



ELEMENT
SUSTAINABILITY

**NO.3 CIRCLE SQUARE,
MANCHESTER**

**LIFE CYCLE ASSESSMENT
CONCEPT DESIGN**

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CONTENTS

Contents.....	2
1. Introduction.....	1
1.1 Life Cycle Assessment (LCA)	1
2. Development Proposals	4
2.1 Development Site Description	4
3. Executive Summary.....	5
4. Life Cycle Assessment	6
4.1 Embodied Carbon Analysis	10
4.2 Comparison of Construction Material	12
4.3 In-use Energy	14
5. Detailed Results	Error! Bookmark not defined.
Appendix A: Full LCA Results – Option 1	15
Appendix B: Full LCA Results – Option 2	16
Appendix C: Full LCA Results – Option 3	17



1. INTRODUCTION

Element Sustainability has been commissioned by Crookes Walker Consulting Limited to carry out this assessment as detailed in the document title.

The study is based on BS EN ISO 14040 and standard lifecycle analysis methodology.

All results and strategies are directly affected by the inputs listed in this document; any deviation from these is bound to output different results. It is important to note that with any modelling exercise there are assumptions and approximations that must be made. Details of assumptions made, and approximations used are supplied as part of the report.

All results are based on the output from computer modelling software which is based on climatic conditions and patterns of use bound not to be identical to the real-life situation. Therefore, these results should be read as those following the calculation methodology, but not as guaranteed real-life observations.

1.1 Life Cycle Assessment (LCA)

Life cycle assessment (LCA) is a method for evaluating the environmental load of processes and products during their life cycle from cradle to grave. It attempts to identify the environmental effects during all stages of the life of a product and produces a figure that represents the environmental load of a product. It is a process that is becoming more widely adopted in the context of national and international environmental regulations.

Increasingly, building designers are looking at some or all the steps of the building lifecycle to guide their decisions; from raw material to manufactured product; including extraction of the materials; energy consumption; manufacture; transportation; use; recycling; and final disposal or end of life.

Life cycle assessment effectively means the designer looks at what happens before and after the final product is used by the building occupant, measuring effects over a typical building's life. A BREEAM compliant LCA for example is conducted over 60 years as standard, though other certifications have different or no standardised building lifespan.

Designers can also use LCA to compare options to find the best balance of cost, durability, overall environmental impacts, functionality, and aesthetics.

For example, some building elements may be cheaper, but degrade faster than others. It may well be better value overall to select a more expensive product that does not need constant replacement. Undertaking an LCA allows the design team to make such informed decisions that would usually not be considered.

In a full LCA, the energy and materials used, along with waste and pollutants produced because of a product or activity are quantified over the whole life cycle.

The ISO 14040 standard refers to LCA as 'the collection and assessment of the inputs and outputs of any potential environmental impacts caused by the product system throughout its life cycle'.





Figure 1 – Stages of Whole Life-cycle Assessment

At the current design stage, the analysis relates purely to the carbon impact of estimated quantities of building materials in the assigned building. Throughout the lifecycle of the building, carbon emissions will also be generated from Energy usage, water consumption, and construction site operations.

Carbon may also be mitigated by the absorption of emissions by the materials on site. These may be fully integrated into LCA analysis once established by design and construction teams.

Construction materials are calculated using the building design to produce BIM data, which in-turn is converted into estimates of material quantities.

The methodology uses like for like impacts using functional units such as required strength or thermal resistance, rather than impact per tonne of material, as for example, comparing steel and concrete structures on a per tonne basis would be meaningless as steel may have a large impact per tonne but much less may be required to perform the same function. Therefore, where less of a material is required to perform the same function, this is accurately represented.

As an example, the functional unit for roofs as defined in the Green Guide to Specification is, “1 sq.m of roof construction, measured horizontally, to satisfy Building Regulations, to a U value of 0.25 W/m²K. To include any repair, refurbishment or replacement over a 60-year building life”.

At this stage of design, the quantities used must be understood as estimates, these may be desired be updated to actual quantities at an appropriate stage however, this is not necessary to fulfil the requirements of the LCA.

As an early stage (RIBA stage 3) LCA, the outputs of this analysis are suitable for optioneering and BREEAM credit allocation. The accuracy is limited by the data available, therefore comparisons with analyses for later stages of the design may vary as layouts and material choices become clear, and the scope of the LCA may change to suit requirements for accreditation or planning.



Product characteristics are taken from the various available databases, such as those provide by RICS, BRE, RIBA and certain product manufacturers. Details of those used are contained in the appendix.



2. DEVELOPMENT PROPOSALS

2.1 Development Site Description

The proposed development site is located in the Circle Square development within Manchester City Centre. The building is proposed to be a high specification office.

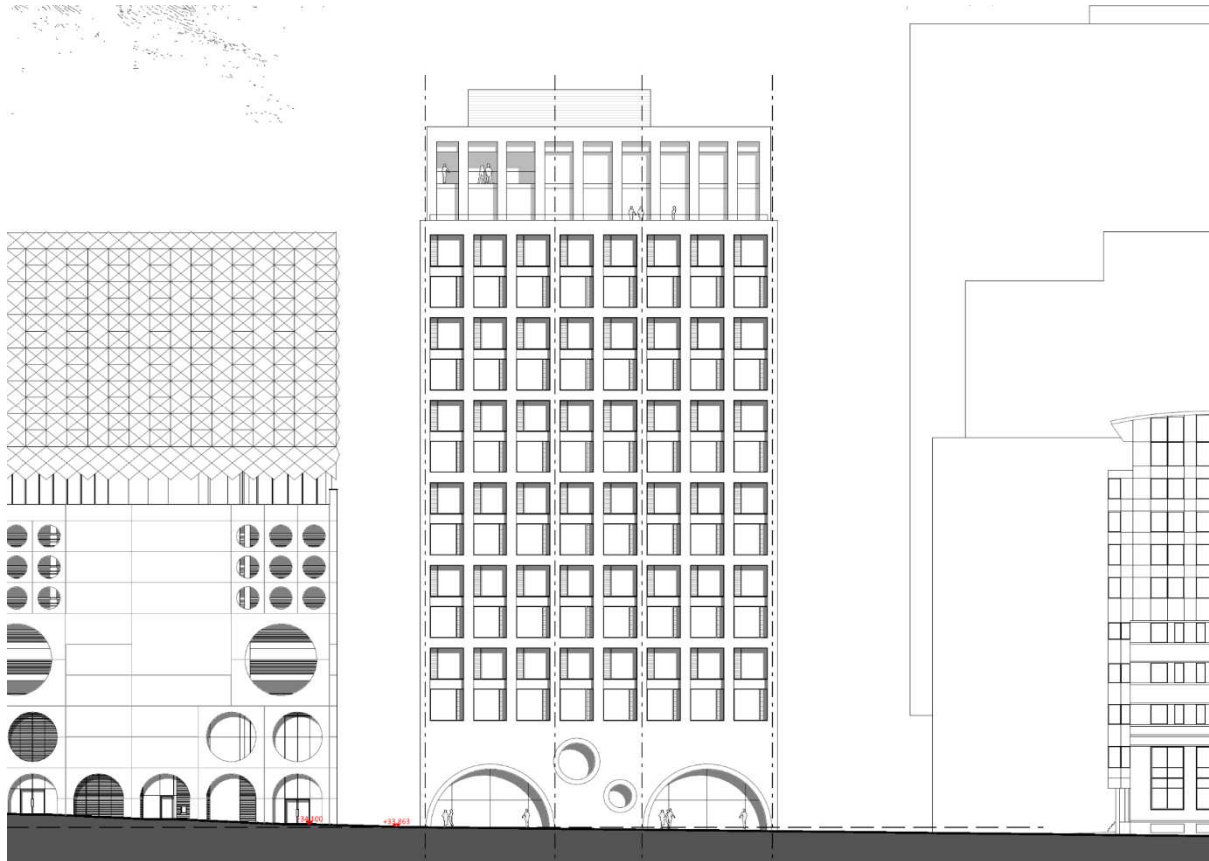


Figure 2 – Image of Development Site



3. EXECUTIVE SUMMARY

The baseline design has been compared to two potential lower carbon options:

	CORE	FRAME	FLOORS/CEILINGS	CLADDING
OPTION 1 (BASELINE)	POURED CONCRETE	STEEL	POURED CONCRETE SUSPENDED CEILINGS CARPET	BRICK
OPTION 2	POURED CONCRETE	STEEL	POURED CONCRETE OPEN CEILINGS CARPET	BRICK
OPTION 3	POURED CONCRETE	STEEL	POURED CONCRETE OPEN CEILINGS LAMINATE FLOOR	BRICK

The results are below, showing a clear saving in carbon from the optimisation of the design:

Embodied Carbon (A1-A5, B1-B4, C1-C4)	Total Carbon Emissions (kgCO ₂ e)	Carbon Emissions per MSQ. (kgCO ₂ e/m ²)
Option 1	32,037,511.00	1,089.82
Option 2	22,251,385.00	756.93
Option 3	21,132,109.00	718.85

Total Carbon (All Stages)	Total Carbon Emissions (kgCO ₂ e)	Carbon Emissions per MSQ. (kgCO ₂ e/m ²)
Option 1	54,749,516.00	1,862.42
Option 2	44,963,391.00	1,529.52
Option 3	43,844,116.00	1,491.45

Table 1 – Summary Stage 3 Results

As discussed in the report, whilst all of these options have a similar impact, open ceiling construction presents lower total impact, and the use of laminate floors instead of carpet further reduces this further.

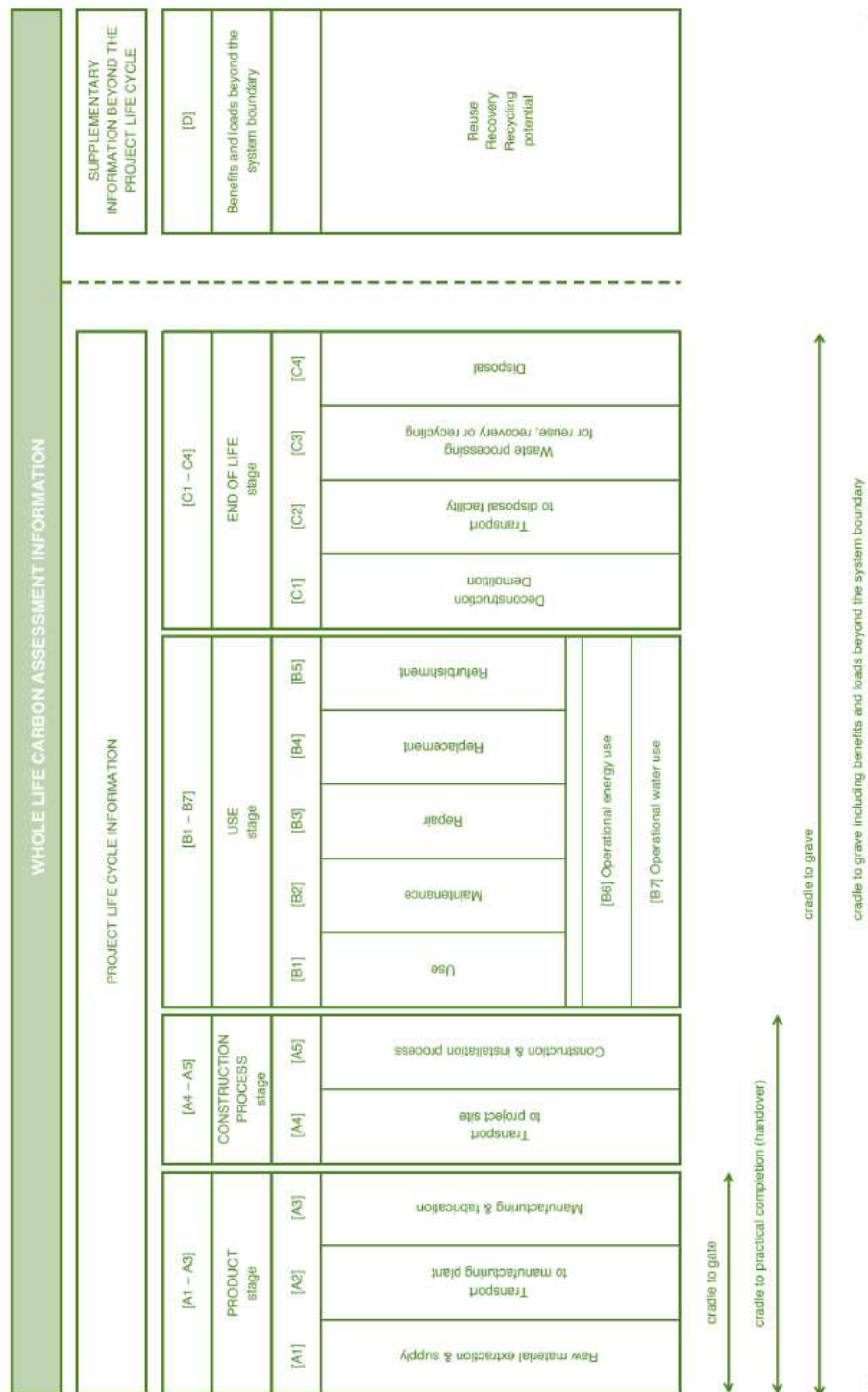
The information gained from the life-cycle analysis presents the developer with the data to optimise design choices to minimise the impact of embedded carbon. This can be achieved with use of life-cycle analysis throughout the project to inform the design, and to provide detailed analysis once technical design is reached, to validate success against this target.

We recommend that this analysis is carried forward through the design process, and updated as designs and calculations are developed, to continue to provide an overview of the impact of the project. The next recommended stage of analysis is at RIBA stage 4, where accurate bills of materials can be used to produce definitive results.



4. LIFE CYCLE ASSESSMENT

A building generates environmental impacts throughout its life cycle. The various stages of this life cycle analysis and included in the assessment are as follows:



(EN15978 modular life-cycle stages, credit BSI)



A1-A3: Product stage, cradle to gate. This covers impacts of a product or material that is ready to ship to construction site, including raw materials extraction, transport, and manufacturing emissions. In case recycled or reused materials are used in this stage, their emissions may be accounted as zero.

For early-stage assessments, the default materials are specified in the methodology:

	Material	Details	Specification
1.	Concrete	Piling	C32/40 20% cement replacement [1]
		Substructure	C32/40 20% cement replacement [1]
		Superstructure	C32/40 20% cement replacement [1]
		Generic concrete	C16/20 0% cement replacement [1]
2.	Steel	Reinforcement bars	97% Recycled Content [2]
		Structural steel sections	20% Recycled Content [3]
		Studwork/Support frames	Galvanised steel, 15% Recycled Content [4]
3.	Blockwork	Precast concrete blocks	Lightweight blocks for building envelope
			Dense blocks for other uses
4.	Timber	Manufactured structural timber CLT, Glulam, etc.	100% FSC/PEFC [5]
		Formwork	Plywood
		Studwork/Framing/Flooring	Softwood
5.	Aluminium	Cladding panels	Aluminium sheet, 35% Recycled Content [6]
		Glazing frames	Aluminium extrusions, 35% Recycled Content [6]
6.	Plasterboard	Partitioning/Ceilings	Min. 60% Recycled Content [7]
7.	Insulation	To floors, roofs & external walls	PIR

(Table 6 from RICS methodology, credit RICS)

A4: Transport to construction site. This covers impacts of a product transport from the factory to the construction site. The transport chain may include interim steps through wholesaler or storage. In cases where transport vehicle can be used for other transport for a return trip, only the actual transport required by the products should be accounted for. Accounting the return trip may vary by calculation tool, and it follows the tool's requirements.



A5: Construction site energy and water use, waste management and other environmental impacts, including material wastage.

B1: Emissions to the environment from the use of the product(s). This means emissions not covered by B2-B7. (This is not included at this design stage as data is not available)

B4-B5: Replacement (B4) and refurbishment (B5) covers planned replacements of whole construction elements to restore them to their required performance level. Replacement of a whole construction element due to damage should be considered as “B4 replacement”. Replacement of a whole construction element as part of a concerted replacement programme for the building should be considered as “B5 refurbishment”. The expected lifecycles of components are listed later in the report.

Building part	Building elements/components	Expected lifespan
Roof	Roof coverings	30 years
Superstructure	Internal partitioning and dry lining	30 years
Finishes	Wall finishes: Render/Paint	30/10 years respectively
	Floor finishes Raised Access Floor (RAF)/Finish layers	30/10 years respectively
	Ceiling finishes Substrate/Paint	20/10 years respectively
FF&E	Loose furniture and fittings	10 years
Services/MEP	Heat source, e.g. boilers, calorifiers	20 years
	Space heating and air treatment	20 years
	Ductwork	20 years
	Electrical installations	30 years
	Lighting fittings	15 years
	Communications installations and controls	15 years
	Water and disposal installations	25 years
	Sanitaryware	20 years
	Lift and conveyor installations	20 years
Facade	Opaque modular cladding e.g. rain screens, timber panels	30 years
	Glazed cladding/Curtain walling	35 years
	Windows and external doors	30 years

(Table 9 from RICS methodology, credit RICS)



B6: Operational energy. This covers all building energy import (including electricity, district heat and cooling and fuels. Any energy produced from renewables on the site is not in the scope (excluding any fuels or imported electricity needed to produce it). Exported energy is not deduced from this.

Operational energy data is derived from DSM energy modelling and includes both regulated and operational energy.

B7: Water use of the building systems and building envelope (excluding in the standard accounting, the water uses of tenants). This covers the life cycle environmental impacts of water, including production and transportation and wastewater treatment.

Water use data is taken from BSRIA rules of thumb for early-stage calculations, this can be replaced by MEP design values once available.

C1-C4: This includes impacts for processing recyclable construction waste flows for recycling (C3) until the end-of-waste stage or the impacts of pre-processing and landfilling for waste streams that cannot be recycled (C4) based on type of material. Additionally, deconstruction impacts include emissions caused by waste energy recovery.

D: Module D contains the benefits and loads beyond the asset life cycle (system boundary). This information module provides transparency for the environmental benefits or loads resulting from reusable products, recyclable materials and/or useful energy carriers leaving a product system e.g., as secondary materials or fuels or in form of exported energy.



4.1 Whole Life Carbon

The lowest overall carbon impact is from the open ceiling, laminate floor option, based on early-stage information, as presented in Table 3.

CATEGORY	OPTION 1	OPTION 2	OPTION 3
A1-A3 MATERIALS	17,205,206.00	14,023,021.00	13,773,943.00
A4 TRANSPORTATION	113,267.00	112,559.00	113,209.00
A5 CONSTRUCTION	1,735,801.00	1,497,073.00	1,463,251.00
B4-B5 REPLACEMENT	12,505,190.00	6,140,820.00	5,393,588.00
B6 ENERGY	21,714,576.00	21,714,576.00	21,714,576.00
B7 WATER	997,430.00	997,430.00	997,430.00
C1-C4 END OF LIFE	478,047.00	477,912.00	388,118.00
TOTAL kgCO₂e	54,749,516.00	44,963,391.00	43,844,116.00
kgCO ₂ e/m ²	1,862.42	1,529.52	1,491.45

Table 2 – Full RIBA Stage 3 LCA Results

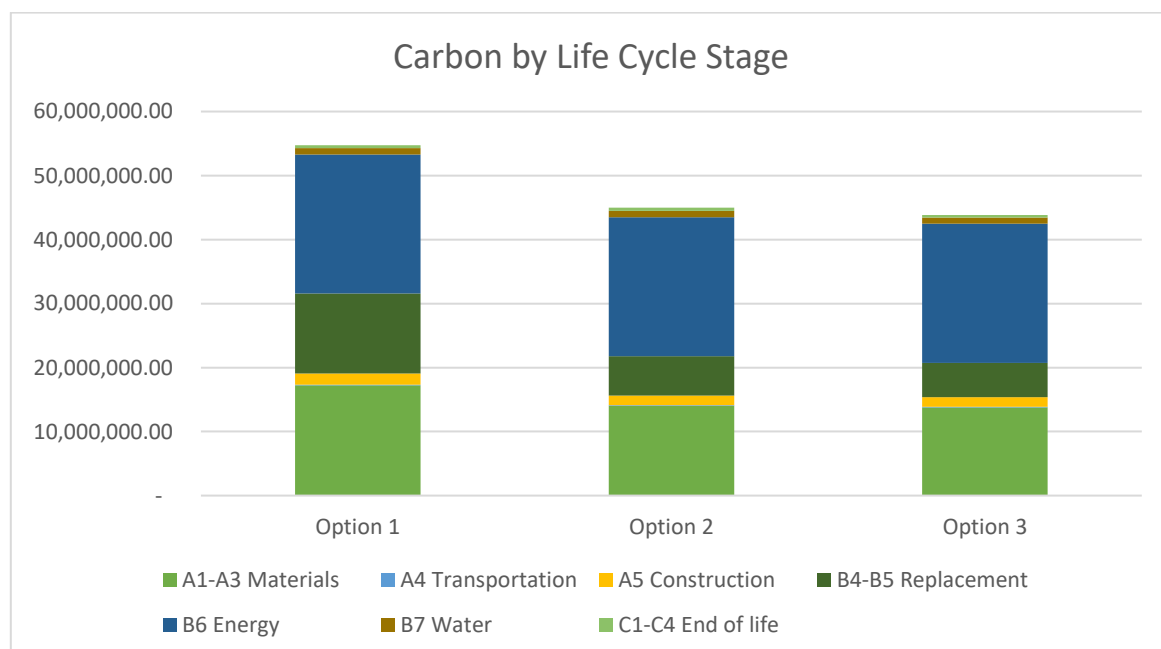


Figure 1 - Results by Life-cycle Stage

Note that as early stage LCA calculations are based on assumptions of the quantities based on the design drawings, the results above are expected to increase as calculated quantities for more details bills of quantities are available.



4.2 Embodied Carbon Analysis

EMBODIED CARBON (A1-A5, B1-B4, C1-C4)	OPTION 1	OPTION 2	OPTION 3
TOTAL CARBON EMISSIONS (kgCO ₂ e)	32,037,511.00	22,251,385.00	21,132,109.00
CARBON EMISSIONS PER MSQ (kgCO ₂ e/m ²)	1,089.82	756.93	718.85

Table 3 – Full RIBA Stage 3 Embodied Carbon

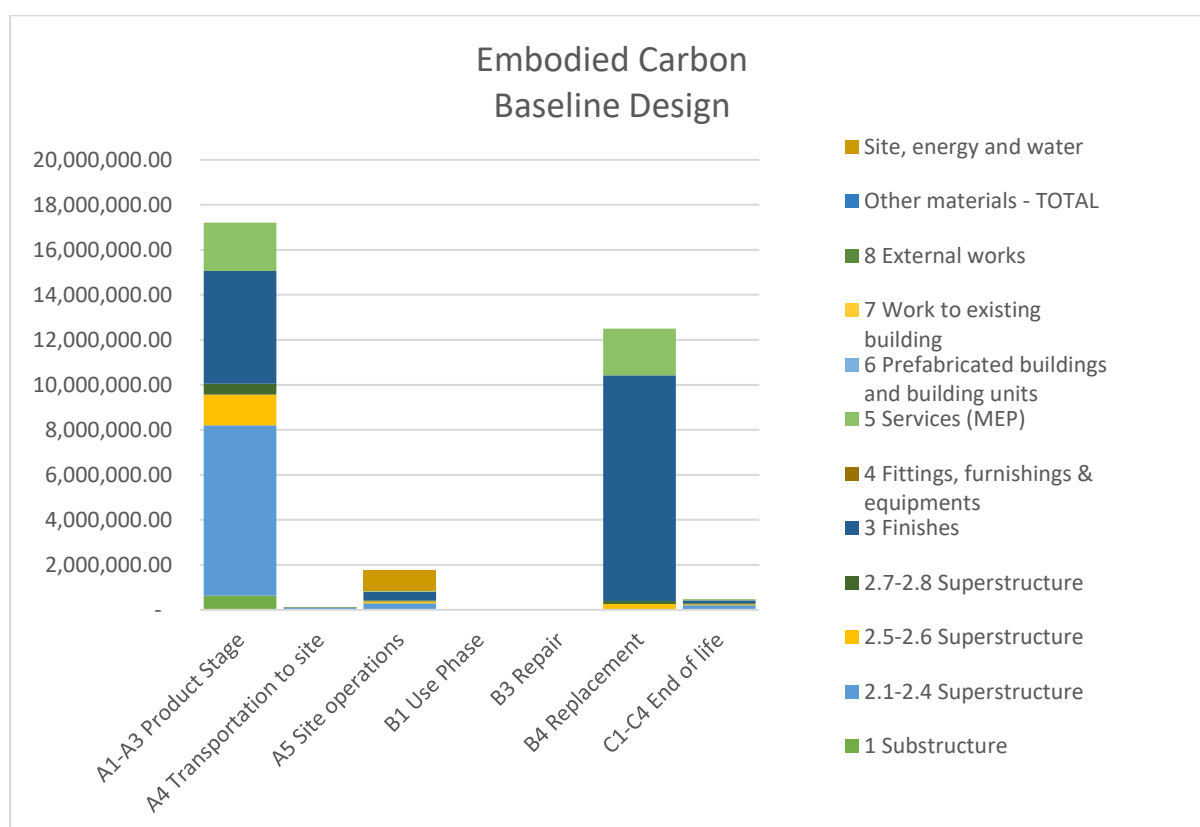


Figure 2 – Embodied Carbon by Element

The chart in Figure 3 presents a breakdown of the various kgCO₂ outputs for only the “embodied” carbon stage, therefore not including energy and water consumption, of the original “baseline” design.

As would be expected, the most significant areas of the impact are in the construction materials, firstly structural, however the finishes also present a high amount of carbon.



4.3 Comparison of Construction Material

Whilst structural aspects of the design are fixed due to supply chain constraints, it is clear that finishes contribute the next largest proportion of carbon, therefore the options assessment is based on this area.

We have assessed three potential construction options for the building:

	CORE	FRAME	FLOORS/CEILINGS	CLADDING
OPTION 1 (BASELINE)	POURED CONCRETE	STEEL	POURED CONCRETE SUSPENDED CEILINGS CARPET	BRICK
OPTION 2	POURED CONCRETE	STEEL	POURED CONCRETE OPEN CEILINGS CARPET	BRICK
OPTION 3	POURED CONCRETE	STEEL	POURED CONCRETE OPEN CEILINGS LAMINATE FLOOR	BRICK

Table 4 – Potential Construction Options

The three design options have differing impacts in terms of the impact of their construction materials.

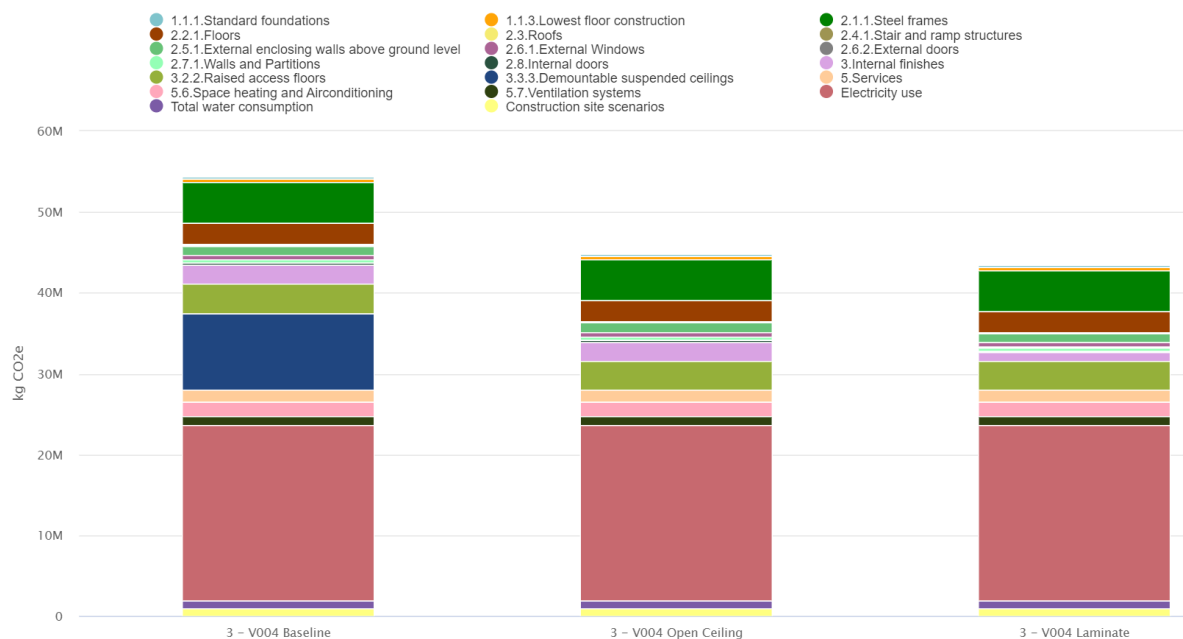


Figure 3 - Comparing Impact of Material Options

Figure 4 clearly shows the impact of removing the high carbon materials in the suspended ceiling option, relative to open alternatives.

Note that no inference is made of the technical feasibility of these methods.



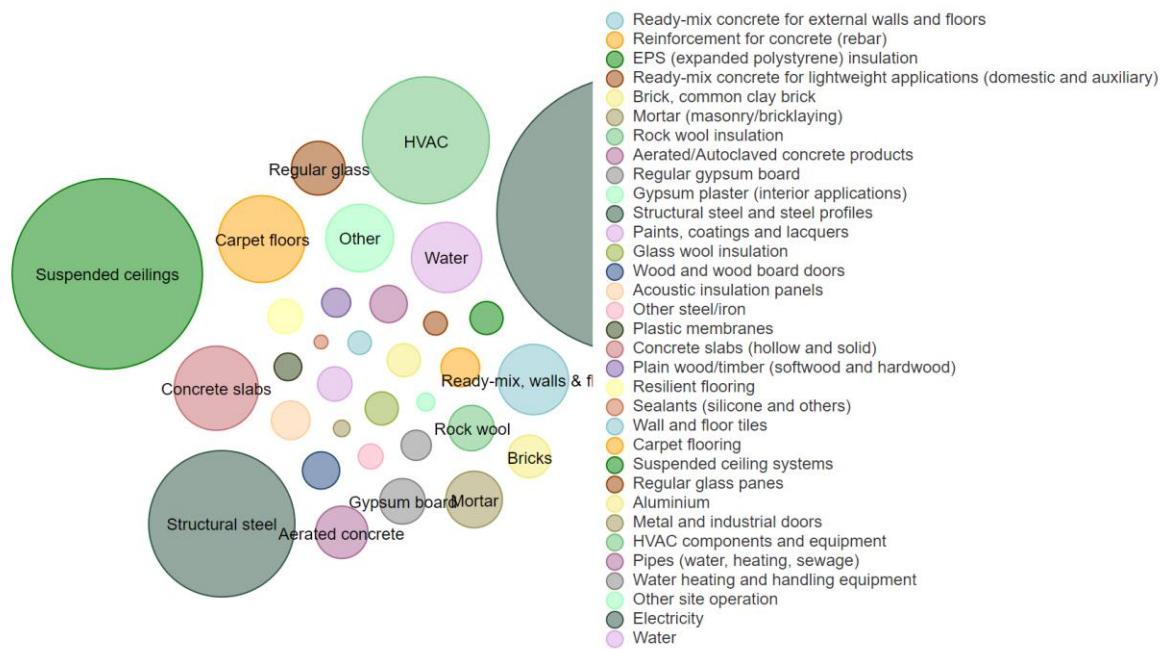


Figure 4 – Bubble Chart Comparing impact of Material Options

The bubble chart (Figure 5), presents the the highest carbon suspended celing option. Here we see the largest contributors to the impact. Focussing on building elements, it is clear that choosing steel and concrete, and interestingly, soft finishes, with a sustainable manufacturing and supply chain can have a large impact on the sustainability of the project. Nb. The large bubble is operational energy, which is partially hidden to better show the materials.



4.4 In-use Energy

Whilst specific in-use energy data to provide comparison of the design options in this report is not yet available, an early-stage indicative energy profile has been produced by Crookes Walker using the CIBSE TM54 methodology. We have on advice, used the mid-range profile from their report.

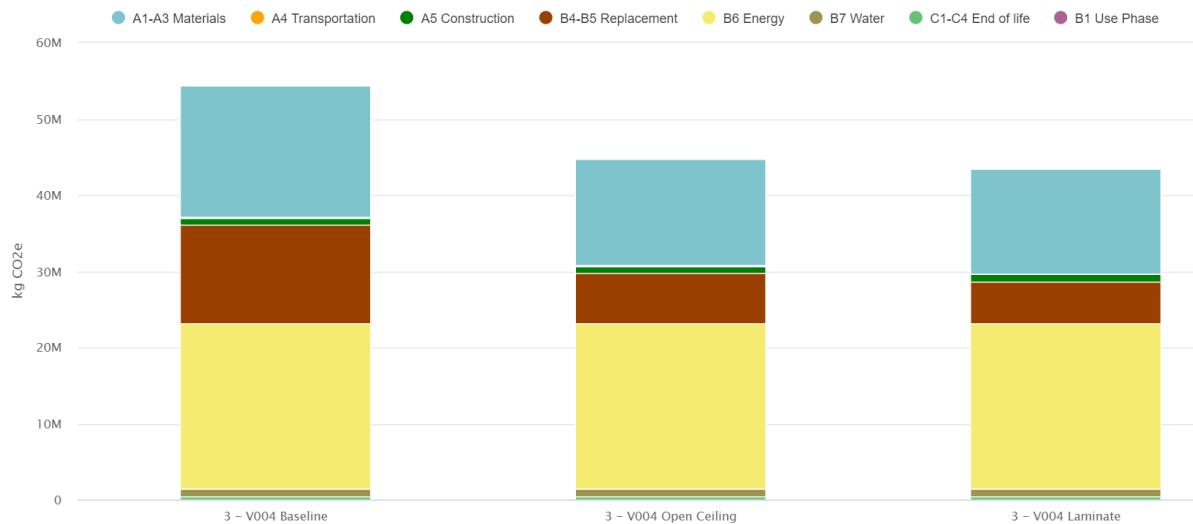


Figure 5 – LCA Including Operational Energy Demand

It can be seen that the predicted in-use energy forms the largest component of the carbon emissions of the building, however, it does not assist with the comparison of our options.



APPENDIX A: FULL LCA RESULTS – OPTION 1

	A1-A3 Product Stage	A4 Transportation to site	A5 Site operations	B1 Use Phase	B3 Repair	B4 Replacement	B6 Operational Energy use	B7 Operational Water use	C1-C4 End of life	D External impacts (not included in totals)	TOTAL kg CO ₂ e
1 Substructure	627,272	26,785	31,596	0	0	7,465			38,429	-109,221	731,548
2.1-2.4 Superstructure	7,575,298	68,231	254,855	0	0	7,465			170,015	-844,176	8,075,864
2.5-2.6 Superstructure	1,360,349	7,777	93,611	0	0	245,620			43,845	-302,633	1,751,203
2.7-2.8 Superstructure	484,695	2,040	36,882	0	0	136,566			33,860	-92,942	694,043
3 Finishes	5,013,017	4,725	380,059	0	0	10,019,531			140,275	-3,442,263	15,557,608
4 Fittings, furnishings & equipments											
5 Services (MEP)	2,144,575	3,708	31,528	0	0	2,088,543			51,622	-1,116,066	4,319,975
6 Prefabricated buildings and building units											
7 Work to existing building											
8 External works											
Other materials - TOTAL											
Site, energy and water			907,270				21,714,576	997,430			23,619,276
TOTAL kg CO ₂ e kg CO ₂ e	17,205,206	113,267	1,735,801	0	0	12,505,190	21,714,576	997,430	478,047	-5,907,300	54,749,516



APPENDIX B: FULL LCA RESULTS – OPTION 2

	A1-A3 Product Stage	A4 Transportation to site	A5 Site operations	B1 Use Phase	B3 Repair	B4 Replacement	B6 Operational Energy use	B7 Operational Water use	C1-C4 End of life	D External impacts (not included in totals)	TOTAL kg CO ₂ e
1 Substructure	627,272	26,785	31,596	0	0	7,465			38,429	-109,221	731,548
2.1-2.4 Superstructure	7,575,298	68,231	254,855	0	0	7,465			170,015	-844,176	8,075,864
2.5-2.6 Superstructure	1,360,349	7,777	93,611	0	0	245,620			43,845	-302,633	1,751,203
2.7-2.8 Superstructure	484,695	2,040	36,882	0	0	136,566			33,860	-92,942	694,043
3 Finishes	1,830,832	4,017	141,332	0	0	3,655,161			140,140	-356,844	5,771,482
4 Fittings, furnishings & equipments											
5 Services (MEP)	2,144,575	3,708	31,528	0	0	2,088,543			51,622	-1,116,066	4,319,975
6 Prefabricated buildings and building units											
7 Work to existing building											
8 External works											
Other materials - TOTAL											
Site, energy and water			907,270				21,714,576	997,430			23,619,276
TOTAL kg CO ₂ e kg CO ₂ e	14,023,021	112,559	1,497,073	0	0	6,140,820	21,714,576	997,430	477,912	-2,821,881	44,963,391



APPENDIX C: FULL LCA RESULTS – OPTION 3

	A1-A3 Product Stage	A4 Transportation to site	A5 Site operations	B1 Use Phase	B3 Repair	B4 Replacement	B6 Operational Energy use	B7 Operational Water use	C1-C4 End of life	D External impacts (not included in totals)	TOTAL kg CO ₂ e
1 Substructure	627,272	26,785	31,596	0	0	7,465			38,429	-109,221	731,548
2.1-2.4 Superstructure	7,575,298	68,231	254,855	0	0	7,465			170,015	-844,176	8,075,864
2.5-2.6 Superstructure	1,360,349	7,777	93,611	0	0	245,620			43,845	-302,633	1,751,203
2.7-2.8 Superstructure	484,695	2,040	36,882	0	0	136,566			33,860	-92,942	694,043
3 Finishes	1,581,755	4,668	107,510	0	0	2,907,929			50,346	-495,019	4,652,207
4 Fittings, furnishings & equipments											
5 Services (MEP)	2,144,575	3,708	31,528	0	0	2,088,543			51,622	-1,116,066	4,319,975
6 Prefabricated buildings and building units											
7 Work to existing building											
8 External works											
Other materials - TOTAL											
Site, energy and water			907,270				21,714,576	997,430			23,619,276
TOTAL kg CO ₂ e kg CO ₂ e	13,773,943	113,209	1,463,251	0	0	5,393,588	21,714,576	997,430	388,118	-2,960,056	43,844,116

