BUILDING PERFORMANCE

Embodied Carbon Assessment Report Summary

Building Name: Ministry of Education Carbon Assessment Trials sample

Building information

- **Typology** – New school building
- **Area assessed** – 963m² gross floor area (GFA) + external floor area for learning
- **Number of storeys** – Two
- **Seismic risk zone** – Low
- **Year of completion** – Unknown

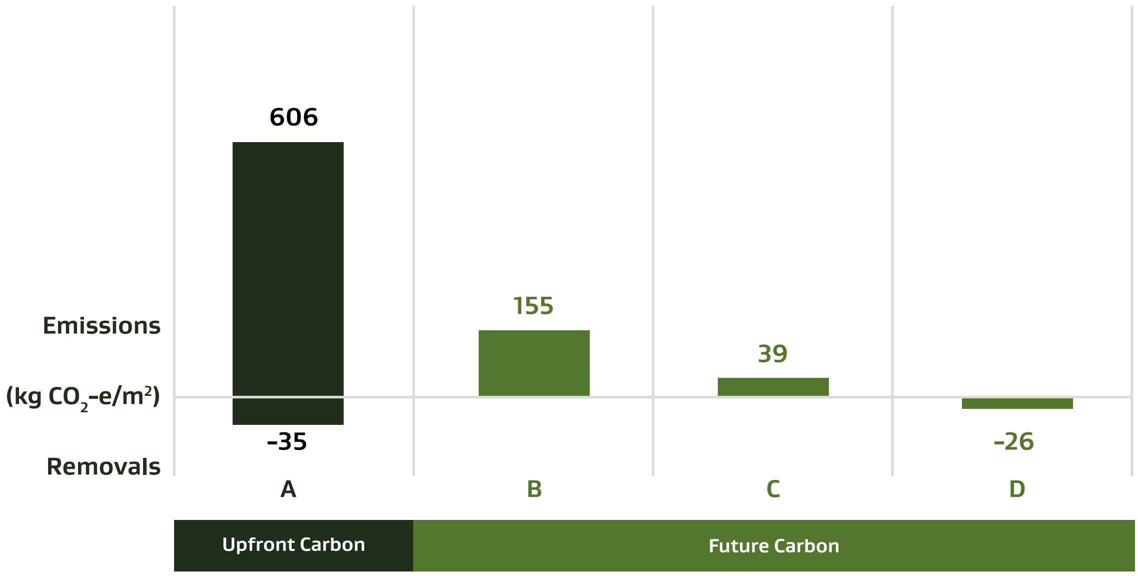
Assessment information

- **Date assessed** – May 2022
- **Purpose** – Ministry of Education trial
- **Design stage** – Post-completion (completed retrospectively primarily for benchmarking purposes)
- **Assessor and role** – Jasmax, architect
- **Life cycle duration** – 50 years
- **Material quantity data source** – Building information model (BIM)
- **Emission factor data source** – eTool database in conjunction with BRANZ datasets and environmental product declarations (EPDs) where available
- **Tool used** – eTool
- **Building element scope** – Ground work, structure, external envelope, non-structural elements, building services

Life Cycle Stages Assesssed

A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	C1	C2	C3	C4	D
☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑

Embodied Carbon by Life Cycle Stage



Assessment Summary

The new school building assessed is a two-storey primary school classroom block of mainly teaching spaces. The assessment was carried out as part of the Carbon Assessment Trials (CAT) programme run by the Ministry of Education (MoE). Findings from these assessments were used by MoE and BRANZ to refine the process for new Life Cycle Assessment (LCA) reporting requirements for school buildings.

Assessments were completed using a template developed by the MoE to compare the embodied carbon of design options, from master planning right through to the as-built stage. This assessment, completed retrospectively, shows the preliminary and detailed design stages. For further details of MoE's LCA reporting requirements for new schools, and the template used for this assessment, see the Ministry of Education.

Assessment Highlights

The MoE carbon assessment template provides a framework to compare the embodied carbon of options at all design stages. Design decisions are refined through optioneering at each stage, and results are presented for the whole building based on the preferred options at the end of each design stage (pages 12-14 and 21-22).

Tables summarise the embodied carbon emissions and potential removals in each life cycle module for each option considered (pages 8-9 and 17-18). Potential removals are then separated into Biogenic Carbon and Module D benefits. The clear breakdown of embodied carbon totals by building element systems and life cycle stages provides insights on where to focus efforts to reduce embodied carbon in future projects (pages 14 and 22).

The greatest opportunities for reducing emissions throughout the lifecycle of a building occur at the beginning of the design process. Due to project timing, this assessment was completed at the end of detailed design, so the opportunity for embodied carbon savings were limited. However, the results are still beneficial for benchmarking purposes and understanding the potential impact of later-stage design decisions on whole of life embodied carbon totals.

MINISTRY OF EDUCATION
TE TĀHUHU O TE MĀTAURANGA

Ministry of Education

Carbon Assessment Trials

School Reporting Template

Trial Building 1 – Concrete/ Steel

Document prepared by:
JASMAX

May 2022

Revision 2

Table of Contents

1.0 Introduction

This report sets out the Life Cycle Assessment (LCA) assumptions and results for this Ministry of Education (MoE) carbon assessment trial project.

The deliverables for each project phase included in this assessment are summarised in Table 1 below:

Table 1:Deliverables Summary

Project Phase	Deliverable Summary
Preliminary Design 50%	Embodied carbon optioneering for largest building elements
Preliminary Design 100%	Full building life cycle analysis to measure embodied carbon, bringing together the preferred optioneered building elements
Developed Design 50%	Embodied carbon optioneering for selected other building elements
Developed Design 100%	Full building life cycle analysis to measure embodied carbon, bringing together the preferred optioneered building elements

2.0 Project Information

2.1 School Property Guide (SPG)

The SPG is a requirement of the MoE to calculate how much space is required for teaching and non-teaching uses.

Table 2: Project SPG

SPG Build Areas

	Build Areas (SQM)
Classroom TS (excl gym)	8
Gymnasium TS	0
Classroom area (at 78 SQM per TS)	624 m²
Gymnasium area	0 m²
Library area	0 m²
Administration area	0 m²
Resource area (at 3 SQM per TS)	24 m²
Hall / Multipurpose area	0 m²
Legitimate area	0 m²
Total net area	648 m²
Total gross area (1.3 multiplier)	842 m²

2.2 Project and Building Description

The design of this project predates the current focus on life cycle carbon emissions, therefore default building systems were typically used.

The school is a Year 1 to 6 primary school located in Auckland. The scope of works for this building (Stage 1) is to construct a standalone teaching space building. The 2-storey building has 8 learning communities, 4 cooking/ maker spaces, a range of smaller breakout/ gather spaces, resource/ storage space, and bathrooms.

The proposed materials suite has been selected to reflect existing built materials within the school. The proposed structure for the building is concrete ground beams/ pads, concrete floor slabs, and a steel and concrete superstructure.

The HVAC for the building varies between the types of spaces and their requirements.

¶ The 8 larger learning communities are to be ventilated by window opening. High level windows are to be actuated with manual push button controls. Space heating is to be provided by electric radiant panel ceiling heaters.

¶ The 4 cooking/ maker spaces are to be ventilated by the outdoor air heat recovery/ AC units, while providing heating and cooling to the space. There are stacked VRF outdoor units to serve dedicated cooking/ maker spaces on each floor.

¶ The toilet cubicles, cleaners' room, and storeroom are to be mechanically ventilated.

2.3 Building Meta-data

Reporting requirements aligned with MBIE's Whole-of-Life Embodied Carbon Assessment: Technical Methodology (MBIE, 2022, p.8), and MoE where available.

Table 3: Building meta-data

Building Meta-data				
City	Auckland			
Postcode				
H1 Climate Zone	Zone 1			
Seismic Zone	Zone 1			
Importance Level	IL3			
Building SPG NFA	648 m^2 (From SPG)			
Building SPG GFA	842 m^2 (From SPG)			
Building External GFA * * External floor area on upper floors used for circulation or outdoor learning, including external stairs if they are needed to access the upper floors of the building.	121 m^2			
GFA Total ** = Building SPG GFA + Building External GFA ** This is to be used as the GFA for carbon per square metre calculations.	**963 m^2**			
Ground Floor Plate Gross Area	423 m^2			
Number of Storeys Above Grade	2-storeys			
Number of Storeys Below Grade	N/A			
Structural Frame Type (pick one).	☒ Steel	Concrete	Timber	Combination
Floor Structures	☒ Concrete	Timber	Combination	

3.0 Modelling Assumptions

3.1 Life Cycle Assumptions

Refer to Table 4 below for life cycle assumptions that are used throughout this report:

Table 4: Life Cycle Assumptions

Life Cycle Assumptions	
Building Design Life	**50-years** (As per MBIE/ Building Act Section 113) Please note that this is for consistent LCA reporting purposes only. We encourage resilient and durable designs to exceed this building design life.
Energy Emissions Factor (Grid)	**Environmental Scenario (as per BRANZ)** Refer to BRANZ scenarios for New Zealand electrical grid *(New Zealand grid environmental factors (module B6)).*
Material Data	Refer to BRANZ module datasets where EPD module data is incomplete (refer Table 6 for carbon data quality hierarchy). The 2022 Reference data list is shown in Table 5 below.
Carbon per m^2 Calculations ($kgCO_2e/m^2$)	Where carbon is to be calculated per square metre, the **GFA Total** is to be used. Refer Table 3 for GFA Total calculations.

Table 5: BRANZ reference datasets

Module	Reference
A4	Construction transport (module A4)
A5	Construction site waste (module A5)
B2	Building materials maintenance (module B2)
B4	Building materials replacement (module B4)
C1	Building end-of-life (module C1)
Materials Data	BRANZ CO_2NSTRUCT.

3.2 Embodied Carbon Assumptions

- Refer to MBIE's Embodied Carbon Data Quality table below for preferred hierarchy of data selection (Table 6).
- Refer to BRANZ module datasets (Table 5) where EPD module data is incomplete.

Table 6: Embodied Carbon Data Quality Hierarchy (MBIE)

Level of Data Quality	Material or product specification and data quality	Material or product embodied carbon data
Highest (preferred) 5	As-built information for material/ product specifications and quantities, that include allowances for site waste	EN 15804 compliant EPD for specific product used in building
4	Detailed Schedule of Quantities, reflecting amounts and specifications of materials included in the building contract	New Zealand sector EN 15804 compliant EPD for product type
3	Quantities take-off from a BIM model used in the design process	Global EN 15804 compliant EPD for product type
2	Rough estimates of material quantities and material types at early stage/ concept design	Embodied carbon data for product type from non-EN 15804 compliant EPD, or other databases
1 Lowest (to be avoided)	Benchmarked material quantity data from similar building types	Default values

3.4 Modelling Tools

See below for tools and data that have been used.

3.4.1 Life Cycle Assessment Modelling - Global Warming Potential

BRANZ LCA Quick	eTool	One Click LCA	Other (please specify)
☐	☒	☐	

3.4.2 Materials Quantity data collection

BIM (Revit / Archicad)	QS	Drawing measure	Other (please specify)
☒			

Refer to Table 6 for quantity data collection hierarchy

4.0 Preliminary Design - 50%

4.1 Summary of Optioneered Building Elements

At this stage of the project, the goal is to compare options for the largest building elements, as these are likely to have the greatest impact on life cycle emissions.

See below for a summary list of the initial building elements considered during preliminary design (Table 7). Strategies have been categorised according to MBIE (refer Table 9). Carbon optioneering results follow in the next sections.

4.1.1 Summary List:

Table 7: Building Elements Summary 50% PD

Building System	Elements (MBIE)	Summary List of optioneered elements
Groundwork / Foundations (i.e. Substructure)	Foundations/ Substructure	¶ Concrete ground beams & pads (standard 30MPa concrete) ¶ Concrete ground beams & pads (Firth EC20 rating, 30MPa) ¶ Concrete ground beams & pads (Firth EC40 rating, 30MPa Concrete)
	Earth retaining structures	¶ *Not applicable*
Structure (i.e. Superstructure)	Ground floor structure	¶ Concrete lowest floor slab (standard 30MPa concrete) ¶ Concrete lowest floor slab (Firth EC20 rating, 30MPa) ¶ Concrete lowest floor slab (Firth EC40 rating, 30MPa Concrete)
	Upper floor(s) structure	¶ Concrete upper floor slabs (standard 30MPa concrete) ¶ Concrete upper floor slabs (Firth EC20 rating, 30MPa) ¶ Concrete upper floor slabs (Firth EC40 rating, 30MPa Concrete)
	Load bearing systems	¶ Concrete column filling & ribs (standard 30MPa concrete) ¶ Concrete column filling & ribs (Firth EC20 rating, 30MPa)) ¶ Concrete column filling & ribs (Firth EC40 rating, 30MPa Concrete)
	Roof structure	¶ *No options considered as this was a retrospective analysis of Preliminary Design*
External Envelope	Cladding/ Façade (incl. openings)	¶ *No options considered as this was a retrospective analysis of Preliminary Design*
	Roof system	¶ *No options considered as this was a retrospective analysis of Preliminary Design*

4.1.2 Limitations & Constraints

Standard structural systems of predominantly steel and concrete were selected due to their often default application to projects resulting from contractor and consultant team preference and familiarity. At the time of this optioneering, the design and costing had progressed beyond the point where changes could be made. Note that carbon was not a defined design criteria during this time, hence the use of status quo.

Foundations/Substructure

Based on geotechnical recommendations and site-specific subsoil classification (C), a shallow substructure was required. Geotechnical recommended that foundation embedment should be at least 600mm below existing ground level, but not more than 750mm due to subsoil conditions. As such, concrete ground beams and pads were designed to meet the site conditions.

Floor Structures

Concrete slabs and interspan ribs were selected due to their good acoustic performance, fire resistance and speed of construction.

Load Bearing Systems

Steel beams, columns, and DHS purlins were selected due to their speed of construction, and they are a well-known construction methodology. The primary 350SHS steel columns are filled with concrete for fire resistance rating (FRR). The structural system also allows for future flexibility, and easier interior re-fitout. The structural system reduced the need for braced walls internally, allowing internal spaces to be reconfigured.

Envelope

Brick cladding was used to reference the existing school, and tie in. Bricks also have good durability and low maintenance. A warm roof system was used because of its better performance than a cold roof. Aluminium joinery was selected due to its durability.

4.2 Optioneering Embodied Carbon Results

4.2.1 Carbon Results for Foundations/ Substructure options: (GWP $kgCO_2e$)

Building Element Options	
1: Standard 30MPa Concrete	Concrete ground beams and pads (standard 30MPa concrete)
2: Firth EC20 rating, 30MPa Concrete	Concrete ground beams and pads (Firth EC20 rating, 30MPa Concrete)
3: Firth EC40 rating, 30MPa Concrete	Concrete ground beams and pads (Firth EC40 rating, 30MPa Concrete)

	Gross Emissions $kgCO_2e$ (excl. module D and biogenic)				Potential Removals $kgCO_2e$ (module D and biogenic)		
	Today	Future		**Total** (Gross)	Biogenic	Benefits	**Total** (Net)
Building Element Options	**A**	**B**	**C**	**Embodied Carbon**	**Biogenic Carbon**	**D**	**Embodied Carbon**
1: Standard 30MPa Concrete	73,878	0	6,722	80,600	528	1,151	82,278
2: Firth EC20 rating, 30MPa Concrete	60,975	0	6,505	67,479	-60	1,151	68,570
3: Firth EC40 rating, 30MPa Concrete	54,950	0	6,505	61,454	-60	1,151	62,545

4.2.3 Carbon Results for Ground Floor Structure options: (GWP $kgCO_2e$)

Building Element Options	
1: Standard 30 MPa Concrete	Concrete lowest floor slab 125mm (standard 30MPa concrete)
2: Firth EC20 rating, 30MPa Concrete	Concrete lowest floor slab 125mm (Firth EC20 rating, 30MPa Concrete)
3: Firth EC40 rating, 30MPa Concrete	Concrete lowest floor slab 125mm (Firth EC40 rating, 30MPa Concrete)

	Gross Emissions $kgCO_2e$ (excl. module D and biogenic)				Potential Removals $kgCO_2e$ (module D and biogenic)		
	Today	Future		**Total** (Gross)	Biogenic	Benefits	**Total** (Net)
Building Element Options	**A**	**B**	**C**	**Embodied Carbon**	**Biogenic Carbon**	**D**	**Embodied Carbon**
1: Standard 30MPa Concrete	56,066	0	3,850	59,915	-1,684	1,256	59,488
2: Firth EC20 rating, 30MPa Concrete	49,640	0	3,737	53,377	-1,988	1,256	52,645
3: Firth EC40 rating, 30MPa Concrete	46,462	0	3,737	50,199	-1,988	1,256	49,467

4.2.4 Carbon Results for Upper Floor Structure options: (GWP $kgCO_2e$)

Building Element Options	
1: Standard 30MPa Concrete	Concrete upper floor slab 100mm + external upper verandah floor slab 75mm (standard 30MPa concrete)
2: Firth EC20 rating, 30MPa Concrete	Concrete upper floor slab 100mm + external upper verandah floor slab 75mm (Firth EC20 rating, 30MPa Concrete)
3: Firth EC40 rating, 30MPa Concrete	Concrete upper floor slab 100mm + external upper verandah floor slab 75mm (Firth EC40 rating, 30MPa Concrete)

	Gross Emissions kgCO₂e (excl. module D and biogenic)				**Potential Removals kgCO₂e** (module D and biogenic)		
	Today	Future		**Total** (Gross)	Biogenic	Benefits	**Total** (Net)
Building Element Options	**A**	**B**	**C**	**Embodied Carbon**	**Biogenic Carbon**	**D**	**Embodied Carbon**
1: Standard 30MPa Concrete	50,859	0	3,907	54,765	-1,743	994	54,016
2: Firth EC20 rating, 30MPa Concrete	44,008	0	3,788	47,796	-2,065	994	46,726
3: Firth EC40 rating, 30MPa Concrete	40,665	0	3,788	44,453	-2,065	994	43,383

4.2.5 Carbon Results for Load Bearing Systems options: (GWP kgCO_2e)

Building Element Options	
1: Standard 30MPa Concrete	Concrete filling for 350SHS columns, and concrete for 150D Interspan ribs that support the upper floor slab (standard 30MPa concrete)
2: Firth EC20 rating, 30MPa Concrete	Concrete filling for 350SHS columns, and concrete for 150D Interspan ribs that support the upper floor slab (Firth EC20 rating, 30MPa Concrete)
3: Firth EC40 rating, 30MPa Concrete	Concrete filling for 350SHS columns, and concrete for 150D Interspan ribs that support the upper floor slab (Firth EC40 rating, 30MPa Concrete)

	Gross Emissions kgCO₂e (excl. module D and biogenic)				**Potential Removals kgCO₂e** (module D and biogenic)		
	Today	Future		**Total** (Gross)	Biogenic	Benefits	**Total** (Net)
Building Element Options	**A**	**B**	**C**	**Embodied Carbon**	**Biogenic Carbon**	**D**	**Embodied Carbon**
1: Standard 30MPa Concrete	23,741	0	1,827	25,569	-810	465	25,223
2: Firth EC20 rating, 30MPa Concrete	20,245	0	1,771	22,016	-961	465	21,520
3: Firth EC20 rating, 30MPa Concrete	15,326	0	1,771	17,097	-961	465	16,601

Please note the biogenic impacts of the options are due to the plywood used in the formwork, which is assumed to be from sustainable sources for all option. The biogenic impact is reduced (more negative) for the Firth concrete mix options, as they do not release biogenic emissions in their manufacture, whereas the Standard concrete mix assumes internationally sourced cement, and hence some small biogenic emissions. The module D values for all options is positive as no closed loop recycling is assumed for the steel reinforcing bars used in these concrete elements.

For all these building system elements, option 1 was selected as the preferred option. At the time of this optioneering, the design and costing had progressed beyond the point where changes could be made. Note that carbon was not a defined design criteria during this time, hence the use of status quo. Option 1 was the least cost and most universally available product at the expense of having the highest carbon emissions.

5.0 Preliminary Design - 100%

5.1 Summary of Building Life Cycle Analysis (Embodied Carbon)

At this stage of the project, the goal is to bring together the preferred options for the optioneered building elements together with all the other building elements and assess the overall emissions of the building.

5.1.1 Summary List

Table 8: Building Element Summary 100% PD

Building System	Elements (MBIE)	Summary List
Groundwork / Foundations (i.e. Substructure)	Foundations/ Substructure	¶ Concrete ground beams & pads (standard concrete)
	Earth retaining structures	¶ *Not applicable*
Structure (i.e. Superstructure)	Ground floor structure	¶ Concrete lowest floor slab (standard concrete)
	Upper floor(s) structure	¶ Concrete upper floor slabs (standard concrete)
	Load bearing systems	¶ Concrete column filling & ribs (standard concrete)
	Roof structure	¶ *No options considered as this was a retrospective analysis of Preliminary Design*
External Envelope	Cladding/ Façade (incl. openings)	¶ *No options considered as this was a retrospective analysis of Preliminary Design*
	Roof system	¶ *No options considered as this was a retrospective analysis of Preliminary Design*

5.1.2 Limitations & Constraints

Standard structural systems of predominantly steel and concrete were selected due to their often default application to projects resulting from contractor and consultant team preference and familiarity. Optioneering was completed retrospectively due to timing of the carbon trial. At the time of this optioneering, the design and costing had progressed beyond the point where changes could be made. Note that carbon was not a defined design criteria during this time, hence the use of status quo.

Based on geotechnical recommendations and site-specific subsoil classifications, shallow substructure was required. Concrete ground beams and pads were designed to meet the site conditions.

Refer to Table 9 below for the scope of the embodied carbon assessment in the following section. Note where default values are to be used at this stage. The embodied carbon assessment results that follow have been categorised as per MBIE (refer Table 9 below).

Table 9: Building Element Categories (Adapted from MBIE)

Building System	Elements (MBIE)	Notes
Groundwork / Foundations (i.e. Substructure)	¶ Foundations/ Substructure ¶ Earth retaining structures ¶ Basements	Refer to Table 13: Appendix 1 for Building System Element scope, categorisation, and level of detail
Structure (i.e. Superstructure)	¶ Ground floor structure ¶ Upper floor(s) structure ¶ Load bearing systems ¶ Roof structure ¶ Stairs *	Refer to Table 13: Appendix 1 for Building System Element scope, categorisation, and level of detail
External Envelope	¶ Cladding/ Façade (incl. openings) ¶ Roof system	Refer to Table 13: Appendix 1 for Building System Element scope, categorisation, and level of detail
Non-Structural Internal Elements	¶ Internal non-loadbearing walls ¶ Internal floor finishes ¶ Internal wall finishes ¶ Internal doors ¶ Ceilings *	**122 $kgCO_2e/m^2$** (BRANZ default value to be used for *Non-structural Internal Elements* in Preliminary Design 100%)
Building Services	¶ HVAC equipment ¶ Lifts and escalators **	**91 $kgCO_2e/m^2$** (Default value to be used for *Building Services* in Preliminary Design 100%)

The default values (in kg CO_2e/m^2) for non-structural internal elements and building services shown above have been provided by BRANZ and were developed in consultation with MoE based on early studies of school buildings. They will be updated as more data become available for schools and are not necessarily valid specifically for other building typologies. However in this assessment, default values have not been used for these building systems as project specific data was available, and calculated using eTool.

* According to the MBIE Embodied Carbon Technical Methodology, this is an additional element that is 'voluntary' for reporting. For this report, this item is mandatory for inclusion due to its notable impact on overall emissions.

** According to the MBIE Embodied Carbon Technical Methodology, this is an additional element that is 'voluntary' for reporting. For this report, this item is also mandatory for inclusion due to its impact on embodied and operational emissions. The MBIE categorised this item as 'Structure', but for consistency with CBI classification it has been re-categorised as a 'Building Services' item in this report.

5.2 Life Cycle Analysis - Embodied Carbon Results

Default values have been provided for non-structural internal elements and services (shown in orange rows). These have been provided on a per square metre basis, so need to be adjusted for total impacts (GFA Total x default values = total impacts).

For this assessment, these default values have been overwritten as data provided within eTool was used to determine project specific embodied carbon: these are shown in green.

5.2.1 Carbon Results for non-structural internal elements and building services: (GWP $kgCO_2e$)

Building Meta-data

GFA Total = Building SPG GFA + Building External GFA	963 m²

Building System	**Gross Emissions kgCO_2e** (excl. module D and biogenic)				**Potential Removals kgCO_2e** (module D and biogenic)		
	Today	Future		**Total** (Gross)	Biogenic	Benefits	**Total** (Net)
	A	**B**	**C**	**Embodied Carbon**	**Biogenic Carbon**	**D**	**Embodied Carbon**
Non-str. Internal Elements kgCO_2e/m² GFA	51	51	20	122	0	-1	121
Non-str. Internal Elements kgCO_2e Total	39,886	65,178	3,821	108,885	-18,490	-2,316	88,079

Building System	**Gross Emissions kgCO_2e** (excl. module D and biogenic)				**Potential Removals kgCO_2e** (module D and biogenic)		
	Today	Future		**Total** (Gross)	Biogenic	Benefits	**Total** (Net)
	A	**B**	**C**	**Embodied Carbon**	**Biogenic Carbon**	**D**	**Embodied Carbon**
Building Services kgCO_2e/m² GFA	15	64	12	91	0	-2	89
Building Services kgCO_2e Total	16,284	68,974	11,338	96,596	-69	-1,638	94,889

5.2.2 Building total Carbon results: (GWP kgCO_2e)

These are the embodied carbon results for the whole building assessed at the preliminary design stage, namely the sum of the embodied carbon values of:

- The preferred options from the building elements that were optioneered at this stage,
- The remaining building elements that were assessed at this stage,
- Building systems that could use values derived from default carbon intensities (in kg CO_2e/m²) in orange rows, shown in green where these have been overwritten.

Building System	**Gross Emissions kgCO_2e** (excl. module D and biogenic)				**Potential Removals kgCO_2e** (module D and biogenic)		
	Today	Future		**Total** (Gross)	Biogenic	Benefits	**Total** (Net)
	A	**B**	**C**	**Embodied Carbon**	**Biogenic Carbon**	**D**	**Embodied Carbon**
Groundwork / Substructure	81,408	0	6,930	88,338	506	1,197	90,040
Structure	291,069	0	12,020	303,089	-4,305	-10,731	288,053
External Envelope	108,591	10,887	2,991	122,470	-6,303	-8,968	107,199
Non-str. Internal Elements	39,886	65,178	3,821	108,885	-18,490	-2,316	88,079
Building Services	16,284	68,974	11,338	96,596	-69	-1,638	94,889
Total	537,404	145,040	37,101	719,544	-28,661	-22,457	668,426
Total + 10% Contingency*	**591,144**	**159,544**	**40,811**	**791,498**	**31,527**	**24,703**	**735,269**
Per m² (GFA Total)	558	151	39	747	-30	-23	694

Per m² (GFA Total) + 10%*	614	166	42	822	-33	-26	764
MoE Carbon Target	*Meets target? Yes* ☐ No ☒			500			

*For this 100% Preliminary Design analysis, the carbon (total and per m²) is reported with a **10% contingency added** to account for extra items (such as fixings) which may not have been accounted for at this stage.

5.2.3 Conclusion

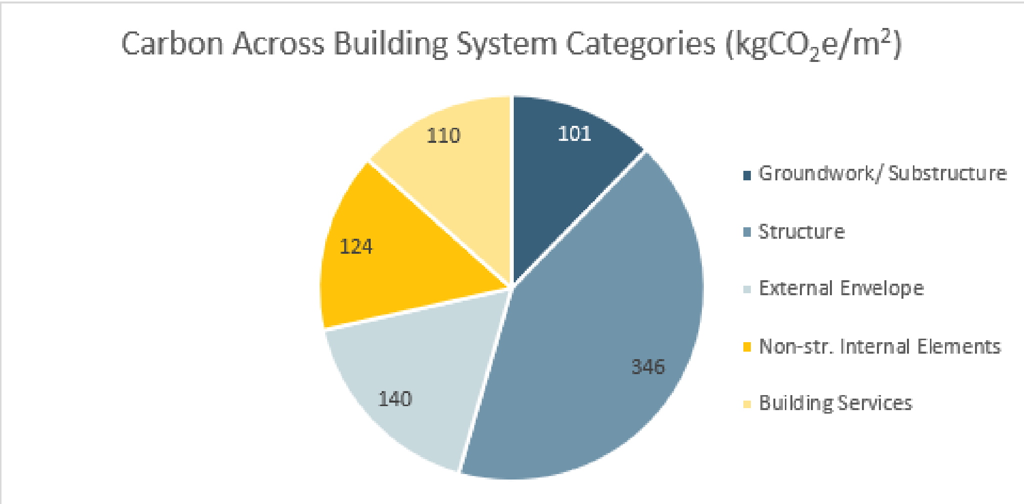
The project exceeds the MoE carbon target. Standard structural systems of predominantly steel and concrete were selected due to their often default application to projects resulting from contractor and consultant team preference and familiarity. These systems are however highly carbon intensive. Optioneering was completed retrospectively due to timing of the carbon trial. Note that carbon was not a defined design criteria during this time, hence the use of status quo for this full LCA at this stage.

Next steps in Developed Design will explore options for floor finishes as these are highly carbon intensive due to their high replacement cycles over the building's lifespan. Note that the design and costing has progressed beyond the point where changes can be made.

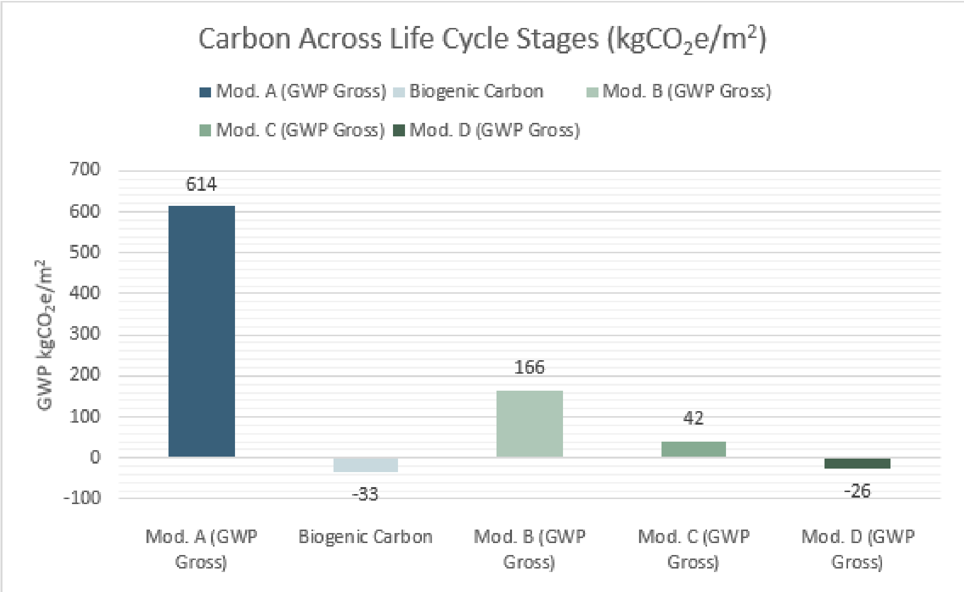
Note that this analysis (100% PD) was done retrospectively, so extra items have been accounted for that typically may not be in these early stages. The carbon software used for this analysis (eTool) has built-in data for detailed items such as fixings. For this reason, the carbon results excluding the 10% added for contingency are likely the most accurate representation of the building's carbon at this stage.

5.3 Life Cycle Analysis - Embodied Carbon Results (Graphed)

The following chart shows embodied carbon (Gross – modules A-C) per m² GFA Total ($kgCO_2e/m^2$) across building system categories. Please note that *Non-Structural Internal Elements* and *Building Services* are based on default carbon intensities at this stage.



The following chart shows embodied carbon (Gross) per m² GFA Total ($kgCO_2e/m^2$) across the life cycle stages.


Carbon Across Life Cycle Stages (kgCO2e/m2)
Mod. A (GWP Gross)
Biogenic Carbon
Mod. B (GWP Gross)
Mod. C (GWP Gross)
Mod. D (GWP Gross)
GWP kgCO2e/m2
700
600
500
400
300
200
100
0
-100
614
-33
166
42
-26
Mod. A (GWP Gross)
Biogenic Carbon
Mod. B (GWP Gross)
Mod. C (GWP Gross)
Mod. D (GWP Gross)

6.0 Developed Design – 50%

6.1 Summary of Optioneered Building Elements

At this stage of the project, the goal is to finalise the largest building elements and optimise design options for specific building elements and building services. Reporting in this section is optional if there are negligible changes to the design that impact carbon.

A summary list of the building elements considered at this stage is provided below (Table 10).

Strategies have been categorised according to MBIE (refer Table 12). Carbon optioneering results will follow in the next sections.

6.1.1 Summary List:

Table 10: Building Element Summary 50% DD

Building System	Elements (MBIE)	Summary List
Groundwork / Foundations (i.e. Substructure)	Foundations/ Substructure	¶ Concrete ground beams & pads (standard concrete)
	Earth retaining structures	¶ *Not applicable*
Structure (i.e. Superstructure)	Ground floor structure	¶ Concrete lowest floor slab (standard concrete)
	Upper floor(s) structure	¶ Concrete upper floor slabs (standard concrete)
	Load bearing systems	¶ Concrete column filling & ribs (standard concrete)
	Roof structure	¶ *No options considered as this was a retrospective analysis of Developed/ Detailed Design*
External Envelope	Cladding/ Façade (incl. openings)	¶ *No options considered as this was a retrospective analysis of Developed/ Detailed Design*
	Roof system	¶ *No options considered as this was a retrospective analysis of Developed/ Detailed Design*
Non-Structural Internal Elements	Internal floor finishes	¶ Jacobsen Shaw carpet tile ¶ Interface CQuest BioX carpet tile ¶ Interface CushionBacRe carpet tile ¶ Forbo Peace woven carpet tile
Building Services	HVAC Equipment	¶ R-410A refrigerant used in the AC unit ¶ R32 refrigerant used in the AC unit (refer 8.1.2 for limitations and constraints with options)

6.1.2 Limitations & Constraints

Provide commentary on limitations and constraints that impacted the proposed carbon reductions.

Internal finishes

Optioneering was completed retrospectively due to timing of the carbon trial. At the time of this optioneering, the design and costing had progressed beyond the point where changes could be made. Note that carbon was not a defined design criteria during this time, hence the use of status quo.

¶ Floor finishes

Carpet has been used in all learning spaces (learning communities and breakout/ focus spaces). Marmoleum has been specified for the cooking/ create spaces as it is an easy to clean/ durable material. Similarly, vinyl has been specified for the bathroom as it is an easy to clean/ durable material for this wet space. The floor finishes have each been selected to be appropriate for the space use, and the areas of specified floor finishes could not be reduced. However, EPD's will be explored to investigate low impact finishes.

EPDs of lower impact carpet tiles has been explored in 6.3.1 optioneering. However, the lower impact products could not be selected for use as the school requested the carpet tiles to match the existing carpet tiles the school has.

¶ Wall finishes

Large areas of acoustic treatment (Covering 1) have been used as per the acoustic requirements of the various learning spaces. This could not be reduced without compromising the acoustics and functionality of the spaces.

HVAC Equipment

Optioneering was completed retrospectively due to timing of the carbon trial. At the time of this optioneering, the design and costing had progressed beyond the point where changes could be made. Note that carbon was not a defined design criteria during this time, hence the use of status quo.

¶ Passive ventilation has been maximised in the 8 learning communities. However, the 4 cooking/ maker spaces require ventilation by the outdoor air heat recovery/ AC units, while providing heating and cooling to the space. The GUF-100RD4 unit that has been specified by the Mechanical Engineer has R-410A as the refrigerant – one of the highest GWP impact refrigerants. A lower impact refrigerant was requested by the Architecture team (R32), but this was not able to be used as the manufacturer equipment is not yet sold as R32 and the heat recovery system would be lost. The operational energy and respective carbon use without the heat recovery system is assumed to be greater than the embodied carbon of the specified AC units for the cooking/ maker spaces, so no alternative options have been selected at this time.

¶ A lift has been specified for the 2-storey building for accessibility. This is a set requirement, and no alternative options have been investigated.

¶ Electric radiant panel heaters (ceiling) have been used throughout the learning communities and smaller learning spaces. The number of panel heaters was increased from 48 at Preliminary Design, to 74 for Building Consent/ Tender – as the Mechanical Engineers decreased the capacity of each and provided more, as an internal review identified that the coverage wasn't correct or appropriate.

6.2 Updated Embodied Carbon Results

Updated carbon results for the finalised building elements selections that were optioneered in the previous design stage.

6.2.1 Carbon Results for Foundations/ Substructure options: (GWP kgCO_2e)

Building Element Options							
1: Standard 30MPa Concrete	Concrete ground beams and pads (standard 30MPa concrete)						
	Gross Emissions kgCO_2e (excl. module D and biogenic)				**Potential Removals kgCO_2e** (module D and biogenic)		
	Today	Future		**Total** (Gross)	Biogenic	Benefits	**Total** (Net)
Building Element Options	**A**	**B**	**C**	**Embodied Carbon**	**Biogenic Carbon**	**D**	**Embodied Carbon**
1: Standard 30MPa Concrete	80,633	0	7,446	88,079	598	1,205	89,882

6.2.3 Carbon Results for Ground Floor Structure options: (GWP kgCO_2e)

Building Element Options							
1: Standard 30MPa Concrete	Concrete lowest floor slab 125mm (standard 30MPa concrete)						
	Gross Emissions kgCO_2e (excl. module D and biogenic)				**Potential Removals kgCO_2e** (module D and biogenic)		
	Today	Future		**Total** (Gross)	Biogenic	Benefits	**Total** (Net)
Building Element Options	**A**	**B**	**C**	**Embodied Carbon**	**Biogenic Carbon**	**D**	**Embodied Carbon**
1: Standard 30 MPa Concrete	55,985	0	3,844	59,829	-1,681	1,255	59,403

6.2.4 Carbon Results for Upper Floor Structure options: (GWP kgCO_2e)

Building Element Options							
1: Standard 30MPa Concrete	Concrete upper floor slab 100mm + external upper verandah floor slab 75mm (standard 30MPa concrete)						
	Gross Emissions kgCO_2e (excl. module D and biogenic)				**Potential Removals kgCO_2e** (module D and biogenic)		
	Today	Future		**Total** (Gross)	Biogenic	Benefits	**Total** (Net)
Building Element Options	**A**	**B**	**C**	**Embodied Carbon**	**Biogenic Carbon**	**D**	**Embodied Carbon**
1: Standard 30MPa Concrete	54,986	0	4,211	59,196	-1,879	1,072	58,389

6.2.5 Carbon Results for Load Bearing Systems options: (GWP kgCO_2e)

Building Element Options		
1: Standard 30MPa Concrete	Concrete filling for 350SHS columns, and concrete for 150D Interspan ribs that support the upper floor slab (standard 30MPa concrete)	
	Gross Emissions kgCO_2e (excl. module D and biogenic)	**Potential Removals kgCO_2e** (module D and biogenic)

	Today	Future		**Total** (Gross)	Biogenic	Benefits	**Total** (Net)
Building Element Options	**A**	**B**	**C**	**Embodied Carbon**	**Biogenic Carbon**	**D**	**Embodied Carbon**
1: Standard 30MPa Concrete	23,153	0	1,768	24,921	-784	450	24,587

6.3 Optioneering Embodied Carbon Result

A summary of the floor finish options that have been explored, and the carbon associated with the options.

6.3.1 Carbon Results for Internal Floor Finish options: (GWP kgCO_2e)

Building Element Options	
1: Jacbobsen Shaw	Jacobsen Shaw carpet tiles (from EPD) in all learning communities and smaller breakout spaces
2: Interface CQuest	Interface CQuest BioX carpet tiles (from EPD) in all learning communities and smaller breakout spaces
3: Interface	Interface CushionBacRe Type 6 nylon carpet tile (from EPD) in all learning communities and smaller breakout spaces
4: Forbo Peace	Forbo Peace woven carpet tile (from EPD) in all learning communities and smaller breakout spaces

	Gross Emissions kgCO_2e (excl. module D and biogenic)				**Potential Removals kgCO_2e** (module D and biogenic)		
	Today	Future		**Total** (Gross)	Biogenic	Benefits	**Total** (Net)
Building Element Options	**A**	**B**	**C**	**Embodied Carbon**	**Biogenic Carbon**	**D**	**Embodied Carbon**
1: Jacobsen Shaw	6,498	28,199	1,290	35,987	0	0	35,987
2: Interface CQuest	386	2,511	192	3,089	4	0	3,093
3: Interface	4,209	17,793	24	22,026	0	-1,278	20,748
4: Forbo Peace	9,986	40,529	24	50,539	4	-7,164	43,380

Optioneering was completed retrospectively due to timing of the carbon trial. At the time of this optioneering, the design and costing had progressed beyond the point where changes could be made.

Option 1 was selected as the preferred option. EPDs of lower impact carpet tiles has been explored in the optioneering, however, the lower impact products could not be selected for use as the school requested the carpet tiles to match the existing carpet tiles the school has.

6.3.2 Carbon Results for HVAC Equipment options: (GWP kgCO_2e)

This used specific data for HVAC systems available in eTool. Refer to section 6.1.2 for summary of HVAC systems that were specified for the project, and limitations of completing optioneering.

7.0 Developed Design – 100%

7.1 Summary of Building Life Cycle Analysis (Embodied Carbon)

At this stage of the project, the goal is to bring together the preferred building elements and assess the overall emissions of the building.

A summary of the final proposed building elements is shown below (Table 11)

7.1.1 Summary List:

Table 11: Building Element Summary 100% DD

Building System	Elements (MBIE)	Summary List
Groundwork / Foundations (i.e. Substructure)	Foundations/ Substructure	¶ Concrete ground beams & pads (standard concrete)
	Earth retaining structures	¶ *Not applicable*
Structure (i.e. Superstructure)	Ground floor structure	¶ Concrete lowest floor slab (standard concrete)
	Upper floor(s) structure	¶ Concrete upper floor slabs (standard concrete)
	Load bearing systems	¶ *No options considered as this was a retrospective analysis of Developed/ Detailed Design*
	Roof structure	¶ *No options considered as this was a retrospective analysis of Developed/ Detailed Design*
External Envelope	Cladding/ Façade (incl. openings)	¶ *No options considered as this was a retrospective analysis of Developed/ Detailed Design*
	Roof system	¶ *No options considered as this was a retrospective analysis of Developed/ Detailed Design*
Non-Structural Internal Elements	Internal floor finishes	¶ Jacobsen Shaw carpet tile
Building Services	HVAC Equipment	¶ R-410A refrigerant used in the AC unit

7.1.2 Limitations & Constraints

Provide commentary on limitations and constraints that impacted the proposed carbon reductions.

Optioneering was completed retrospectively due to timing of the carbon trial. At the time of this optioneering, the design and costing had progressed beyond the point where changes could be made. Note that carbon was not a defined design criteria during this time, hence the use of status quo. Refer section 9.2.1 for limitations and constraints.

Refer to Table 12 below for the scope of the embodied carbon assessment in the following section. Embodied carbon assessment results that follow have been categorised as per MBIE (refer Table 12 below).

Table 12: Building Element Categories (Adapted from MBIE)

Building System	Elements (MBIE)	Notes
Groundwork / Foundations (i.e. Substructure)	¶ Foundations/ Substructure ¶ Earth retaining structures ¶ Basements	Refer to Table 13: Appendix 1 for Building System Element scope, categorisation, and level of detail
Structure (i.e. Superstructure)	¶ Ground floor structure ¶ Upper floor(s) structure ¶ Load bearing systems ¶ Roof structure ¶ Stairs *	Refer to Table 13: Appendix 1 for Building System Element scope, categorisation, and level of detail
External Envelope	¶ Cladding/ Façade (incl. openings) ¶ Roof system	Refer to Table 13: Appendix 1 for Building System Element scope, categorisation, and level of detail
Non-Structural Internal Elements	¶ Internal non-loadbearing walls ¶ Internal floor finishes ¶ Internal wall finishes ¶ Internal doors ¶ Ceilings *	Refer to Table 13: Appendix 1 for Building System Element scope, categorisation, and level of detail
Building Services	¶ HVAC equipment ¶ Lifts and escalators **	Refer to Table 13: Appendix 1 for Building System Element scope, categorisation, and level of detail

* According to the MBIE Embodied Carbon Technical Methodology, this is an additional element that is 'voluntary' for reporting. For this report, this item is mandatory for inclusion due to its notable impact on overall emissions.

** According to the MBIE Embodied Carbon Technical Methodology, this is an additional element that is 'voluntary' for reporting. For this report, this item is also mandatory for inclusion due to its impact on embodied and operational emissions. The MBIE categorised this item as 'Structure', but for consistency with CBI classification it has been re-categorised as a 'Building Services' item in this report.

7.2 Life Cycle Analysis - Embodied Carbon Results

Climate Change – (GWP $kgCO_2e$)

These are the embodied carbon results for the whole building assessed at the developed design stage, namely the sum of the embodied carbon values of:

- ¶ The preferred options from the building elements that were optioneered at this stage,
- ¶ The remaining building elements that were assessed at this stage.

Note no default carbon intensity values are to be used for building elements at this stage.

	Gross Emissions $kgCO_2e$ (excl. module D and biogenic)				**Potential Removals $kgCO_2e$** (module D and biogenic)		
	Today	Future		**Total** (Gross)	Biogenic	Benefits	**Total** (Net)
Building System	**A**	**B**	**C**	**Embodied Carbon**	**Biogenic Carbon**	**D**	**Embodied Carbon**
Groundwork / Substructure	90,237	0	7,758	97,995	494	1,295	99,783
Structure	326,246	0	12,740	338,986	-9,865	-12,258	316,863
External Envelope	102,503	10,579	2,796	115,878	-5,931	-9,227	100,720
Non-str. Internal Elements	46,853	66,209	3,823	116,885	-18,462	-2,754	95,669
Building Services	17,836	71,819	11,367	101,021	-71	-1,939	99,011
Total	583,675	148,606	38,484	770,765	-33,835	-24,883	712,047
Per m^2 (GFA Total)	**606**	**154**	**40**	**800**	-35	-26	739
MoE Carbon Target	*Meets target?* Yes ☐ No ☒			**500**			

7.2.1 Conclusion

The project exceeds the MoE carbon target. Standard structural systems of predominantly steel and concrete were selected due to their often default application to projects resulting from contractor and consultant team preference and familiarity. These systems are however highly carbon intensive. Optioneering was completed retrospectively due to timing of the carbon trial. At the time of this optioneering, the design and costing had progressed beyond the point where changes could be made. Note that carbon was not a defined design criteria during this time, hence the use of status quo for this full LCA at this stage.

The floor finishes are highly carbon intensive but have been specified for their durability and ease of maintenance. Lower carbon alternatives were explored in optioneering but note that the design and costing has progressed beyond the point where changes could be made.

The AC units that have been specified use a highly carbon intensive refrigerant. The manufacturer could not substitute this for a lower impact refrigerant without losing the heat recovery system.

The embodied carbon increased between preliminary design (747 kgCO2e/m2 excluding 10% contingency) and developed design (800 kgCO2e/m2). This is due to numerous reasons, for example:

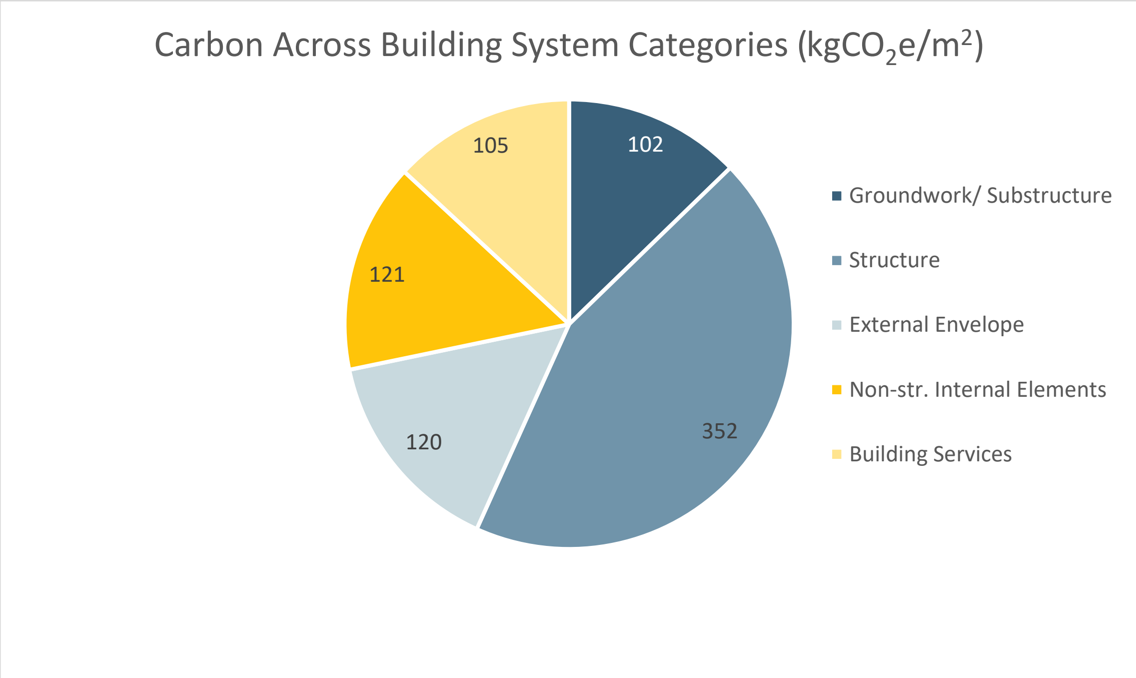
- ¶ The structural sizes of numerous ground beams and pad footings was increased at DD (refer Appendix). The substructure embodied carbon (gross) increased from 92 kgCO2e/m2 in PD to 102 kgCO2e/m2 in DD.
- ¶ The superstructure design (primary and secondary members) was refined in the DD stages, increasing the volumes of concrete and steel required.
- ¶ The number of panel heaters was increased from 48 at Preliminary Design, to 74 for Building Consent/ Tender – as the Mechanical Engineers decreased the capacity of each and provided more, as an internal

review identified that the coverage wasn't correct or appropriate. This however increased the embodied carbon of the Building Services.

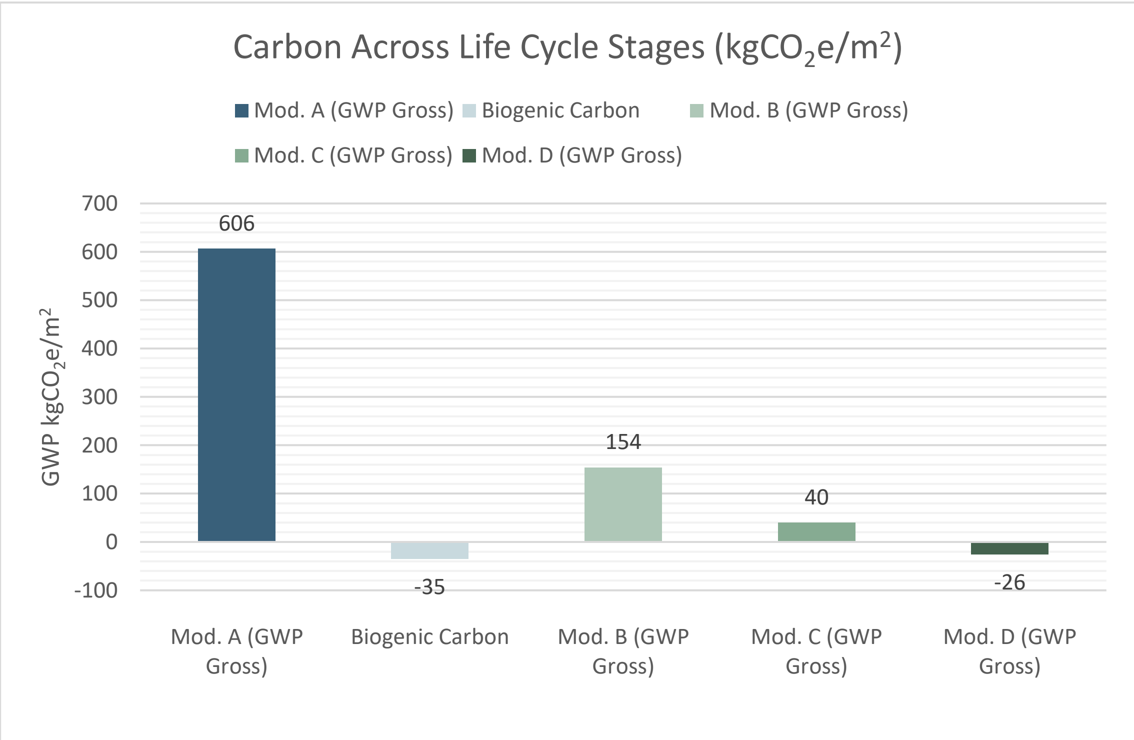
¶ Acoustic panelling was added during the DD stages for acoustic performance.

7.3 Life Cycle Analysis - Embodied Carbon Results (Graphed)

The following chart shows embodied carbon (Gross – modules A-C) per m² GFA Total ($kgCO_2e/m^2$) across building system categories.



The following chart shows embodied carbon per m² GFA Total ($kgCO_2e/m^2$) across the life cycle stages.



8.0 Appendices

8.1 Appendix 1: Building System Elements Categorisation, Scope, and Level of Detail

Refer to Table 13 below for a description of Building System Elements categorisation, scope, and level of detail to be used during life cycle analyses. Elements for inclusion are not limited to those noted in the 'Include' column – these are examples of the type of scope and level of detail that is expected, and common elements that may be ambiguous with categorisation.

Table 13: Appendix 1

Building System	Elements	Include	Exclude
Groundwork / Foundations (i.e. Substructure)	Foundations/ Substructure	¶ Products below the underside of the ground floor slab ¶ Foundations ¶ Hardfilling ¶ Piles ¶ Damp proof membrane ¶ Steel reinforcing bar	¶ Formwork ¶ Fixings ¶ External hard landscaping surfaces and substructures outside building perimeter ¶ External services, including drainage
	Earth retaining structures	¶ Retaining walls	¶ Temporary scaffolding ¶ External hard landscaping retaining walls outside building perimeter
	Basements	¶ Excavation ¶ Basement walls	¶ Temporary scaffolding
Structure (i.e. Superstructure)	Ground floor structure	¶ Ground floor structure (slab, joists etc) ¶ Steel reinforcing bar in concrete slab ¶ Damp proof membrane ¶ Concrete nibs (e.g. building perimeter, or in wet areas)	¶ Foundations ¶ Substructure ¶ Formwork ¶ Temporary scaffolding ¶ Floor finishes ¶ External hard landscaping surfaces outside building perimeter (e.g. pavers)
	Upper floor(s) structure	¶ Upper floor structures (slab, double tees, joists etc.) ¶ Upper floor verandah structure ¶ Concrete nibs (e.g. building perimeter, or in wet areas)	¶ Formwork ¶ Temporary scaffolding ¶ Floor finishes

	Load bearing systems	¶ Gravity and lateral structural frames ¶ Columns and beams ¶ Steel reinforcing bar in concrete columns ¶ Load bearing walls ¶ Secondary structure (e.g. stair stringers) ¶ Steel flitch connections (for LVL and CLT) ¶ Intumescent paint ¶ Paint finish to structure	¶ Fixings (e.g. nails, screws, nail plates, bolts) ¶ Formwork ¶ Plasterboard or paint finish to load bearing walls ¶ External wall studs ¶ External wall rigid air barrier
	Roof structure	¶ Rafters ¶ Purlins ¶ Steel cable bracing ¶ Steel angles	¶ Fixings (e.g. nails, screws, nail plates, bolts) ¶ Roof covering ¶ Roof insulation ¶ Roof internal finishes
	Stairs *	¶ Primary stair flight (concrete, timber etc.) ¶ Steel reinforcing bar in concrete ¶ Landings	¶ Fixings (e.g. nails, screws, nail plates, bolts) ¶ Handrails ¶ Balustrades ¶ Stair floor finish (e.g. carpet) ¶ Supporting structure (e.g. steel stringers, columns and beams)
External Envelope	Cladding/ Façade (incl. openings)	¶ Paint finish to cladding if applicable ¶ Cladding layer ¶ Rigid air barrier ¶ Membrane ¶ Wall framing (studs, top and bottom plate, nogs) ¶ Insulation ¶ Internal plasterboard layer ¶ Curtain wall & mullions ¶ Soffits ¶ Openable external windows ¶ External door leaf (slid core, hollowcore, glazed etc.) ¶ Paint finish to door leaf (undercoat, primer, top coat)	¶ Fixings (e.g. nails, screws, nail plates, bolts) ¶ Cladding/ Façade secondary elements (seals, brackets) ¶ Flashings ¶ Scotias ¶ Internal paint finish ¶ External windows and doors ¶ Skylights ¶ Fixed curtain wall panels ¶ Curtain wall mullions ¶ Door hardware ¶ Door security (e.g. emergency break glass, request exit buttons, card readers) ¶ Window security and hardware ¶ Curtains/ blinds

		¶ Door jamb (timber, aluminium) ¶ External louvres/ grilles	
	Roof system	¶ Roof covering ¶ Insulation ¶ Membrane ¶ Internal finishes ¶ Rigid air barrier ¶ Skylights	¶ Fixings (e.g. nails, screws, nail plates, bolts) ¶ Rafters ¶ Purlins ¶ Fall protection systems ¶ Photovoltaic array ¶ Gutters ¶ Downpipes ¶ Flashings ¶ Monkeytoe platforms
Non-structural Internal Elements	Non-loadbearing walls	¶ Wall framing (studs, top and bottom plate, nogs) ¶ Wall lining (e.g. plasterboard) ¶ Insulation ¶ Bulkheads ¶ Timber batten screening ¶ Balustrades ¶ Handrails	¶ Fixings (e.g. nails, screws, nail plates, bolts) ¶ Paint finishes ¶ Wall coverings (e.g. Autex) ¶ Decorative boards/ panels ¶ Acoustic clips ¶ Sealant (fire rated around penetrations)
	Internal floor finishes	¶ Floor finish (carpet, vinyl, marmoleum, tiles etc) ¶ Adhesive/ glue ¶ Grout ¶ Concrete grind and polish	¶ Fixings (e.g. nails, screws, nail plates, bolts) ¶ Floor structure i.e. slab or joists ¶ Floor finish underlay ¶ Skirting ¶ Tactile indicators ¶ Stair nosings
	Internal wall finishes	¶ Paint finishes (undercoat, primer, top coat) ¶ Wall coverings (e.g. Autex) ¶ Plywood (if exposed finish) ¶ Decorative board/ panel ¶ Bathroom finishes (wall tiles, seratone panels)	¶ Fixings (e.g. nails, screws, nail plates, bolts) ¶ Plasterboard ¶ Skirting ¶ Cornices ¶ Angles to exposed edges of wall coverings e.g. Autex ¶ Timber batten screening ¶ Balustrades ¶ Handrails ¶ Curtains/ blinds
	Internal doors	¶ Door leaf (solid core, hollowcore, glazed etc)	¶ Door hardware ¶ Door security (e.g. emergency break

		¶ Paint finish to door leaf (undercoat, primer, top coat) ¶ Door jamb (timber, aluminium)	glass, request exit buttons, card readers) ¶ Lintels above doorway
	Ceilings *	¶ Plasterboard and finishes ¶ Ceiling tiles ¶ Primary suspension grid system ¶ Timber framing	¶ Fixings (e.g. nails, screws, nail plates, bolts) ¶ Edge trim ¶ Acoustic clips ¶ Sealants
Building Services	HVAC equipment	¶ HVAC ¶ Refrigerants	¶ Water ¶ Drainage ¶ Electrical services ¶ Other building systems e.g. fire and security systems
	Lifts and Escalators **	¶ Lifts (housing and passenger car) ¶ Escalators ¶ Refer BRANZ CO_2NSTRUCT for carbon data on lifts	¶ Lift structure i.e. steel columns or beams on lift shaft perimeter Lift perimeter walls
	Other Significant	¶ Photovoltaic array	

* According to the MBIE Embodied Carbon Technical Methodology, this is an additional element that is 'voluntary' for reporting. For this report, this item is mandatory for inclusion due to its notable impact on overall emissions.

** According to the MBIE Embodied Carbon Technical Methodology, this is an additional element that is 'voluntary' for reporting. For this report, this item is also mandatory for inclusion due to its impact on embodied and operational emissions. The MBIE categorised this item as 'Structure', but for consistency with CBI classification it has been re-categorised as a 'Building Services' item in this report.

8.3 Appendix 3: Glossary

Refer to Table 14 below for definitions of common terms used throughout this report.

Table 14: Appendix 3

Term	Definition	Source
Biogenic Carbon	Biogenic carbon involves biological sources such as trees, plants and soil. In a carbon cycle, trees capture CO_2 from the atmosphere during photosynthesis and store it. The carbon that has been sequestered in this way is released at a later stage when timber is burned or rots away. Because timber stores carbon, assuming it comes from sustainable forests (replanted after harvest), it has a low carbon footprint as a house material.	BRANZ

Carbon Dioxide equivalent (or CO_2eq)	A measure of the global warming caused by all greenhouse gases released by a specific activity. In addition to Carbon Dioxide (CO_2), it includes the impacts of other greenhouse gases, which are typically less significant than the impact of CO_2, but are included for completeness.	MBIE, 2020
Carbon Emissions	A shorthand term for emissions of all greenhouse gases, CO_2 and others, which cause global warming.	MBIE, 2020
	• Emissions caused by non-renewable energy use, at all life cycle stages (any modules in A, B, C or D). • Emissions caused by processes that emit greenhouse gasses, at all life cycle stages (any modules in A, B, C or D).	MBIE, 2022
Carbon Footprint	A measure of the carbon emissions derived from a Life Cycle Assessment (LCA) study, reported in the impact category of climate change or Global Warming Potential (GWP), measured in CO_2e.	MBIE, 2020
Carbon Removals	• Use of natural materials that store sequestered carbon that has been removed from the atmosphere by organic growth (module A1). • Carbonation of concrete during the building's lifetime (module B1). • Potential benefits that may be realised by recycling material after end-of-life, avoiding future emissions from the use of virgin material (module D).	MBIE, 2022
Embodied Carbon	A shorthand term for whole-of-life embodied carbon. For construction materials or products, this is the amount of carbon emissions released throughout their supply chains, including raw material extraction and transportation, manufacturing process, construction site activities and material losses, repair, maintenance and replacement, as well as the end-of-life processing. For a building, the embodied carbon is the sum of the embodied carbon of all the constituent materials or products within the building.	MBIE, 2020
Environmental Product Declaration (EPD)	This is a third-party verified report of Life Cycle Assessment (LCA) results for a construction material product or material. It uses ISO and often also EN standards. It documents the actual environmental performance of the product or material across a number of impact categories, including embodied carbon, usually reported under 'Global Warming Potential' (GWP) in units of kg CO_2e.	MBIE, 2020
Greenhouse Gases	Gases that trap heat in the earth's atmosphere, contributing to global warming. The most prevalent ones are Carbon Dioxide (CO_2), Methane (CH4), Nitrous Oxide (N2O), and fluorinated gases (such as CFCs, HCFCs, HFCs etc. found in refrigerants). Of these, CO_2 causes the largest warming impact.	MBIE, 2020

Life Cycle Assessment (LCA)	A method of assessing the environmental impacts associated with all stages of a product's life, from raw material extraction to its processing, manufacture, distribution, use, repair, maintenance, and end of life treatment.	MBIE, 2020
Operational Carbon	Carbon emissions attributable to the operation of buildings. See the MBIE Transforming Operational Efficiency Framework.	MBIE, 2020

8.4 Appendix 4: Carbon Reduction Strategies (MBIE)

Below are carbon reduction strategies as described by MBIE (2020).

1. Maximise **New Build Efficiency**: ensure the size and quantity of new buildings are proportional to the need, upgrade existing buildings so they can be used effectively, and increase the longevity of new buildings and their components to reduce avoidable new build in the future.

Factor	Ways to reduce emissions	Source
Consider size of new buildings that will meet user needs	When developing the brief for a new building, consider the efficiency of the new building being proposed, and alternative ways to meet the end user's needs.	MBIE, 2020
Repurposing existing buildings/value of heritage	Make the use of existing buildings a viable alternative to building new, using retrofit or upgrade work if required.	MBIE, 2020
Flexibility and Resilience	Ensure buildings will still be usable after earthquakes, the effects of climate change, and other potential changes over the design life, and are flexible enough to be adjusted with minimal impact if the user needs change, avoiding emissions from future rebuilds.	MBIE, 2022
Building to last	Ensure building performance settings reflect the likely design life that can be achieved, enabling all the residual life of a building to be used.	MBIE, 2020

2. Increase building **Material Efficiency**: use less material in new buildings, including reducing waste and minimising replacement over the building's life cycle.

Factor	Ways to reduce emissions	Source
Appropriate performance requirements	Stipulate realistic and reasonable performance requirements for the design of the building components to meet the end-user requirements. Ensure excessive or multiple contingencies are not embedded in the design process.	MBIE, 2020
The efficient use of materials by designers	Only specify as much material as required to meet performance requirements – and not more (lean design). Consider material quantities at the concept design stage of a building, to ensure its form is conducive to high material efficiency.	MBIE, 2020
Reduce construction waste	Reduce waste of materials in construction and upstream processes to minimise production to only as much as is required. This will reduce production and transportation emissions, as well as sector economic efficiency. Apply manufacturing methodology to the supply chain for construction products.	MBIE, 2022
Long lasting construction materials and products	Reuse construction materials and products in new buildings where they outlive the design life of their original building. Design buildings for deconstruction to enable efficient recovery of components for reuse. Consider a model of building owners 'leasing' construction materials and products, rather than buying them, enabling them to be used for other buildings in future with appropriate foresight. Embodied carbon emissions can therefore be shared across multiple buildings.	MBIE, 2020

3. Reduce the **Carbon Intensity** of the materials used in new buildings: either by making design choices to use low-carbon materials over high-carbon alternatives, and/or reducing the embodied carbon of the construction materials.

Factor	Ways to reduce emissions	Source
Reduce emissions from materials/products without affecting properties	Improve energy efficiency of production processes to reduce emissions, or substitute constituent parts of a construction product with low carbon alternatives (e.g. cement replacements). Greater visibility and understanding of embodied carbon will encourage competition among manufacturers to do this.	MBIE, 2020
Sourcing materials and products as close as possible to site	Reduce carbon emissions from transportation.	MBIE, 2020
Increased use of low carbon materials	Use appropriate data and tools in the design process to highlight the benefits of low carbon alternatives to traditional materials and products, e.g. biobased or recycled/reused products.	MBIE, 2022