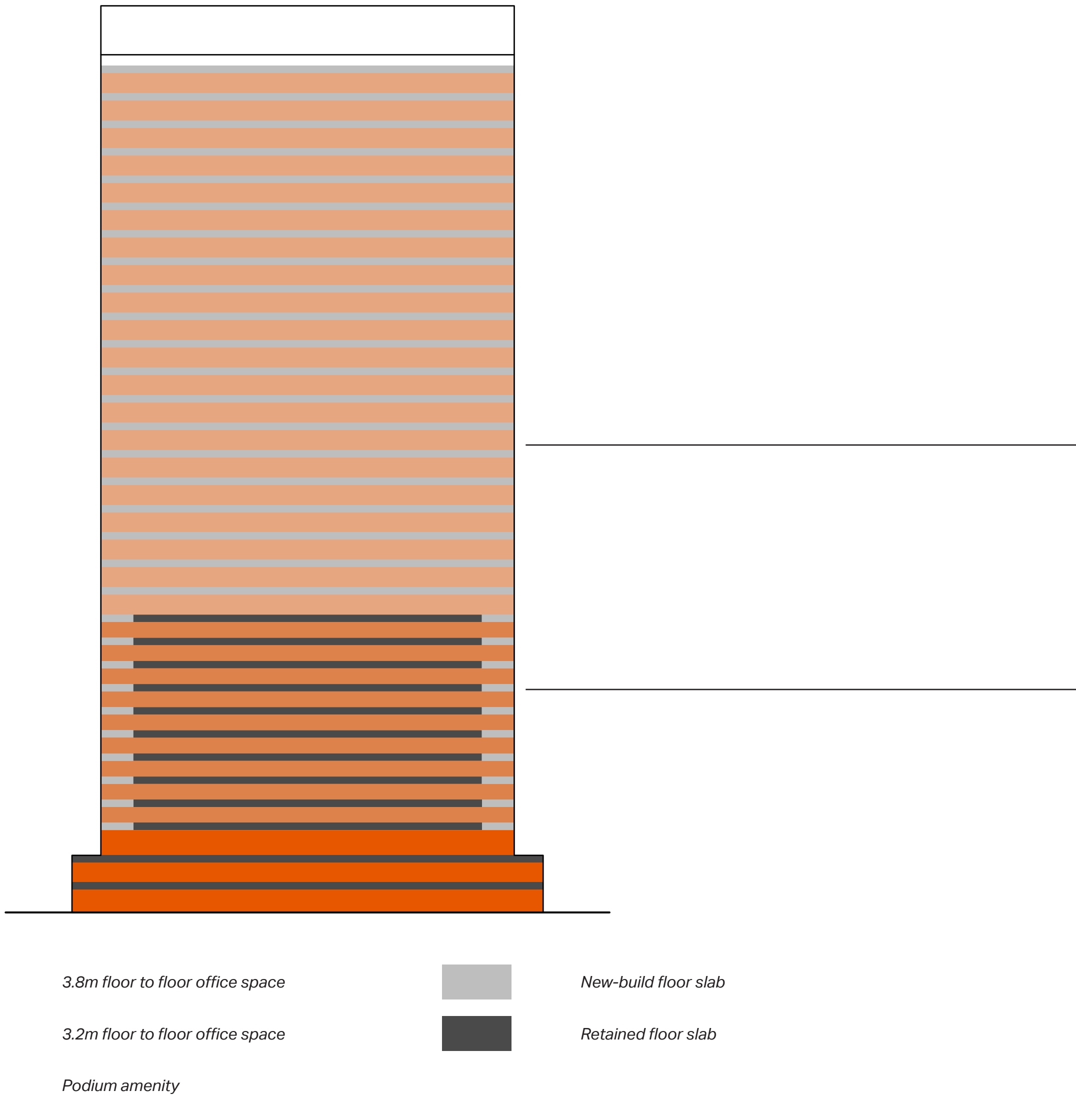
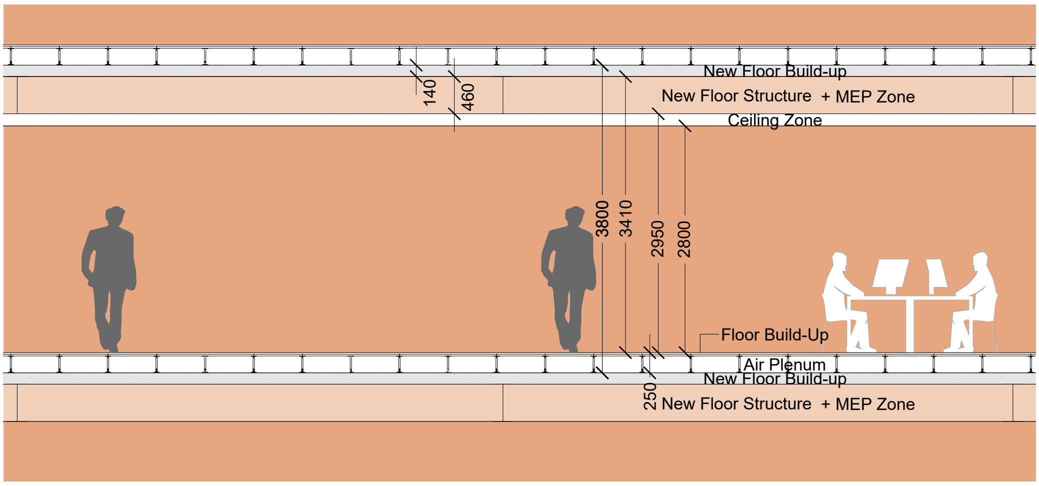


Figure 16.14 Programme stack diagram (above) and room sections (opposite)

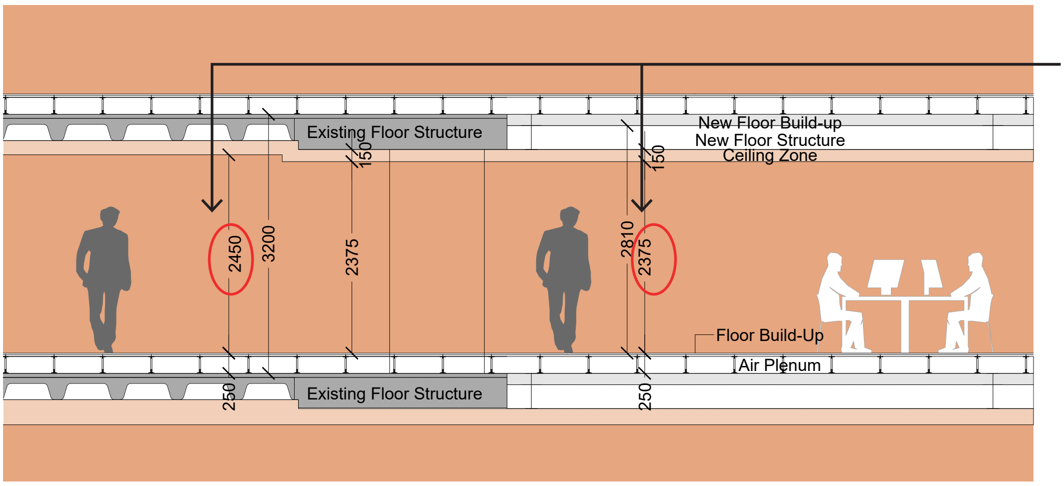
UPPER STACK

Floor to floor 3,800mm
Floor to ceiling 2,800mm



LOWER STACK (DROPPED CEILING)

Floor to floor 3,200mm
Floor to ceiling 2,375mm (2,450mm achievable under areas of existing ribbed slab)



Floor to ceiling height of 2,375mm compromises quality of space. With the extension, there is even more quantum of compromised floor space. 2,450mm achievable only under areas of existing ribbed slab. These levels could be delivered without a dropped ceiling and achieve 2,425mm clear (refer to Section 16.3.2).

Structural Retention
This option would retain all existing floor slabs below (and including) Level 12, with new build floors above. This gives 13 retained slabs in total with 20 new-build slabs.

There would be 29 storeys in total above the podium for a total of 32 storeys.

For this option, the core and slab retention strategy would reduce the need for any new major penetrations in the existing floor slabs, by removing the north pinwheel arm, and consolidating all new core elements in this area. The south pinwheel arm would be removed to alleviate the double column arrangements and improve floorplate flexibility.

This would result in approximately 41% of the structure retained by carbon (or 45 % by volume). This is shown schematically in Figure 16.15.

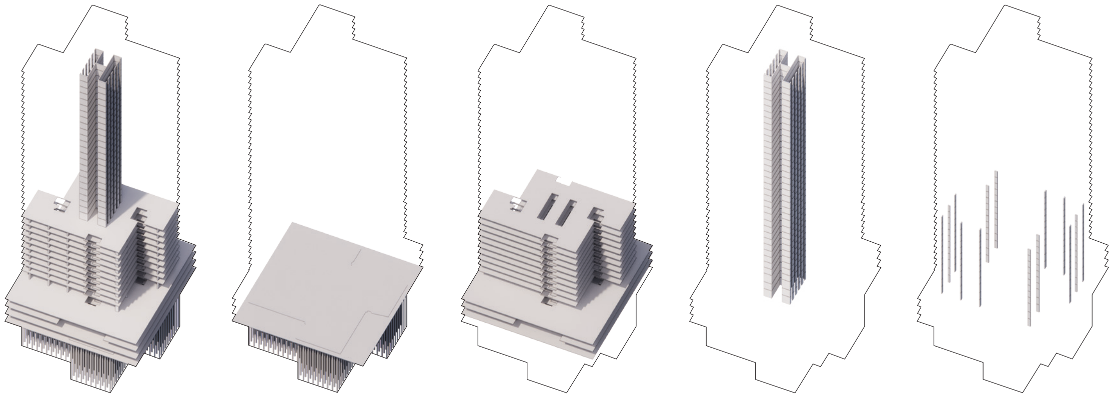
Future-proofed
Flexibility of the floorplates would be inhibited by having to work within the constraints of the existing column grid due to retaining most of the existing slabs in the lower portion of the stack. In the central area, existing columns would be positioned with spans that are not ideal for a modern office layout, and would be irregular meaning they are difficult to subdivide rationally.

In the upper stack where new slabs are proposed, it would be possible to transfer to a new grid over a few storeys. However transfer structures are inefficient from a carbon perspective, and ultimately the grid would remain constrained by being largely dependent on the existing building grid.

From an adaptability perspective, the opportunity to design in double-height amenity spaces, or additional soft spots would be limited to areas of new slab (either the extended areas or the new slabs above Level 12). This would inhibit the building being able to change to suit future trends, increasing its risk of becoming obsolete prematurely. Over the full building, this limitation is not insignificant applying to approximatively 34% of the levels (10 out of 29 storeys), as well as the podium.

This limitation is extended to the ability to design the structural system for ease of disassembly, promoting material reuse and reducing potential waste in the future.

How adaptability and design for disassembly is imagined in the new structural system is shown in Section 18.

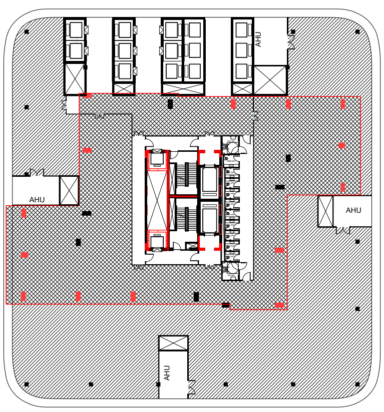


MAXIMUM POSSIBLE WITHOUT EXTENSION*
89 %

	OVERALL	FOUNDATION	SLAB	CORES	COLUMNS
Embodied Carbon	**3,681** tCO2e	**1,683** tCO2e	**1,160** tCO2e	**679** tCO2e	**158** tCO2e
Ratio of Carbon	**41** %	**19** %	**13** %	**8** %	**2** %

** Assumes no floorplate extension (i.e. working within the existing envelope), meaning new risers need to be cut out of the existing floorplate. Refer to Section 15. With extended floorplates, possibility exists to position risers outside of this existing footprint, resulting in potential higher degrees of retention.*

Figure 16.15 Embodied carbon and retention of structure broken down by structural element



Potential double height above L12 only

Potential double height all floors

Wherever there are not existing slabs there is potential for double height amenity spaces and additional soft spots to be introduced.

Figure 16.16 Opportunities for structural adaptability

Health & Safety and Buildability
Buildability would be complex. The risk of unknowns in the existing structure is increased with greater levels of retention, and the lack of consistency from level to level is likely to introduce further complexity at each of the interfaces between existing and new structure.

A large part of the construction complexity is driven by the temporary works requirements. In this case there would be moderate temporary works required on the retained slab levels where there would be unconstrained slab edges. Where the existing satellite cores would be removed, the key is maintaining continuity of the perimeter ring beam to support the retained slab, meaning that new construction would be required prior to demolition of the satellite cores. This would introduce an additional health & safety risk by having demolition and construction activities happening simultaneously and in close proximity (see Figure 16.17).

The central core would need to be braced before demolition of the existing slabs above Level 12, as it would be unconstrained once these levels are removed. Some temporary back propping would however be required for below grade retaining walls.

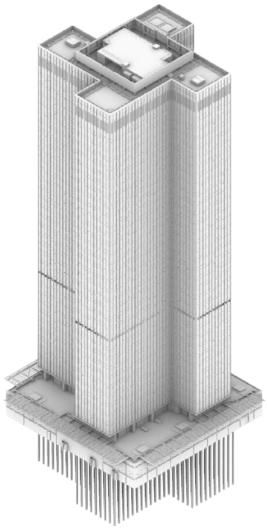
The construction sequence is shown schematically in Figure 16.17.

Efficiency and Viability
This option would be challenging from a viability perspective because it would still deliver a significant amount of compromised floor space. All the retained levels would retain the existing building floor to floor height of 3,200m, which was shown in Volume One (and Section 2 of this document), to be challenging for delivering a modern office offering, making leasing difficult on these floors, if not impossible.

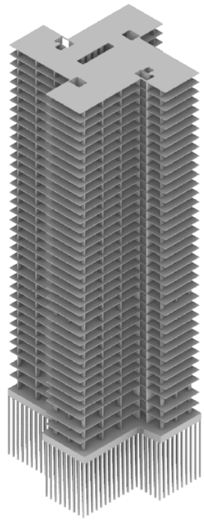
Floorplate efficiency would be 66%.

Lab-enabled
This option presents no opportunity for lab-enabled spaces due to floor to floor heights being too low for lab use.

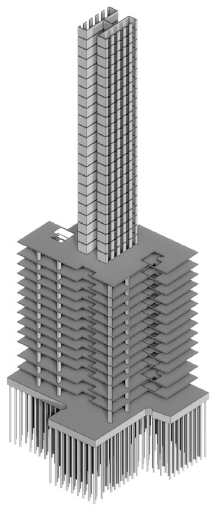
Site Capacity
This option significantly improves site capacity, and would have the capacity to provide widespread public realm upgrades due to its scale. Refer to Volume One Section 5.4. It does not provide the in-demand lab-enabled space required in London.



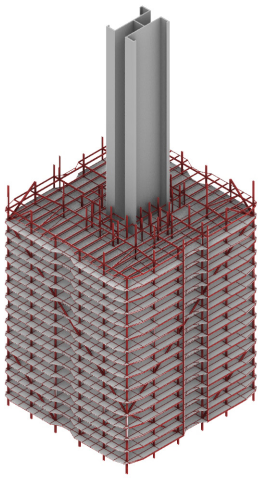
1. EXISTING BUILDING
Construction sequence is complex, due to the retained floor slabs and unrestrained core



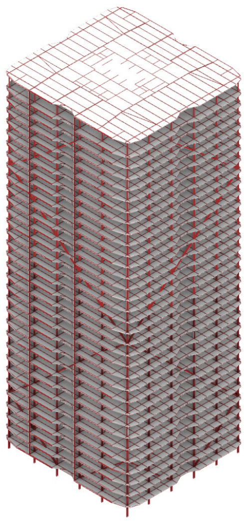
2. REMOVE FACADE
Existing facade carefully deconstructed and materials used in recycling and upcycling



3. REMOVE UPPER SLABS
Slabs are removed back to the core in the upper stack and pinwheel arms trimmed off in the lower stack. Further temporary works required to restrain the free-standing core



4 EXTEND FLOORPLATES
Construction of the permanent steels and floorplates can begin using conventional methods



5. COMPLETED STRUCTURE
The structure is completed and installation of facade, services, vertical transport, etc. can follow

Figure 16.17 Construction sequence diagram

16.3.4 Partial Retention and Extension - Retain Consecutive Slabs (Office and Lab)

Description

This option would retain part of the existing floor slabs below Level 12, and build new slabs above. It would maintain the central core structure. The southern portions of the existing slabs would be removed below Level 12, in order to provide double-height space suitable for lab use. This position is not ideal due to the additional solar exposure of the south-facing, double height spaces, but it is constrained by requiring continuity of the floor slab from the north core lifts. The remainder of the floorplate would be intended as write up spaces adjacent to the labs. Existing slabs would maintain the existing floor to floor height of 3,200mm, with 6,400mm for the lab spaces, while new slabs would have a floor to floor height of 3,800mm suitable for office use. Floors would be extended to deliver an expanded floorplate.

The section and floor slab retention diagrams are shown in Figure 16.18. The programme stack and room sections are shown in Figure 16.19 overleaf.

Level 12 is chosen as the split between the lower retained stack and the upper portion where new slabs would be built out. This is because the existing Level 12 is an MEP service level and has a larger floor to floor height (3.9m) than the typical existing office floors (3.2m), but does result in a single comprised office floor. The vertical transport strategy would be reliant on using double decker lifts (reducing the footprint of lifts required and therefore resulting in improved floorplate efficiency), but these are contingent on a consistent inter-storey height. The alternatives are twin lifts (which can accommodate varying inter-storey heights) for which there is a single-source supply procurement risk, or using conventional single-decker lifts, but this would inflate the core and significantly erode the net to gross efficiency. Respectively, these two alternatives result in a level of risk that is unacceptable to the development (if the twin lifts cannot be procured the development cannot go ahead as planned), and a net to gross efficiency that will be not be viable to deliver. Accordingly, within the constraints of the vertical transport strategy, it would not be possible to retain a single level with an odd floor to floor height.

RETAIN CONSECUTIVE SLABS (OFFICE AND LAB)

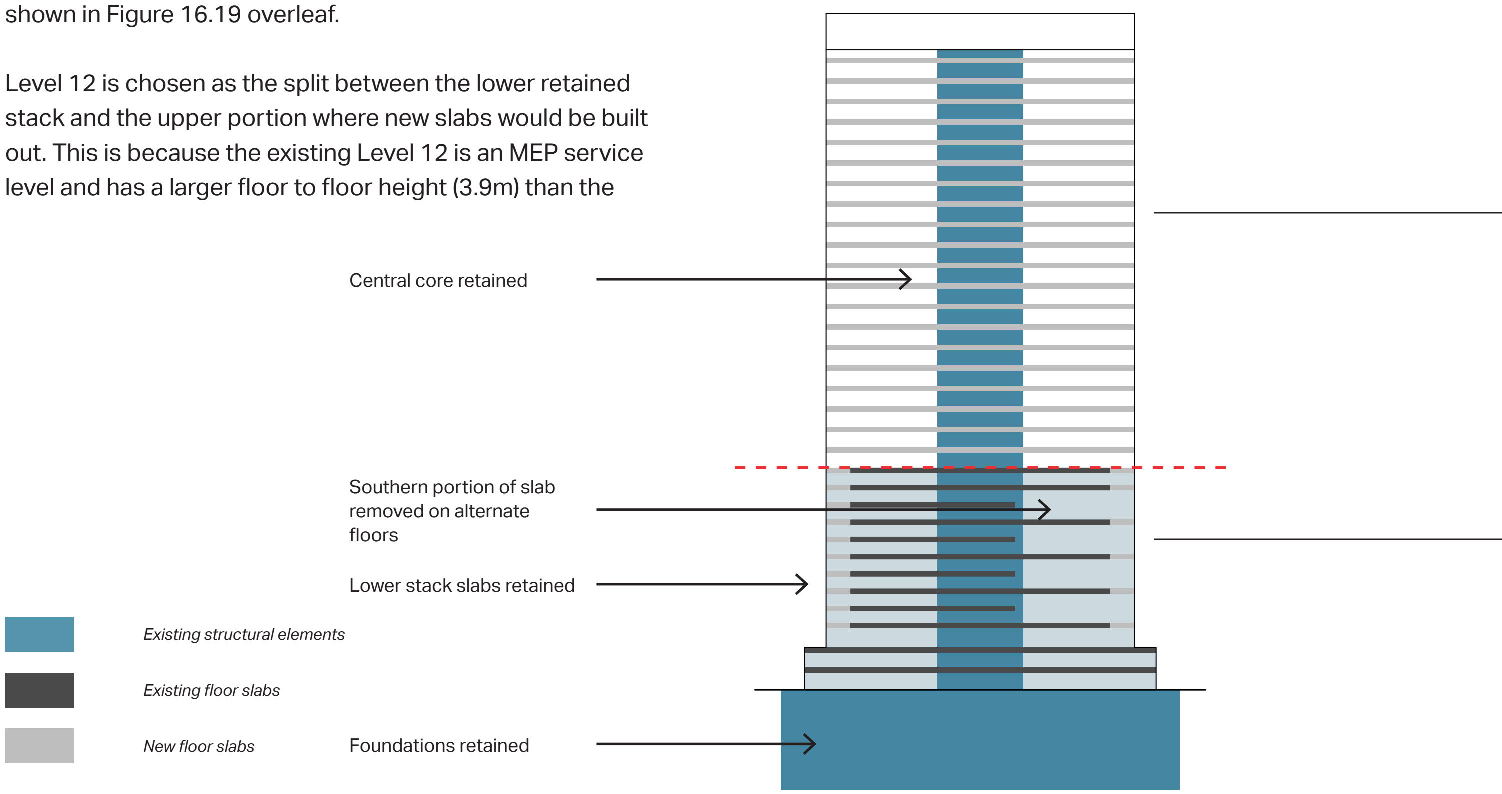
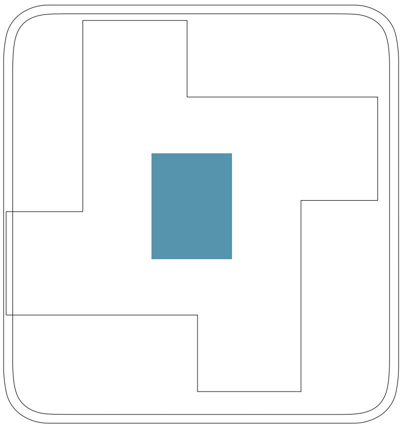
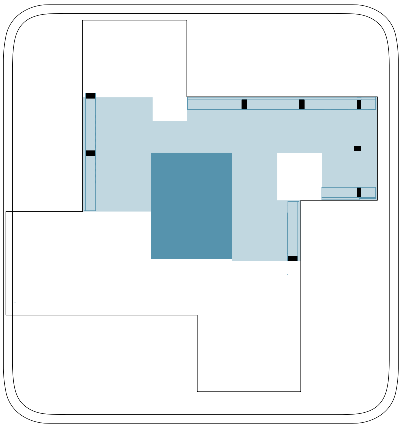


Figure 16.18 Diagram showing retained structural elements in this option (section above and slabs opposite)

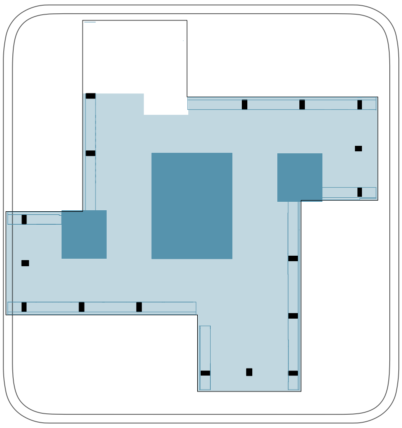
UPPER STACK
Central core retained, floorplates and satellite cores removed



LOWER STACK (LAB-ENABLED AREAS)
Central core retained, most central floor slab retained, satellite cores and southern slab removed



LOWER STACK (LAB-ENABLED WRITE UP)
Central core retained, most floor slab retained, satellite cores and northern pinwheel arm removed



PROGRAMME AND SECTION STACK

Retain Consecutive Slabs (Office and Lab)

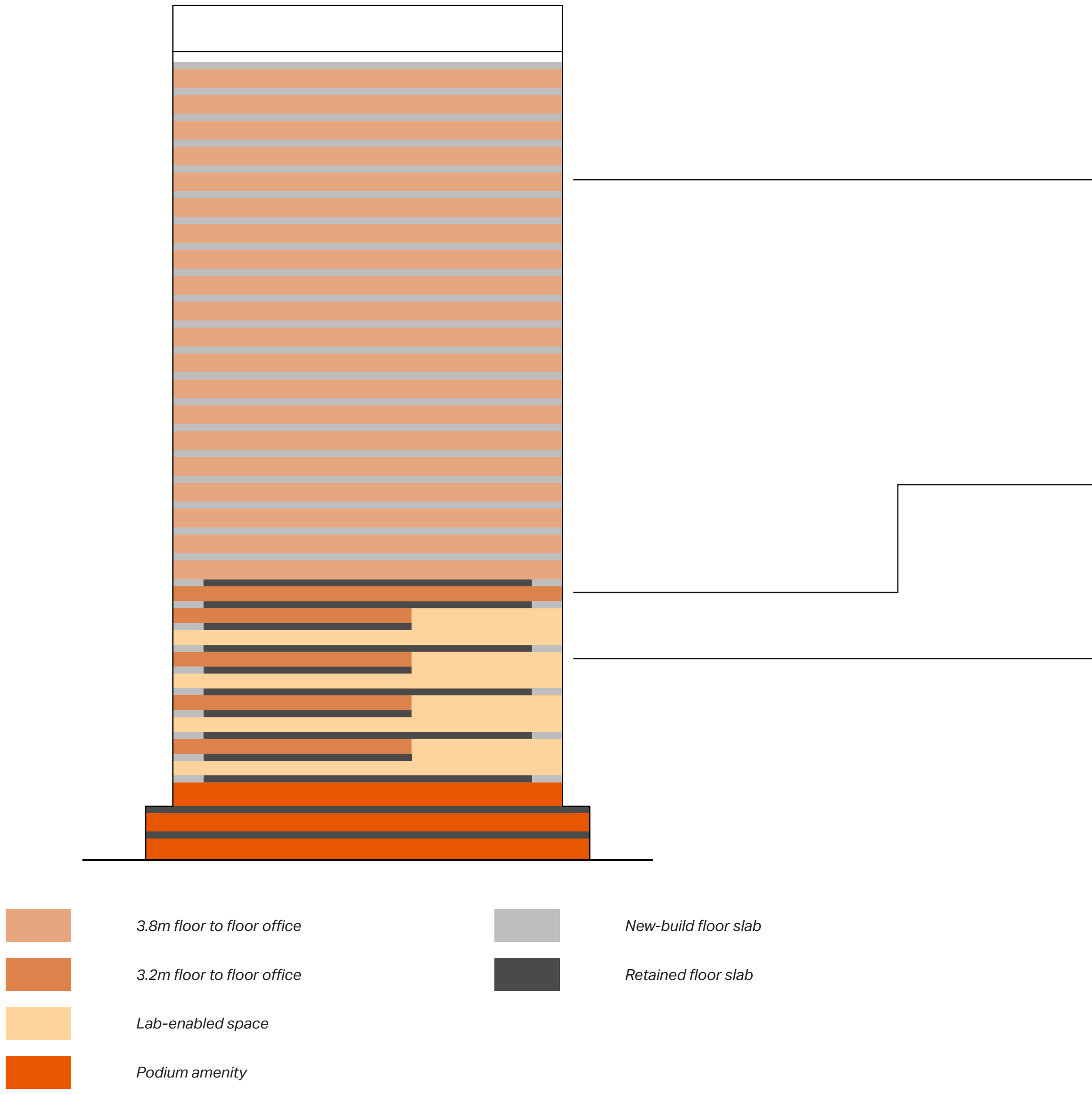
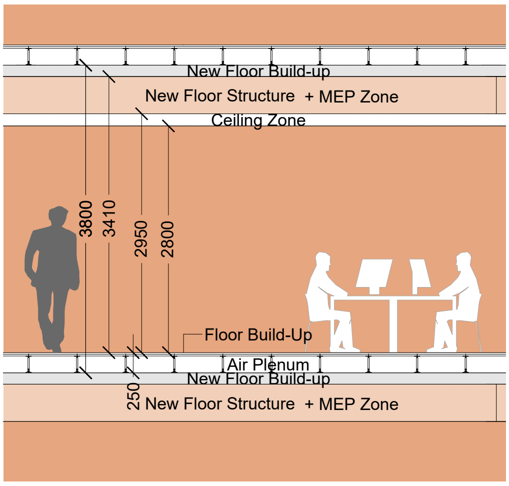
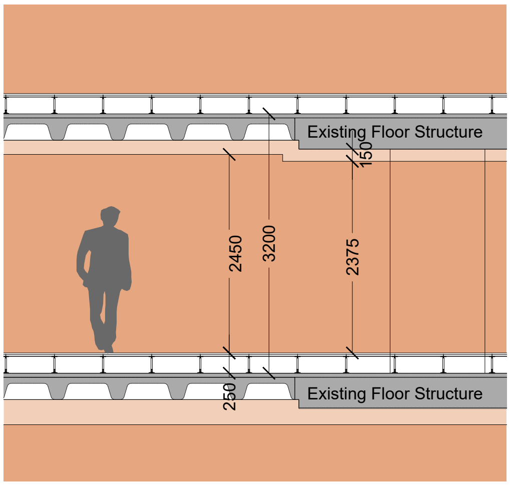


Figure 16.19 Programme stack diagram (above) and room sections (opposite)

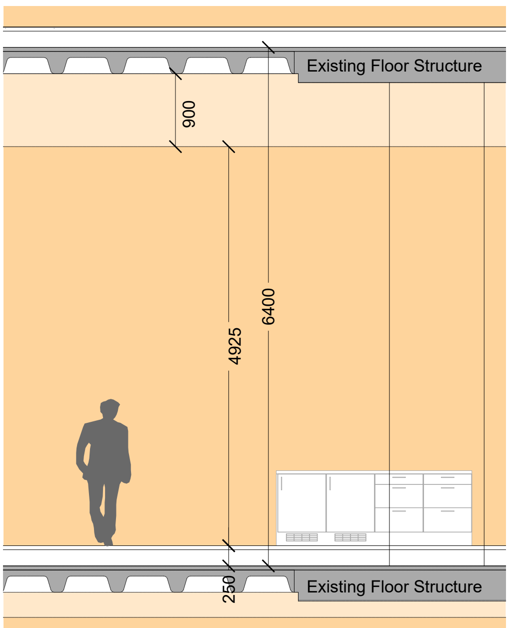
UPPER STACK
Floor to floor 3,800mm
Floor to ceiling 2,800mm



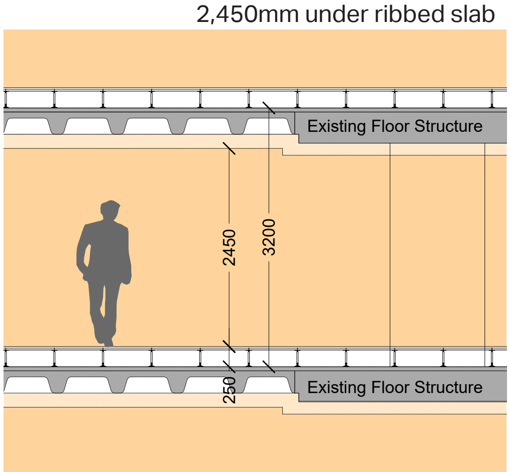
LOWER STACK
Floor to floor 3,200mm
Floor to ceiling 2,375 mm
2,450mm under ribbed slab



LAB-ENABLED SPACE
Floor to floor 6,400mm
Floor to ceiling 4,925mm



LAB-ENABLED WRITE UP SPACE
Floor to floor 3,200mm
Floor to ceiling 2,375mm
2,450mm under ribbed slab



Structural Retention
This option would retain part of the existing floor slabs below (and including) Level 12, and build new slabs above. This gives 13 retained slabs with 20 new-build slabs. 4 of the retained slabs would be trimmed back to provide double height lab spaces.

There would be 29 storeys in total above the podium for a total of 32 storeys.

For this option, the central core is retained with a new centralised north core. The north pinwheel arm would be trimmed back to facilitate the new core area.

During construction significant temporary works would be required. Full-height temporary works would be needed to support retained areas of slabs during demolition, particularity at unsupported slab edges. At the same time, there would be temporary works required during demolition to protect slabs and workers below. Figure 16.21 shows an example of the type of temporary works required.

This would result in approximately 41% of the structure retained by carbon (or 45 % by volume). This is shown schematically in Figure 16.20.

Future-proofed
Many of the issues around future proofing are the same as in the other consecutive slabs partial retention option from Section 16.3.3.

Flexibility of the floorplates would be inhibited by having to work within the constraints of the existing column grid due to retaining most of the existing slabs in the lower portion of the stack. This would lead to several double column arrangements. In the central area, existing columns would be positioned with spans that are not ideal for a modern office layout, and would be irregular meaning they are difficult to subdivide rationally.

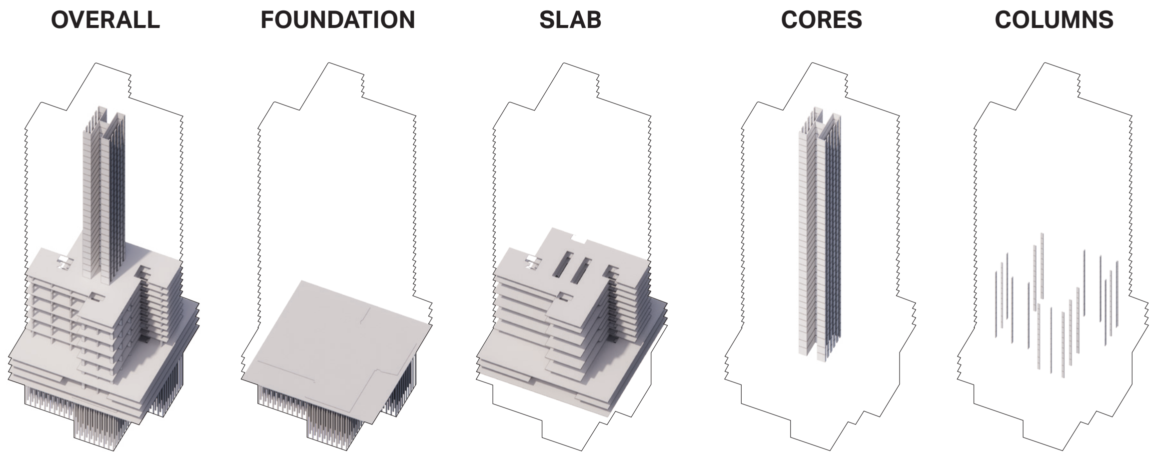
The desire to retain structure results in a compromised office-only level at Level 11.

In the upper stack where new slabs are proposed, it would be possible to transfer to a new grid over a few storeys. However transfer structures are inefficient from a carbon perspective, and ultimately the grid would remain constrained by being largely dependent on the existing building grid.

From an adaptability perspective, the opportunity to design in double-height amenity spaces, or additional soft spots would be limited to areas of new slab (either the extended areas or the new slabs above Level 12). This would inhibit the building being able to change to suit future trends, increasing its risk of becoming obsolete prematurely. Over the full building, this limitation is not insignificant applying to approximatively 34% of the levels (10 out of 29 storeys), as well as the podium.

This limitation is extended to the ability to design the structural system for ease of disassembly, promoting material reuse and reducing potential waste in the future.

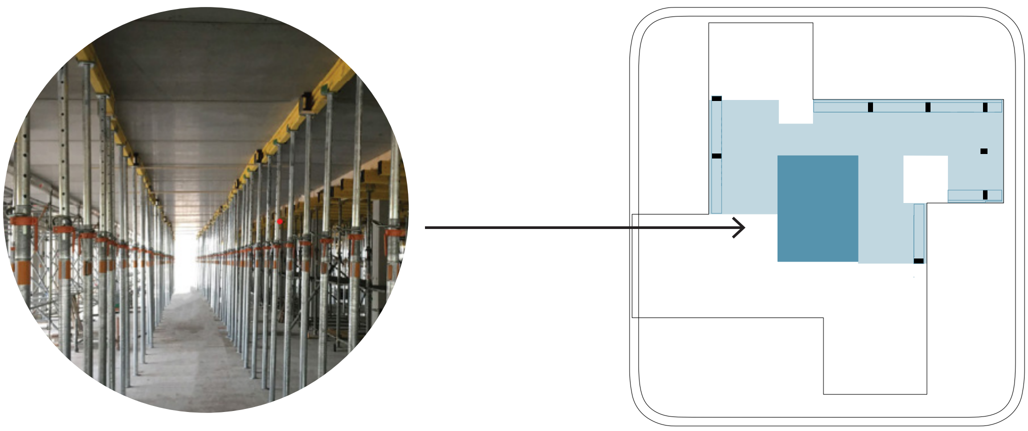
How adaptability and design for disassembly is imagined in the new structural system is shown in Section 18.



	MAXIMUM POSSIBLE WITHOUT EXTENSION* 89 %				
Embodied Carbon	**3,650** tCO2e	**1,683** tCO2e	**1,101** tCO2e	**679** tCO2e	**187** tCO2e
Ratio of Carbon	**41** %	**19** %	**12** %	**8**%	**2** %

* Assumes no floorplate extension (i.e. working within the existing envelope), meaning new risers need to be cut out of the existing floorplate. Refer to Section 15. With extended floorplates, possibility exists to position risers outside of this existing footprint, resulting in potential higher degrees of retention.

Figure 16.20 Embodied carbon and retention of structure broken down by structural element



Full-height temporary works required to support slabs during demolition

Figure 16.21 Full-height temporary works required to support slabs during demolition

Health & Safety and Buildability
Like the other consecutive slabs partial retention option from Section 16.3.3, buildability would be complex. The risk of unknowns in the existing structure is increased with greater levels of retention, and the lack of consistency from level to level is likely to introduce further complexity at each of the interfaces between existing and new structure.

A large part of the construction complexity would be driven by the temporary works requirements. In this case there would be complex temporary works required on the retained slab levels where there would be unconstrained slab edges. Where the existing satellite cores would be removed, the key is maintaining continuity of the perimeter ring beam to support the retained slab, meaning that new construction would be required prior to demolition of the satellite cores. This would introduce an additional health & safety risk by having demolition and construction activities happening simultaneously and in close proximity.

Some temporary back propping would be required for below grade retaining walls where the ground floor slab would be removed to enable new piling.

The construction sequence is very similar to the other consecutive slabs partial retention option from Section 16.3.3, shown schematically in Figure 16.17. A key difference here is trimming back the lab levels to create the double-height spaces.

With the double-height spaces, the existing column spans would be doubled accordingly (6.4m instead of the existing 3.2m span). These columns would need to be strengthened to accommodate this, which would likely be achieved by concrete or steel jacketing. See techniques in Figure 16.23.

Efficiency and Viability
This option would be challenging from a viability perspective because it would deliver a solution that is ultimately inefficient and compromised.

By delivering the lab-enabled spaces by omitting every other existing floor level, the resulting floor to floor height of 6,400mm would be over dimensioned. The same level of servicing could be achieved in approximately 4,100mm. This leads to a volumetric inefficiency, where significantly more area could be delivered within the same envelope, and it does not optimise the site's capacity.

The write-up spaces and/or office spaces that share volume with labs in the lower portion of the stack, would have a floor to floor height of 3,200mm, which was shown in Feasibility Volume One (and Section 2 of this document), to be challenging for delivering a modern office offer. These spaces would be difficult to let due to the market demanding greater floor to ceiling heights.

The core layout in this option would deliver net to gross efficiency of 66% (see Section A.4).

Site Capacity
This option improves site capacity, and would have the capacity to provide public realm upgrades due to its scale. Refer to Volume One Section 5.4. It does provide the in-demand lab-enabled space required in London, but in way that is not spatially efficient.

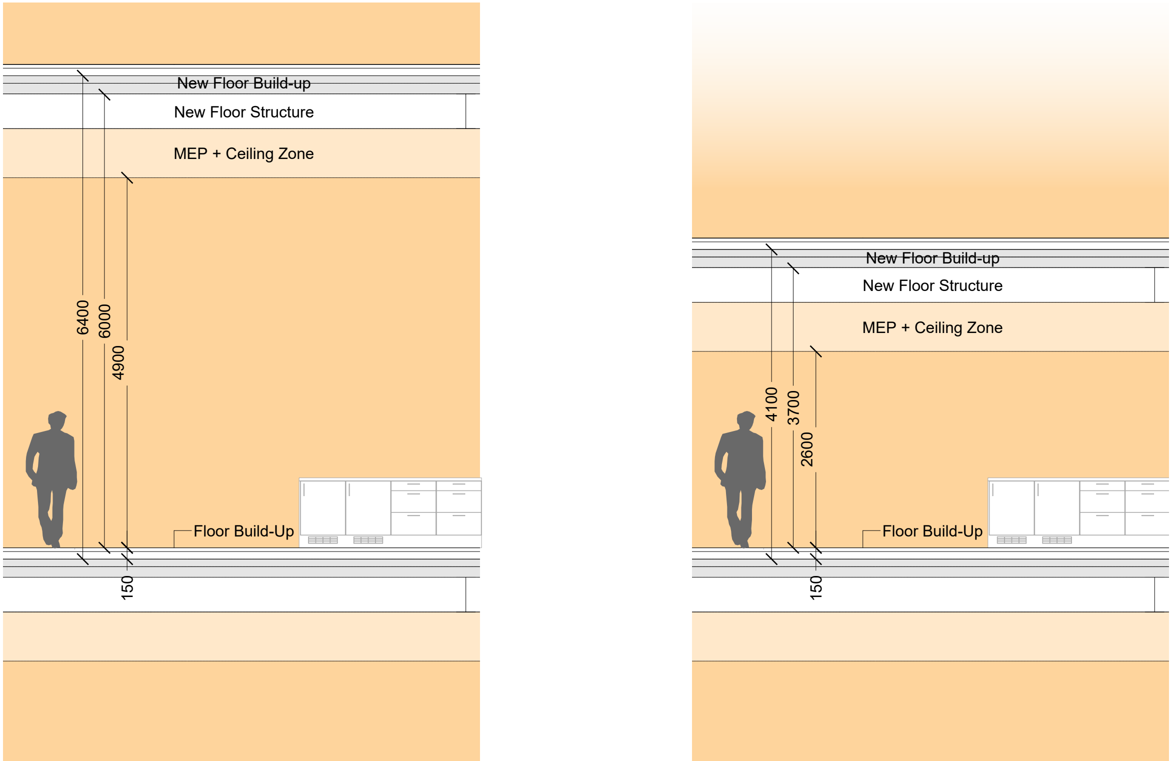


Figure 16.22 The lab spaces are volumetrically inefficiency as they could be delivered in 4,100mm floor to floor

OPTIONS FOR COLUMN STRENGTHENING

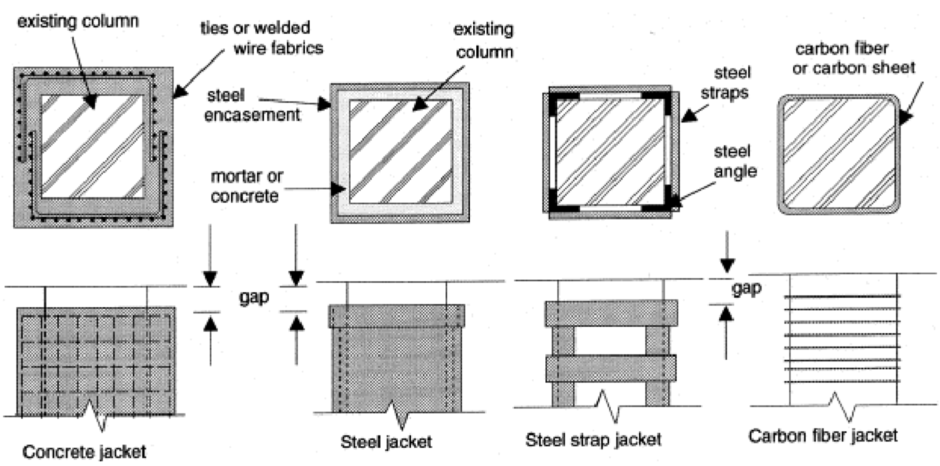


Figure 16.23 Techniques for strengthening retained columns where column spans are increased

16.3.5 Partial Retention and Extension - Retain Interstitial Slabs (Office)

Description

This option would retain strategic slabs throughout the section, in a way that allows the floor to floor height to be reset. Every 6th slab above the podium would be retained, the remaining 5 removed, and 4 new slabs added in between. Floors would be extended to deliver an expanded floorplate.

It would maintain the central core structure, and relevant columns throughout. The north, west, and south arms of the pinwheel would be trimmed back entirely to avoid the double column arrangements and improve flexibility, especially as the column positions from the retained floors must be maintained throughout the stack.

Floor to floor heights would not be consistent. Most floors would have 3,840mm floor to floor, but there would be some with 3,980mm. This is due to incorporating the additional height from existing Level 12 which is an MEP service level. The uppermost two levels would have a floor to floor height of 4,080mm.

While the office levels floor to floor heights would indeed be compatible with a modern office offering, they would vary through the stack:

- 5 storeys at 3,840mm in the lower stack
- 5 storeys at 3,980mm in the mid stack
- 15 storeys at 3,840mm in the upper stack
- 2 storeys at 4,080mm at the crown.

This would make the stack incompatible with a double-decker vertical transportation strategy. Considerations for the alternatives (twin lifts or conventional single-decker lifts) are as per Section 16.3.3. Respectively they present an unacceptable level of risk to the development, and a net to gross efficiency that will be not be viable to deliver.

The section and floor slab retention diagrams are shown in Figure 16.24. The programme stack and room sections are shown in Figure 16.25 overleaf.

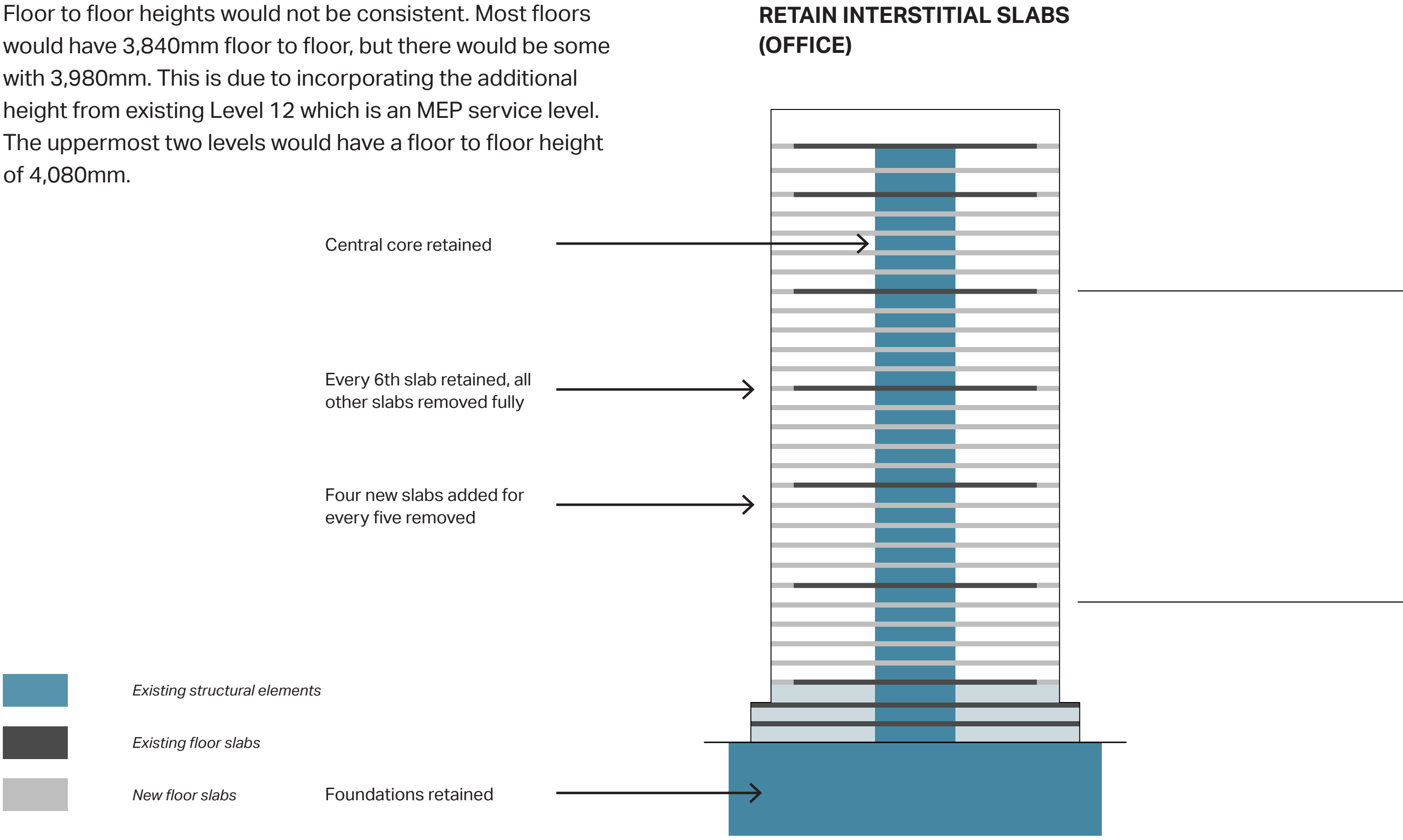
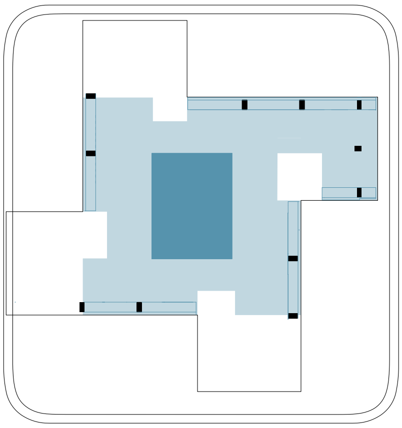
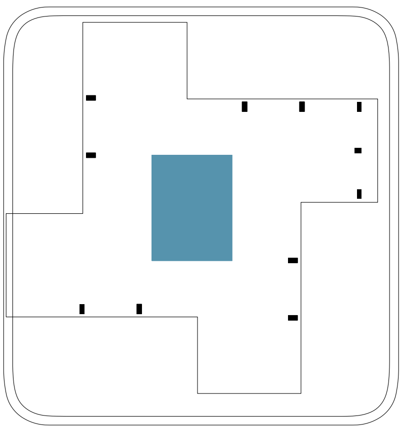


Figure 16.24 Diagram showing retained structural elements in this option (section above and slabs opposite)

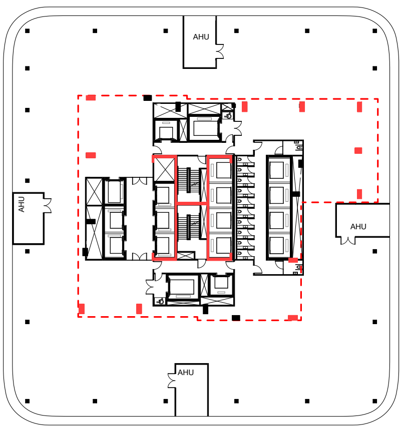
EVERY 6TH LEVEL STACK
Central core retained, most floor slab retained, north, west, south pinwheel arms and satellite cores removed



ALL OTHER LEVELS
Central core retained, floorplates removed



INDICATIVE CORE LAYOUT
Expanded Central Core

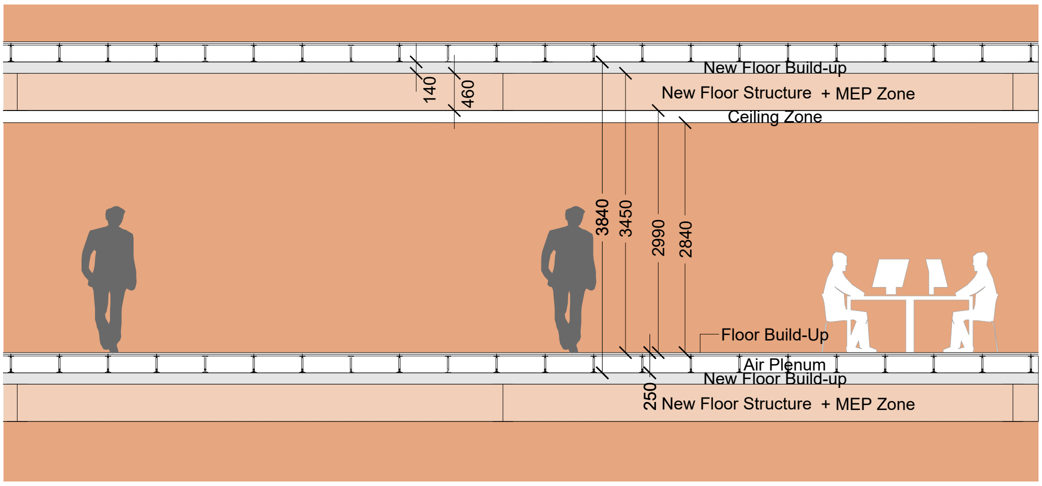


PROGRAMME AND SECTION STACK
Retain Interstitial Slabs (Office)

Figure 16.25 Programme stack diagram (above) and room sections (opposite)

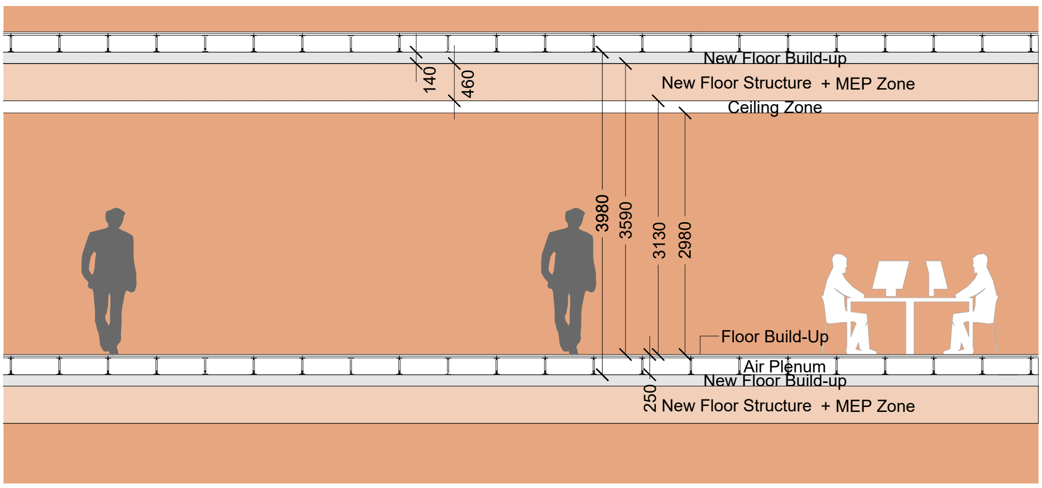
OFFICE SPACE

Floor to floor	3,840mm
Floor to ceiling	2,840mm



OFFICE SPACE

Floor to floor	3,980mm
Floor to ceiling	2,980mm



Structural Retention
This option would strategically retain interstitial floor slabs to allow the new-build floor slabs built in between to reset the floor to floor heights. It gives 9 retained slabs dispersed throughout the stack with 21 new-build slabs in between.

There would be 27 storeys in total above the podium, for a total of 30 storeys.

This option would retain the existing central core, but all four satellite cores would be removed. The north, west, and south pinwheel arms would be trimmed back entirely to improve floorplate flexibility.

Retaining the slabs together with the central core option would lead to the requirement for many new core penetrations within the existing slab areas. The resulting floor slab retention would be quickly eroded due to the new penetrations, and the demolition due to the ribbed slabs.

This would result in approximately 38% of the structure retained by carbon (or 42% by volume). This is shown schematically in Figure 16.26.

During construction significant temporary works and coordination would be required. Full-height temporary works would be needed to support retained areas of slabs during demolition, particularity at unsupported slab edges. At the same time, there would be temporary works required during demolition to protect slabs and workers below. Because the columns would be retained throughout the stack (driven by having retained floors throughout the stack), they must be reinforced/restrained because during demolition of the slabs. This would necessitate a complex construction/ deconstruction methodology, and introduce further temporary works.

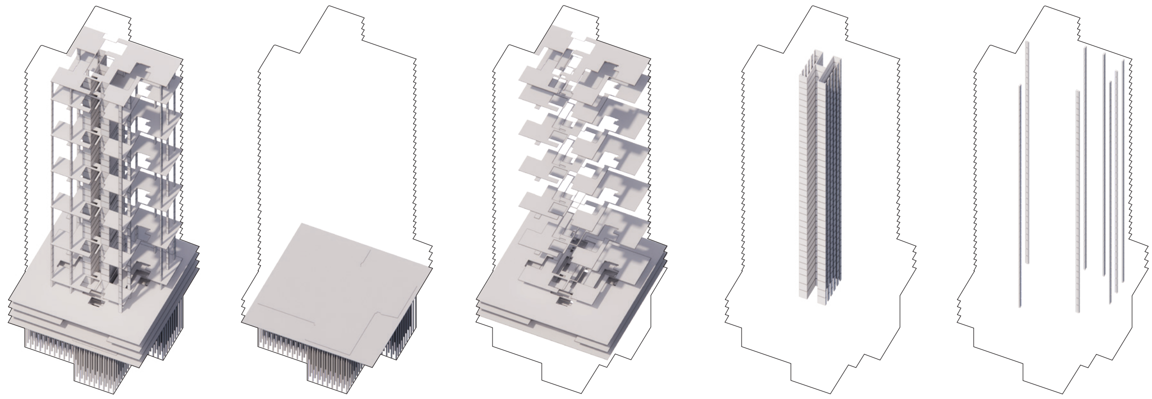
Future-proofed
Flexibility of the floorplates would be inhibited by a compromised column arrangement, having to work within the constraints of the existing column grid due to the retained slabs. Unlike the consecutive slabs partial retention options in the preceding Sections, in this option there would be retained slabs throughout the stack. This means that it would not be practical to transfer column grids between the retained and new-build stacks. This leads to all slabs having to work within the constraints of the retained columns. Though the double column arrangements could be somewhat mitigated by removing three of the four pinwheel arms, in the central area, existing columns would be positioned with spans that are not ideal for a modern office layout, and would be irregular meaning they are difficult to subdivide rationally.

From an adaptability perspective, the opportunity to design in double-height amenity spaces, or additional soft spots would be limited to areas of new slab (either the extended areas or the new interstitial slabs).

Even the new areas would be compromised to an extent, because the structural system options available for the new-build areas would be limited by the complex construction methodology that is required to retain the interstitial slabs. Pre-fabricated, modular systems are best-suited to being disassembled non-destructively, but these systems need to be "dropped in" and this methodology would be incompatible with the steelwork required to temporarily brace the retained structures. The result is that the ensuing floor system is likely to be poured in-situ, which is not readily disassembled.

This lack of adaptability is a key inhibitor as the aim with the structural system is to design something long-lasting, and flexible and adaptable to future trends, to reduce the risk of premature obsolescence.

How adaptability and design for disassembly is imagined in the new structural system is shown in Section 18.



MAXIMUM POSSIBLE WITHOUT EXTENSION*
89 %

	OVERALL	FOUNDATION	SLAB	CORES	COLUMNS
Embodied Carbon	**3,359** tCO_2e	**1,683** tCO_2e	**861** tCO_2e	**552** tCO_2e	**263** tCO_2e
Ratio of Carbon	**38** %	**19** %	**10** %	**6** %	**3** %

** Assumes no floorplate extension (i.e. working within the existing envelope), meaning new risers need to be cut out of the existing floorplate. Refer to Section 15. With extended floorplates, possibility exists to position risers outside of this existing footprint, resulting in potential higher degrees of retention.*

Figure 16.26 Embodied carbon and retention of structure broken down by structural element

Health & Safety and Buildability
In this option, the nature of the retention would make buildability highly complex. The risk of unknowns in the existing structure is increased with greater levels of retention, and the lack of consistency from level to level is likely to introduce further complexity at each of the interfaces between existing and new structure.

The construction sequence is shown schematically in Figure 16.27. The complexity comes from having demolition and new construction happening simultaneously in the same spaces, itself introducing an additional health & safety risk. A key factor is maintaining stability of the existing cores and columns during demolition. A method to achieve this, would be to install the steel framework before the existing slabs are removed. A challenge here is that this new steelwork ideally would align with structure of the new floor levels (so that it could become permanent steels), but these levels do not align with the existing slabs. The result is that workers would need to work in tight spaces, installing steels extremely close to existing concrete slabs. At the same time, satellite cores would need to be replaced with new columns before the intermediary floors can be removed.

Once the steels are in and the relevant slabs are removed, the floorplates can be extended using in-situ concrete slabs. As outlined previously, having the steels in place with existing slabs above precludes any "drop in" systems. However even pouring concrete in this manner would be complex as construction would be happening around steels and portions of existing slab.

Like the other options, there would be complex temporary works required on the retained slab levels where there would be unconstrained slab edges. This is exacerbated where the new penetrations would be formed in the existing slab system. There would be additional temporary works required to prop the below-grade retaining walls where portions of the ground floor slab would be removed.

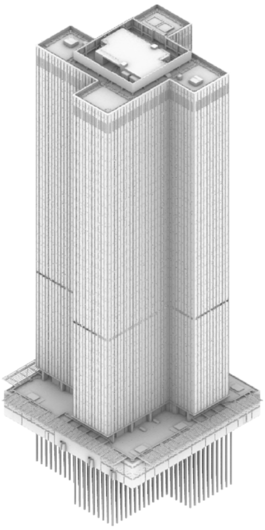
Efficiency and Viability
This option would be challenging from a viability perspective because it would deliver a solution that is complex and costly to build, with low efficiencies, and ultimately would not deliver high levels of retained structure.

Lab-enabled
This option presents no opportunity for lab-enabled spaces due to floor to floor heights being too low for lab use.

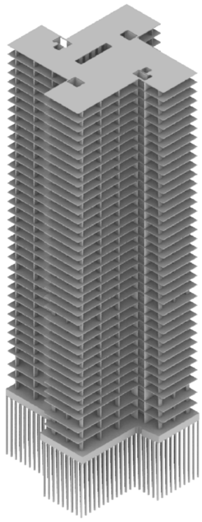
In order to accommodate lab-enabled spaces, an alternative stack could be developed with sufficient floor to floor heights. This stack is shown in Figure 16.28 overleaf.

This option has all the same limitations, construction complications, and the like as the office only option. Like the office only option, the stack split would not accommodate an efficient double-decker vertical strategy. Ultimately there would be a lot of complexity added to deliver only a small fraction of retained structure.

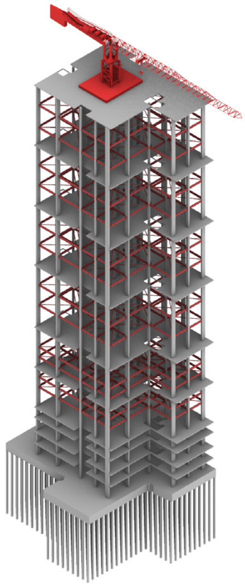
Site Capacity
This option improves site capacity, and would have the capacity to provide public realm upgrades due to its scale. Refer to Volume One Section 5.4. It could provide the in-demand lab-enabled space required in London, if the interstitial slabs are strategically chosen to support lab-enabled uses.



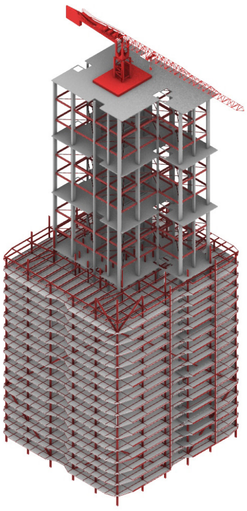
1. EXISTING BUILDING
Construction sequence is complex, due to the retained floor slabs and unrestrained core



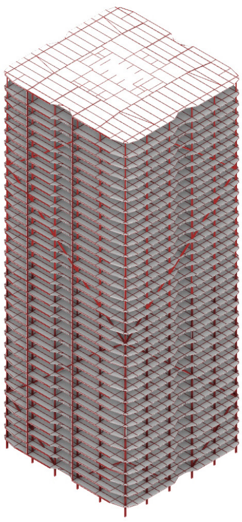
2. REMOVE FACADE
Existing facade carefully deconstructed and materials used in recycling and upcycling



3. REMOVE INTERSTITIAL SLABS
Steels installed before interstitial slabs are removed to restrain columns. Satellite cores need to be replaced with columns before intermediary floors are removed



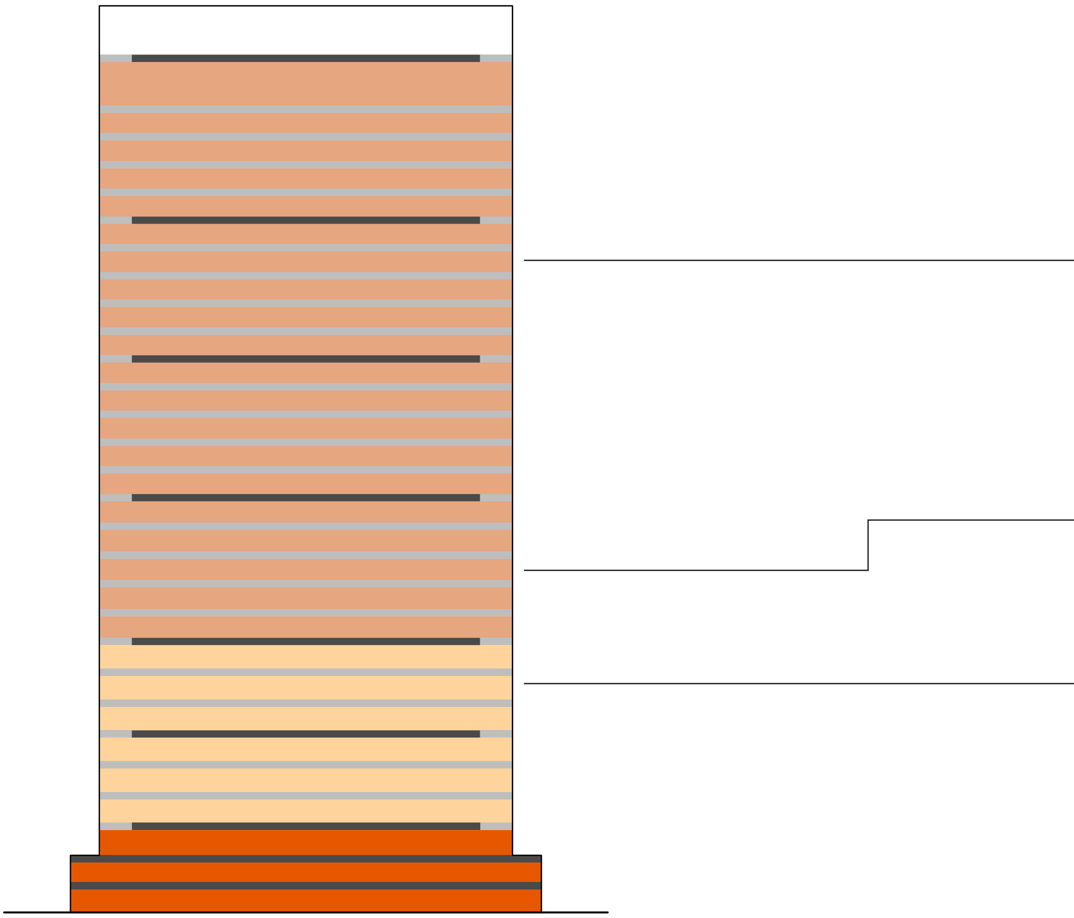
4 EXTEND FLOORPLATES
Permanent steels installed and floorplates extended using in-situ concrete slabs



5. COMPLETED STRUCTURE
The structure is completed and installation of facade, services, vertical transport, etc. can follow

Figure 16.27 Construction sequence diagram

PROGRAMME AND SECTION STACK
Retain Interstitial Slabs (Office and Lab)



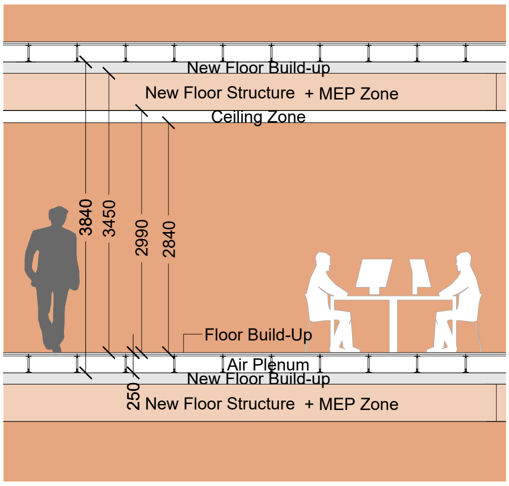
	High quality office space		*New-build floor slab*
	Compromised, low quality office space		*Retained floor slab*
	Lab-enabled space		
	Podium amenity		

Figure 16.28 Programme stack diagram for office and lab (above) and room sections (opposite)

OFFICE SPACE

Floor to floor 3,840mm

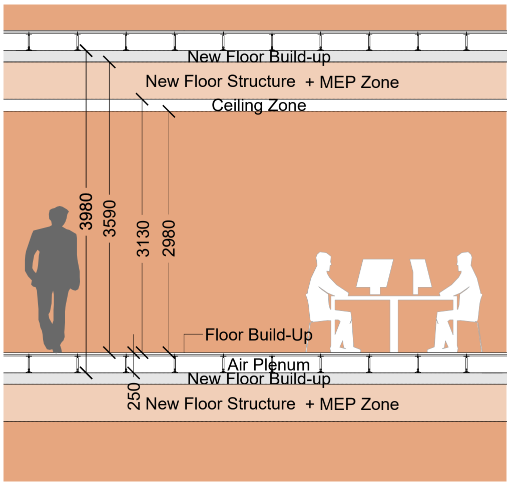
Floor to ceiling 2,840mm



OFFICE SPACE

Floor to floor 3,980mm

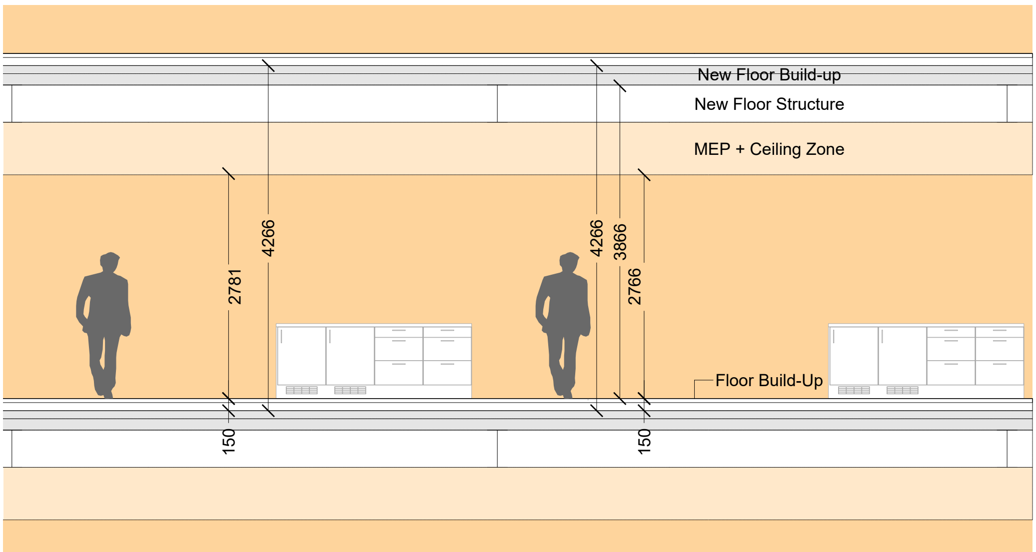
Floor to ceiling 2,980mm



LAB-ENABLED SPACE

Floor to floor 4,266mm

Floor to ceiling 2,781mm



16.3.6 Partial Retention and Extension - Retain the Core

Description

This option would retain the central core and the below ground substructure and foundations only. All slabs would be removed and built from new, enabling freedom to choose floor to floor heights for optimum efficiency. The floor footprint would be extended to deliver an expanded floorplate.

This option would provide the flexibility to include lab-enabled space with floor to floor height of 4,100mm in the lower stack, with office floors above with a floor to floor height of 3,800mm, as shown in this option.

The vertical transport strategy would be reliant on using double decker lifts (reducing the footprint of lifts required and therefore resulting in improved floorplate efficiency). All levels have the same inter-storey height, and are therefore appropriate for the vertical transportation strategy.

The section and floor slab retention diagrams are shown in Figure 16.29. The programme stack and room sections are shown in Figure 16.30 overleaf.

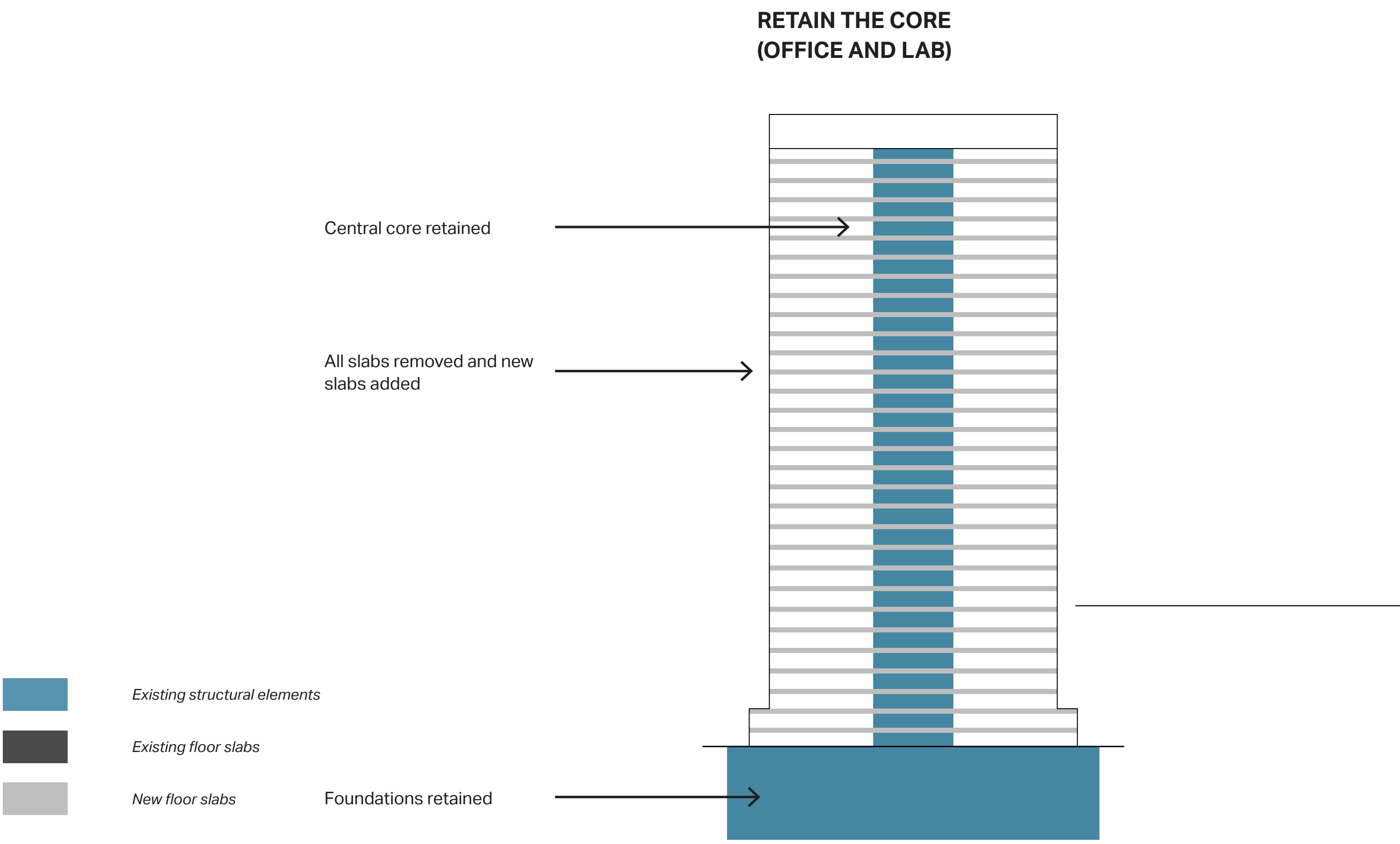
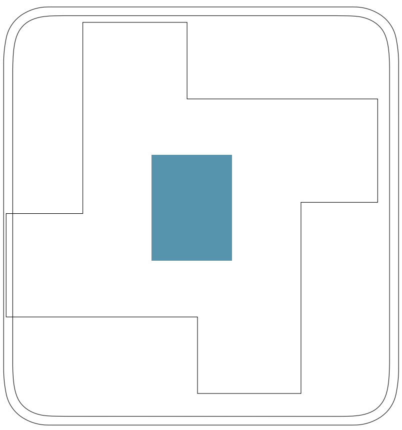
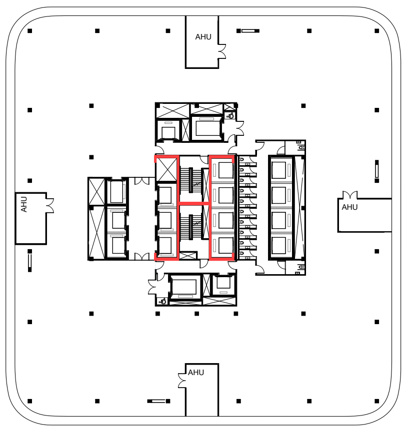


Figure 16.29 Diagram showing retained structural elements in this option (section above and slabs opposite)

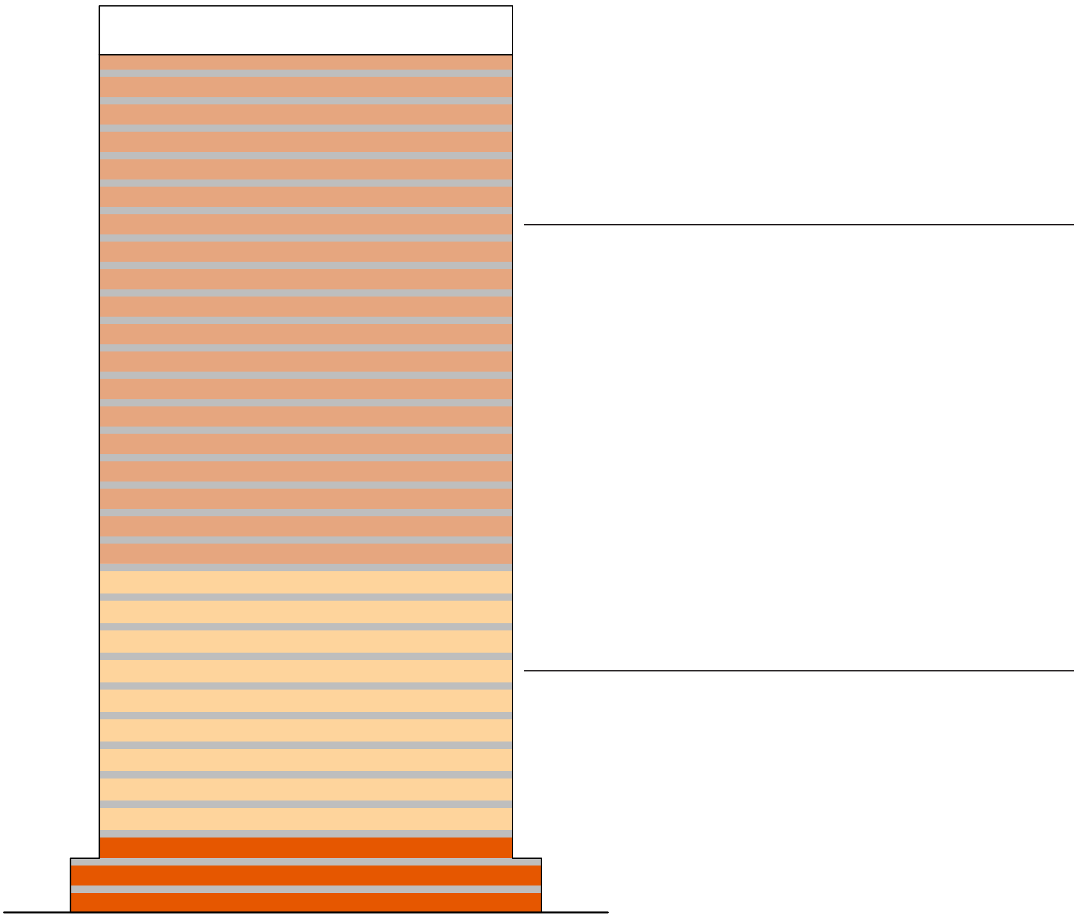
ALL LEVELS
Central core retained, floorplates removed



INDICATIVE CORE LAYOUT
Expanded Central Core



PROGRAMME AND SECTION STACK
Retain the Core



3.8m floor to floor office

Potential to include lab-enabled space

New-build floor slab

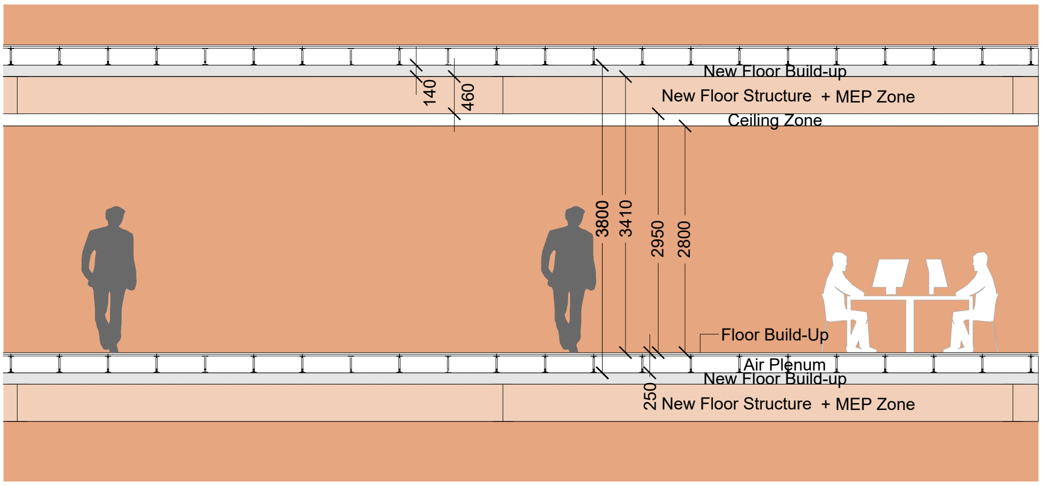
Retained floor slab

Figure 16.30 Programme stack diagram (above) and room sections (opposite)

OFFICE SPACE

Floor to floor 3,800mm

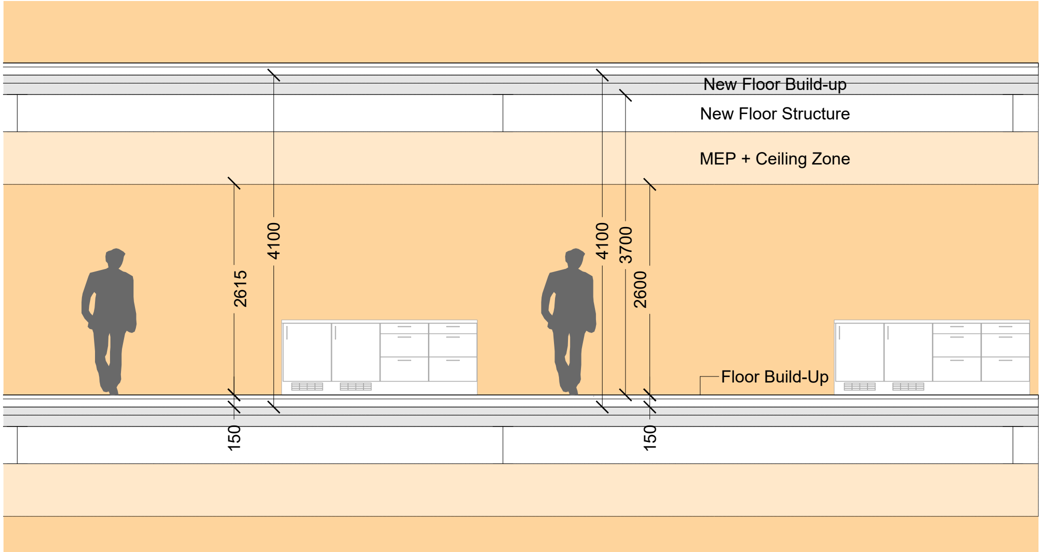
Floor to ceiling 2,800mm



POTENTIAL LAB-ENABLED SPACE

Floor to floor 4,100mm

Floor to ceiling 2,600mm



Structural Retention
This option would retain the central core and foundation only, with all new-build floor slabs including columns.

There would be 27 storeys in total above the podium, of which in this example 9 are lab-enabled, and 18 are office only, differentiated by their floor to floor heights. There would be 30 storeys in total.

This option would retain the existing central core, but all four satellite cores would be removed. The floorplates would allow freedom to choose optimised grids which improve flexibility compared to the floorplates that retain grid elements.

This would result in approximately 25% of the structure retained by carbon (or 31% by volume). This is shown schematically in Figure 16.32.

During construction, temporary works would be required to brace the free-standing core (see Figure 16.32). But the extent of temporary works would be significantly less onerous than in the options that retain floor slabs, as there would be no slabs to support, and no slab edges to prop.

Future-proofed
Flexibility of the floorplates would be uninhibited by existing column arrangements. The column grid could be optimised to best suit the floor layouts, leading to clear spans that enable flexible layouts.

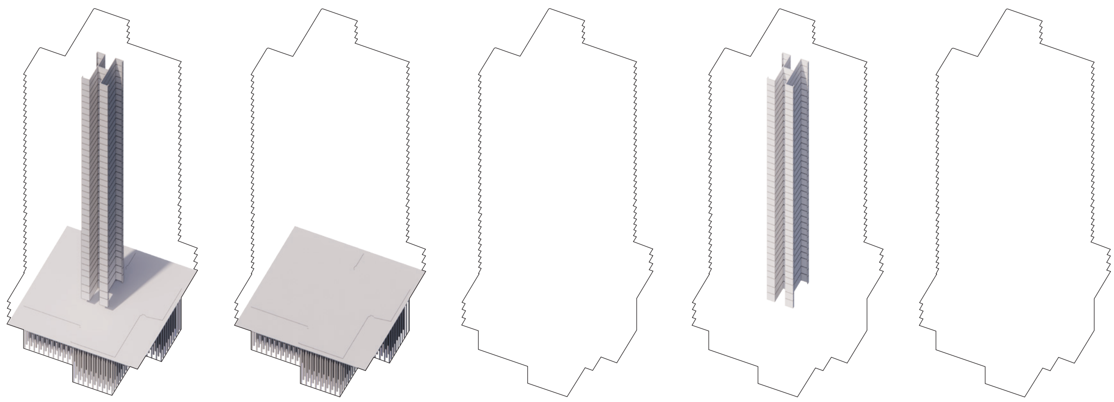
While the lower stack is enabled for lab space, it would be suitable for use as office space if desired. With its floor to floor height of 4,100mm, it is not over-dimensioned for an office, so this flexibility comes at little cost to efficiency.

From an adaptability perspective, all floor structure would be new build, so all areas would present the opportunity to design in double-height amenity spaces, or additional soft spots.

Unlike the options that retain interstitial slabs, because the construction would occur in a "blue sky" environment, there is no limitation on floor systems. Accordingly, pre-fabricated, "drop in" systems could be used which would enable the systems to be designed for disassembly at end of life.

This adaptability is a key value, as the aim with the structural system is to design something long-lasting, flexible, and adaptable to future trends, to reduce the risk of premature obsolescence and avoid waste in the future.

How adaptability and design for disassembly is imagined in the new structural system is shown in Section 18.



MAXIMUM POSSIBLE WITHOUT EXTENSION*
89 %

	OVERALL	FOUNDATION	SLAB	CORES	COLUMNS
Embodied Carbon	**2,235** tCO2e	**1,683** tCO2e	**0** tCO2e	**552** tCO2e	**0** tCO2e
Ratio of Carbon	**25** %	**19** %	**0** %	**6** %	**0** %

** Assumes no floorplate extension (i.e. working within the existing envelope), meaning new risers need to be cut out of the existing floorplate. Refer to Section 15. With extended floorplates, possibility exists to position risers outside of this existing footprint, resulting in potential higher degrees of retention.*

Figure 16.31 Embodied carbon and retention of structure broken down by structural element

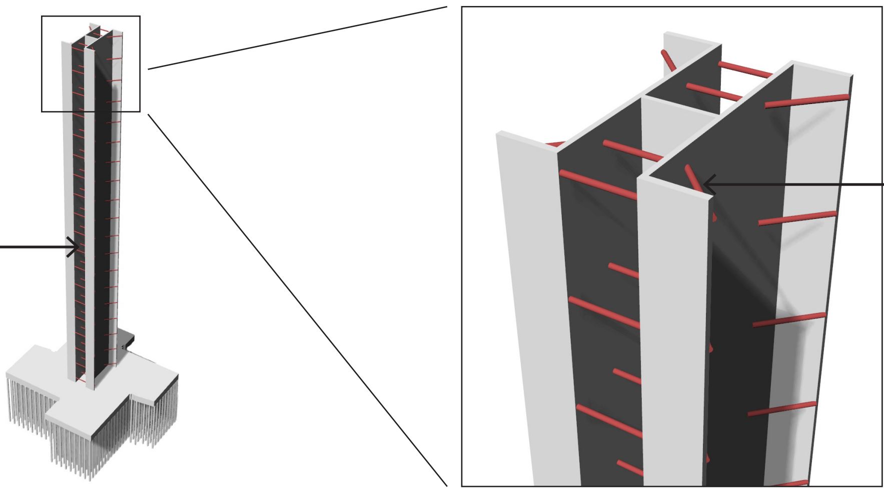


Figure 16.32 Indicative temporary works required to brace retained core

Health & Safety and Buildability
Buildability in this option would be moderately complex due to retaining the unrestrained central core. Compared to all the other preceding options however, there would be a lower risk of unknowns in the existing structure affecting design or programme.

The construction sequence is shown schematically in Figure 16.33. Apart from retaining the core, this would be a more conventional demolition and construction sequence than the other options. Not having demo and new-build operatives working simultaneously and in close proximity would reduce the risks around health & safety.

Initially the slabs would be removed back to the core top down. To minimise the temporary works required to brace the core, it would be intended to leave the front walls of lift shafts in place during demolition to reduce temporary propping. Some propping would likely still be required, a provisional solution to restrain the existing front core walls against out of plane buckling is shown in Figure 16.32. These walls would be retained on the floors where the lifts do not stop. In addition to these temporary works, some back propping would be required to the below grade retaining walls where the ground floor slab would be removed.

Once the slabs are entirely removed, construction of the permanent steels could begin using conventional, "blue sky" methods. Working without overhead constraints, means pre-fabricated, "drop in" structural systems could be used, reducing time on site and the associated risks to heath & safety.

Efficiency and Viability
This option would deliver a solution that balances structural retention with construction complexity and its associated risks. It would provide efficient floorplates with regular inter-storey heights, meaning it works with a compact core based on a double-decker vertical transportation strategy.

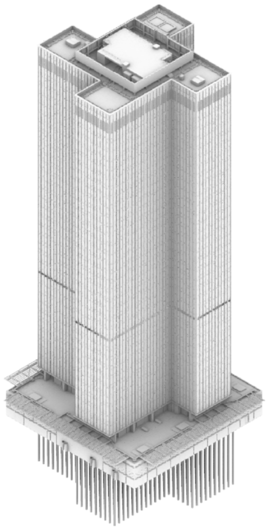
With regards to volumetric efficiency, this option would generate as much area as possible within the massing envelope, while delivering the desired floor to floor heights for both lab and office spaces.

Accordingly, it is likely that this option would be viable.

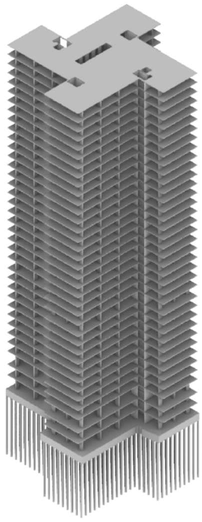
Lab-enabled
This option delivers lab-enabled spaces in the lower portion of the stack with a floor to floor height of 4,100mm. This flexibility cannot be delivered with a lower floor to floor height without compromises.

This floor to floor height is also suitable for use as office space, without the floors being over-dimensioned and volumetrically inefficient.

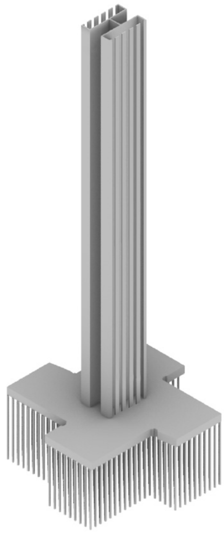
Site Capacity
This option significantly improves site capacity, and would have the capacity to provide widespread public realm upgrades due to its scale. Refer to Volume One Section 5.4. It provides the in-demand lab-enabled space required in London in way that is spatially efficient.



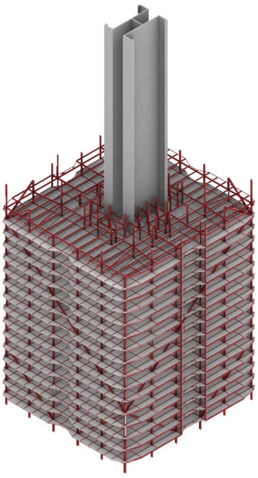
1. EXISTING BUILDING
Construction sequence is moderately complex due to the unrestrained core



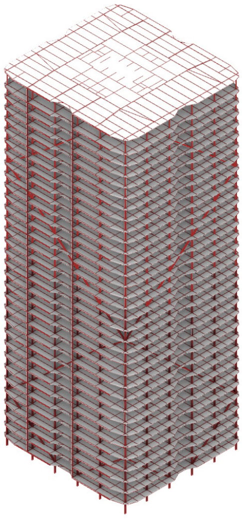
2. REMOVE FACADE
Existing facade carefully deconstructed and materials used in recycling and upcycling



3. REMOVE SLABS
Slabs are removed back to the core, further temporary works may be required to restrain the free-standing core



4 EXTEND FLOORPLATES
Construction of the permanent steels and floorplates can begin using conventional methods



5. COMPLETED STRUCTURE
The structure is completed and installation of facade, services, vertical transport, etc. can follow

Figure 16.33 Construction sequence diagram

16.3.7 New Build

Description
This option would demolish and recycle the full existing tower. No structure would be retained (including foundation and substructure). The floor footprint would be extended to deliver an expanded floorplate.

All cores, columns, and slabs would be built from new, enabling freedom to choose floor to floor heights for optimum efficiency.

The lower stack, up to and including Level 11, would comprise lab-enabled space with floor to floor height of 4,100mm in this example. All floors above would be office floors (Levels 12 - 29 inclusive) with a floor to floor height of 3,800mm.

The vertical transport strategy would be reliant on using double decker lifts (reducing the footprint of lifts required and therefore resulting in improved floorplate efficiency). All levels have the same inter-storey height, and are therefore appropriate for the vertical transportation strategy.

The section and floor slab retention diagrams are shown in Figure 16.34. The programme stack and room sections are the same as in the previous option (Section 16.3.6), and are shown in Figure 16.35 overleaf.

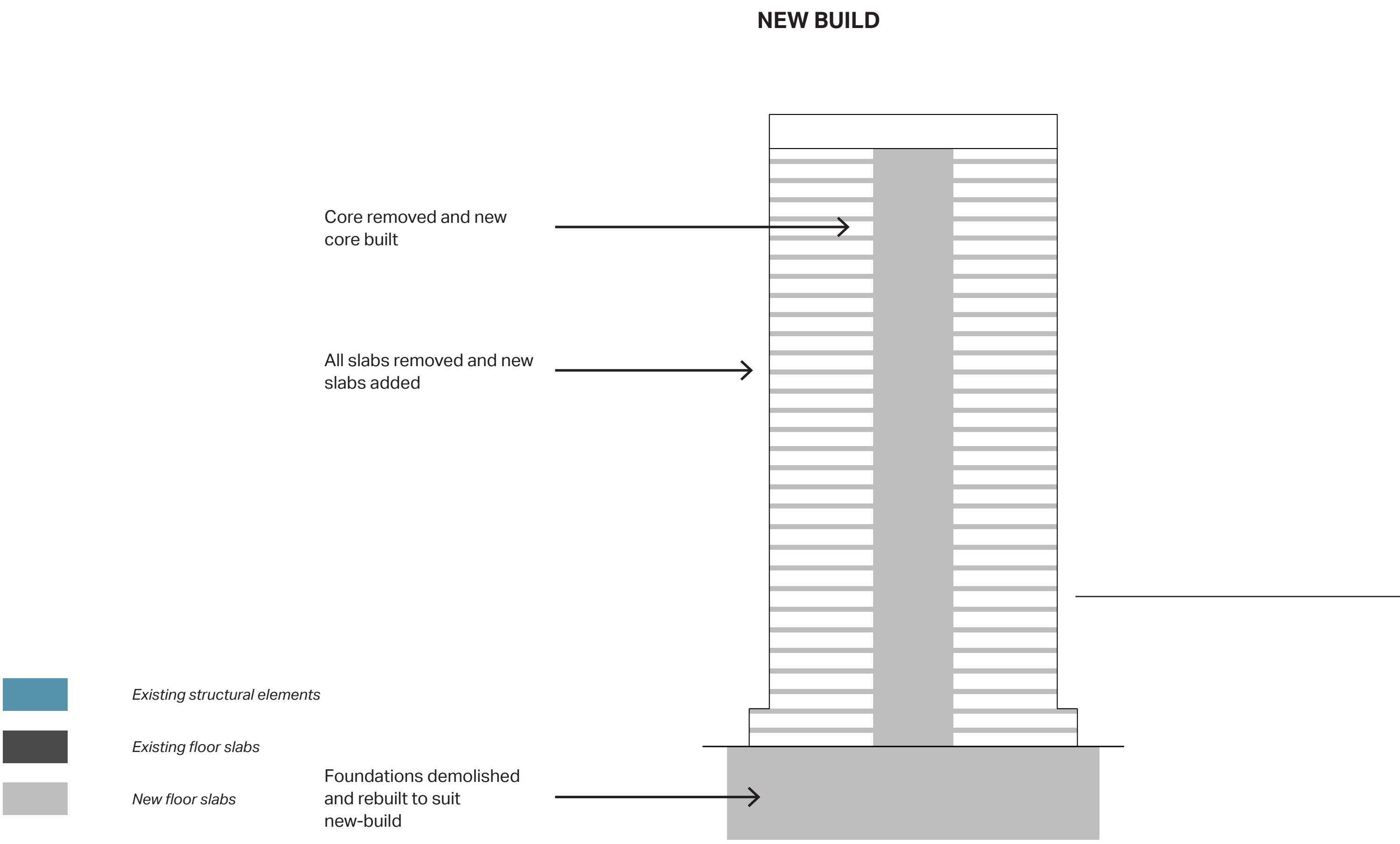
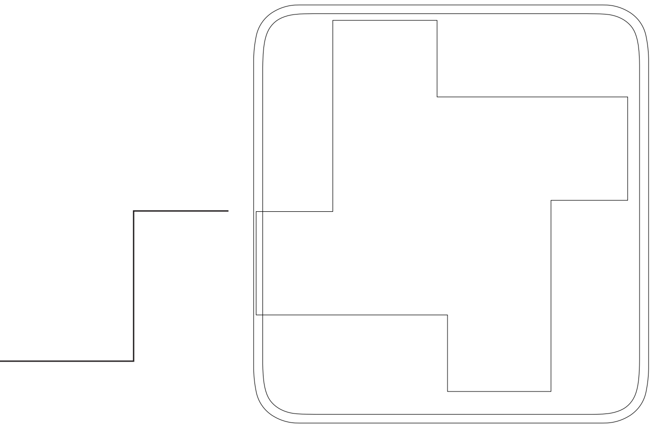
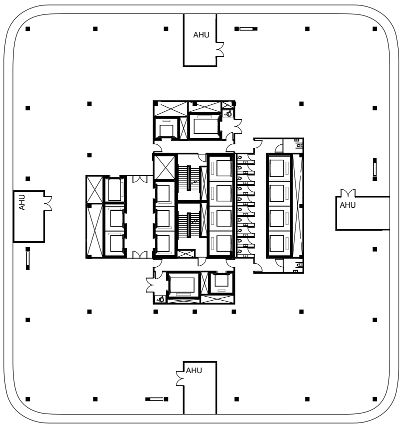


Figure 16.34 Diagram showing retained structural elements in this option (section above and slabs opposite)

ALL LEVELS
Core removed, floorplates removed, all rebuilt



INDICATIVE CORE LAYOUT
Expanded Central Core



PROGRAMME AND SECTION STACK
New Build

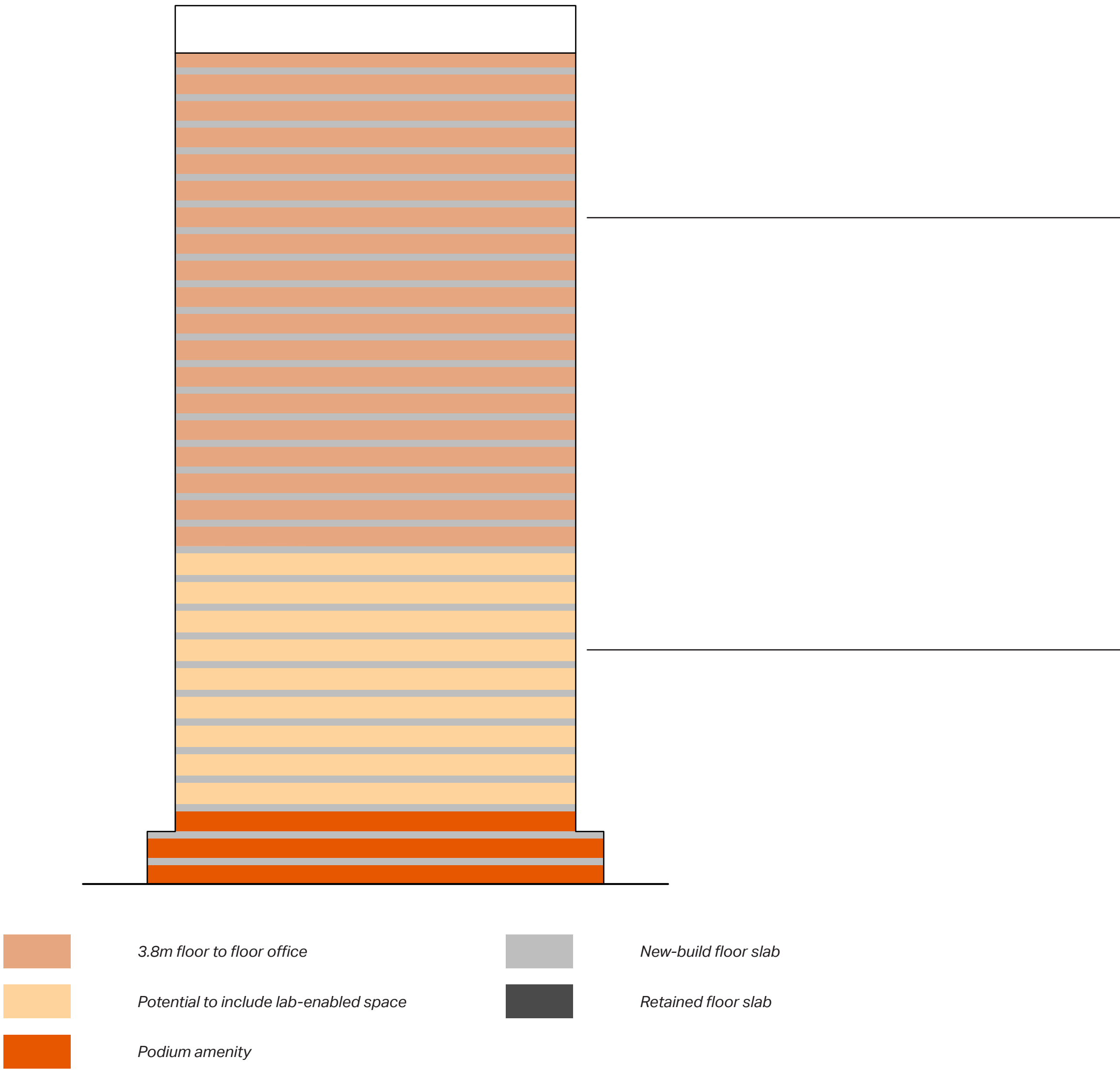
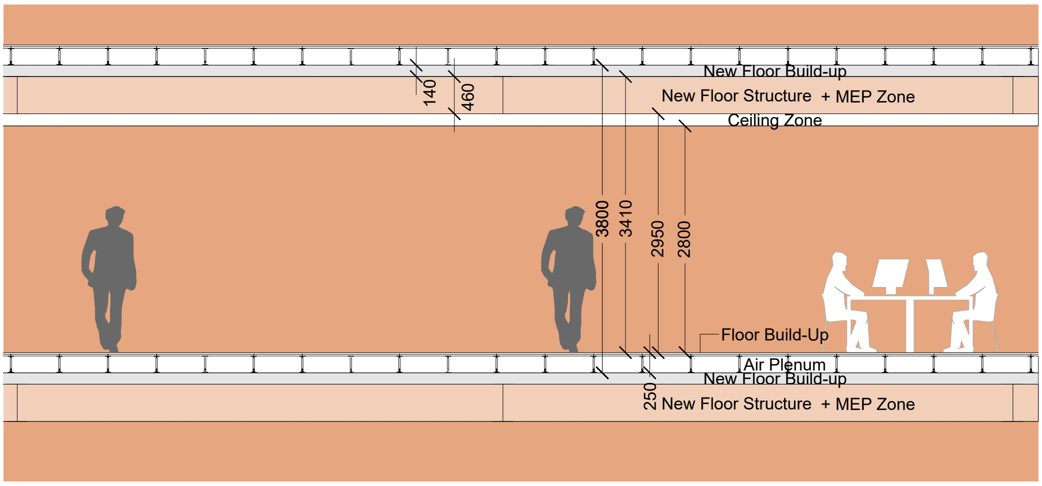


Figure 16.35 Programme stack diagram (above) and room sections (opposite)

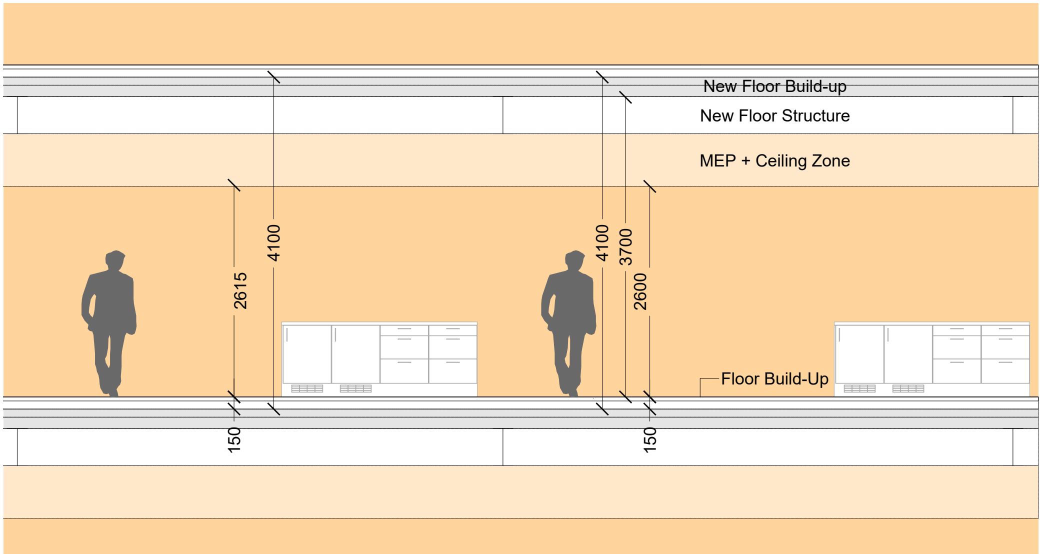
OFFICE SPACE

Floor to floor 3,800mm
Floor to ceiling 2,800mm



POTENTIAL LAB-ENABLED SPACE

Floor to floor 4,100mm
Floor to ceiling 2,600mm



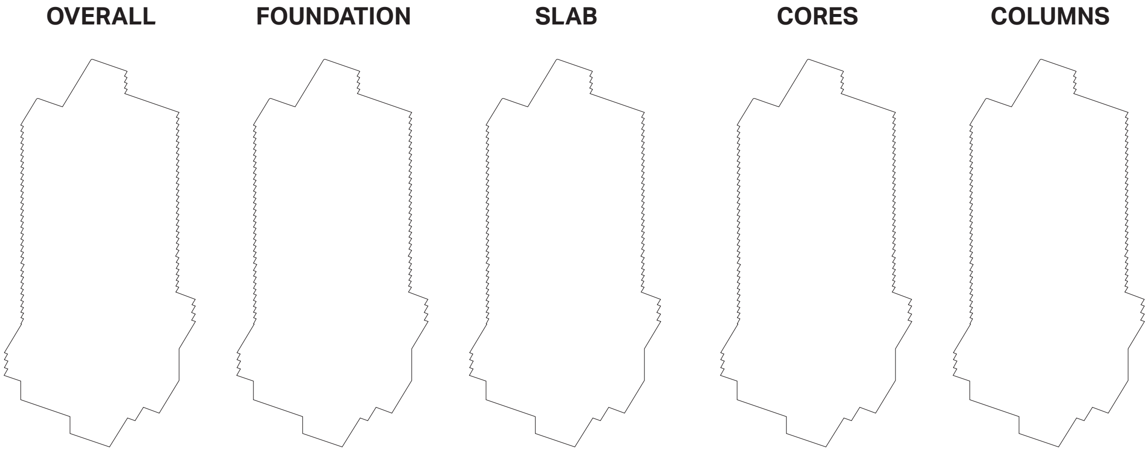
Structural Retention
This option would be a conventional demolition and re-build. No elements would be retained.

There would be 27 storeys in total above the podium, of which in this example 9 are lab-enabled, and 18 are office only, differentiated by their floor to floor heights. There would be 30 storeys in total.

For this option the expanded centralised core is proposed. In this case it would be an entirely new core. The floorplates, all built from new, would allow freedom to choose optimised grids which improves flexibility compared to the floorplates that retain grid elements.

This would result in 0% of the structure retained (by carbon or volume). This is shown schematically in Figure 16.36.

Future-proofed
Future proofing (flexibility and adaptability) is the same as the retain the core option in Section 16.3.6.



	OVERALL	FOUNDATION	SLAB	CORES	COLUMNS
Embodied Carbon	**0** tCO2e	**0** tCO2e	**0** tCO2e	**0** tCO2e	**0** tCO2e
Ratio of Carbon	**0** %	**0** %	**0** %	**0** %	**0** %

Figure 16.36 Embodied carbon and retention of structure broken down by structural element

Health & Safety and Buildability
Buildability would be the least complex of all the options, as it is a conventional demo and re-build. Compared to all the other options, there would be the lowest risk of unknowns in the existing structure affecting design or programme. However, coordination around the existing piles would still be required.

The construction sequence is shown schematically in Figure 16.37. The conventional demo and re-build means not having demo and new-build operatives working simultaneously and in close proximity, reducing the risks around health & safety.

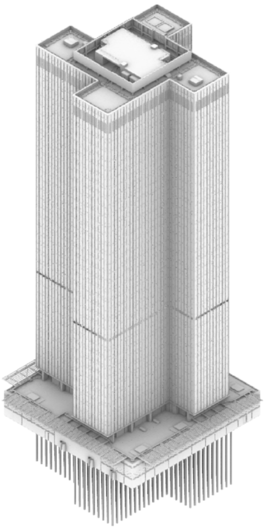
Compared to other options, the temporary works requirement would be significantly reduced with no above-ground structure to prop. Some temporary back propping would however be required for below grade retaining walls.

Once the building is demolished, construction of the new structure could begin using conventional, "blue sky" methods. Working without overhead constraints, means pre-fabricated, "drop in" structural systems could be used, reducing time on site and the associated risks to heath & safety.

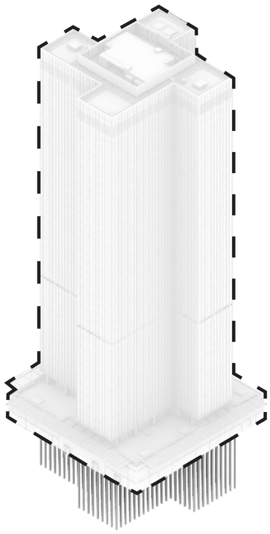
Efficiency and Viability
Considerations are the same as the core retention option in Section 16.3.6.

Lab-enabled
Considerations are the same as the core retention option in Section 16.3.6.

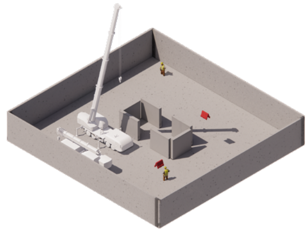
Site Capacity
Considerations are the same as the core retention option in Section 16.3.6.



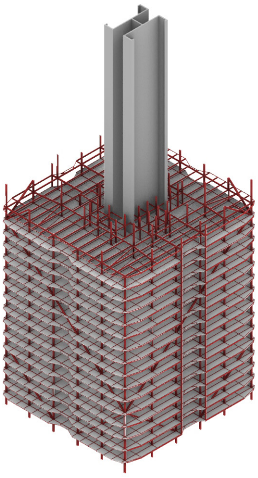
1. EXISTING BUILDING
Construction sequence is conventional demolition and rebuild



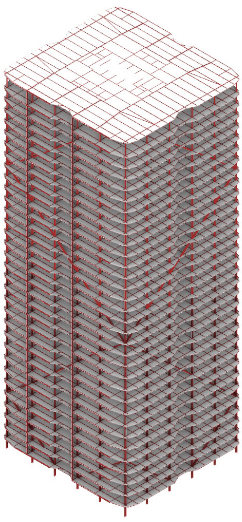
2. FULL DEMOLITION
Entire building is demolished including basement



3. NEW FOUNDATION
Dig new basement and foundation taking care to avoid existing piles



4 NEW PRIMARY STRUCTURE
Construction of new primary structure can begin using conventional methods

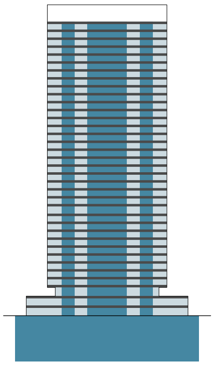
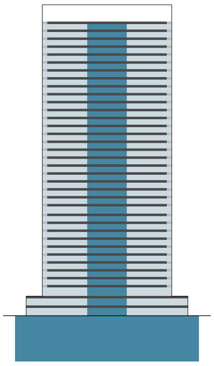
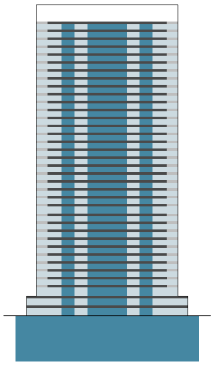
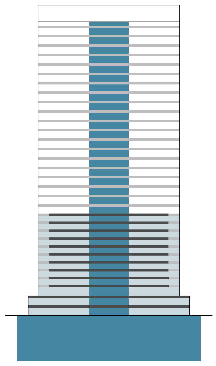


5. COMPLETED STRUCTURE
The structure is completed and installation of facade, services, vertical transport, etc. can follow

Figure 16.37 Construction sequence diagram

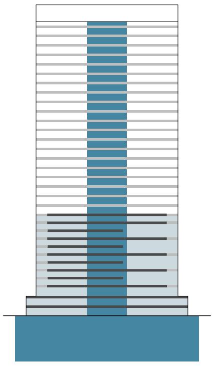
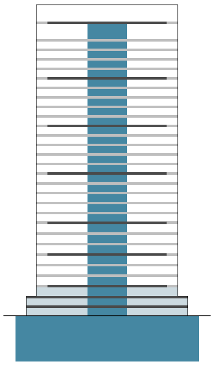
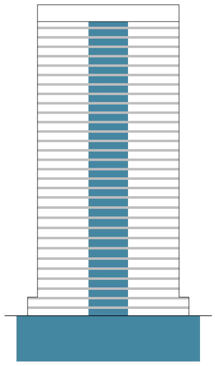
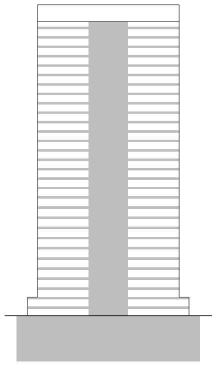
16.4 Summary and Comparison

The matrix on this page summarises and compares the options presented in this section. More detail against each of these considerations is contained within the respective sections.

	Major Refurbishment*	**Retention & Partial Extension - Max Retention**	**Retention & Extension - "Full" Retention**	**Partial Retention & Extension - Retain Consecutive Slabs (Office)**
	 *WLCA in Section 17*	 *WLCA in Section 17*	 *WLCA in Section 17*	
Buildability and Temporary Works	Moderate. High risk of unknowns in using all existing structure. Complex but localised temporary works required to support unconstrained slab edges on all levels.	Moderate. High risk of unknowns in using all existing structure. Complex but localised temporary works required to support unconstrained slab edges on all levels.	Moderate. High risk of unknowns in using all existing structure. Complex but localised temporary works required to support unconstrained slab edges on all levels. Propping to below grade retaining walls required if ground slab is removed to facilitate new piling.	Moderate. High risk of unknowns in using all existing structure in lower stack and retaining unconstrained core. Complex but localised temporary works required to support unconstrained slab edges. Propping to below grade retaining walls required if ground slab is removed to facilitate new piling.
Floor to Ceiling Height	2,425-2,475mm (exposed services) 2,375-2,450mm (with ceiling)	2,425-2,475mm (exposed services) 2,375-2,450mm (with ceiling)	2,425-2,475mm (exposed services) 2,375-2,450mm (with ceiling)	2,425-2,475mm (lower stack, exposed services) 2,375-2,450mm (lower stack, w/ ceiling) 2,800mm (upper stack, with ceiling)
Structural Salvage	89% (by carbon) 90% (by volume)	93% (by carbon) 92% (by volume)	84% (by carbon) 85% (by volume)	41% (by carbon) 45% (by volume)
Flexibility in Use	Limited by existing grids. Existing loading capacity limits possible uses. No lab-enabled space.	Limited by existing grids. Existing loading capacity limits possible uses. No lab-enabled space.	Limited by existing grids. Existing loading capacity limits possible uses in areas of existing slabs. No lab-enabled space.	Limited by existing grids on retained floors. Grids above impacted by tying in to existing columns. Existing loading capacity limits possible uses in areas of existing slabs. No lab-enabled space.
Adaptability and Design for Disassembly	Limited. Opportunities for building in soft spots and design for disassembly limited by existing structure.	Limited. Opportunities for building in soft spots limited by existing structure. Design for disassembly limited to very small areas of new construction only.	Limited. Opportunities for building in soft spots limited by existing structure. Design for disassembly limited to areas of new construction only.	Limited. Opportunities for building in soft spots limited by existing structure in lower stack. In upper stack all areas offer opportunities for soft spots/amenity. Design for disassembly limited to areas of new construction only.

** Shown in Volume One not to be feasible.*

Best balance of structural retention and quality, flexibility, adaptability, and buildability.

	Partial Retention & Extension - Retain Consecutive Slabs (Office and Lab)	**Partial Retention & Extension -** Retain Interstitial Slabs (Office / Office and Lab)	**Partial Retention & Extension -** Retain the Core	**New Build**
				
		WLCA in Section 17	*WLCA in Section 17*	*WLCA in Section 17*
	Complex. High risk of unknowns in using existing structure in lower stack and retaining unconstrained core. Extensive temporary works required to support unconstrained slab edges especially at double-height lab-enabled levels. Propping to below grade retaining walls required if ground slab is removed to facilitate new piling.	Complex. Retaining unconstrained interstitial slabs and added H&S risk with simultaneous demolition and new construction. Strengthening required to unbraced columns spanning retained slabs. Extensive temporary works required for interstitial slabs and propping to below grade retaining walls required if ground slab is removed to facilitate new piling.	Moderate. Retaining unconstrained core but lower risk of unknowns. Bracing needed for core and propping to below grade retaining walls if ground floor slab is removed to facilitate new piling.	Good. Conventional demolition and rebuild minimises risk of unknowns, but coordination around existing piles required. No existing structure to be constrained but back propping required for below grade retaining walls where ground floor slab is removed to facilitate new piling.
	2,375-2,450mm (retained office or lab-enabled write up, with ceiling) 4,925mm (lab-enabled, with ceiling) 2,800mm (new office, with ceiling)	2,840-2,980mm (office, with ceiling) 2,781mm (lab-enabled, with ceiling)	2,800mm (office, with ceiling) 2,600mm (lab-enabled, with ceiling)	2,800mm (office, with ceiling) 2,600mm (lab-enabled, with ceiling)
	41% (by carbon) 45% (by volume)	38% (by carbon) 42% (by volume)	25% (by carbon) 31% (by volume)	0 % (by carbon or volume)
	Limited by existing grids on retained floors. Grids above impacted by tying in to existing columns. Lab-enabled spaces can be double-height office or amenity, but would be inefficient.	Limited by existing grids on retained floors. All grids impacted by tying in to existing columns. Lab-enabled spaces can be used as offices, but would be inefficient.	Clear spans enable flexible layouts. Lab-enabled spaces can be used as offices.	Clear spans enable flexible layouts. Lab-enabled spaces can be used as offices.
	Limited. Opportunities for building in soft spots limited by existing structure in lower stack. In upper stack all areas offer opportunities for soft spots/amenity. Design for disassembly limited to areas of new construction only.	Limited to soft spots only by having to use in-situ concrete slabs. Design for disassembly limited by existing floor structure and in-situ options for new build floorplates due to coordination with bracing structure.	Good. All areas offer opportunities for soft spots/amenity. All floor structure is new so can be designed for disassembly.	Good. All areas offer opportunities for soft spots/amenity. All floor structure is new so can be designed for disassembly.

17

Euston Tower

Carbon Assessments

17.1 Methodology and Assumptions

17.1.1 General

This section presents the results of a whole life-cycle carbon assessment (WLCA) for the options presented in Section 16. The WLCA is conducted as a comparative study to evaluate the carbon impact of the degree of structural retention of the existing tower. The following paragraphs describe the general assumptions used across the different options to establish a fair comparison, before presenting the results of the assessments.

It is important to initially understand that a full cost plan based embodied carbon assessment was not undertaken for options in this assessment. Rather carbon estimates were derived from indicative calculations and data taken from the portfolio data from the project consultants. This data is shown transparently in terms of life-cycle stages [A-C] and [A1-A5] values for each building element under each option. The consultants involved each have a portfolio of more than 40 buildings delivered to RICS methodology WLCA, and thus an excellent understanding of what the appropriate carbon performance of each building element under each option would be in a reasonable delivery scenario. For most elemental categories, this portfolio data was utilised to inform the selection of appropriate data.

The options assessed and the key differences between them is summarised in Figure 17.1. The Major Refurbishment is included in this Section as a bookend, though it has been shown not to be feasible in Volume One.

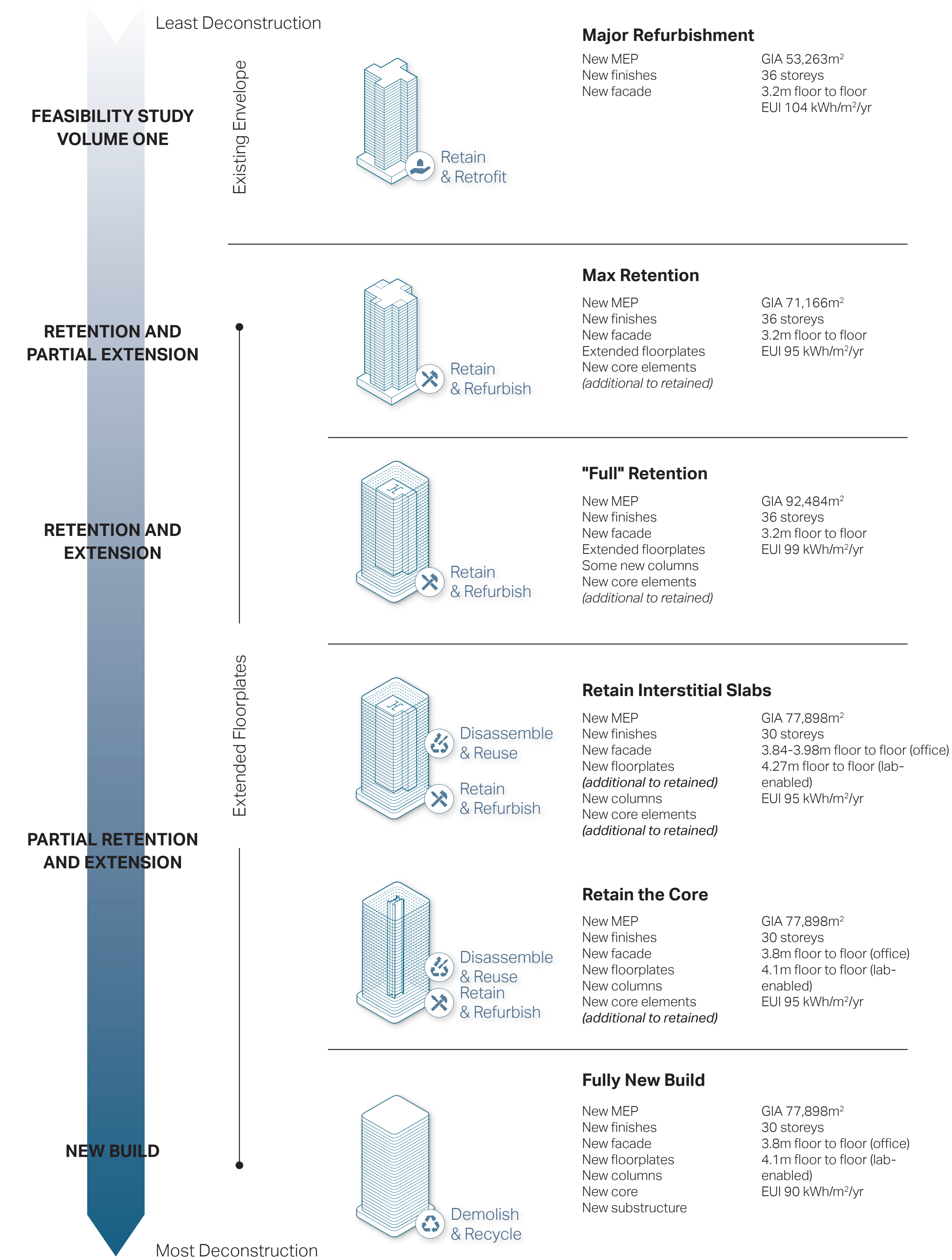


Figure 17.1 Overview of key assumptions for each option appraised in the WLCAs

17.1.2 Method Statement

Carbon Factors [A1-A3]
Three categories in particular typically dominate the emissions on commercial office and/or lab-enabled buildings: structures, building services and facades. Additional work was undertaken in these three categories to ensure that the values provided were appropriate for each option.

Material specification is consistent across options for all building elements,

The structural embodied carbon calculations have been based on benchmark data from RICS and The Inventory of Carbon and Energy (ICE). Typical new build and refurbishment materials quantities (steel, concrete, and reinforcement) have been calculated and a corresponding embodied carbon rate per square metre attributed to each construction type. Carbon factor assumptions are shown in Figure 17.2. Each of the proposals have been assessed to calculate the proportion of new and existing structure for the particular scheme (including additional substructure elements, as required) and the total structural embodied carbon calculated on a pro-rata basis.

The building services embodied carbon calculations have been based upon best practice industry benchmark data for new build and refurbishment scenarios as outlined in "WBCSD Net-zero buildings Where do we stand?". This guidance has been utilised to provide a clear prediction of the overall MEP services embodied carbon per square meter [A-C] to be attributed for each of the options appraised.

The $kgCO_2e/m^2$ GIA impact of facades is directly linked to the facade area to floor area ratio. Therefore, to calculate the appropriate GIA intensity impact, it was important to first measure the area of the facade under each option and use this metric to determine the overall intensity impact. Instead of a consistent GIA-based intensity metric, which does not appropriately reflect varied facade area to floor area ratios, facades are applied with a consistent $kgCO_2e/m^2$ facade surface area (FSA) impact. This is also in accordance with the latest calculation methodologies such as the September 2022 CWCT Guidance, and also reflects how facade manufacturers typically report results. Within the early feasibility studies, a calculation of facade resulted in a GIA-based performance of 114.2 $kgCO_2e/m^2$ GIA. Working backwards, this equates to an FSA-based impact of 352 $kgCO_2e/m^2$ FSA [A1-A5]. This reflects a reasonable level of performance that would be expected for the proposed facade typology and was therefore the rate used for the facades within options. With the differing GIAs and facade areas, this therefore resulted in a custom GIA-based façade intensity metric that reflected the specifics of that particular option.

As all internal walls, doors, finishes and fittings would be replaced in every option, the intensity metric utilised remains the same throughout all assessed options, reflecting the fact that the same target performance rates could be achieved under each option and so as not to give preferential treatment to any single option within these categories.

MATERIAL	ELEMENT	$KGCO_2E/M^2$ [A1-A5]	NOTES
Steel	Structural steel generally excluding connections and ancillaries	1.79	Average UK supply (BCSA)
Steel	Facade connection	1.79	Average UK supply (BCSA)
Steel	Connections and ancillaries	2.51	Typical UK BOF
Steel	Reinforcing bar	0.84	Average UK supply
Concrete	In situ and precast concrete generally	0.19	Average UK cement mix

Figure 17.2 Carbon factors [A1-A5] used for structural assessment

Transportation Emissions [A4]
Transport emissions [A4] were not split out from [A1-A3] and [A5] when reporting upfront emissions using the internal benchmark values and therefore these are not set out material-by-material. However, as the majority of data that underpins the intensity allocations came from internal portfolios of data (particularly from Sweco), based on design information from other projects, it is reasonable to state that all values for transport are in accordance with the design values set out within the RICS Professional Statement "Whole life carbon assessment for the built environment (2017)" methodology. These are the distances that should be applied when actual procurement information remains unknown.

Construction Site Energy Use and Waste [A5]
This section can be separated into two parts: construction site emissions [A5s] and construction site waste [A5w]. The methodology for each is set out below.

For [A5s], it is understood that there is a strong link between emissions from site and the time spent on site to deliver the particular option (i.e. construction programme). For this reason, main contractor Lendlease were asked to make an assessment of programme length against each option within the feasibility study. These were assessed against a new build, which from Sweco's portfolio of new construction buildings typically had an [A5s] impact of approximately 30 $kgCO_2e/m^2$ GIA, and a completion programme of around 72 months provided by Lendlease. The 30 $kgCO_2e/m^2$ GIA was then apportioned based on the comparable allocated programme for the other options within the options appraisal.

Although site impacts are not wholly dictated by the length of programme, given that they are also impacted by complexity of works and elementally-specific considerations, this method of apportionment was deemed an appropriate way to reflect the fact that the emissions from site activities associated with a lighter refurbishment were not going to be to the same scale as a deconstruction and rebuild scheme. Input from a main contractor on programme lengths helped to support and underwrite the methodology so that it was specific to each option.

[A5w] impacts were calculated in a similar way to [A4], i.e. not separated from the [A1-A5] values. As the data largely came from portfolio databases of the involved consultants, [A5w] can be assumed to be applied as per the RICS Professional Statement "Whole life carbon assessment for the built environment (2017)" methodology. The [A5w] data therefore uses default WRAP waste values as applied within software such as One Click and is included within reported [A1-A5] values.

Assumptions for Life-cycles of Materials
Assumptions for life-cycle replacement of materials has been completed on an element-by-element basis rather than the coarser 15-year cycle set out in guidance such as the GLA's "Whole Life Carbon Assessment Guidance (March 2023)". Different elemental categories will typically have different levels of replacement over the life-cycle. All assessment studies are observed over a 60-year reference study period (RSP).

Firstly, for each option in the feasibility study, the [A-C] impact of each building element is apportioned between life-cycle categories [A1-A5] and categories [B-C]. This is informed by Sweco's design stage portfolio data from a large sample of buildings of relevant use type, which demonstrate how carbon emissions are typically distributed between life-cycle stages. Given that all of these data sources are informed by the same life-cycle allocation method (informed itself by guidance within the RICS Professional Statement "Whole life carbon assessment for the built environment"), there is a strong correlation between life-cycle stage distribution between projects, which has informed the allocations within the options appraisal.

This method is important for elements such as facades. Ensuring that carbon is distributed appropriately within the life cycle stages of facades ensures that the [B-C] impacts are not unfairly allocated or weighted. Only secondary facade materials over the RSP are typically replaced in facades (typically at year 25-30), not the entire system, so only 25% of [A-C] emissions usually fall within [B-C]. This method therefore helps to better reflect realistic life-cycle embodied carbon emissions for each element, and demonstrated why the basic GLA method is not appropriate in most cases.

Elemental categories which typically include replacement are then isolated. The following replacement cycles are then allocated to the relevant categories:

- Facades & external doors
  30 years, 1 replacement over RSP (secondary components only)
- Internal walls & doors
  30 years, 1 replacement over RSP
- Finishes
  10 years, 5 replacements over RSP
- FF&E
  10 years, 5 replacements over RSP
- Building Services
  15 years, 3 replacements over RSP
- Refrigerants
  15 years, 3 replacements over RSP (to align with building services).

Substructure and superstructure elements are considered to last the whole RSP and therefore do not have replacement emissions allocated to them.

The impacts associated with demolition and temporary works all fall within [A1-A5] and therefore are not relevant to the [B] emissions.

It is acknowledged that even within single elemental category different materials may have different replacement cycles (for example in building services, ASHPs may be replaced every 15 years, light fittings every 20 and ducts every 40), the chosen method still allows for an additional layer of granularity compared to the basic GLA method and helps to demonstrate the different life-cycle replacement cycles between elemental categories.

Methodology for Calculating Building Services Emissions
Assumptions for the embodied carbon calculations have been based on data from "WBCSD Net-zero buildings Where do we stand?". This report presents and discusses the results of six case studies developed from Arup projects using whole life carbon assessment of buildings based on the WBCSD Framework and enabled appropriate benchmarks to be taken for the new office construction and major refurbishment options as a baseline life-cycle estimate for [A1-A5] and [B-C], with an overall [A-C] value provided for each option.

Due to the early design stage and the limited maturity of the information available at feasibility stage, these published, industry-recognised benchmarks have been applied to the Partial Retention and Extension, and New Build options, with engineering judgment applied to account for the difference in anticipated embodied carbon for the remaining options.

The summary of the rationale is outlined in Figure 17.3.

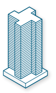
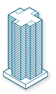
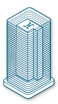
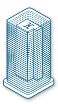
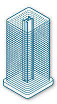
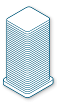
	OPTION	$KGCO_2E/M^2$ [A-C]	DIFFERENCE	NOTES
	Major Refurbishment	427	+4% against baseline estimate for refurbishment	Services are constrained with compromised distribution routes and additional offsets around existing downstands and satellite cores. Existing basement is compromised with offsets and dual distribution anticipated.
	Retention and Partial Extension - Max Retention	415	+1% against baseline estimate for refurbishment	Services are constrained with compromised distribution routes and additional offsets around existing downstands. Existing basement is compromised with offsets and dual distribution anticipated.
	Retention and Extension - "Full" Retention	411	Baseline estimate for refurbishment	*WCBSD benchmark assumption for refurbished office.* Services are constrained with compromised distribution routes and additional offsets around existing downstands and satellite cores. Existing basement is compromised with offsets and dual distribution anticipated.
	Partial Retention and Extension - Retain Interstitial Slabs	378	-8% against baseline estimate for refurbishment	Service installation unconstrained on the floor plate and cores but existing basement is compromised with offsets and dual distribution anticipated.
	Partial Retention and Extension - Retain the Core	378	-8% against baseline estimate for refurbishment	Service installation unconstrained on the floor plate and cores but existing basement is compromised with offsets and dual distribution anticipated.
	New Build	362	Baseline estimate for new build	*WCBSD benchmark assumption for new build office.* All new basement and services distribution. Optimised SMEP to achieve industry benchmarks for new build construction.

Figure 17.3 Basis of estimation for building services embodied carbon [A1-A5]

Methodology for Calculating Operational Energy Use
Due to the early design stage and the limited maturity of the information available at feasibility stage, published, industry-recognised benchmarks have been applied to the New Build options.

In a similar manner to the approach taken for the embodied carbon, engineering judgment has then been applied to account for the difference in anticipated energy use intensity for the remaining options accounting for the compromised installation of the MEP services.

Typical high-rise office buildings in London currently consume ca. 140 - 160kWh/m^2 of energy. The Low Energy Transformation Initiative (LETI) energy performance targets for commercial office buildings outline a suite of interventions which have been used to target a benchmark performance of the New Build option against the LETI 2025-2030 target of 90 kWh/m^2 GIA.

This target has then been proportioned to match the various scenarios to predict the energy consumption that could be anticipated, recognising the resulting impact the constrained service installation and the compromised fabric and service integration may have on the central plant sizing, and increased energy associated with the pressure drop increase for fan and pump systems.

Operational energy emissions [B6] was converted using National Grid FES 2021 'steady progression' scenario, with a change in carbon factor applied every 5 years, until 2050.

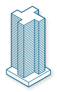
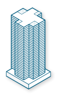
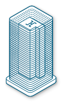
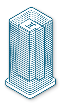
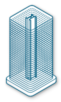
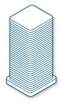
	OPTION	EUI (KWH/ M^2/YR)	DIFFERENCE	NOTES All options assume all-new facade with all-electric MEP and fully new plant. Differences in EUI are due only to constraints for services distribution.
	Major Refurbishment	104	+15%	Services are constrained with compromised distribution routes and additional offsets through the basement downstands and existing risers sizes with consequential impact on SFP and pump energy use.
	Retention and Partial Extension - Max Retention	95	+5%	Service installation unconstrained on the floorplate and cores but existing basement is compromised with offsets and dual distribution anticipated.
	Retention and Extension - "Full" Retention	99	+10%	Services are constrained with compromised distribution routes and additional offsets around existing downstands but optimised over the existing floor plates. Existing basement is compromised with offsets and dual distribution anticipated.
	Partial Retention and Extension - Retain Interstitial Slabs	95	+5%	Service installation unconstrained on the floorplate and cores but existing basement is compromised with offsets and dual distribution anticipated.
	Partial Retention and Extension - Retain the Core	95	+5%	Service installation unconstrained on the floorplate and cores but existing basement is compromised with offsets and dual distribution anticipated.
	New Build	90	Baseline estimate for new build	All new basement and services distribution. Optimised SMEP to achieve industry benchmarks for new build construction.

Figure 17.4 Basis of estimation for energy use intensity (kWh/m^2/year)

Methodology for Calculating Deconstruction Emissions
A comprehensive Pre-demolition Audit has been conducted, as detailed in Volume One. This contained significant quantified detail on the existing materials, products and systems within Euston Tower, which have facilitated a more detailed assessment of the demolition impacts of each option within the feasibility study.

Importantly, consistent metrics for existing materials have been provided within the Pre-demolition Audit (tonnes of material). The materials were scheduled out and run through One Click LCA, using the percentage targets for reuse, recycling, recovery, and landfill for each identified material/product to split the quantities, and model their end of life impacts in life-cycle modules [C2-C4] with accuracy, using One Click's end of life (EoL) activity selection tool. This provided a total $kgCO_2e$ [C2-C4] for all materials based on their differing end of life treatments.

These emissions were then assigned to the various feasibility options based on the material to be removed and retained under each scenario.

Life-cycle module [C1], which covers the emissions associated with the physical process of demolition, has been calculated based on the percentage of material retained compared to that removed. The RICS Professional Statement notes that, in the absence of specific information, WLCA modellers are to assume that [C1] emissions equate to 3.4 $kgCO_2e/m^2$. However, as with the method under [A5s], clearly there would be fewer emissions associated with a lighter refurbishment compared to a full deconstruction & rebuild under [C1]. The mass of materials removed has therefore been used to scale the RICS metric: the less material removed, the lower the $kgCO_2e/m^2$ value. This is more appropriate for demolition than a programme-based metric as the data is available to understand the extent of material removed under each option. Therefore, the [C1] factor for the Major Refurbishment is significantly lower than for the New Build option.

It is noted that by the guidance of RICS, demolition emissions should technically be reported separately. However, for the purposes of this feasibility study, it is thought that deconstruction emissions need to be included in the WLCA, as this is surely a critical part of the decision-making. Therefore, all emissions associated with demolition in each option have been included in the [A1-A5] values, to show the various impacts of deconstruction on the WLCA during the site preparation phase. This also accords with the forthcoming RICS Professional Statement Second Edition, which will look to include demolition emissions in [A5] reporting.

Level of Detail
The carbon assessments herein are feasibility stage assessments. They cover the main building elements, are not based on detailed bills of quantities / cost plans, and contain no contingencies. It is acknowledged that the carbon estimates are likely to be lower than a detailed WLCA that forms part of a full planning application, but they are appropriate for comparison between development options at this stage of development, and as all are undertaken on the same basis, provide a genuine comparison.

Lab-enabled Spaces
The initial comparisons in this Section assume all areas are fit out and operated as office to enable like-for-like comparison (including those that have higher floor to floor heights to accommodate potential lab fit outs). The flexibility to offer spaces to lab users is a benefit in some options, but is not considered a driver.

It is acknowledged that lab spaces generally have to respond to more stringent ventilation and power criteria, resulting in higher embodied carbon of mechanical installations and higher energy consumption.

Accordingly, where lab-enabled spaces are present in the options the uplift for fit out and operation as a lab space is shown separately. This is applicable to the: Partial Retention and Extension - Retain Interstitial Slabs, Partial Retention and Extension - Retain the Core, and New Build options.

The lab-enabled floors represent approximately the following proportion of above-podium GIA in each relevant option:

- Retain Interstitial Slabs (Office and Lab) 23%
- Retain the Core 33%
- New Build 33%.

Methodology for Calculating Building Services Emissions for Lab-enabled Spaces

It is acknowledged that there is a paucity of high quality data on the embodied carbon impacts of lab-enabled spaces. The allowances for the office-only estimates (as detailed in Figure 17.3) have been used as a starting point and uplifted accordingly.

In this case, the increased embodied carbon is associated with the more intensive services provision demanded by lab-enabled spaces. The following are assumed:

- Air Handling Units (AHUs) typically 50% larger
- Provision of Fan Coil Units (FCUs) to offset higher cooling loads
- Provision of ducts, grilles, chilled water pipework, insulated to the FCUs above
- Provision of larger capacity for small power distribution commensurate the electrical demands (see overleaf).

The estimates for building services embodied carbon have been taken as 2x that for the office-only cases. These figures reflect a "full-building" figure, and are therefore pro-rated according to the extent of the lab-enabled space in each relevant option.

There is no impact on the structure or facade, as this is already accounted for as part of the base build in the estimates in Figure 17.3.

The summary of the rationale is outlined in Figure 17.5.

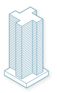
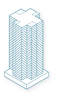
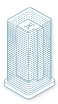
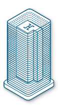
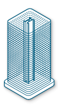
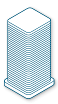
OPTION	$KGCO_2E/M^2$ [A-C]	DIFFERENCE	NOTES
 Major Refurbishment	n/a	n/a	No lab-enabled spaces possible.
 Retention and Partial Extension - Max Retention	n/a	n/a	No lab-enabled spaces possible.
 Retention and Extension - "Full" Retention	n/a	n/a	No lab-enabled spaces possible.
 Partial Retention and Extension - Retain Interstitial Slabs	756	-8% against baseline estimate for refurbishment	Service installation unconstrained on the floor plate and cores but existing basement is compromised with offsets and dual distribution anticipated.
 Partial Retention and Extension - Retain the Core	756	-8% against baseline estimate for refurbishment	Service installation unconstrained on the floor plate and cores but existing basement is compromised with offsets and dual distribution anticipated.
 New Build	725	Baseline estimate for new build	*2x WCBSD benchmark assumption for new build office.* All new basement and services distribution. Optimised SMEP to achieve industry benchmarks for new build construction.

Figure 17.5 Basis of estimation for building services embodied carbon [A1-A5] for lab-enabled spaces

Methodology for Calculating Operational Energy Use for Lab-enabled Spaces
Similar to that for the embodied carbon, good data on Energy Use Intensity (EUI) for lab-enabled spaces is scarce, thought it is expected that lab-enabled spaces have 3-5x higher EUIs than offices.

The following are assumed:

- The power allowances recommended in the BCO Science Guide 2021 were cross referenced with the British Land Labs Guide
- An allowance for 24-hour operation for fridges and freezers, fume cupboards, chemical stores, other automated equipment, and the like.

The estimates for building services EUI carbon have been taken as 3x that for the office-only cases (see Figure 17.4). These figures reflect a "full-building" figure, and are therefore pro-rated according to the extent of the lab-enabled space in each relevant option.

The summary of the rationale is outlined in Figure 17.6.

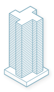
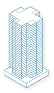
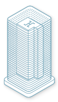
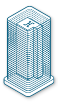
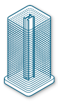
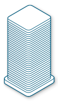
	OPTION	EUI (KWH/ M^2/YR)	DIFFERENCE	NOTES All options assume all-new facade with all-electric MEP and fully new plant. Differences in EUI are due only to constraints for services distribution.
	Major Refurbishment	n/a	n/a	No lab-enabled spaces possible.
	Retention and Partial Extension - Max Retention	n/a	n/a	No lab-enabled spaces possible.
	Retention and Extension - "Full" Retention	n/a	n/a	No lab-enabled spaces possible.
	Partial Retention and Extension - Retain Interstitial Slabs	285	+5%	Service installation unconstrained on the floorplate and cores but existing basement is compromised with offsets and dual distribution anticipated.
	Partial Retention and Extension - Retain the Core	285	+5%	Service installation unconstrained on the floorplate and cores but existing basement is compromised with offsets and dual distribution anticipated.
	New Build	270	Baseline estimate for new build	All new basement and services distribution. Optimised SMEP to achieve industry benchmarks for new build construction.

Figure 17.6 Basis of estimation for energy use intensity (kWh/m^2/year) for lab-enabled spaces

17.2 WLCA Results

17.2.1 Major Refurbishment

An option for refurbishment is explored with the aim of returning the tower to operation with the least intervention possible.

A summary of the interventions and results is shown in Figure 17.7.

The breakdown of embodied carbon by building element, and the whole life-cycle estimates are shown in Figure 17.8 and Figure 17.9 respectively.

Demolition and strip out
The emissions calculated in relation to the demolition and strip out are estimated at 19 $kgCO_2e/m^2$.

Temporary works
Emissions associated with temporary works are small given the limited extent of intervention in the proposal. An allowance of 5 $kgCO_2e/m^2$ is included.

Structures
Carbon estimates for the structures have been provided by Arup. No new carbon emissions are envisaged in the substructure, as the proposal reuses the existing foundations and basement as is. In the superstructure, 50 $kgCO_2e/m^2$ is allowed for, covering works necessary to support the existing structure.

Facades
The existing facade is removed and replaced with a new, high-performance facade that is commensurate with the modern performance standards expected in a high-end London development. The new facade is supported on the existing tower's structure.

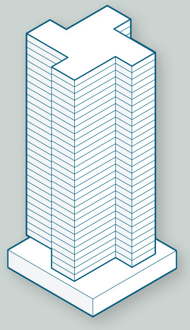
The proposed façade system is estimated as 352 $kgCO_2e/m^2$ FSA [A1-A5] over a facade surface area of 23,600 m^2. As noted in the methodology, the per m^2 facade area carbon emissions are consistent, the form factor (the ratio of facade surface area to gross floor area) influences the figures when reported on a per m^2 GIA basis. This results in 156 $kgCO_2e/$ m2GIA [A1-A5] and 223 $kgCO_2e/m^2$ GIA [A-C].

Internal walls & doors, finishes, and FF&E
For internal walls & doors, finishes, and FF&E, a benchmark figure has been assumed in the absence of design information at this stage.

Building services and refrigerants
All-new MEP systems are proposed with carbon estimates provided by Arup. The fundamental room-side and central systems are proposed to be the same across all options, refer to methodology in Section 17.1.2. MEP embodied carbon is estimated as 122 $kgCO_2e/m^2$ [A1-A5] and 406 $kgCO_2e/m^2$ [A-C].

External works
No new carbon emissions are envisaged for external works as the existing is retained as is.

Site activities
The site programme is anticipated to be a relatively short duration given the limited interventions in the proposal. An allowance of 9 $kgCO_2e/m^2$ [A1-A5] is included which is pro-rated from an allowance for a full new construction with an estimated programme duration of 22 months provided by Lendlease.



Retain
& Retrofit

Major Refurbishment

A refurbishment to return tower to operation aiming to be as unintrusive as possible. Structures are retained and strengthened with new facades, internal finishes, FF&E, and MEP anticipated.

New internal finishes	New floorplates
FF&E	New columns
New MEP	New core
New facade	New substructure

Retained structure	89 % (carbon) / *90 % (vol)*
GIA	*53,263 m^2*
Upfront carbon	*406 $kgCO_2e/m^2$ [A1-A5]*
Whole life carbon	*1,125 $kgCO_2e/m^2$ [A-C]*
Operational energy	*104 $kWh/m^2/yr$*
Number of storeys	*36 storeys*
Floor to floor height	*3.2 m (office only)*

Figure 17.7 Overview of key assumptions and results for the carbon assessment

Operational energy and carbon

Notwithstanding the all-new MEP systems and facade, the proposal's overall operational energy performance is worse than current best practice due to compromised distribution routes and additional offsets through the basement downstands and existing risers sizes with consequential impact on SFP and pump energy use.

The EUI is estimated as 104 kWh/m²/year estimated by Arup. Operational energy emissions [B6] was converted using National Grid FES 2021 'steady progression' scenario, with a change in carbon factor applied every 5 years, until 2050.

The breakdown of embodied carbon by building element, and the whole life-cycle estimates are shown in Figure 17.8 and Figure 17.9 respectively.

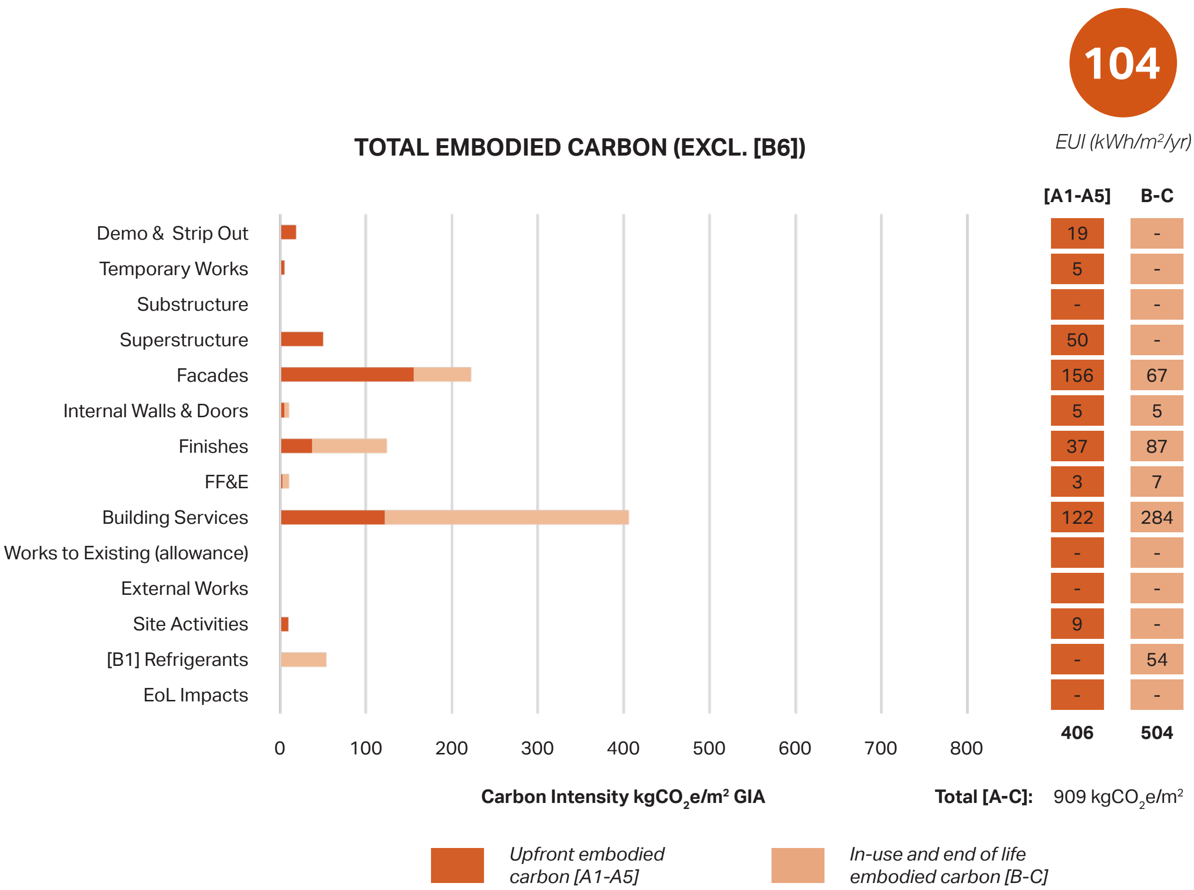
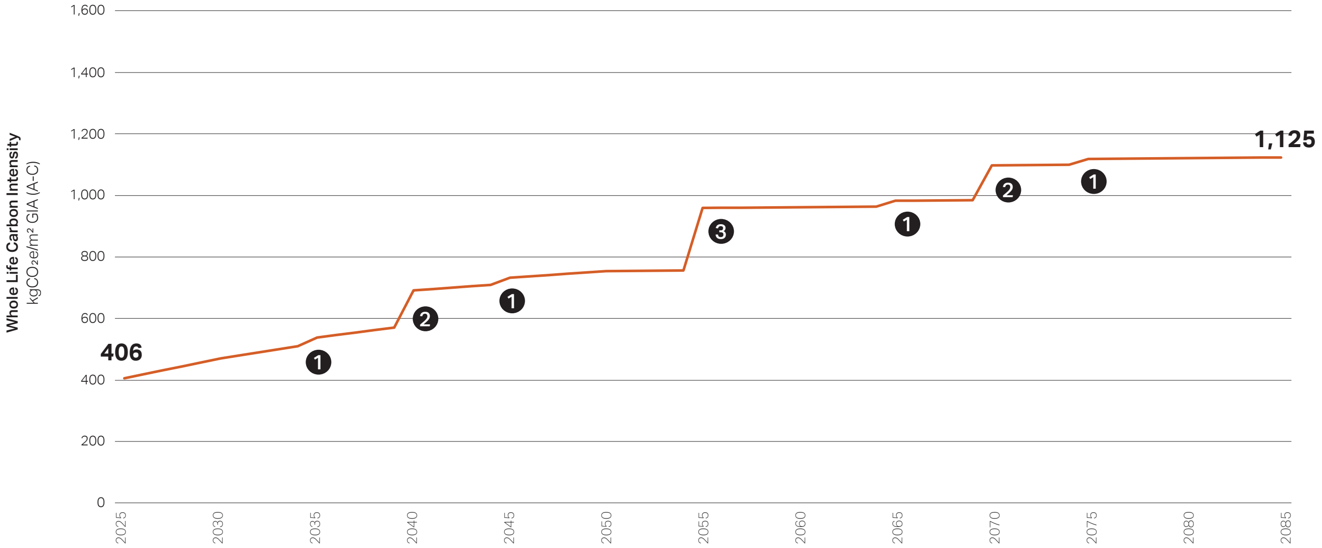
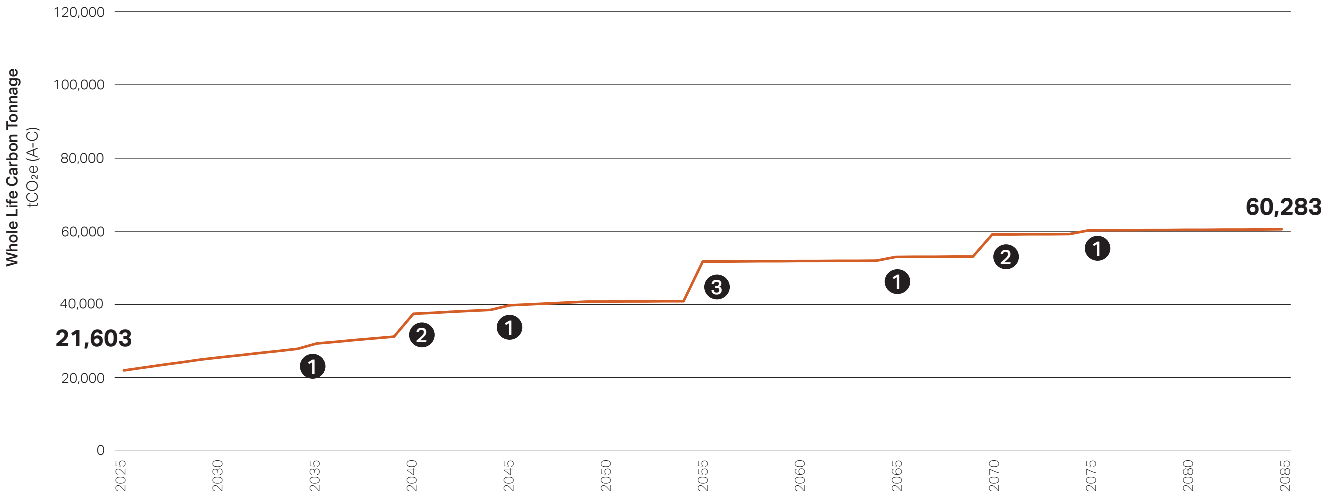


Figure 17.8 Breakdown of embodied carbon by building element

WHOLE LIFE CARBON [A-C]





1. *Finishes and FF&E are replaced*
2. *Building services are replaced as they reach end of service life*
3. *Secondary components in the facade systems are replaced as they reach end of service life, assuming new IGUs throughout. Internal walls and doors are replaced. Finishes and FF&E are replaced at the same time*

Figure 17.9 Whole life-cycle carbon estimate with interventions over time

17.2.2 Retention and Partial Extension - Max Retention

An option for refurbishment is explored with the aim of returning the tower to operation with the maximum structural retention possible.

A summary of the interventions and results is shown in Figure 17.10.

The breakdown of embodied carbon by building element, and the whole life-cycle estimates are shown in Figure 17.11 and Figure 17.12 respectively.

Demolition and strip out
The emissions calculated in relation to the demolition and strip out are estimated at 14 $kgCO_2e/m^2$.

Temporary works
Emissions associated with temporary works are small given the limited extent of intervention in the proposal, but still greater than the Major Refurbishment due to the works required for the floorplate extension. An allowance of 10 $kgCO_2e/m^2$ is included.

Structures
Carbon estimates for the structures have been provided by Arup. A small allowance of 15 $kgCO_2e/m^2$ is made for the additional substructure required to support the external cores and extended floorplate. In the superstructure, 55 $kgCO_2e/m^2$ is allowed for, covering the additional material in the floorplate extension.

Facades
The existing facade is removed and replaced with a new, high-performance facade that is commensurate with the modern performance standards expected in a high-end London development. The new facade is supported on the existing tower's structure.

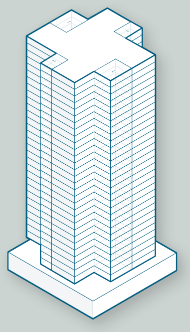
The proposed facade system is estimated as 352 $kgCO_2e/m^2$ FSA [A1-A5] over the facade area. As noted in the methodology, the per m^2 facade area carbon emissions are consistent, the form factor (the ratio of facade surface area to gross floor area) influences the figures when reported on a per m^2 GIA basis. This results in 114 $kgCO_2e/m^2$ GIA [A1-A5] and 162 $kgCO_2e/m^2$ GIA [A-C].

Internal walls & doors, finishes, and FF&E
For internal walls & doors, finishes, and FF&E, a benchmark figure has been assumed in the absence of design information at this stage.

Building services and refrigerants
All-new MEP systems are proposed with carbon estimates provided by Arup. The fundamental room-side and central systems are proposed to be the same across all options, refer to methodology in Section 17.1.2. MEP embodied carbon is estimated as 119 $kgCO_2e/m^2$ [A1-A5] and 395 $kgCO_2e/m^2$ [A-C].

External works
No new carbon emissions are envisaged for external works as the existing is retained as is.

Site activities
Compared to the major refurbishment, the site programme is anticipated to be slightly longer owing to the additional work required on the floorplate extension. An allowance of 17 $kgCO_2e/m^2$ is included which is pro-rated from an allowance for a full new construction based on the length of the programme using programme input from Lendlease. The assumed programme length is 40 months.



Retain
& Refurbish

Retention and Partial Extension - Max Retention

A refurbishment to return tower to operation.
Structure is entirely retained and floorplates extended, but keeping within the existing loading capacity.
New facades, internal finishes, FF&E, and MEP are anticipated.

New internal finishes	Extended floorplates
FF&E	New columns
New MEP	New core elements
New facade	New substructure

Retained structure	93 % (carbon) / *92 % (vol)*
GIA	*71,166 m^2*
Upfront carbon	*398 $kgCO_2e/m^2$ [A1-A5]*
Whole life carbon	*886 $kgCO_2e/m^2$ [A-C]*
Operational energy	*95 $kWh/m^2/yr$*
Number of storeys	*36 storeys*
Floor to floor height	*3.2 m (office only)*

Figure 17.10 Overview of key assumptions and results for the carbon assessment

Operational energy and carbon
Since the Retention and Partial Extension scheme is not dependent on the existing satellite cores for MEP distribution, an improved operational energy performance is assumed compared to the major refurbishment scheme.

The EUI is estimated as 95 kWh/m²/year estimated by Arup. Operational energy emissions [B6] was converted using National Grid FES 2021 'steady progression' scenario, with a change in carbon factor applied every 5 years, until 2050.

The breakdown of embodied carbon by building element, and the whole life-cycle estimates are shown in Figure 17.11 and Figure 17.12 respectively.

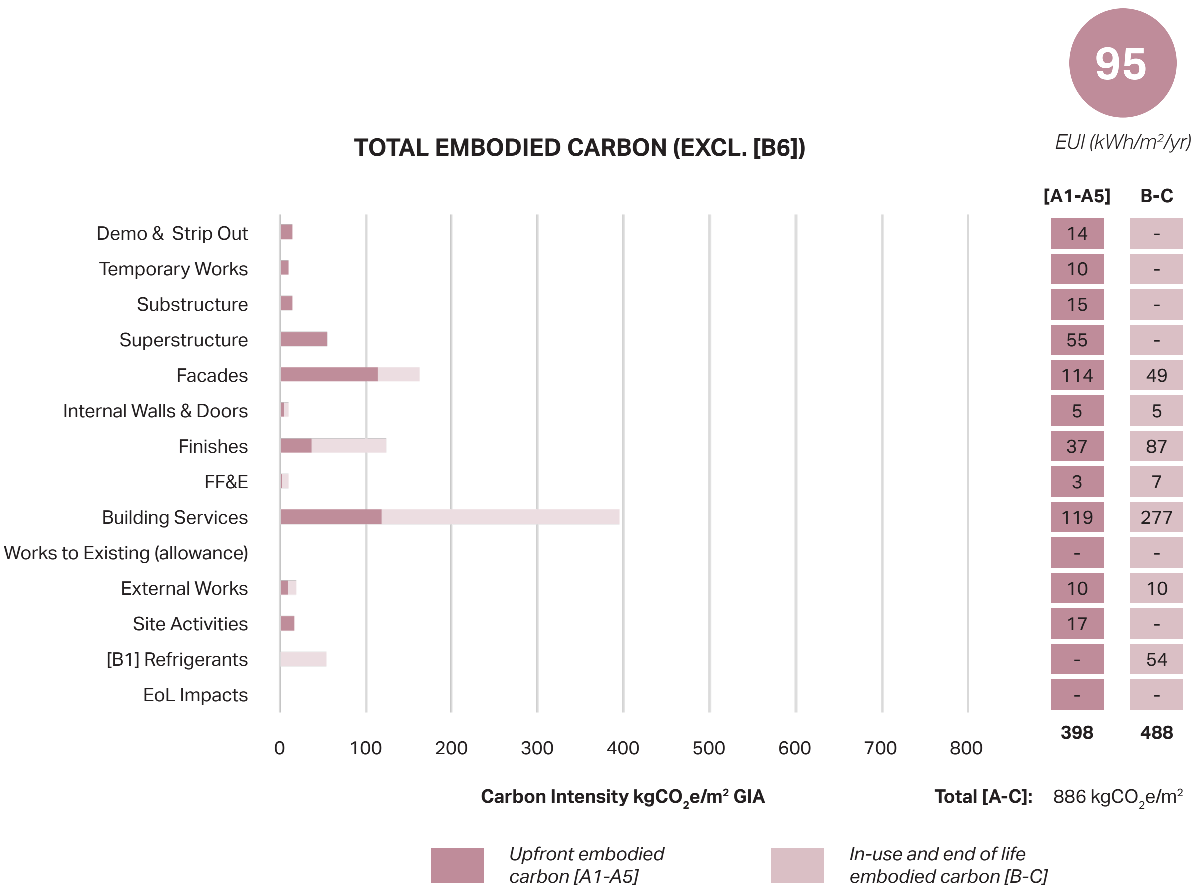


Figure 17.11 Breakdown of embodied carbon by building element

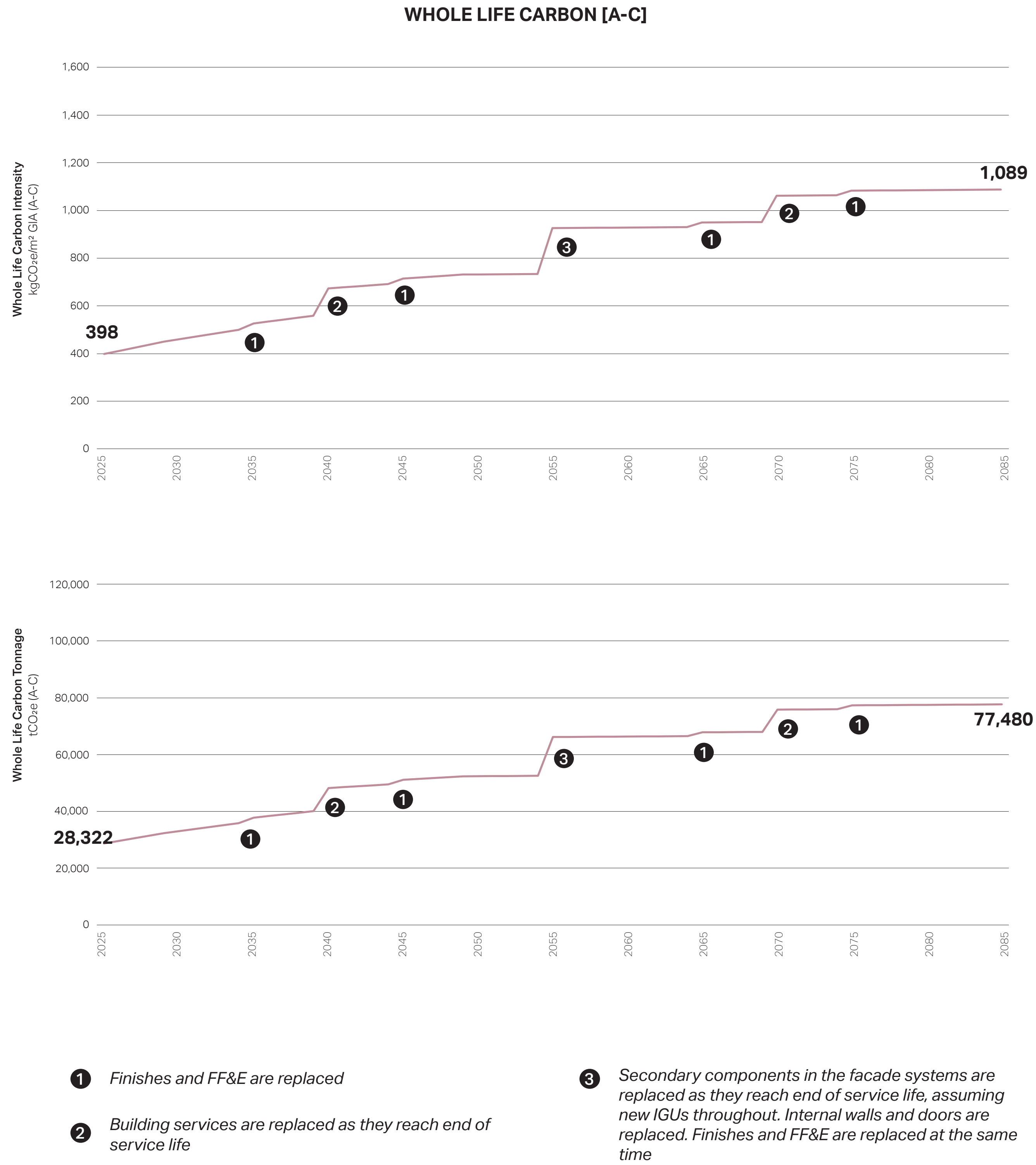


Figure 17.12 Whole life-cycle carbon estimate with interventions over time

17.2.3 Retention and Extension - "Full" Retention

A retention and extension is explored with the aim of updating the tower to modern standards while retaining as much of the existing building as possible.

A summary of the interventions and results is shown in Figure 17.13.

The breakdown of embodied carbon by building element, and the whole life-cycle estimates are shown in Figure 17.14 and Figure 17.15 respectively.

Demolition and strip out
The emissions calculated in relation to the demolition and strip out are estimated at 17 $kgCO_2e/m^2$.

Temporary works
Emissions associated with temporary works capture the full-height temporary works required to support exposed slab edges during demolition and construction, and the temporary protection required to protect workers and slabs below, wherever existing slabs are demolished. An allowance of 22 $kgCO_2e/m^2$ is included.

Structures
Carbon estimates for the structures have been provided by Arup. The carbon emissions for the substructure are low for a building of this scale, due to the retention of the existing foundations and basement. Additional substructure is proposed only where the extended tower comes down outside the footprint of the existing foundations. This is estimated as 35 $kgCO_2e/m^2$.

While the aim for the superstructure is to retain as much as possible, there are nonetheless significant structural interventions required to deliver the extended floor plates. The existing satellite cores are removed, and the floor plates are trimmed back and stabilised on the north, west and south sides. At a high level, the new works comprise additional primary structure, supplementary stability systems at the perimeter to counteract for the modified core arrangement and increased wind area, and the extensions to the floor plates. These works are estimated as 158 $kgCO_2e/m^2$

Facades
A new, high-performance facade that is commensurate with the modern performance standards expected in a high-end London development is assumed to replace the existing facade.

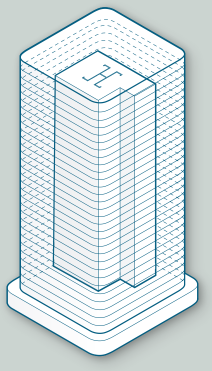
The proposed façade system is estimated as 352 $kgCO_2e/m^2$ FSA [A1-A5] over a facade surface area of 23,500 m^2. As noted in the methodology, the per m^2 facade area carbon emissions are consistent, the form factor (the ratio of facade surface area to gross floor area) influences the figures when reported on a per m^2 GIA basis. This results in 89 $kgCO_2e/m^2$ GIA [A1-A5] and 128 $kgCO_2e/m^2$ GIA [A-C].

Internal walls & doors, finishes, and FF&E
For internal walls & doors, finishes, and FF&E, a benchmark figure has been assumed in the absence of design information at this stage.

Building services and refrigerants
All-new MEP systems are proposed with carbon estimates provided by Arup. The fundamental room-side and central systems are proposed to be the same across all options, refer to methodology in Section 17.1.2. MEP embodied carbon is estimated as 117 $kgCO_2e/m^2$ [A1-A5] and 390 $kgCO_2e/m^2$ [A-C].

External works
One of the benefits of the retention and extension scheme is that its scope is sufficiently wide to unlock improvements to the public realm. An allowance of 19 $kgCO_2e/m^2$ is included. For consistency the same assumptions have been used across all scenarios that deliver upgrades to the public realm.

Site activities
Compared to a new build, the site programme is anticipated to be somewhat shortened owing to the extent of retention in the proposal, although the programme will be impacted by requiring a more careful deconstruction. An allowance of 19 $kgCO_2e/m^2$ is included which is pro-rated from an allowance for a full new construction based on the length of the programme using programme input from Lendlease. The assumed programme length is 45 months.



Retain
& Refurbish

Partial Retention and Extension - "Full" Retention

A deep refurbishment retaining substructure, core, and superstructure. New facade, internal finishes, FF&E, and MEP anticipated.

New internal finishes	Extended floorplates
FF&E	Additional columns
New MEP	New core
New facade	New substructure

Retained structure	84 % (carbon) / *85 % (vol)*
GIA	*92,484 m^2*
Upfront carbon	*512 $kgCO_2e/m^2$ [A1-A5]*
Whole life carbon	*1,210 $kgCO_2e/m^2$ [A-C]*
Operational energy	*99 $kWh/m^2/yr$*
Number of storeys	*36 storeys*
Floor to floor height	*3.2 m (office only)*

Figure 17.13 Overview of key assumptions and results for the carbon assessment

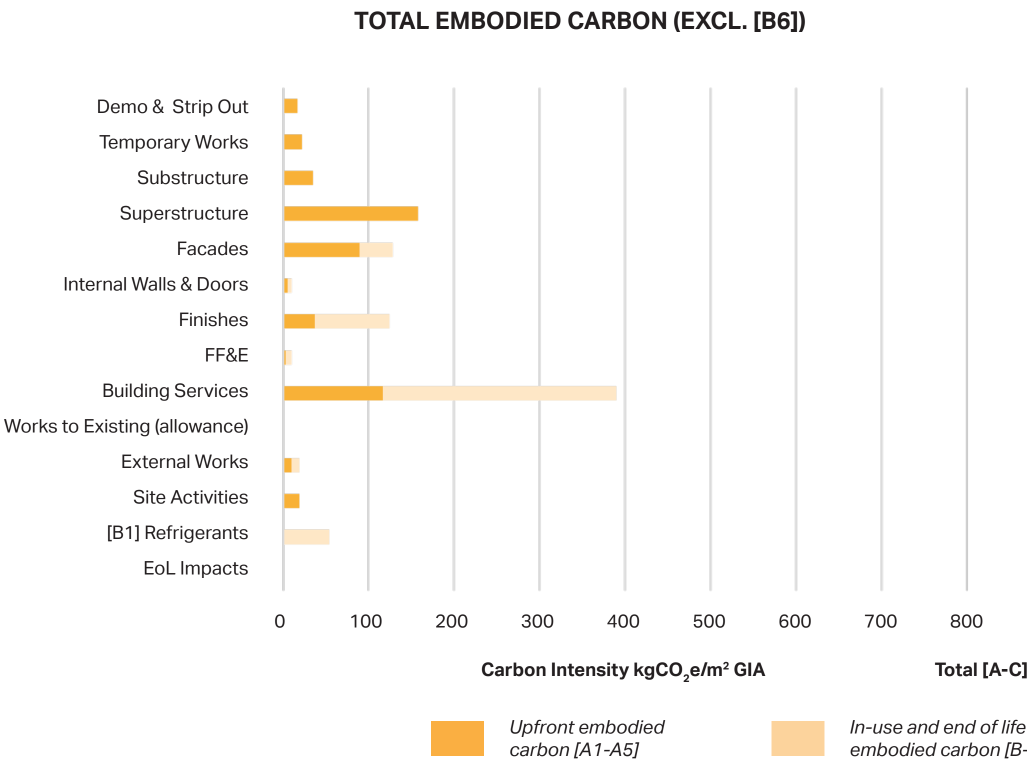
Operational energy and carbon
Notwithstanding the all-new MEP systems and facade, the proposal's overall operational energy performance is worse than current best practice due to compromised distribution routes and additional offsets around existing downstands (but optimised over the floorplates).

The EUI is estimated as 99 kWh/m²/year estimated by Arup. Operational energy emissions [B6] was converted using National Grid FES 2021 'steady progression' scenario, with a change in carbon factor applied every 5 years, until 2050.

The breakdown of embodied carbon by building element, and the whole life-cycle estimates are shown in Figure 17.14 and Figure 17.15 respectively.

99

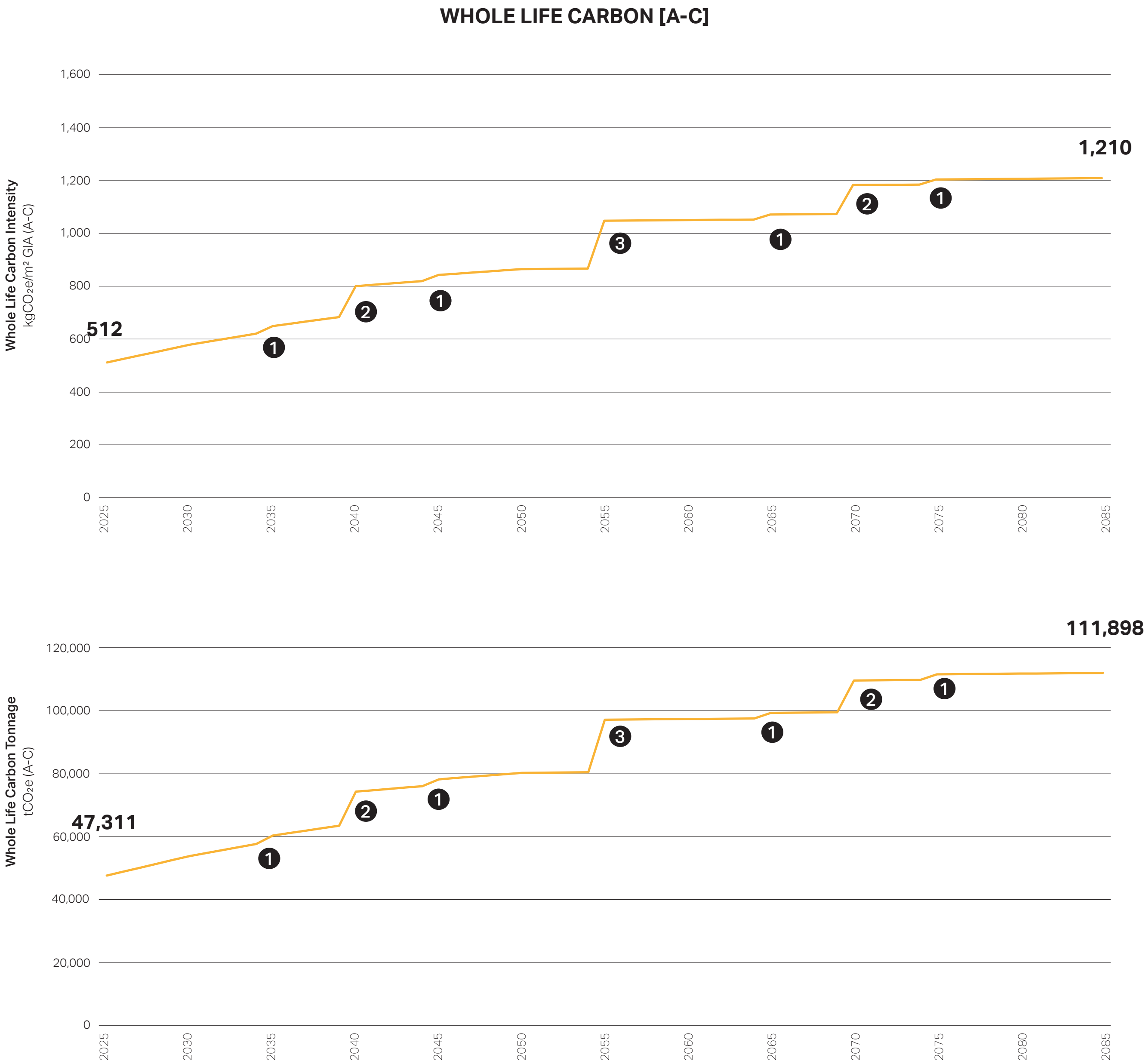
EUI (kWh/m²/yr)



	[A1-A5]	B-C
Demo & Strip Out	17	-
Temporary Works	22	-
Substructure	35	-
Superstructure	158	-
Facades	89	38
Internal Walls & Doors	5	5
Finishes	37	87
FF&E	3	7
Building Services	117	273
Works to Existing (allowance)	-	-
External Works	10	10
Site Activities	19	-
[B1] Refrigerants	-	54
EoL Impacts	-	-
	512	**474**

Total [A-C]: 985 kgCO$_2$e/m²

Figure 17.14 Breakdown of embodied carbon by building element



1. Finishes and FF&E are replaced
2. Building services are replaced as they reach end of service life
3. Secondary components in the facade systems are replaced as they reach end of service life, assuming new IGUs throughout. Internal walls and doors are replaced. Finishes and FF&E are replaced at the same time

Figure 17.15 Whole life-cycle carbon estimate with interventions over time

17.2.4 Partial Retention and Extension - Retain Interstitial Slabs

An option that retains interstitial slabs is explored with the aim of updating the tower to modern standards while retaining as much of the existing building as possible.

This option is similar to retention and extension, but where every approximately 6th slab is retained, and 4 new slabs in between, delivering improved floor to floor heights and greater flexibility.

A summary of the interventions and results is shown in Figure 17.16.

The breakdown of embodied carbon by building element, and the whole life-cycle estimates are shown in Figure 17.17 and Figure 17.18 respectively.

Demolition and strip out
The emissions calculated in relation to the demolition and strip out are estimated at 20 $kgCO_2e/m^2$.

Temporary works
Emissions associated with temporary works capture the full-height temporary works required to support exposed slab edges during demolition and construction, and the temporary protection required to protect workers and slabs below, wherever existing slabs are demolished. An allowance of 22 $kgCO_2e/m^2$ is included.

Structures
Carbon estimates for the structures have been provided by Arup. The carbon emissions for the substructure are low for a building of this scale, due to the retention of the existing foundations and basement. Additional substructure is proposed only where the extended tower comes down outside the footprint of the existing foundations. This is estimated as 35 $kgCO_2e/m^2$.

While the aim for the superstructure is to retain as much as possible, there are nonetheless significant structural interventions required to deliver the retention of the interstitial slabs and the extension thereof. The existing satellite cores are removed, and the floor plates are trimmed back and stabilised on the north, west and south sides, the retained columns are supported and the interstitial slabs are removed. At a high level, the new works comprise additional primary structure, supplementary stability systems at the perimeter to counteract for the modified core arrangement and increased wind area, additional stability of the retained columns, the extensions to the floor plates and the new floor plates. These works are estimated as 258 $kgCO_2e/m^2$

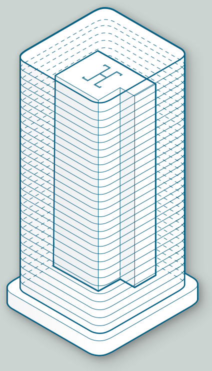
Facades
A new, high-performance facade that is commensurate with the modern performance standards expected in a high-end London development is assumed to replace the existing facade.

The proposed façade system is estimated as 352 $kgCO_2e/m^2$ FSA [A1-A5] over a facade surface area of 23,500 m^2. As noted in the methodology, the per m^2 facade area carbon emissions are consistent, the form factor (the ratio of facade surface area to gross floor area) influences the figures when reported on a per m^2 GIA basis. This results in 106 $kgCO_2e/$ m2GIA [A1-A5] and 152 $kgCO_2e/m^2$ GIA [A-C].

Internal walls & doors, finishes, and FF&E
For internal walls & doors, finishes, and FF&E, a benchmark figure has been assumed in the absence of design information at this stage.

Building services and refrigerants
All-new MEP systems are proposed with carbon estimates provided by Arup. The fundamental room-side and central systems are proposed to be the same across all options, refer to methodology in Section 17.1.2. MEP embodied carbon is estimated as 108 $kgCO_2e/m^2$ [A1-A5] and 359 $kgCO_2e/m^2$ [A-C].

This assumes that the fit out is for office only including in the spaces with larger floor to floor heights that are designed as lab-enabled. This is chosen to provide a like for like comparison with the other options since they cannot accommodate any laboratory spaces, and the laboratory MEP equipment is more carbon intensive than that for offices.



Retain
& Refurbish

Partial Retention and Extension - Retain Interstitial Slabs

Retention of substructure, core and interstitial floor plates. Interstitial floor plates extended with new superstructure, and new facade, internal finishes, FF&E, and MEP. Re-use demolition arisings on site where possible.

New internal finishes	Additional and extended floorplates
New FF&E	Additional columns
New MEP	New core
New facade	New substructure

	Office-only	Office & lab
Retained structure	38 % (carbon) / *42 % (vol)*	
GIA	*77,898 m²*	
Upfront carbon	*627 $kgCO_2e/m^2$ [A1-A5]*	*654 $kgCO_2e/m^2$ [A1-A5]*
Whole life carbon	*1,288 $kgCO_2e/m^2$ [A-C]*	*1,479 $kgCO_2e/m^2$ [A-C]*
Operational energy	*95 $kWh/m^2/yr$*	*141 $kWh/m^2/yr$*
Number of storeys	*30 storeys*	
Floor to floor height	*3.84-3.98 m (office)* *4.27 m (lab)*	

Figure 17.16 Overview of key assumptions and results for the carbon assessment

External works
One of the benefits of this scheme is that its scope is sufficiently wide to unlock improvements to the public realm. An allowance of 19 $kgCO_2e/m^2$ is included. For consistency the same assumptions have been used across all scenarios that deliver upgrades to the public realm.

Site activities
Compared to a new build and in contrast to the other retention options, the site programme is anticipated to be longer owing to the complexity of the retention in the proposal. An allowance of 23 $kgCO_2e/m^2$ is included based on an allowance e input from Lendlease.

Operational energy and carbon
Notwithstanding the all-new MEP systems and facade, the proposal's overall operational energy performance is somewhat worse than current new build best practice due to compromises in the distribution in the existing basement with offsets and dual distribution anticipated (but optimised over the floorplates).National Grid FES 2021 'steady progression' scenario, with a change in carbon factor applied every 5 years, until 2050.

The breakdown of embodied carbon by building element, and the whole life-cycle estimates are shown in Figure 17.17 and Figure 17.18 respectively.

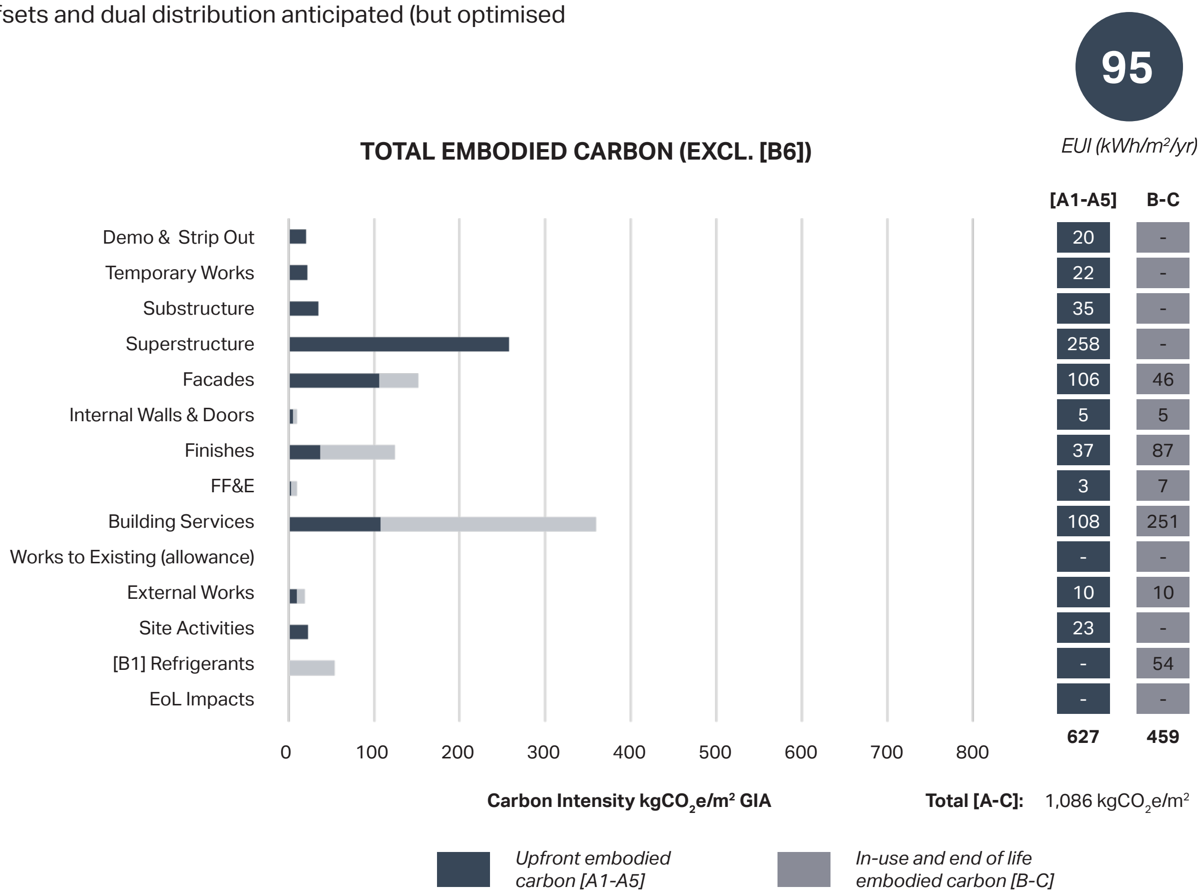
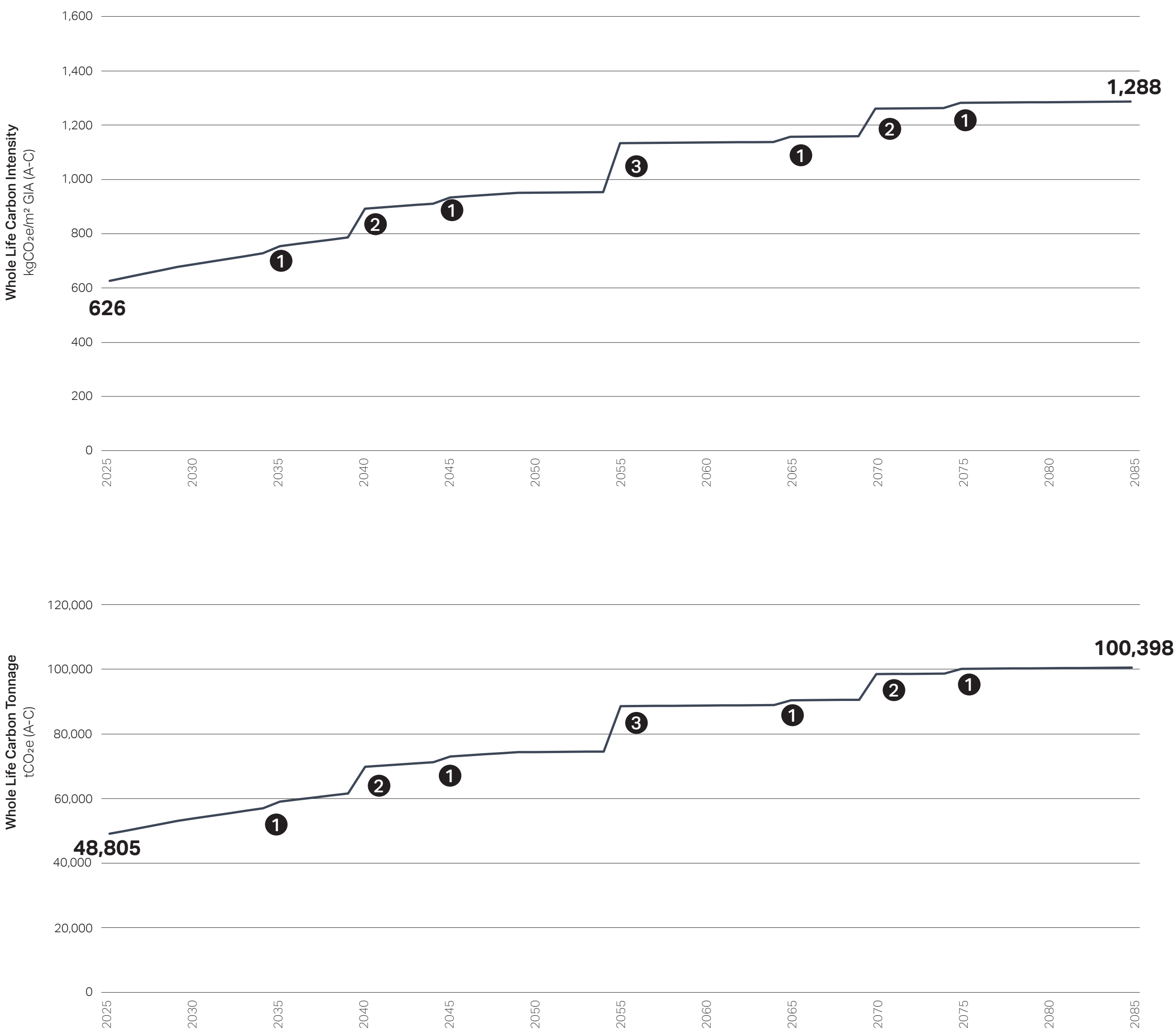


Figure 17.17 Breakdown of embodied carbon by building element

WHOLE LIFE CARBON [A-C]



❶ *Finishes and FF&E are replaced*

❷ *Building services are replaced as they reach end of service life*

❸ *Secondary components in the facade systems are replaced as they reach end of service life, assuming new IGUs throughout. Internal walls and doors are replaced. Finishes and FF&E are replaced at the same time*

Figure 17.18 Whole life-cycle carbon estimate with interventions over time

Lab-enabled

The comparisons in this Section assume all areas are fit out as office to enable comparison. If this option had the lab-enabled spaces fit out and operating as labs, considering the increased intensity for building services embodied carbon and energy demand, the following would result:

- Total upfront embodied carbon [A1-A5]
  654 $kgCO_2e/m^2$
- In-use embodied carbon [B-C, excl. B6]
  523 $kgCO_2e/m^2$
- Whole life-cycle carbon [A-C, excl. B6]
  1,177 $kgCO_2e/m^2$.
- Whole life-cycle carbon [A-C, incl. B6]
  1,479 $kgCO_2e/m^2$.

The embodied carbon results and EUI are blended according to the split of office-only and lab-enabled space thought the whole building. Assumptions are presented in Section 17.1.2.

The breakdown of embodied carbon by building element, and the whole life-cycle estimates are shown in Figure 17.19 and Figure 17.20 respectively.

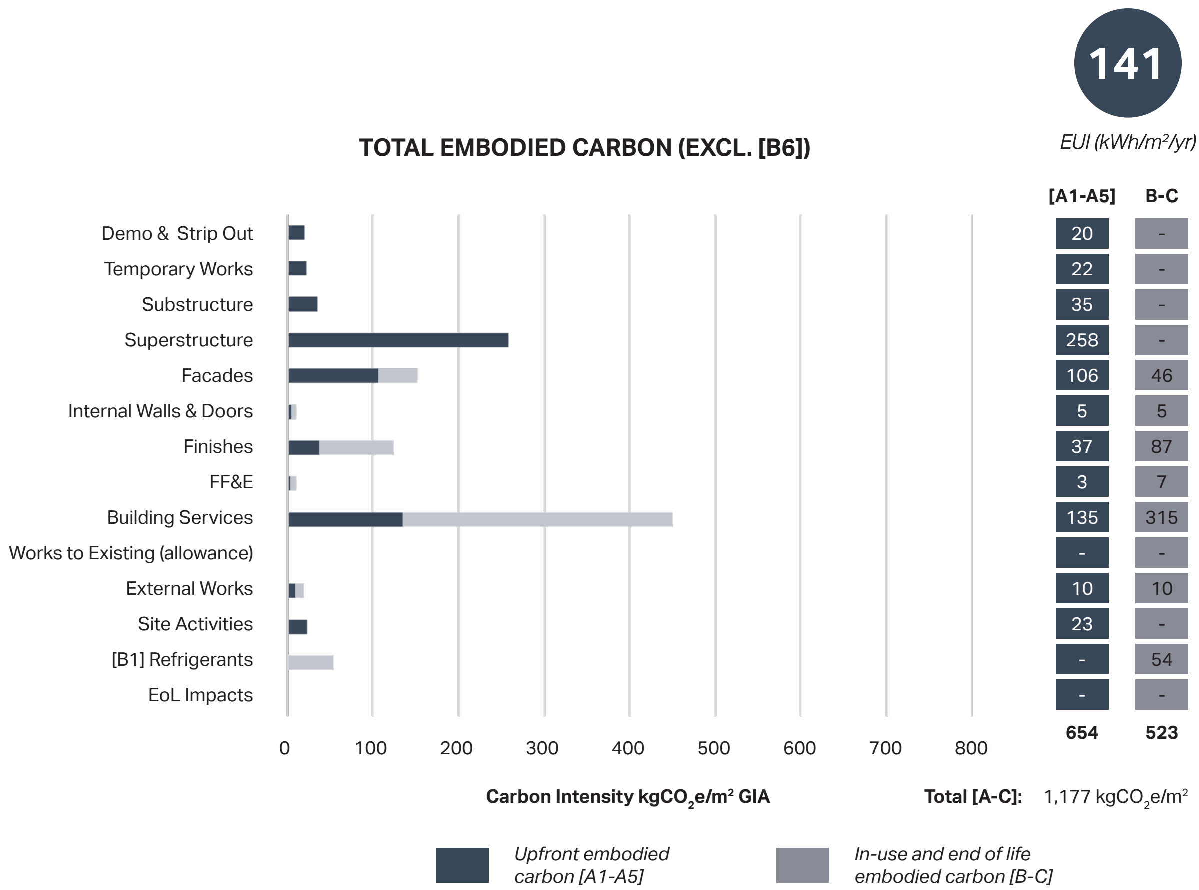
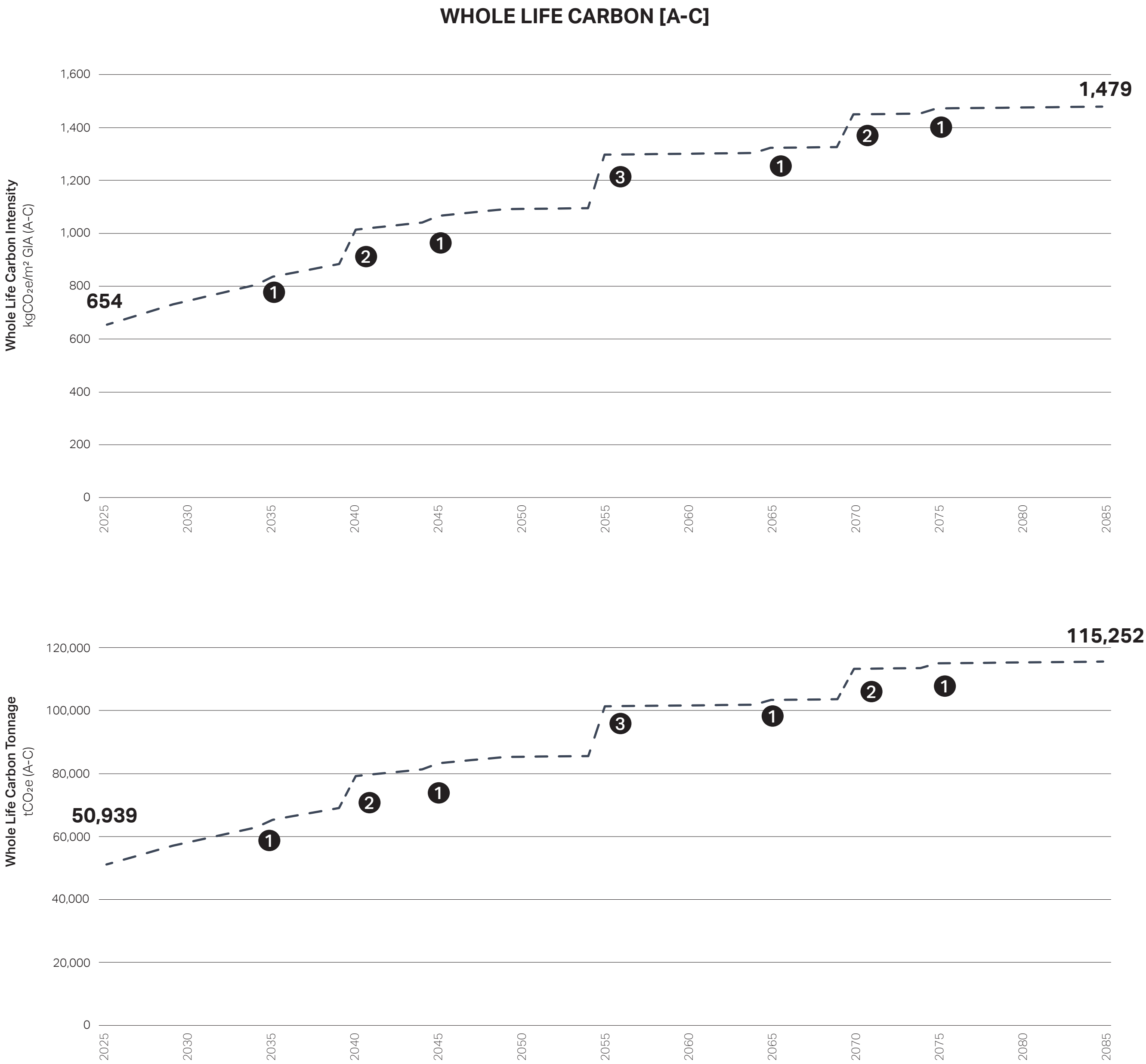


Figure 17.19 Breakdown of embodied carbon by building element for lab-enabled scenario



1 *Finishes and FF&E are replaced*

2 *Building services are replaced as they reach end of service life*

3 *Secondary components in the facade systems are replaced as they reach end of service life, assuming new IGUs throughout. Internal walls and doors are replaced. Finishes and FF&E are replaced at the same time*

Figure 17.20 Whole life-cycle carbon estimate with interventions over time for lab-enabled scenario

17.2.5 Partial Retention and Extension - Retain the Core

A partial retention and extension is explored with the aim of updating the tower to modern standards while retaining as much of the existing building as possible. This option is similar to the retention and extension, but with entirely new floorplates delivering improved floor to floor heights and greater flexibility.

A summary of the interventions and results is shown in Figure 17.21.

The breakdown of embodied carbon by building element, and the whole life-cycle estimates are shown in Figure 17.22 and Figure 17.23 respectively.

Demolition and strip out
The emissions calculated in relation to the demolition and strip out are estimated at 21 $kgCO_2e/m^2$.

Temporary works
Emissions associated with temporary works are relatively low given the lessened extent of temporary works required in the proposal compared to those with greater retention. An allowance of 15 $kgCO_2e/m^2$ is included.

Structures
Carbon estimates for the structures have been provided by Arup. The carbon emissions for the substructure are low for a building of this scale, due to the total retention of the existing foundations and basement. Additional substructure is proposed only where the extended tower comes down outside the footprint of the existing foundations. This is estimated as 35 $kgCO_2e/m^2$.

Similar to the retention and extension option, the existing satellite cores are removed, but the existing floorplates and columns are removed in their entirety. The new works therefore comprise new primary structure, all new floor plates, and supplementary stability systems at the perimeter to counteract for the modified core arrangement and increased wind area. These works are estimated as 262 $kgCO_2e/m^2$.

Facades
A new, high-performance facade that is commensurate with the modern performance standards expected in a high-end London development is assumed to replace the existing facade.

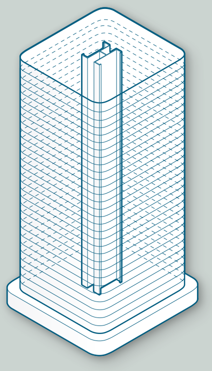
The proposed façade system is estimated as 352 $kgCO_2e/m^2$ FSA [A1-A5] over a facade surface area of 23,100 m^2. As noted in the methodology, the per m^2 facade area carbon emissions are consistent, the form factor (the ratio of facade surface area to gross floor area) influences the figures when reported on a per m^2 GIA basis. This results in 104 $kgCO_2e/$ m2GIA [A1-A5] and 149 $kgCO_2e/m^2$ GIA [A-C].

Internal walls & doors, finishes, and FF&E
For internal walls & doors, finishes, and FF&E, a benchmark figure has been assumed in the absence of design information at this stage.

Building services and refrigerants
All-new MEP systems are proposed with carbon estimates provided by Arup. The fundamental room-side and central systems are proposed to be the same across all options, refer to methodology in Section 17.1.2. MEP embodied carbon is estimated as 108 $kgCO_2e/m^2$ [A1-A5] and 359 $kgCO_2e/m^2$ [A-C].

This assumes that the fit out is for office only including in the spaces with larger floor to floor heights that are designed as lab-enabled. This is chosen to provide a like for like comparison with the other options since they cannot accommodate any laboratory spaces, and the laboratory MEP equipment is more carbon intensive than that for offices.

External works
One of the benefits of the retention and extension scheme is that its scope is sufficiently wide to unlock improvements to the public realm. An allowance of 19 $kgCO_2e/m^2$ is included. For consistency the same assumptions have been used across all scenarios that deliver upgrades to the public realm.



Retain & Refurbish

Disassemble & Reuse

Partial Retention and Extension - Retain the Core

Retention of substructure and core. Floor plates extended with new superstructure, and new facade, internal finishes, FF&E, and MEP. Re-use demolition arisings on site where possible.

- New internal finishes
- New FF&E
- New MEP
- New facade
- New floorplates
- New columns
- New core
- New substructure

Retained structure	25 % (carbon) / *31 % (vol)*	
GIA	*77,898 m²*	
	Office-only	Office & lab
Upfront carbon	627 *kgCO_2e/m² [A1-A5]*	666 *kgCO_2e/m² [A1-A5]*
Whole life carbon	*1,288 kgCO_2e/m² [A-C]*	*1,562 kgCO_2e/m² [A-C]*
Operational energy	*95 kWh/m²/yr*	*162 kWh/m²/yr*
Number of storeys	*30 storeys*	
Floor to floor height	*3.8 m (office)* *4.1 m (lab)*	

Figure 17.21 Overview of key assumptions and results for the carbon assessment

Site activities

Compared to a new build, the site programme is anticipated to be somewhat shortened owing to the extent of retention in the proposal, although the programme will be impacted by requiring a more careful deconstruction. An allowance of 27 $kgCO_2e/m^2$ is included which is pro-rated from an allowance for a full new construction based on the length of the programme using programme input from Lendlease. The assumed programme length is 64 months.

Operational energy and carbon

Notwithstanding the all-new MEP systems and facade, the proposal's overall operational energy performance is somewhat worse than current new build best practice due to compromises in the distribution in the existing basement with offsets and dual distribution anticipated (but optimised over the floorplates).

The EUI is estimated as 95 kWh/m^2/year estimated by Arup. Operational energy emissions [B6] was converted using National Grid FES 2021 'steady progression' scenario, with a change in carbon factor applied every 5 years, until 2050.

The breakdown of embodied carbon by building element, and the whole life-cycle estimates are shown in Figure 17.22 and Figure 17.23 respectively.

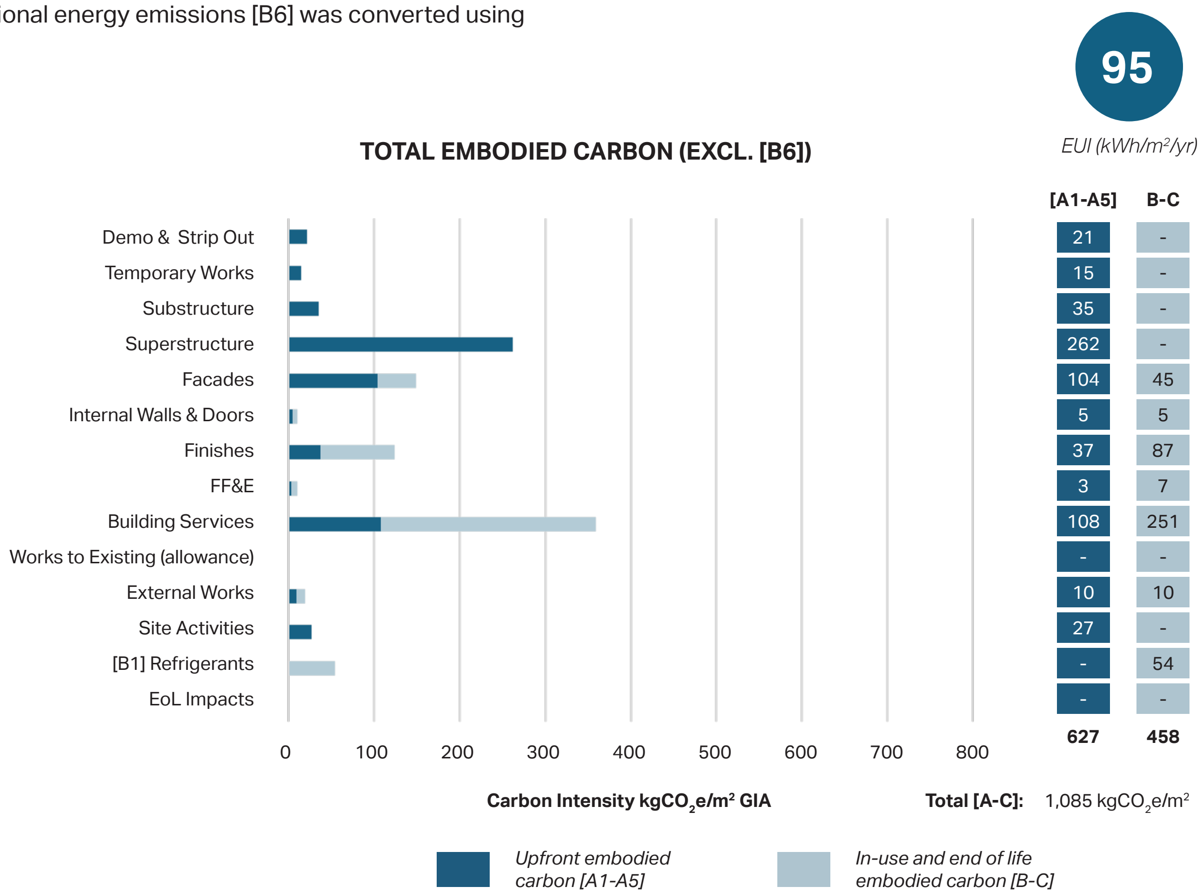
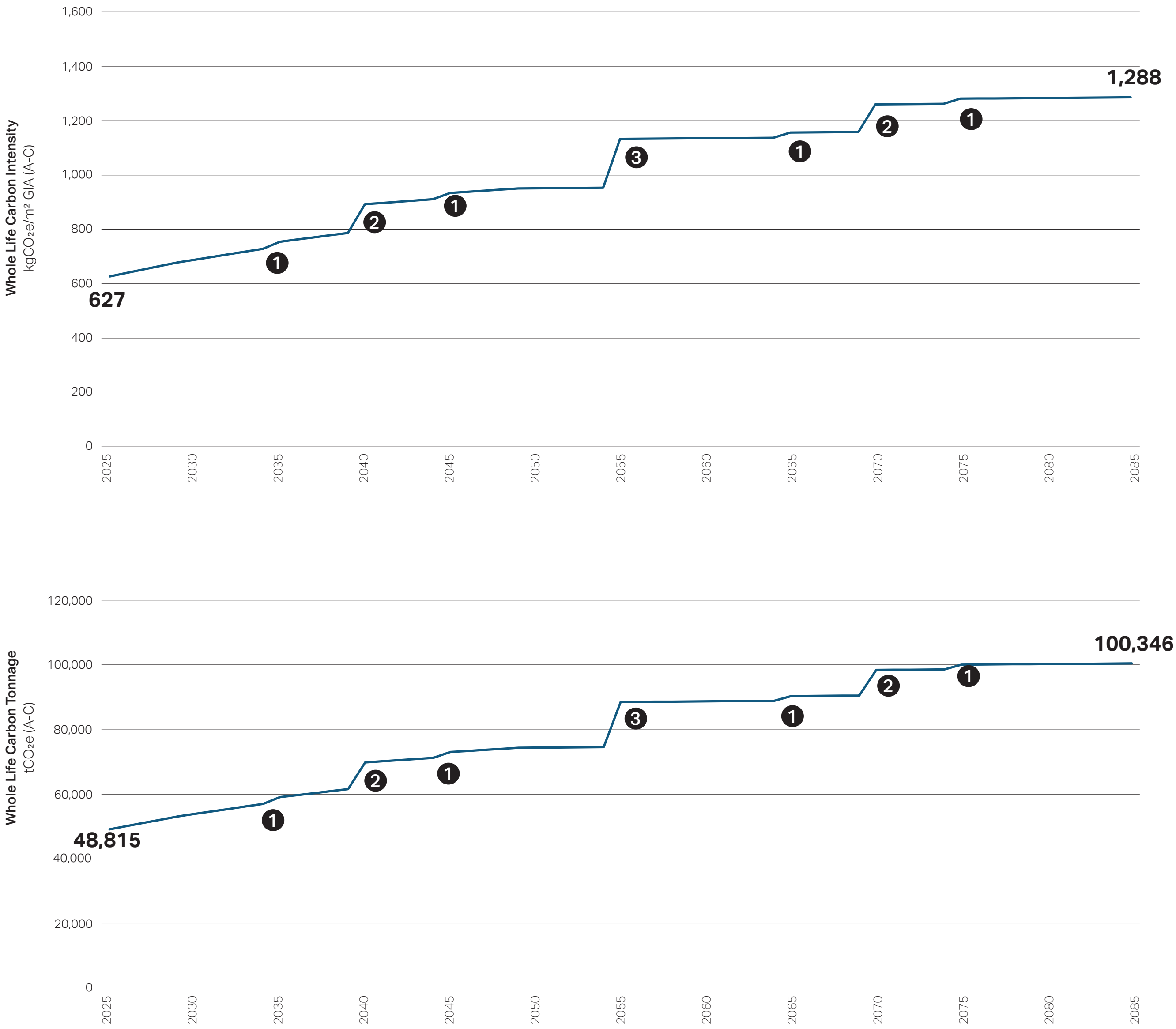


Figure 17.22 Breakdown of embodied carbon by building element

WHOLE LIFE CARBON [A-C]



1 Finishes and FF&E are replaced

2 Building services and refrigerants are replaced as they reach end of service life

3 Secondary components in the facade systems are replaced as they reach end of service life, assuming new IGUs throughout. Internal walls and doors are replaced. Finishes and FF&E are replaced at the same time

Figure 17.23 Whole life-cycle carbon estimate with interventions over time

Lab-enabled

The comparisons in this Section assume all areas are fit out as office to enable comparison. If this option had the lab-enabled spaces fit out and operating as labs, considering the increased intensity for building services embodied carbon and energy demand, the following would result:

- Total upfront embodied carbon [A1-A5] 666 $kgCO_2e/m^2$
- In-use embodied carbon [B-C, excl. B6] 550 $kgCO_2e/m^2$
- Whole life-cycle carbon [A-C, excl. B6] 1,216 $kgCO_2e/m^2$.
- Whole life-cycle carbon [A-C, incl. B6] 1,562 $kgCO_2e/m^2$.

The embodied carbon results and EUI are blended according to the split of office-only and lab-enabled space thought the whole building. Assumptions are presented in Section 17.1.2.

The breakdown of embodied carbon by building element, and the whole life-cycle estimates are shown in Figure 17.24 and Figure 17.25 respectively.

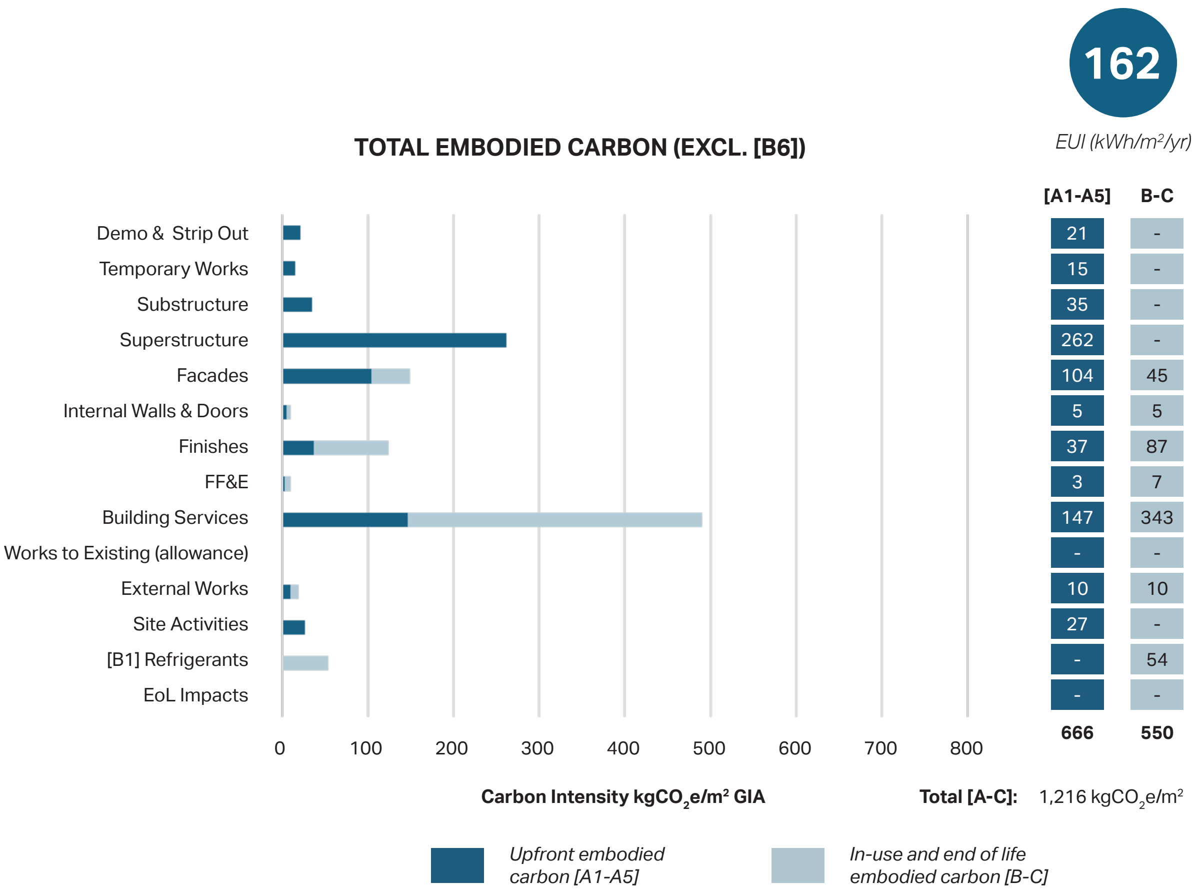
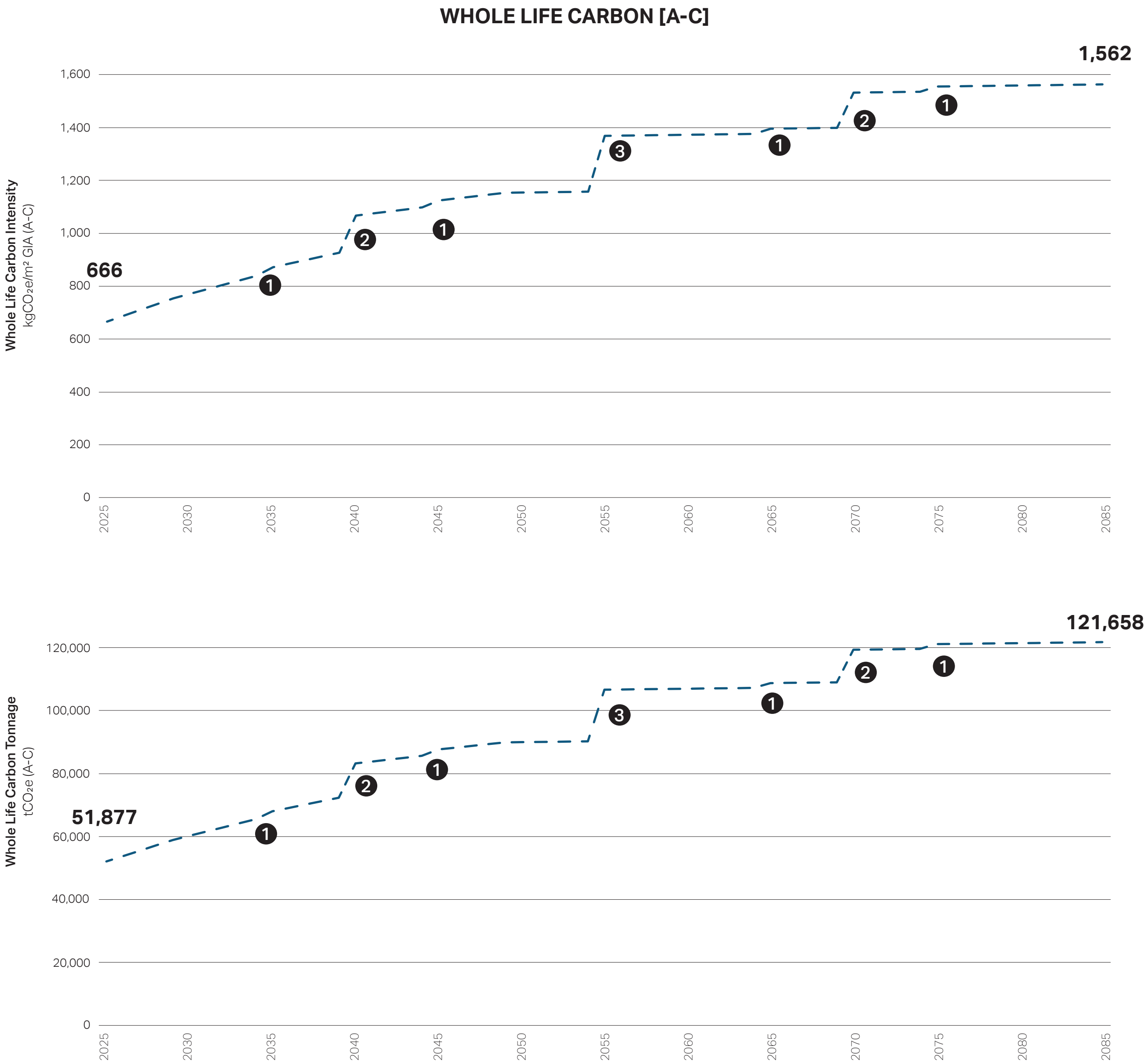


Figure 17.24 Breakdown of embodied carbon by building element for lab-enabled scenario



1 Finishes and FF&E are replaced

2 Building services and refrigerants are replaced as they reach end of service life

3 Secondary components in the facade systems are replaced as they reach end of service life, assuming new IGUs throughout. Internal walls and doors are replaced. Finishes and FF&E are replaced at the same time

Figure 17.25 Whole life-cycle carbon estimate with interventions over time for lab-enabled scenario

17.2.6 New Build

A new build scheme is explored with the aim of delivering a tower to modern standards with no compromises imposed by the existing building. This option delivers 100% new build comprising all-new: foundations and basement, frame and primary structure including cores, floorplates, facade, finishes, FF&E, and MEP systems.

In the appraisal, this option is intended as a bookend to the other options, studying what would be the impact of a totally unconstrained build.

A summary of the interventions and results is shown in Figure 17.26.

The breakdown of embodied carbon by building element, and the whole life-cycle estimates are shown in Figure 17.27 and Figure 17.28 respectively.

Demolition and strip out
The emissions calculated in relation to the demolition and strip out are estimated at 24 $kgCO_2e/m^2$.

Temporary works
Of all the options, emissions associated with temporary works are lowest given the lessened extent of temporary works required in the proposal compared to those with greater retention. An allowance of 10 $kgCO_2e/m^2$ is included.

Structures
Carbon estimates for the structures have been provided by Arup. The carbon emissions for the substructure are significantly higher than any of the other options, due to the totally new foundation and basement proposed. Providing new foundations and basement helps to de-risk the construction programme since the new building is no longer in any way structurally-reliant on the existing. This is estimated as 72 $kgCO_2e/m^2$.

For the superstructure, the works comprise new primary structure, floor plates, and stability systems. The stability system is delivered by perimeter bracing and the new cores are free to be positioned flexibly as they are not used as part of the stability system. These works are estimated as 262 $kgCO_2e/m^2$.

Facades
A new, high-performance facade that is commensurate with the modern performance standards expected in a high-end London development is assumed to replace the existing facade.

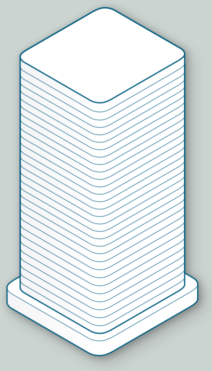
The proposed façade system is estimated as 352 $kgCO_2e/m^2$ FSA [A1-A5] over a facade surface area of 23,100 m^2. As noted in the methodology, the per m^2 facade area carbon emissions are consistent, the form factor (the ratio of facade surface area to gross floor area) influences the figures when reported on a per m^2 GIA basis. This results in 104 $kgCO_2e/$ m2GIA [A1-A5] and 149 $kgCO_2e/m^2$ GIA [A-C].

Internal walls & doors, finishes, and FF&E
For internal walls & doors, finishes, and FF&E, a benchmark figure has been assumed in the absence of design information at this stage.

Building services and refrigerants
All-new MEP systems are proposed with carbon estimates provided by Arup. The fundamental room-side and central systems are proposed to be the same across all options, refer to methodology in Section 17.1.2. MEP embodied carbon is estimated as 103 $kgCO_2e/m^2$ [A1-A5] and 344 $kgCO_2e/m^2$ [A-C].

This assumes that the fit out is for office only including in the spaces with larger floor to floor heights that are designed as lab-enabled. This is chosen to provide a like for like comparison with the other options since they cannot accommodate any laboratory spaces, and the laboratory MEP equipment is more carbon intensive than that for offices.

External works
One of the benefits of the retention and extension scheme is that its scope is sufficiently wide to unlock improvements to the public realm. An allowance of 19 $kgCO_2e/m^2$ is included. For consistency the same assumptions have been used across all scenarios that deliver upgrades to the public realm.



Demolish
& Recycle

New Build

Option demolishes and recycles the full existing tower. No structure is retained (including foundation and substructure).

- New internal finishes
- New FF&E
- New MEP
- New facade
- New floorplates
- New columns
- New core
- New substructure

	Office-only	Office & lab
Retained structure	*0 %*	
GIA	*77,898 m²*	
Upfront carbon	*660 $kgCO_2e/m^2$ [A1-A5]*	*698 $kgCO_2e/m^2$ [A1-A5]*
Whole life carbon	*1,312 $kgCO_2e/m^2$ [A-C]*	*1,572 $kgCO_2e/m^2$ [A-C]*
Operational energy	*90 $kWh/m^2/yr$*	*158 $kWh/m^2/yr$*
Number of storeys	*30 storeys*	
Floor to floor height	*3.8 m (office)* *4.1 m (lab)*	

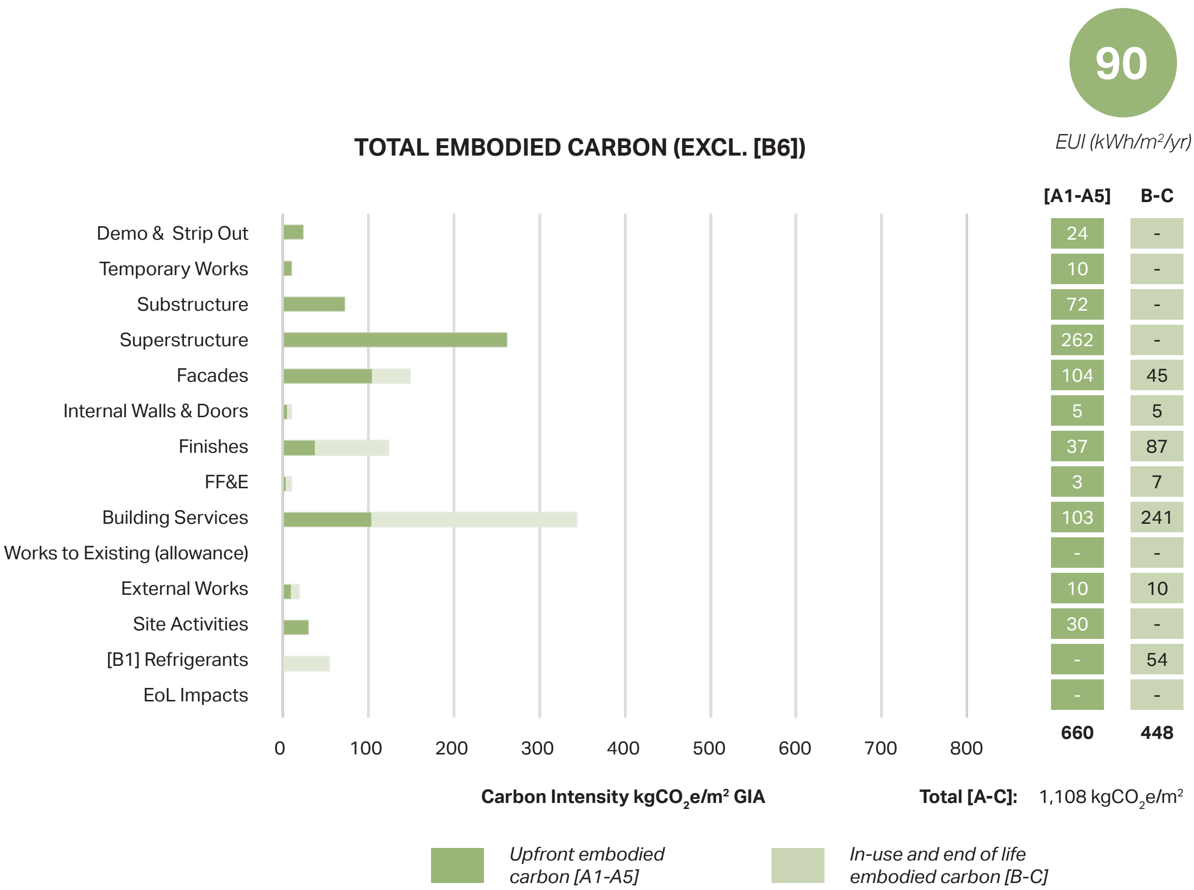
Figure 17.26 Overview of key assumptions and results for the carbon assessment

Site activities
The fully new build scheme is anticipated to have a construction programme of 72 months. This is somewhat mitigated by not needing to do as much of a careful deconstruction. An allowance of 30 kgCO_2e/m^2 is included for a full new construction based on the length of the programme using programme input from Lendlease.

Operational energy and carbon
The proposal's overall operational energy performance is current best practice due to optimised packaging and distribution.

The EUI is estimated as 90 kWh/m^2/year estimated by Arup. Operational energy emissions [B6] was converted using National Grid FES 2021 'steady progression' scenario, with a change in carbon factor applied every 5 years, until 2050.

The breakdown of embodied carbon by building element, and the whole life-cycle estimates are shown in Figure 17.27 and Figure 17.28 respectively.

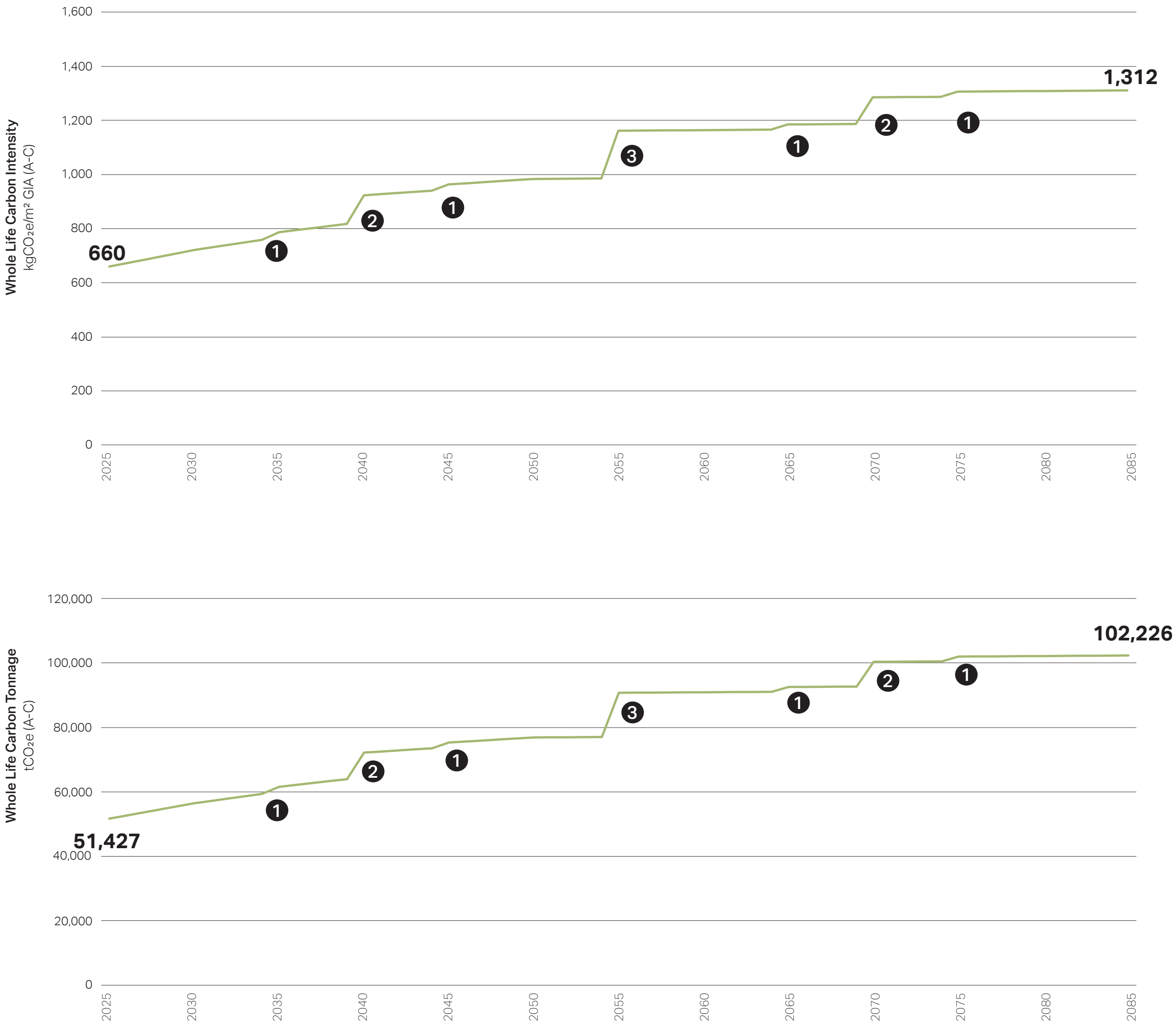


	[A1-A5]	B-C
Demo & Strip Out	24	-
Temporary Works	10	-
Substructure	72	-
Superstructure	262	-
Facades	104	45
Internal Walls & Doors	5	5
Finishes	37	87
FF&E	3	7
Building Services	103	241
Works to Existing (allowance)	-	-
External Works	10	10
Site Activities	30	-
[B1] Refrigerants	-	54
EoL Impacts	-	-
	660	**448**

Total [A-C]: 1,108 kgCO_2e/m^2

Figure 17.27 Breakdown of embodied carbon by building element

WHOLE LIFE CARBON [A-C]



1. *Finishes and FF&E are replaced*
2. *Building services and refrigerants are replaced as they reach end of service life*
3. *Secondary components in the facade systems are replaced as they reach end of service life, assuming new IGUs throughout. Internal walls and doors are replaced. Finishes and FF&E are done at the same time*

Figure 17.28 Whole life-cycle carbon estimate with interventions over time

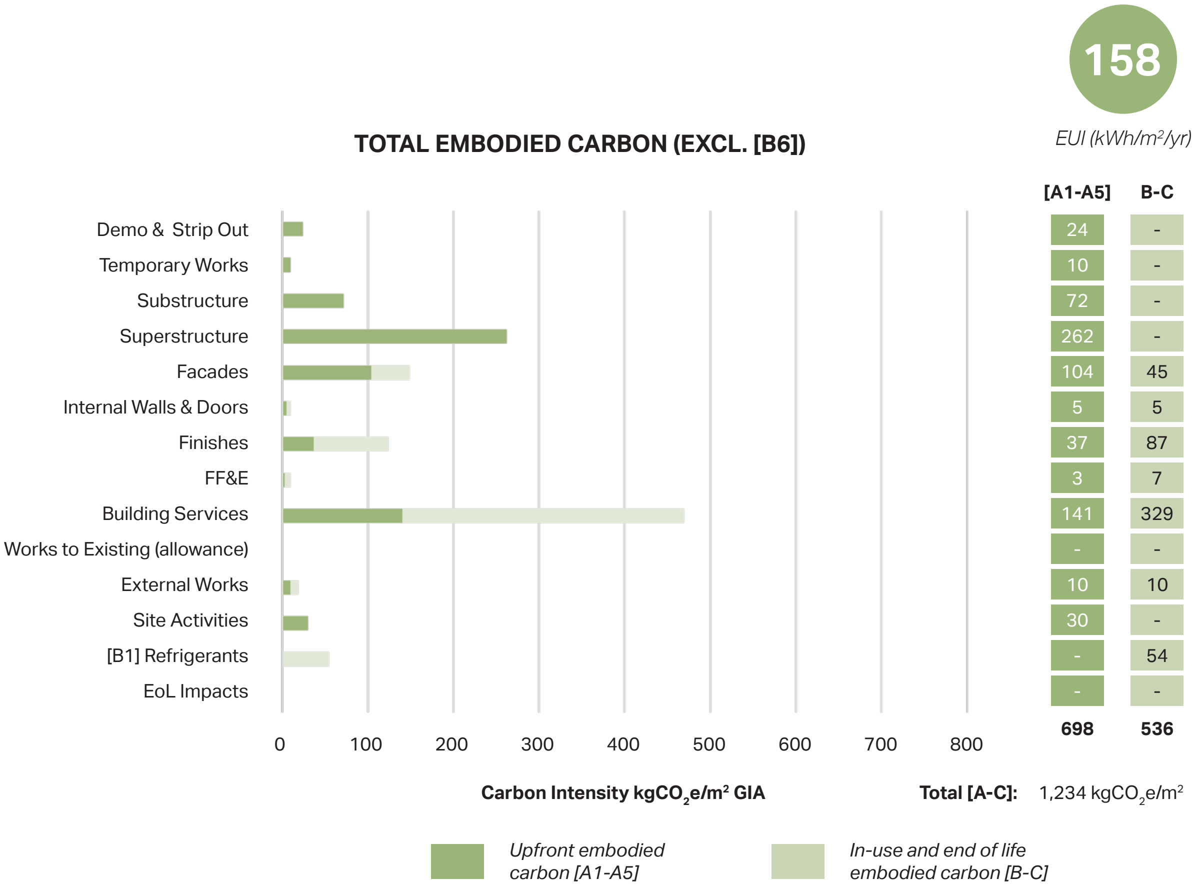
Lab-enabled

The comparisons in this Section assume all areas are fit out as office to enable comparison. If this option had the lab-enabled spaces fit out and operating as labs, considering the increased intensity for building services embodied carbon and energy demand, the following would result:

- Total upfront embodied carbon [A1-A5] 698 $kgCO_2e/m^2$
- In-use embodied carbon [B-C, excl. B6] 539 $kgCO_2e/m^2$
- Whole life-cycle carbon [A-C, excl. B6] 1,234 $kgCO_2e/m^2$.
- Whole life-cycle carbon [A-C, incl. B6] 1,572 $kgCO_2e/m^2$.

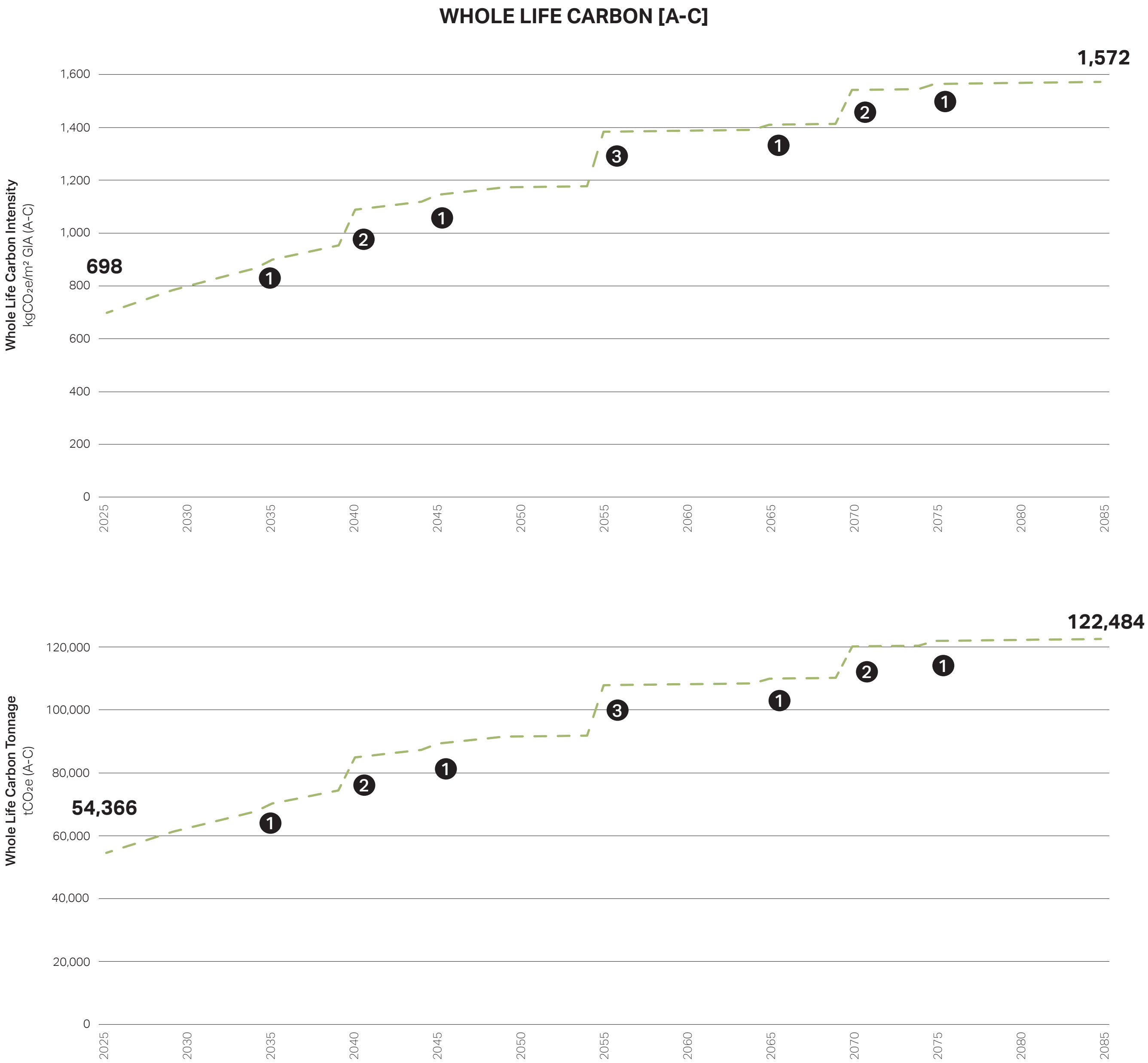
The embodied carbon results and EUI are blended according to the split of office-only and lab-enabled space thought the whole building. Assumptions are presented in Section 17.1.2.

The breakdown of embodied carbon by building element, and the whole life-cycle estimates are shown in Figure 17.29 and Figure 17.30 respectively.



	[A1-A5]	B-C
Demo & Strip Out	24	-
Temporary Works	10	-
Substructure	72	-
Superstructure	262	-
Facades	104	45
Internal Walls & Doors	5	5
Finishes	37	87
FF&E	3	7
Building Services	141	329
Works to Existing (allowance)	-	-
External Works	10	10
Site Activities	30	-
[B1] Refrigerants	-	54
EoL Impacts	-	-
	698	536

Figure 17.29 Breakdown of embodied carbon by building element for lab-enabled scenario



1. *Finishes and FF&E are replaced*
2. *Building services and refrigerants are replaced as they reach end of service life*
3. *Secondary components in the facade systems are replaced as they reach end of service life, assuming new IGUs throughout. Internal walls and doors are replaced. Finishes and FF&E are done at the same time*

Figure 17.30 Whole life-cycle carbon estimate with interventions over time for lab-enabled scenario

17.3 Summary and Comparison

17.3.1 Embodied carbon by building element

The comparative breakdown of embodied carbon by building element is shown in Figure 17.31. The breakdown is split for office-only scenarios above, and for those where the lab-enabled space is fitted out and operating as lab below.

Office-only
In total tonnage terms, which should be the primary measure, the Major Refurbishment and Retention & Partial Extension - Max Retention have the lowest upfront and whole life-cycle carbon, but deliver significantly less floor area. Notwithstanding that they retain the existing building's compromised floor to floor height, both options are unlikely to be viable considering the work required to replace existing plant and facades, and in the case of the latter, the additional cantilever structure and external cores.

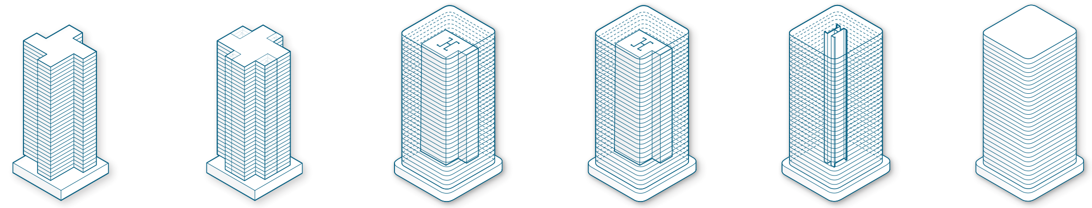
Between the remainder of the options, the upfront carbon is similar due to different areas delivered, with the Partial Retention and Extension - Retain the Core option having the lowest whole life-cycle carbon, as it best balances the upfront spend and operational energy in use. Noting that is comparative, in absolute terms, to the Partial Retention and Extension - Retain Interstitial Slabs option, but it delivers this carbon performance without the limitations or buildability complexity imposed by retaining the interstitial slabs.

In intensity terms, the Retention & Partial Extension - Max Retention option has the lowest upfront and whole life-cycle carbon, owing to the extent of intervention. There is greater spread across the other options. The Retention & Extension - "Full" Retention option is relatively low because of the larger area delivered than other extension schemes. The options that introduce new floor to floor heights and less compromised floorplates (Partial Retention & Extension - Retain Interstitial Slabs, Partial Retention and Extension - Retain the Core, and New Build) are similar, both upfront and considering whole life-cycle carbon.

Office & lab
The options that do not introduce new floor to floor heights cannot accommodate lab-enabled spaces.

The Partial Retention and Extension - Retain Interstitial Slabs option has the lowest carbon performance of the three options, but this is because it delivers less lab-enabled area (approximately 23% of GIA compared to 33% for the others), being constrained by which slabs can be retained.

If the lab areas were normalised throughout, the trends would follow that for the office-only scenarios, and the Partial Retention and Extension - Retain the Core option would deliver the lowest carbon performance by all measures.



OFFICE-ONLY

	Major Refurbishment		Retention & Partial Extension - Max Retention		Retention & Extension - "Full" Retention		Partial Retention & Extension - Retain Interstitial Slabs		Partial Retention & Extension - Retain the Core		New Build	
WLC Intensity *[A-C]*	*1,125 $kgCO_2e/m^2$*		*1,089 $kgCO_2e/m^2$*		*1,210 $kgCO_2e/m^2$*		*1,288 $kgCO_2e/m^2$*		*1,288 $kgCO_2e/m^2$*		*1,312 $kgCO_2e/m^2$*	
WLC Tonnage *[A-C]*	*60,283 tCO_2e*		*77,480 tCO_2e*		*111,898 tCO_2e*		*100,398 tCO_2e*		*100,346 tCO_2e*		*102,226 tCO_2e*	
	[A1-A5]	**B-C**	**[A1-A5]**	**B-C**	**[A1-A5]**	**B-C**	**[A1-A5]**	**B-C**	**[A1-A5]**	**B-C**	**[A1-A5]**	**B-C**
Demo & Strip Out	19	-	14	-	17	-	20	-	21	-	24	-
Temporary Works	5	-	10	-	22	-	22	-	15	-	10	-
Substructure	-	-	15	-	35	-	35	-	35	-	72	-
Superstructure	50	-	55	-	158	-	258	-	262	-	262	-
Facades	156	67	114	49	89	38	106	46	104	45	104	45
Internal Walls & Doors	5	5	5	5	5	5	5	5	5	5	5	5
Finishes	37	87	37	87	37	87	37	87	37	87	37	87
FF&E	3	7	3	7	3	7	3	7	3	7	3	7
Building Services	122	284	119	277	117	273	108	251	108	251	103	241
Works to Existing (allowance)	-	-	-	-	-	-	-	-	-	-	-	-
External Works	-	-	10	10	10	10	10	10	10	10	10	10
Site Activities	9	-	17	-	19	-	23	-	27	-	30	-
[B1] Refrigerants	-	54	-	54	-	54	-	54	-	54	-	54
EoL Impacts	-	-	-	-	-	-	-	-	-	-	-	-
TOTALS	**406**	**504**	**398**	**488**	**512**	**474**	**627**	**459**	**627**	**458**	**660**	**448**

OFFICE & LAB

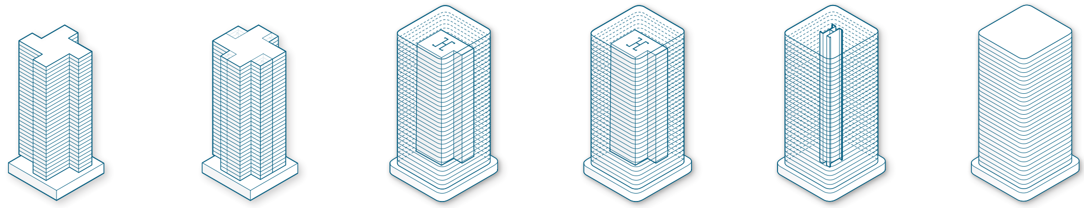
	Major Refurbishment		Retention & Partial Extension - Max Retention		Retention & Extension - "Full" Retention		Partial Retention & Extension - Retain Interstitial Slabs		Partial Retention & Extension - Retain the Core		New Build	
WLC Intensity *[A-C]*	*n/a*		*n/a*		*n/a*		*1,479 $kgCO_2e/m^2$*		*1,562 $kgCO_2e/m^2$*		*1,572 $kgCO_2e/m^2$*	
WLC Tonnage *[A-C]*	*n/a*		*n/a*		*n/a*		*115,252 tCO_2e*		*121,659 tCO_2e*		*122,484 tCO_2e*	
	[A1-A5]	**B-C**	**[A1-A5]**	**B-C**	**[A1-A5]**	**B-C**	**[A1-A5]**	**B-C**	**[A1-A5]**	**B-C**	**[A1-A5]**	**B-C**
Demo & Strip Out	N/A as these options do not accommodate lab-enabled uses						20	-	21	-	24	-
Temporary Works							22	-	15	-	10	-
Substructure							35	-	35	-	72	-
Superstructure							258	-	262	-	262	-
Facades							106	46	104	45	104	45
Internal Walls & Doors							5	5	5	5	5	5
Finishes							37	87	37	87	37	87
FF&E							3	7	3	7	3	7
Building Services							135	315	147	343	141	329
Works to Existing (allowance)							-	-	-	-	-	-
External Works							10	10	10	10	10	10
Site Activities							23	-	27	-	30	-
[B1] Refrigerants							-	54	-	54	-	54
EoL Impacts							-	-	-	-	-	-
TOTALS							**654**	**523**	**666**	**550**	**698**	**536**

Figure 17.31 Breakdown of embodied carbon by building element

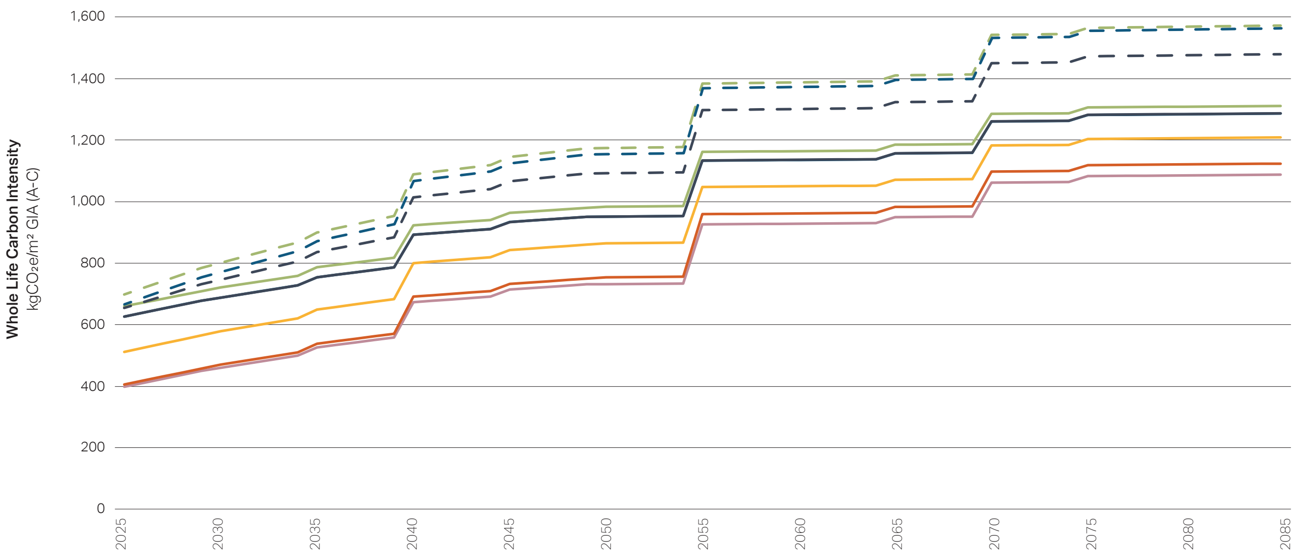
17.3.2 Whole life-cycle carbon

The comparative whole life-cycle estimates are shown in Figure 17.32. The curves for office-only are shown as solid curves, and those where the lab-enabled space is fitted out and operating as lab are shown as dashed curves.

The same considerations described in Section 17.3.1 apply.



	Major Refurbishment	Retention & Partial Extension - Max Retention	Retention & Extension - "Full" Retention	Partial Retention & Extension - Retain Interstitial Slabs	Partial Retention & Extension - Retain the Core	New Build
OFFICE-ONLY						
WLC Intensity *[A-C]*	*1,125 kgCO_2e/m²* *60,283 tCO_2e*	*1,089 kgCO_2e/m²* *77,480 tCO_2e*	*1,210 kgCO_2e/m²* *111,898 tCO_2e*	*1,288 kgCO_2e/m²* *100,398 tCO_2e*	*1,288 kgCO_2e/m²* *100,346 tCO_2e*	*1,312 kgCO_2e/m²* *102,226 tCO_2e*
OFFICE & LAB						
WLC Intensity *[A-C]*	*n/a*	*n/a*	*n/a*	*1,479 kgCO_2e/m²*	*1,562 kgCO_2e/m²*	*1,572 kgCO_2e/m²*
WLC Tonnage *[A-C]*	*n/a*	*n/a*	*n/a*	*115,252 tCO_2e*	*121,659 tCO_2e*	*122,484 tCO_2e*



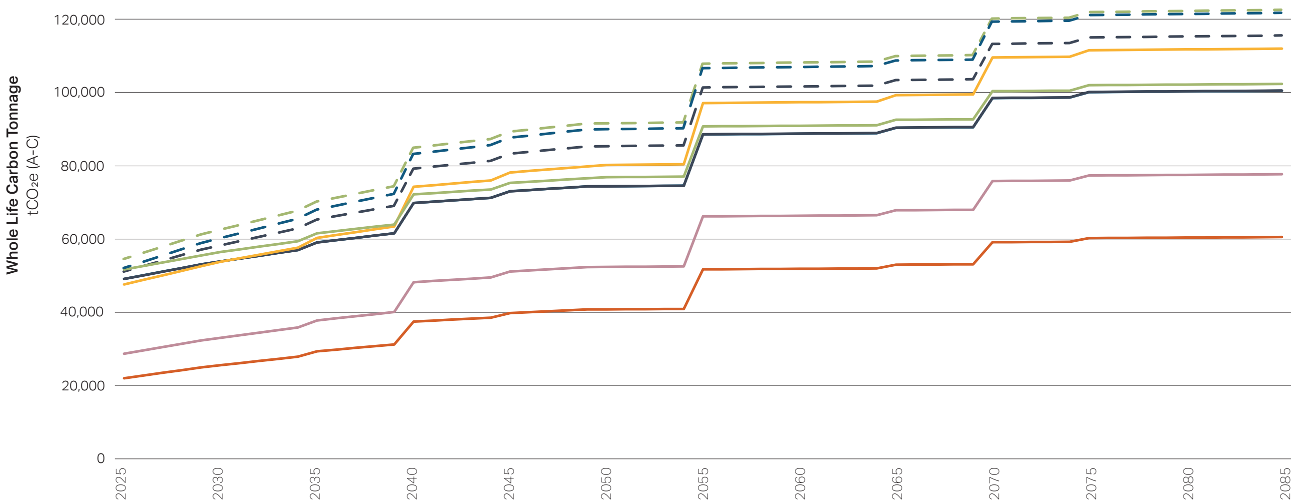
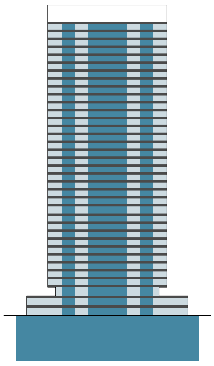


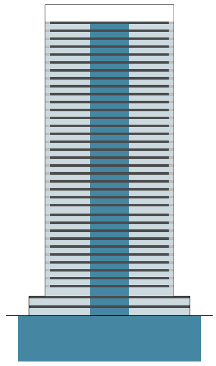
Figure 17.32 Whole life-cycle carbon estimate over time for all options

The matrix on this page summarises and compares the options presented for carbon assessments in this section. More detail against each of these considerations is contained within the respective sections.

Major Refurbishment



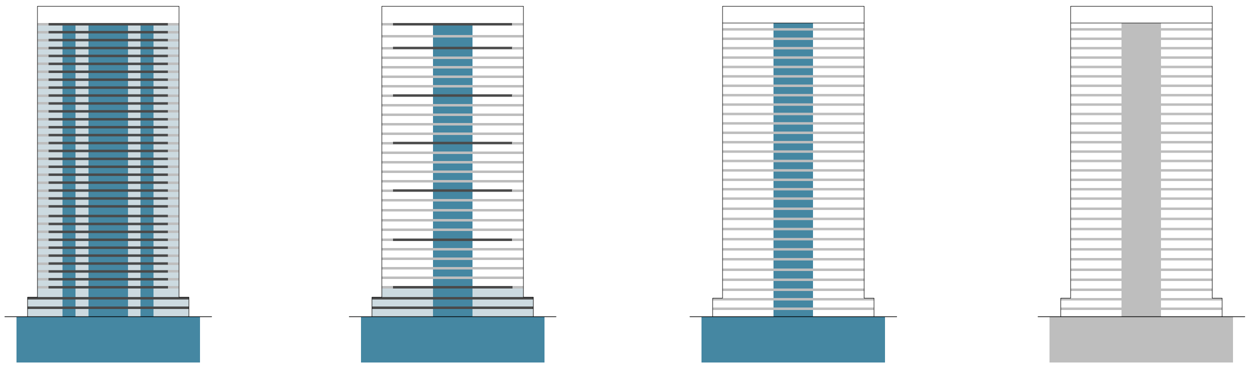
Retention & Partial Extension - Max Retention



	Major Refurbishment	Retention & Partial Extension - Max Retention
Retained structure	89% (carbon) 90% (vol)	93% (carbon) 92% (vol)
GIA	53,263 m^2	71,166 m^2
Upfront carbon [A1-A5]	21,603 tCO_2 406 $kgCO_2e/m^2$	28,322 tCO_2 398 $kgCO_2e/m^2$
Whole life-cycle carbon [A-C]	60,283 tCO_2 1,125 $kgCO_2e/m^2$	77,480 tCO_2 1,089 $kgCO_2e/m^2$
EUI	104 $kWhm^2$/year	95 $kWhm^2$/year
Floor to floor height	3.2 m (office)	3.2 m (office)

** The area of lab-enabled space delivered in this option is lower than the other options, due to constraints on retaining slabs. See Section 17.1.2. If the lab areas were normalised throughout, the trends would follow that for the office-only scenarios, and the Partial Retention and Extension - Retain the Core option would deliver the lowest carbon performance by all measures.*

Retention & Extension - "Full" Retention	**Partial Retention & Extension -** Retain Interstitial Slabs	**Partial Retention & Extension -** Retain the Core	**New Build**



Retention & Extension - "Full" Retention	Partial Retention - Retain Interstitial Slabs		Partial Retention - Retain the Core		New Build	
84% (carbon) 85% (vol)	38% (carbon) 42% (vol)		25% (carbon) 31% (vol)		0%	
92,484 m^2	77,898 m^2		77,898 m^2		77,898 m^2	
	Office-only	Office & lab*	Office-only	Office & lab	Office-only	Office & lab
47,311 tCO_2 512 $kgCO_2e/m^2$	48,805 tCO_2 627 $kgCO_2e/m^2$	50,939 tCO_2 654 $kgCO_2e/m^2$	48,815 tCO_2 627 $kgCO_2e/m^2$	51,877 tCO_2 666 $kgCO_2e/m^2$	51,427 tCO_2 660 $kgCO_2e/m^2$	54,366 tCO_2 698 $kgCO_2e/m^2$
	Office-only	Office & lab*	Office-only	Office & lab	Office-only	Office & lab
111,898 tCO_2 1,210 $kgCO_2e/m^2$	100,398 tCO_2 1,288 $kgCO_2e/m^2$	115,252 tCO_2 1,479 $kgCO_2e/m$	100,346 tCO_2 1,288 $kgCO_2e/m^2$	121,659 tCO_2 1,562 $kgCO_2e/m^2$	102,226 tCO_2 1,312 $kgCO_2e/m^2$	122,484 tCO_2 1,572 $kgCO_2e/m^2$
	Office-only	Office & lab*	Office-only	Office & lab	Office-only	Office & lab
99 $kWhm^2$/year	95 $kWhm^2$/year	141 $kWhm^2$/year	95 $kWhm^2$/year	162 $kWhm^2$/year	90 $kWhm^2$/year	158 $kWhm^2$/year
3.2 m (office)	3.84 - 3.98 m (office) 4.27 m (lab)		3.8 m (office) 4.1 m (lab)		3.8 m (office) 4.1 m (lab)	

18

Euston Tower

Resource Efficiency & Future Proofing

18.1 General

CPG Energy efficiency and adaptation Paragraphs 9.10 - 9.12 set out suggestions for how developments may optimise resource efficiency at various stages of a project life-cycle.

All major applications and new buildings are required to submit a resource efficiency plan. This requirement is acknowledged, and a detailed response will form part of the Circular Economy Statement and Whole Life-cycle Carbon Assessment (WLCA) to be submitted as part a full planning application.

This section briefly sets out the strategies and approaches for resource efficiency, the principles of which are applicable regardless of the development option pursued.

Figure 18.1 Original Euston Tower under construction, photo undated thought to be ca. 1968

18.2 Design Stage

18.2.1 Deconstruction, Reuse, Recycling

The carbon impacts of these proposed interventions would be mitigated, so far as possible, by a detailed deconstruction, reuse, and recycling strategy.

This strategy would, strategically and transparently, analyse the materials to be removed as part of the proposals, and seek alternative uses that maintain as much of the material value as possible. The aim would be to both minimise waste, and also, to reuse these materials (and their historic, associated carbon emissions) in the most beneficial manner possible. The strategy is shown schematically in Figure 18.2.

As part of this strategy, a pre-demolition audit has been conducted, identifying the materials to be removed as part of the proposals. While there exist established routes for avoiding waste going to landfill, many materials are, in fact, downcycled, that is, they are modified and used as materials at lower value (they can also never be returned to the value that they had).

By focussing on the key material hotspots, those that are either large in carbon or quantity (or both, see Figure 18.3), the strategy will be to move as many of these key materials up the hierarchy, as is technically and feasibly possible. Acknowledging that the largest material fraction is concrete (for which a genuine recycling route does not yet exist at scale), this will endeavour to use these materials beneficially elsewhere so that their historical carbon emissions continue to be used. Tangible progress has been made on innovative ways of reusing disused concrete. More information is contained in the Circular Economy Statement that accompanies the full planning application.

All deconstruction materials on site will be carefully segregated so that their optimal end of life routes can be achieved. Examples of strategies for facade materials are presented in Volume One Section 7.5.

A Circular Economy Statement focussing on material reuse and recycling is submitted as part of a full planning application.

MATERIAL REUSE AND RECYCLING HIERARCHY

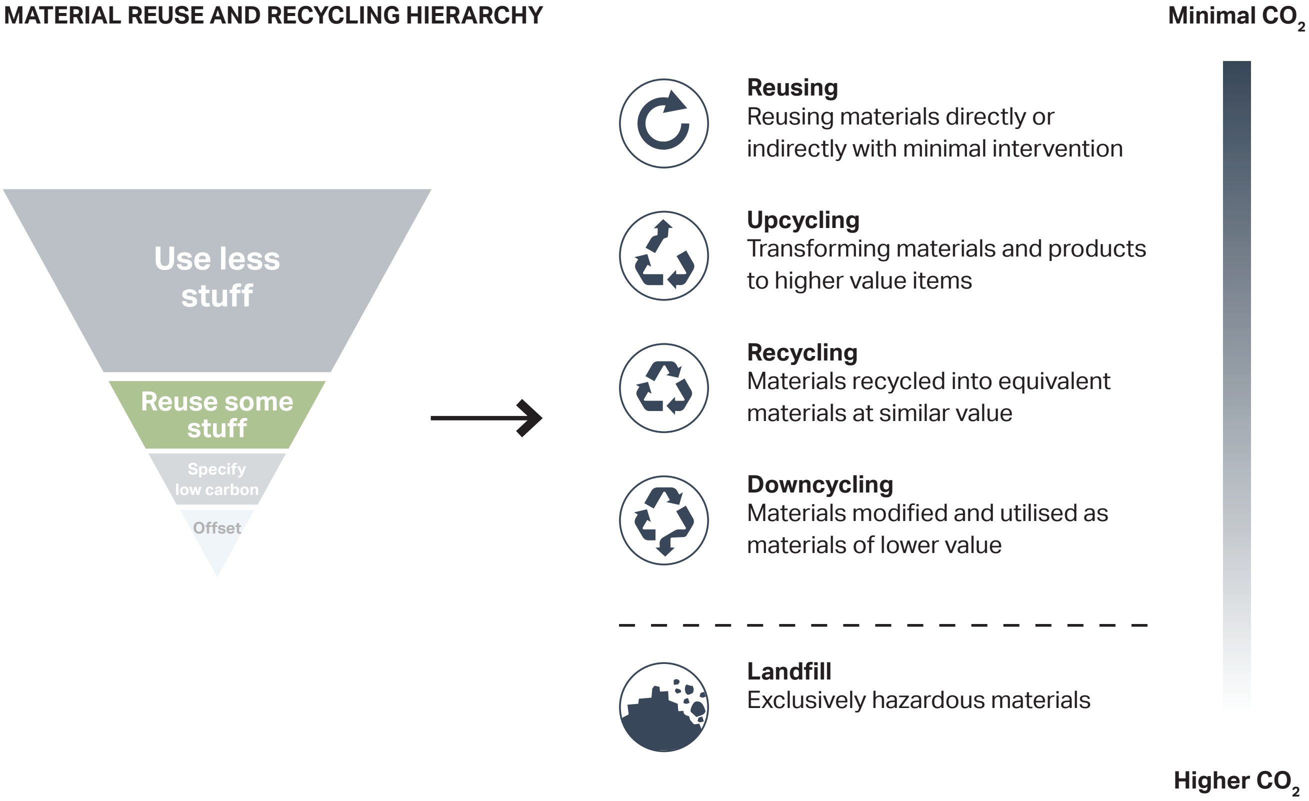


Figure 18.2 Hierarchy for material reuse and recycling

MOST IMPACTFUL MATERIALS FOR REUSE AND RECYCLING

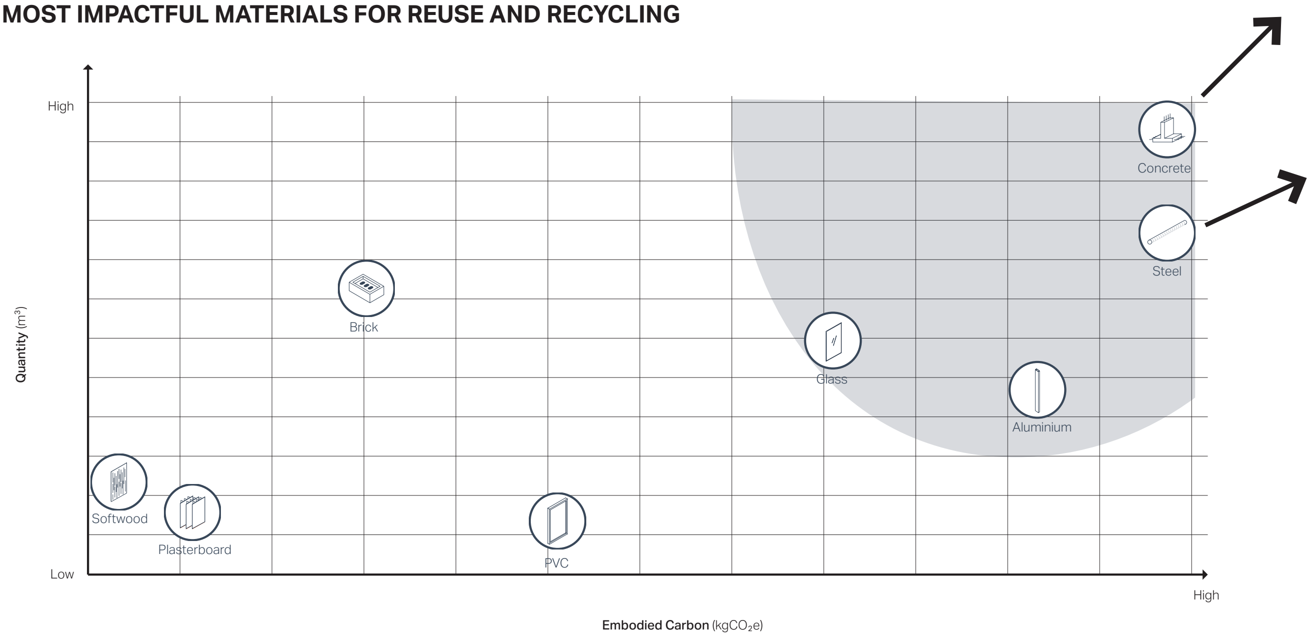


Figure 18.3 Diagram for identifying key material hotspots

18.2.2 Use Less Stuff

For the new build elements, the design approach is to use as little as possible, be that material, energy, or carbon.

For embodied carbon, the strategy is to maximise material efficiency in the first instance. For structures and facades this means designing optimised systems, while for MEP the approach is to reduce material intensity through smart and integrated system selection (e.g. the number of local AHUs is driven by the desire not to have underfloor ductwork distribution).

The focus initially is on design. Following design optimisation, low carbon materials will be selected and specified during procurement. Robust and durable materials will also be selected as appropriate, particularly for finishes in areas susceptible to high traffic.

For energy demand, the building will be developed in line with the energy hierarchy (refer to Volume One Section 3).

- **Be Lean** A fabric first approach will be adopted, utilising passive measures to use less energy. This will be achieved with a high performance facade, limiting solar gains through passive shading and limited glazing areas with low g-values. An on-floor plant strategy may be proposed to maximise controllability and reduce energy waste. High efficiency plant and services, combined with facade performance, will ensure a lean building.
- **Be Clean** No existing local networks. The proposal will be enabled for future connection to heat networks.
- **Be Green** An all-electric building using simultaneous air source heat pumps will be proposed to maximise energy efficiency and reduce carbon emissions in operation. This will have a dual benefit of not harming local air quality. Renewable energy will be maximised where possible (heat pumps in heating and photovoltaic panels). REGO-backed electricity will be procured where possible.
- **Be Seen** Building Management Systems (BMS) will be implemented within the Proposed Development. These systems will oversee and monitor the performance of building systems and services, offering insights into equipment and system efficiency as well as overall energy consumption. The BMS will be enabled to continuously monitor and analyse the actual energy performance post-construction.

As the project is GLA-referable, a WLCA and Circular Economy Statement complete with bill of materials will be produced as part of a full planning application.

HIERARCHY OF NET ZERO CARBON DESIGN

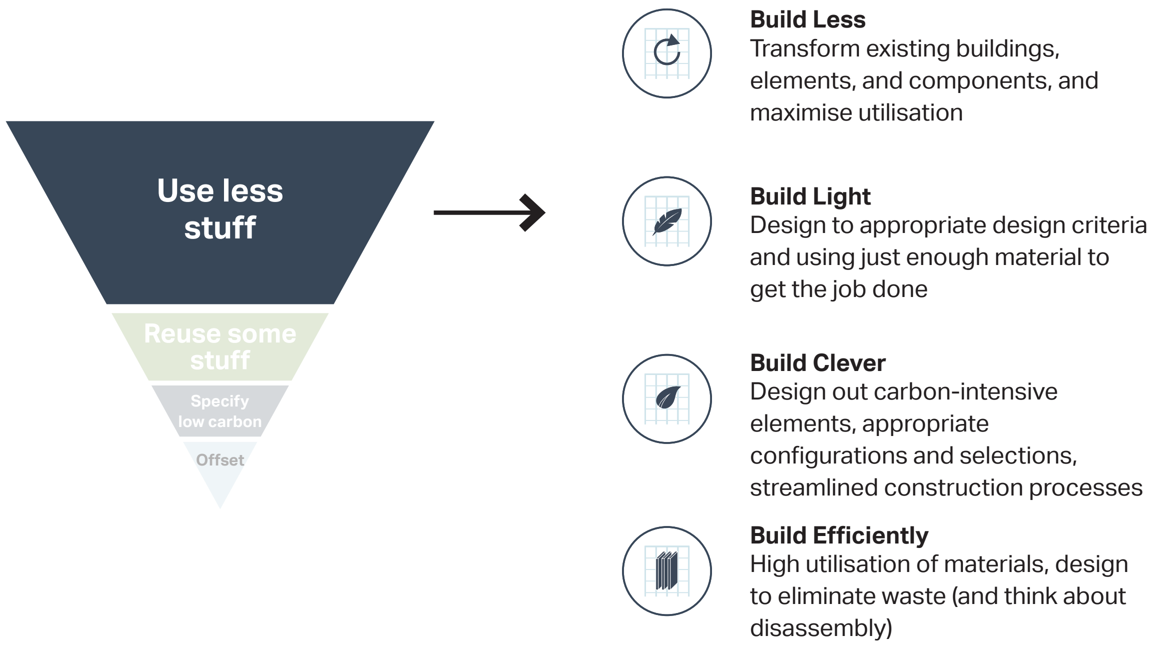


Figure 18.5 Hierarchy for net zero embodied carbon design

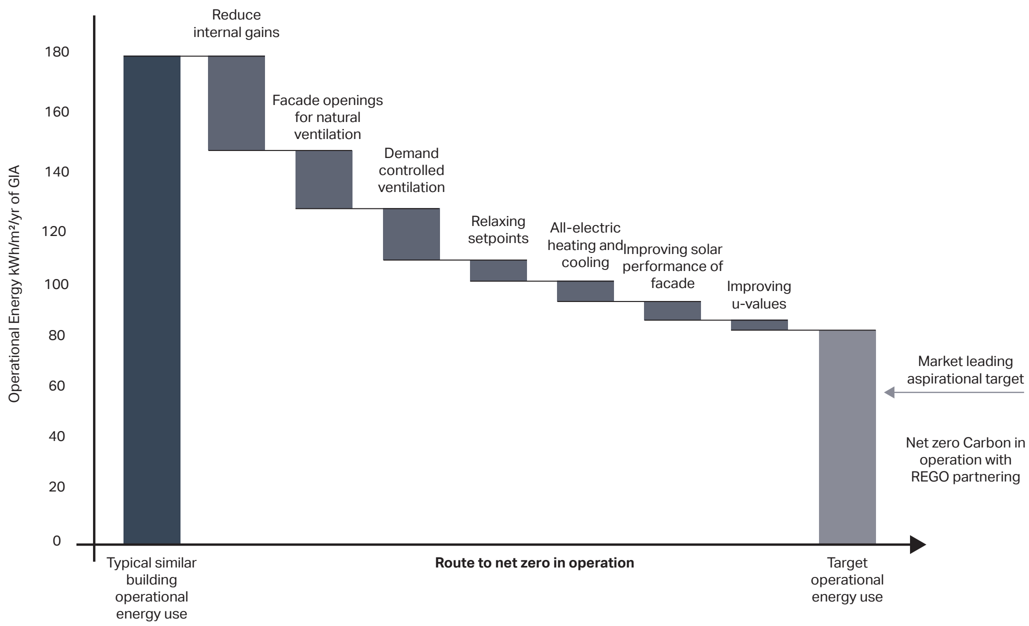


Figure 18.4 Route to net zero carbon in operation

18.3 Construction and Operation Stage

18.3.1 Fossil Fuel-Free Construction Site

During construction, the aim will be to run an best-in-class site, considering all resources used. With Lendlease, it is an ambition to run a fossil fuel-free site, with electric equipment used wherever technically, practically, and feasibly possible. Where this is not the case, alternative fuels will be considered (e.g. HVO provided it is responsibly sourced and palm-oil free).

As detailed in the Pre-demolition Audit in Volume One, waste targets will be in line with the GLA's targets for construction and demolition waste and excavation:

- **CDE** 95% diversion from landfill
- **Excavation** 95% to beneficial use.

A site and operational waste management plan will be submitted as part of a full planning application.

Transportation of materials and waste will be assessed and interrogated as part of the WLCA process, when it comes to procurement. A sustainable procurement plan will be produced in line with the BREEAM requirements, and preference will be given to local sourcing where there is clear benefit to doing so.

As the project is GLA-referable, a post-completion WLCA and Circular Economy Statement complete with bill of materials and end of life routes will be produced, so that actual performance can be tracked.

18.3.2 Best-in-class Metering for NABERS

The aim for the project is to achieve a best-in-class NABERS rating. Because this is based on actual data, this places emphasis on the metering & monitoring strategy during operation. Noting that actual energy demand is contingent on usage and behaviours, the building will be tuned post-completion to optimise its real-world energy performance.

The project will also prototype the British Land Material Passport strategy, collecting and storing data for key materials that facilitates their future reuse or recycling. This will be developed in the later project stages, beyond a planning application.

STANDARD

lendlease

Alternative Fuels

Sustainability

Approver's name and title
Simon Gorski – Managing Director Construction Europe

Last review date:
May 2023

Classification
PUBLIC

Purpose

Lendlease no longer accept liquid and gaseous fossil fuels on any of our construction projects. This is part of our Mission Zero commitment to eliminate all Scope 1 emissions from the fuels we burn, on our journey to achieving Net Zero Carbon by 2025 and Absolute Zero Carbon by 2040. This Standard has been developed to help our Europe business meet the objectives of our Mission Zero Roadmap.

Standard

This Standard applies to liquid and gaseous fossil fuel consumption on all our construction projects, including diesel, petrol, liquid petroleum gas (LPG) and gas to liquid (GTL). Low carbon fuels and energy must be used in their place. These include renewable fuels produced from biomass waste and residue (including HVO), low carbon hydrogen and electric plant and equipment.

For all low carbon fuels used on site, specific evidence must be provided with each delivery, this includes fuel delivery tickets and the associated supply chain traceability documentation when using renewable fuels. This is to confirm the fuel's sustainability credentials. Lendlease accepts renewable fuels from biomass waste and residue except those from palm oil industry related waste feedstocks (such as palm oil mill effluent (POME) and palm fatty acid distillate (PFAD)).

If a construction project must use diesel, petrol, LPG or GTL on-site, a material use justification form must be submitted and approved by a relevant member of Lendlease Construction's Executive Leadership Team (ELT) prior to the specification or use of the fuel. Submission of these to the ELT must come from the Lendlease Project Director.

Contact	Details
Sustainability Europe	SustainabilityEUROPE@lendlease.com

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As at April 2023 | Uncontrolled when printed | Page 1 of 1

Figure 18.6 Lendlease alternative fuels standard

18.4 End of Life Stage

18.4.1 General

Two of the key principles underpinning our approach are design for long life and flexibility/adaptability, and design for disassembly (demountability).

The lack of adequate capacity for flexibility/adaptability and demountability is one of the aspects that makes working with the existing building so challenging.

This approach can be summarised as ensuring "good bones", meaning a building where the core foundational elements are well-designed, high-quality, long-lasting, and flexible.

The approach uses the “Building in Layers” framework. This means each layer is considered with its own life-cycle, and to support reuse and recycling, different building layers are independent, accessible, and removable while maintaining value, where this is technically, practically, and economically feasible.

The "Building in Layers” framework highlights the importance of the structure. The longevity of the other building layers (facade, services, etc.) is predicated on the longevity of the structure. If the structure cannot be easily adapted to changing requirements, the strategies employed for the other building elements are unlikely to mitigate significant waste and avoid premature obsolescence. This does not diminish the importance of the other building layers, but it highlights that ensuring "good bones" must get the structural elements right. Accordingly, this has been a key focus of our approach.

The following sections outline our approach to these principles, with further information is contained within the circular economy strategy as part of the full planning application.

18.4.2 Baseline and pioneering approach

The baseline position in our approach is a steel-framed building with a "soft core", see Section 18.4.3. Steel framing is proposed as a lightweight solution to minimise load on the retained foundations and enable a load-balancing approach. The steel framing is recoverable at end of life, either for reuse or recycling, and is significantly improved over the in-situ concrete frame in the existing tower.

The ambition for our approach is to explore routes for improving the end of life recoverability of the structural floor systems. This is pioneering and not typically business as usual.

Accordingly, two fundamental structural floor systems are considered:

- Baseline composite metal deck floor system
- Pioneering precast concrete plank system.

The precast option, which could enable better recoverability of the decks, is innovative and bespoke, and therefore needs to be studied, developed, and proven. It is our ambition to continue to study this as the design is developed.

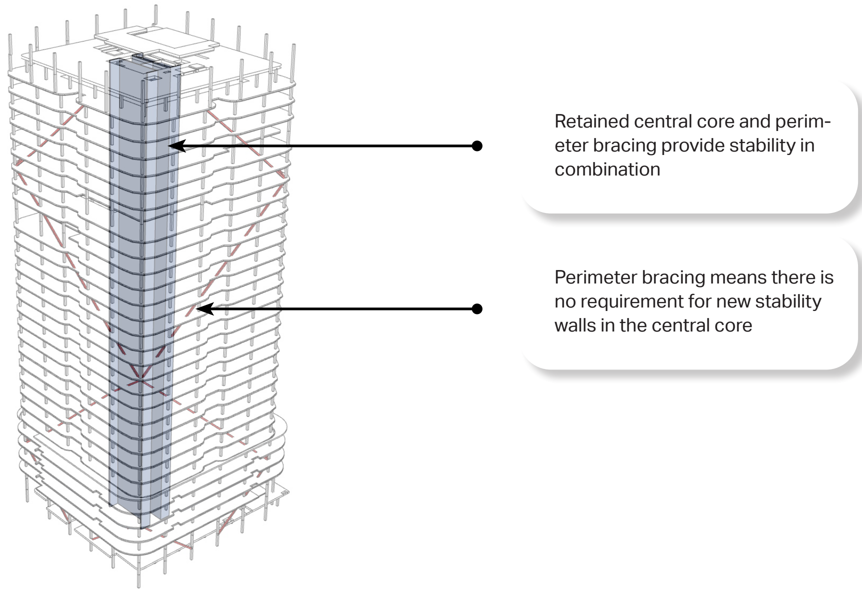
18.4.3 Soft core principle

Adaptability of the structural system is enabled by using a so-called soft core approach.

The overall stability of the structure is derived through the perimeter-braced steel frame and retained central core in combination (maximising use of the existing core’s capacity). This means no new stability walls are required in the central core, and it is therefore free to be adapted as required, which is made easier by it being framed in steel (to minimise self-weight and avoid additional loads on the existing foundations). This is distinct from a typical reinforced concrete stability core, where changes at the core are more challenging to achieve due to their impact on stability.

The principle is shown in Figure 18.7

SOFT CORE PRINCIPLES



Overall stability system

Overall stability is provided by the central core and perimeter bracing in combination. This means there is no requirement for new stability walls in the central core, and the core can be more easily adapted.

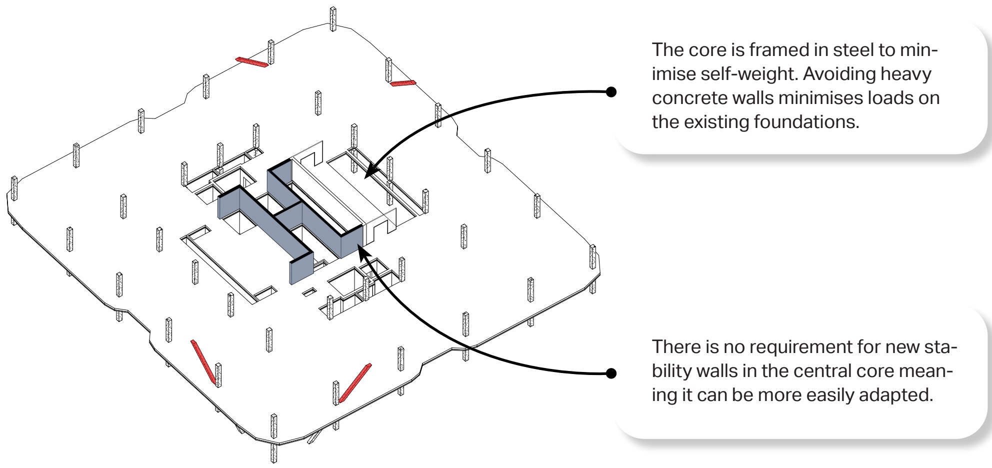


Figure 18.7 Perimeter braced frame enables the soft core approach

18.4.4 Flexibility

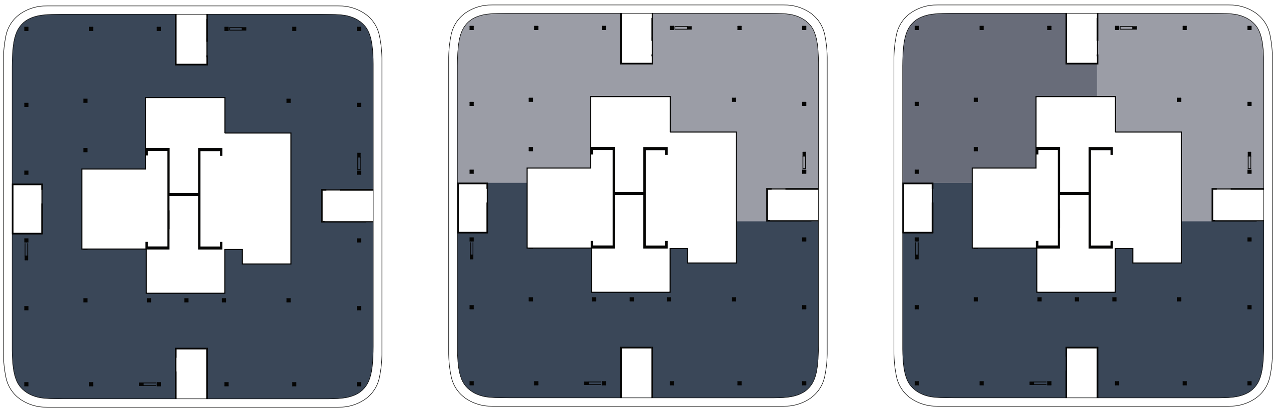
Our understanding of **flexibility** is as per the Greater London Authority's definition: "*A building that has been designed to allow easy rearrangement of its internal fit-out and arrangement to suit the changing needs of occupants*".

Flexibility is likely to accommodate change on a short term time horizon. This means responding to relatively small, and possibly relatively frequent, occupier demands. These changes can occur during leases, or in between leases of different occupiers, such that they may occur several times throughout a building's lifespan, often less than 25 years. These changes should be accommodated in a way that minimises waste, but do not interfere with the overall building operation.

The following measures are proposed to improve flexibility.

BUILDING LAYER	STRATEGY	DESCRIPTION
Structure	Structural grids Soft core	Rational, optimised internal column grid, with regular and clear spans offering flexible layouts. Soft-core principle enables easier flexibility around the core.
Structure	Floor system Soft spots	Composite metal deck floor system is accommodating of local penetrations. Design will include structural soft spots for slab openings, to enable connectivity between multi-floor occupiers for double height spaces and/or other inter-storey connections.
Facade **Space**	Planning grids Potential inclusion of openable vent	Facade and spatial layout is based on a standardised and regular planning grid. This modularity simplifies planning and enhances flexibility in layout design. The 1.5m grid aligns with material dimensions and construction practices. Potential inclusion of openable vents in the facade make it flexible to different occupier demands.
Space	Regular floorplate Multi-tenant layouts	Regular floorplate is suitable for a range of workplace designs. Spatial and core arrangement is designed to enable floors to accommodate multiple tenants across floors, and up to two and three tenants on a single lab-enabled and office floorplate respectively.
Services **Space**	Distribution Climate change allowance	All-air ventilation system with no on-floor ductwork means spatial layouts can be changed without requiring re-configuration of the ventilation system. All power and data distribution is accessible, either exposed at high level on the lab-enabled floors, or within the raised access floor on the office floors. Services designed with an allowance for climate change.

SINGLE AND MULTI-TENANT LAYOUTS



SINGLE TENANT
Allows a single tenant use of the entire floor plate

TWO TENANTS
It is possible to split office levels into two tenancies

THREE TENANTS
It is possible to split office levels into three tenancies

Figure 18.8 Diagram showing indicative multi-tenant layouts

INDICATIVE SOFT SPOT STRATEGY

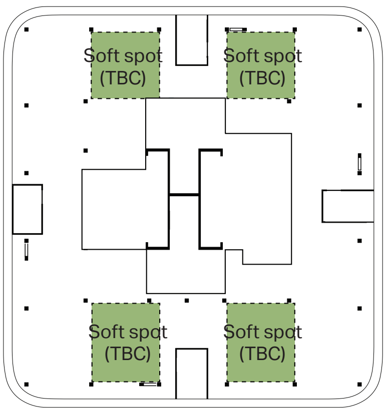


Figure 18.9 Diagram showing indicative soft spot strategy (all locations TBC)

18.4.5 Adaptability

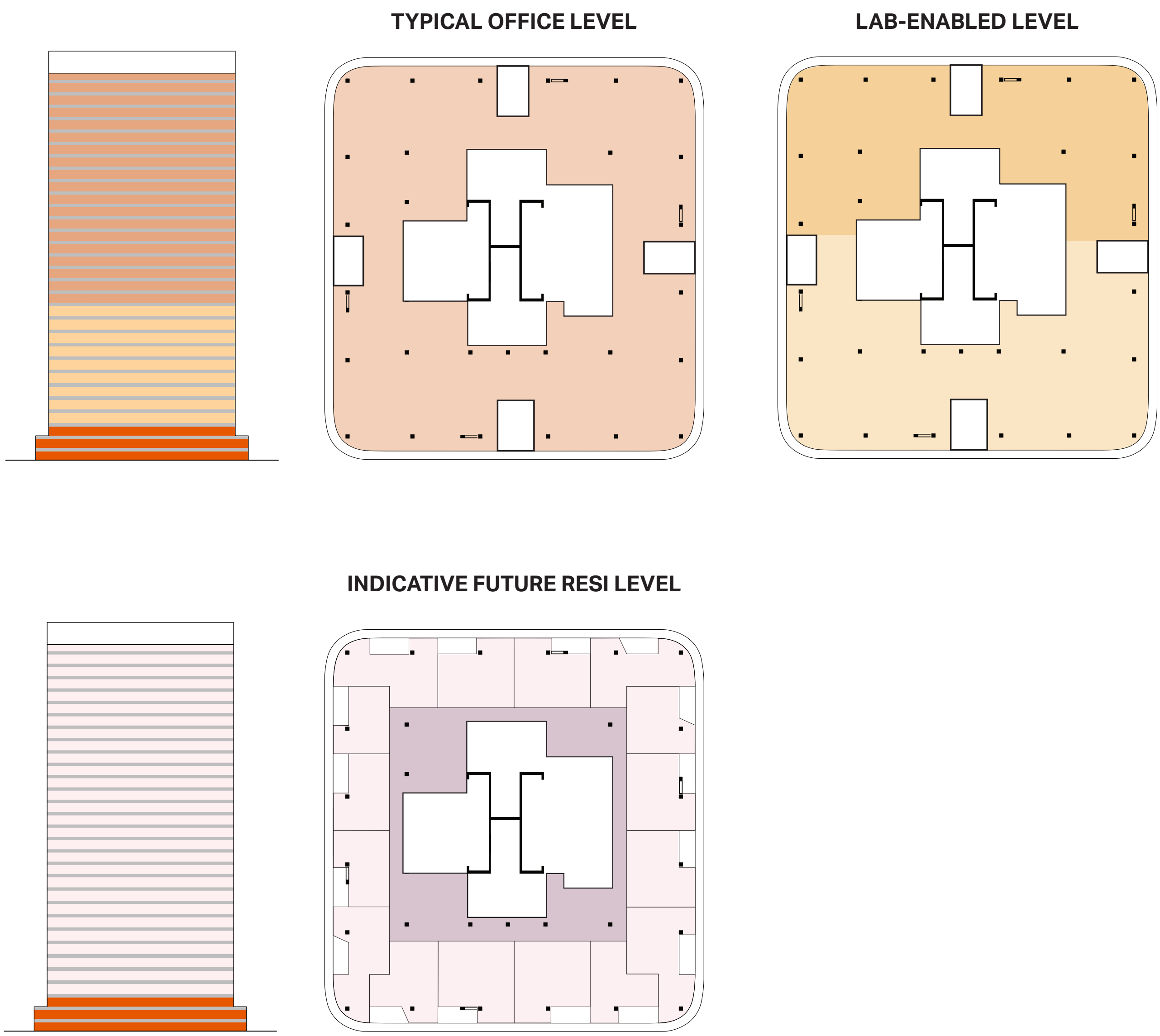
Our understanding of **adaptability** is as per the Greater London Authority's definition: "*a building that has been designed with thought of how it might be easily altered to prolong its life, for instance by alteration, addition, or contraction, to suit new uses or patterns of use*".

Adaptability is likely to accommodate change on a longer term time horizon. This means responding to relatively major, and less frequent, geometric changes. These are unlikely to occur in the short term, possibly only once or twice during a building's lifetime. Accommodating such change is key to preventing premature obsolescence and minimising waste. These types of changes are considered as invasive, and are likely to occur with a period of interference to the overall building operation.

The following measures are proposed to improve adaptability.

BUILDING LAYER	STRATEGY	DESCRIPTION
Structure **Space**	Loading capacity Riser adaptation Floor to floor height Floor system	Structural loading and floor to floor height have sufficient capacity for a range of future alternative uses (e.g. residential). Soft core principle enables adaptations to the core, such as additional lifts, risers, etc., without impacting on the overall structural stability system. Composite metal deck floor system is accommodating of local penetrations. Floor to floor heights are optimised, and proposed with sufficient capacity to accommodate change of use, without having to deconstruct the floors. The full structure would be retained in this change of use scenario.
Facade	Planning grids Glazing ratio Potential inclusion of openable vent Building in layers	Planing grid and regular floorplate make it possible to retain the facade in a residential conversion. Glazing ratio is limited to control heat gain, and where included, the openable vent could be adapted to provide additional ventilation, or similarly via the inset balconies. Should conversion necessitate a different facade (due to material lifespan or performance), the facade is independent of the primary structure and could be removed without impacting the structure. All primary materials are separable and recyclable.
Services	Plant space Services access	Space for central services, and riser allowances, are likely to accommodate that required for residential use. If needed, structural adaptations are less intrusive due to soft core. All services are accessible and removable via BMU/goods lifts.
Services **Space**	Multi-use layouts	The design includes lab-enabled spaces, which is achieved through a structural design that allows for the heightened vibration criteria, and an increased floor to floor height to accommodate required servicing provisions. These floors are flexible and can equally function as standard commercial office, without requiring changes to the facade or services provisions.

ADAPTABILITY FOR CHANGE OF USE



KEY

Lab-enabled space

Write up space

Office

Residential

Access

Podium amenity

Figure 18.10 Diagram showing indicative change of use

18.4.6 Design for disassembly

Our understanding of **design for disassembly** is as per the Greater London Authority's definition: "*designed to allow the building and its components to be taken apart with minimal damage to facilitate reuse or recycling*". The final phrase is important to consider, because it implies the importance of recoverability.

Baseline
As outlined in Section 18.4.2, the proposal comprises a steel-framed structure.

The floor structure will be a lightweight solution infilling the steel frame, see Figure 18.11. The baseline position is a composite metal deck. The composite metal deck solution is suited to in-use adaptation as it is accommodating to incorporating new penetrations. This is particularly relevant at the soft core where new risers or penetrations may be needed in the future. The system is proposed as a baseline as it can best balance embodied carbon, programme, circularity, and is a proven solution.

Not only is a steel-framed structure more adaptable than a concrete-framed structure in-use, unlike a typical in-situ concrete system, the proposed steel frame has an established reuse/recycling end of life pathway. Accordingly, in this baseline scenario, the proposed steel frame would be designed to be disassembled at end of life, such that the steel members could be reused. Any members that are found not to be reusable, would be sent for recycling. The composite metal deck will be separated into its constituent materials and recycled using advanced recycling techniques.

BASELINE STRUCTURAL SYSTEM SKETCH

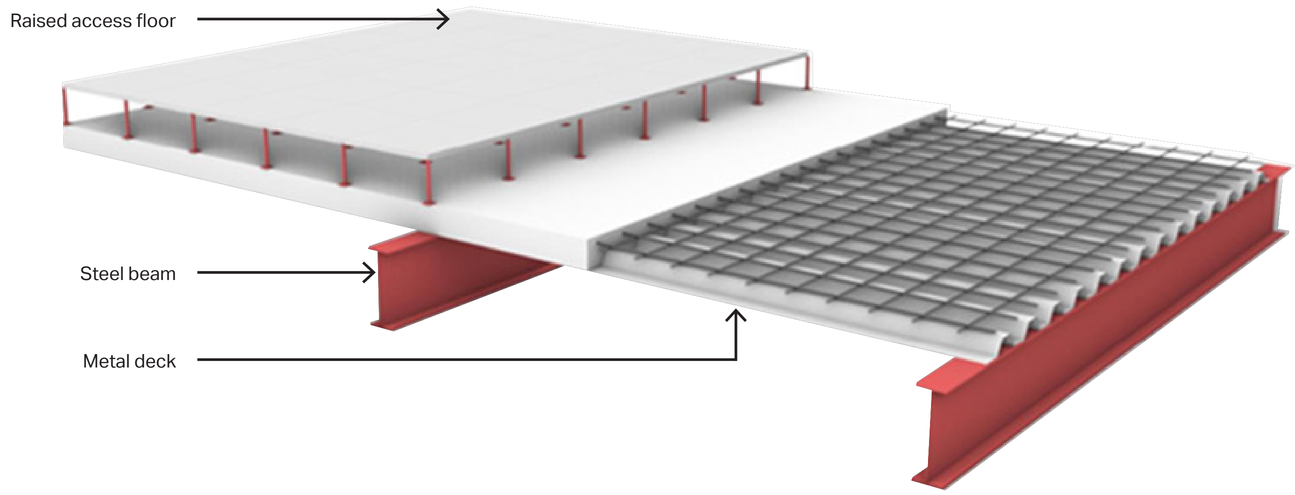
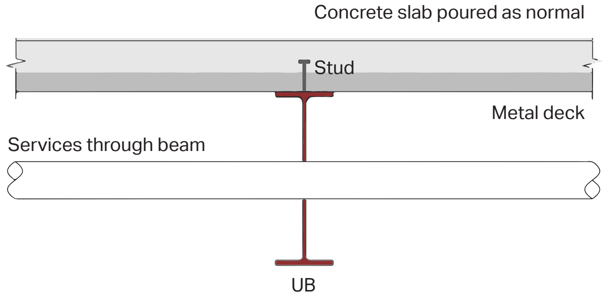


Figure 18.11 Sketch of baseline structural floor system components

FLOOR SYSTEM CONNECTION DETAILS



CONNECTION TO BEAM

A conventional composite metal deck
connected using shear studs

Figure 18.12 Diagram showing conventional (left) and demountable connection to improve recoverability

Pioneering
An alternative floor structure uses precast planks, with the aim of improving the end of life recoverability of the floor systems.

This is a pioneering option, and is being investigated by the project team. It does not represent a commitment to pursuing this route.

In this case, the structural floor system for the new-build portions of the tower would be pre-stressed precast planks, supported on shelf plates and recessed within the beam depth. The planks are grouted together to act as a rigid diaphragm. A sketch of the floor system is shown in Figure 18.13.

Unlike a typical in-situ concrete system, the proposed steel and precast plank structural floor system is constructed using a series of pre-fabricated parts. The intention in the design is to assemble these parts in such a way that facilitates non-destructive disassembly.

The procedure below illustrates indicatively the steps that would be required to disassemble the floor system. Acknowledging that the desire for non-destructive disassembly is in tension with the need to provide a rigid diaphragm action, our ambition is to continue exploring options and ideas that rely on mechanical connections.

1. During constriction, grout would be added between the planks and the beams to provide rigid diaphragm action between the planks. The grout would be broken out, with the intention that it is weak enough to knock off by hand.
2. Each plank contains a steel bar embedded within it and passing through the steel beam for robustness. This is for safety purposes to protect against planks falling should the structural integrity of the primary frame be undermined. The bar would be cut back to facilitate removal.
3. With the grout and steel bar removed, the planks are loose on the shelf angles. They would be lifted out individually, and stored safely for later use.
4. The bare steel frame could be disassembled using any methodology that makes practical sense. If it is to be reused as-is, then the bolts would be unbolted and the beams and columns removed whole. But if it is to be reused in a different application, it may be more practical to cut the connections with an acetylene torch before transporting beams and columns for repurposing.

18.4.7 Risk of Disproportionate Collapse

Euston Tower is a Class 3 building and must conform to appropriate robustness requirements to guard against disproportionate collapse. In all scenarios, effective horizontal and vertical ties will be provided though structural elements as required. A systematic risk assessment of the building will be completed, and the critical situations identified will be designed against. Special care will be taken to ensure that both the reuse of structural elements, and any design to promote ease of deconstruction, will be compatible with these requirements. Note that the floorplates are designed to resist appreciable diaphragm forces arising from lateral loading under wind and as such are inherently resilient.

PIONEERING STRUCTURAL SYSTEM SKETCH

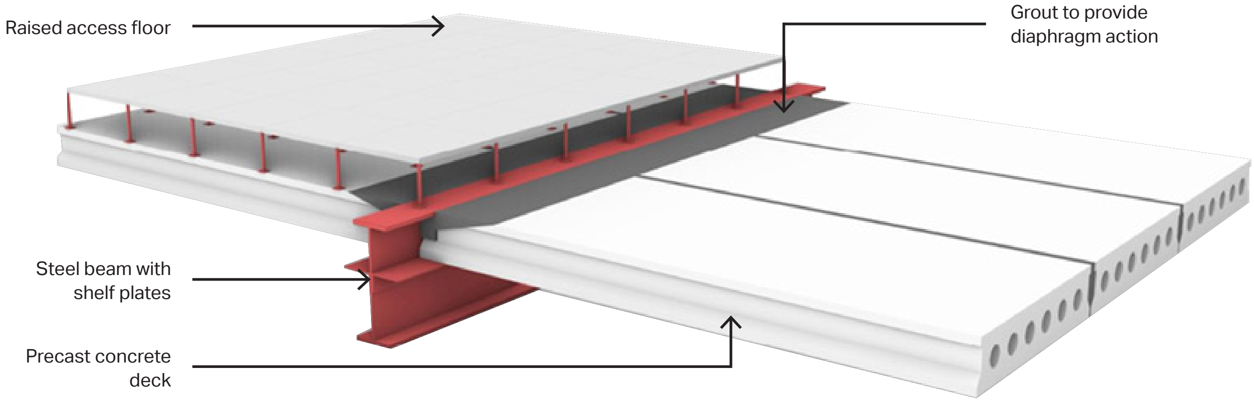
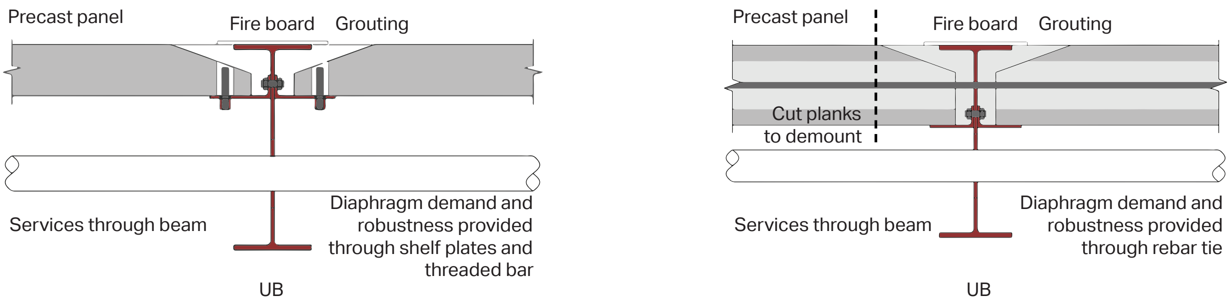


Figure 18.13 Sketch of pioneering structural floor system components

FLOOR SYSTEM CONNECTION DETAILS



IDEAL CONNECTION

Precast planks are wholly recoverable at original size

ALTERNATIVE CONNECTION

Precast planks are recoverable but would need to be cut and therefore shortened during deconstruction

Figure 18.14 Diagram showing ideal (left) and alternative connections

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Euston Tower

Conclusion

19.1 Conclusion

Sections 17 and 18 have presented approaches to retention of the existing building as part of its redevelopment. They have been assessed systemically and transparently, in respect of architectural, technical, end of life, and carbon considerations. Within these assessments, the following possible options have been studied for a building that retains varying degrees of the existing structure:

- **Major Refurbishment**
  Shown in Volume One not to be feasible.
- **Retention and Partial Extension**
  Max Retention
- **Retention and Extension**
  "Full" Retention
- **Partial Retention and Extension (Disassemble and Reuse)**
  Retain Connective Slabs (Office)
  Retain Connective Slabs (Office and Lab)
  Retain Interstitial Slabs (Office) / (Office and Lab)
  Retain the Core
- **New Build**
  New Build.

Volume One of this Feasibility Study showed that it is not feasible to upgrade the existing building to modern standards within the existing envelope. The resulting space would be compromised and unattractive from a letting perspective, primarily due to its disconnected floor layouts, and low floor to ceiling heights that are not commensurate with the type of space the letting market demands for a building of this scale.

Daylighting levels have been established for a floorplate within the existing envelope and at the existing floor to floor height. By comparison to floorplates not within the existing envelope, it was shown that the areas of well-daylit space reduce materially when the floorplate is extended outwards, even by a small amount. This reduction in well-daylit space is however mitigated with an increased floor to floor height, with the benefit that the absolute area of well-daylit space exceeds that for the floorplate within the existing envelope and at the existing floor to floor height. This provision of a high amount of well daylit space is necessary to create the high quality spaces that are attractive to the large tenants, who are essential to a successful letting strategy for a building of this scale, and to deliver on the environment the Knowledge Quarter is seeking to foster.

In order to provide reasonable on-floor efficiencies, the vertical transportation strategy makes use of double-decker lifts. This presents a compromised position for the use of options which retain existing slabs, while resolving the floor to floor height issues previously described, because the vertical transportation strategy is contingent on having consistent inter-storey heights to avoid prohibitive efficiencies by using single-decker lifts. In addition, there is an unacceptable procurement risk to the development by procuring twin lifts due to their being only a single supplier.

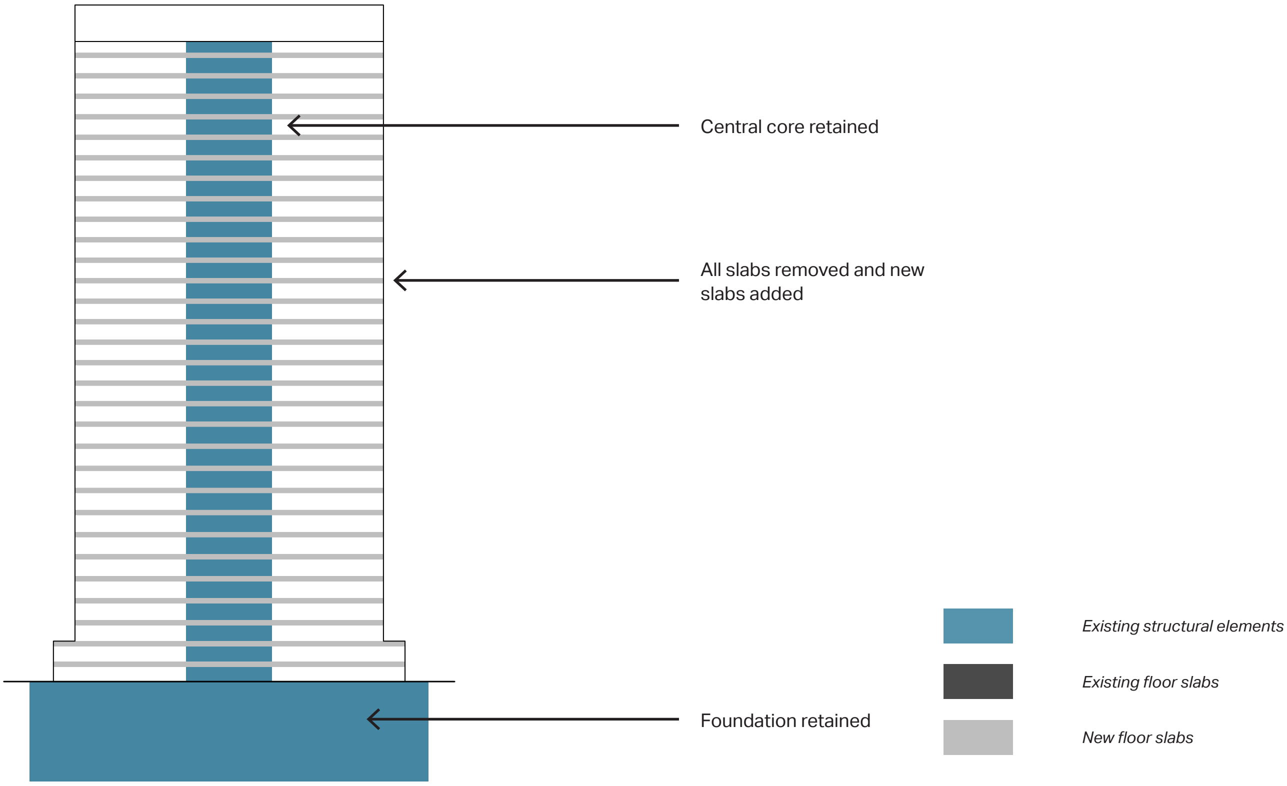
Whole life-cycle carbon assessments (WLCAs) have been conducted for selected options with varying degrees of retention. With respect to total tonnage and intensity of carbon emissions, the Retain the Core option presents the lowest whole life-cycle carbon position when compared with the other options that resolve the floor to floor height issues previously described (Retain Interstitial Slabs and New Build). This is in spite of the Retain the Core Option retaining 31% (by volume) of the existing structure compared to 42% (by volume) for the Retain Interstitial Slabs option.

The Retain the Core and New Build options are relatively similar when considering both total tonnage and intensity of carbon emissions. This is primarily because the majority of the carbon emissions are in the above ground works, where the two options are materially similar, and while the New Build option includes a new basement and central core, the additional carbon associated with constructions is identified to be offset in whole life-cycle terms by its slightly improved operational performance (by comparison to the Retain the Core option).

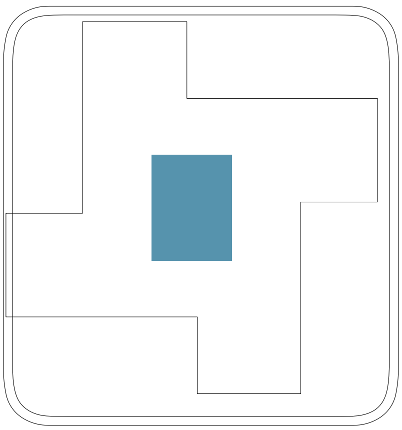
It is acknowledged that the position is prima facie finely balanced from a letting perspective and also in whole life-cycle carbon terms. Both options address the issues around daylighting, floor to floor height and quality of space in a way that can be delivered practically and efficiently. They also do so while offering flexible floorplates with clear spans, unconstrained by the existing building grid, and a floor system that could be adapted over time and disassembled easily at its eventual end of life.

On balance, the Retain the Core option is identified to be preferable. This is because it offers the best balance of structural retention, quality, flexibility, and adaptability. And it does so with a whole life-cycle carbon position that is the lowest of the options that deliver the quality of space which is necessary for the redevelopment of Euston Tower to be successful.

RETAIN THE CORE



ALL LEVELS
Central core retained, floorplates removed



INDICATIVE CORE LAYOUT
Expanded Central Core

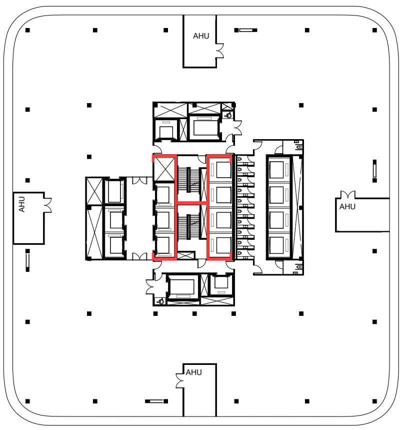


Figure 19.1 Diagram showing retained structural elements and possible core layout in the proposed option

A

Euston Tower

Appendices

Appendices

List of Appendices

A Floorplate Layout

In developing the floorplate and core layouts, the starting point was to retain as much as possible of the existing slab.

The amount of the existing slab which could be retained is linked to the location of additional core elements which, as shown in Feasibility Volume One and Section 15, require voids to be punched through the existing slab. The existing slab consists of the structural ring beam, ribbed slab zones, and flat slab zones. Because the ribbed slabs span in a single direction, when additional voids are introduced there can be larger amounts of existing slab removed than just the void itself. Therefore multiple options for core layout were considered.

The following options are studied:

- Retain Everything Existing (Dispersed Core)
- Retain Everything Existing and Remove Central Core
- Retain Central Core with New North Core
- Retain Central Core with Centralised North Core
- Retain Central Core and Two Satellite Cores
- Retain And Expand Central Core.

All options are assessed using the same, typical extended floorplate, and uses a decentralised ventilation system as the basis for proposals. The extent of this floorplate is intended to be indicative of one plausible extension only, and it does not presuppose the outcome of any developments around massing.

Ultimately the conclusions are not sensitive to the shape or absolute dimensions of the extended floorplate. This to say that the outcome of this assessment would be the same regardless of the shape of the extension.

A.1 Retain Everything Existing (Dispersed Core)

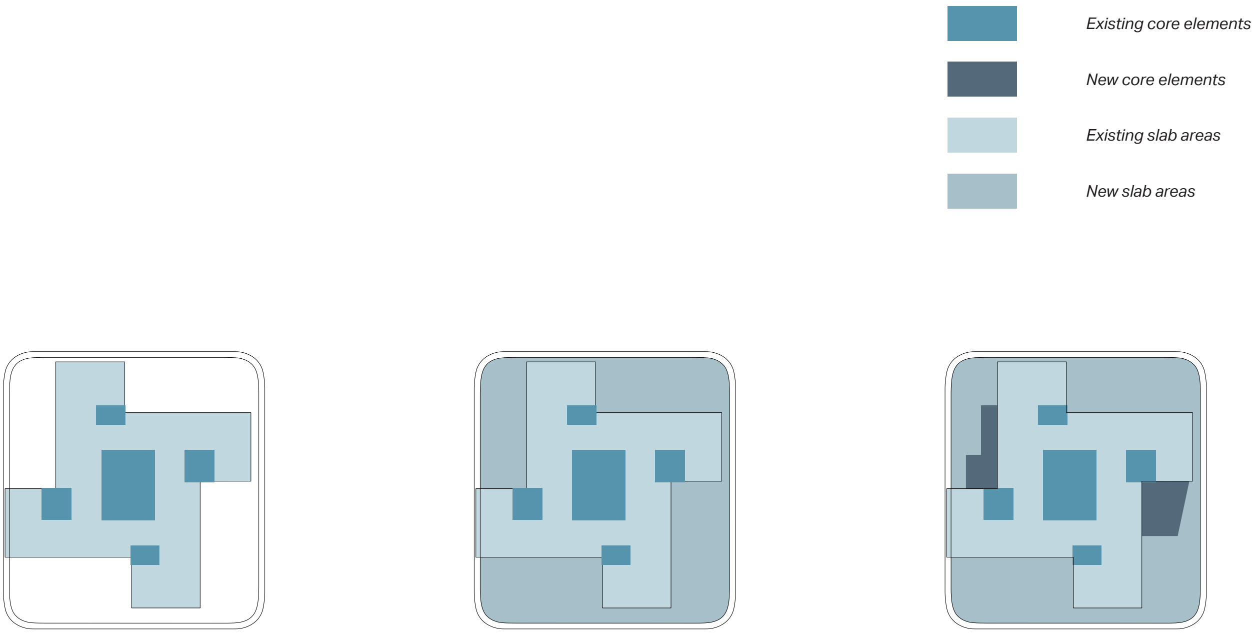
This is the option that aims to retain as much as possible of the existing slab, while delivering the upgrades required by Building Regulations, and an extended floorplate. The resulting floorplate is shown in Figure A.1, where retained structural elements are indicated in red.

To achieve this, the central core and satellite core structures would be retained, along with all relevant columns. All new core elements would be designed to be outside the footprint of the existing floorplate, meaning no new penetrations would be required in the existing slabs. The east and west satellite cores would remain as escape cores complete with fire-fighting lifts. Evacuation lifts and additional passenger lifts to these cores would be appended outside of the existing footprint. For the north and south satellite cores, the existing stairs would be removed and the cores would become riser shafts (the other two existing stairs are sufficient for escape).

While this would result in potentially maximised slab retention, the core would essentially be elongated to the width of the floorplate and dispersed. The resulting floorplate would be disconnected, especially the area that is sandwiched between the central core and the new western core elements. Flexibility would be inhibited by retaining the north and south satellite cores, and the pinch points at the double column arrangements which are needed because the columns supporting the existing slab must be maintained in their original locations.

Floorplate retention would be very near to 100%, retaining on average 149 tCO_2e per storey.

This core layout would be inhibiting to connectivity and flexibility for a contemporary office.



Existing central core, all satellite cores and existing slab are retained

Floor plate is extended with pinwheel fully maintained

All new core area is added in areas of extended floorplate, no core penetrations required in existing

Figure A.2 Diagram showing elements that are retained in this option and the position of new core elements

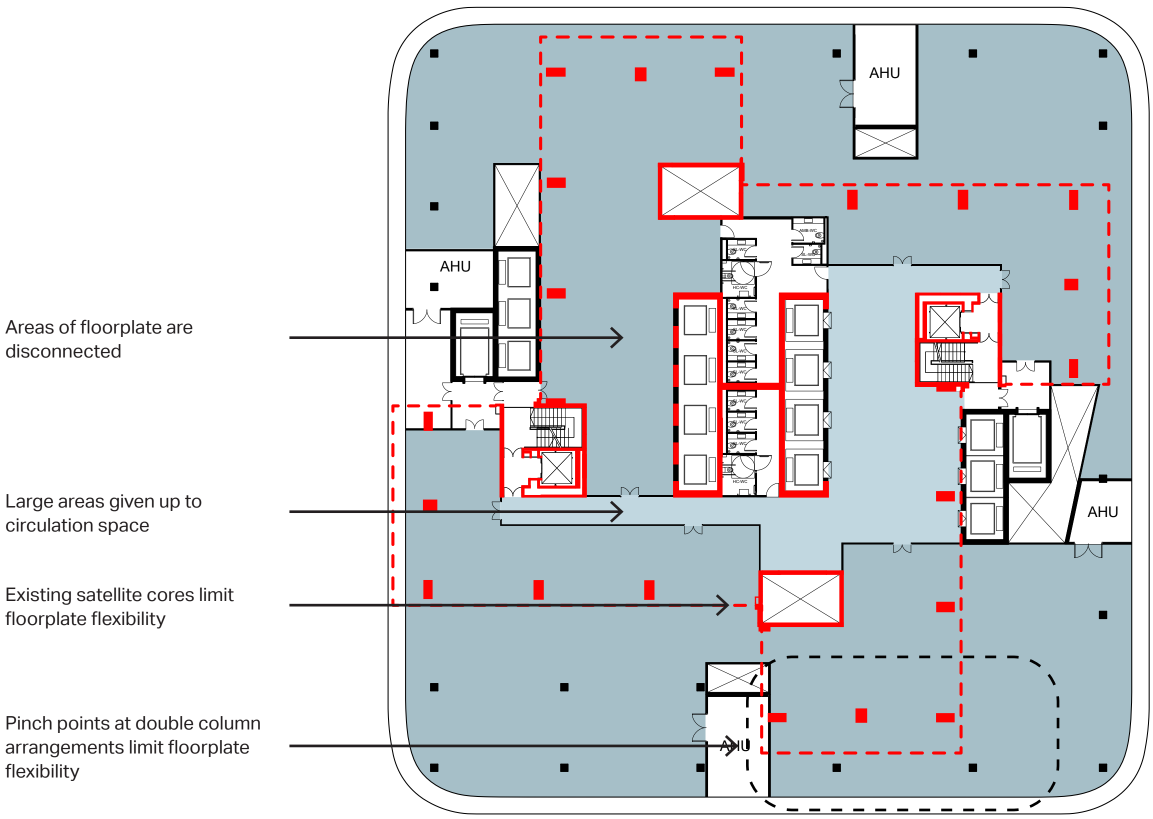


Figure A.1 Indicative floorplate and core layout with all new core elements outside of the existing slab footprint

A.2 Retain Everything Existing and Remove Central Core

One way to improve the connectivity of this floorplate would be to relieve the pressure on the central core area. In this case total removal of the existing central core was considered, with all new core elements incorporated outside the footprint of the existing floorplate. The void left over from removal of the central core would be filled in and become a part of the usable floorplate.

This move appears to be a natural progression from the limitations of the layout in Section A.1.

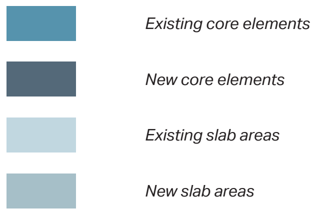
While this may be attractive diagrammatically (see Figure A.4), there are a number of practical and programmatic hurdles that preclude this option being considered further.

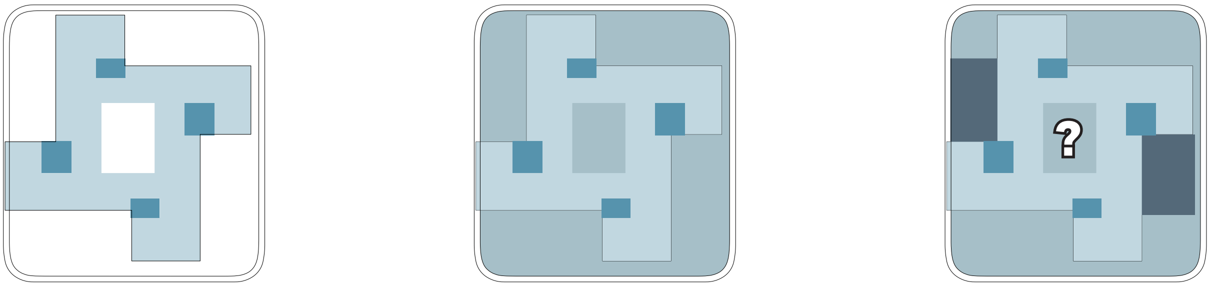
From a structural perspective, the key is to maintain stability of the primary structure before the existing central core (which currently provides said stability) could be removed. Practically this means building a full new stability structure (either temporary or permanent) ahead of removing the existing core.

From a construction sequencing perspective, there are two ways that this could be achieved. One way would be to construct a full temporary works bracing around the outside of the existing building. Another way would be to construct and install the permanent perimeter bracing system that is proposed for the extended floorplates. In this case new floor slabs would need to be installed at the perimeter bracing system's nodes to enable the diaphragm action that is required for lateral stability. This is all before the central core could be removed.

With a new stability in place, columns would be added around the core, and the slabs would be temporarily propped on every level to support slab edges. The core walls would be cut out and removed, noting that the practical aspects of removal would be contingent on the temporary stability strategy chosen. Finally the resulting void would be in-filled with new floor slab.

This core layout would ultimately not be viable when considering the practical and programmatic implications.





All satellite cores and existing slab are retained, existing central core removed

Floor plate is extended with pinwheel fully maintained, central core area is filled in

All new core area is added in areas of extended floorplate, no core penetrations required in existing

Figure A.3 Diagram showing elements that are retained in this option and the position of new core elements

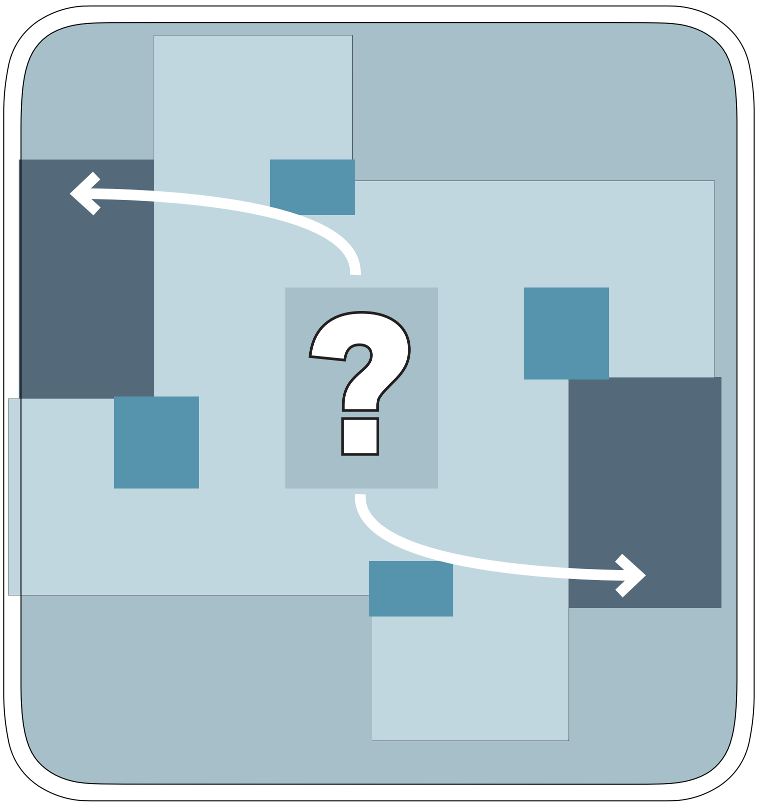


Figure A.4 Diagram showing concept intent for removing central core

A.3 Retain Central Core with New North Core

Another way to improve the connectivity of the floorplate from Section A.1 would be to consolidate all the new core elements in a single area. Doing so effectively relies on removing the existing satellite cores, but all other structure (vertical and horizontal) would remain.

To achieve this, the central core structure would be retained, along with all relevant columns. All new core elements would be designed to land outside the footprint of the existing floorplate, meaning no new penetrations would be required in the existing slabs. The voids left by the removed satellite cores would be in-filled and form part of the open floorplate.

Fire fighting lifts, escape stairs, and evacuation lifts would be consolidated within the footprint of the existing central core. The new passenger lifts, both low-rise and high-rise, along with new risers, would be provided in the north-east corner of the floorplate. These penetrations would be designed to fall only in areas of the new extended floorplate.

This corner of the floorplate is chosen because it minimises the impact on natural daylight and sunlight, and faces directly onto neighbouring buildings. All other elevations have uninterrupted views, and the western elevations interact with Regent's Place Plaza.

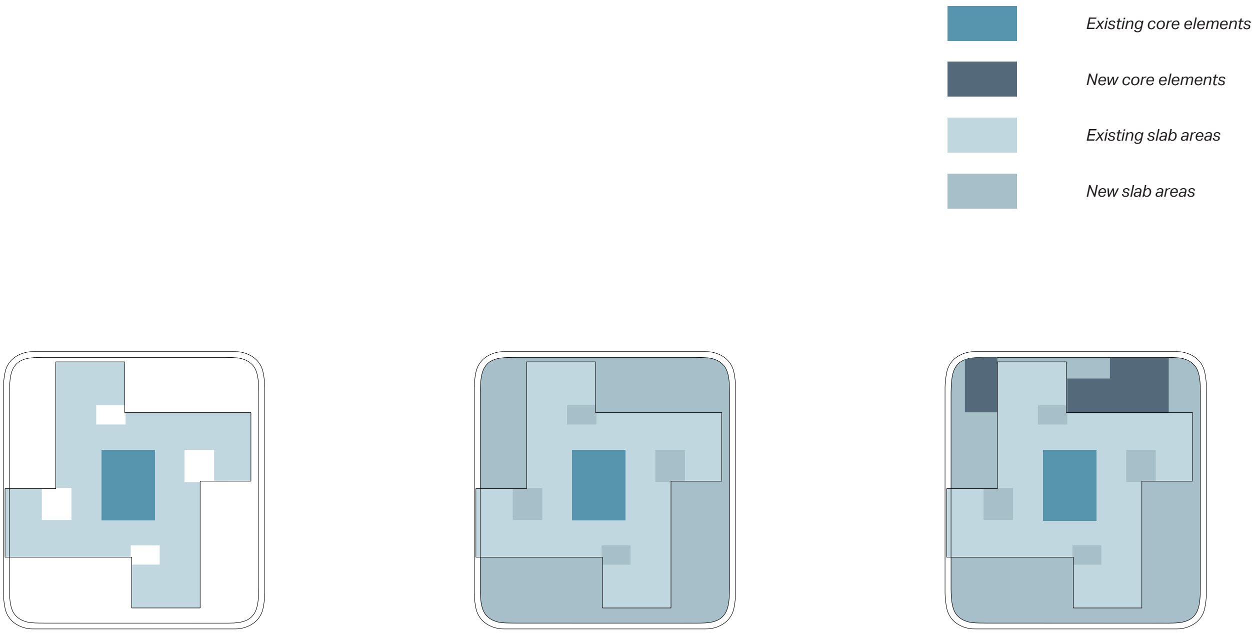
The resulting floorplate would have slightly reduced structural retention compared with the maximum retention option in Section A.1, but improved connectivity enabled by removing the satellite cores and consolidating the new core elements. However, having both an offset core and central core results in a disconnected floorplate, and the inability to split the floorplate for more than two tenancies. With the passenger lifts all at one end of the floorplate, the lease span in some areas would be as much as 40m, significantly larger than a typical 12-15m. Flexibility would still be somewhat inhibited by the pinch points at the double column arrangements which are needed because the columns supporting the existing slab must be maintained in their original locations.

The north core lift location would limit the floorplate to a maximum of two tenancies, and the MEP distribution strategy would be compromised by having to cross through tenant areas.

Floorplate retention would be 97%, retaining on average 144 tCO_2e per storey (of 149 tCO_2e per storey).

While this core arrangement looks plausible on a single plan, it would be challenging (but not impossible to resolve) with inclined or stepped elevations, used to reduce the massing of the tower in longer views.

This core layout would be inhibiting to connectivity and flexibility for a contemporary office.



Existing central core and existing slab are retained. Satellite cores removed

Floorplate is extended with pinwheel fully maintained. Satellite core areas are filled in

All new core area is added in areas of extended floorplate, no core penetrations required in existing

Figure A.6 Diagram showing elements that are retained in this option and the position of new core elements

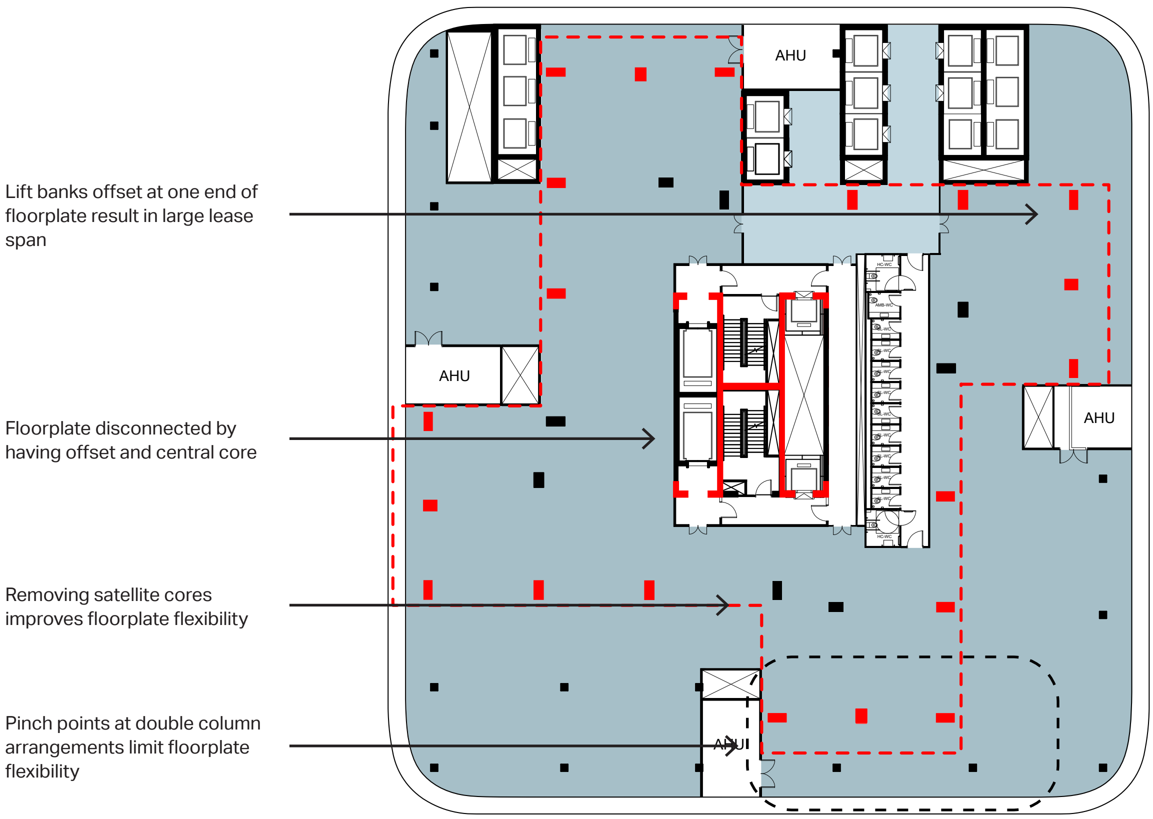


Figure A.5 Indicative floorplate and core layout with all new core elements outside of the existing slab footprint

A.4 Retain Central Core with Centralised North Core

The floorplate layout could be improved by centralising the new north core. See Figure A.7.

To achieve this, the central core structure would be retained, along with all relevant columns. Instead of all new core elements landing outside of the existing floorplate as in the preceding options, here the north arm of the pinwheel would be removed, along with the relevant sections of the perimeter ring beam, to accommodate the new core elements.

Fire fighting lifts, escape stairs, and evacuation lifts would be consolidated within the footprint of the existing central core. The new passenger lifts, both low-rise and high-rise, along with new risers, would be provided along the north edge of the floorplate.

The existing satellite cores would be removed and the resulting voids in-filled to form part of the open floorplate.

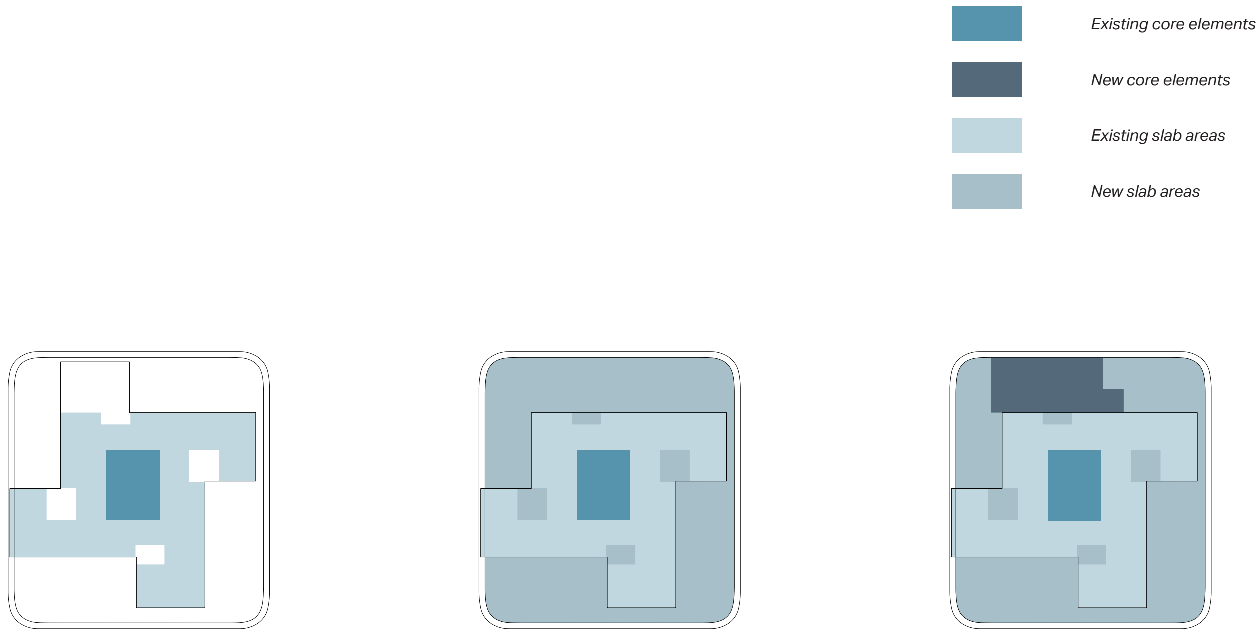
The resulting floorplate would be fundamentally similar to the one shown in Section A.3, but with further reduced structural retention owing to removal of the north pinwheel arm. Connectivity would be slightly improved by centralising the north core, by having more circulation central to the floorplate. But the large lease span, and disconnect by having both offset and central cores, would not be improved. Flexibility would still be inhibited by the pinch points at the double column arrangements which are needed because the columns supporting the existing slab must be maintained in their original locations.

The north core lift location would limit the floorplate to a maximum of two tenancies, and the MEP distribution strategy would be compromised by having to cross through tenant areas.

Floorplate retention would be 86%, retaining on average 128 tCO_2e per storey (of 149 tCO_2e per storey).

As in Section A.3, this core arrangement looks plausible on a single plan, but it would be challenging with inclined or stepped elevations, used to reduce the massing of the tower in longer views.

This core layout would be inhibiting to connectivity and flexibility for a contemporary office.



Existing central core and most existing slab are retained. Satellite cores and north arm removed

Floorplate is extended with remaining pinwheel fully maintained. Satellite core areas are filled in

New core area is added in area where north arm was removed. No core penetrations required in existing

Figure A.8 Diagram showing elements that are retained in this option and the position of new core elements

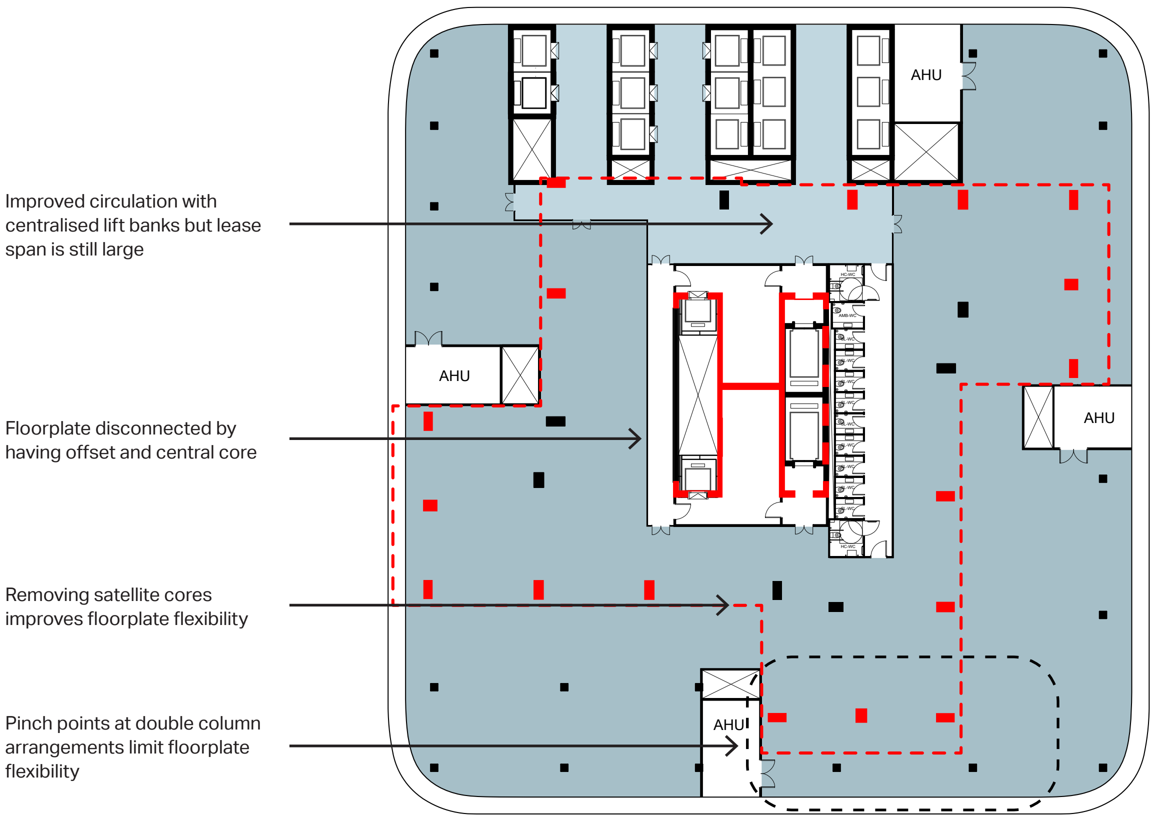


Figure A.7 Indicative floorplan and core layout with all new core elements consolidated where the north pinwheel arm has been removed

A.5 Retain Central Core and Two Satellite Cores

In each of the preceding options, by aiming to retain as much of the structure as possible, the floor layout would result in a split core arrangement. The analysis shows that, to varying degrees, such an arrangement would be detrimental to floorplate connectivity.

It is therefore clear that a single, central core arrangement would be preferable.

The layout in Figure A.9 shows one such arrangement, the key difference from the previous options being that in this case new core elements would be added within the footprint of the existing floor slab.

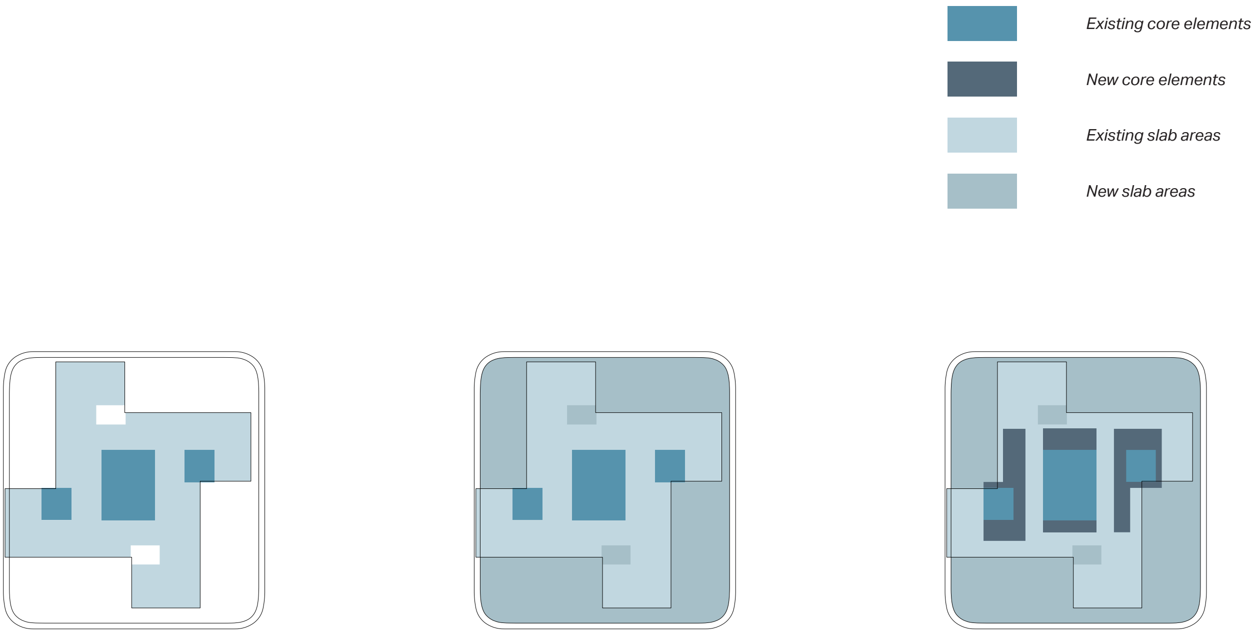
To achieve this, the central core and the east and west satellite core structures would be retained, along with all relevant columns. The east and west satellite cores would remain as escape cores complete with fire-fighting lifts. Evacuation lifts, additional passenger lifts, and new risers would be appended to these cores. The north and south satellite cores would be removed entirely to improve connectivity, and the resulting voids in-filled to form part of the floorplate.

As shown in Feasibility Volume One, introducing new penetrations in the existing floor slabs results in larger holes than required, and the positions of these penetrations are limited by coordination with the existing structure (avoiding perimeter ring beam and pile caps). It was subsequently shown that this layout is incompatible with retaining the full foundation, as certain lift pits would clash with the existing pile cap.

Notwithstanding these limitations, the resulting floorplate with its central core would offer good connectivity and reasonable lease spans. Flexibility would be inhibited by the pinch points at the double column arrangements which are needed because the columns supporting the existing slab must be maintained in their original locations. This could be mitigated by looking at options for the extent of floor slab retained.

Floorplate retention would be 75%, retaining on average 111 tCO_2e per storey (of 149 tCO_2e per storey).

While this core would result in relatively low structural retention, it would still retain the central core, two of the four satellite cores, and a large portion of the existing floorplate. At the same time it would present improved connectivity and efficiency.



Existing central core, east and west satellite cores, and existing slab are retained

Floorplate is extended with pinwheel fully maintained. North and south satellite core areas and filled in

Cores expanded with new core area. Significant penetrations required in existing slabs

Figure A.10   Diagram showing elements that are retained in this option and the position of new core elements

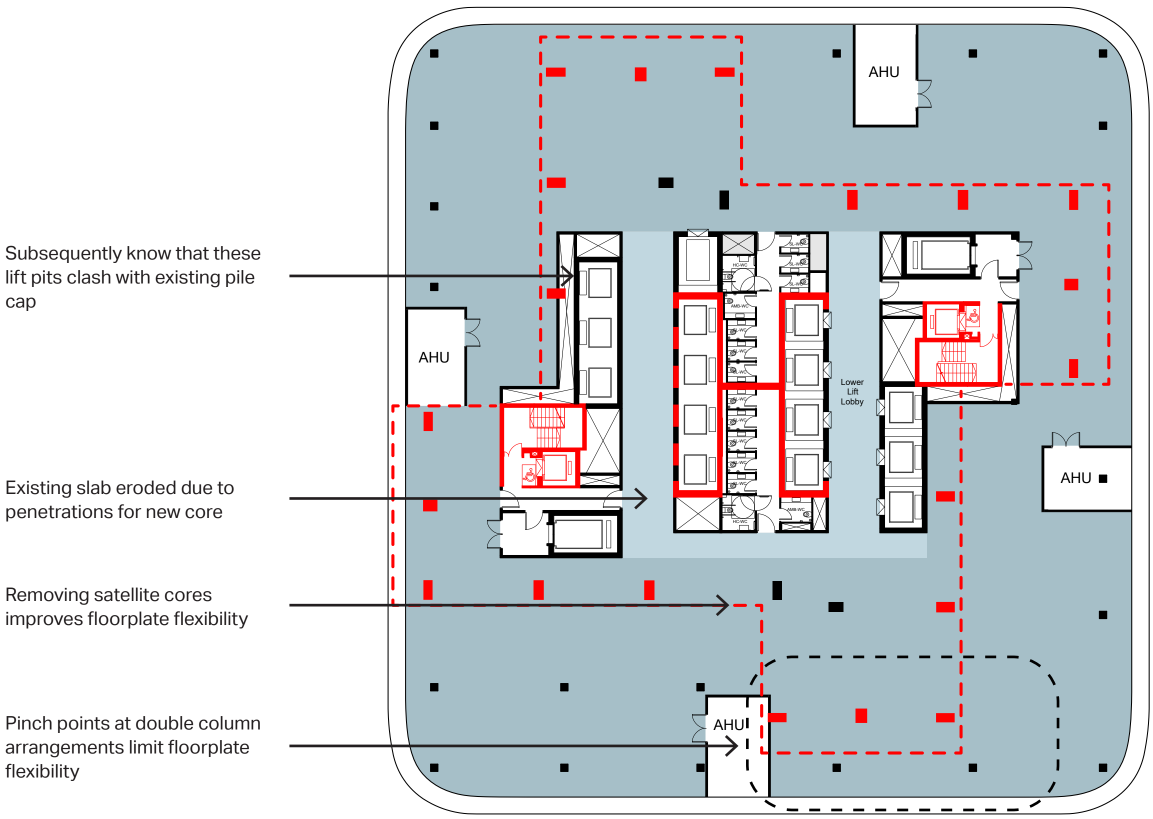


Figure A.9   Indicative floorplate and core layout with all new core elements located around the existing central core and satellite cores in the existing floor slab

A.6 Retain and Expand Central Core

Another option for a single, central core arrangement is the core layout shown in Figure A.11. Like the option in Section A.5, in this case new core elements would be added within the footprint of the existing floor slab.

To achieve this, the central core would be retained along with all relevant columns. Escape stairs would be located within the central area of the retained core, while fire-fighting lifts, evacuation lifts, additional passenger lifts and the like would be added in the areas around the retained central core.

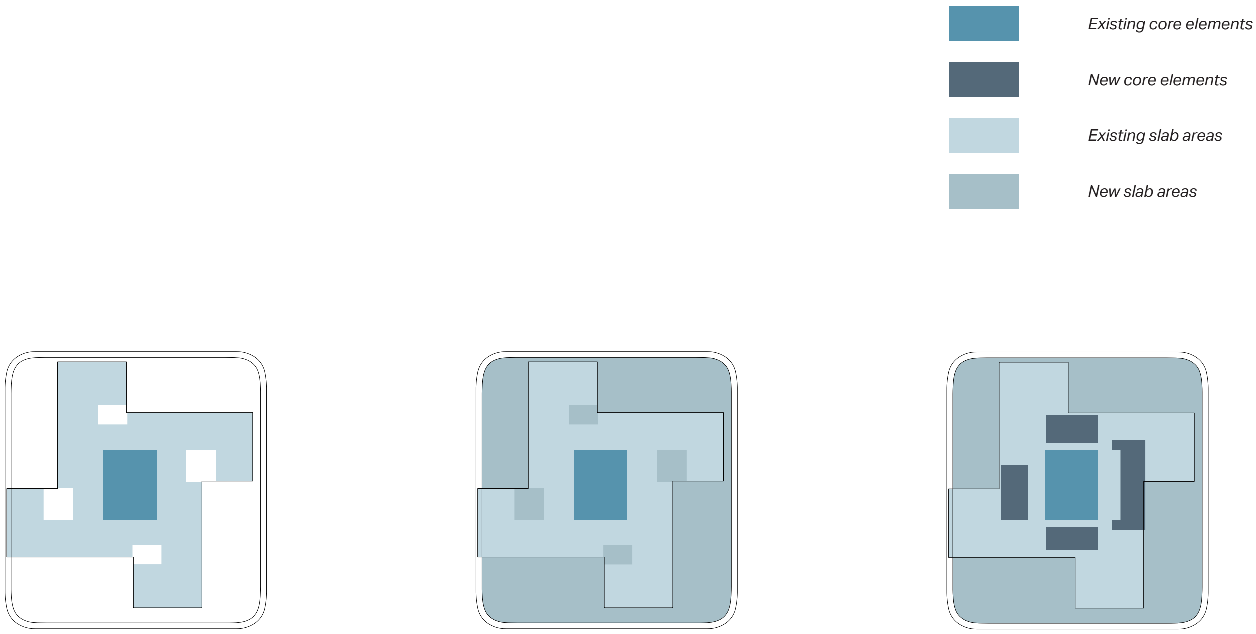
All four satellite cores would be removed entirely to improve connectivity, and the resulting voids in-filled to form part of the floorplate.

As shown in Feasibility Volume One, introducing new penetrations in the existing floor slabs results in larger holes than required (due to over-removal of the ribbed slabs), and the positions of these penetrations are limited by coordination with the existing structure (avoiding perimeter ring beam and pile caps).

Notwithstanding these limitations, the resulting floorplate with its central core would offer good connectivity and reasonable lease spans. Flexibility would be somewhat inhibited by the pinch points at the double column arrangements which are needed because the columns supporting the existing slab must be maintained in their original locations. This could be mitigated by looking at options for the extent of floor slab retained.

Floorplate retention would be 79%, retaining on average 117 tCO_2e per storey (of 149 tCO_2e per storey).

While this core would result in one of the lowest overall structural retention of the options in this section, it would still retain the central core, and a large portion of the existing floorplate. At the same time it would allow improved connectivity and efficiency.



Existing central core and existing slab are retained. Satellite cores are removed

Floorplate is extended with pinwheel fully maintained. Satellite core areas and filled in

New core area is added around central core. Significant penetrations required in existing slab

Figure A.12 Diagram showing elements that are retained in this option and the position of new core elements

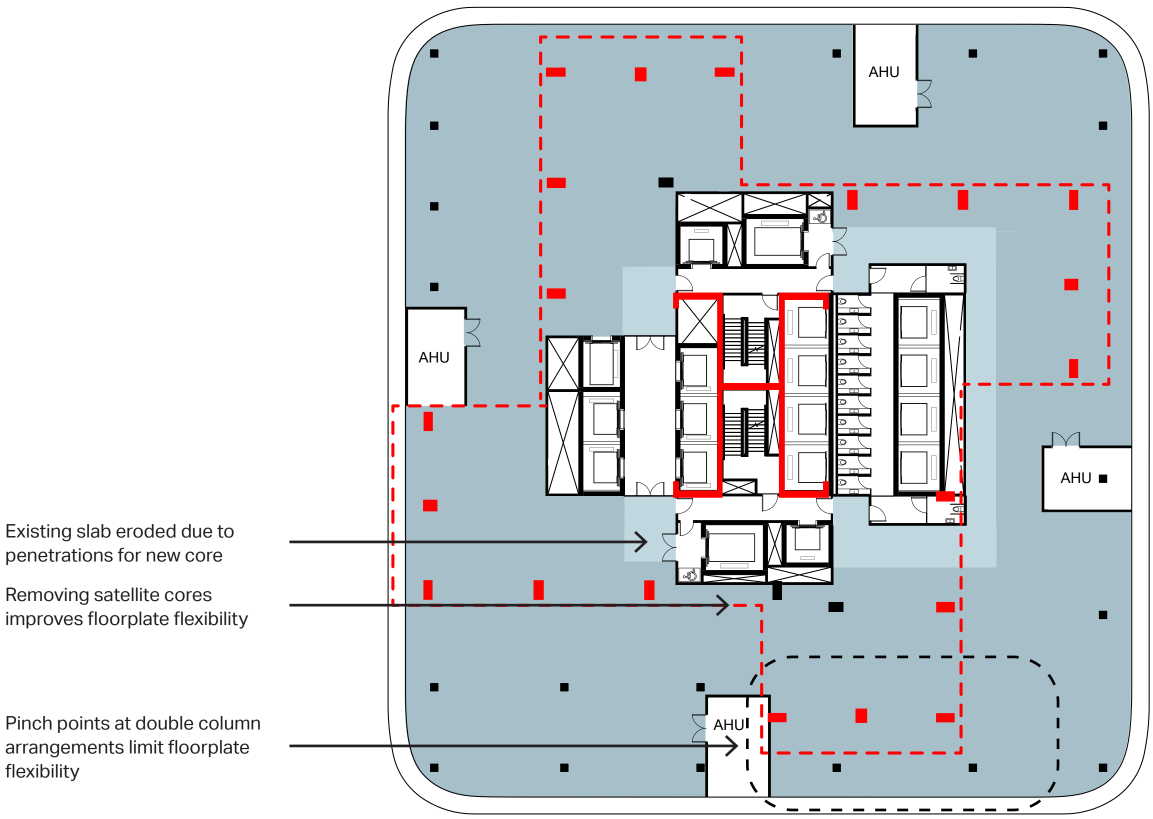
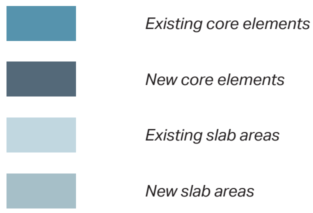


Figure A.11 Indicative floorplate and core layout with all new core elements located around the existing central core in the existing floor slab

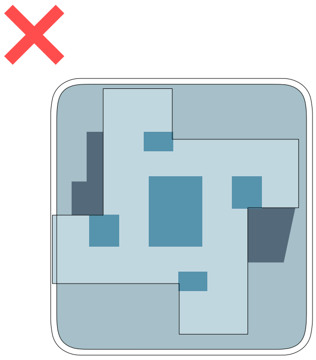
A.7 Summary

This Section has studied different floorplate and core layouts with the primary aim of retaining as much of the existing structure as possible.

Structural retention is a key consideration, but so is connectivity, and efficiency. Figure A.13 summarises the options presented in this section.

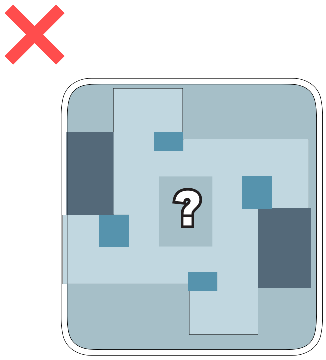


RETAIN EVERYTHING EXISTING (DISPERSED CORE)



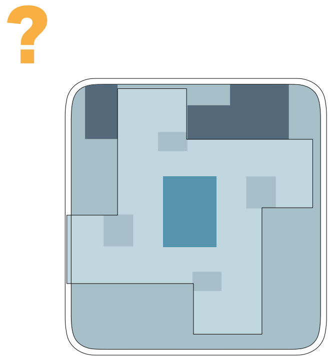
This core layout would be inhibiting to connectivity and flexibility for a contemporary office, though structural retention would be maximised.

RETAIN EVERYTHING AND REMOVE CENTRAL CORE



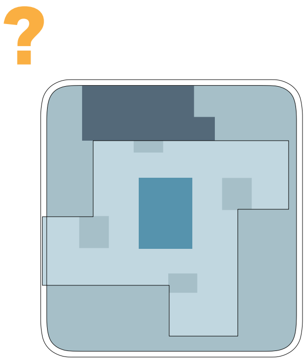
Practically and programmatically this core would not be viable.

RETAIN CENTRAL CORE WITH NEW NORTH CORE



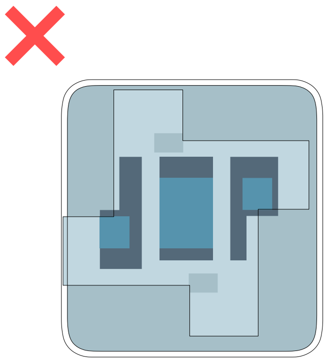
This core layout would be inhibiting to connectivity and flexibility for a contemporary office.

RETAIN CENTRAL CORE WITH CENTRALISED NORTH CORE



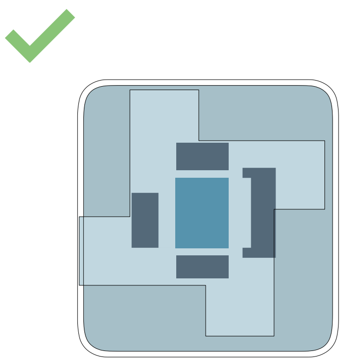
This core layout would be inhibiting to connectivity and flexibility for a contemporary office.

RETAIN CENTRAL CORE AND TWO SATELLITE CORES



This core layout would present improved connectivity and efficiency, but would be incompatible with existing pile cap. Structural retention would be relatively low, though still retain the central core, two satellite cores, and a portion of the existing floorplate

RETAIN AND EXPAND CENTRAL CORE



This core layout would present improved connectivity and efficiency. Structural retention would one of the lowest, though still retain the central core, and a portion of the existing floorplate.

Figure A.13 Summary of floorplate layout options

B Extent of Slab

In developing the floorplate and core layouts, the starting point was to retain as much as possible of the existing slab. This leads to the natural inclination to provide new core elements outside of the footprint of the existing slab.

However, as shown in Appendix A, when doing so the floorplates would generally result in split core arrangements, with poor connectivity and flexibility. This could be alleviated with a central, consolidated core, but this would require significant new penetrations in the existing floor slabs.

In Feasibility Volume One and Section 15, it was shown how the existing floorplate is quickly eroded when new penetrations are punched through, due to a combination of the ribbed slab structure and buildability constraints.

This Section examines options for retaining different portions of the existing floor slabs. The following options are studied:

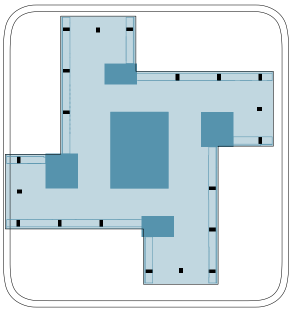
- Retain Everything Existing
- Retain Everything Except the South Pinwheel Arm
- Retain the Central Square and the East and West Pinwheel Arms
- Retain the Central Square and the East Pinwheel Arm
- Retain the Pinwheel Arms
- Retain No Existing Slab.

These options are shown diagrammatically in Figure B.1. Of course it is possible to combine options to produce other permutations, but these options are chosen as the logical touch-points from which conclusions about the other permutations can be derived.

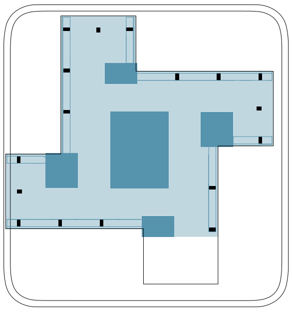
All options are assessed using the same, typical extended floorplate, and use a decentralised ventilation system as the basis for proposals. The extent of this floorplate is intended to be indicative of one plausible extension only, and it does not presuppose the outcome of any developments around massing.

Ultimately the conclusions are not sensitive to the shape or absolute dimensions of the extended floorplate. This to say that the outcome of this assessment would be the same regardless of the shape of the extension.

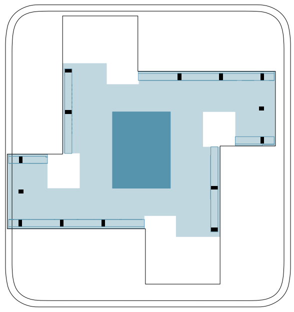
RETAIN EVERYTHING



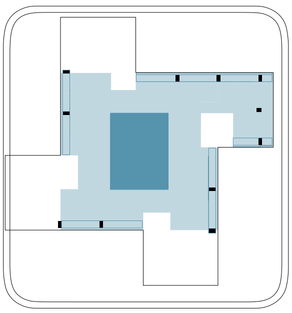
RETAIN EVERYTHING EXCEPT SOUTH PINWHEEL ARM



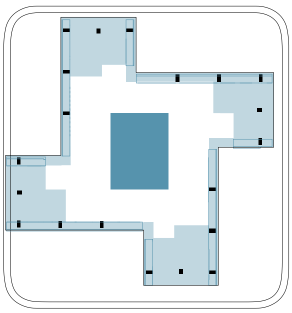
RETAIN THE CENTRAL SQUARE AND EAST AND WEST PINWHEEL ARMS



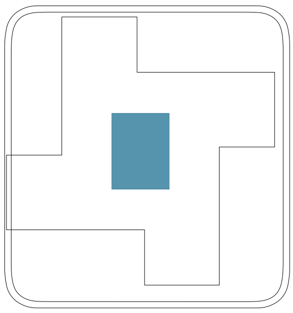
RETAIN THE CENTRAL SQUARE AND THE EAST PINWHEEL ARM



RETAIN THE PINWHEEL ARMS



RETAIN NO EXISTING SLAB



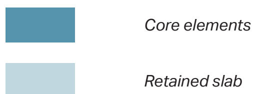


Figure B.1 Overview of slab extent options studied in this Section

B.1 Retain Everything Existing

In this option the aim is to retain the full extent of the existing pinwheel. As shown in Feasibility Volume One and Section 15, it is not possible to do so unless all new core areas are located outside of the existing floorplate, due to the upgrades required to meet current Building Regulations and the increased servicing necessitated by the extended floorplates.

However it was shown in Appendix A, that the core in such a layout would be too dispersed, resulting in a disconnected floorplate.

Figure B.3 overlays the proposed core with the existing floorplate and structural system. The columns supporting the existing slab must be maintained in their original locations which would create pinch points on the floorplates, and significantly reduce flexibility.

In this scenario, there would be reduced opportunities to design the structural systems for adaptability, or the ability to include soft spots. These opportunities would be limited to areas of new-build slab only.

This option presents maximum retention, but its floorplate would be disconnected and have limitations on flexibility and adaptability.

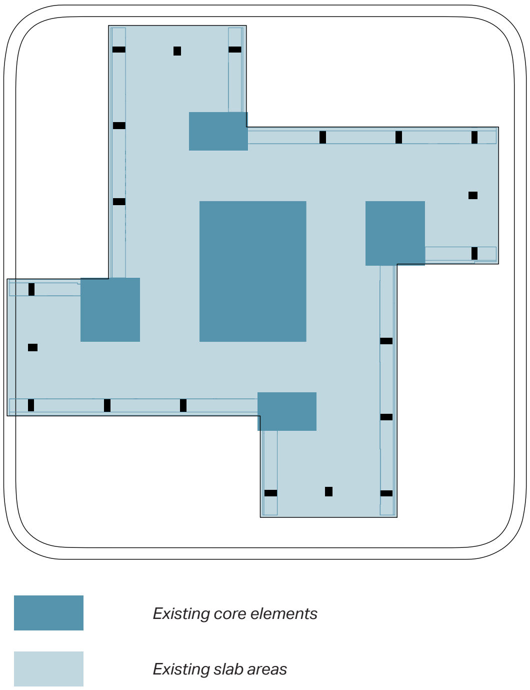
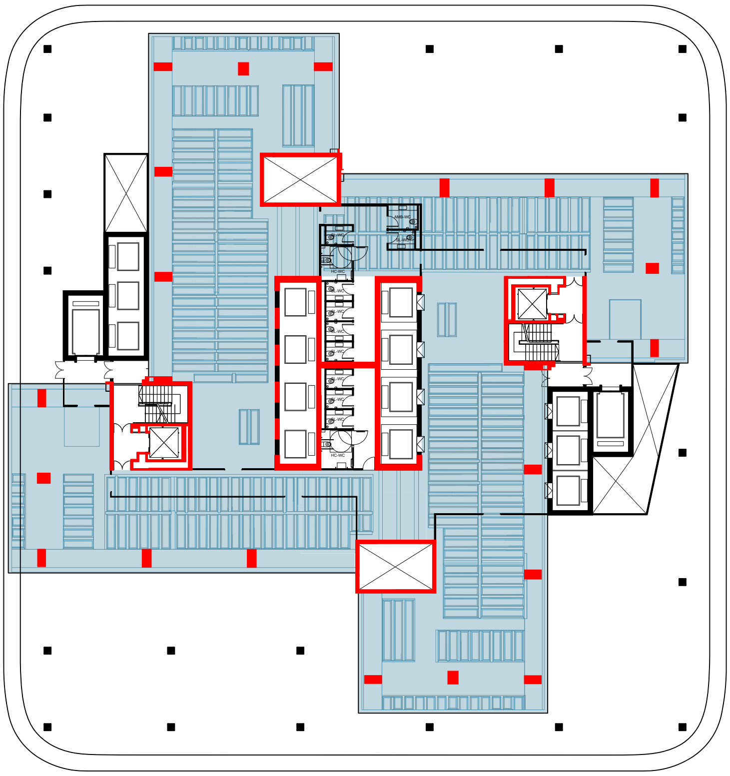


Figure B.2 Diagram showing elements that are retained in this option



Retained cores and columns

Existing slab areas

Figure B.3 *Structural overlay showing the extent of existing slab and structure retained with dispersed core layout*

B.2 Retain Everything Except the South Pinwheel Arm

A natural follow on from the option shown in Section B.1, would be to remove the pinwheel arms that inhibit flexibility, while retaining the remainder of the existing floorplate. This is shown schematically in Figure B.4.

This approach would alleviate the pinch points due to the double column arrangements, and in turn improve flexibility of the floorplate layout. Noting however that all other columns would be retained, they must remain in their original positions, constraining possible options for the grid layout.

Temporary works requirements would be similar to that in the Retain Everything Existing option, with the addition of full-height temporary propping required to the unconstrained edge of the south pinwheel arm.

Figure B.6 shows the structural implications of these moves overlaid on the existing structural system. Key here is removing the south pinwheel arm in a way that makes sense structurally, therefore the whole pinwheel arm would be removed back to the next column line. Continuity of the perimeter ring beam would generally be maintained through retention of all four satellite cores.

In this scenario, there would be reduced opportunities to design the structural systems for adaptability, or the ability to include soft spots. These opportunities would be limited to areas of new-build slab only.

This option presents high levels of retention and slightly improved flexibility. It would still require extensive intervention and temporary works.

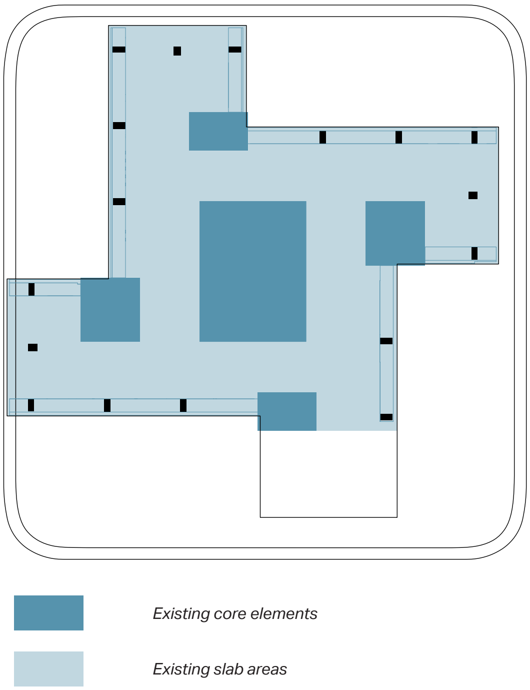
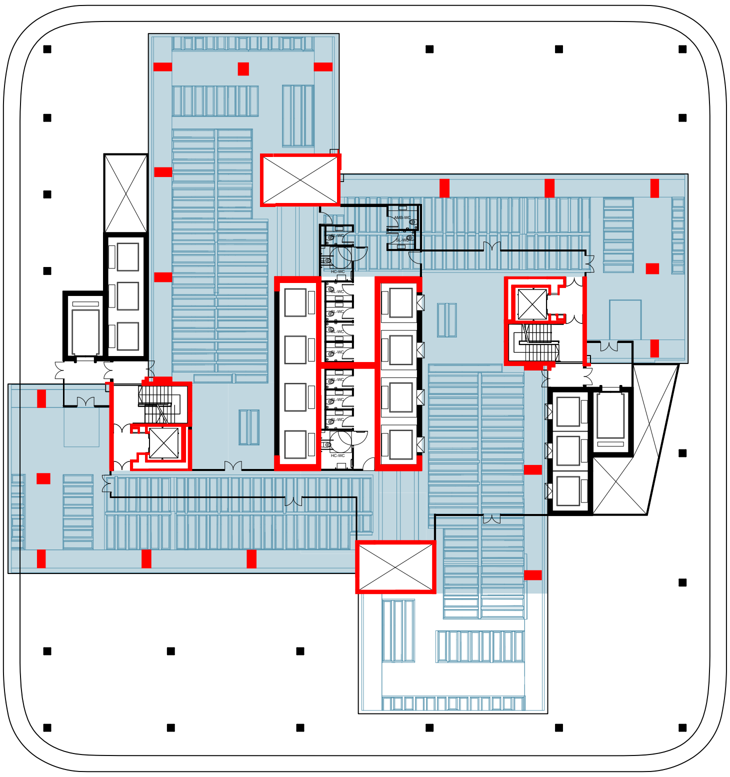


Figure B.4 Diagram showing elements that are retained in this option



Retained cores and columns

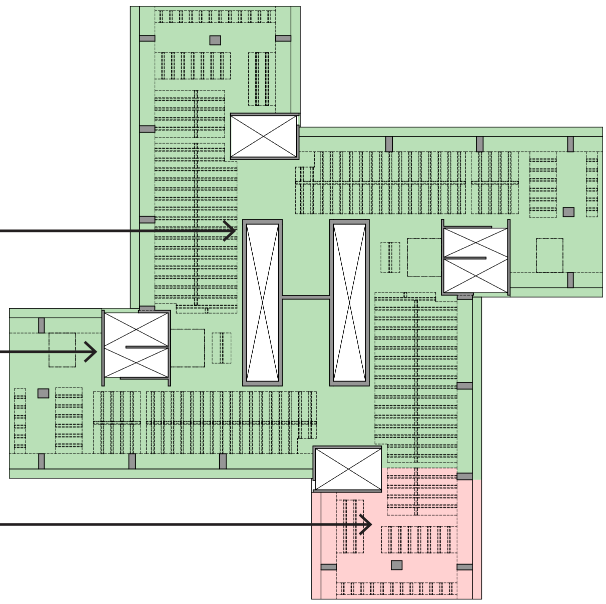
Existing slab areas

Figure B.5 *Structural overlay showing the extent of existing slab and structure retained with dispersed core layout*

No new penetrations required around core

All cores retained therefore no additional supporting construction required

Slab cut back to column line on south arm to reduce impact of existing grid. Full-height temporary propping required to unconstrained slab edges



New supporting construction

Existing slab removed

Existing slab retained

Figure B.6 *Structural diagram showing interventions required to existing structure*

B.3 Retain the Central Square and the East and West Pinwheel Arms

Another option for existing slab retention and in trying to improve flexibility and adaptability, would be to remove one or more of the pinwheel arms entirely (in this case the north and south arms are removed). In this option, the perimeter ring beam would be maintained and, where possible along with all central slab within the line of the ring beam. All slab and columns falling outside of this footprint would be removed and replaced with new construction. This is shown schematically in Figure B.7.

Like the option in Appendix B.2 this approach would alleviate the pinch points due to the double column arrangements, and in turn improve flexibility of the floorplate layout. The central columns that would be retained must remain in their original positions, constraining possible options for the grid layout. Adaptability would be unchanged, as though there is greater extent of new floor slab, this is mostly taken up by the central north core.

Temporary works requirements would be similar to that in the Retain Everything Except the South Pinwheel Arm option, with the addition of another unconstrained slab edge on the north pinwheel arm.

Figure B.8 shows the structural implications of these moves overlaid on the existing structural system. Unlike the previous option, key here is maintaining continuity of the perimeter ring beam to support the retained slab, meaning that new construction would be required prior to demolition of the satellite cores. This would introduce an additional health & safety risk by having demolition and construction activities happening simultaneously and in close proximity.

In this scenario, there would be reduced opportunities to design the structural systems for adaptability, or the ability to include soft spots. These opportunities would be limited to areas of new-build slab only.

This option presents high levels of retention and improved flexibility. It would still require extensive intervention and temporary works.

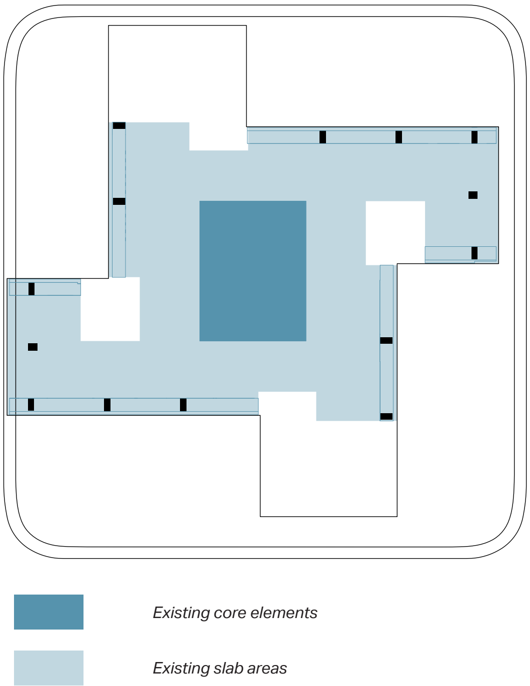


Figure B.7 Diagram showing elements that are retained in this option

Retained cores and columns

Existing slab areas

Figure B.9 *Structural overlay showing the extent of existing slab and structure retained with centralised north core layout*

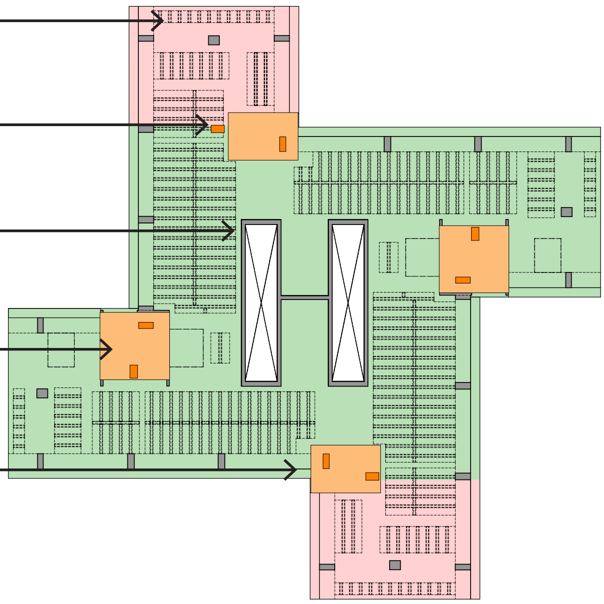
Slab cut back on north and south arms to reduce impact of existing grid. Full-height temporary propping required to unconstrained slab edges

Column integrated with north core wall

Minimal new penetrations required around core

Indicative new slab thickening to pick up existing slab edges

New construction necessary to hold up remaining structure. To be completed prior to demolition.



New supporting construction

Existing slab removed

Existing slab retained

Figure B.8 *Structural diagram showing interventions required to existing structure*

B.4 Retain the Central Square and the East Pinwheel Arm

A logical progression from the previous option for existing slab retention, and in trying to improve flexibility and adaptability, would be to remove further pinwheel arms. In this case, the north, west, and south arms would be removed entirely, with the east arm retained. The perimeter ring beam would be maintained and all central slab within the line of the ring beam. All slab and columns falling outside of this footprint would be removed and replaced with new construction. This is shown schematically in Figure B.10.

Like the previous option, this approach would alleviate the pinch points due to the double column arrangements, as well as more of the central columns, and in turn improve flexibility of the floorplate layout. The central columns that would be retained must remain in their original positions, constraining possible options for the grid layout. Adaptability would generally be improved across the floorplate as there is greater extent of new floor slab which could be designed to accommodate soft spots and for disassembly.

Temporary works requirements would be similar to that in the Retain the Central Square and the East and West Pinwheel Arms option, with the addition of another unconstrained slab edge on the west pinwheel arm in this case.

Figure B.11 shows the structural implications of these moves overlaid on the existing structural system. Key here is maintaining continuity of the perimeter ring beam to support the retained slab, meaning that new construction would be required prior to demolition of the satellite cores. This would introduce an additional health & safety risk by having demolition and construction activities happening simultaneously and in close proximity.

In this scenario, the opportunities to design the structural systems for adaptability, the ability to include double height spaces or soft spots would be improved, but limited to being outside the central area (i.e. in areas of new construction only).

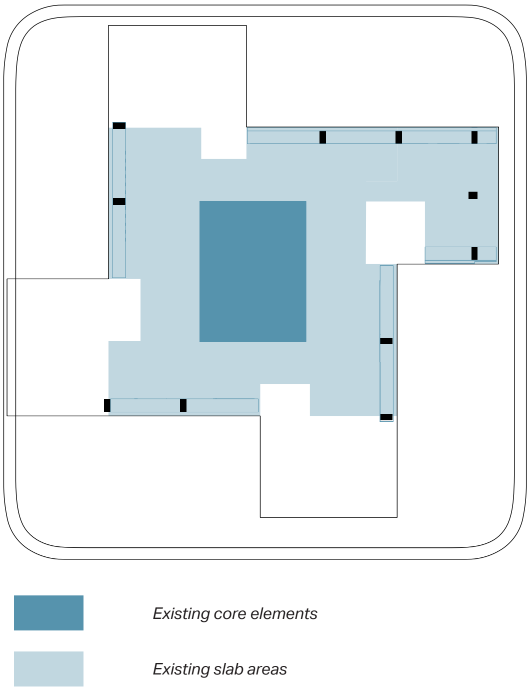


Figure B.10 Diagram showing elements that are retained in this option

This option presents moderate levels of retention and improved flexibility. It would still require extensive intervention and temporary works.

Retained cores and columns

Existing slab areas

Figure B.12 Structural overlay showing the extent of existing slab and structure retained with centralised north core layout

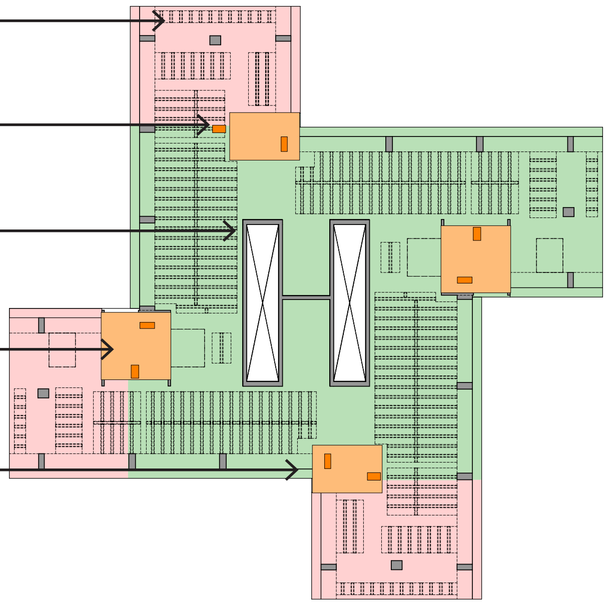
Slab cut back on three arms to reduce impact of existing grid. Full-height temporary propping required to unconstrained slab edges

Column integrated with north core wall

Minimal new penetrations required around core

Indicative new slab thickening to pick up existing slab edges

New construction necessary to hold up remaining structure. To be completed prior to demolition.



New supporting construction

Existing slab removed

Existing slab retained

Figure B.11 Structural diagram showing interventions required to existing structure

B.5 Retain the Pinwheel Arms

The preceding options have focussed on maximising retained floor slab by positioning the new core elements outside the central zone of the existing floor plate. However, as shown in Appendix A, when doing so the floorplates would generally result in split core arrangements, with poor connectivity and flexibility.

This could be alleviated with a central, consolidated core, but this would require significant new penetrations to central core area, ultimately eroding the extent of floor slab retained. A natural option might be to try retaining all slab *outside* of this area. This leads to the option shown schematically in Figure B.13, where the pinwheel arms would be retained while the central core area would be removed to make way for the new core arrangement.

This option would provide good flexibility for the new central core, and alleviate some of the temporary works required for making the new penetrations. However, by retaining the pinwheel arms entirely, the double column arrangement from the Retain Everything Existing option would be reintroduced, hindering floorplate flexibility

Crucially the remaining pinwheel would effectively be remote. This structure must be linked to the central core at all times, which would require a complex construction methodology. The perimeter ring beam and corresponding columns must be retained so far as possible, new construction would be required prior to demolition of the satellite cores to maintain this link, and significant, complicated temporary works would be needed during demolition and construction. Temporary steels would be required at least every third level. This added complexity would be likely to result in a construction cost premium, and additional embodied carbon.

The structural implications are shown in Figure B.14. Like the other options that have simultaneous demolition and construction, there would be an additional health & safety risk by having these activities happening simultaneously and in close proximity.

This option would reduce the intervention required to the central slab area for a central core. But its construction would be complex, and it would require excessive temporary works.

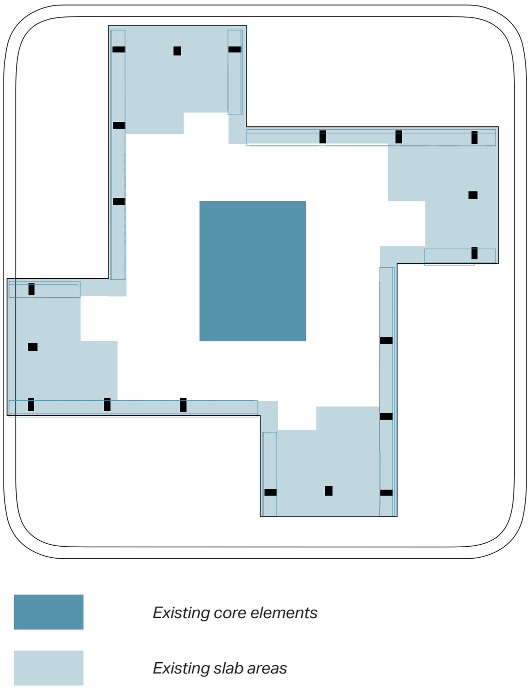


Figure B.13 Diagram showing elements that are retained in this option

Retained cores and columns

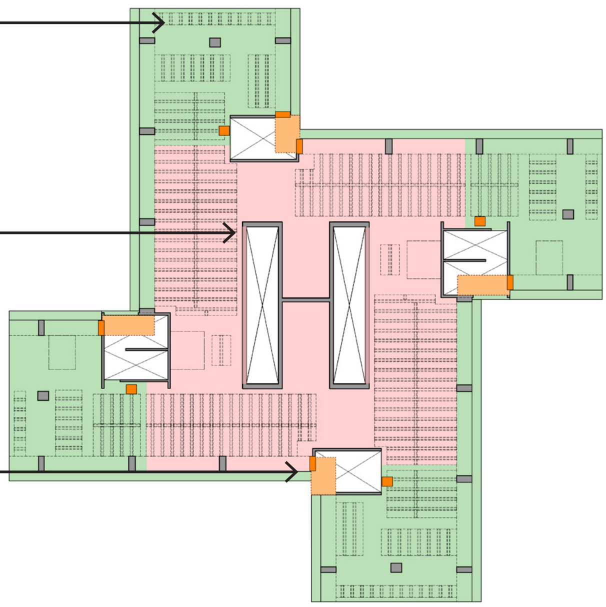
Existing slab areas

Figure B.15 Structural overlay showing the extent of existing slab and structure retained with central expanded core layout

Leaving only arms remote from core requires complex methodology

Good flexibility for new core

New construction necessary to hold up remaining structure. To be completed prior to demolition.



New supporting construction

Existing slab removed

Existing slab retained

Significant temporary works during demolition and construction to link the remaining structure with the central core. Steels required at least every third level.

Figure B.14 Structural diagram showing interventions required to existing structure

B.6 Retain No Existing Slab

The other bookend of the slab retention options is the option shown schematically in Figure B.16 where no slab is retained, but the core would be retained.

For the floorplate design, this would result in the most flexibility for grids and cores. Crucially it would also enable the new floorplates to be designed fully for adaptability, meaning new holes, double height spaces, and the like could be introduced in a relatively unintrusive manner. This goes together with being designed for disassembly, ensuring that components and materials could be more easily separated at end of life to reduce waste.

Compared to all the other options, this would be the least complex to deliver, reduce the risk of unknowns, and minimise the extent of temporary works required, with no need for slab support or slab edge propping (limited to retaining the core). The structural implications are shown in Figure B.17.

Health & safety risk would be improved compared to the other options, by minimising simultaneous demolition and construction in close proximity.

While this option would retain only the core, it presents reduced risks around buildability and an opportunity to design a new floor system that would be flexible, adaptable, and disassemblable.

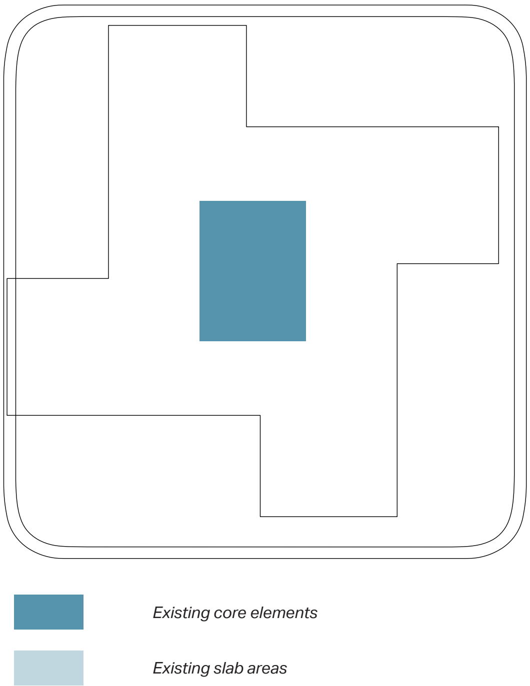
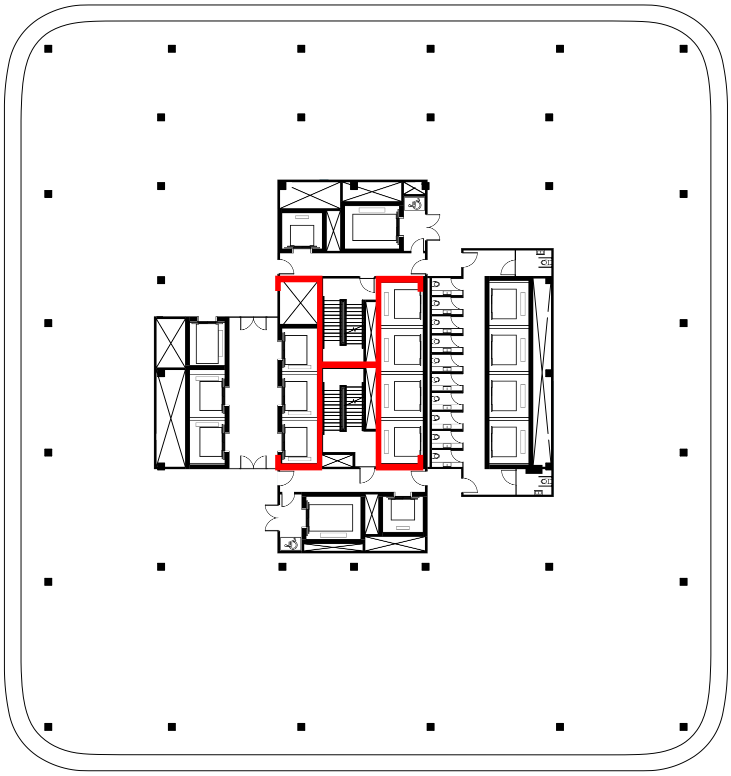


Figure B.16 Diagram showing elements that are retained in this option



Retained cores and columns

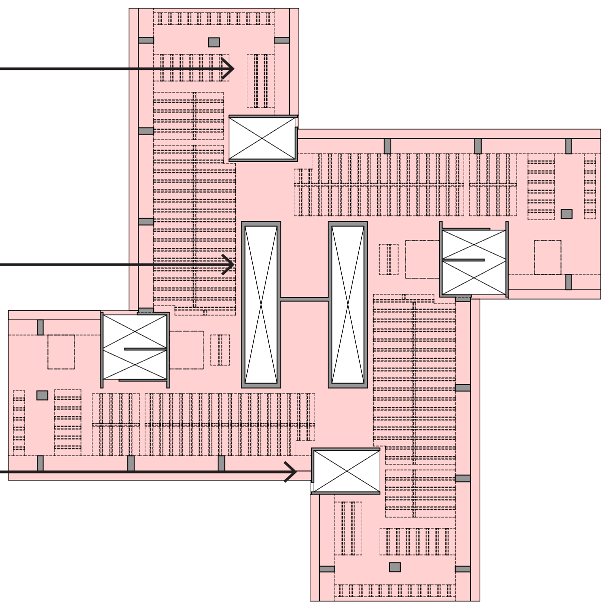
Existing slab areas

Figure B.18 Structural overlay showing the extent of the structure retained with centralised expanded core layout

All slab elements removed, leaving only core

Most flexibility for grids and cores

Doesn't achieve objective of maximising retention



New supporting construction

Existing slab removed

Existing slab retained

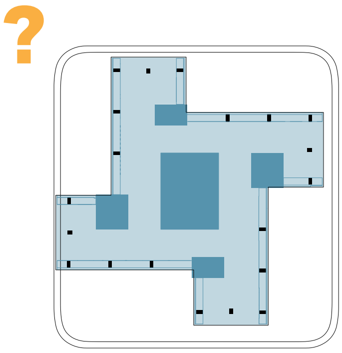
Figure B.17 Structural diagram showing interventions required to existing structure

B.7 Summary

This Section has studied different options for extent of slab retention each associated with a particular core layout. The options presented are some discrete possibilities, but not exhaustive, chosen because they illuminate the general issues and considerations associated with floor slab retention. It is possible to combine these options to arrive at other possibilities for retention, but the issues faced would be similar.

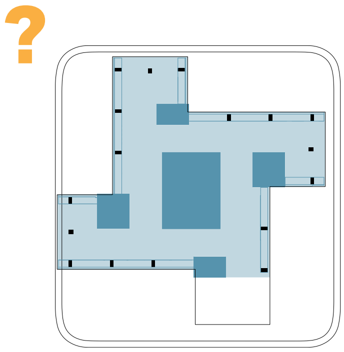
The primary aim is to retain as much of the existing structure as possible. Of course structural retention is a key consideration, but so is flexibility, adaptability, and buildability (construction complexity, temporary works required, and the like). The diagrams alongside summarise the options presented in this section.

RETAIN EVERYTHING EXISTING



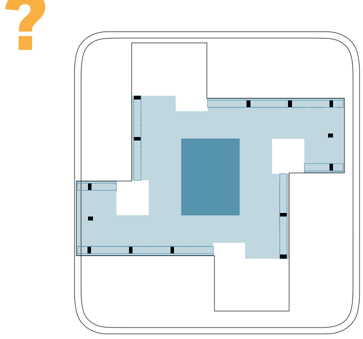
This option presents maximum retention, but its floorplate would be disconnected and has limitations on flexibility and adaptability.

RETAIN EVERYTHING EXCEPT THE SOUTH PINWHEEL ARM



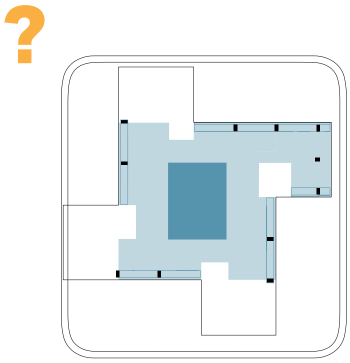
This option presents high levels of retention and only slightly improved flexibility. It would still require extensive intervention and temporary works.

RETAIN THE CENTRAL SQUARE AND THE EAST AND WEST PINWHEEL ARMS



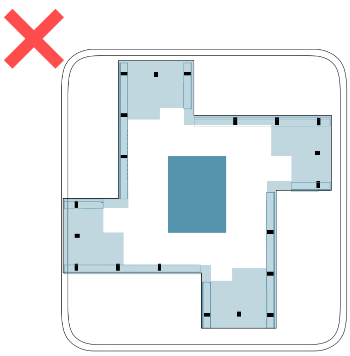
This option presents high levels of retention and somewhat improved flexibility. It would still require extensive intervention and temporary works.

RETAIN THE CENTRAL SQUARE AND THE EAST PINWHEEL ARM



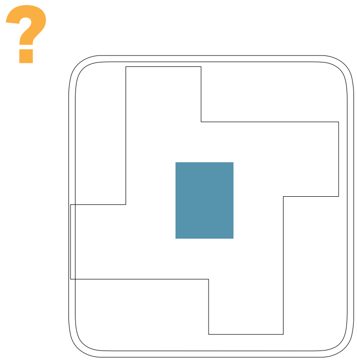
This option presents moderate levels of retention and improved flexibility and adaptability. It would still require extensive intervention and temporary works.

RETAIN THE PINWHEEL ARMS



This option would reduce the intervention required to the central slab area. But its construction would be complex, and it would require significant temporary works.

RETAIN NO EXISTING SLAB



While this option would retain only the core, it presents reduced risks around buildability and an opportunity to design a new floor system that would be flexible, adaptable, and disassemblable.

Core elements

Retained slab

Figure B.19 Summary of slab retention options

C Extent of Section

This Section evaluates how much of the existing building could be retained vertically, while achieving as many of the brief requirements as possible.

There are a multiple elements to consider within this parameter, specifically:

- Central core
- Satellite cores
- Number of slabs retained.

It was shown in Appendix A that retaining the satellite cores, along with the upgrades required for Building Regulations compliance and the extended floorplates, would generally be too inhibiting to floorplate flexibility. Therefore, all studies in this Section assume the central core, substructure, and foundation would be retained.

For the number of slabs retained, there are various ways this could be delivered, ranging from retaining all slabs, through retaining some interstitial slabs, to retaining no slabs at all. This Section highlights some of the options for consideration in this regard.

Ultimately it is possible to combine parameters to produce a myriad of permutations. The studies presented here are not exhaustive, instead they are chosen to be indicative of the issues and conclusions stemming from such combinations.

The following are evaluated in this section:

- Retain Every Slab (All Cores, or Central Core Only)
- Retain Interstitial Slabs and Central Core
- The Retain the Core and New Build studies are not detailed in this Section as they retain no floor slabs, but they are studied in detail in as part of the options appraisal in Section 16.

C.1 Retain Every Slab

In this option, all existing floor slabs would be retained. Two sub-options for core retention are: retain all cores, or retain only the central core.

Crucially, although technically possible from an engineering perspective, this option is not feasible from a commercial viewpoint, regardless of core arrangement. **Ultimately the existing 3,200mm floor to floor height is challenging for delivering a modern office offering. Retaining every slab would only create a larger quantum of highly compromised floor space. At the same time, retaining every slab would carry the existing column grid, and retain many of the limitations of the existing structure, hindering flexibility and adaptability in-use, and potential for non-destructive disassembly at end of life.**

Regarding the cores, as shown in Appendix A, retaining the satellite cores would result in a floorplate that inhibits the connectivity and flexibility required for a modern office.

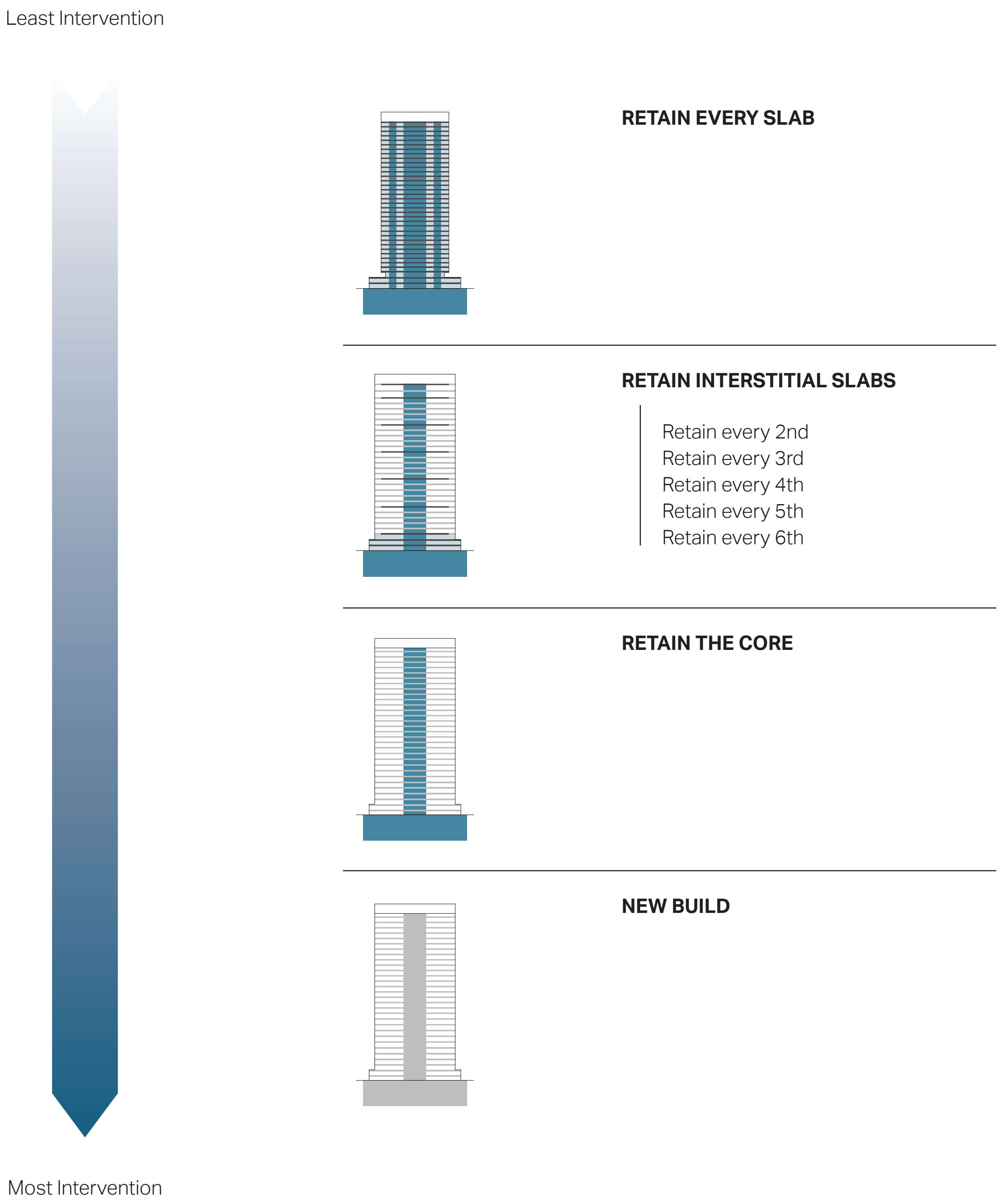


Figure C.1 Spectrum of retention for vertical structure (Retain the Core and New Build studies shown for completeness only (detailed in Section 4.6)

C.2 Retain Interstitial Slabs and Central Core

In trying to alleviate the pressure on the constrained floor to floor height, a natural progression is to retain interstitial floors rather than all of them.

This leads to the various sub-options which are explained in this Section, where removing interstitial slabs (and inserting some new slabs) would allow the floor to floor heights to be strategically reset. The sub-options range from: retaining every second slab to retaining every sixth.

Retain Every 2nd Slab
This option is shown diagrammatically in Figure C.3. Every second slab would be retained and every other slab would be removed fully.

16 slabs would be retained above the podium.

This would result in a significant loss of floor area within the existing height, essentially a poor volumetric efficiency. The maximum GIA would be reduced by 50%, relative to a baseline area assuming full floorplate retention within the existing envelope.

The resulting floor to floor height of 6.4m would be over-dimensioned and inefficient, regardless of whether the space is programmed for office or lab.

This option would result in poor volumetric efficiency and over-dimensioned floor to floor heights. Flexibility, adaptability, and disassembly would be limited by the retained slabs and columns.

Retain Every 3rd Slab
This option is shown diagrammatically in Figure C.2. Every third slab would be retained and the two others removed fully. A single new slab would be added to replace those removed.

11 slabs would be retained above the podium.

This would result in a significant loss of floor area within the existing height, essentially a poor volumetric efficiency. The maximum GIA is reduced by 34%, relative to a baseline area assuming full floorplate retention within the existing envelope.

The resulting floor to floor height of 4.8m would be over-dimensioned and inefficient, regardless of whether the space is programmed for office or lab.

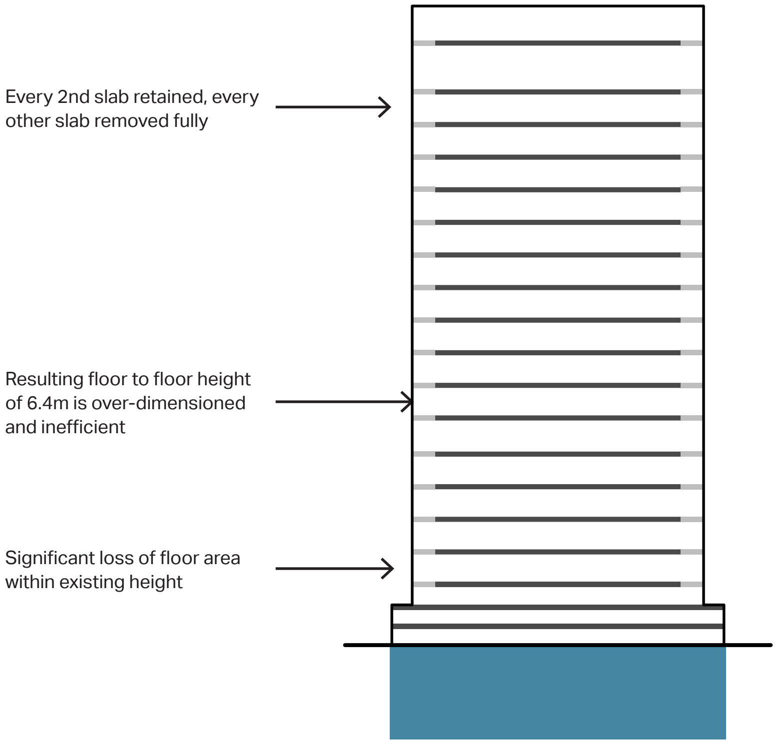
This option would result in poor volumetric efficiency and over-dimensioned floor to floor heights. Flexibility, adaptability, and disassembly would be limited by the retained slabs and columns.

RETAIN EVERY 2ND SLAB

Existing structural elements

Existing floor slabs

New floor slabs

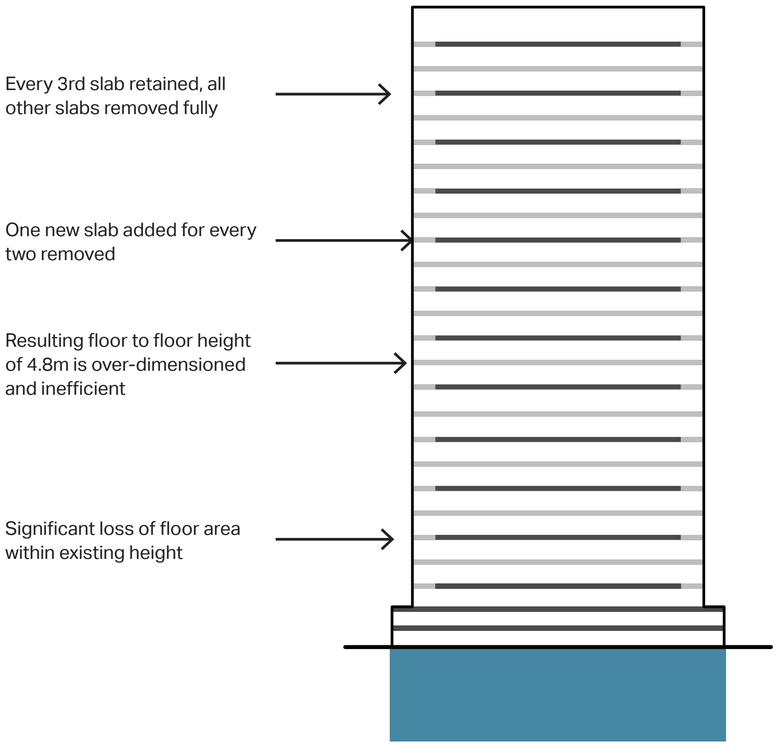


Nº	Slabs retained above podium	**16**
m²	GIA reduction*	**~50** %
	Typical floor to floor	**6.4** m

* Relative to baseline area assuming 100% of floorplates retained with existing envelope

Figure C.3 Diagram showing retention of every 2nd slab above the podium

RETAIN EVERY 3RD SLAB



Nº	Slabs retained above podium	**11**
m²	GIA reduction*	**~34** %
	Typical floor to floor	**4.8** m

* Relative to baseline area assuming 100% of floorplates retained with existing envelope

Figure C.2 Diagram showing retention of every 3rd slab above the podium

Retain Every 4th Slab
This option is shown diagrammatically in Figure C.5. Every fourth slab would be retained and the three others removed fully. Two new slabs would be added to replace those removed.

8 slabs would be retained above the podium.

This would result in a significant loss of floor area within the existing height, essentially a poor volumetric efficiency. The maximum GIA is reduced by 25%, relative to a baseline area assuming full floorplate retention within the existing envelope.

The resulting floor to floor height of 4.3m would be over-dimensioned and inefficient, regardless of whether the space is programmed for office or lab.

This option would result in poor volumetric efficiency and over-dimensioned floor to floor heights. Flexibility, adaptability, and disassembly would be limited by the retained slabs and columns.

Retain Every 5th Slab
This option is shown diagrammatically in Figure C.4. Every fifth slab would be retained and the four others removed fully. Three new slabs would be added to replace those removed.

7 slabs would be retained above the podium.

This would result in a loss of floor area within the existing height, but here the reduction of the maximum GIA would be reduced by 22%, relative to a baseline area assuming full floorplate retention within the existing envelope. The volumetric efficiency would be reduced compared to the existing envelope, but would be somewhat mitigated by the new floors.

The resulting floor to floor height of 4.0m would be over-dimensioned and inefficient for offices, but workable for a lab space. The floor to floor height of the uppermost level would be 6.4m because it is effectively the remaining height after maximising retention with even floor to floor height distribution below (it would not be possible to retain the other slabs and reset the heights evenly within the existing height).

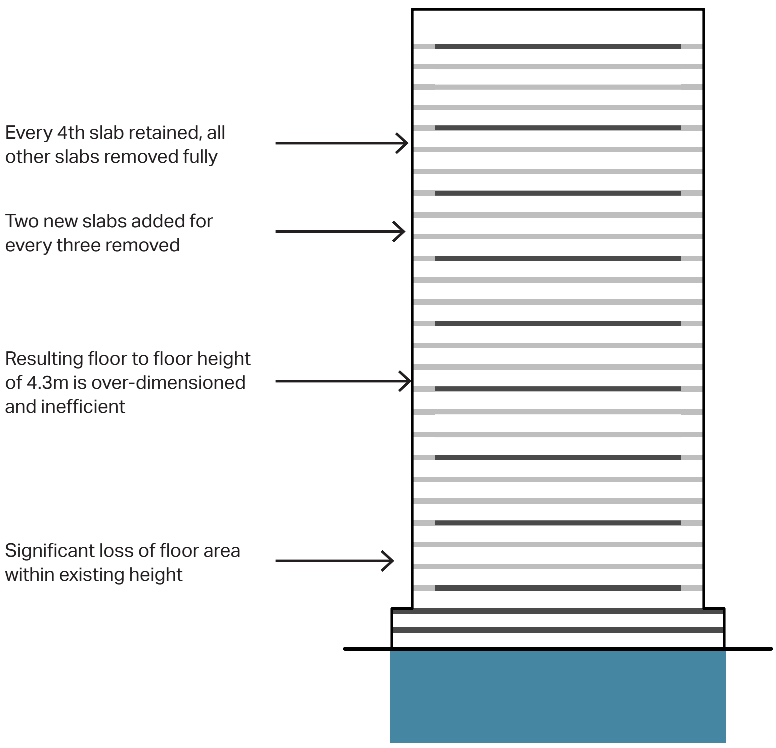
Notwithstanding that the floor to floor height would be over-dimensioned for offices, this option has potential to maximise the opportunity for lab-enabled space. Flexibility, adaptability, and disassembly would be limited by the retained slabs and columns.

Existing structural elements

Existing floor slabs

New floor slabs

RETAIN EVERY 4TH SLAB

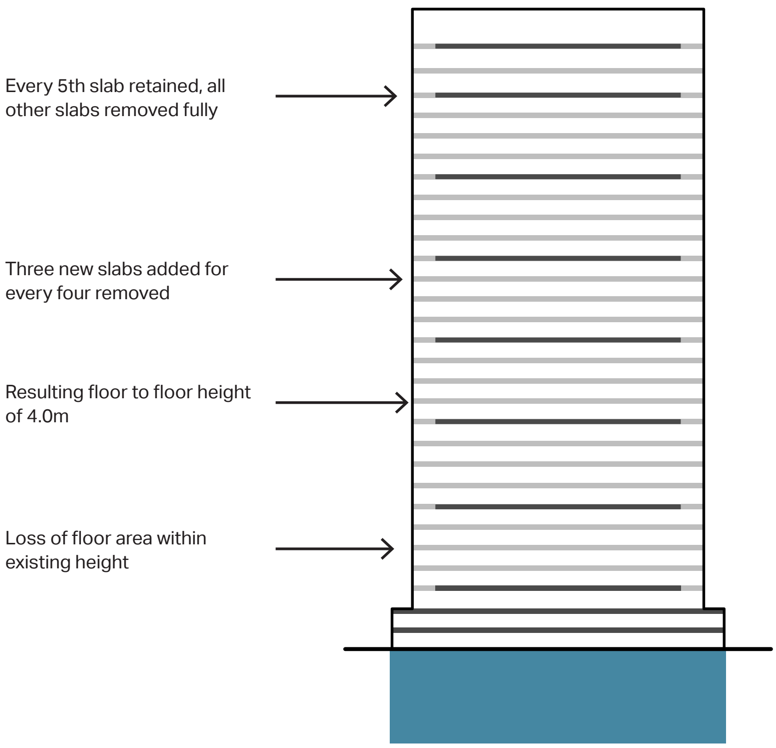


Nº	Slabs retained above podium	8
m²	GIA reduction*	~25%
	Typical floor to floor	4.3 m

* Relative to baseline area assuming 100% of floorplates retained with existing envelope

Figure C.5 Diagram showing retention of every 4th slab above the podium

RETAIN EVERY 5TH SLAB



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Nº	Slabs retained above podium	7
m²	GIA reduction*	~22 %
	Typical floor to floor	4.0 m

* Relative to baseline area assuming 100% of floorplates retained with existing envelope

Figure C.4 Diagram showing retention of every 5th slab above the podium

Retain Every 6th Slab
This option is shown diagrammatically in Figure C.6. Every sixth slab would be retained and the five others removed fully. Four new slabs would be added to replace those removed.

6 slabs would be retained above the podium.

This would result in a loss of floor area within the existing height, but here the maximum GIA would be reduced by 19%, relative to a baseline area assuming full floorplate retention within the existing envelope. The volumetric efficiency would be reduced compared to the existing envelope, but would be somewhat mitigated by the new floors.

The resulting floor to floor height would be inconsistent, most floors would be 3.84m but some floors would be 3.98m. This is due to the existing Level 12 (MEP level) having a 0.7m larger floor to floor height than the typical existing office levels.

The floor to floor height of the uppermost level would be 6.4m because it is effectively the remaining height after maximising retention with even floor to floor height distribution below (it would not be possible to retain the other slabs and reset the heights evenly within the existing height).

Notwithstanding the varied floor to floor heights, which are also contingent on whether lab-enabled floors are included, as a principle this option has potential for further consideration. Flexibility, adaptability, and disassembly would be limited by the retained slabs and columns.

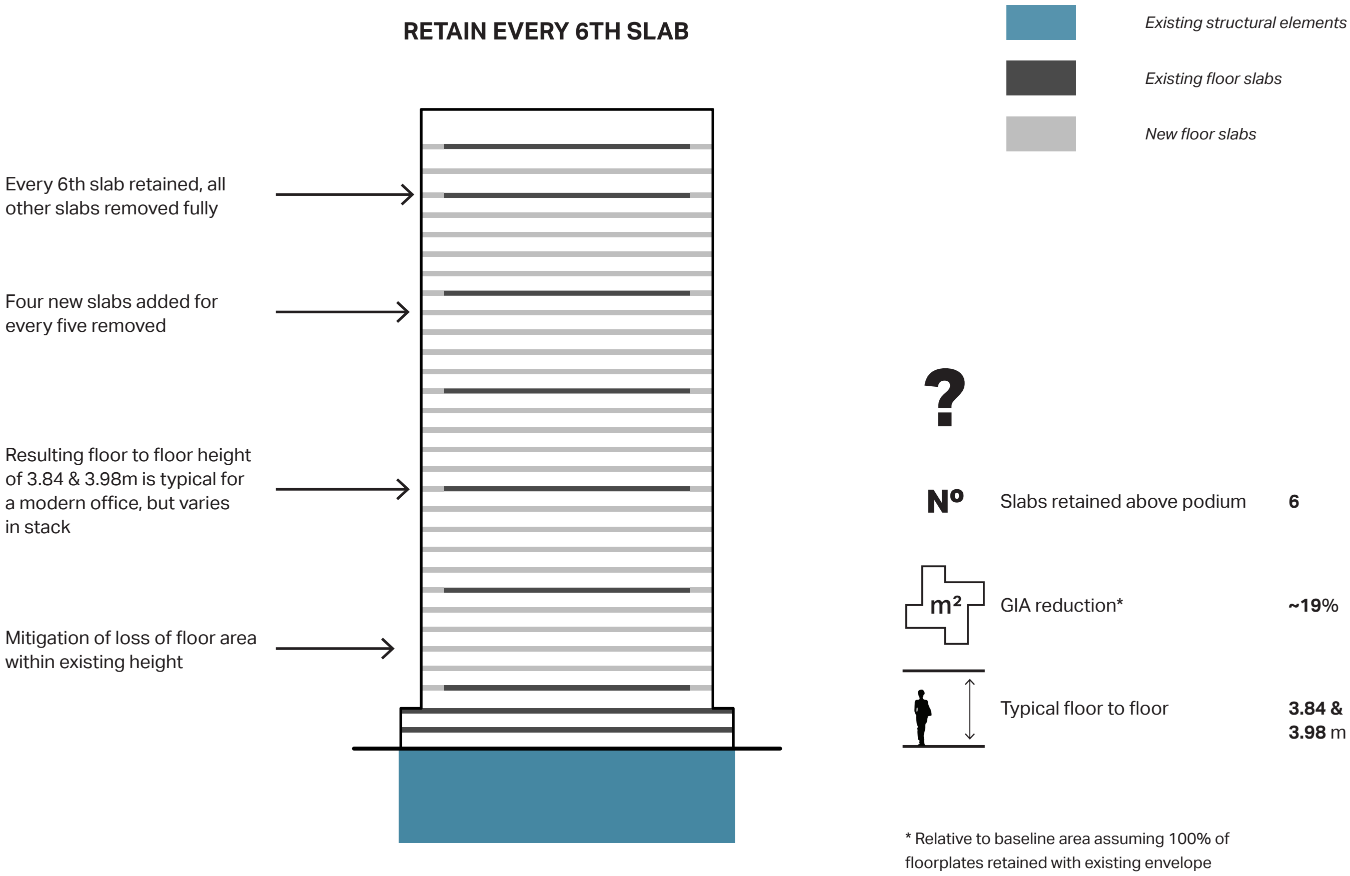

Figure C.6 Diagram showing retention of every 6th slab above the podium

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