301 St Vincent Street, Glasgow

BREEAM 2014 RFO – Mat 01
Building Life Cycle Assessment

OCIM Limited

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1.0

Introduction

1.0 Introduction

This report presents the life cycle assessment (LCA) completed for the development at 301 St Vincent Street, Glasgow. There was an initial LCA assessment undertaken during RIBA Stage 2 to inform design development and promote low whole life carbon (WLC) design.

This BREEAM Compliant Mat 01 exercise reflects design options during RIBA stage 2 and the modelling was completed using Sturgis, an approved LCA assessment tool for BREEAM 2014, with the credit score awarded to be **6 + Exemplary Credit** in the Mat 01 RFO Calculator tool.

The goal of this study was to provide an assessment of the building's environmental performance from a life cycle perspective in accordance with the IMPACT methodology developed by the BRE. The life cycle performance of the building was calculated and analysed. The LCA model was also used to form a deeper understanding of life cycle impacts and identify potential improvements in the current design and/or similar future designs.

The LCA has itemized and assessed the significant impacts for all materials and processes covering raw materials extraction and manufacturing, construction, on-going operational and maintenance and end-of-life management of the building. All impacts have been calculated and categorised into the life cycle phases defined in EN 15978 and according to the IMPACT methodology developed by the BRE.

1.1 Life Cycle Analysis Background

Whole life-cycle carbon (WLC) emissions are the total greenhouse gas emissions arising from a development over its lifetime, from the emissions associated with raw material extraction, the manufacture and transport of building materials, to installation/ construction, operation, maintenance, and eventual material disposal.

Operational carbon emissions will make up a declining proportion of a development's WLC emissions as operational carbon targets become more stringent. To fully capture a development's carbon impact, a whole life-cycle approach is needed to capture its unregulated emissions (i.e., those associated with cooking and small appliances), its embodied emissions (i.e., those associated with raw material extraction, manufacture and transport of building materials, and construction) and emissions associated with maintenance and eventual material disposal.

The development should calculate WLC emissions through a nationally recognised WLC Carbon Assessment and demonstrate actions taken to reduce life-cycle carbon emissions.

1.2 LCA Scope, Assumptions & Limits

To provide a holistic view of the GWP, the whole life carbon assessment accounts for all components relating to the project during all life stages over a predicted 60-year building service life.

Whole Life Carbon emissions are attributed to four main categories taken from BS EN 15978. The categories are:

- Product Stages (module A1 to A3): The carbon emissions generated at this stage arise from extracting the raw materials from the ground, their transport to a point of manufacture and then the primary energy used (and the associated carbon impacts that arise) from transforming the raw materials into construction products.
- Construction (module A4 to A5): These carbon impacts arise from transporting the construction products to site, and their subsequent processing and assembly into the building.
- In-Use Stages (module B1 to B5): This covers a wide range of sources from the embodied carbon emissions associated with the operation of the building, including the materials used during maintenance, replacement, and refurbishment.
- End of Life Stages (module C1 to C4): The eventual deconstruction and disposal of the existing building at the end of its life takes account of the on-site activities of the demolition contractors. No 'credit' is taken for any future carbon benefit associated with the reuse or recycling of a material into new products.

The scope of the assessment covers the following building elements:

- Part 1: Fabric and Structure
- Part 2 and 3: Building Services
- Landscaping

In accordance with ISO14040/44 standards and RICS Professional Statement, the assumptions, and limitations of the LCA have been identified and they relate to the following:

- Building Life Expectancy: The life expectancy of the building has a large impact on the results of the LCA. Typically, buildings with larger life spans have proportionally lower impacts in construction stages, while higher impacts due to operation. In this assessment, a predicted building life span of 60 years and material life spans as referenced from the RICS Professional Statement.
- The whole life carbon data source used is based on EPD data published by manufacturers.
- Building geometry and material quantities are based on cost plans and drawings.
- The scope of materials assessed includes and exceeds the scope required in BREEAM Mat 01.
- All work was undertaken prior to the end of the Detailed Design Stage for 301 St Vincent Street, Glasgow.

2.0

Life Cycle Analysis Results & Discussions

2.0 Life Cycle Analysis Results & Discussions

2.1 LCA Results

Table 2-1111Table 2-11 shows the LCA results for CO_2e emissions (GWP). The full analysis is also submitted as part of the assessment. The table highlights GWP environmental impact break down associated with each building element within the system boundaries.

Emissions of construction materials (A1 to A5) have been assessed to be **11,122 tonnes of CO_2e.** The whole-life carbon emissions, including demolition at end of life, are **24,952 tonnes of CO_2e.**

Embodied Carbon over Life Cycle (TCO2e) (Aligned with LETI Scope)		Upfront Carbon [A1-A5]	Life cycle impacts [B2-B5]	End of life impacts [C1-C4]	Whole Life Carbon (TCO_2e)
Substructure		-	-	-	-
Superstructure	Frame	333	0	2	335
	Upper Floors	553	0	47	601
	Roof	63	32	2	96
	Stairs and ramps	25	0	3	28
	External walls	157	161	3	322
	Glazed façade	2,011	2,044	32	4,087
	Internal Walls and Doors	456	471	14	941
Finishes		2,485	2,411	69	4,743
F,F & E		80	55	6	112
Building services		4,698	8,396	79	13,172
Works to Existing Building		2	0	0	2
External Works		260	221	15	496
Demolition		0	0	17	17
Total Embodied Carbon		**11,122**	**13,790**	**289**	**24,952**
Embodied Carbon intensity (kg CO_2e/m^2 GIA)		**256**	**317**	**7**	**573**

Table 2-1111: Carbon (GWP) summary of the development following the BREEAM assessment scope

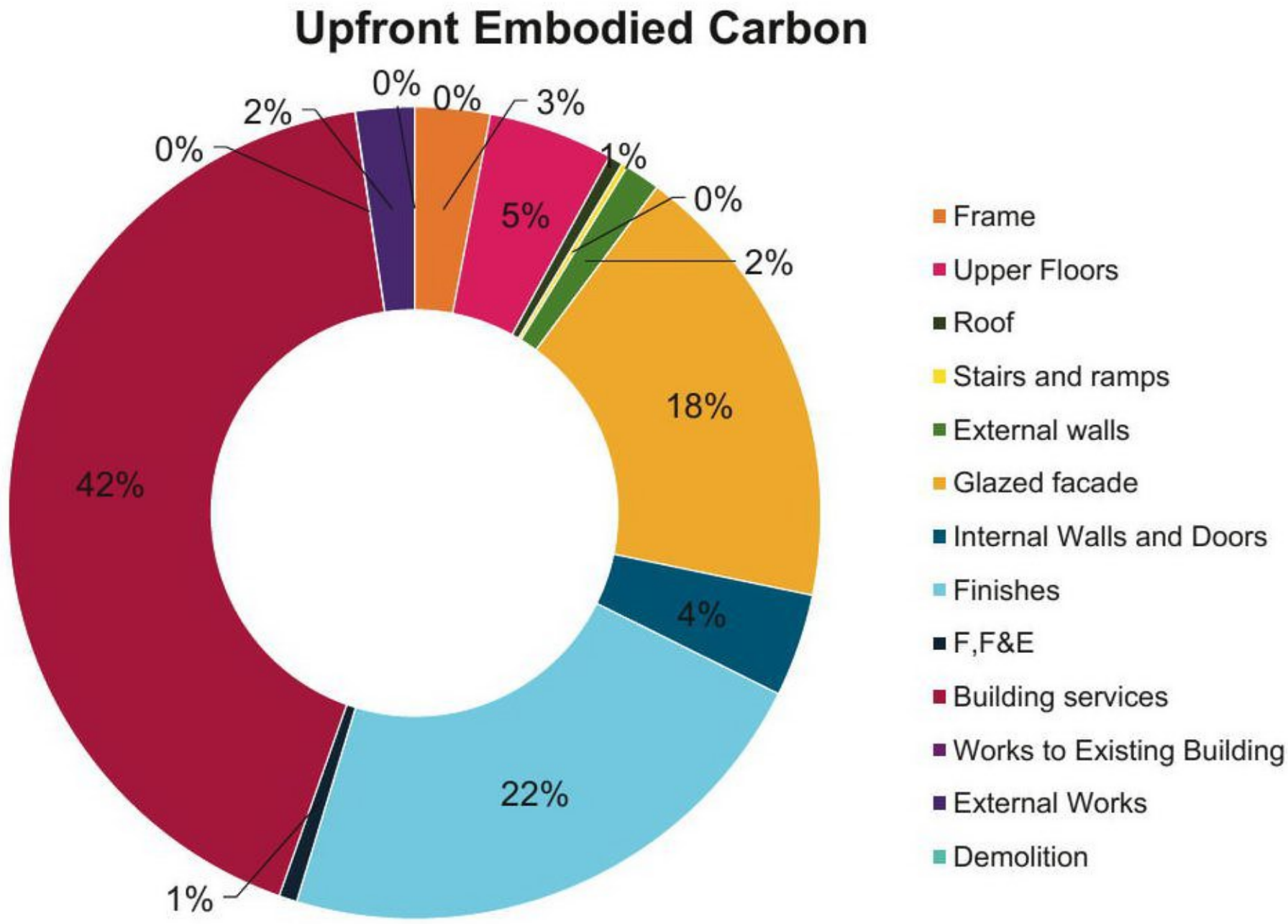

Figure 2-1111: Global warming (GWP) grouped by RICS category breakdown

From the assessment results (Figure 2-1111Figure 2-11), the combined building services have the highest building element emissions accounting for 42% of the total upfront carbon emissions.

Emissions over the life-cycle of the development (WLC emissions) are also shown in Table 2-1111Table 2-11. Similarly, the emissions are drivenby the building services due to the expected replacement, maintenance & refurbishment events.

BREEAM formated Project Carbon Budget Summary - BASELINE	A1-A5	A1-C4							
	Carbon at Practical Completion (exc. c/seq) (KgCO2e)	Whole Life Carbon (inc. c/seq) ($KgCO_2e$)	Whole Life Carbon (inc. c/seq) ($KgCO_2e/m^2$)	Whole Life ODP (kgCFC11e)	Whole Life AP (kgSO2e)	Whole Life EP (kg(PO4)3-e)	Whole Life POPC (kgC2H4e)	Whole Life ADPF (MJ)	Whole Life Water (m3)
1.0 Substructure	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2.1 Frame	332,938	334,643	8	1.63E-02	8.15E+01	1.34E+01	8.14E+00	1.35E+05	1.06E+03
2.2 Upper Floors	553,333	600,559	14	4.72E+00	6.85E+05	1.00E+05	6.60E+04	1.35E+09	3.30E+05
2.3 Roof	62,699	96,374	2	1.31E-01	1.73E+04	2.52E+03	1.66E+03	3.40E+07	9.27E+03
2.4 Stairs and ramps	25,398	27,905	1	1.39E-01	2.03E+04	2.96E+03	1.95E+03	4.00E+07	9.94E+03
2.5 External walls	157,467	321,620	7	2.34E-02	1.13E+03	1.00E+02	8.07E+01	3.47E+06	3.93E+03
2.6 Windows and external doors	2,010,524	4,087,144	94	1.26E+00	2.52E+04	2.69E+03	-6.48E+02	4.51E+07	1.40E+07
2.7 Internal Walls and Partitions	350,129	710,220	16	1.46E-01	1.75E+03	9.72E+01	4.22E+02	7.80E+06	1.20E+05
2.8 Internal Doors	105,464	230,519	5	4.81E-03	1.64E+03	1.18E+02	5.66E+01	4.23E+06	3.77E+03
3.1 Wall Finishes	187,499	513,112	12	1.13E-01	9.29E+02	2.18E+04	2.58E+02	4.78E+06	2.98E+04
3.2 Floor Finishes	2,281,060	4,207,719	97	6.07E-01	4.97E+04	9.45E+03	2.21E+03	6.04E+07	6.26E+06
3.3 Ceiling Finishes	16,296	21,877	1	3.17E-04	1.99E+00	2.67E-01	1.91E-01	3.69E+03	5.13E+02
4 Fittings, Furnishings and Equipment	80,482	112,093	3	1.17E+00	7.86E+02	1.28E+02	9.59E+01	2.63E+06	1.39E+08
5 Services	4,697,548	13,172,442	303	6.26E+02	1.52E+04	1.64E+03	1.36E+03	3.07E+07	5.53E+04
6 Prefabricated Buildings and Building Units	123,572	247,180	6	2.51E-01	1.35E+03	1.88E+02	2.09E+02	1.46E+05	1.18E+04
7 Works to Existing Buildings	1,925	2,296	0	2.84E-06	6.88E-02	3.15E-03	5.73E-03	1.66E+02	6.53E+01
8 External Works	259,544	496,013	11	4.35E-01	1.05E+04	1.15E+03	2.74E+03	3.27E+07	9.17E+03
Demolition	0	17,094	0	2.65E-07	1.21E+02	3.01E+01	1.72E+01	3.23E+05	8.27E+01
	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	11,245,877	25,198,811	579	635	831,098	143,040	76,402	1,617,734,943	160,297,231

Table 2-2222: Whole Life Cycle environmental impacts per sub-element

Table 2-2222Table 2-22 above shows the Life Cycle Analysis results by sub-element of all the wider environmental impacts:

- Global warming (GWP)
- Ozone depletion potential (OPD)
- Acidification (AP)
- Eutrophication (EP)
- Formation of ozone of lower atmosphere (POCP)
- Abiotic depletion (MJ)
- Water (m^3)

2.2 LCA Conclusions & Integration into Design Decision-Making Process

	Design Option	Description of Replacement Option	Reason for Choosing/Not choosing
1	**Concrete**	Local sourcing of concrete – less than 15km.	To be further investigated at a later stage.
2	**Concrete**	High cement replacement for concrete, 50% GGBS.	Possible structural implications and supply issues. Contractor to review availability.
3	**Steel**	Use of reclaimed steel.	Possible supply issue. Contractor to review availability.
4	**Reinforcement**	Use of low carbon rebar made from Electric Arc Furnace / renewable energy.	Possible supply issues or cost implications. Contractor to review the availability
5	**Curtain walling**	High recycled aluminium for curtain walling framing and spandrel panels.	Cost implications. To be further investigated at a later stage.
6	**Internal walls**	Low carbon plasterboard (Fermacell or equivalent).	Cost implications. To be further investigated at a later stage.
7	**Wall finishes**	Low carbon paint, low carbon ceramic tiles, low carbon plaster.	Cost implications. To be further investigated at a later stage.
8	**Floor finishes**	Refurbished Raised Access Floor.	Possible supply issue. To be further investigated at a later stage.
9	**Floor finishes**	Low carbon carpet tiles, Marmoleum tiles instead of vinyl tiles.	Cost implications. To be further investigated at a later stage.
10	**Building services**	Nationally sourced equipment – within 300km.	Possible supply issue. Contractor to review availability.

Table 2-3333: Concept Design options appraisal summary table

For this development, the majority of the embodied carbon impact is within the building services, as expected in major internal refurbishments .Equally, it is expected that the majority of the whole life carbon is associated with the high rate of replacement of MEP equipment due to the anticipated maintenance and repair.

Reductions can still be made with the internal finishes, such as ensuring that the finishes contain higher recycled content, utilising Environmental Product Declaration (EPDs) to inform the specifier on the product's environmental impacts, and ensuring that cradle-to-cradle certification which provide details of their advised end-of-life. All of these aspects should be considered during specification and procurement.

There are a few other design options that are still in discussion for the development's key carbon hotspot – Building Services, namely:

- Minimise ductwork crossovers
- Procure low carbon insulation
- Avoid having refrigerant pipework running through the building as it creates higher leakage and maintenance events through life cycle
- Retain and reuse the existing equipment, including tanks and risers
- Use LED driver that are replaceable and upgradable throughout the life of the fitting
- Specify low GWP refrigerants and reduce overall refrigerant charge
- Ensure low leakage rates for refrigerants and ensure refrigerants are 100% recovered
- Ask the manufacturer for product data sheets, and input into the embodied carbon impact of equipment. Specifically, ask whether the product has an EPD (Environmental Product Declaration) to ensure transparency of carbon impact.
- Specify equipment with longer lifespans

These are to be addressed with the design and construction team during the remainder of the Technical Design and through the Construction stage in relation to all relevant design factors, such as, but not limited to: whole-life carbon and environmental impact, cost, delivery time, procurement route and aesthetics.

The LCA used a robust methodology to assess the environmental impacts of the development. The study is based on accurate knowledge of the development and uses current best practice datasets in the field of LCA. The calculation methodologies applied to the datasets used to, account for and report on, the environmental impacts are in accordance with the IMPACT methodology.

The LCA shows that building services make up the largest portion of the total environmental impacts. The preceding improvement recommendations have been presented for consideration by the design and construction teams, both for the current development and future buildings.

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