

# Cambridge Halls MMU

## RIBA Stage 3 Life Cycle Embodied Carbon Assessment

Reference: CAM-ARP-ZZ-ZZ-RP-WLC-0001  
P01 | 14 March 2025

This report takes into account the particular instructions and requirements of our client. It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.



# Executive Summary

## Context

This Whole Life Carbon assessment (WLCA) has estimated the embodied carbon at post completion and the whole life embodied carbon across the 60-year reference study period for the Stage 2 design of Cambridge Halls. Operational carbon emissions from energy use and water consumption are out of scope of this assessment. Results presented in the report assume no grid decarbonisation as is standard for WLCAs because grid decarbonisation is outside the building developer, and owners control, and should not be relied upon to meet targets or report emissions.

## Results

The RIBA stage 2 results for Cambridge Halls, shown below, provide a baseline value that can be improved upon throughout the design, and help us to identify key reduction opportunities to be explored at the next stage.

### Upfront Embodied Carbon

(A1-A5 excluding sequestration)

**789 kgCO<sub>2</sub>e/m<sup>2</sup>**

(52,492 tCO<sub>2</sub>e)

### Whole-Life Embodied Carbon

(A-C excluding sequestration)

**1,405 kgCO<sub>2</sub>e/m<sup>2</sup>**

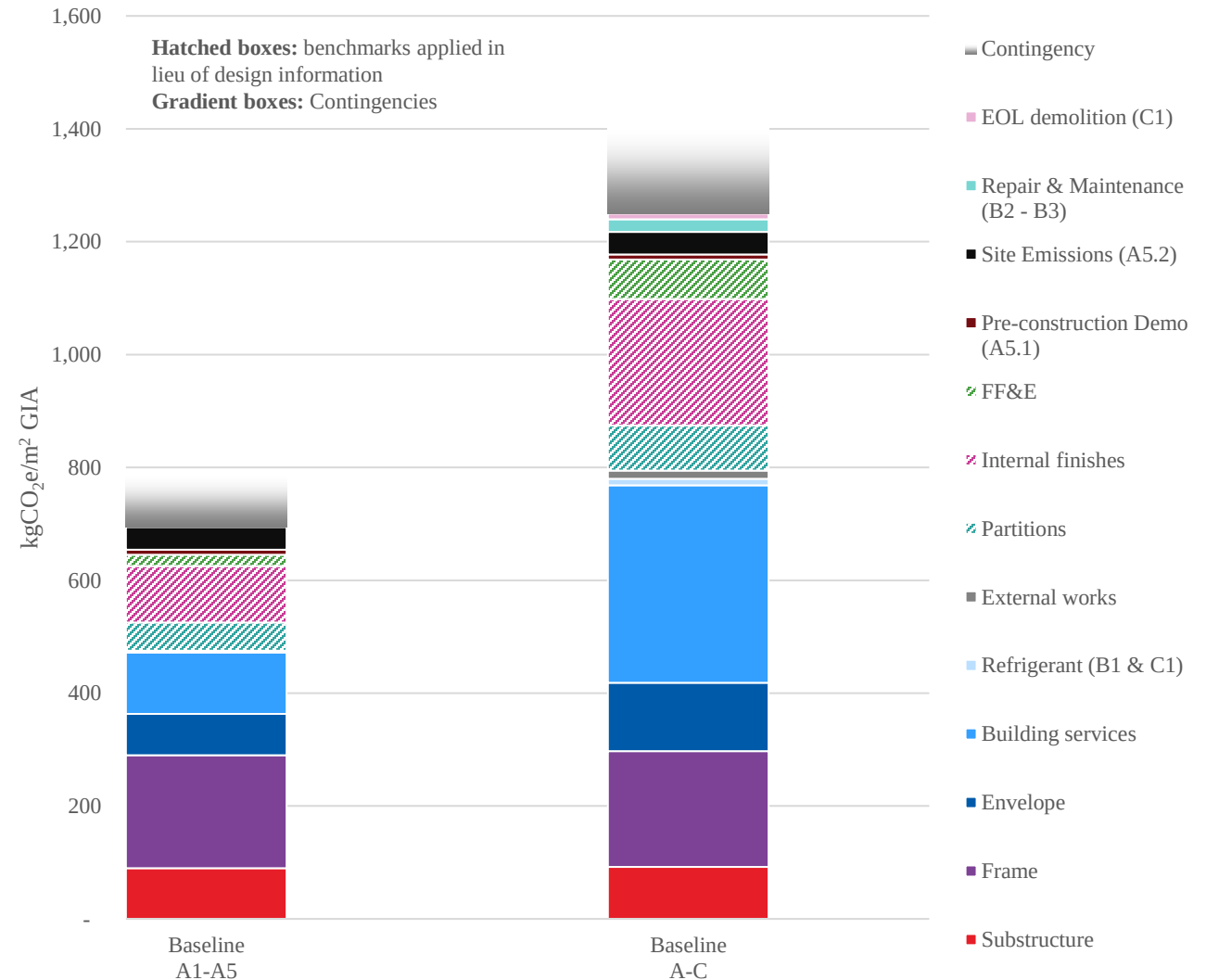
(93,413 tCO<sub>2</sub>e)

## Material Hotspots and High Impacts

This assessment has identified several key carbon hotspots across the design life of the building, focusing on the in-scope fit out elements:

- C40/50 Concrete for piles, core walls, floor slabs, and external walls (50.6%, A1-A3)
- Steel reinforcement in Concrete (10.5%, A1-A3)
- Precast insulated panels (4.7%, A1-A3)

## RICS Ed.2 Embodied Carbon Results [kgCO<sub>2</sub>e/m<sup>2</sup> GIA]



# Executive Summary

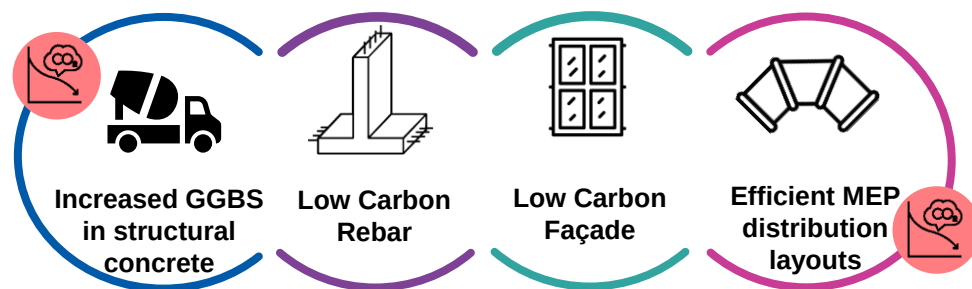
## Comparison to target/benchmarks/performance?

These results show that the RIBA Stage 2 design for Cambridge Halls is not currently meeting the project RIBA 2030 A-C target. However, based on the RIBA Business as Usual (BaU) benchmark, Cambridge Halls reflects the upper end of current practice.

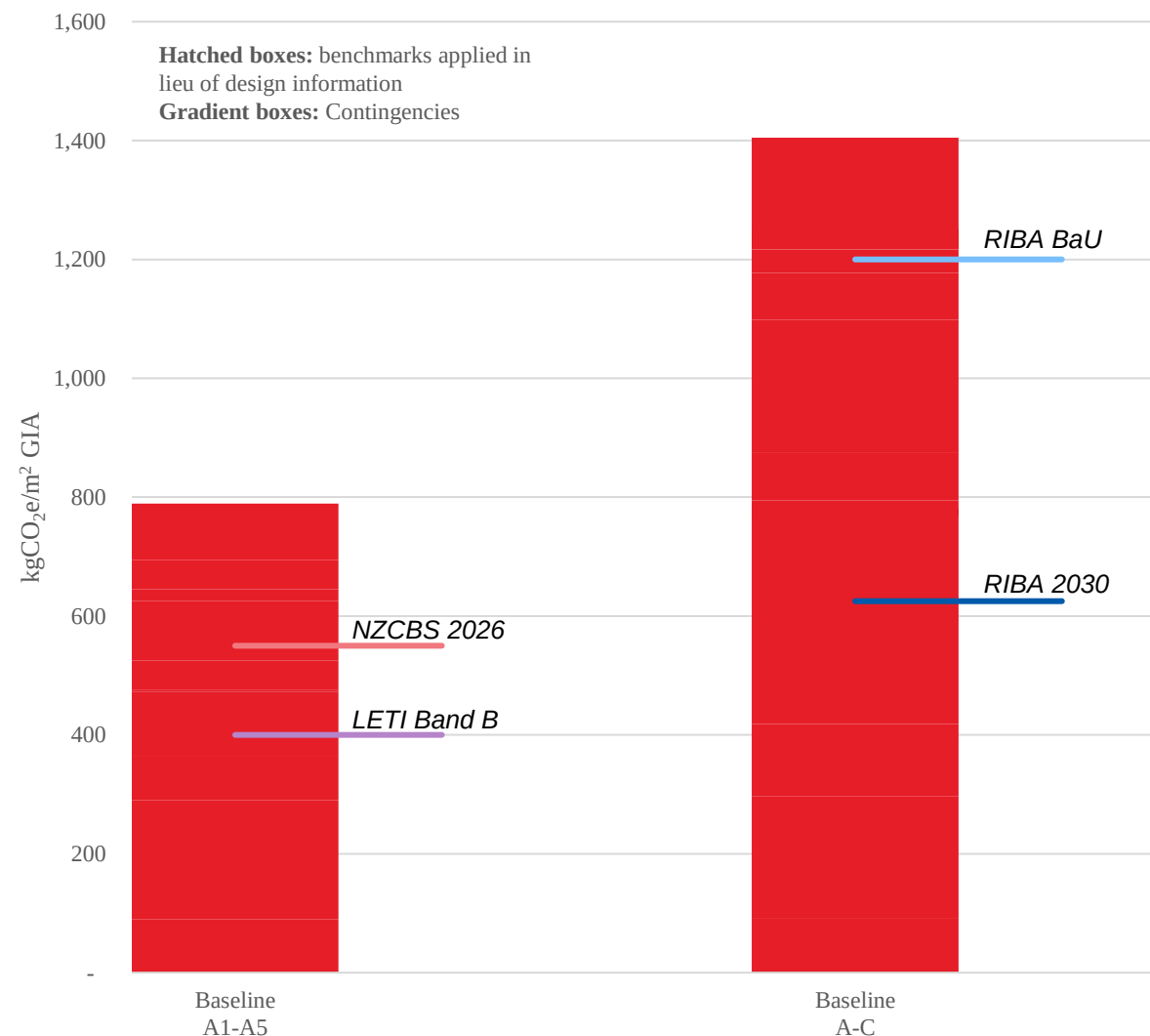
It is understood within the industry that the RIBA 2030 target is challenging to achieve and is a substantial improvement from the RIBA BaU benchmark for residential buildings. The target is based on historic assessment data that did not accurately account for all material impacts of a building, in particular MEP and fit out items. As such projects currently struggle to meet these targets and the industry is trying to update these based on more recent assessment data. For example, the UK Net Zero Carbon Building Standard (NZCBS), launched last year, presents upfront embodied carbon targets which we recommend are adopted for the project in addition to the A-C target.

## Next Steps

At RIBA Stage 3, the design team should carry out whole life carbon optioneering on key decisions, to minimise the environmental impact of the project. A holistic approach should be taken to ensure that a reduction in embodied carbon does not result in an increase in operational carbon, and to ensure that emissions are not just moved between building layers. The diagram below shows four priority design opportunities that should be explored, based on the hotspots identified in the current design. However, if the project targets are to be met, then a more radical approach to reductions may be required, that embraces circular economy principles, such as maximising material reuse on site.



## RICS Ed.2 Embodied Carbon Results [kgCO<sub>2</sub>e/m<sup>2</sup> GIA]



*Context*

Introduction

# Introduction

## Project Overview

### Context

This WLCA has been prepared on behalf of Unite Students and Manchester Metropolitan University and the study assesses the RIBA Work Stage 2 embodied carbon impacts of the proposed MMU Cambridge Halls development. This whole life cycle assessment (WLCA) has followed the standard approach to carbon measurement and assessment in the built environment. It has been undertaken in accordance with the RICS Professional Statement 'Whole life carbon assessment for the built environment, 2<sup>nd</sup> edition' and aligns with BS EN 15978:2011.

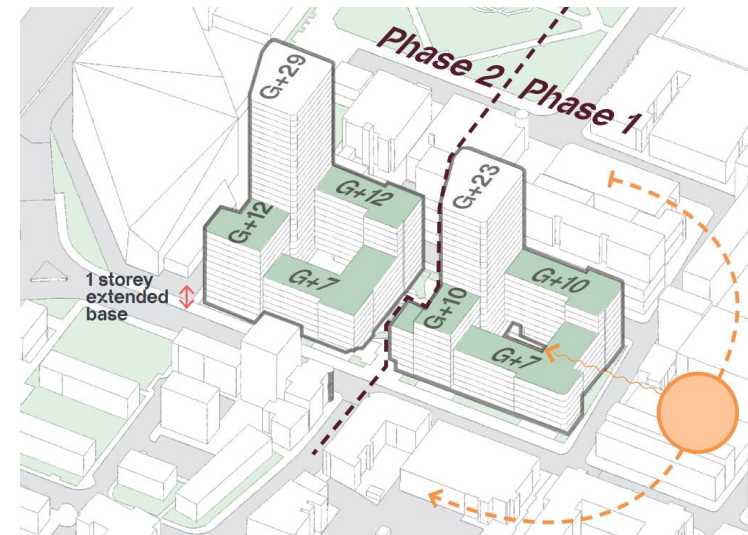
This assessment has also been undertaken in line with BREEAM UK NC V6 Mat01 requirements for a residential building.

### Project Description

The project involves the demolition of the existing building (17,036m<sup>2</sup> GEA) and the erection of new residential buildings (66,507m<sup>2</sup> GIA), comprising 28 upper-floors. The buildings will be completed in two phases. The first phase providing ~1,100 bedrooms by September 2029, and Phase 2 an additional ~200 bedrooms by September 2030. The buildings will provide a mix of bedrooms and studios for 1,428 students, along with study spaces, social spaces, gyms, and wellness facilities. External amenity and recreation areas will be located within lower courtyards and roof top areas.

### Site & Location

The site is located within the Manchester Metropolitan University All Saints Campus, connected to the wider university Birley Fields Campus and city centre by pedestrian and public transport routes.



Proposed developments



Site location

# Introduction

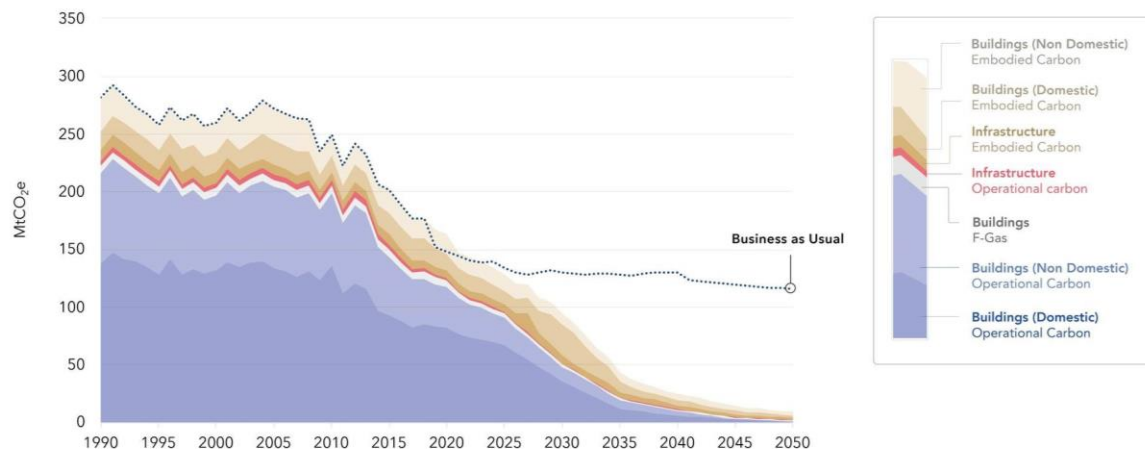
## Aims and Objectives

### Climate Breakdown and Emergency

According to the United Nations, the Built Environment contributes around 40% of all global carbon output and 50% of extracted material.

The UK built environment is currently responsible for 25% of total UK greenhouse gas emissions and is on course to fall well short of being net zero carbon by the national target of 2050 (UKGBC, Whole Life Carbon Roadmap A Pathway to Net Zero).

The Roadmap below demonstrates that as operational emissions decrease, mainly due to building improvements and grid decarbonisation, then embodied carbon will form over half of built environment emissions by 2035. These emissions are resulting in climate change impacts; droughts, fires, rising sea levels, flooding, storms and declining biodiversity.



Historic (1990-2018) Built Environment emissions (excluding transport), with business-as-usual projections applied (BEIS EEP to 2040, with trendline extended to 2050), as referenced in the Net Zero Whole Life Carbon Roadmap: A Pathway for the UK Built Environment. UK Green Building Council, 2021, London, UK

### Aims and Objectives

The aim of this study is to assess the embodied carbon emissions associated with the Cambridge Halls development as well as achieving the BREEAM Mat01 concept design credits.

The following objectives help to achieve this aim:

- Inform the client and design team of the embodied carbon associated with the RIBA WS2 design at practical completion (A1-A5), over life cycle (A, B1-B5, C, 60 years) and report separately on the next product system (D).
- Appraise 4 No. Superstructure design options, 2No. Substructure design options and 4 No. Hard landscaping design options, to support the client and design team to understand the embodied carbon impacts of the different options and achieve the BREEAM Mat01 concept design credits.
- Identify the key building elements with the highest embodied carbon ( $\text{kgCO}_2\text{e}$ )
- Investigate a range of interventions to determine options for carbon emission reduction and propose recommendations to ensure low carbon design decisions continue to be embedded into the design.
- Evaluate the building's WS2 embodied carbon against the RIBA benchmarks, as per Unite Students Net Zero Carbon Pathway, as well as the Net Zero Carbon Building Standard embodied carbon benchmarks.

# Introduction

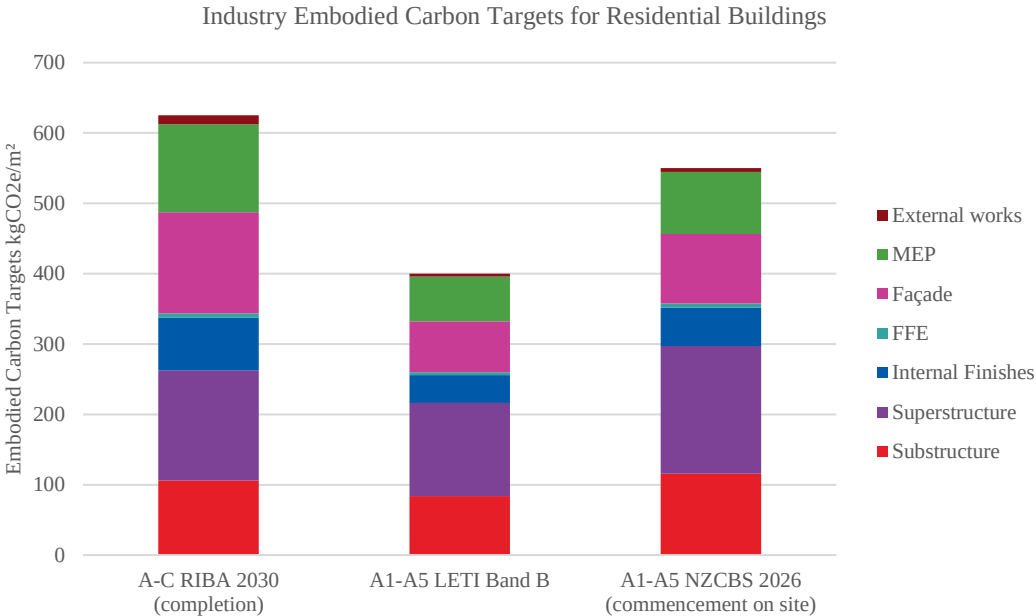
## Aims and Objectives

### Project Targets

Unite's ambition is to align with the RIBA 2030 challenge, across their projects, which sets A-C embodied carbon targets based on the year of completion. Cambridge Halls Phase 01 is due to complete in 2029, and Phase 02 in 2030, therefore the residential 2030 target of 625 kgCO<sub>2</sub>e/m<sup>2</sup> has been selected for Cambridge Hall. This is likely to be a very challenging target, considering that the RIBA business as usual benchmark for residential buildings is 1,200 kgCO<sub>2</sub>e/m<sup>2</sup> A-C. The outputs of this RIBA Stage 2 assessment should help to identify hotspots that can be targeted for reduction at the next design stage.

As well as setting a target for A-C it can be helpful to have an A1-5 target, as these are the emissions most within the design team's control. Considering A1-A5 emissions is also vital to enable us to stay within carbon budgets and mitigate the worst impacts of climate breakdown. Unite does not have an organisational A1-A5 target, so at the start of RIBA stage 2, [LETI guidance](#) aligning industry embodied carbon targets was used to derive one, based on an equivalent band rating to the RIBA 2030 target (band B). Since this, the UK Net-Zero Carbon Buildings Standard (NZCBS) pilot has been released, providing targets based on the year of commencement on site. The A1-A5 targets for LETI Band B and NZCBS (2026 commencement date) are 400 kgCO<sub>2</sub>e/m<sup>2</sup> and 495 kgCO<sub>2</sub>e/m<sup>2</sup> respectively.

The table to the right shows these targets split by building element, based on the [GLA WLC guidance](#) for residential buildings. These splits and the GLA targets (which RIBA 2030 aligns with) are based on historic assessment data, that did not accurately account for MEP EC. Through discussions with the GLA we know the data does not consistently account for emissions related to refrigerant leakage (which can be a large proportion of MEP emissions). Additionally, when comparing the values presented for A1-A5 and A-C it is also clear the assumed replacement cycles for MEP are not aligned with RICS/CIBSE guidance, underestimating embodied carbon. As we have gained more insight into MEP embodied carbon, we have found projects struggle to meet these targets, because we are now accounting for the emissions more accurately. Therefore, a bespoke MEP target should be set at stage 3 based on more recent LCA outputs and the stage 2 results for the project.



|                    | Embodied Carbon Targets kgCO <sub>2</sub> e/m <sup>2</sup> |                                         |                            |
|--------------------|------------------------------------------------------------|-----------------------------------------|----------------------------|
|                    | A1-A5 LETI Band B                                          | A1-A5 NZCBS 2026 (commencement on site) | A-C RIBA 2030 (completion) |
| Substructure       | 84                                                         | 116                                     | 106                        |
| Superstructure     | 132                                                        | 182                                     | 156                        |
| Internal Finishes  | 40                                                         | 55                                      | 75                         |
| FFE                | 4                                                          | 6                                       | 6                          |
| Façade             | 72                                                         | 99                                      | 144                        |
| Building Services* | 64                                                         | 88                                      | 125                        |
| External works     | 4                                                          | 6                                       | 13                         |
| Whole building     | 400                                                        | 550                                     | 625                        |

\*Building Services embodied carbon target should be set at stage 3 based on more recent LCA outputs and the stage 2 results for the project.

*Embodied Carbon Assessment*  
Methodology

# Methodology

## Aligning to Industry Standards

### Definitions

**Product Stage:** Modules A1-A3, Product stages only includes carbon emissions attributed to the extraction and manufacturing of materials only.

**Upfront Embodied Carbon:** Modules A1-A5, Product stage emissions plus those associated with transportation of materials from factory gate to site and their assembly.

**Life Cycle Embodied Carbon:** Modules A1-A5, B1-B5, C1-C and D. Upfront embodied carbon emissions plus emissions associated with maintenance, repair, replacement and refurbishment as well as end of life emissions related to the disposal of materials. Next product system emissions are reported separately.

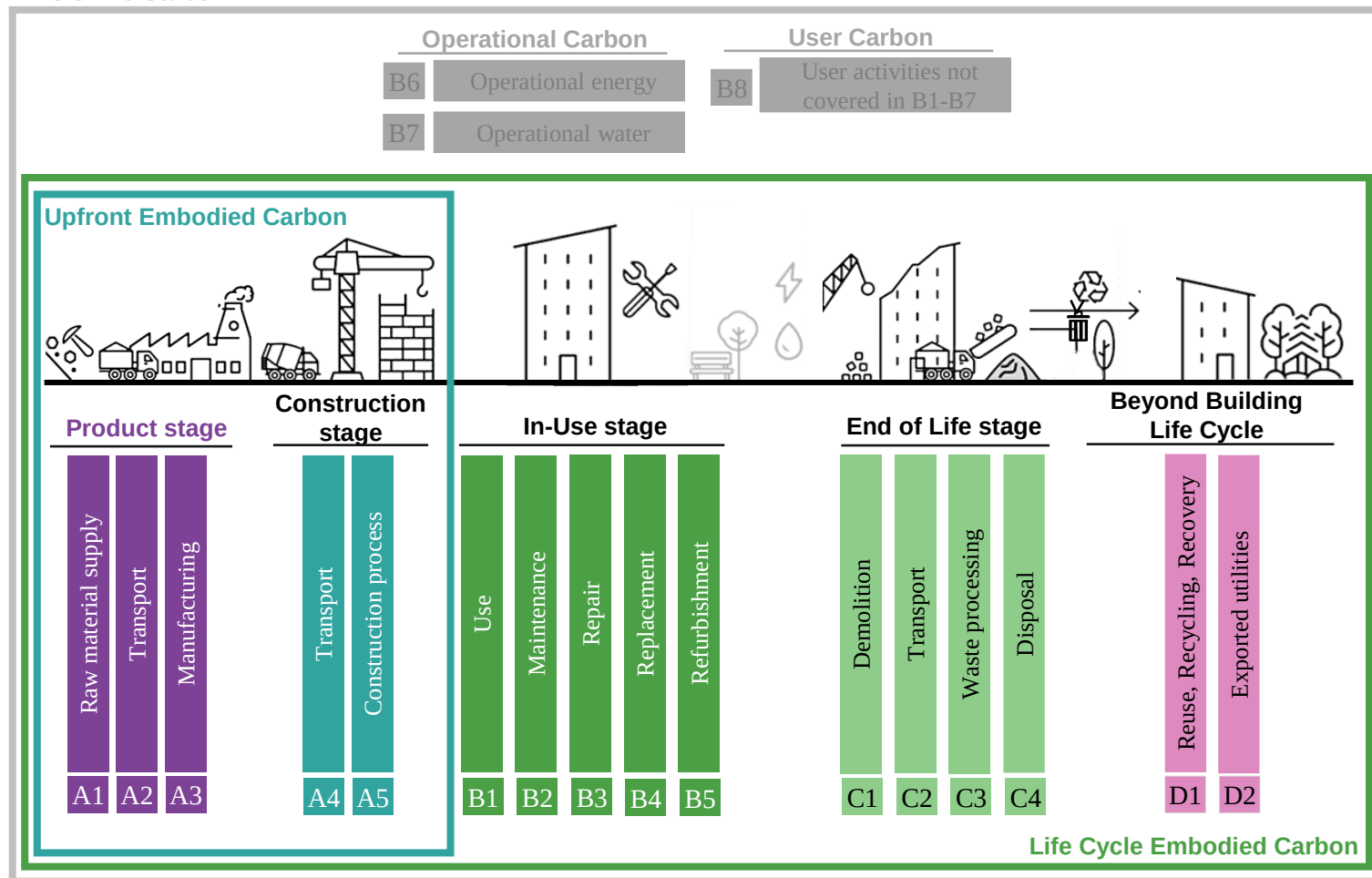
**Whole Life Carbon:** Modules A, B, C and D covering the system boundary for a WLCA over the asset's life cycle. Includes annual operational emissions from energy and water plus life cycle embodied carbon, however this is not within the scope of this assessment.

### Project Scope

For the purpose of this LCA, the **life cycle embodied carbon stage (A, B1-B5, C, 60 years)** is the focus. **The upfront embodied carbon stage (A1-A5)** has been highlighted as the module in which most carbon emissions are concentrated. Benefits beyond the system boundary (D), such as sequestration, are reported separately.

Operational and user carbon is not within the scope of this LCA and has not been included.

### Whole Life Carbon



# Methodology

## Assumptions

This LCA was primarily carried out using OneClick LCA software and is reporting emissions at practical completion (modules A1-A5) and emissions over building life cycle (modules A-C, 60 years). Please see the appendix for more detailed information on the LCA process, generally and as it applies to this project.

### Gross Internal Area

The modelled Gross Internal Area (GIA) is 66,507m<sup>2</sup>, as per the Stage 2 Report.

### Material Specifications and Sizes

The design team have provided the material specification, product types and quantities that have been proposed for the final Stage 2 design and the BREEAM options appraisal schemes.

Due to the early stage of the project, specific suppliers have not yet been determined for all the materials in the design. Therefore, information from representative materials, which reflects the anticipated sourcing location and manufacturing technology for the material in the design, have been chosen from trusted databases.

### Material Life Spans and Building Life

The Reference Study Period (RSP) is assumed as standard to be 60 years for non-domestic projects. This does not mean the building shall only be designed to last for 60 years and is a standard assumption to enable fair comparisons to benchmarks, targets, and other WLCAs. All the materials life spans use the RICS default values and building services components and materials life spans use further guidance from CIBSE Guide M.

### Non-Building Items

Key building and construction aspects use RICS 2<sup>nd</sup> Edition guidance to estimate embodied carbon figures. The following standard practice RICS defined assumptions have been used:

- Construction Site Activities (A5.2) – 40 kgCO<sub>2</sub>e/m<sup>2</sup>
- Maintenance (B2) – greatest value of 10 kgCO<sub>2</sub>e/m<sup>2</sup> or 1% of A1-A5 impacts
- Repair (B3) – 25% of B2 impacts
- End-of-Life Demolition (C2) – 25% of A5.2 impacts

### Arup Benchmarks

For any building elements that cannot be quantified at Stage 2 (i.e. finishes, doors, FF&E, partitions), Arup internal benchmarks were used in lieu of design information. These benchmarks were informed by as-built project data and industry benchmarks and were carefully selected for this project to match the design intent.

As designs progress through the subsequent RIBA stages, the LCA for the Cambridge Halls project should be updated. Benchmarks should be replaced with design information as it becomes available.

### Transport Distances

As suppliers have not yet been specified, the default RICS values based on assumptions of whether materials are generally locally, nationally, European or globally sourced, have been used.

### Software

This WLCA has been undertaken using OneClick LCA software and the appropriate tools:

- ‘Whole life carbon assessment, RICS - 2nd Edition’ for full RICS-scope LCA models
- ‘LCA for BREEAM UK’ for BREEAM models

The OneClick LCA software is compliant with the BS EN 15978, RICS, and BREEAM.



# Methodology

## Completeness of Assessment

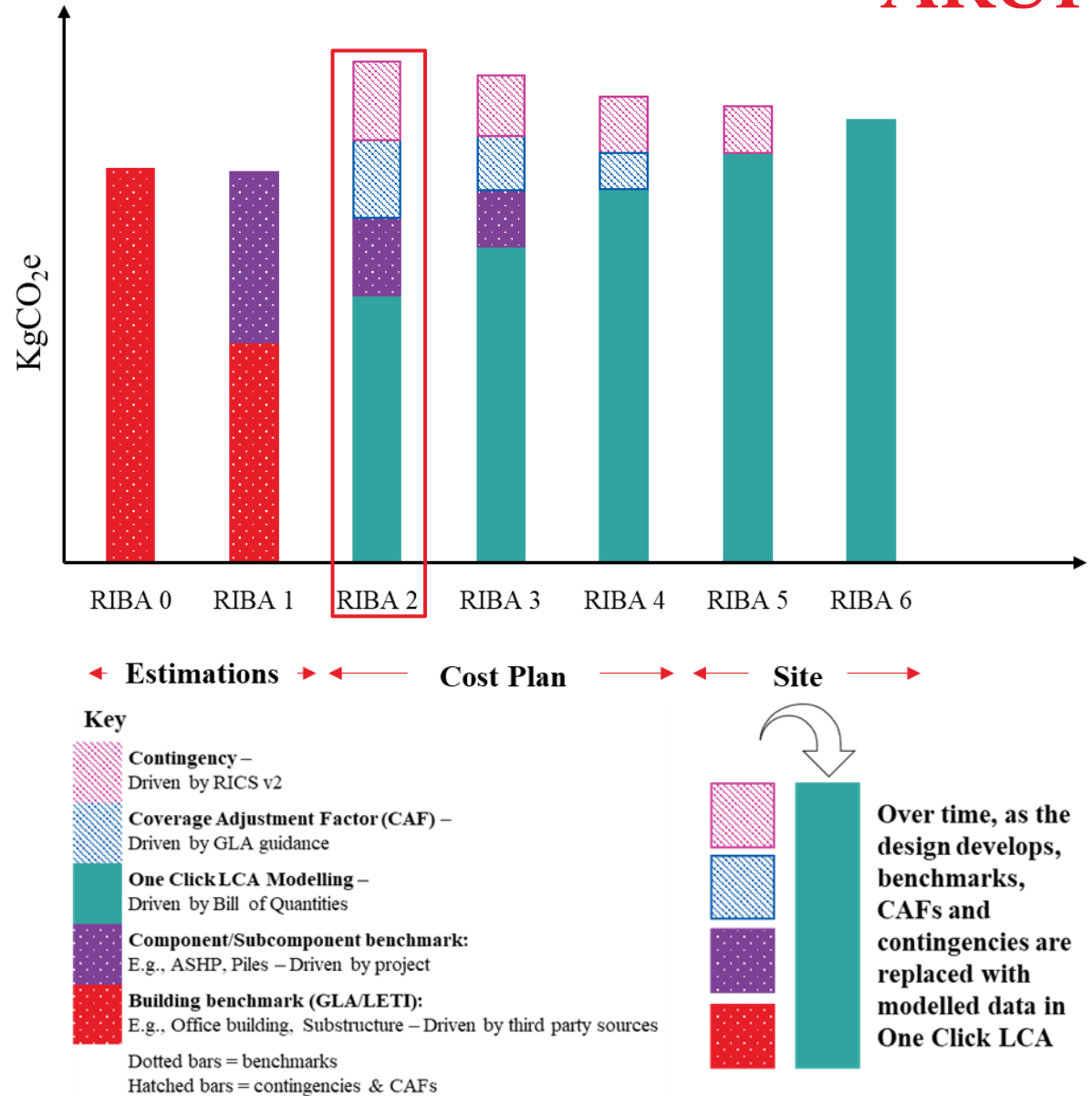
The RICS 2<sup>nd</sup> Edition 'Whole Life Carbon' guidance requires that 95% of the cost of each major element (e.g., substructure, superstructure) is included in the modelling, allowing for some smaller items to be excluded. This approach is based on the correlation between high cost and high environmental impact for materials.

A cost plan was not available for this assessment. Therefore, the assessment has relied on quantities and materials supplied by the design team.

Typically, as highlighted in the diagram in the right, Stage 2 LCAs are based on information from cost plans. This enables several 'known unknown elements' to be accounted for in the assessment through coverage adjustment factors (CAF) based on the apportioned cost to unknown items. As a cost plan has not been used there is potentially several unidentified unknown elements not accounted for in the assessment.

Therefore, to ensure a robust assessment of the carbon, a contingency of 20% has been used. This includes the RICS 2<sup>nd</sup> Edition recommended 15%, and an additional 5% allowance for the unidentified unknowns at this early design stage.

As time progresses, the completeness and accuracy of the assessment will improve due to advanced design development. Therefore, as shown below, the contingency factors, CAF and benchmarks will decrease and will be substituted with One Click modelling of specific material and components.

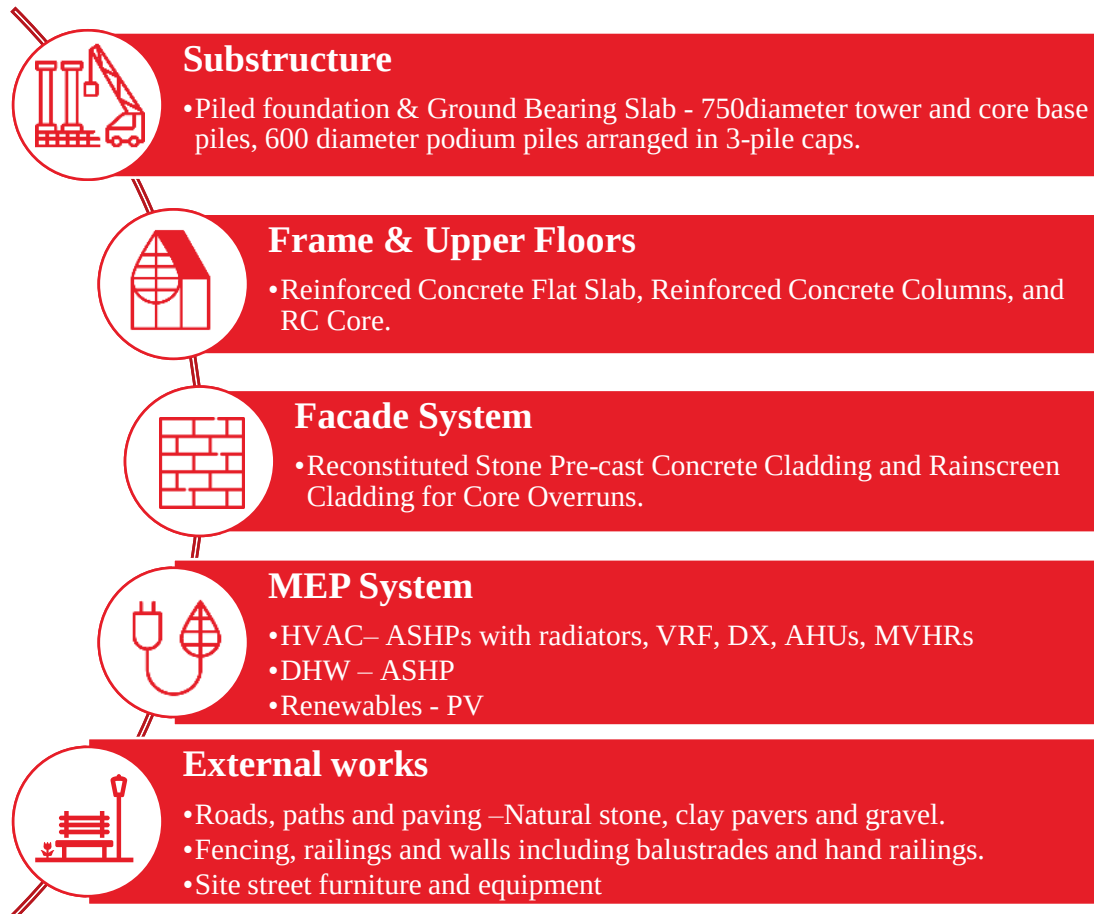


Typical basis of assessment at each RIBA work stage

# Methodology

## Proposed RIBA Stage 2 Development

The Proposed Development has been modelled at Stage 2, with the following design strategies:



## Benchmarks

Due to the early design stage, information was not available for several key building elements:

- Internal Partitions
- Internal Doors
- Finishes
- FF&E

The carbon impact of these aspects has been accounted for using benchmarks which represent typical impacts from these aspects for residential buildings.

# *Embodied Carbon Assessment* Results

# Results

## Embodied Carbon Overview

The **Upfront Embodied Carbon** for S2 approximately **789 kgCO<sub>2</sub>e/m<sup>2</sup> (52492 tCO<sub>2</sub>e)** (A1-A5 excluding sequestration).

The **Whole-life Embodied Carbon** for S2 approximately **1405 kgCO<sub>2</sub>e/m<sup>2</sup> (93,423 tCO<sub>2</sub>e)** (A-C excluding sequestration).

The RIBA Stage 2 Whole Building Life Cycle Analysis demonstrates an estimated life cycle embodied carbon figure (A-C, excluding in-use operational carbon) of 789 kgCO<sub>2</sub>e/m<sup>2</sup> for Cambridge Halls. Upfront embodied carbon (A1-A5) accounts for 57% of the life cycle embodied carbon (A – C). Most of the upfront embodied carbon is derived from the product stages (A1-A3), which includes the raw material extraction, transportation and manufacturing of the necessary materials and products.

The structural frame represents the most carbon-intensive building element in Cambridge Halls, contributing 200 kgCO<sub>2</sub>e/m<sup>2</sup> of upfront embodied carbon. Cambridge Halls is 29 storeys, this building requires extensive concrete structures to support each floor. These load-bearing elements necessitate substantial quantities of concrete and reinforcement steel—materials with inherently high embodied carbon factors.

| Life Cycle Stages              | A1-A5                   |                                    |                                    |                                    | A-C                      |                                    |                                    |                                    |
|--------------------------------|-------------------------|------------------------------------|------------------------------------|------------------------------------|--------------------------|------------------------------------|------------------------------------|------------------------------------|
| Building Element               | Upfront Carbon Baseline |                                    | NZCBS 2026 Target                  | Current Benchmark*                 | Embodied Carbon Baseline |                                    | RIBA 2030 Target                   | Current Benchmark*                 |
|                                | tCO <sub>2</sub> e      | kgCO <sub>2</sub> e/m <sup>2</sup> | kgCO <sub>2</sub> e/m <sup>2</sup> | kgCO <sub>2</sub> e/m <sup>2</sup> | tCO <sub>2</sub> e       | kgCO <sub>2</sub> e/m <sup>2</sup> | kgCO <sub>2</sub> e/m <sup>2</sup> | kgCO <sub>2</sub> e/m <sup>2</sup> |
| Substructure                   | 5976                    | 90                                 | 116                                | 179                                | 6,126                    | 92                                 | 106                                | 204                                |
| Frame                          | 13,314                  | 200                                | 182                                | 281                                | 13,641                   | 205                                | 156                                | 300                                |
| Envelope                       | 4870                    | 73                                 | 99                                 | 153                                | 8,060                    | 121                                | 144                                | 276                                |
| Partitions**                   | 3,325                   | 50                                 | Incl. in frame                     | Incl. in frame                     | 5,321                    | 80                                 | Incl. in frame                     | Incl. in frame                     |
| Internal finishes**            | 6,651                   | 100                                | 55                                 | 85                                 | 14,898                   | 224                                | 75                                 | 144                                |
| FF&E**                         | 1,330                   | 20                                 | 6                                  | 9                                  | 4,655                    | 70                                 | 6                                  | 12                                 |
| Building services              | 7,233                   | 109                                | 88                                 | 136                                | 23,270                   | 350                                | 125                                | 240                                |
| Refrigerant (B1)               |                         |                                    |                                    |                                    | 768                      | 12                                 |                                    |                                    |
| External Works                 | 215                     | 3                                  | 6                                  | 9                                  | 967                      | 15                                 | 13                                 | 24                                 |
| Pre-construction Demo (A5.1)** | 596                     | 9                                  | -                                  | -                                  | 596                      | 9                                  | -                                  | -                                  |
| Site Emission (A5.2)**         | 2660                    | 40                                 | -                                  | -                                  | 2,660                    | 40                                 | -                                  | -                                  |
| Repair & Maintenance (B2&B3)   | -                       | -                                  | -                                  | -                                  | 1,487                    | 22                                 | -                                  | -                                  |
| EOL demolition (C1)            | -                       | -                                  | -                                  | -                                  | 665                      | 10                                 | -                                  | -                                  |
| Assessment Total               | 46170                   | 694                                | 550                                | 850                                | 83,114                   | 1250                               | 625                                | 1200                               |
| Contingency                    | 6321                    | 95                                 | -                                  | -                                  | 10,299                   | 155                                | -                                  |                                    |
| Grand Total                    | 52492                   | 789                                | 550                                | 850                                | 93,423                   | 1405                               | 625                                | 1200                               |

\*Based on GLA benchmarks and RIBA business as usual values for residential buildings, contingency is not applied to benchmarks.

\*\*Based on GLA benchmarks for residential buildings, contingency is not applied to benchmarks.

# Results

## Embodied Carbon Overview

Building services is a significant contributor to Cambridge Hall's life cycle embodied carbon. The building services contribution is greater to the whole life cycle embodied carbon compared to the upfront carbon due to the component's shorter life spans and frequent replacement cycles relative to structural and façade aspects. Building services account for 38% of the total in-use (module B) embodied carbon for Cambridge Halls.

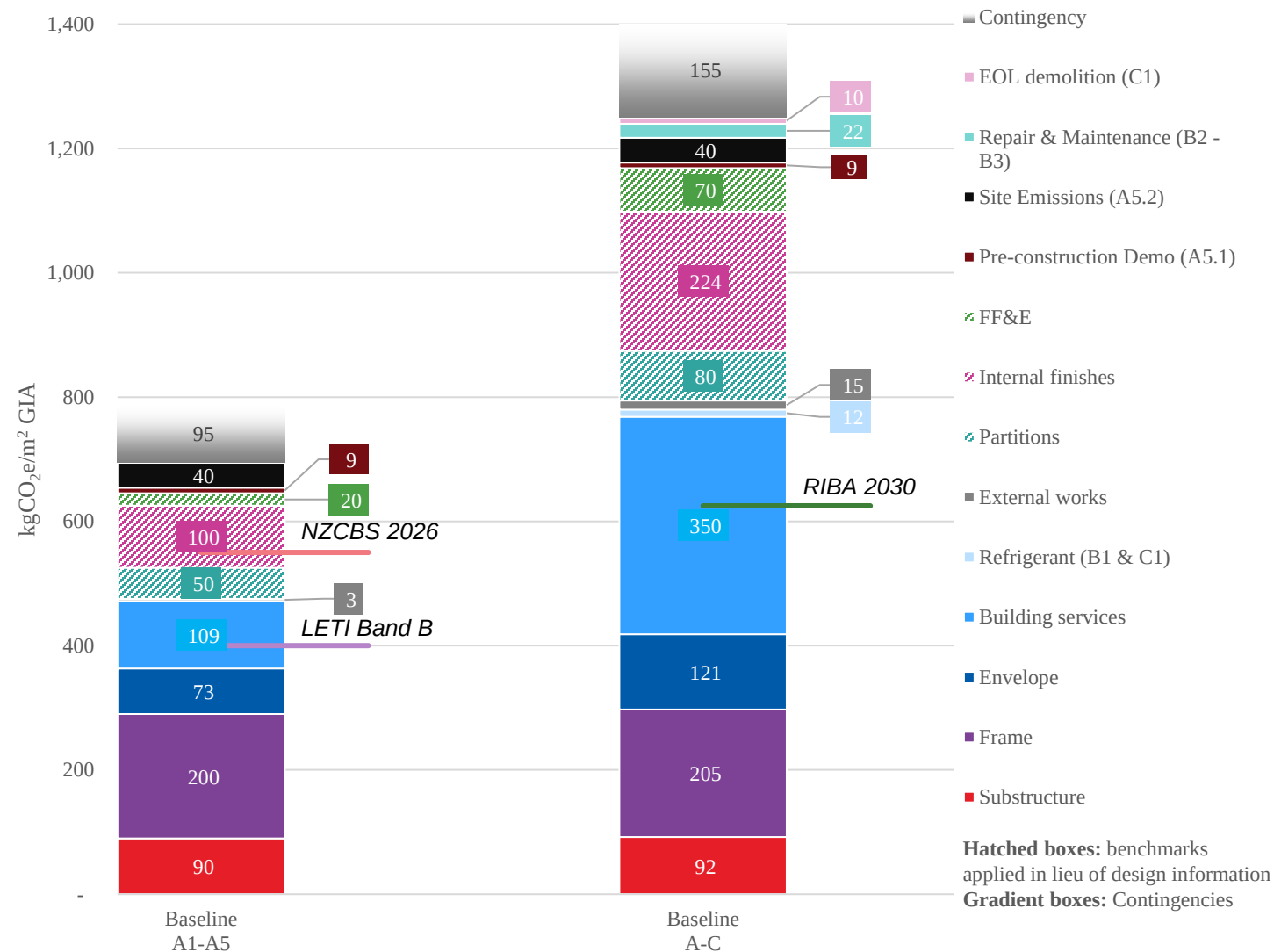
Structural elements, including frame and substructure, are also key contributors to Cambridge Hall's embodied carbon. In particular, structural elements are the biggest contributor to the upfront embodied carbon accounting for 37%.

As Unite has most control over upfront embodied carbon emissions, and structural elements account for most of these, reduction of emissions from the structure should be a key focus going into the Stage 3 design.

21.5% of the upfront carbon impacts come from FF&E, Partitions, and Finishes building aspects which have been accounted for with benchmarks due to a lack of design information. In the following design stages, the LCA results should be updated based on specific information.

As previously noted, Unite's ambition to align with the RIBA 2030 target will be challenging given the current standard practice across the industry falls well short of this target. The following section highlights carbon reduction measures which could be implemented to close the gap to this target. Presented carbon reduction measures target the carbon hot spots this study has identified, detailed on the next page.

RICS Ed.2 Embodied Carbon Results [kgCO<sub>2</sub>e/m<sup>2</sup> GIA]



# Results

## Material Hotspots

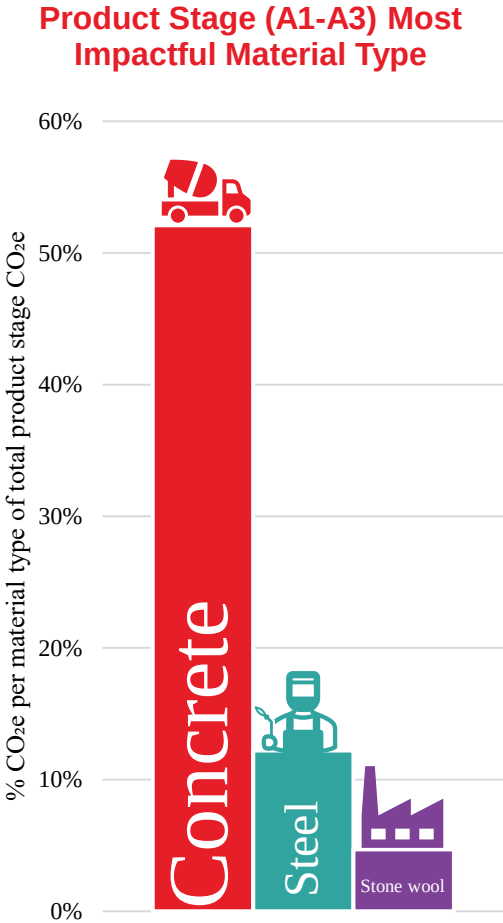
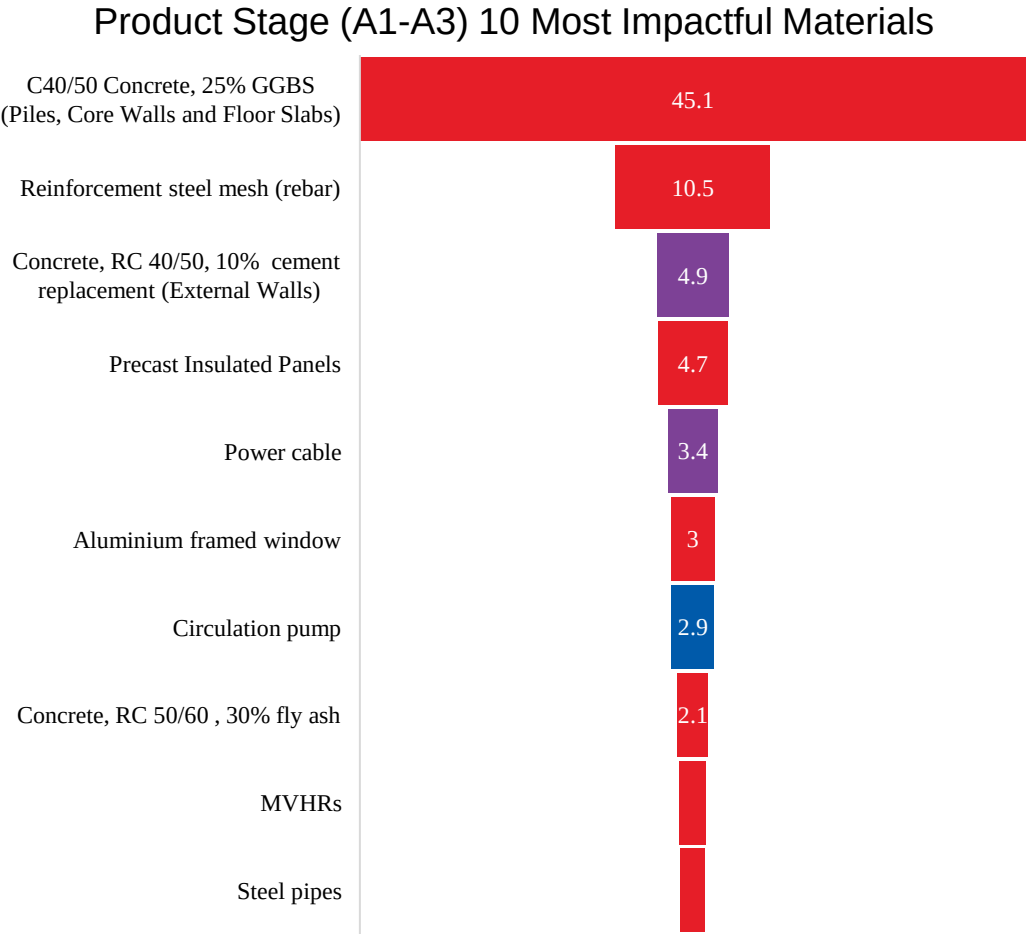
Cambridge Halls most impactful material is Ready-mix concrete RC 40/50, 25% GGBS accounting for 45% of the product stage embodied carbon. The concrete is primarily used in the substructure and superstructure in the piles and floor slabs. The second most impactful material is steel accounting for 10.5% of the embodied carbon ,which primarily derives from steel reinforcement in the concrete.

Most of the concrete used in the Cambridge halls WS2 baseline LCA model has 25% GGBS cement replacement, which is aligned with RICS Ed.2 Guidance.

This highlights that a significant carbon saving could be derived from using a concrete with a lower carbon factor, such as a concrete with a greater proportion of GGBS. Since GGBS is a byproduct of manufacturing iron and steel with blast arc furnaces, there is a limited global supply of GGBS, as electric arc furnaces are increasingly being used to manufacture iron and steel.

The head of climate action at the IStructE stated “A project using GGBS will reduce its emissions by using less cement, but that means another project somewhere else in the world will have to use more cement, so overall, on a global scale, nothing changes.” Therefore, specifying increased quantities of GGBS should be carefully considered.

Thus, it is recommended that during RIBA Stage 3, the design team should aim to optimise the substructure and superstructure design where feasible, to reduce the total quantity of concrete and steel reinforcement bar needed in Cambridge Halls.



*Embodied Carbon Assessment*

Carbon Reduction Opportunities

# Carbon Reduction Opportunities

## Summary

This report highlights various carbon hotspots in the Cambridge Halls project which the design team should focus on in the following design stages to prioritise their carbon reduction efforts. The table below summarises some of the carbon reduction opportunities that should be explored by the design team. These are explored in more detail in the *Carbon Reduction Opportunities Report* issued by Arup.

| Opportunity                                                                    | Responsibility                             | Action                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|--------------------------------------------------------------------------------|--------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Increased GGBS Content and                                                     | Structural Engineers                       | Increasing the GGBS content in concrete to 50% presents a significant opportunity to reduce embodied carbon. Specifying increased quantities of GGBS should be carefully considered, as this may divert resources from other projects.                                                                                                                                                                                                                                                                                                                                                           |
| Low Carbon Rebar                                                               | Structural Engineers                       | Incorporating Xcarb for reinforcement steel can reduce upfront embodied carbon emissions. When specifying any electric arc steel, the global impact on carbon reductions should be considered as there is limited supply within the industry.                                                                                                                                                                                                                                                                                                                                                    |
| Low Carbon Façade                                                              | Architect                                  | High-quality double-glazing units with argon gas between panes offers a lower-carbon alternative to triple glazing units, whilst still maintaining high levels of thermal performance. Research has found this approach provides an estimated 23% reduction in glazing embodied carbon compared to typical triple glazing units.                                                                                                                                                                                                                                                                 |
| Efficient MEP Distribution Layouts                                             | MEP Engineers                              | More comprehensive modelling of the ductwork, pipework, containment and cabling will enable an exploration of lower carbon routing choices, as well as more accurate measurement of the MEP distribution emissions.                                                                                                                                                                                                                                                                                                                                                                              |
| Specification and procurement of finishes, fittings, furnishing and equipment. | Architects, Contractor, Interior Designers | It is important for the team to consider the replacement cycles and longevity of products in specification and procurement, as short product lifecycles will typically increase Stage A-C whole life carbon results overall.                                                                                                                                                                                                                                                                                                                                                                     |
| Integrating Circular Economy Principles                                        | Design Team, Contractor, Unite, and MMU    | <ul style="list-style-type: none"> <li>Explore the opportunity to provide material passports for high impact materials (steel, concrete, glazing, large MEP equipment).</li> <li>The Stage 2 design already includes re-using brick from the existing structures onsite. Consider whether bricks that aren't able to be re-used within walls could be utilised in landscaping or as crushed aggregate for sub bases.</li> <li>Where equipment and distribution is available from other buildings this could be tested and then reused where salvageable components can be integrated.</li> </ul> |
| Stage 3 and 4 Review process                                                   | All; led by Sustainability Consultant      | This WLCA should be updated in line with changes to the design during work stage 3 and 4. Additionally, more specific materials should be used as further specifications are made. This will ensure that there is an accurate assessment of embodied carbon data and current assumptions can be verified or amended. Efforts should be made to align the assessment to a cost plan and to capture the FFE, finishes, and internal walls and partitions items which have been accounted for using benchmarks due to lack of information at Stage 2.                                               |

*BREEAM Optioneering Assessment*

BREEAM Mat01 Results

# BREEAM

## Overview

BREEAM (Building Research Establishment's Environmental Assessment Method) is the world's leading and most widely used environmental assessment method for buildings. It sets the standard for best practice in sustainable design and has become the de facto measure used to describe a building's environmental performance.

BREEAM embraces a wide range of topics which cover the whole construction process, from site selection through to handover and post-occupancy evaluation. The sustainability aspects covered within BREEAM are split into ten categories.

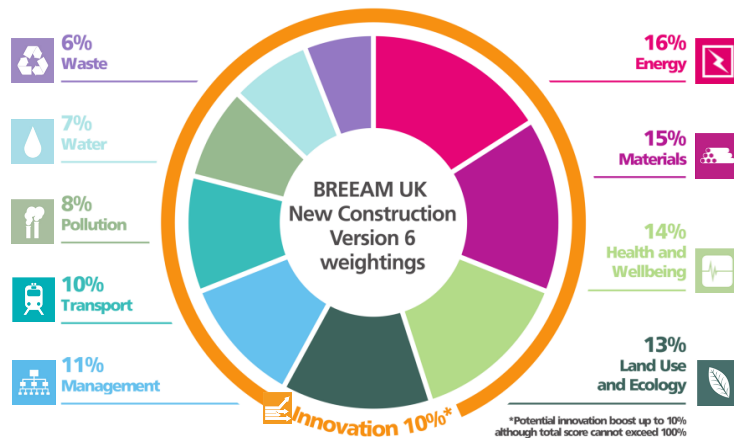


Image taken from BREEAM UK New Construction V6 manual

## Targeted Credits

The BREEAM UK New Construction V6, Mat 01 issue 'Environmental impacts from construction products - Building life cycle assessment (LCA)' includes seven credits (Criteria 1 to 7) and three exemplary credits (Criteria 8 to 18) are available.

The following Mat01 criterion are targeted for the MMU Cambridge Halls development, thus aiming to achieve 5 BREEAM credits at concept design.

### Superstructure

#### Criterion 1:

Comparison with the BREEAM LCA benchmark during Concept Design. (Office, industrial and retail buildings only)

#### Criterion 2:

Comparison with the BREEAM LCA benchmark during Technical Design. (Office, industrial and retail buildings only)

#### Criterion 3-5:

**Carry out building LCA options appraisal of 2 to 4 significantly different superstructure design options during concept design. (All building types)**

**Targeted**

### Substructure

#### Criterion 6 & 7:

**Substructure and hard landscaping options appraisal during Concept Design. (All building types)**

**Targeted**

### Exemplary Level Criteria

#### Criterion 8 & 9:

Core building services options appraisal during Concept Design. (All building types)

#### Criterion 10-14:

LCA and LCC alignment. (All building types)

#### Criterion 15-18:

Third party verification. (All building types)

# BREEAM

## Building Design Options- Superstructure

This report is a point in time LCA from an appraisal of four options for the superstructure during the RIBA WS2 of the MMU Cambridge Halls development. The results section of this report considers the embodied carbon impacts of all four options.

The preferred design choice was baseline design “Option 1- Reinforced Concrete Flat Slab.”

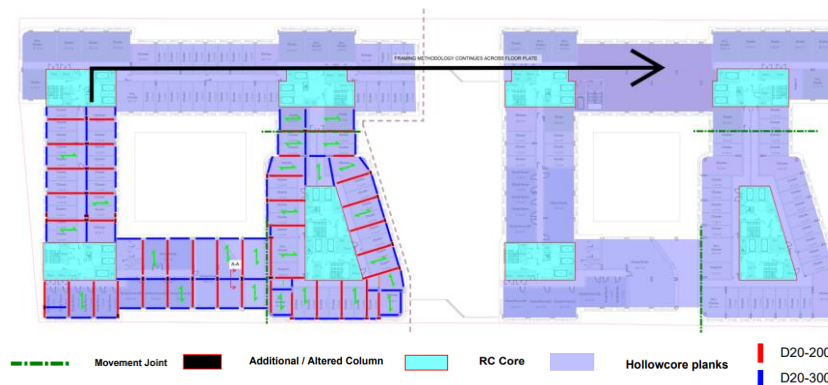
Since this appraisal the chosen design (option 1) has been refined. Therefore, the results for the full building LCA presented in the earlier sections of the report differ to the results presented within this BREEAM section of the report.

This has allowed for fair comparative assessment to take place, as the design team are not refining design options that are not being taken forward.

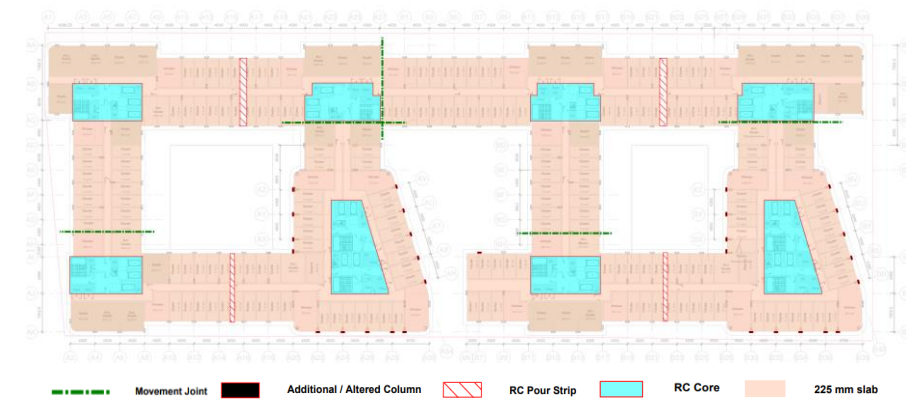
Option 1- Reinforced Concrete Flat Slab



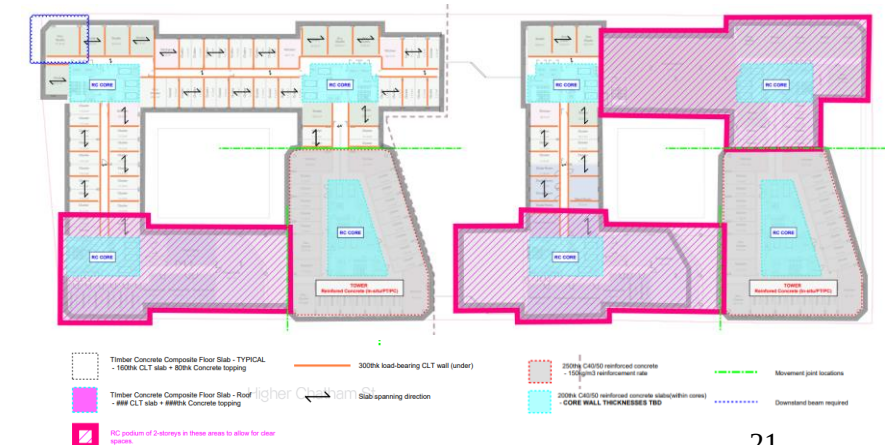
Option 3- Precast Slab



Option 2- Post-Tensioned Flat Slab



Option 4- Hybrid Timber-Concrete Frame



# BREEAM

## Building Design Options – Substructure and Hard Landscaping

This report is a point in time LCA from an appraisal of two substructure options and four hard landscaping options during the RIBA WS2 of the MMU Cambridge Halls development. The results section of this report considers the embodied carbon impacts of all six options.

The preferred design choices were the baseline designs:

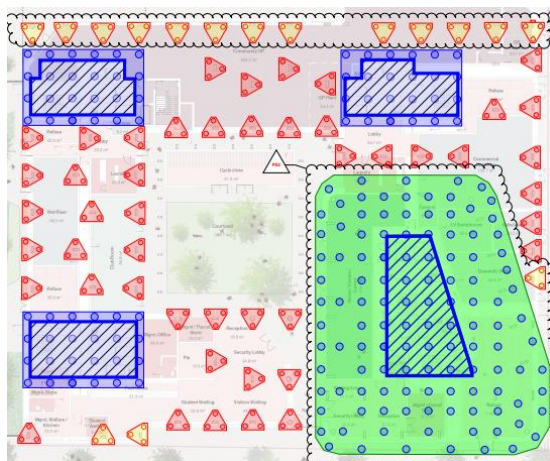
- Option 1: Substructure Baseline
- Option 2: Hard Landscaping Baseline

Since this appraisal, the chosen substructure design (option 1) has been refined. Therefore, the results for the full building LCA presented in the earlier sections of the report differ to the results presented within this BREEAM section of the report.

This has allowed for fair comparative assessment to take place, as the design team are not refining design options that are not being taken forward.

### Option 1: Substructure Baseline

Piled Foundation - 3-pile caps (750dia & 600dia piles)



### Option 4: Hard Landscaping Alternative 1

- Natural stone paving
- Clay pavers
- Exposed aggregate concrete surfaces



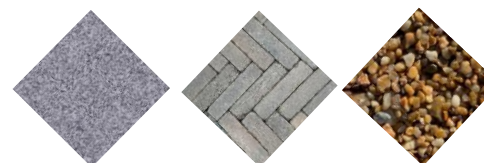
### Option 2: Hard Landscaping Baseline

- Natural stone paving
- Clay pavers
- Breedon gravel surfaces



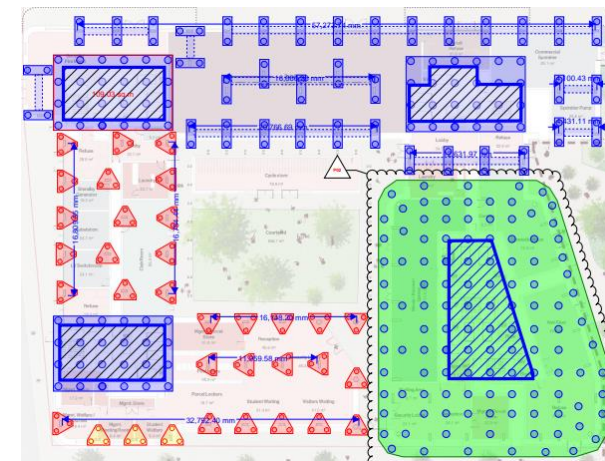
### Option 5: Hard Landscaping Alternative 2

- Chinese granite paving
- Concrete Dutch style pavers
- Porous resin bound gravel surfaces



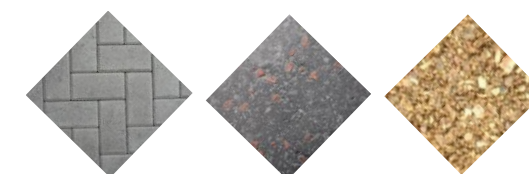
### Option 3: Substructure Alternative 1

Piled Foundation – twin pile caps & 3-pile caps (750dia piles) with ground beams



### Option 6: Hard Landscaping Alternative 3

- High quality concrete block paving
- HRA with coloured chippings
- Self binding gravel surfaces



# BREEAM

## BREEAM Method

BREEAM provides an accepted methodology for LCAs and outlines which elements should be in-scope to ensure an appropriate level of comparability between assessments. The tables below outline the in-scope elements for Superstructure, Substructure and Hard Landscaping. These building elements, where present, have been included in the relevant BREEAM models.

The OneClick LCA for BREEAM UK tool is included in the 'Building LCA tools recognised by BREEAM' list. For the BREEAM options comparison, the 'OneClick LCA (LCA for BREEAM UK)' materials database was used.

| Superstructure- In-scope      |    | Substructure & Hard Landscaping In-scope          |                             |                                                                                                                                                                                                                                                                                                      |                                |
|-------------------------------|----|---------------------------------------------------|-----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|
| 1. Frame                      | 1. | Steel frames                                      | 1. Substructure             | 1.                                                                                                                                                                                                                                                                                                   | Standard foundations           |
|                               | 2. | Space decks                                       |                             | 2.                                                                                                                                                                                                                                                                                                   | Specialist foundation systems  |
|                               | 3. | Concrete casings to steel frames                  |                             | 3.                                                                                                                                                                                                                                                                                                   | Lowest floor construction      |
|                               | 4. | Concrete frames                                   |                             | 4.                                                                                                                                                                                                                                                                                                   | Basement excavation            |
|                               | 5. | Timber frames                                     |                             | 5.                                                                                                                                                                                                                                                                                                   | Basement retaining walls       |
|                               | 6. | Other frame systems                               |                             |                                                                                                                                                                                                                                                                                                      |                                |
| 2. Upper floors               | 1. | Floors                                            | 2. Roads, paths and pavings | 1.                                                                                                                                                                                                                                                                                                   | Roads, paths and pavings       |
| 3. Roof                       | 1. | Roof structure                                    |                             | 2.                                                                                                                                                                                                                                                                                                   | Special surfacings and pavings |
|                               | 2. | Roof coverings                                    |                             | Include hard landscaping that is installed as part of the project under assessment and: <ul style="list-style-type: none"><li>• Is within a defined curtilage of the building</li><li>• Or is clearly more associated with it</li></ul> Hard landscaping with no such distinction shall be excluded. |                                |
|                               | 3. | Specialist roof systems                           |                             |                                                                                                                                                                                                                                                                                                      |                                |
|                               | 4. | Rooflights, skylights and openings                |                             |                                                                                                                                                                                                                                                                                                      |                                |
| 4. Stairs and ramps           | 1. | Stair or ramp structures                          |                             |                                                                                                                                                                                                                                                                                                      |                                |
| 5. External walls             | 1. | External enclosing walls above ground floor level |                             |                                                                                                                                                                                                                                                                                                      |                                |
|                               | 2. | External enclosing walls below ground level       |                             |                                                                                                                                                                                                                                                                                                      |                                |
|                               | 3. | Solar or rain screening                           |                             |                                                                                                                                                                                                                                                                                                      |                                |
| 6. Windows and external doors | 1. | External windows                                  |                             |                                                                                                                                                                                                                                                                                                      |                                |

## Key Notes

### Normalisation to gross internal area (GIA)

The summary visuals presented in this report are normalised to the building GIA at the time of the options appraisal because current carbon reporting standards in the UK are primarily based on the kgCO<sub>2</sub>e/m<sup>2</sup> GIA metric. This GIA was 65377m<sup>2</sup>, which is marginally lower than the GIA of the current building assessed in the previous sections of this report. The BREEAM Mat 01 reporting tool normalises WLC impacts to NIA. Therefore, the visuals presented in this report differ from the numbers submitted in the BREEAM Mat 01 tool.

### Transport Emission Factors

BREEAM environmental impact factors for transport (A4 emissions) are substantially lower than those recommended in recent UK WLCA practice. For the transport distances, the latest industry guidance from RICS 2<sup>nd</sup> Edition Professional Statement was followed. Although RICS 2<sup>nd</sup> Edition recommends two transport legs, the OneClick BREEAM tool only allows inputs for one transport leg therefore the guidance for the first leg was used. This means A4 emissions are under-represented by the BREEAM Mat 01 results.

### Construction Site Emissions (A5)

For the construction site emission, the RICS 2<sup>nd</sup> Edition suggests a default value of 40 kgCO<sub>2</sub>e/m<sup>2</sup> is for the entire building. However, for the options appraisal, this module was not included in the results as all options will have an identical site emissions value, having no effect on the comparative analysis. However, the excavation impact of the soil was considered for all the substructure elements under module A5.

# Results

## Superstructure Options appraisal

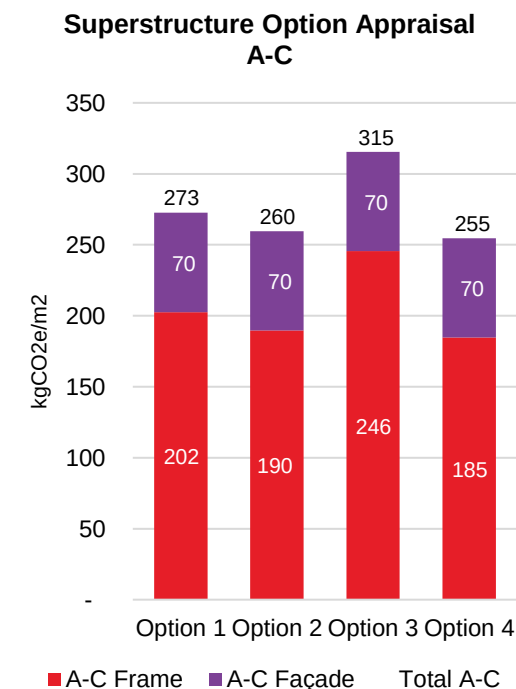
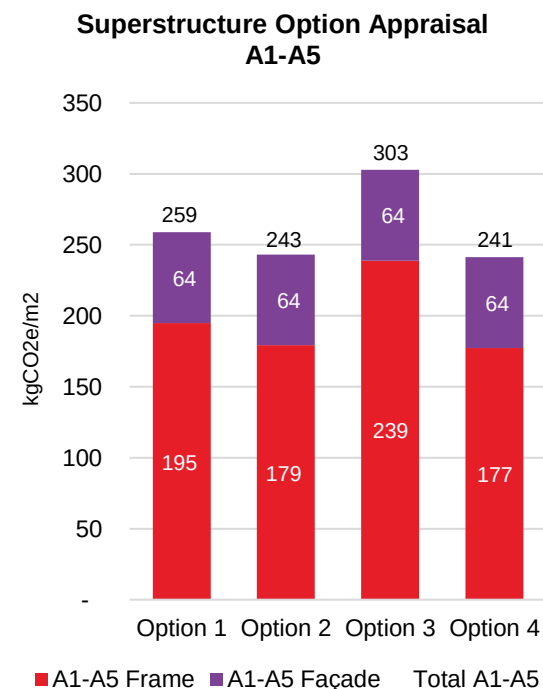
4no. substantially different design options were considered at RIBA Stage 2 to understand the embodied carbon impact of different superstructure typologies; they are presented in the table below:

| Superstructure Options                  | Description                                                                         | Chosen Option |
|-----------------------------------------|-------------------------------------------------------------------------------------|---------------|
| <b>Option 1</b><br>Mat01_CD_SuperS_Opt1 | Reinforced Concrete Flat Slab<br>Aluminium cladding panels and precast stone panels | X             |
| <b>Option 2</b><br>Mat01_CD_SuperS_Opt2 | Post-Tensioned Flat Slab<br>Aluminium cladding panels and precast stone panels      |               |
| <b>Option 3</b><br>Mat01_CD_SuperS_Opt3 | Precast Slab<br>Aluminium cladding panels and precast stone panels                  |               |
| <b>Option 4</b><br>Mat01_CD_SuperS_Opt4 | Hybrid Timber-Concrete Frame<br>Aluminium cladding panels and precast stone panels  |               |

The results presented on this page have been categorised into Frame and Façade. Below outlines which sub-elements have been included within each category:

- **Frame:** frame, floors, roofs, roof coverings & stairs.
- **Façade:** external walls, windows and external doors.

|                                                             | A1-A5<br>Frame | A-C<br>Frame | A1-A5<br>Façade | A-C<br>Façade | A1-A5<br>Total | A-C<br>Total |
|-------------------------------------------------------------|----------------|--------------|-----------------|---------------|----------------|--------------|
| <b>Option 1</b><br>(kgCO <sub>2</sub> e/m <sup>2</sup> GIA) | 195            | 202          | 64              | 70            | 259            | 273          |
| <b>Option 2</b><br>(kgCO <sub>2</sub> e/m <sup>2</sup> GIA) | 179            | 190          | 64              | 70            | 243            | 260          |
| <b>Option 3</b><br>(kgCO <sub>2</sub> e/m <sup>2</sup> GIA) | 239            | 246          | 64              | 70            | 303            | 315          |
| <b>Option 4</b><br>(kgCO <sub>2</sub> e/m <sup>2</sup> GIA) | 177            | 185          | 64              | 70            | 241            | 255          |



# Results

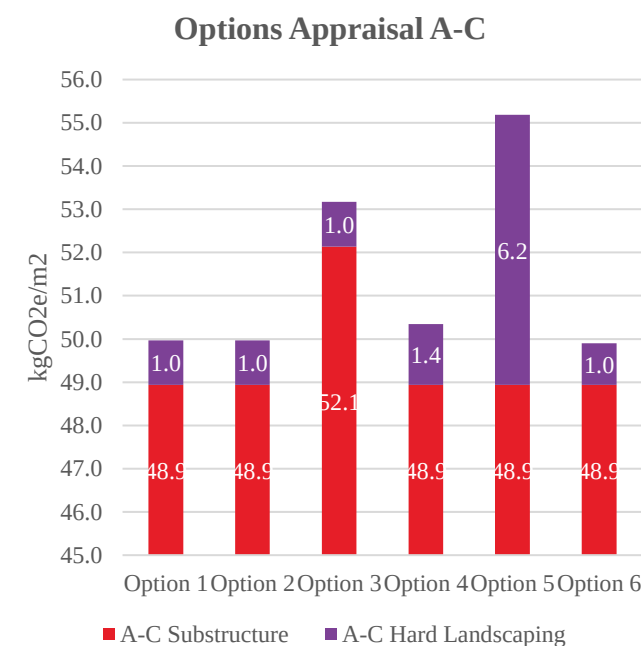
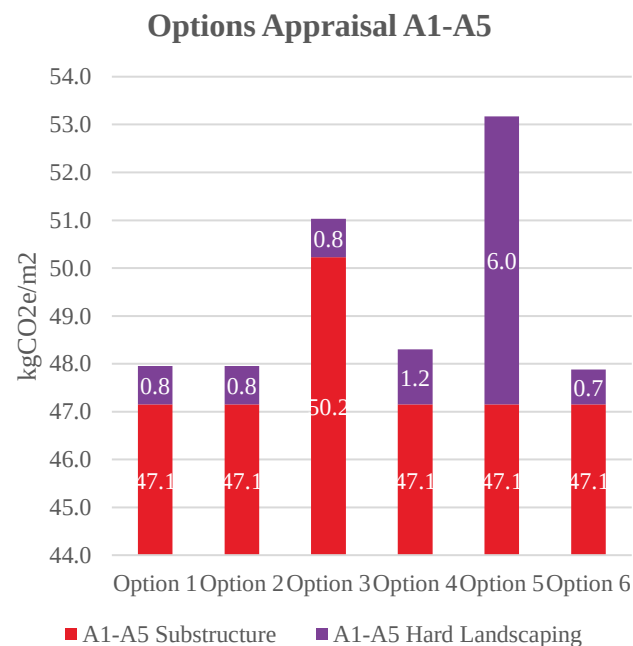
## Substructure and Hard Landscaping

| Substructure and Hard Landscaping Options | Description                                                                                                   | Chosen Option |
|-------------------------------------------|---------------------------------------------------------------------------------------------------------------|---------------|
| <b>Option 1</b><br>Mat01_CD_SubS_HL_Opt1  | Three-pile pile caps<br>Natural stone, clay pavers, and Breedon gravel surfacing                              | X             |
| <b>Option 2</b><br>Mat01_CD_SubS_HL_Opt2  | Three-pile pile caps<br>Natural stone, clay pavers, and Breedon gravel surfacing                              | X             |
| <b>Option 3</b><br>Mat01_CD_SubS_HL_Opt3  | Twin pile caps with ground beams<br>Natural stone, clay pavers, and Breedon gravel surfacing                  |               |
| <b>Option 4</b><br>Mat01_CD_SubS_HL_Opt4  | Three-pile pile caps<br>Natural stone, clay pavers, and exposed aggregate concrete surfacing                  |               |
| <b>Option 5</b><br>Mat01_CD_SubS_HL_Opt5  | Three-pile pile caps<br>Chinese granite, concrete Dutch style pavers, and resin bound gravel surfacing        |               |
| <b>Option 6</b><br>Mat01_CD_SubS_HL_Opt6  | Three-pile pile caps<br>Concrete block paving, HRA with coloured chippings, and self binding gravel surfacing |               |

The results presented on this page have been categorised into Substructure and Hard Landscaping. Below outlines which sub-elements have been included within each category:

- **Substructure:** foundations.
- **Hard Landscaping:** roads, paths, and paving.

| (kgCO <sub>2</sub> e/m <sup>2</sup> GIA) | A1-A5 Substructure | A-C Substructure | A1-A5 Hard Landscaping | A-C Hard Landscaping | A1-A5 Total | A-C Total |
|------------------------------------------|--------------------|------------------|------------------------|----------------------|-------------|-----------|
| <b>Option 1</b>                          | 47.1               | 48.9             | 0.8                    | 1.0                  | 48.0        | 50.0      |
| <b>Option 2</b>                          | 47.1               | 48.9             | 0.8                    | 1.0                  | 48.0        | 50.0      |
| <b>Option 3</b>                          | 50.2               | 52.1             | 0.8                    | 1.0                  | 51.0        | 53.2      |
| <b>Option 4</b>                          | 47.1               | 48.9             | 1.2                    | 1.4                  | 48.3        | 50.3      |
| <b>Option 5</b>                          | 47.1               | 48.9             | 6.0                    | 6.2                  | 53.2        | 55.2      |
| <b>Option 6</b>                          | 47.1               | 48.9             | 0.7                    | 1.0                  | 47.9        | 49.9      |



# Appendix

## A.1 Guidance on use of LCA

The WLCA should primarily be used as a process for understanding embodied carbon impact and supporting the consideration of embodied impacts in decision-making. While LCA is also used for reporting whole-building embodied carbon footprints (e.g. for disclosure and benchmarking), it is important to note that such a value (and values for building element categories) are susceptible to change.

While a key aim is for the LCA model to represent the project as accurately as possible, reported carbon impacts can vary due to a number of reasons including the LCA software/tool used, information inputs/availability of design detail (i.e. quantities, build-ups and specifications) and changes to carbon factors above and continually updated software, databases and EPD data. The reported carbon impact should be considered with this in mind, and attention given to the use of LCA as a process and decision-making aid, rather than focussing solely on the final reported value.

Generally, it is expected that the overall modelled carbon footprint of the project will change with different iterations of the model. This change could be net positive or net negative and is not necessarily reflective of carbon savings made within specific elements of the project. For example, it is often the case that little information is available regarding the design of internal finishes, FF&E and building services in the early stages of design and therefore these element categories above and susceptible to adjustments, often increases, in embodied carbon as more detailed design information becomes available at later stages. Such adjustments should be viewed in the context of the design detail available, and the variables noted above and should not detract from embodied carbon efficiencies achieved through the design (and through the use of the LCA process) which would minimise any potential net increase.

### WLCA Purpose

- **Environmental Accountability:** It assesses environmental impact across an asset's life cycle, from construction to decommissioning.
- **Holistic Decision-Making:** WLCA informs decisions by balancing environmental, economic, and social factors, ensuring sustainable outcomes.
- **Climate Resilience:** It ensures infrastructure projects withstand climate change, considering extreme weather events and rising sea levels.
- **Biodiversity and Circular Economy:** WLCA integrates these principles, promoting responsible resource use.
- **Transparency and Collaboration:** WLCA fosters collaboration among stakeholders, clarifying roles and responsibilities.

### Key Consideration for Design Teams

- **Resource Constraints:** Prioritize significant components due to limited resources.
- **Level of Confidence:** Balance precision and practicality.
- **Holistic View:** Consider interactions among elements.
- **Thresholds:** Focus on critical aspects.
- **Iterative Evolution:** Recognize that carbon assessments evolve over time due to changing inputs, methodologies, and assumptions.

### Key Consideration for WLCA Practitioners

- **Dynamic Nature:** Carbon assessments are highly likely to evolve during a project's multi-year lifespan.
- **Inputs and Methodologies:** Expect changes in data availability, scientific understanding, and assessment methodologies.
- **Guidance Updates:** Stay informed about evolving industry guidance and standards.
- **Adaptive Reporting:** Develop a reporting framework that accommodates updates without disrupting project continuity.
- **Scenario Analysis:** Consider alternative scenarios to assess sensitivity to changing inputs.
- **Documentation:** Rigorously document assumptions, data sources, and methodologies.
- **Stakeholder Communication:** Transparently communicate changes to stakeholders.
- **Continuous Learning:** Embrace a learning mindset and adapt assessments as needed.

## A.2 Glossary of terms

**BIM:** Building Information Model (BIM) is a digital representation of physical and functional characteristics of a construction project. A BIM is a shared knowledge resource for information which helps to form a basis for decisions during the lifecycle of the construction project.

**Carbon dioxide equivalent (CO<sub>2</sub>e):** A measure used to compare the emissions from various greenhouse gases based upon their global warming potential in a common unit over a 100-year period. E.g. 1 kg of methane is converted into the amount of CO<sub>2</sub> needed to cause the same effect, in this case 23 kg. Therefore 1 Kg methane has a CO<sub>2</sub> equivalent of 23.

**Embodied carbon at Practical Completion:** Carbon emissions arising from the product stages (A1-A3) and construction process stages (A4-A5).

**Embodied carbon over Life Cycle:** Carbon emissions arising from the product stages (A1-A3), construction process stages (A4-A5), use stages (B1-B5) and end-of-life stages (C1-C4).

**Environmental impact:** A change to the environment, whether adverse or beneficial, wholly or partially, resulting from environmental aspects.

**Greenhouse gas:** Any atmospheric gas which absorbs thermal radiation emitted by the Earth's surface. This traps heat in the atmosphere and keeps the surface at a warmer temperature than would otherwise be possible.

**Greenhouse effect:** The greenhouse effect is the process by which radiation from a planet's atmosphere warms the planet's surface to a temperature above what it would be without its atmosphere.

**Global Warming Potential (GWP):** The standard metric used to calculate CO<sub>2</sub>-equivalent emissions of different greenhouse gases in carbon budgets and the Kyoto Protocol. GWP measures the total radiative forcing over a given period (usually 100 years) after a pulse emission, relative to that from the same mass of CO<sub>2</sub>.

**IMPACT (Integrated Material Profile And Costing Tool):** A specification and database for software developers to incorporate into their tools to enable consistent Life Cycle Assessment

(LCA) and Life Cycle Costing (LCC). IMPACT compliant tools work by allowing the user to attribute environmental and cost information to drawn or scheduled items in the BIM. Put simply, IMPACT takes quantity information from the BIM and multiplies this by environmental impact and/or cost 'rates' to produce an overall impact and cost for the whole (or a selected part) of the design.

**Life cycle:** consecutive and interlinked stages on the life of the object under consideration.

**Life Cycle Assessment (LCA):** is a process to evaluate the environmental burdens associated with a product, process or activity:

- By identifying and quantifying energy and materials used and wastes released to the environment;
- To access the impact of those energy and materials used and releases to the environment; and
- To identify and evaluate opportunities to affect environmental improvements.

The assessment includes the entire life cycle (from cradle to grave) of the product, process or activity encompassing extracting and processing of raw materials, manufacturing, transportation and distribution; use and re-use; maintenances; recycling and final disposal.

**Recycling:** Recycling is the process of converting waste materials into new materials and objects. A recovery operation by which waste materials are reprocessed into products, materials or substances either for the original purpose or other purposes.

**Refurbishment:** Modification and improvements to an existing building in order to bring it up to an acceptable condition.

**Whole life Carbon:** Overall embodied carbon and the carbon associated with the building's operation (heating, cooling, powering, providing water etc.). It comprises stages A1-A5, B1-B7, C1-C4 and D.

## A.3 RICS Categories

| Level 1                                                            | Level 2                                                                                                                                                                                                                                   |
|--------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>0.1 Treatment and demolition works &amp; Facilitating works</b> | 0.1.1 Toxic/contaminated material treatment & Demolition works<br>0.1.2 Facilitating works                                                                                                                                                |
| <b>1 Sub-structure</b>                                             | 1.1 Foundations and piling<br>1.2 Basement retaining walls and lowest slab                                                                                                                                                                |
| <b>2 Superstructure (Frame)</b>                                    | 2.1 Frame<br>2.2 Upper floors<br>2.3 Roof<br>2.4 Stairs, ramps and safety guarding                                                                                                                                                        |
| <b>Superstructure (Envelope)</b>                                   | 2.5 External envelope including roof finishes<br>2.6 Windows and external doors                                                                                                                                                           |
| <b>Superstructure (Partitions)</b>                                 | 2.7 Internal walls<br>2.8 Internal doors                                                                                                                                                                                                  |
| <b>3 Finishes</b>                                                  | 3.1 Wall finishes<br>3.2 Floor finishes<br>3.3 Ceiling finishes                                                                                                                                                                           |
| <b>4 FF&amp;E</b>                                                  | 4 FF&E                                                                                                                                                                                                                                    |
| <b>5.1 Public Health</b>                                           | 5.1.1 Sanitaryware<br>5.1.2 Cold water systems<br>5.1.3 Drainage and rainwater                                                                                                                                                            |
| <b>5.2 Heating, Ventilation and Cooling (HVAC)</b>                 | 5.2.1 Space heating and hot water<br>5.2.2 Dedicated cooling installations<br>5.2.3 Air movement<br>5.2.4 Ventilation air terminals, ductwork and ancillaries, control dampers, attenuation, fire safety related to ventilation equipment |

| Level 1                                                                                                                                                                                                       | Level 2                                                                                                                                                                                                                                    |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>5.3 Electrical installations</b>                                                                                                                                                                           | 5.3.1 Lighting<br>5.3.2 Electrical services for power, communications, security, IT and fire detection                                                                                                                                     |
| <b>5.4 On site renewable energy generation</b>                                                                                                                                                                | 5.4.1 On site renewable energy generation                                                                                                                                                                                                  |
| <b>5.5 Systems including Life safety, Fuel installations, Lift and conveyor installations, Services equipment Disposal installations, Specialist installations, Builders work in connection with services</b> | 5.5.1 Life safety<br>5.5.2 Fuel installations<br>5.5.3 Lift and conveyor installations<br>5.5.4 Specialised and communal waste disposal<br>5.5.5 Specialist installations & maintenance<br>5.5.6 Builders work in connection with services |
| <b>6 Pre-fabricated buildings and units</b>                                                                                                                                                                   | 6 Pre-fabricated buildings and building units                                                                                                                                                                                              |
| <b>7 Works to existing buildings</b>                                                                                                                                                                          | 7 Works to existing buildings                                                                                                                                                                                                              |
| <b>8 External Works</b>                                                                                                                                                                                       | 8.1 Roads, paths, pavings, surfaces<br>Fencing, railings, walls<br>External fixtures<br>8.2 Soft landscape, planting, irrigation<br>8.3 External drainage<br>External services<br>Minor building works                                     |

# WLCA Best Practice Frameworks & Guidance

There are many different frameworks for undertaking WLCAs as shown below.

RICS guidance, among other standards, has been used to inform this WLCA and how Arup responds to a number of study limitations. The methodologies used, their limitations, and how they may be addressed, are outlined in this Appendix.

| Frameworks & Guidance                                                                                                  |                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|------------------------------------------------------------------------------------------------------------------------|------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Environmental Management - Lifecycle Assessment - Principles and Framework, 2006                                       | ISO 14040:2006   | This international standard outlines the principles and framework for conducting WLCAs, including goal and scope definition, inventory analysis, impact assessment, and interpretation. It provides guidelines to assess the environmental aspects and potential impacts throughout a product's lifecycle.                                                                                                                                                                           |
| Sustainability of Construction Works - Assessment of Environmental Performance of Buildings - Calculation Method, 2011 | BS EN 15978:2011 | This European standard specifies a calculation method, specifically for buildings, based on WLCAs and other quantified environmental information, to assess the environmental performance of building projects. It provides the means for reporting and communication of the assessment outcome, applicable to new and existing buildings and refurbishment projects.                                                                                                                |
| Whole Life Carbon Assessment for the Built Environment, 1st Edition, 2017                                              | RICS Ed.1        | Published by the Royal Institution of Chartered Surveyors (RICS), this guidance provides a methodology for assessing whole lifecycle carbon impacts in the built environment. It aims to standardise the approach to carbon assessment, promoting consistency and transparency in reporting.                                                                                                                                                                                         |
| Whole Lifecycle Carbon Assessments Guidance, 2022                                                                      | GLA WLC Guidance | Issued by the Greater London Authority (GLA), this document offers guidance on conducting whole lifecycle carbon assessments for building projects in London. It aims to support the Mayor's ambition for London to be a zero-carbon city by providing a consistent approach to evaluating and reducing carbon emissions throughout a building's lifecycle. It refers to BS EN 15978:2011 as the principal methodology, and to the RICS Professional Statement for further guidance. |
| Whole Life Carbon Assessment for the Built Environment, 2nd Edition, 2023                                              | RICS Ed.2        | An updated version of the RICS guidance, this edition incorporates the latest industry practices and standards for whole life carbon assessment. It supersedes the previous edition (2017) and has been in full effect from 1 July 2024, providing enhanced methodologies and case studies to support professionals in reducing carbon emissions in building projects.                                                                                                               |

## A.4 Model Basis

### Project ID Matrix (RICS Professional Statement)

|                                   |                                                                                                                                                             |
|-----------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Date of assessment</b>         | July 2024 – March 2025                                                                                                                                      |
| <b>Project type</b>               | Apartment building                                                                                                                                          |
| <b>Assessment objective</b>       | Embodied carbon assessment at practical completion and over life cycle of Cambridge Halls aiming to reduce its carbon footprint through low carbon measures |
| <b>Project location</b>           | Manchester                                                                                                                                                  |
| <b>Date of project completion</b> | 2029 - 2030                                                                                                                                                 |
| <b>Property type</b>              | Commercial residential apartments (Student Residential)                                                                                                     |
| <b>Building description</b>       | 29-storey building with a central concrete core, steel frame with precast slabs, ASHP, VRF and DX heating and cooling.                                      |
| <b>Size</b>                       | Modelled to a GIA of 66,507m <sup>2</sup> (Stage 2 Report)                                                                                                  |
| <b>Project design life</b>        | 60 years                                                                                                                                                    |

|                                  |                                                                                                                                                                                                                                                                                         |                                                                                                         |
|----------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------|
| <b>Assessment scope</b>          | Building Elements:<br>See RICS Scope Table                                                                                                                                                                                                                                              | Product stage [A1-A3]<br>Construction process stage [A4–A5]<br>Use stage [B1-B7]<br>End of Life [C1-C4] |
| <b>Assessment stage</b>          | RIBA Stage 2                                                                                                                                                                                                                                                                            |                                                                                                         |
| <b>Data sources</b>              | <p><b>Primary sources:</b><br/>Stage 2 Design Information Collated from Design Team</p> <p><b>Secondary sources:</b><br/>EPD / material carbon data sources are curated by OneClick, as appropriate for the LCA context, i.e. data sources for UK assessments, or for BREEAM Mat01.</p> |                                                                                                         |
| <b>Assumptions and scenarios</b> | The Stage 2 LCA is based on the latest information received from the design team and the RICS default specifications where there is a lack of detailed information.                                                                                                                     |                                                                                                         |

## A.5 Assumptions Log

The following assumptions have been made during the Stage 2 Life Cycle Embodied Carbon Assessment in order for as many materials as possible to be accounted for. Assumptions should be verified during later stage LCAs.

| Building element                  | Items in cost plan that may not have been explicitly modelled                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|-----------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Substructure                      | Based on quantities and aligned to specifications provided by the structural engineers.<br>Only information provided by the structural engineer has been modelled: <ul style="list-style-type: none"> <li>Waterproof and damp-proof membranes were not included as quantities and specifications were not provided by the structural engineers.</li> <li>Any subbase for the substructure has not been accounted for as information was not provided.</li> </ul>                                    |
| Superstructure Frame              | <ul style="list-style-type: none"> <li>Based on quantities and aligned to specifications provided by the structural engineers.</li> <li>Stair landings have been assumed to be 3.12m<sup>2</sup> as per stair quantity information from the structural engineer, 1 landing is assumed per dogleg stair.</li> <li>A precast stair unit has been used to model the stairs based on the required height for the stairs to span due to no available information on the weight of the stairs.</li> </ul> |
| Superstructure Façade             | <ul style="list-style-type: none"> <li>Blue roof attenuation crates are assumed to be 12kg/m<sup>2</sup> based on typical products.</li> <li>An equal split of porous screed/gravel/mulch finish for the blue roof has been assumed as instructed by the civil engineers.</li> <li>Roof ballast has been assumed to be 50mm thick as is typical.</li> <li>Reclaimed masonry from demolition has been assumed to have a thickness of 65mm and a density of 2000kg/m<sup>3</sup>.</li> </ul>          |
| Internal Partitions               | No information on internal partitions was available so the following benchmark has been applied.                                                                                                                                                                                                                                                                                                                                                                                                    |
| Internal Doors                    | No information on internal doors was available so the following benchmark has been applied.                                                                                                                                                                                                                                                                                                                                                                                                         |
| Furniture, Fittings and Equipment | A large number of Furniture, Fittings and Equipment (FF&E) items have not been specified at Stage 2 to enable a thorough assessment. The following benchmark has been applied.                                                                                                                                                                                                                                                                                                                      |
| Finishes                          | No information on finishes was available so the following benchmark has been applied.                                                                                                                                                                                                                                                                                                                                                                                                               |

| Element                               | A1-A3 Product stage (excl. sequestered carbon) | A4 | A5-3 | B4 | C2 | C3 | C4 |
|---------------------------------------|------------------------------------------------|----|------|----|----|----|----|
| 2.7.Internal walls and partitions     | 73                                             | 4  | 9    | 2  | 0  | 0  | 0  |
| 2.8.Internal doors                    | 73                                             | 4  | 9    | 2  | 0  | 0  | 0  |
| 3.Finishes                            | 46                                             | 3  | 5    | 24 | 1  | 6  | 0  |
| 4.Fittings, furnishings and equipment | 46                                             | 3  | 5    | 24 | 1  | 6  | 0  |

Table of applied benchmarks

## A.5 Assumptions Log

The following assumptions have been made during the Stage 2 Life Cycle Embodied Carbon Assessment in order for as many materials as possible to be accounted for. Assumptions should be verified during later stage LCAs.

| Building element  | Items in cost plan that may not have been explicitly modelled                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|-------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Building services | <p>Various benchmarks have been used where various MEP systems had not yet been completely designed at Stage 3, in order to ensure a thorough assessment accounting for most areas of building services:</p> <ul style="list-style-type: none"> <li>• Allowance for the CCTV System, including intruder alarm and PA/VA system, is based on a benchmark value for offices .</li> <li>• Allowance for access control based on benchmark value for offices. Per square metres GIA.</li> <li>• Allowance for fire alarm detectors based on benchmark value for offices per square metres GIA.</li> <li>• Allowance for Sub Mains Cabling and LV distribution cabling is based on a benchmark for power cabling system for apartment buildings per square metres GIA.</li> <li>• Allowance for earthing and lighting protection are based on benchmarks for earthing and lighting protection systems in apartments and single room occupancy buildings based on building GIA.</li> <li>• Allowance for emergency lighting is based on a benchmark for offices, based on building GIA.</li> <li>• WC alarm system induction loop has been accounted for based on an emergency voice messaging system for an office based on building GIA.</li> </ul> <p>Several items have been excluded from the assessment at this stage due to a lack of sufficient information to enable modelling:</p> <ul style="list-style-type: none"> <li>• External Lighting</li> <li>• IT/AV</li> <li>• BMS System</li> <li>• Communication System</li> </ul> <p>WC alarm system has been assumed to include 107 pull cords, based on the number of accessible WCs specified in the Stage 2 report.</p> <p>The lifts have all been conservatively assumed to cover all 29 floors.</p> <p>Ring main unit is assumed to be 6.6kV based on the supply of electricity in the area.</p> <p>The following thickness of pipework are assumed:<br/> uPVC Condensate - 3.5mm<br/> uPVC Foul Drainage – 7mm<br/> cPVC Sprinkler – 3.5mm</p> <p>Where the mechanical engineer has only provided units of equipment, weights have been determined based on typical products from common suppliers. Where there are not EPDs for typical products with the specified capacity of the equipment, weights have been scaled based on capacities.</p> |

## A.5 Assumptions Log

The following assumptions have been made during the Stage 2 Life Cycle Embodied Carbon Assessment in order for as many materials as possible to be accounted for. Assumptions should be verified during later stage LCAs.

| Building element                     | Items in cost plan that may not have been explicitly modelled                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|--------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| External Works                       | <p>The impact of planting has not been accounted for due to the product's transient nature and uncertainty of life spans – this is a standard approach in LCAs.</p> <p>Steel and Timber seating has been based on a product size of 500mm width by 500mm depth.</p> <p>Steel and Timber Platform seats have been based on a product 1m in height.</p> <p>Picnic tables have been assumed to be 1.4m x 2m x 0.75m</p> <p>Steel pull up bars have been assumed to be 16.5kg based on a generic product</p> <p>The 21 units of pergolas provided by the architect has been assumed to be 157.5m<sup>2</sup> based on area of a pergola detailed on one of the floor plans, this has been accounted for conservatively by using an aluminium pergola product in absence of a specific timber and steel product.</p>                                                              |
| Transport Distances                  | Transport distances are all based on default values from RICS 2 <sup>nd</sup> Edition.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Service Lives                        | Service lives have been aligned to the default recommendations defined in RICS 2 <sup>nd</sup> Edition, Table 20. For MEP equipment service lives are primarily based on CIBSE Guide M Appendix 12.A1, as this provides more detailed and specific guidance for MEP systems. Where there is differences between CIBSE Guide M and RICS Edition 2 service life recommendations, the more conservative number has been used.                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| End of Life of the Proposed Building | <p>The demolition of the proposed building at its End-of-Life (EoL) stage is captured under Life cycle stage C. To account for C1 in construction, the RICS guidance suggests an allowance per square metre GIA; this results in an overall allowance for C1. The overall allowance should be divided across the various RICS categories. This was done proportionally depending on cost.</p> <p>Life-cycle stages C2-C4 are determined within the OneClick tool, assuming market-standard EoL scenarios for each material associated with the LCA. The EoL scenarios for products have also been reviewed by the LCA assessors, to ensure aggregable assumptions about the product materials have been made. EoL transport and processing emissions are informed by the material quantities and UK-relevant market scenarios for EoL processing of different materials.</p> |
| Contingencies                        | An uncertainty factor of 20% has been determined and applied across all RICs categories. This is a combination of a 15% contingency based on the design stage and an uplifted 5% contingency due to modelling not being based on a cost plan and an anticipated quantity of unidentified items not accounted for in the assessment.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |

## A.6 Study Limitations

In addition to limitations stated throughout the report, where analysis and reporting is explained, there are independent additional limitations of this WLCA study that should be noted as per the below:

- The primary scope of this study is emissions at practical completion (modules A1-A5) and over lifecycle (60-years lifespans, modules A-C). Module D (reuse, recovery and recycling potential) is reported separately.

Module D limitations as per RICS Ed.2:

- It mainly occurs beyond the building Lifecycle and outside the system boundary of the project being assessed
- It includes inherent uncertainty regarding the treatment of building components many decades in future.
- Alternative design options have been evaluated individually and independently.
- The alternative options are based on material quantity estimates by the design team, not a fully designed solution.
- The design team will need to further develop an understanding of the feasibility of alternative design options, throughout detailed design and costing exercises.

ARUP