BUILDING PERFORMANCE

Embodied Carbon Assessment Report Summary

Building Name: Heke Rua Archives Building

Building information

- **Typology** – New office/archive building
- **Area assessed** – 19,869m² gross floor area (GFA)
- **Number of storeys** – Ten (including one below ground)
- **Seismic risk zone** – High
- **Year of completion** – 2026 (expected)

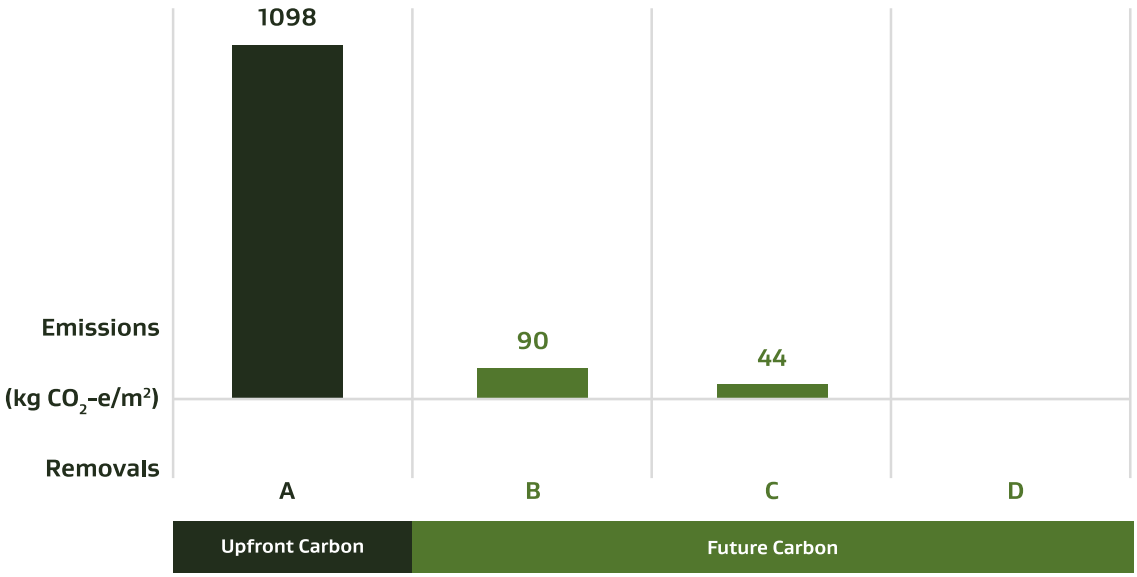
Assessment information

- **Date assessed** – September 2023
- **Purpose** – Carbon Neutral Government Programme (CNGP)
- **Design stage** – Developed design
- **Assessor and role** – WT, advisor
- **Life cycle duration** – 50 years
- **Material quantity data source** – Developed design construction cost estimate
- **Emission factor data source** – BRANZ CO_2NSTRUCT for modules A1-A3, in-house data sets for modules B3-B5, other BRANZ & NZGBC Green Star tool datasets for remaining modules
- **Tool used** – NZGBC Green Star Embodied Carbon Calculator for modules A1-A3 and in-house method for modules B-C
- **Building element scope** – Ground work, structure, external envelope, non-structural elements

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

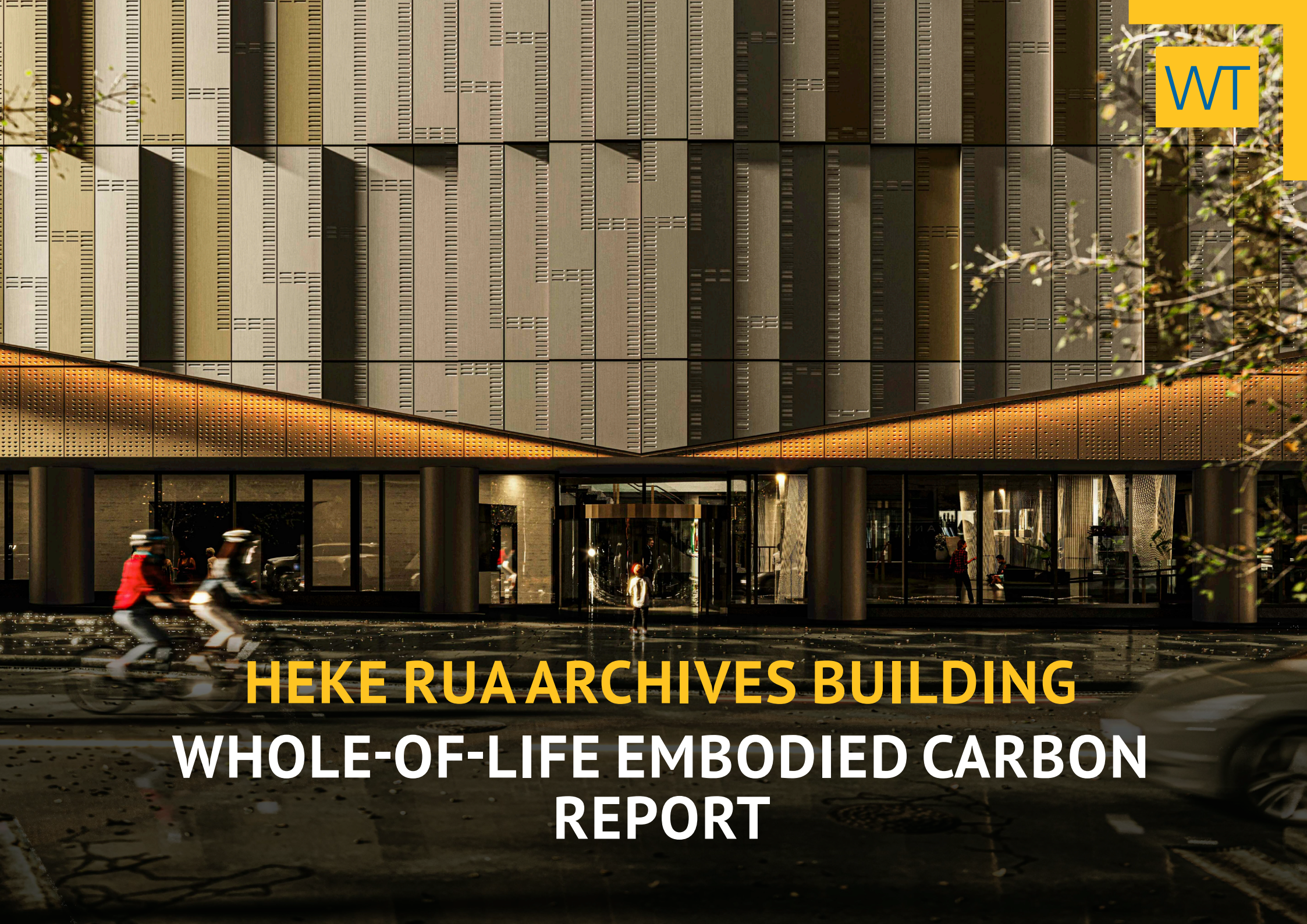
This assessment is of a large government building, and the results are intended to support Archives New Zealand in meeting their obligations under the Carbon Neutral Government Programme (CNGP). As new non-residential buildings of this scale are relatively uncommon in Aotearoa/New Zealand, assessing the embodied carbon of this building is especially useful for developing future baselines.

Assessment Highlights

The assessment clearly states the scope of the assessment in terms of lifecycle stages and building elements. For readers who may be unfamiliar with embodied carbon terms, this report includes an introduction to common terms and concepts (pages 8-9).

This assessment states the reasoning behind assumptions made, which have a large impact on the results.
The assessors chose to use their internal database to determine the emissions associated with maintenance and replacement cycles (modules B3-B5). Their cycle length assumptions lead to higher reported values in these modules when compared to data given in the BRANZ service life datasheets. To ensure the results were still comparable to others in industry, an assessment using BRANZ data was also provided (appendix A, page 33).

This assessment includes the sources for all the emissions factors and material quantity data, graded against the data quality hierarchy (pages 18-20). Module A5 emissions included allowances for construction waste as well as on-site construction activities. The quantities of the key materials and products used in the assessment are given in full, allowing the material efficiency of the building to be benchmarked as well as the embodied carbon (appendix B, pages 35-41). Presenting this data along with a comprehensive list of references gives this assessment a high degree of transparency.



HEKE RUA ARCHIVES BUILDING

WHOLE-OF-LIFE EMBODIED CARBON REPORT

INTRODUCTION

The Heke Rua Archives building is a nine-storey multi-purpose commercial building located in Wellington, Aotearoa New Zealand. The building is due to complete construction in 2026 and is located opposite the National Library on Aitken Street.

The aim of the building is to provide a resilient, environmentally friendly, fit-for-purpose environment for Archives New Zealand and the National Library to store and manage New Zealand's history.

This report presents the results of the Whole-of-Life Embodied Carbon assessment undertaken for the Heke Rua Archives building and details the scope, methodology, data sources, and assumptions supporting the results.

The results of the assessment are intended to align with MBIE's Building for Climate Change (BfCC) programme and support Archives New Zealand in meeting their obligations under the Carbon Neutral Government Programme (CNGP).

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THIS REPORT IS AUTHORED BY WT NEW ZEALAND'S ADVISORY TEAM

WHAT IS WHOLE-OF-LIFE EMBODIED CARBON?

Whole-of-Life Embodied Carbon is defined as "*all carbon emissions attributable to the construction materials and products across the lifecycle of the building.*" (MBIE, 2022)

Whole-of-Life Embodied Carbon considers the emissions across the full supply chain of product and construction materials, construction process (and the waste arising), repair, maintenance, replacement and the processes at the end-of-life of a building.

Embodied Carbon excludes emissions associated with the operation of the building, typically from the energy used for heating, cooling, lighting, and water consumption (this is instead, known as Operational Carbon).

Other terms used throughout the industry include Life Cycle Assessment (LCA) and Cradle-to-Grave Assessment. (MOE, 2023)

WHY IS WHOLE-OF-LIFE EMBODIED CARBON IMPORTANT?

Following the Paris Agreement and worldwide efforts to limit global warming temperature increases to 1.5°C above pre-industrial levels, Aotearoa New Zealand has committed to a net zero carbon emissions future by 2050 through the Climate Change Response (Zero Carbon) Amendment Act 2019.

To achieve these targets, Aotearoa New Zealand must reduce the Whole-of-Life Embodied Carbon of buildings.

"An inefficient building can be renovated and improved to reduce future in-use emissions, but the clock cannot be turned back on Embodied Carbon. What is required is a whole life approach to decarbonisation".

—Royal Institute of Chartered Surveyors (RICS), 2021

20%

of New Zealand's carbon emissions are from the building and construction sector (Thinkstep, 2022)

74%

of New Zealanders agree that the Government needs to do more to help reduce New Zealand's impact on the environment (EECA, 2021)

39%

of the world's global carbon emissions are from the building and construction sector (Thinkstep, 2022)

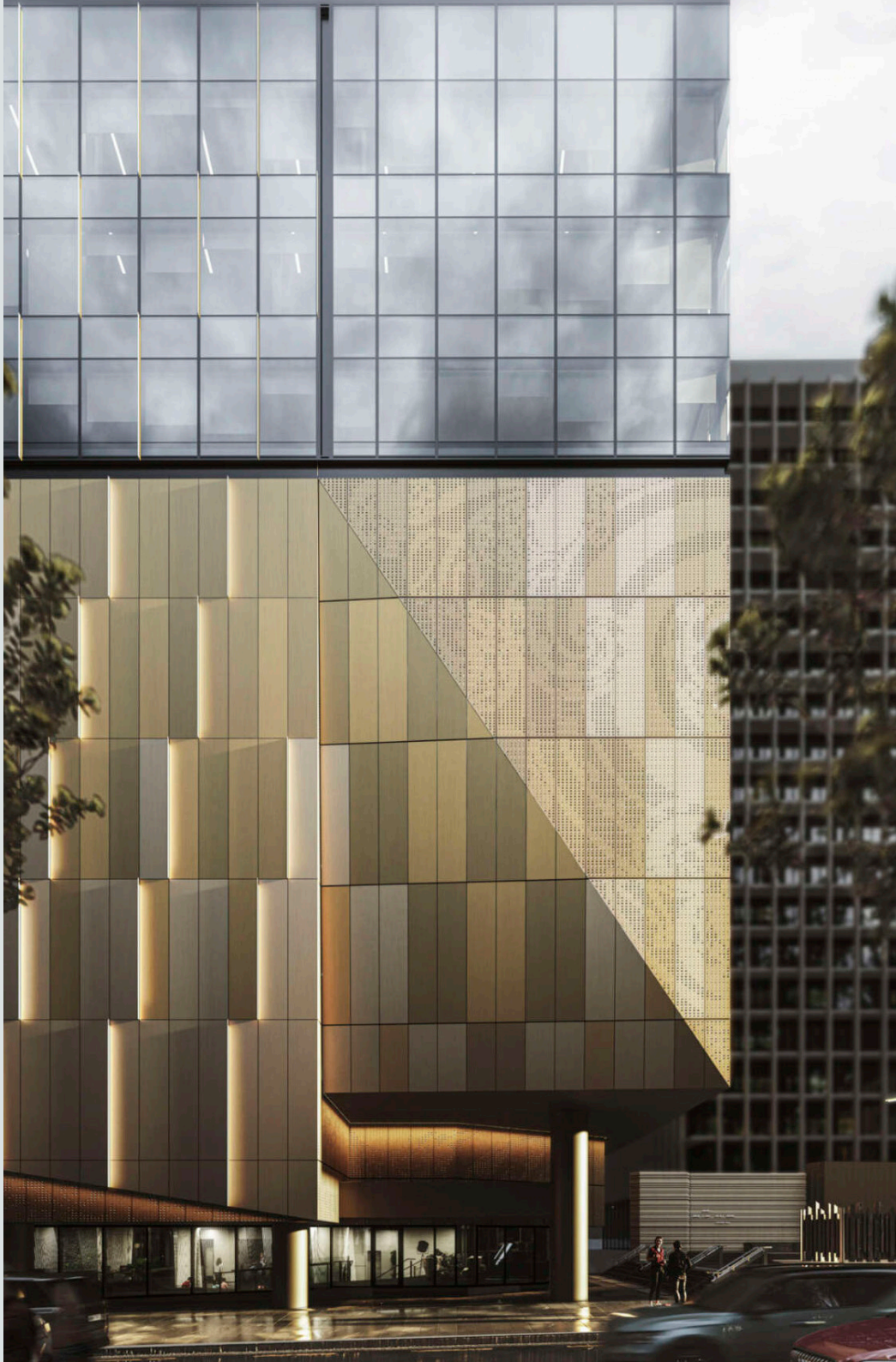
EXECUTIVE SUMMARY

Reducing Whole-of-Life Embodied Carbon is one of the greatest challenges faced by the building and construction sector.

Whilst several international and local methodologies have been developed to ensure a consistent method of assessing Whole-of-Life Embodied Carbon, there is still a severe lack of product-specific Embodied Carbon data and Whole-of-Life Embodied Carbon assessment examples to be able to create baselines for reduction of Whole-of-Life Embodied Carbon in Aotearoa New Zealand.

The Whole-of-Life Embodied Carbon assessment undertaken for the Heke Rua Archives building uses international and local methodologies and tools to estimate the Whole-of-Life Embodied Carbon for a purpose-built building to provide the Aotearoa New Zealand construction industry with a local assessment for a large civic building.

This report hopes to demonstrate the use of methodologies and present the results of a Whole-of-Life Embodied Carbon Assessment to help with establishing Aotearoa New Zealand baselines to set reduction targets.



IMPACT

Undertaking this assessment highlighted that Aotearoa New Zealand still has a long way to go regarding the measuring, reporting and baseline of Whole-of-Life Embodied Carbon.

This report hopes to assist the Aotearoa New Zealand building and construction sector with measuring Whole-of-Life Embodied Carbon using local methodologies and tools, and how to present results to assist with industry-wide baselining.

DISCLAIMER

This Whole-of-Life Embodied Carbon Assessment was completed during the early stages of construction and is based on design information.

The Whole-of-Life Embodied Carbon results is an estimate based on the methodologies and assumptions outlined in the report. Significant as-built data needs to be available to increase the accuracy of the Whole-of-Life Embodied Carbon estimate, however, this information will not become available until practical completion.

To obtain more accurate Whole-of-Life Embodied Carbon results, WT recommends a re-assessment is undertaken when as-built information is availabile. As-built information would also see an increase in the scope of Life Cycle Modules and Building Elements included in the assessment.

"Until we have a comprehensive, and comparable (for both scope and span of study), carbon dataset for New Zealand's building stock, it is too early to say if we will be higher or lower Embodied Carbon than the industry averages calculated in other countries. Local data is required for local decisions."

— Thinkstep, 2021

DEFINITIONS

CARBON EMISSIONS
Emissions of greenhouse gas(es) to the atmosphere. Examples include combustion of fossil fuels and greenhouse gases released from chemical reactions.

CARBON FOOTPRINT
The sum of carbon emissions and carbon removals over a full or partial product life cycle. Equivalent to GWP-total.

CARBON FOOTPRINT OF PRODUCT (CFP)
A method for the quantitative evaluation of the carbon footprint of a product or service system through its life cycle. Standardised by ISO 14067:2018.

CARBON REMOVALS
Removals of greenhouse gas(es) from the atmosphere. Examples include removal of $C0_2$ from the air by plants during photosynthesis and by cement-containing materials during carbonation.

CARBON STORAGE
The storage of carbon captured from the atmosphere for a period of time, resulting in the temporary reduction in the concentration of greenhouse gas(es) in the atmosphere.

END-OF-LIFE EMBODIED CARBON:
Carbon Emissions associated with deconstruction/demolition, transport from site, waste processing and disposal phases of a building's life cycle which occur after its use (modules C1-C4).

ENVIRONMENTAL PRODUCT DECLARATION (EPD):
Document containing data on the potential environmental impacts of a product or service calculated using LCA following a set of Product Category Rules. An EPD must be independently verified as compliant with ISO 14025:2006 and a relevant PCR and published by an EPD programme operator.

FOSSIL FUEL
Any class of hydrocarbon containing materials of biological origin occurring within the Earth's crust that can be used as a source of energy. Fossil Fuels include coal, petroleum, natural gas, oil, bitumen and tar sands.

GLOBAL WARMING POTENTIAL (GWP)
The heat absorbed by greenhouse gas(es) in the atmosphere, measured as carbon dioxide equivalent. Carbon dioxide equivalent ($C0_2e$) is calculated using the intergovernmental Panel on Climate Change's (IPCC's) Global Warming Potential indicator, typically using a 100-year time horizon (GWP100), with the latest version being from the IPCC's Sixth Assessment report (AR6).

GWP-BIOGENIC (GWP-B OR GWPB):
Net of:
- Carbon Emissions from degradation of biomass via incineration, landfill, composting, or an accounting adjustment (reported as a positive number), and;
- Carbon Removals from non-biogenic sources, e.g., through carbonation of cement (a negative number).

GWP-FOSSIL (GWP-FOR GWPF):
Net of:
- Carbon Emissions from non-biogenic sources, e.g., combustion of fossil fuels and emissions from chemical processes (reported as a positive number), and;
- Carbon Removals from non-biogenic sources, e.g., through carbonation of cement (a negative number).

GWP-LULUC (GWP-L OR GWPL)
Carbon emissions and removals from Land Use and Land Use Change (LULUC) describes changes in carbon stocks, such as soil carbon. EN 15804+A2:2019 does not allow negative numbers (e.g., net sequestration of carbon in the soil) and instead requires these to be set to zero.

GWP-STORED (GWP-S OR GWPS)
The GWP avoided by removals of CO_2 into biomass from all sources except native forests (CEN, 2019, section C.2.4). GWP-stored should be a negative number, as it is a removal of CO_2 from the atmosphere. In EPDs following EN 15804+A2, there will be a statement of "Biogenic carbon content in product". To convert this to GWP-stored, multiply by -44/12 to convert stored elemental carbon to equivalent carbon dioxide.

GWP-TOTAL (GWP-T OR GWPT):
- Upfront Carbon = GWP-fossil + GWP-luluc + (GWP-biogenic-GWP-stored)
- Whole-of-Life Embodied Carbon = GWP-fossil + GWP-luluc + GWP-biogenic

LIFE CYCLE ASSESSMENT (LCA)

A method for the quantitative evaluation of the potential environmental impacts of a product or service system through its life cycle. Standardised by ISO 14040:2006 and ISO 14044:2006.

OPERATIONAL CARBON

Carbon Emissions associated with energy used to operate the building (module B6), operational water use (module B7) and fugitive emissions of refrigerants (module B1). In corporate carbon footprinting, these emissions are known as scope 1 and scope 2 emissions.

PRODUCT CATEGORY RULES (PCR)

A specific set of rules for completing an LCA of a particular product category and publishing an EPD. Only EPDs conducted according to the same PCR are comparable. The two main PCR documents for building products are EN 15804 and ISO 21930.

UPFRONT EMBODIED CARBON

Carbon Emissions caused by the production of materials, transport of materials to the construction site and the construction of the building, prior to the building being occupied (modules A1-A5).

USE STAGE EMBODIED CARBON

Carbon Emissions associated with materials and processes needed to maintain the building during use such as for maintenance, repair, refurbishment or replacement (modules B1-B5).

WHOLE-OF-LIFE EMBODIED CARBON

Carbon Emissions associated with materials and construction processes throughout the whole life cycle of a building, excluding operational energy use (module B6) and operational water use (module B7). This includes Upfront Embodied Carbon, Use Stage Embodied Carbon, and End-of-Life Embodied Carbon but excludes Operational Carbon.

CALCULATION METHODOLOGY

The calculation methodology followed for this Whole-of-Life Embodied Carbon assessment aligns primarily with MBIE's Building for Climate Change (BfCC) programme. Given MBIE's BfCC programme is still under development, the below additional methodologies and standards were used to calculate the Whole-of-Life Embodied Carbon.

- MBIE Whole-of-Life Embodied Carbon Assessment: Technical Methodology
- Green Star NZ Embodied Carbon Methodology
- RICS Whole Life Carbon Assessment for the Built Environment First Edition
- BS EN 15978:2011 – Sustainability of Construction Works – Assessment of Environmental Performance of Buildings – Calculation Method
- ISO 14040:2006 – Environmental Management – Life Cycle Assessment – Principles and Framework
- ISO 14044:2006 – Environmental Management – Life Cycle Assessment – Requirements and Guidelines.

PROJECT OVERVIEW

DATE OF ASSESSMENT: 01 SEPTEMBER 2023

PROJECT TYPE: NEW BUILD

PROJECT LOCATION: 2-12 AITKEN STREET, THORNDON, WELLINGTON, 6011, NEW ZEALAND

DATE OF PROJECT COMPLETION: 2026

BUILDING DETAILS

BUILDING TYPE	OFFICE/STORAGE BUILDING
IMPORTANCE LEVEL	3
H1 CLIMATE ZONE	CLIMATE ZONE 3
BUILDING AREA (GFA)	19,869M^2
PROJECT DESIGN LIFE	50 YEARS
NUMBER OF STORIES ABOVE GRADE	9
NUMBER OF STORIES BELOW GRADE	1
STRUCTURAL FRAME	STEEL
FLOOR STRUCTURE	CONCRETE

LIFE CYCLE MODULES

LIFE CYCLE MODULES AS PER BS EN 15978

	PRODUCT STAGE			CONSTRUCTION STAGE		USE STAGE							END OF LIFE STAGE				BEYOND LIFE STAGE
MODULE NAME	RAW MATERIAL SUPPLY	TRANSPORT	MANUFACTURING	TRANSPORT	CONSTRUCTION AND INSTALLATION PROCESS	BUILDING USE	MAINTENANCE	REPAIR	REFURBISHMENT	REPLACEMENT	OPERATIONAL ENERGY USE	OPERATIONAL WATER USE	DECONSTRUCTION AND DEMOLITION	TRANSPORT	WASTE PROCESSING	DISPOSAL	REUSE, RECOVERY, AND RECYCLING
MODULE CODE	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D

CRADLE TO GATE

CRADLE TO PRACTICAL COMPLETION

CRADLE TO PRACTICAL COMPLETION

SCOPE OF ASSESSED LIFE CYCLE MODULES

A1-A3 – PRODUCT AND CONSTRUCTION MATERIALS

Raw material supply (A1) includes the emissions generated from raw material extraction, transportation to industrial units and processing. Module A1 also includes the loss of raw materials and energy. Transport impacts (A2) includes exhaust emissions resulting from the transport of all raw materials from suppliers to the manufacturing facility and accounts for the impacts of production of fuels.

Manufacturing impacts (A3) includes the manufacturing of the products and construction materials and fuels used by the machines, as well as handling of waste formed in the manufacturing processes at the manufacturing facility until end-of-waste state.

A4 – TRANSPORT

Module A4 includes emissions resulting from the transport of products and construction materials from the manufacturing facility to the building site as well as the environmental impacts of production of fuels.

A5 – CONSTRUCTION AND INSTALLATION PROCESS

Module A5 includes the emissions resulting from energy use during site operations, the environmental impacts of production of fuels, energy and water as well as handling of waste until end-of-waste state.

B3-B5 – REPAIR, REFURBISHMENT AND REPLACEMENT

Modules B3-B5 include the repair, refurbishment and replacement of products and construction materials after they reach the end of their service life.

The replacement of building product and materials includes the environmental impacts from raw material supply, manufacturing and transportation to site as well as handling of waste until end-of-waste state.

C1-C4 – END-OF-LIFE

Modules C1-C4 include impacts for the deconstruction and demolition (C1), transportation of waste to a waste processing facility (C2) and processing recyclable construction waste flows for recycling (C3) until end-of-waste state or the impacts of pre-processing and landfilling for waste streams that cannot be recycled (C4) based on the end-of-life type of the material.

Deconstruction impacts include emissions caused by waste energy recovery.

OUT-OF-SCOPE LIFE CYCLE MODULES

The following pages state the Life Cycle Modules excluded from this Whole-of-Life Embodied Carbon assessment and details the rationale for exclusion.

B1 – BUILDING USE

Module B1 includes:

- Any carbon emitted from building components during the life of a building (e.g., release of greenhouse gases from HFC blown insulation
- Carbonation of concrete during the building's life (as a carbon removal)

The design of the building and industry-wide debated nature of including carbon removals in Whole-of-Life Embodied Carbon assessments paired with the Green Star NZ Embodied Carbon Methodology stating Module B1 can be assumed to be under the cut-off rules (and excluded from the assessment unless there is a good reason that it should be included) has supported the decision to exclude Module B1 from the assessment.

B2 – MAINTENANCE

Module B2 includes:

- Washing the building
- Repainting
- Repointing mortar

The design of the building means there is little external painting and repointing of mortar. The internal repainting period is accounted for in modules B3-B5. Therefore, for the building, the Embodied Carbon for washing the building is the only factor within the scope of module B2.

The low amount of Embodied Carbon associated with the washing of the building and the Green Star NZ Embodied Carbon Methodology stating Module B2 can be assumed to be under the cut-off rules (and excluded from the assessment unless there is a good reason that it should be included) has supported the decision to exclude Module B2 from the assessment.

OUT-OF-SCOPE LIFE CYCLE MODULES CONTINUED

B6 – OPERATIONAL ENERGY USE

Operational carbon is excluded from this assessment as it does not form part of the Embodied Carbon.

B7 - OPERATIONAL WATER USE

Operational carbon is excluded from this assessment as it does not form part of the Embodied Carbon.

D – REUSE, RECOVERY, RECYCLING

The Embodied Carbon associated with waste processing for reuse, recovery and recycling is accounted for in Module C3.

Module D considers the potential carbon benefits calculated as carbon removals that decrease the Whole-of-Life Embodied Carbon.

Whilst most assessments report these carbon removals separately given the controversial nature of its inclusion amongst LCA practitioners, due to the considerable hypotheses and assumptions that need to be made to undertake the calculations paired with the results not affecting the results for modules A-C (Cradle-to-Grave), Module D has been excluded from this assessment.

SCOPE OF ASSESSED BUILDING ELEMENTS

BUILDING SYSTEM	INCLUDED IN ASSESSMENT	EXCLUDED FROM ASSESSMENT
GROUND WORK	• Substructure/Foundations • Earth Retaining Structures • Basements	• Vegetation • Hard Landscaping • External Services, including Drainage
STRUCTURE	• Ground Floor Structure • Upper Floor Structure • Loadbearing Systems: Gravity and Lateral Structural Frames and Walls • Roof Structure	• Temporary Works (Formwork, Scaffolding etc.) Used during Construction that are not reused • Stairs • Lifts and Escalators
EXTERNAL ENVELOPE	• Cladding/Façade Primary Elements • External Wall Insulation • Roof Covering and Insulation • External Windows/Glazing and Doors	• Cladding/Façade Secondary Elements (Seals, Brackets etc.)
NON-STRUCTURAL INTERNAL ELEMENTS	• Non-Loadbearing Walls • Internal Doors • Floor and Wall Finishes	• Ceilings • Fixtures, Fittings and Furniture
BUILDING SERVICES	• Excluded in assessment, see Appendix A for details.	• HVAC Equipment • Water, Drainage, Electrical Services • Other Building Systems such as Fire and Security Systems

SCOPE RATIONALE – BUILDING ELEMENTS

The assessed building elements are responsible for the bulk of the Whole-of-Life Embodied Carbon over the life of the building. The excluded elements (apart from Building Services) generally contribute to <5% of the Whole-of-Life Embodied Carbon. The lack of Aotearoa New Zealand specific information, data for the excluded elements, and the heavy reliance on generic data for the calculations, as well as MBIE's Whole-of-Life Embodied Carbon Assessment: Technical Methodology, informed the building element inclusion/exclusion criteria.

The building elements included and excluded from the assessment align with MBIE's BfCC programme, except for the additional exclusion of building services given the lack of Aotearoa New Zealand-specific data and as-built information. Appendix A shows additional results including an allowance for building services.

This Whole-of-Life Embodied Carbon Assessment was undertaken upon completion of the design, during the early stages of construction. Given the timing, it was impossible to obtain as-built information, meaning the highest level of data quality available for the calculations was Level 4.

DATA SOURCES

DATA QUALITY HIERARCHY

LEVEL OF DATA QUALITY	SPECIFICATION AND QUANTITY DATA	EMBODIED CARBON DATA
5 (Highest)	As-built information for product/material specifications and quantities that include allowances for site waste	EN 15804 compliant EPD for specific product/material used in the building
4	Detailed Schedule of Quantities, reflecting amounts and specifications of materials included in the building contract allowances for site waste	New Zealand sector EN 15804 compliant EPD for material product type
3	Quantities take-off from a BIM model used in the design process	Global EN 15804 compliant EPD for product/material 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)	Baselined material quantity data from similar building types	Default values

SPECIFICATION AND QUANTITY DATA QUALITY

Module: A1-A3

Product and Construction Materials

Data Quality Level: 4

The majority of the product/material specifications and quantities were based off the Elemental Developed Design Construction Cost Estimate produced by RLB.

The product/material specifications and quantities in the Elemental Developed Design Construction Cost Estimate were cross-referenced with the Detailed Design Architectural Drawings and Specification produced by Warren and Mahoney and Detailed Design Structural Drawings, Design Features Report (DFR) and Structural Specification produced by Aurecon.

EMBODIED CARBON DATA QUALITY

MODULE	DATA QUALITY LEVEL
A1-A3 **PRODUCT AND CONSTRUCTION MATERIALS**	Data Quality Level: 3-4 All product and construction materials Embodied Carbon data used the BRANZ CO_2NSTRUCT database (BRANZ, 2023) included in NZGBC's Green Star Embodied Carbon Calculator v1.0 (NZGBC, 2023). If the database and calculator did not include level 3-4 Embodied Carbon data or was missing Embodied Carbon data for the product or construction material, the Embodied Carbon data was researched and incorporated into the database used to undertake the calculations. The materials/products specified in the Elemental Developed Design Construction Cost Estimate produced by RLB were matched as closely as possible with the BRANZ CO_2NSTRUCT Database embedded in the Green Star NZ Embodied Carbon Calculator. If no matching product/material was found, the conservative default values from the BRANZ CO_2NSTRUCT Database were used. The BRANZ CO_2NSTRUCT database is Aotearoa New Zealand's most current and complete Embodied Carbon database. It is updated annually as EPDs and other sources of data become available.
A4 **TRANSPORT**	Data Quality Level: 3 All transport data used the database in NZGBC's Green Star Embodied Carbon Calculator v1.0 (NZGBC, 2023) which consolidated several databases but mostly the emission factors developed by the Ministry for the Environment (MfE, 2022).
A5 **CONSTRUCTION AND INSTALLATION PROCESS**	Data Quality Level: 3 Embodied Carbon data for the construction and installation process used both the BRANZ Construction Site Waste Datasheet (BRANZ, 2023) and in the absence of site-specific data, a default emission factor of 25 $kgCO_2/m2$ was used for on-site construction activity (RICS, 2023), referenced in the Green Star NZ Embodied Carbon Methodology (NZGBC, 2023).

EMBODIED CARBON DATA QUALITY CONTINUED

MODULE	DATA QUALITY LEVEL
B3-B5 **MAINTENANCE AND PRODUCT/MATERIAL REPLACEMENT**	Data Quality Level: 4 The maintenance and material replacement (lifecycle) data used WT's database. WT is one of Aotearoa New Zealand's largest independent Quantity Surveying, Project Management and Advisory firms with extensive asset and facilities management experience with a good understanding of "best practice" and "industry-standard practice". WT has extensive experience in operational and capital expenditure forecasting, Whole-of-Life Costing and Long Term Maintenance Planning (LTMP). WT's database has more frequent maintenance and replacement requirements than the BRANZ Service Life and Materials Maintenance Datasheets (BRANZ, 2023). This assessment understands the importance of consistent data and following MBIE's BfCC and NZGBC's Embodied Carbon calculation methodologies for baselining purposes, therefore, additional calculations were undertaken using the BRANZ datasheets as well. These results can be found in *Appendix A*.
C1-C4 **END-OF-LIFE**	Data Quality Level: 3 Embodied Carbon data for the end-of-life stages of products and materials used the BRANZ Building End-of-Life datasheet (BRANZ, 2023).

CALCULATION ASSUMPTIONS

PRODUCT AND MATERIAL QUANTITIES (A1-A3)

Steel reinforcing and structural framing quantities were estimated based on standard industry practices for a large commercial building. The calculation methodology and inputs were determined using WT's extensive commercial Quantity Surveying and estimating experience.

Details of the steel reinforcing and structural framing calculation methodologies and inputs can be found in Appendix B.

TRANSPORT DISTANCES OF PRODUCTS AND MATERIALS TO SITE (A4)

The transport distances were estimated based on manufacturer's information and standard industry practice.

Details of transport distances (locations of last major manufacturing and processing) can be found in Appendix B.

ON-SITE CONSTRUCTION ACTIVITY (A5)

An emission factor of 25 kgC02e/m^2 was used to estimate the on-site construction impacts in the absence of on-site energy use data. This emission factor was developed by RICS (RICS, 2023) and is referenced in the Green Star NZ Embodied Carbon Methodology (NZGBC, 2023).

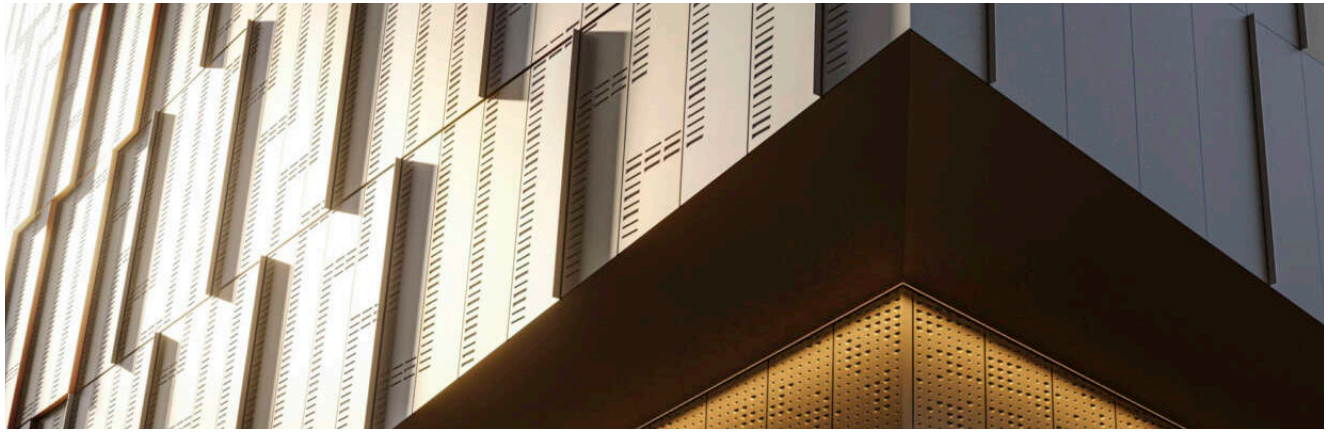
PRODUCT/MATERIAL REPLACEMENT CYCLES (B3-B5)

For the design life scenarios, it is assumed products and materials reaching the end of their life at the same time as the building design life (i.e. 50 year) will not be replaced.

END OF LIFE SCENARIO (C1-C4)

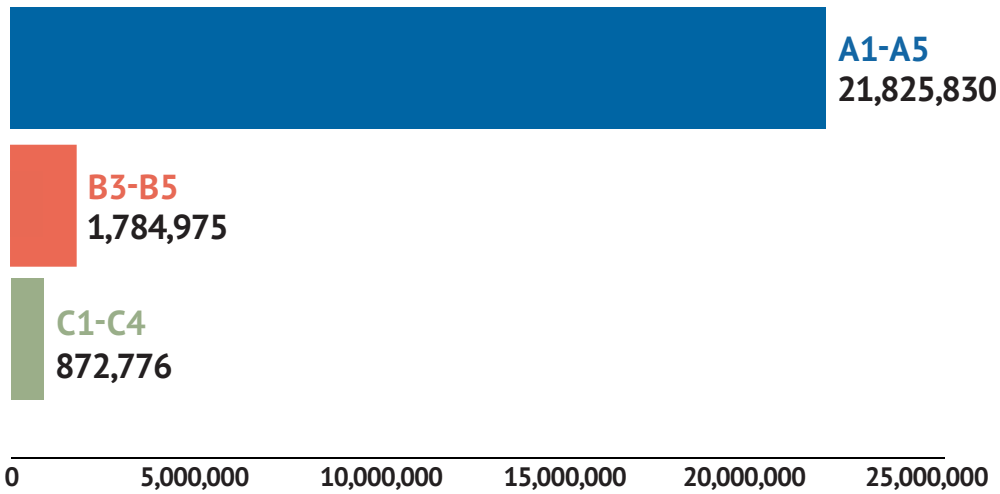
At the end of the building design life, the assessment assumes the building is deconstructed, demolished and disposed of.

A more likely real-life scenario would be an Engineering and condition assessment to determine the remaining lives of products and materials at the end of the design life of the building. This approach is difficult to calculate prior to the building being in operation, therefore, a more suitable approach is to recommend the recalculation of the Embodied Carbon at the end of the building design life to determine the remaining life of the building and predict further product/material Embodied Carbon emissions.



ASSESSMENT RESULTS

50 YEAR WHOLE-OF-LIFE EMBODIED CARBON TOTALS



The majority of the Whole-of-Life Embodied Carbon emissions for the Heke Rua Archives building are in modules A1-A5 (Upfront Stage). Modules A1-A5 contribute to 89.1% of the total Embodied Carbon whilst modules B3-B5 (Use Stage) and C1-C4 (End-of-Life Stage) only contribute 7.3% and 3.6% respectively.

The majority of the material quantities and Whole-of-Life Embodied Carbon sit in the structure, which is not refurbished or replaced throughout the use of the building.

Whilst the distribution of the Embodied Carbon is consistent with similar Life Cycle Assessments undertaken in Aotearoa New Zealand, the 1,232kgCO_2e/m^2 Embodied Carbon Value is high (albeit there is limited baselining available for a building of this scale and use in Aotearoa New Zealand).

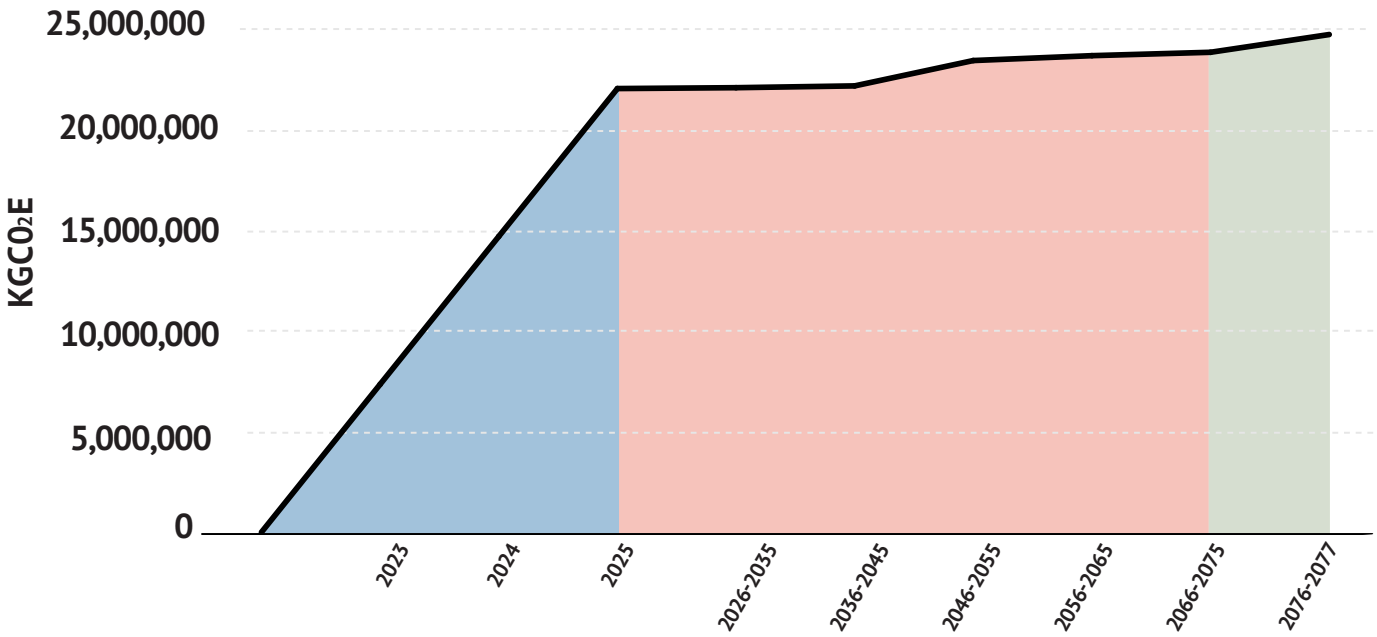
Whilst the Whole-of-Life Embodied Carbon (total and per m^2) may seem high, given the highly resilient nature of the building design, the building is expected to last much longer than the 50 year specified design life.

The highly resilient nature of the building and high quantity of steel and concrete were the key elements determining the Whole-of-Life Embodied Carbon for the building.

Whole-of-Life Embodied Carbon per m^2 = 1,232kgCO_2e/m^2

ASSESSMENT RESULTS

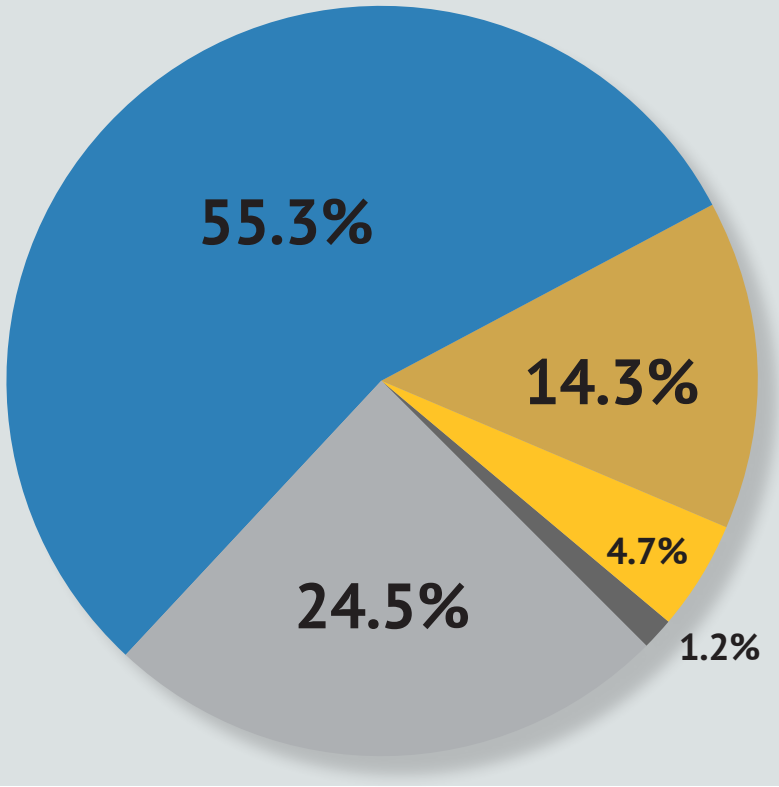
50 YEAR WHOLE-OF-LIFE EMBODIED CARBON



LIFE CYCLE STAGE	EMBODIED CARBON ($KGC0_2E$)	EMBODIED CARBON ($KGC0_2E/M^2$)	PERCENTAGE (%)
PRODUCT AND CONSTRUCTION STAGES (A1-A5)	21,825,830	1,098	89.1%
USE STAGE (B3-B5)	1,784,975	90	7.3%
END OF LIFE STAGE (C1-C4)	872,776	44	3.6%
TOTAL	**24,483,581**	**1,232**	

- The first three years of the project's life emits the majority of the Whole-of-Life Embodied Carbon across the Life Cycle of the building.
- The 50 year Use Stage of the building (years 2026-2076) includes Embodied Carbon Emissions of product/material replacement.
- The End-of-Life Stage of the building (years 2076-2077) includes the Embodied Carbon Emissions associated with the deconstruction, demolition and disposal of the building.

UPFRONT EMBODIED CARBON (A1-A3) BREAKDOWN BY BUILDING ELEMENT



Modules A1-A3 contribute 83.5% of the Whole-of-Life Embodied Carbon.

Given the high proportion of Embodied Carbon these modules contribute, it is important to understand what building elements are the main contributors.

The three main building element categories contributing to the Upfront Embodied Carbon (A1-A3) are:

2.1 Frame & 2.2 Upper Floors (55.3%)

1.1 Substructure (24.5%)

2.3 Roof & 2.5 External Walls (14.3%)

The three main building element categories contributing to the Upfront Embodied Carbon (A1-A3) reflect the majority of the product/material quantities (refer Appendix B).

The replacement cycles for the above building element categories is the design life of the building meaning these building elements and their Embodied Carbon is 'locked-in' and unaltered until the end-of-life of the building.

UPFRONT EMBODIED CARBON (A1-A3) BREAKDOWN BY PRODUCT/MATERIAL

Modules A1-A3 contribute 83.5% of the Whole-of-Life Embodied Carbon.

Given the high proportion of Embodied Carbon these modules contribute, it is important to understand what building elements are the main contributors.

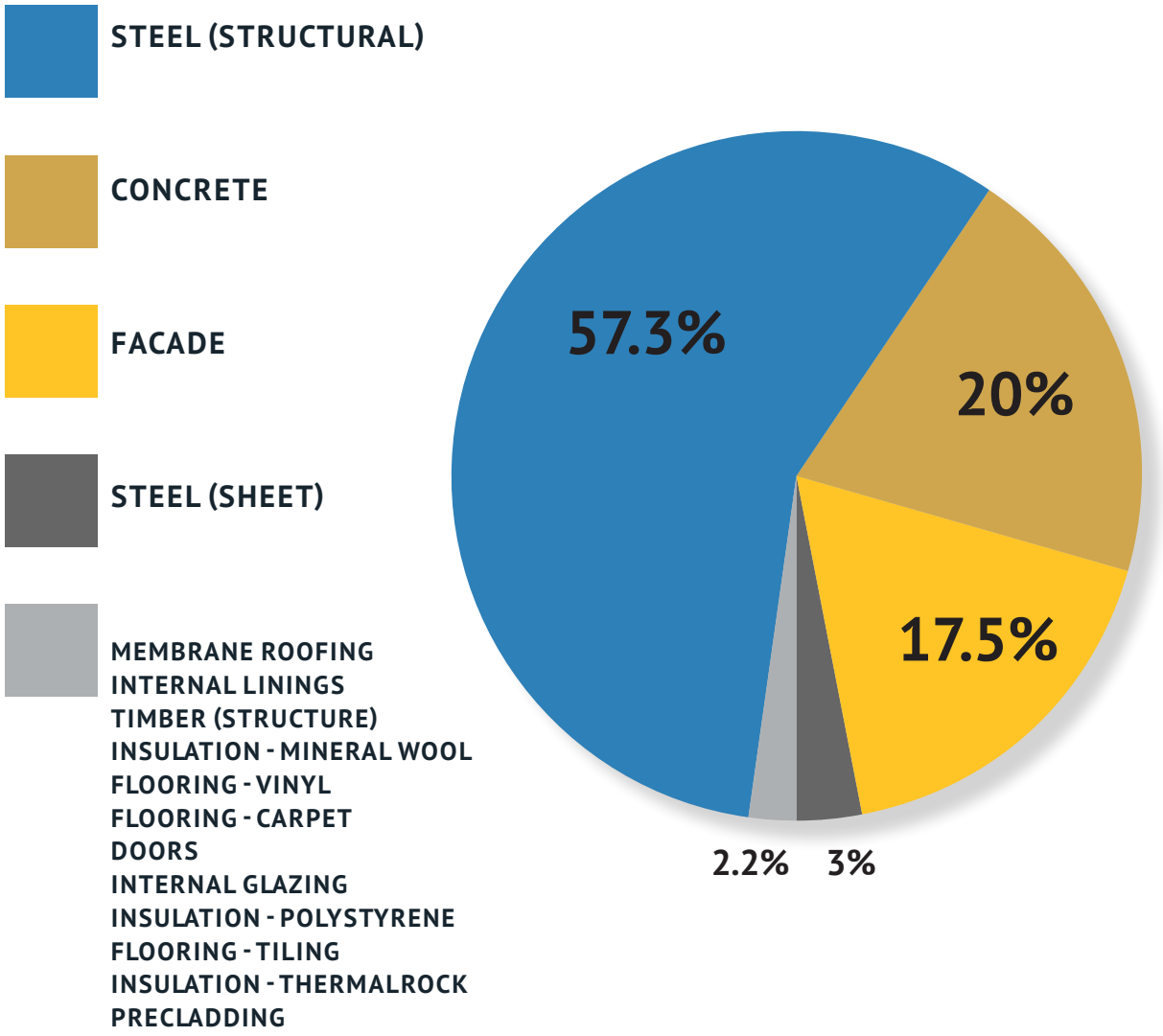
The three materials/products that contribute the majority of the Upfront Embodied Carbon (A1-A3) are:

Steel (Structural) (57.3%)

Concrete (20.0%)

Façade (17.5%)

These materials/products also have the highest quantities (refer Appendix B) and fall into the three main building element categories contributing the Upfront Embodied Carbon (A1-A3) as shown on page 24.



KEY POINTS

The Whole-of-Life Embodied Carbon Assessment undertaken for the Heke Rua Archives building showed:

- The majority (83.5%) of the Whole-of-Life Embodied Carbon is in the Products and Materials Stage (Cradle-to-Gate, Life Cycle Modules A1-A3).

- The majority of the Whole-of-Life Embodied Carbon is in the building structure which consists of mostly steel and concrete.

- There is little Whole-of-Life Embodied Carbon baseline results for the building size, type and use.

- How to use Aotearoa New Zealand specific methodologies and tools to undertake a Whole-of-Life Embodied Carbon Assessment.

SUMMARY

The rationale behind considering Whole-of-Life Embodied Carbon is to highlight that carbon emissions prior to the building use that are 'locked in' upon practical completion, are as important, if not more important than the operational carbon emissions during the use of the building.

The Whole-of-Life Embodied Carbon assessment undertaken for the Heke Rua Archives building clearly demonstrates this logic, with the majority (83.5%) of Whole-of-Life Embodied Carbon being associated with the raw material extraction and manufacturing of products and materials (Modules A1-A3).

More Whole-of-Life Embodied Carbon assessments need to be undertaken in Aotearoa New Zealand to establish baselines to set reduction targets and ensure the continued development of Aotearoa New Zealand-specific methodologies, tools and legislation.

This report hopes to assist the Aotearoa New Zealand building and construction sector with measuring Embodied Carbon using Aotearoa New Zealand-specific methodologies, tools and how to present results.

The Carbon Neutral Government Programme (CNGP) has been developed to accelerate the reduction of emissions within the public sector. This report assists Archives New Zealand in meeting their obligations under the CNGP and developing a baseline for public sector buildings to set reduction targets.

Measuring and reducing Whole-of-Life Embodied Carbon is vital to reduce Aotearoa New Zealand's carbon footprint and meet the country's goal of achieving net zero carbon emissions by 2050.

"An inefficient building can be renovated and improved to reduce future in-use emissions, but the clock cannot be turned back on Embodied Carbon. What is required is a whole life approach to decarbonisation".

— Royal Institute of Chartered Surveyors (RICS), 2021

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With over 15 years' experience in the New Zealand facilities and asset management industry, Alex is an extremely experienced leader in the industry. His experience includes leading several property/facilities entities as well as being the project lead on the only FM/AM All of Government panel procurement.

Based in Wellington, Alex has formed relationships with many government departments and local body authorities who have used WT to successfully implement new FM delivery solutions.

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As a NZGBC Future Thinker and FMANZ Affiliate, with a Bachelors of Building Science in Sustainable Engineering Systems and Project Management, Michael is a progressive individual in shaping the future of sustainable construction.

As an expert in Embodied Carbon, please do not hesitate to contact Michael with any questions you may have.

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Mark is a MNZIQS Member of the New Zealand Institute of Quantity Surveyors and Member of the Carbon Working Group as well as a trustee member of the International Cost Management Standard ICMS.

Mark has 45+ years of experience in the design and build of many projects across a range of sectors and international markets.

Mark is known for his effective application of commercial as well as technical knowledge and expertise. His project experience includes Christchurch Cathedral, the Remutaka Rail Tunnel Ventilation, Auckland Airport Phase 2&3, and Greymouth Hospital.

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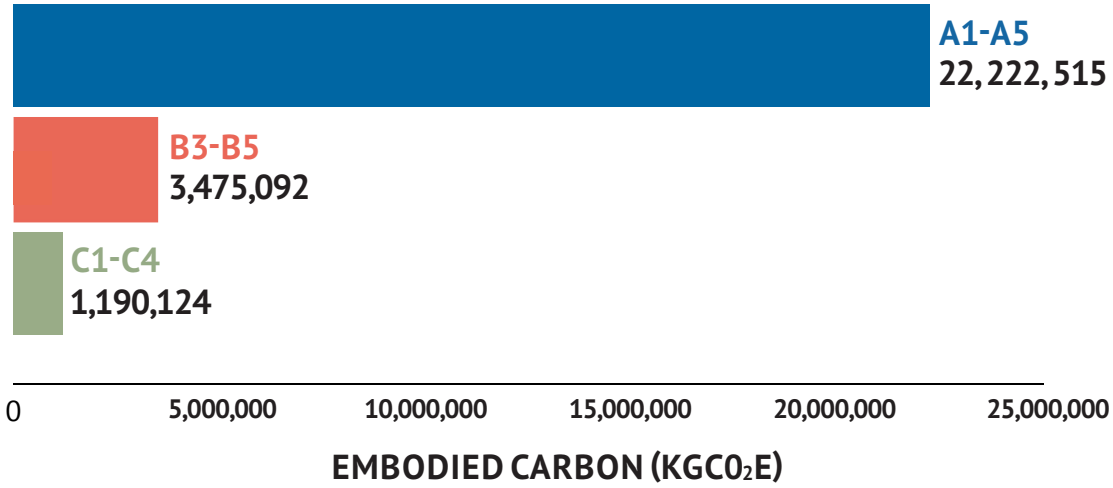
APPENDIX A

DETAILED SCENARIO RESULTS

50 YEAR RESULTS INCLUDING BUILDING SERVICES

50 YEAR WHOLE-OF-LIFE EMBODIED CARBON TOTALS



LIFE CYCLE STAGE	EMBODIED CARBON ($KGC0_2E$)	EMBODIED CARBON ($KGC0_2E/M^2$)
PRODUCT AND CONSTRUCTION STAGES (A1-A5)	22,222,515	1,118 (82.7%)
USE STAGE (B3-B5)	3,475,092	175 (12.9%)
END OF LIFE STAGE (C1-C4)	1,190,124	60 (4.4%)
TOTAL	**26,887,731**	**1,353**

The lack of as-built information and New Zealand specific building services data made it difficult to calculate the Whole-of-Life Embodied Carbon of the Building Services in HRA, this was the main reasoning for the exclusion from the scope of assessment.

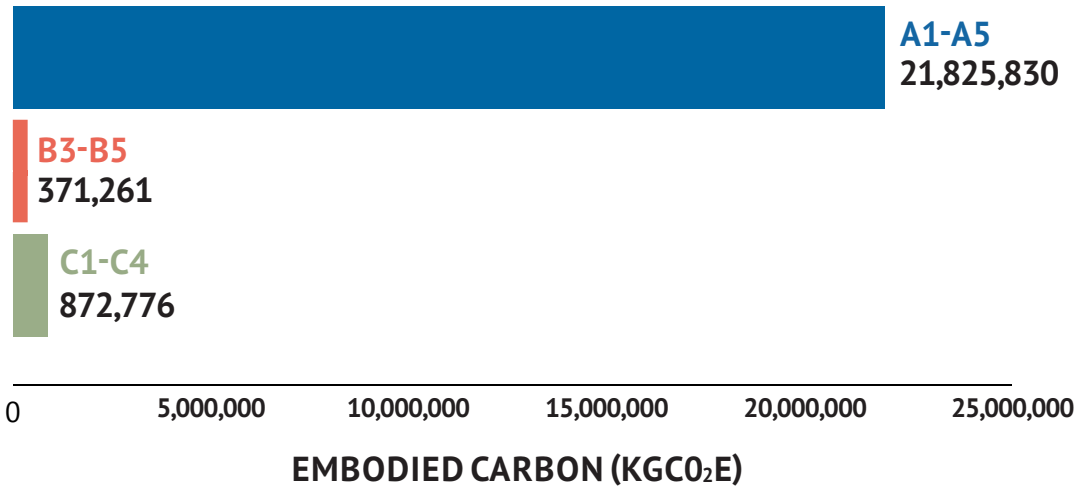
For a more accurate representation of the Whole-of-Life Embodied Carbon for HRA, WT recognise building services need to be included in the scope of the assessment given their higher contribution to the Use Stage Carbon than other building elements.

The additional results shown here include a Whole-of-Life Embodied Carbon allowance based on BRANZ Study Report SR479 using the split across life cycle modules as MOE's Whole-of-Life Carbon Assessment guidance.

The Whole-of-Life Embodied Carbon estimate per m^2 including building services is 1,353 $kgC0_2/m^2$.

50 YEAR RESULTS USING BRANZ REPLACEMENT CYCLES

50 YEAR WHOLE-OF-LIFE EMBODIED CARBON TOTALS



LIFE CYCLE STAGE	EMBODIED CARBON ($KGC0_2E$)	EMBODIED CARBON ($KGC0_2E/M^2$)
PRODUCT AND CONSTRUCTION STAGES (A1-A5)	21,825,830	1,098 (94.6%)
USE STAGE (B3-B5)	371,261	19 (1.6%)
END OF LIFE STAGE (C1-C4)	872,776	44 (3.8%)
TOTAL	**23,069,867**	**1,161**

The Whole-of-Life Embodied Carbon assessment results discussed in the report harness WT's building maintenance and replacement database. WT understand that MBIE's BfCC programme is encouraging the use of the BRANZ building element replacement cycles. Therefore, for the purposes of having comparable results, additional calculations were undertaken using the BRANZ database.

WT's database has more onerous requirements for building elements, increasing the Whole-of-Life Embodied Carbon. The Whole-of-Life Embodied Carbon results using the BRANZ database are lower than the results of using WT's database.

The Whole-of-Life Embodied Carbon per m^2 using the BRANZ database is 1,161 $kgC0_2/m^2$.

APPENDIX B

CALCULATION DATA AND INPUTS

CONCRETE REINFORCING

ELEMENT	REINFORCING KG/M^3
FOOTINGS	150 KG/M^3
PILES AND PILE CAP	150 KG/M^3
SLAB	150 KG/M^3
RETAINING WALL	300 KG/M^3
BEAM	350 KG/M^3
COLUMN	400 KG/M^3
BASE ISOLATOR PILASTER	480 KG/M^3

TIMBER FRAMING

ELEMENT	FRAMING % OF WALL AREA
FRAMING	25%

PRODUCT/MATERIAL SOURCE LOCATION

PRODUCT/MATERIAL	SOURCE LOCATION
STEEL (STRUCTURAL)	AUCKLAND, NEW ZEALAND
CONCRETE	AUCKLAND, NEW ZEALAND
FAÇADE	AUCKLAND, NEW ZEALAND
STEEL (SHEET)	AUCKLAND, NEW ZEALAND
MEMBRANE ROOFING	AUCKLAND, NEW ZEALAND
INTERNAL LININGS	AUCKLAND, NEW ZEALAND
TIMBER (STRUCTURE)	AUCKLAND, NEW ZEALAND
INSULATION - MINERAL WOOL	EUROPE
FLOORING - VINYL	USA
FLOORING - CARPET	AUCKLAND, NEW ZEALAND
DOORS	AUCKLAND, NEW ZEALAND

PRODUCT/MATERIAL SOURCE LOCATION CONTINUED

PRODUCT/MATERIAL	SOURCE LOCATION
INTERNAL GLAZING	AUCKLAND, NEW ZEALAND
INSULATION - POLYSTYRENE	AUCKLAND, NEW ZEALAND
FLOORING - TILING	CHINA
INSULATION - THERMALROCK	USA
PRECLADDING	AUCKLAND, NEW ZEALAND

ON-SITE WASTE %

PRODUCT/MATERIAL	ON-SITE WASTE %
STEEL (STRUCTURAL)	1%
CONCRETE	5%
FAÇADE	0%

ON-SITE WASTE % CONTINUED

PRODUCT/MATERIAL	ON-SITE WASTE %
STEEL (SHEET)	5%
MEMBRANE ROOFING	5%
INTERNAL LININGS	15%
TIMBER (STRUCTURE)	5%
INSULATION - MINERAL WOOL	5%
FLOORING - VINYL	5%
FLOORING - CARPET	5%
DOORS	0%
INTERNAL GLAZING	0%
INSULATION - POLYSTYRENE	5%
PRECLADDING	5%

PRODUCT/MATERIAL QUANTITIES

PRODUCT/MATERIAL	QUANTITY
STEEL (STRUCTURAL)	3,991,966 KG
CONCRETE	25,043,929 KG
FAÇADE	13,352 M^2
STEEL (SHEET)	95,940 KG
MEMBRANE ROOFING	2,869 KG
INTERNAL LININGS	340,331 KG
TIMBER (STRUCTURE)	338,537 KG
INSULATION - MINERAL WOOL	46,550 KG
FLOORING - VINYL	16,148 KG
FLOORING - CARPET	1,236 KG
DOORS	920 M^2

PRODUCT/MATERIAL QUANTITIES CONTINUED

PRODUCT/MATERIAL	QUANTITY
INTERNAL GLAZING	25,229 KG
INSULATION - POLYSTYRENE	5,353 KG
FLOORING - TILING	21,768 KG
INSULATION - THERMALROCK	7,225 KG
PRECLADDING	5,140 KG