External Research Report ER98 [2024]

Quantifying timber waste generated from construction and demolition sector in New Zealand

Hannah Kelly, Raquelle de Vine and Chris Purchas

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1222 Moonshine Rd, RD1, Porirua 5381

Private Bag 50 908, Porirua 5240
New Zealand

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Executive Summary

Scope

- Identify the quantity and profile of timber waste generated during construction and deconstruction activities.
- Identify the typical fate of timber waste following demolition or removal from a building at the end of its life.

Findings

>80% of all timber waste was **treated sawn**

H1.2 treated was **the most commonly wasted** treated timber type

95% of all timber waste was **off-cuts** or **like new** pieces

Framing project stages were the most wasteful generating **45%* of timber waste**
(*) average across the three study projects

Recommendations

- Investigate commercially viable options for the recovery of treated timber waste within New Zealand, particularly the south of the North Island and South Island.
- Construction organisations and researchers should utilise the methodology developed as part of this study to build on this dataset for timber and other C&D waste streams.
- Further assessment should be completed to understand and quantify the total material brought to a site compared with the total material which becomes waste.
- Improvements of data collection for deconstruction nationally will provide more clarity regarding the scale of C&D materials from deconstruction.
- Further exploration regarding how circular systems can be embedded to the C&D industry.

Insights

Treated timber (H1.2) is commonly used for temporary works where it is not necessarily required (treated timber tends to be of more reliable quality).

There is a lack of commercial options for recovery of treated timber within the southern half of the North Island and South Island of New Zealand

Deconstruction data across New Zealand doesn't specify treatment of recovered timber.

Procurement of materials and design are critical in reducing the generation of waste timber during construction.

Ready-to build projects are often more resource efficient than one-off architectural designed buildings.

Glossary

Word	Definition
Building structure	The skeleton or the framework of a building. It usually comprises beams, columns, walls, slabs, foundations, and roof trusses.
Cavity	A designed space/gap within a wall. The cavity is typically filled with insulation material to improve energy efficiency and provide sound insulation.
Cladding	Material applied over another to provide layers and used to provide a degree of thermal insulation and weather resistance, and to improve the appearance of buildings.
Confidence interval	A range which is expected to contain the parameter being estimated within a specified probability.
Construction and demolition (C&D) waste	Solid waste typically including building materials, packaging, metal, plasterboard, timber, concrete and rubble resulting from construction, renovation and demolition of buildings (BRANZ, 2024).
Damaged	Material which has been physically altered and unable to be used in its original form.
Deconstruction	A way of breaking down building materials for reuse and recycling. By making reuse a key focus it requires more sorting of materials, but also minimises the need for expensive, and noisy, heavy machinery like diggers (BRANZ, 2024).
Demolition	The process of dismantling existing buildings. Buildings are demolished as a building has reached the end of its serviceability, its structural integrity has been compromised or when contaminants are found to be present, or when fire damage has occurred (BRANZ, 2024).
Dependant variable	A variable whose value depends on an independent variable. Changes in the dependant variable are what you aim to measure to try and understand the relationship between two variables.
Dwangs	*Otherwise known as nogs,* a short usually horizontal piece of timber fixed between framings.
Engineered timber (untreated)	Engineered timber products are made by binding wood fibres and/or sawdust with adhesives to create products which are designed to be stronger and more durable than sawn timber. Untreated engineered timber is often used in internal wall lining. Examples of engineered product timbers include laminated veneer lumber (LVL), glulam, medium density fibreboard (MDF) and plywood.

Word	Definition
Engineered timber (treated)	Engineered timber products are made by binding wood fibres and/or sawdust with adhesives to create products which are designed to be stronger and more durable than sawn timber. Treated engineered timber can be used in mid floor framing and decorative components of a build. Examples of treated engineered product timbers include laminated veneer lumber (LVL) and plywood.
Fit out	A stage in the construction process which involves customising the interior of a space to meet specific functional and aesthetic requirements.
Foundation	A stage in the construction process which securely connects the structure to the ground.
Formwork	The surface, supports and framing used to define the shape of concrete until the concrete is self-supporting.
Independent variable	A variable that does not change because of changes in another variable you are trying to measure.
Infill development	A development within the Outer Residential Area involving the creation of a second and only additional household unit which is outside the footprint of an existing household unit and on a fee simple site of less than 1000 m^2 (Wellington City Council, 2024).
Internal finishing and trim	A stage in the construction process which involves interior finishes, such as flooring, drywall, doors, windows, and cabinetry, being installed.
Internal wall linings	A stage in the construction process which involves the installation of various components to enhance the structural integrity, appearance and functionality of interior walls.
Like new	Used when describing waste materials to indicate the material is in similar condition to the original form when purchased and is able to be reused. For the purpose of this study 'like new' timber were lengths >0.5 m which are easier to reuse.
Midfloor framing	A stage in the construction process which involves construction of floor framing, the subfloor is supported by light beams called floor joists or joists which in turn are supported by heavier beams called girders; the girders pass the load to columns.
Native (untreated)	Timbers which are native to New Zealand and untreated. These are high value timbers which are commonly used internally for detailing & some internal framing. Examples of native timbers include Kauri, Rimu and Tōtara. Some of these timbers may also be treated before use.
Nogs	*Otherwise known as dwangs,* short usually horizontal piece of timber fixed between framing.
Off-cut	A piece of material left over after cutting a larger piece. Often these are smaller pieces which are unusable due to size. For the purpose of this study 'off-cut' were lengths <0. 5m which are unlikely to be reused.
Pallet (untreated)	Portable timber platforms used for handling, storing, or moving materials and products. Pallets are typically constructed of untreated timber and are only treated if used in international shipping or entering New Zealand from overseas.
Polynomial fit	A form of nonlinear regression used to define the relationship between two variables.

Word	Definition
Predictive interval	A predictive interval provides a range in which a new observation is expected to fall within a certain level of confidence, given what has been observed in the data so far.
Prefabricated (treated)	Prefabricated / precoated timbers are timber elements which have been painted or coated either prior to arriving or on site. This includes timbers with painted surfaces, protective coatings, seals, or decorative finishes. Typically, these timbers are used in cladding and finishing. A common example is Formply.
Ready-to-build	Pre-designed buildings (typically residential) which can be customised to the client's specifications.
Reversible joints	Methods which join materials by using mechanical elements including, click joints, bolting and screwing which allow for 'reverse' disassembly.
Roof framing	A structure that spans the walls of the building and supports the roof covering.
Sawn non-native (treated)	Both planer gauged and rough sawn timbers which are treated before use. These timbers are often used in external areas or in areas with direct contact with water or soil and insects. The treatment protects the timber from moisture absorption, insect boring and can have flame retardant properties. In New Zealand Radiata pine is often treated with treatments ranging from H1 to H6 using a range of solvent and water borne chemicals including Boron, copper, combined copper/chrome/arsenic (CCA), tin and a range of organo-metallic compounds.
Sawn non-native (untreated)	Sawn timbers which are not treated before use. These types of timbers are typically used in internal areas which are at low risk of exposure to moisture and decay, including internal framing. An example of untreated sawn timber is Radiata pine. Another common example that is an exception to the above is Kwila, a hardwood used in decking.
Wall framing	The vertical and horizontal members of exterior walls and interior partitions.
Waste	Means anything disposed of or discarded; including a type of waste that is defined by its composition or source (for example, construction and demolition waste or timber waste); and includes any component or element of diverted material, if the component or element is disposed of or discarded (Ministry for the Environment, 2008).

1 Introduction

1.1 Scope

This project is aimed at providing improved information on timber waste generation both in building construction and demolition (C&D), including composition and typical fate of timber C&D waste, to supplement existing data that supports carbon foot printing and life cycle assessments (LCAs) of buildings. This report summarises the methodologies applied and findings including high-level commentary on the status quo approach currently adopted to deal with timber C&D waste.

Timber waste exists in the construction and demolition sector throughout the material and project life cycle. From processing raw materials, designing the building through to renovations or demolition, there are a series of actions (with respective owners) that could be addressed to improve timber waste management and reduce the timber C&D waste ending up in landfill.

For the purposes of this project, we focused on three main areas:

- Identifying the quantity and profile of timber waste generated during construction (Construction).
- Identifying the quantity and profile of timber waste generated during demolition (Demolition).
- Typical fate of timber waste following demolition or removal from a building / site (End of life).

1.2 Current Situation

In Aotearoa New Zealand, 50% of all waste sent to landfill annually is from construction and demolition (C&D) activities (BRANZ, 2024). It is estimated that 31% of this (205,856 tonnes) is timber (Nelson, Elliot, Pickering, & Beg, 2022). As an organic material, when decomposing in landfill timber contributes to biogenic methane levels, of which 94% of all waste emissions were biogenic methane in 2019 (Ministry for the Environment , 2022). With increased demolition and construction taking place across New Zealand if current practices continue as they are the quantity of timber waste entering landfill will continue to increase. The reasons for these high quantities are not fully understood. Potential drivers of timber wastage may include:

- The increasing usage of timber in construction (attributed to innovations in timber products).
- Over-ordering of materials in the industry (to avoid delays).
- A lack of recovery options for timber in particular CCA treated timber due to its toxicity.
- A “throw it away” mentality.

There are significant environmental, social and economic impacts of construction waste such as, unsustainable depletion of resources, pollution to land, air and water, significant greenhouse gas emissions and demands on waste infrastructure. The costs of providing and utilising waste services as well as the loss of potential value in the material also have an economic impact. Collectively the environmental hazards and flow on financial impacts affects society.

It has been evident for several decades now that Aotearoa New Zealand needs to address its management of C&D waste and, as a result, both the construction sector and the government are driving initiatives to do so.

Policy Context

The management of construction and demolition waste takes place within the context of several Government initiatives and legislative measures as summarised below.

The Building Act 2004

The Building Act (2004) outlines sustainability principles that the administering authorities must take account of. These include:

- the efficient and sustainable use of materials
- the reduction of waste during the construction process.

The Waste Minimisation Act 2008 (WMA)

The WMA's aim is to drive a reduction of the amount of waste we generate and dispose of in Aotearoa New Zealand. One way the Act seeks to achieve this is to impose a levy on all waste disposed of in landfills to generate funding for initiatives minimise waste.

As of July 2024, the levy on municipal waste being sent to class 1 landfills has increased from $50 to $60 and will be increasing to $75 by 1 July 2027. Typically, C&D waste is sent to a class 2 landfill where the costs for disposal have also increased, from $20 to $30 per tonne and will be increasing to $45 per tonne by 1 July 2027 (Ministry for the Environment, 2024).

Te rautaki para – Aotearoa New Zealand Waste Strategy (2023)

The Te rautaki para, Waste Strategy Aotearoa New Zealand outlines a vision that commits New Zealand to a low-emissions, low-waste circular economy, by 2050. Phase One of the Waste Strategy includes actions relating to circular management of products and materials as well as actions to reduce emissions from waste. The supporting targets for Phase One also indicate the Government's desire to reduce waste generation, disposal and associated emissions. Within the strategy timber has been identified as a significant organic material that can be diverted from landfill to reduce emissions and create further value through recovery. It also acknowledges the building and construction sector's role in reducing the amount of timber being sent to landfill and the need to support the infrastructure and systems to improve this further.

Building for Climate Change

In 2022 Building for Climate Change amendments to the Building Act were proposed to reduce the building and construction sectors emissions and support the construction of more climate resilient buildings. The proposed changes identified the opportunity to address a regulatory gap to include requirements for waste minimisation plans when constructing or demolishing buildings. This work, if implemented, will encourage the sector to further:

- Design and deconstruct buildings in a way that minimises waste produced.
- Recycle and re-use building materials effectively; minimise waste produced onsite.
- Optimise recovery and diversion initiatives within regions.

Emissions Reduction Plan

In 2022 Aotearoa New Zealand's first emissions reduction plan was published outlining the country's approach to limit global temperature rise to 1.5˚C above pre-industrial levels. It includes strategies, policies and actions to achieve the first emissions budget. The building and construction sector is identified as a key sector to contribute, waste was identified as one of the sectors that accounts for a portion of the building and construction sectors emissions. Relevant key actions listed under the EMP are:

- Reduce and divert construction and demolition waste to beneficial uses.
- Support the building and construction sector to minimise waste through research and improved capability.
- Invest in sorting and processing infrastructure for construction and demolition materials.
- Enable the separation of construction and demolition materials.

Sector Context

The building and construction sector has a focus on reducing the amount of timber going to landfill. This is driven by cost, environmental and emission reporting requirements and a general awareness of the usefulness of the material. Some of the ways the sector is doing this is through:

- Improving designs and plans that reduce waste.
- Protecting the materials delivered to site to avoid damage.
- Ordering fewer materials to avoid surplus.
- Minimising off-cuts.
- Using prefabricated elements where feasible.
- Diverting timber waste from landfill.

Some of the current ways that timber is diverted from landfill include:

- Offering the materials to site teams or community groups to encourage reuse of the materials.
- Sending the material to a sorting centre where it is often repurposed or chipped for recycling or recovery. Options for the chip depends on whether it is treated or untreated. In the North Island, treated chip can go to Golden Bay Cement to be used as boiler fuel. However, there are no current options for treated timber recycling in the South Island.
- Promoting renovating, refitting or refurbishing rather than demolition.
- Where demolition is required taking a deconstruction approach to recover the value in materials where feasible.

1.3 Partners

This project would not have been possible without the support of the project partners who have been actively involved over the last two years. Throughout the project stages the project partners have each contributed to key parts of the study. Working alongside BRANZ (our client) we worked with the Environmental Solutions Research Centre at Unitec (ESRC) and Auckland University of Technology to develop the methodologies used. Their input from past studies and experience was integral to developing effective methodologies.

The data collection for the project required both on the ground data collection for construction data and a desktop review of deconstruction. Naylor Love Enterprises Limited and the Naylor Love Canterbury Ltd team provided insights throughout the project as well as being involved in on the ground data collection for a commercial project. Classic Builders Christchurch and Flip Homes provided residential sites and data collection and WasteCo NZ assisted by hosting and assisting with the sort and weigh data collection. Auckland Council, Kāinga Ora and the TROW Group provided their deconstruction data. All partners involved in this project and their involvement in the project are detailed in Table 1.1.

Table 1.1: Project partners

Organisation	Project involvement
Environmental Solutions Research Centre at Unitec (ESRC)	Methodology
Auckland University of Technology (AUT)	
FLIP Homes	Construction sites – data collection
Naylor Love Canterbury Ltd	
Classic Builders Christchurch	
Kāinga Ora	Deconstruction data
Auckland Council	
TROW Group	

2 Methodology

2.1 Methodology developed

As the aim of this study was to investigate the composition of timber generated during construction and deconstruction of buildings, we decided to prepare a list of typical timber categories found in the construction sector. These would be used to categorise the different types of timber during data collection. These classifications are detailed below:

- Sawn non-native (untreated) – Sawn timbers which are not treated before use. These types of timbers are typically used in internal areas which are at low risk of exposure to moisture and decay. An example untreated sawn timber is Radiata pine. Another common example that is an exception to the above is Kwila, commonly used in decking.
- Sawn non-native (treated) – Both planer gauged and rough sawn timbers which are treated before use. These timbers are often used in externally or structurally and may have direct contact with the outdoors. The treatment protects the timber from moisture absorption, insect boring and can have flame retardant properties. A common example of treated sawn timbers is Radiata pine.
- Native timber (untreated) – Timbers which are native to New Zealand and untreated. These are high value timbers which are commonly used internally for detailing and externally for decking. Examples of native timbers include Kauri, Rimu and Tōtara.
- Prefabricated (treated) – timber elements which have been painted or coated either prior to arriving or on site. This includes timbers with painted surfaces, protective coatings, seals, or decorative finishes. Typically, these timbers are used in cladding and finishing. A common example is Formply.
- Engineered product (untreated) – Engineered timber products are made by binding wood fibres and/or sawdust with adhesives to create products which are designed to be stronger and more durable than sawn timber. Untreated engineered timber is often used in internal wall lining. Examples of engineered product timbers include laminated veneer lumber (LVL), glulam, medium density fibreboard (MDF) and plywood.
- Engineered product (treated) – Treated engineered timber can be used in mid floor framing and decorative components of a build. Examples of treated engineered product timbers include laminated veneer lumber (LVL) and plywood.
- Pallet (untreated) – Portable timber platforms used for handling, storing, or moving materials and products. Pallets are typically untreated and only treated if used in international shipping or entering New Zealand from overseas.

A further aim of the research was to understand at which stage of construction these timber waste profiles were being generated. Project stages were defined using previous construction waste research alongside conversations with the construction industry to define the stages in the construction process. The project stages are detailed below:

- Foundation.
- Wall framing.
- Midfloor framing.
- Roof framing.
- Cavity and cladding.
- Internal wall linings.
- Internal finishing and trim; and
- Fit out.

The study estimated the quantity and profile of timber waste generated using these project stages during one commercial construction project and two residential construction projects by using on-site data collection in collaboration with three construction organisations.

For all three projects and in collaboration with the onsite teams, we used a webhosted survey platform to collect data on the timber waste composition using visual observation which are based upon volume estimates.

2.2 Construction data collection

The intended methodology to collect data from the three sites was to visually estimate the timber waste data as the material was leaving site and undertake sort and weigh audits where feasible. Visual data was selected as the primary data collection source to maximise the quantity of data which can be collected with minimal time and resource required. This would allow for the research to gather a larger dataset than a sort and weigh audit alone.

Visual audit method:

- All timber was placed in waste container as generated on site.
- A visual estimate of the volume and composition of materials in the waste container was taken at defined intervals (25%, 50%, 75%, and 100%). This was determined by the availability of a designated person on site to take the images. To assist the team on site, guides/ marks were made to show the proportion fullness in the waste container to easily identify fullness level.
- Each data entry taken was captured for the top 25% layer which is closest to the top of the waste container as it was difficult to determine the composition below this layer. This meant that if the waste container was 75% full, the data entry record was recording the waste between the 50% and 75% fullness level.
- Ideally, five images were taken of the waste container for each estimate, these were one from each of the four sides of the skip and a birds-eye view image, if possible (refer to Figure 2.2). Photos from multiple angles helped to identify the material quantity and type correctly for quality assurance purposes. Where waste containers (skips) were overloaded, additional images were taken.
- The sites were required to categorise the 'quality' of each timber type in the waste container. This would allow the study to explore how much reusable timber was being disposed of compared to damaged timber. The data collection question provided the following options for the timber quality:
  - Like new (whole piece).
  - Off cut (small piece).
  - Damaged.
- A web-hosted data collection tool (Survey123) designed by T+T was used for the collection of data throughout the study.
- Comments were made for data entries if they had anomalies to assist with the quality assurance (QA) process, e.g. if a material category is selected and there were multiple sub-categories it was helpful to define the subcategory if it was not a pre-defined field in the survey form.

The data collection method has been detailed in a flow diagram in Figure 2.1.

After all the data had been collected, we took the total skip weight and used this to calculate total weight for each timber type by the 25% splits based on the visual estimate of the volumes.

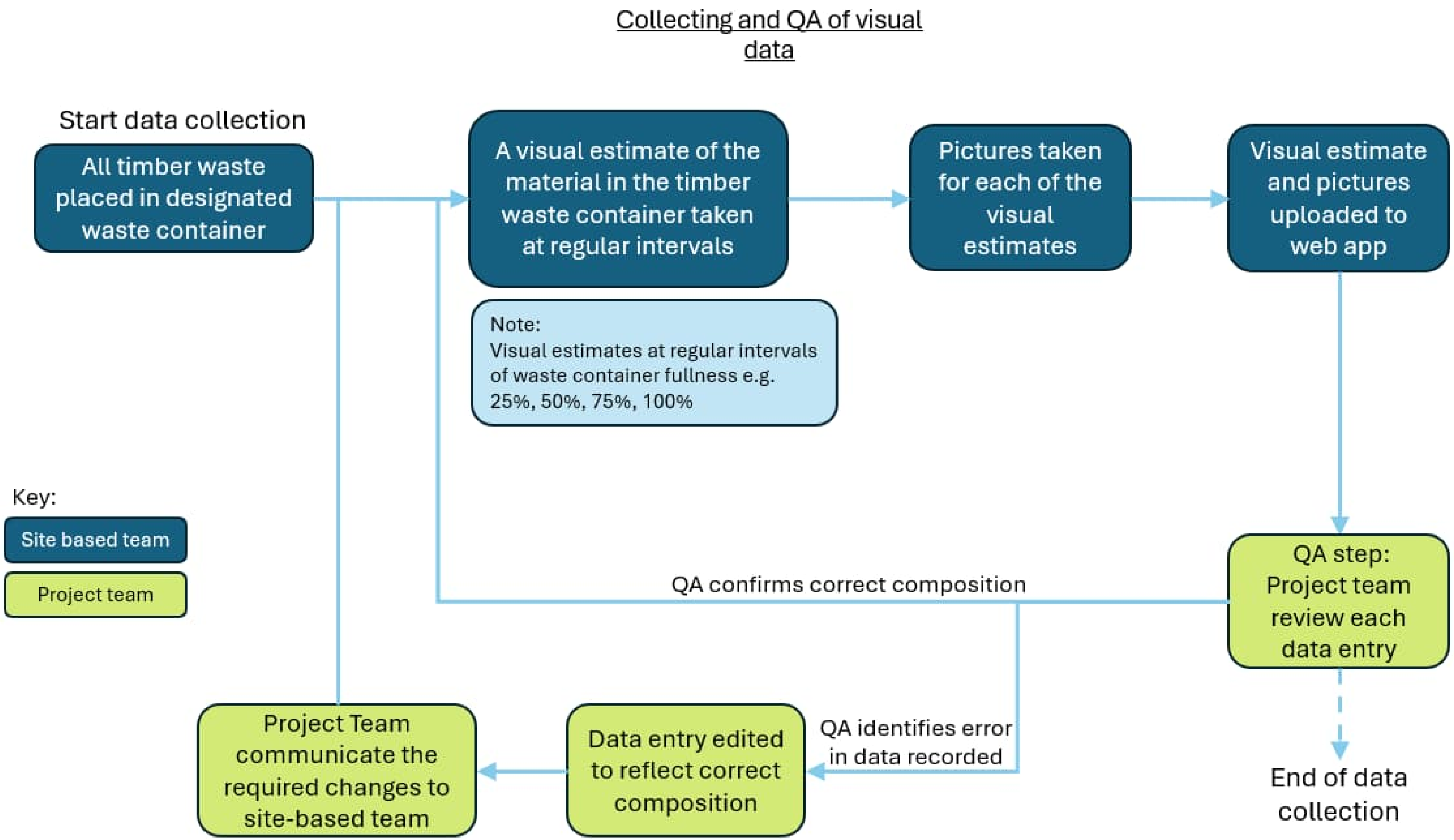

Figure 2.1: The collection and Q+A of visual data

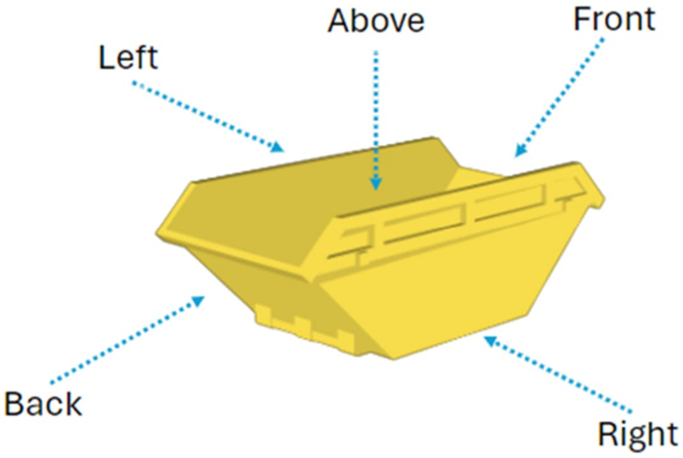

Figure 2.2: Recommended images to be taken of the waste container

A physical sort and weigh methodology provides greater assurance of the quality of data collected and enables calibration of quantity estimates from visual data collected. The assumption being that if the sort and weigh audit data correlated well with the visual data this would mean the visual data methodology was working effectively. The sort and weigh data also provides a basis for providing feedback to the personnel completing the visual estimates, 'calibrating' their visual assessments.

The sort and weigh audit method is detailed below:

- Of the skips that were visually audited, 8 were also sorted and weighed.
- Once a skip was full the timber was placed into specific categories in appropriate containers (skip/wheelie/clear area). For timber it was sorted into the categories from the visual assessment:
  - Untreated sawn (non-native)
  - Native timber (untreated)
  - Treated sawn (non-native)
  - Prefabricated (pre-coated element)
  - Engineered product (treated)
  - Engineered product (untreated)
  - Pallet (untreated)
- Each category was weighed using calibrated scales.
- The weight of the containers was taken when it was empty (tare weight) and then again once it had been filled with timber.
- This data was compared with visual assessment data with the aim of accessing the confidence interval for the visual assessments.
- The process of the sort and weigh is shown in Figure 2.3.

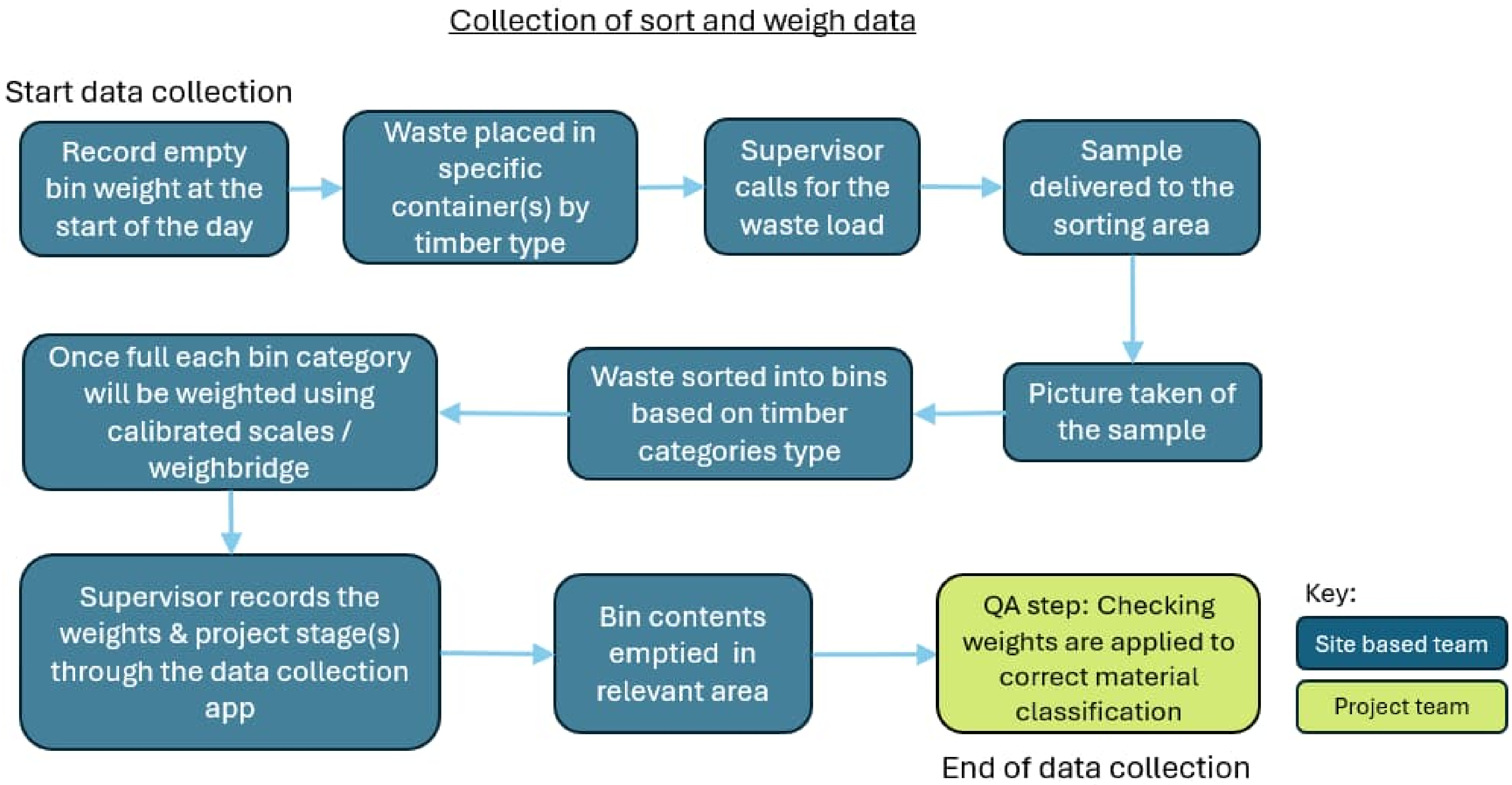

Figure 2.3: The collection of sort and weigh data

2.3 Demolition / Deconstruction

T+T are working with construction and deconstruction organisations to gather and collate deconstruction data. This element of the project is intended to assess the quantities and composition of timber waste from deconstruction projects. A key aspect of this data collection and analysis is to assess the quality and consistency of this data.

At the planning stage for the project, it was expected that that the datasets would include the following information:

- Quantities of each material type (volume and / or weigh).
- Some classification or commentary on items which could be reused as their original intended purpose.
- The end-of-life destination for each material type (e.g. recovery facility, second hand shop, new build), to identify opportunities and commentary on potential future diversion targets.

The methodology to be applied to demolition waste quantification included estimating the quantity and profile of timber waste generation from the projects where demolition had previously taken place. The study would use desktop analysis of existing datasets collected by a housing developer.

2.4 End of life

Through research and data collection we aimed to identify the typical fates of different timber wastes following demolition and/or removal from site during construction by conducting surveys with an engaged group of stakeholders.

Construction and demolition waste management varies on a project basis and may be dependent on:

- Regional practice and availability of waste management infrastructure.
- Construction programme.
- Organisational values and policy (including clients, contractors, designers, suppliers).

In our experience, it can be difficult to gather quantitative data on end-of-life destinations, particularly if a breakdown of the waste material is required (i.e. by type of timber C&D waste). In our experience it can be more effective to collect qualitative data from a range of sources.

Information that is typically available and can be used to characterise standard timber waste management practice on construction and demolition sites includes:

- skip demand at different project stages.
- typical percentage over-buying of particular materials.
- financial impact of recycling or on-selling materials.
- types of timber that can be reused on site or within broader company operations (e.g. formwork).

We developed a web-hosted survey for use on a phone to collect information and help to build a picture of the end of life for different types of timber C&D waste. Our aim during the research was to collaborate with stakeholders, developing the survey considering target audience and data that can be readily compiled and compared.

3 Overview of data collection

3.1 Construction data collection

This research project followed the construction of the three sites detailed below.

Site One

Construction period – 16 months

Build type – Commercial

Site One consists of two main buildings. A Supported Housing building consists of 23 individual apartments with ensuite, 3 lounges, a large communal kitchen and laundry, split over 2 levels. The structure is a pre-nailed timber frame with some internal and external ply bracing walls. The first floor is constructed from engineered (LVL) timber joist with ply flooring. The roofs are a mixture of pre-cut truss's, engineered (LVL) pitched roofs (cut and fabricated on site) and flat roofs constructed with engineered joists (LVL) with treated ply over.

A Wrap Around Services building is a mixture of offices and clinical space over 2 levels with a large roof top garden. There is a large central atrium which is full height. The structure is primarily glulam timber (Glulam is another form of engineered timber) with minimal steel around the stair core and for bracing. The glulam columns, beams and rafters were prefabricated and assembled on site, a pre-nailed timber frame sits within the glulam structure and also forms the partition walls between the interior spaces. The walls are lined with bracing ply. The first floor and roof are engineered timber (LVL) joist with ply flooring and roofing substrate.

The interior linings of both buildings are mostly plasterboard, stopped and painted with some areas of feature plywood. The exterior cladding is a mixture of clay bricks sourced from Canterbury, metal long run cladding and some small areas of cedar shiplap cladding (untreated). The roofing is long run metal on the pitched roofs and a bituminous membrane roof over Kingspan insulation board on the flat roofs.

Figure 3.1: Site One artists impression

Site Two

Construction period – 7 months.

Build type – Residential

Site Two is a 120 m^2 residential build. The project is an infill development built on steep topography. The build is a two-storey timber structure consisting of two bedrooms, one living space, a kitchen and outdoor deck which wraps around two external walls.

The structure is a pre-nailed timber frame with some internal and external bracing. The roof for the property was constructed using timber rafters and weatherboard, with the cladding on the property a combination of timber battens and timber weatherboard. Internally the sub-flooring is a sheathing timber with plywood being used on the flooring and wall linings.

The decking which is present on two external walls of the property is a treated timber product.

Figure 3.2: Site Two artists impression

Site Three

Construction period – 7 months.

Built type – Residential

Site Three is a 212m^2 ready-to-build residential building. It was classified as a 'typical' build, indicating a standard design used by them. The build is a single story four-bedroom home with; two bathrooms, an open plan kitchen and dining and an adjacent lounge as well as an attached two car garage.

The structure is a pre-nailed timber frame with some internal and external bracing. The roof is pre-nailed H1.2 timber trusses and purlins with metal ceiling battens. The roofing overlay is rib profiled metal roofing. The interior linings are plasterboard, stopped and painted. The exterior cladding is a mixture of brick veneer and a fibre cement weatherboard.

Figure 3.3: Site three artist's impression

Construction data collection overview

The data collection for the project started in April 2023 and continued until July 2024. Table 3.1 provides an overview of the data collected during this period.

Table 3.1: Study sites overview

Project	Construction period	Visual data entries	Sort and weigh data entries
Site One	April 2023 – July 2024	70	8
Site Two	November 2023 – May 2024	2	0
Site Three	November 2023 – May 2024	4	0

Visual data collection

Working with the site teams, we used the T+T webhosted survey platform to collect data on the timber waste composition using visual observations for all three sites.

Sites One and Three were able to have a designated timber skip on site, therefore the visual data methodology detailed in Section 2.2 was followed for these two sites. However, due to the topography of Site Two and the limited space outside of the site boundary, the approach for data collection had to be amended. All timber waste from construction activities was stockpiled within the site boundary before a trailer would collect the material (Figure 3.4). As the waste accumulated the site arranged for all timber waste to be carried down to a trailer to be taken for disposal. During this phase the visual data was collected as the trailer was filled.

Sort and weigh data collection

The project intended to conduct a sort and weigh to calibrate the visual data for Site One and Site Three. Site Two was excluded from the sort and weigh audits due to lack of available space to conduct the audit in a safe manner.

For Site One a total of eight sort and weight audits were conducted covering roof framing to fit out.

For Site Three as there was only one timber skip for the duration of the project the aim was to conduct a sort and weigh audit on this skip as it was full. The intension was to have the skip arrive at the designated sorting location on the same day as two skips from Site One, however the skip which arrived was not the timber skip the team were expecting. It was unclear whether the skip had left site prior to the sort and weigh audit or was sent directly to the waste recovery facility for sorting. As such the project team were only able to conduct sort and weigh audits for Site One.

The physical sorting of the waste was undertaken by T+T and also supported by the project partners including an apprentice carpenter which enabled correct classification of the timbers and project stages.

Figure 3.4: Site Two waste collection and transportation method

3.2 Carpenters focus group

A focus group of carpenters was conducted to explore their specific experiences in handling timber as a material and waste across commercial and residential build sites within New Zealand. The purpose of the focus group was to:

1. further inform which timber material management methods are used within the C&D sector
2. identify which management methods contribute towards waste timber; and
3. identify the typical fates of different timber wastes following demolition and/or removal from site during construction.

The focus group was facilitated as a semi-structured interview with a group of four carpenters ranging in experience. All carpenters were from the same organisation, and based at Site One during the data collection. The sample of participants selected for this focus group were individuals who work directly with timber material day-to-day and who are responsible for timber material and its waste management across all stages of construction.

The focus group participants' experience ranged from an apprentice with one year of work experience in the construction sector, to experienced carpenters who have worked across both residential and commercial construction and demolition projects for over 20 years both in Aotearoa New Zealand and internationally.

The focus group was held in person on site. The interviewer/focus group lead had a predefined list of guiding questions to prompt conversation. The guiding questions focused on the three purpose points listed above.

Following the focus group, thematic coding was used to analyse the conversation. The process of data analysis included:

- listening to the recording of the focus group conversation for the focus group lead to become re-familiarised with the conversations and immerse into the data
- developing codes to apply to the transcription of the data, these included:
  - types of work the carpenters were undertaking
  - experiences and observations
  - the waste material / timber type
  - material management methods
  - beliefs and quotes stating perceptions of situations
  - factors that influenced decision making
- using the codes themes were then developed
- the data was then consolidated and interpreted.

into and analysis of the conversation took place to find common themes. The full analysis of the carpenters focus group is detailed in Section 4.3 and an overview of the thematic analysis is detailed in Appendix E.

3.3 Deconstruction data collection

As discussed in Section 2.4 the intension of this study was to review data from deconstruction projects to understand the timber composition through pre-existing datasets collected. During the project we reached out to several deconstruction organisations, social enterprises and local councils who have undertaken deconstruction activities to request deconstruction and demolition data collected. A total of 11 deconstruction reports were sourced covering sites in Auckland, Nelson and Wellington.

4 Data collection findings and discussion

The findings from the data collection stage and analysis are reviewed in this section of the report.

Figure 4.1: Site One Wrap Around Services building interior

Table 4.1: Overview of findings

	Site 1	Site 2	Site 3
Overview of project	Construction of commercial building with residential facilities.	Construction of a 160 m^2 residential home over two stories.	Construction of a 221 m^2 single levelled home.
Total tonnes of timber waste from the project	31.028	1.165	0.195
Number of 9m^3 timber skips used	26	N/A trailers used	1.5
Waste which is treated timber (%)	84%	92%	100%
Category with the highest portion of timber waste	Sawn non-native (treated) 49%	Sawn non-native (treated) 69%	Sawn non-native (treated) 92%
Actual recovery rate (1)	69%	0%	58%
Potential recovery rate (H1.2 and untreated)	69%	80%	58%
Potential recovery (untreated only)	16%	8%	0%

Note – Actual and potentially recoverable timber for Christchurch sites includes untreated and H1.2 treated timber. This is due to a processing facility available in the city which has a market for H1.2 timber.

(1) 'Actual recovery rate' is the recovery rate achieved by the waste contractor used or the recovery sought by the project. Where 0% is recorded this is due to all timber waste going to landfill with no commercial recovery option in the region.

4.1 Construction

Site One

Visual data that was collected from Site One showed treated sawn timber was the most common waste timber classification at 49% of the total timber waste (Figure 4.1). Pallets and prefabricated timber were the second most common timber wastes, both being 14% of overall timber collected. The majority of the timber placed in the skips for disposal was treated timber with 84% being a form of treated timber. The high quantity of treated timber waste was anticipated from this study as the building is a 100% timber framed construction as demonstrated in Figure 4.2 and Figure 4.3. As required by building regulations all framing and structure timber must be treated.

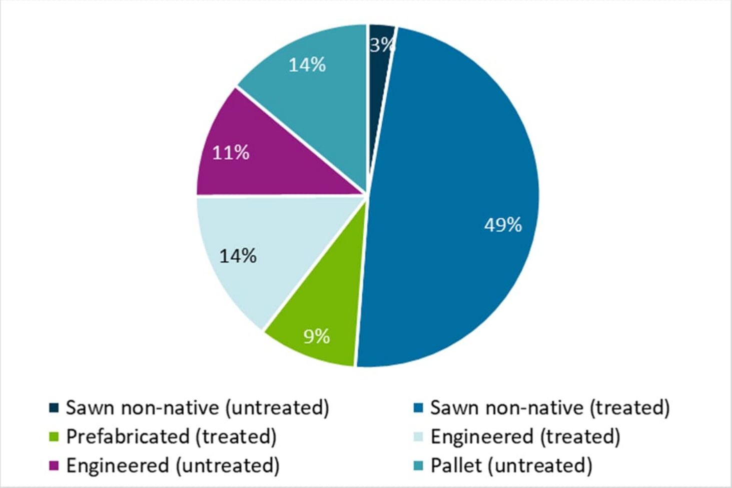

Figure 4.2: Site One composition of all wood from visual estimates

The timber profile across project stages is shown in Figure 4.3, composed of the weights of each timber type. Non-native sawn (treated) timber was the biggest waste stream across all the project stages except for fit out. The most non-native sawn (treated) timber was present during wall framing and internal wall linings which were the two project stages with the most waste timber. The second most common waste timber was engineered product (untreated). Engineered product (untreated) was common through midfloor framing, roof framing and internal wall linings. Pallets were also a high timber waste stream common in wall framing, cavity and cladding and internal wall linings. The most untreated material was used in the wall framing project stage along with fit out, with untreated timber having the best potential for recovery.

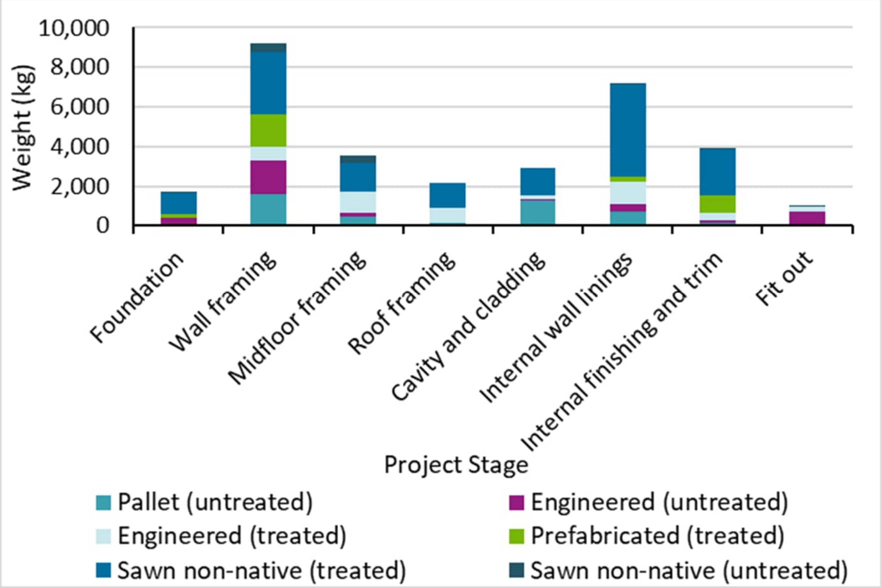

Figure 4.3: Site One weight of each timber type for the project stages

A review of the quality of timber which was disposed of is detailed in Figure 4.4. The data demonstrates that 92% of the timber disposed was 'like new' or an off-cut. These timber pieces predominantly came from the wall framing, internal wall linings and internal finishing and trim project stages and were predominantly off cuts as demonstrated in Figure 4.5. The 5% of damaged and unusable timber also predominantly came from the same project stages.

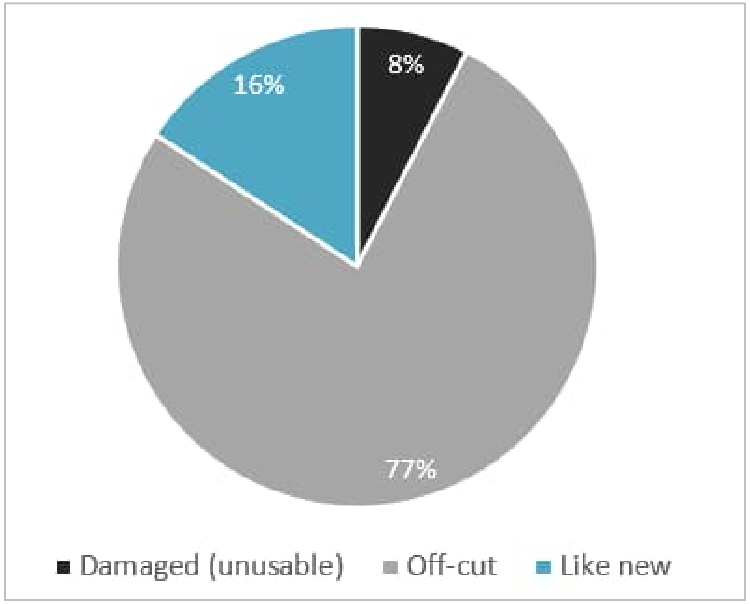

Figure 4.4: Site One quality of waste timber

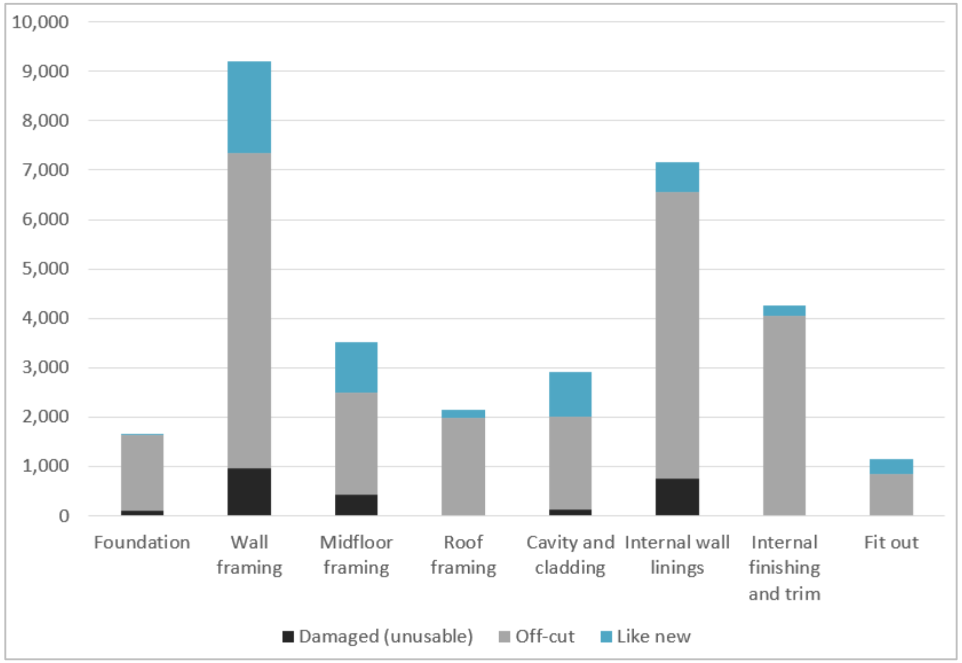

Figure 4.5: Site One quality of waste timber by project stage

Sort and weigh audits were also undertaken at Site One to calibrate and verify the visual data. A comparison of the eight sort and weigh, and visual data skip collections are shown in Figure 4.6. Sawn non-native (treated) timber has the highest portion for both sort & weigh and visual audits with a difference of 1.59% in overall composition. Engineered product was also similar between the data collection methods with a difference in composition of 0.07%. The biggest differences in composition were for engineered (treated) (7.29%) and prefabricated (treated) (5.6%) timber.

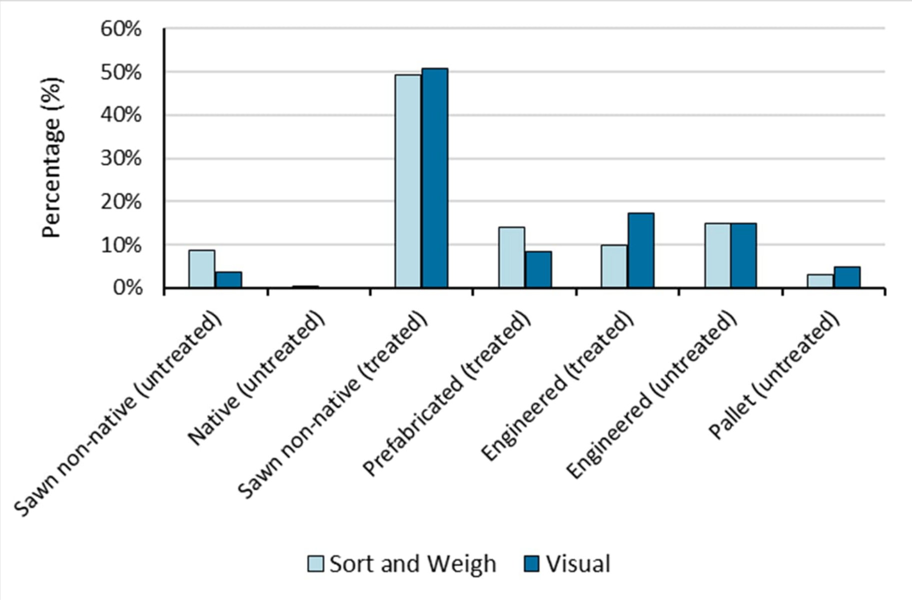

Figure 4.6: A comparison of visual and sort & weigh timber for the 8 skips that were audited visually and sort & weighed for Site One.

Sort and weigh data

To understand how accurate the visual assessments of the skips were, eight skips of timber waste were selected to be included in sort and weigh audits. Using the data collected from the sort and weigh and comparing this to the visual data collected of the same skips a least squares linear regression was used to understand the relationship between data. The analysis provided 64% of certainty in the visual data can being explained by the sort and weigh data. This means, there is a statistically significant relationship between the visual and sort and weight data providing confidence that the visual data is representative of the actual weights of the skips.

More information regarding the regression analysis completed to identify the relationship between the sort and weigh and visual data can be found in Appendix D.

Site waste management practices

The site team on this project made a conscious effort to reduce waste timber where possible. This was driven by cost of material and the Site Manager's objective to reuse materials as much as possible before deciding if a material is a waste. The following measures were put in place on Site One to reduce waste from the first day on site:

- A conscious decision was made to use H1.2 treated timber for foundation bracing. After the foundation had cured the formwork was dismantled cleaned and cut down to relevant lengths to be reused for nogs to strengthen walls during the framing stage.
- A rule was implemented on site where any length of timber longer than 300 mm would be kept and used as nogs, and where these lengths were H1.2 they would be stored in an enclosed storage unit to protect them from prolonged exposure to the rain and sunlight.

- Off-cuts of materials were utilised on site where feasible. For example, plywood was used throughout the project and where off-cuts were a reasonable size these were reutilised for packing out walls, protecting elements of the build and for the walkways on the roof before the structure was complete.
- Utilised product stewardship schemes where off-cuts or packaging, in particular pallets, could be returned to the manufacturer and reused or reprocessed.
- Some elements of the build including the main structure, midfloor engineered joists, roof joists, and kitchen cabinetry were prefabricated offsite. This meant that the main structure was slotted and blotted together on site without the generation of waste from off-cuts. The Site Manager noted that due to the technical design elements of this build during the prefabrication, waste at these stages was lower than an average project.

Although effort was made on site to reduce waste where possible there were also parts of the project which were more wasteful than others. The visual and sort and weigh data demonstrated the following:

- Wall framing and internal wall linings were the most wasteful project stages for timber with 9.04 t and 7.05 t of timber waste materials recorded respectively. The reason being that due to the design of the Wrap Around Services building there was a lot more cutting required to fit specific dimensions as per the design. This results in a large quantity of off-cuts where the lengths of timber were unable to be reused for structural elements of the build.
- These findings were echoed in the carpenter's survey conducted on site. Refer to Section 4.3 of this report for further insights from the carpenters survey.

Figure 4.7: Site One framing under construction.

Figure 4.8: Site One roof framing.

Site Two

Visual data collected for Site Two showed that Sawn non-native (untreated) timber (69%) was the highest portion of waste wood retrieved from the site (Figure 4.9). This was the same finding to that of Site One. Prefabricated (treated) timber (13%) was the second highest portion of waste timber, followed by engineered (treated) timber (10%)

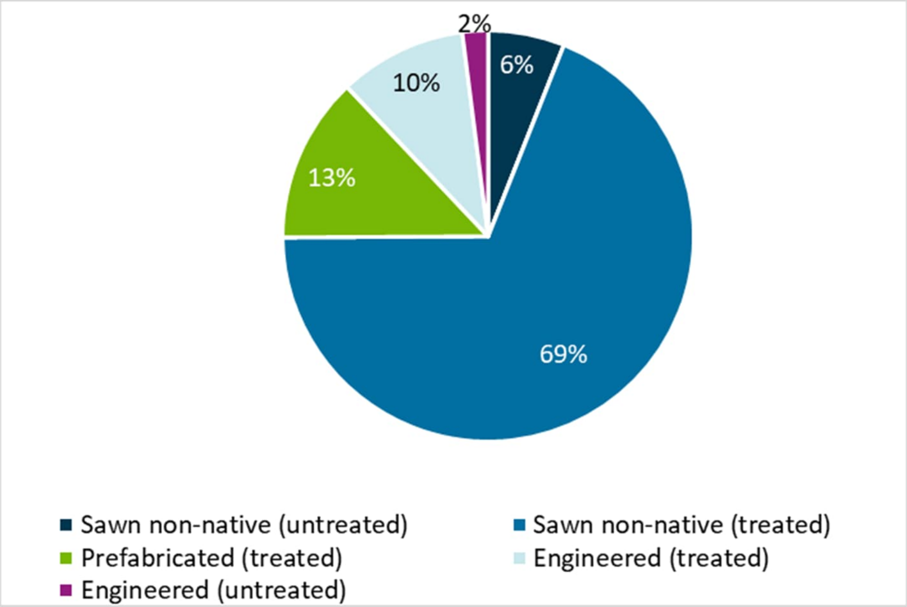

Figure 4.9: Site Two composition of wood from visual estimates.

Sawn non-native (treated) timber was the most common waste timber throughout the project stages (Figure 4.10). The amounts varied but stayed consistent from the foundation project stage to roof cladding. Prefabricated (treated) timber was present in the cavity and cladding project stage and the internal wall linings to the fit-out stage. These were some similar patterns to what was found for Site One, with sawn non-native (treated) timber being the most dominant waste timber type.

Of all the waste timber removed from the project, 92% was treated, leaving 8% untreated and able to be recovered.

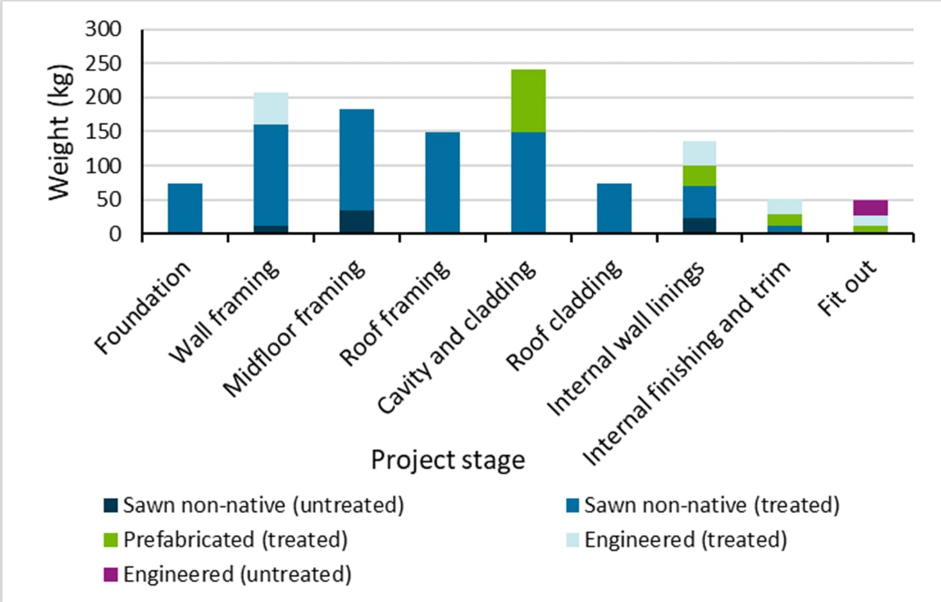

Figure 4.10: Site Two weight of each timber type for the project stages.

A review of the quality of timber which was disposed of is detailed in Figure 4.11. The data demonstrates that 94% of the timber disposed was off-cuts. This covered project stages foundations through to roof cladding and four main timber categories (sawn non-native (treated), prefabricated (treated), engineered (treated and untreated). The remaining 6% of damaged and unusable timber came from sawn non-native (untreated) timber across the same project stages. This is attributed to damaged pallets.

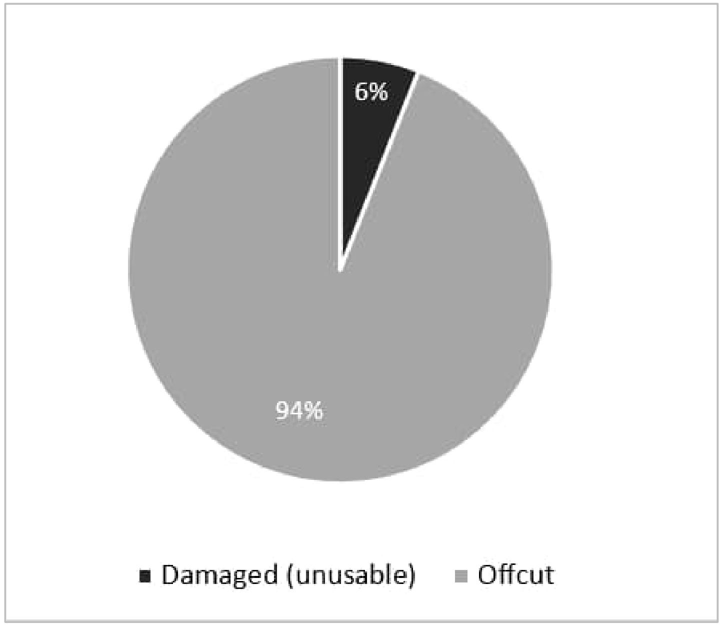

Figure 4.11: Site Two quality of waste timber.

Site waste management practices

As this project was an architecturally designed residential building, as opposed to a ready-to-build property there were more unique design elements. With more unique elements came more waste from the construction process, in particular during the framing process.

During the project there were some purposeful decisions made to use a treated timber source for some elements rather than untreated elements where they typically would have been used. This includes using H1.2 timber for foundation bracing over untreated timber. This decision was made due to the lower price of treated timber and greater reliability for foundation bracing with less warps likely than untreated timber. There was also an instance where the incorrect timber material was delivered to site. H1.2 was specified for the midfloor framing construction however, H3 was delivered to site by mistake. The decision was made to utilise the material to avoid delays to the programme, however this resulted in more H3 waste being generated than anticipated.

Due to the nature of the topography on the site, structural elements including wall framing were prefabricated offsite. This was driven by the unique structure and ensuring precision in the framing elements rather than waste reduction on site, noting that there was no waste container on the site and waste was stockpiled around the boundary (Figure 4.12). Where untreated timber waste was generated on site this was retained for the client and some of the site team to be used as firewood. The Site Manager also made a conscious effort to retain the larger elements of timber, those greater than 1 meter in length, predominantly from the foundation bracing, to be reused on other projects.

As this project was based in Wellington City which has limited options for timber recovery, in particular treated timber recovery, all waste generated from the construction, which was not being reused on another project was sent directly to landfill.

Figure 4.12: Site Two waste management storage method.

Site Three

At Site Three the waste timber generated on the project was only visually assessed and consisted of sawn non-native (treated) and prefabricated (treated) timber. The composition of the timber waste is shown in Figure 4.13 with sawn non-native (treated) timber 92% of the timber waste.

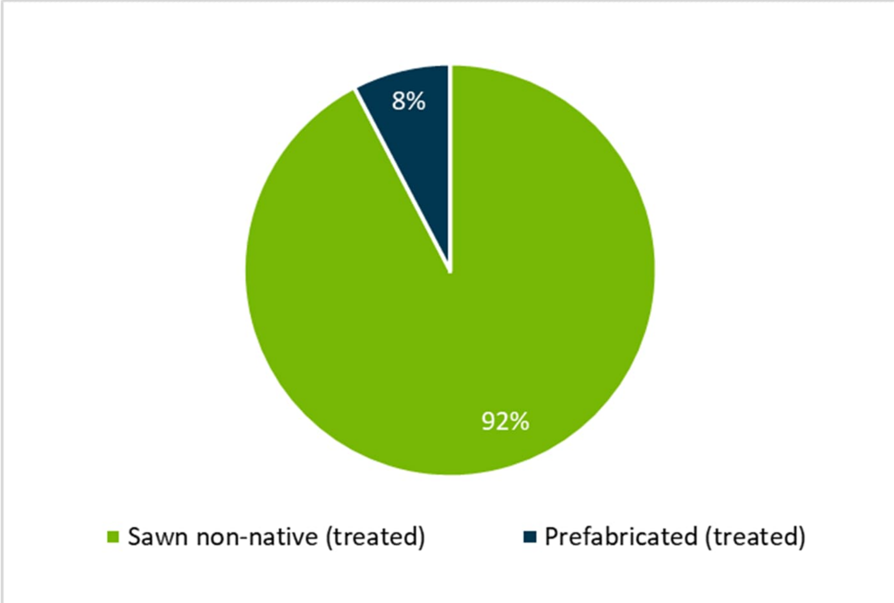

Figure 4.13: Site Three composition of wood from visual estimates.

The timber waste generation across all project stages is detailed in Figure 4.14. Timber from wall framing, roof framing, and cavity & cladding consisted only of sawn non-native (treated), whereas the internal finishing and trim project stage consisted of only prefabricated (treated) timber. The results for Site Three show a similar trend to that of Site One and Site Two with sawn non-native (treated) timber being the largest portion of waste timber from wall framing, roof framing and cavity and cladding.

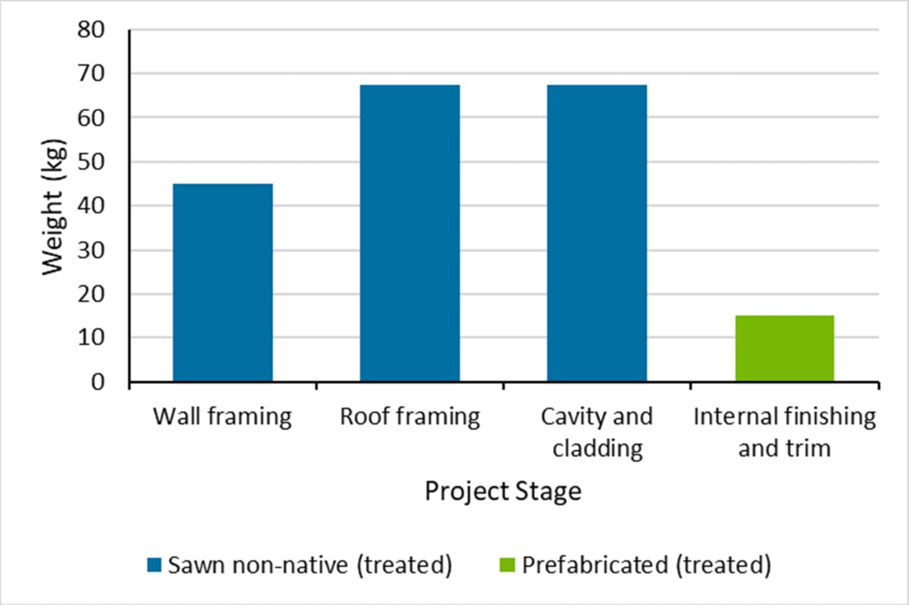

Figure 4.14: Site Three weight of each timber type for the project stages.

A review of the quality of timber which was disposed of is detailed in Figure 4.11. The data demonstrates that 92% of the timber disposed was off-cuts. This covered the sawn non-native (treated) timber from the following project stages: wall framing, roof framing and cavity and cladding. The remaining 8% of like new timber came from prefabricated (treated) timber across the internal finishings and trim stage.

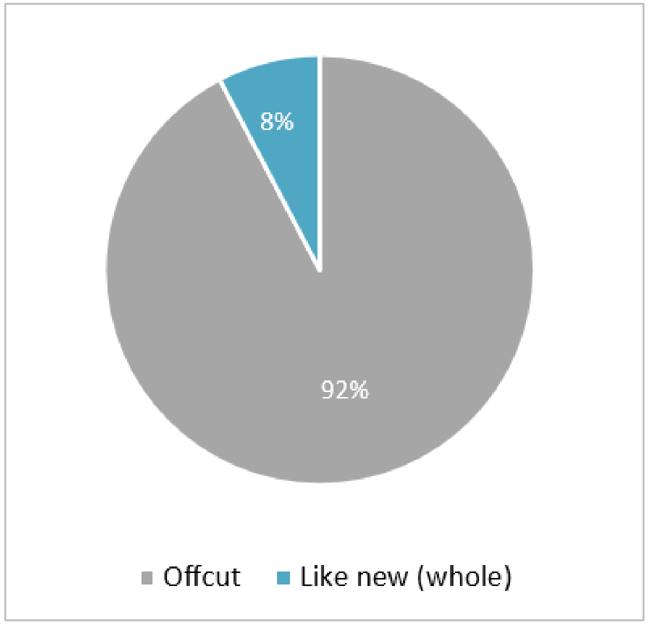

Figure 4.15: Site Three quality of timber waste.

Site waste management practices

The site team indicated that this build would likely not produce large quantities of timber waste and across limited project stages due to the nature of it being a “ready-to-build” project, particularly in comparison to a bespoke or architectural build (Figure 4.16). This was mainly due to measures put in place to increase efficiencies and cost savings for standardised ready-to-build projects on the market. Some of these measures which are relevant to this build include:

- Reusable framing used for foundation bracing.
- Pre-nailed framing for internal walls and roof trusses.

- Ordering only the materials and lengths which are required for the project. The organisation has worked to refine its ordering process with supply of specific timber specifications less of an issue due of the quantity of material orders the company places annually.
- Readily available and cost-efficient materials are often prioritised in the design and specifications of ready-to-build properties. This ensures the builds can take place efficiently and at a lower cost to the client. As a result, less timber is used in the build itself. This does not necessarily mean less overall waste generation onsite, it is likely that other C&D waste streams are still generated.

Some other considerations that can limit the use of timber materials or resultant timber waste on ready-to-build sites are the relationships with suppliers that enable the return of any surplus materials, due to high volume of orders and turn over. As well as the contracting out of landscaping services who take away any excess timber.

Lastly it was highlighted by the Site Manager that the organisation commonly experience challenges working with sub-contractors who are not aligned with the lead company's environmental initiatives / values and a general lack of interest in material recovery. This may be due to sub-contractors on these projects being paid a lump sum for their element of the build, therefore the faster they complete the work the faster they can move onto their next job. As a result, they are less likely to engage with some the sustainability initiatives on site (e.g. segregated bins for diversion of materials from landfill), which results in more C&D waste being sent to landfill. Having a consistent team on site working throughout the project stages can have a more positive impact on material recovery. This was demonstrated at Site One where the organisation employees the carpenters directly, therefore they felt greater ownership of the project and outcomes.

Figure 4.16: Site Three timber waste generation.

End of life options

This study investigated the timber waste generation from three construction projects. These projects were intentionally chosen to be outside of the Auckland region as within Auckland the scale of the construction sector is much greater and there is access to industry that have readily available options for timber waste recovery, including C&D specific resource recovery facilities (Green Gorilla) and markets for treated timber (Golden Bay Cement for biofuel).

The sites included in this study cover the recovery options available in Christchurch and Wellington only. Currently within Christchurch there is a waste and resource recovery contractor who can recover all untreated and H1.2 treated timber (where feasible). All mixed and timber skips are put through a sort line and the untreated and H1.2 timber that is recovered is then chipped and sold on to a landscaping supplier that uses the material for landscaping and a biofuel source. All other treated timber is sent to Kate Valley landfill.

Within Wellington there are currently no readily available recovery markets for timber from construction. All timber waste from Site Two which was not retained for reuse was sent directly to landfill.

4.2 Deconstruction

The study has identified the following during the deconstruction review stage:

- Often the deconstruction reports and registers would itemise objects e.g. doors or cabinetry without any of the following details:
  - Mass or volume of the object.
  - Material(s) of the object.
  - Quality of the object.
  - Material joining methods used noting reverse joining methods allow for easier deconstruction and disassembly of materials.
- Inconsistent reporting with some objects or materials recorded, however materials which typically are at end-of-life stage and destined for landfill are not recorded. These often include elements of a building which are unrecoverable e.g. carpet tiles which have been glued to the surface, light fittings which are damaged.
- Inconsistent reporting of final destination of an object or material with lack of following through the material chain. *Has the object or material ended up at the desired destination?*
- Due to the detailed classification of the timber types developed for this research (detailed in Section 2.1), and the deconstruction data received lacking detail on materials of objects or elements of the building, it became extremely difficult to align any of the deconstruction elements to the categories developed for this study. If the study were to try to categorise elements which we knew were timber, many assumptions would have been made which would have impacted the validity of the data presented.

Due to the reasons detailed above this study has been unable to undertake a quantitative analysis of timber waste coming from deconstruction activities.

4.3 Carpenters focus group

The focus group was facilitated as a semi-structured interview with a group of four carpenters ranging in experience, all from the same organisation, based at Site One. The focus group session was spilt into three main elements as detailed in 3.2. The findings from the conversations are detailed below:

Timber material management in construction

The group collectively agreed that framing timber and formwork is often the most wasteful timber element on construction projects. One of the main reasons being the minimum required lengths to be used, so if off-cuts are generated it is unlikely that they can be reused.

When asked what timber material management methods the participants actively see take place in the industry many responses were in relation to how the material is managed when on site, rather than earlier on in the design lifecycle process. This is maybe due to the fact the participants are site based and would only have visibility of timber management whilst on site rather than at design and planning stage. Typical timber management methods discussed include using off-cuts for nogs, reuse on other sites (formwork), stockpiling areas for materials, donation to community groups / the public or use as firewood. Further conversation revealed that behaviours regarding management of materials in general is highly influenced by the attitudes and behaviours of the Site Manager and Foreman. One participant detailed that when they first started as a labourer, they learnt from the carpentry team what pieces of off-cuts would be useful to keep.

“oh, I’ll chuck it away. They're like, no, it's the size of your forearm that's a keepable piece.”

The participants had mixed responses in relation to changes in timber management practices over time. When discussing the reuse of timber elements on site respondents noted that this was out of the ordinary. It was noted that commercial sites look for reuse opportunities at the start of the project, but by the end, when there are less opportunities to use off-cuts etc, this shifts to disposal. One opinion which was shared by those who had been working in the industry over 10 years was that the quality of timber has declined since they started. This results in materials getting damaged more easily, resulting in greater waste.

The value of timber was recognised by the participants, as they discussed the manufacturing processes and steps involved in how the timber they use on site arrives in the desired product required. It was discussed that the participants are aware of the value as they work with the material and have been educated on the value (cost of the material, required processing to get from raw material to building component etc), however, others on site who do not work specifically with one material tend to have less respect for the value of these materials.

“I've stacked logs on a corner and then watch labourers pick them all up thinking they were just rubbish.”

There is an opportunity for greater communication and education of the value of materials across all roles in the construction sector to stress the importance of sustainable decision making.

Timber material management in deconstruction/demolition

The participants discussed that the main drivers for deconstruction of a build or certain elements of a building include heritage, recovery of native timber / undamaged materials or for personal gain (individuals taking home a material of interest). There was a general opinion that deconstruction is not an enjoyable task as you are working with older materials and more menial tasks are required such as de-nailing timber.

End of life options for timber

Similar to the discussion around deconstruction, recovery at the end of life of timber on construction projects goes back to the drivers of the individual and those running the project. People will often salvage what they can if the timber is of interest or the Site Manager / Foreman will leave a pile of the *"good stuff for the boys to take"*. Where there is a reuse, recycle mentality on site, such as at Site One where the interview took place if the site team do not want the material the Site Manager or Foreman will arrange for community groups or individuals who have approved the project to collect the materials. This was a common occurrence for timber pallets at Site One.

When the discussion transitioned to awareness of how timber waste is managed in New Zealand the group were aware that their site sends the timber for recovery, although they were not 100% sure which timber groups could be recovered. Although they noted the most common option for timber is landfill. One participant discussed how the waste was no longer their issue when it leaves site so *"it's not like we're thinking about it every time it leaves the site."*

There were strong opinions regarding the lack of equity of recovery services available across New Zealand and mention of a *"North Island and South Island divide"*, although services in Auckland (recovery and biofuel) were the only North Island options mentioned.

> *"What I think would be great is for there to be a way to recycle treated timber in the South Island. I know that in the North Island they burn it at Golden Bay cement. But if there was a way to kind of chip it up and turn it into a structural MDF board or chipboard that could be used in buildings. Like that could be cool."*

The conversation continued with individuals stating the international opinion of New Zealand compared to the reality is very different (referring to emissions and wastefulness).

> *"It's how much people are willing to invest towards it (waste recovery services), and for a country that prides itself on being green, you know, how much investment are we putting back into it."*

The focus group session with the carpenters at Site One provided context to why certain stages of a project are more wasteful than others and, aligned with the quantitative data collected. Therefore, the conversations were of great value to this research study.

A full breakdown of the thematic coding from the carpenter's focus group is detailed in Appendix E.

5 Challenges and opportunities

As part of this research the project team have identified several challenges. If these challenges were able to be addressed during the data collection stage of the project these have been detailed as ‘opportunities sought’. However, where these challenges were unable to be addressed during the project or where further opportunities could be pursued these have been detailed as ‘recommendations’. These have been detailed in Table 5.1.

Table 5.1: The challenges, opportunities and recommendations.

Reference	Challenges *Faced/identified during the project*	Opportunities sought *Implemented during the project*	Recommendations *For future investigations*
1	Finding projects willing to allow the data collection to take place.	T+T used this as an opportunity to educate the site team on the importance of the research. We actively engaged the site team to assist us in collecting the data and would undertake site visits to ensure the partners were aware that we were engaged in the project and could provide support as required.	Begin conversations with potential partners as early as possible and have a clearly defined list of requirements for the projects to be within scope of the research. It would also help to set expectations for the organisation’s responsibility early on.
2	Challenges of data granularity and comparing deconstruction datasets due to the various methods of data collection used across the sector.	As part of the methodology guidance created in this project Section 6 covers ‘considerations for collecting deconstruction data’. This is to act as a guide for those undertaking deconstruction data collection to encourage consistency across the sector.	There are further opportunities to develop the methodology document including producing supporting documents e.g. checklists and templates for deconstruction data collection to ensure consistency across the sector.
3	Challenges of visual data capture with limited time to capture waste data before it needs to be taken off site due to space limitations.	As part of this study, we decided to include a requirement for data capture to take place at four defined stages of skip fullness (25%, 50%, 75% and 100%) to ensure the project could capture the maximum amount of data without having to undertake sort and weigh audits on each load.	If possible, it would be beneficial to set up a static camera to capture visual data of the skip as it fills in real time (photo taken every 15 minutes during work hours). This would allow for more accurate data classification through capturing each item placed in the waste container.

Reference	Challenges *Faced/identified during the project*	Opportunities sought *Implemented during the project*	Recommendations *For future investigations*
4	There is a lack of recovery options for timber waste, in particular treated timber from the C&D sector, with the majority being sent to landfill.	Discussions took place with waste and resource recovery organisations who have a process in place for recovering H1.2 treated timber. However, it was noted that it is reliant on a consistent feedstock of material before connections to a market can be established.	Further research should be undertaken regarding the options for processing treated timber within New Zealand to decrease the quantities going to landfill.
5	Lack of accessibility to data.	No opportunities were able to be implemented during the project.	Investigate the feasibility of a publicly available database so that C&D waste data can be readily accessible.
6	Due to time limitations the study was unable to conduct sort and weigh audits throughout all project stages.	No opportunities were able to be implemented during the project.	Undertake at least one sort and weigh audit for each project stage. This would have allowed for a greater review of quality for the timber types and to assess the confidence interval for the project as a whole.
7	During review of the visual data we recognised that when converting the visual estimates (%) to a m^3 value that the full skip would not be utilised due to the shapes and cuts of timber in the skips.	For Site One a void space of 1.5 m^3 was applied as standard across all 100% full 9 m^3 skips to allow for the inevitable gaps between timber waste in the skip. This assumption was verified with the Site Manager.	Before analysing visual data assign a standard void space value. Alternatively, a study could be completed before the first waste container is removed from site to assess the actual void space. However, this would be a timely exercise measuring all timber waste before it is placed in the waste container.
8	Where projects have multiple subcontractors working for a short period on a project there is less commitment to waste reduction and site processes.	No opportunities were able to be implemented during the project.	Including information in the inductions regarding site processes and holding subcontractors to account for their actions. Noting this can be difficult on projects where there are multiple trades.
9	This project only included three sites for construction data collection. The data found in this study may not be representative of timber waste generation across New Zealand.	No opportunities were able to be implemented during the project.	Expand this current study to include more construction sites, increasing the dataset to get a better understanding timber waste from other construction types.

Reference	Challenges *Faced/identified during the project*	Opportunities sought *Implemented during the project*	Recommendations *For future investigations*
10	Subjectivity of visual and sort & weigh surveys challenging the consistency and identification of timber types and treatment.	Prior to the data collection taking place T+T provided training and guidance documents to brief the personnel entering the data for the project stages, timber classifications and what materials from their respective project fell into each category. During the visual data collection we used the same personnel for data collection to provide consistency to the data. T+T also reviewed each visual data entry to ensure the classifications were representative of the defined timber classifications.	Preparing training and guidance material to support the site-based team collecting the data. Regular site visits to check in on the data collection process.

6 Conclusion

This study has identified the scale of the issue of timber waste entering landfills from the C&D sector within New Zealand, including the composition and project stages which contribute to this issue. Due to the scale of the study including only three construction projects it has not been large enough to be able to provide an updated figure for the percentage of timber which is sent to landfill nationally. This study has however identified the following findings:

- Within the study area of Christchurch which is where Site One and Site Three were based untreated timber is being chipped and put into garden products e.g. mulch. Due to the lack of commercial options for recovery of treated timber within the southern half of the North Island and South Island of New Zealand all timber tends to be grouped into one waste container for disposal, often to landfill.
- Due to the site team's involved in this study's poor experience with the quality of untreated timber (often warped), their construction organisations will often specify H1.2 as a more reliable source where it is not required e.g. temporary boxing for foundations. As a result, this generated more treated timber as offcuts and damaged from the sites in this study. It is assumed this is common practice across the industry.
- Treated sawn timber (non-native) was the most wasted timber category found during the construction element of this study. With treated timber being the largest portion of waste altogether at >80%.
- Framing which includes wall, mid-floor and roof framing were the most wasteful stages of construction for all three projects averaging 45% of the total waste composition. This finding was echoed by the carpenter focus group with all respondents agreeing framing, even when prefabricated, was a very wasteful activity.
- Across all three projects >95% of the timber waste recorded was an off-cut or like new pieces. Noting the practices which each site took towards waste management it is viewed that the off-cuts were pieces of timber which could (a) no longer be used on the project or (b) would not be of use to another project within the organisation. The images taken from the visual data capture however does demonstrate the timber was still in a usable quality.
- There are significant challenges of data granularity in deconstruction data across New Zealand which resulted in this study being unable to compare deconstruction datasets in line with the methodology developed. One of the greatest opportunities from this study is to work as a sector to further develop a consistent method and approach to collecting deconstruction data.
- Within residential construction projects considered in this study, the architecturally designed build generated more waste than the ready-to-build project. Due to the nature of ready-to-build construction, efficiencies are easier to implement, reducing the total waste generation. It could also be assumed that this is the case with commercial buildings, although due to the nature of commercial construction, these are more likely to be unique builds.

7 Applicability Statement

This report has been prepared for the exclusive use of our client BRANZ, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

8 Acknowledgments

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9 Declaration of conflicting interests

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Appendix A LCA datasheet – Construction (Module A5)

Table Appendix A.1 : Updates recommended for timber elements of BRANZ Construction Site Waste Datasheet (Module A5)

Main material	CBI Code	Work Section	Main material	Construction site waste (% by mass over mass in building)	Typical (current)					Future (potential)				
					Fate of building waste (% material by mass)				Recycling Route/technology	Fate of building waste (% material by mass)				Recycling Route/technology
				Typical	Reuse	Recycling	Recovery (Energy)	Landfill / Cleanfill		Reuse	Recycling	Recovery (Energy)	Landfill / Cleanfill	
Sawn non-native (untreated)	-	-	-	10	10%	15%	0%	75%	Pieces cut for other functions.	-	-	-	-	-
Sawn non-native (treated)	-	-	-	10	5%	5%	0%	90%	Pieces cut for other functions.	-	-	-	-	-
Native timber (untreated)	-	-	-	10	10%	5%	0%	75%	Pieces cut for other functions.	-	-	-	-	-
Prefabricated (treated)	-	-	-	5	0%	10%	0%	90%	Pieces cut for other functions.	-	-	-	-	-
Engineered product (untreated)	-	-	-	5	0%	10%	0%	90%	Pieces cut for other functions.	-	-	-	-	-
Engineered product (treated)	-	-	-	5	0%	10%	0%	90%	Pieces cut for other functions.	-	-	-	-	-
Pallet (untreated)	-	-	-	5	5%	5%	0%	90%	Pieces cut for other functions.	-	-	-	-	-

Appendix B LCA data sheet – Deconstruction (Module C1)

Review of the data in this research project was unable to provide data to update BRANZ Module C1 Building end of Life Waste Datasheet

Appendix C Raw datasheet

Table Appendix C.1 : Site One timber waste profile by stage (kg)

	Foundation	Wall framing	Midfloor framing	Roof framing	Cavity and cladding	Internal wall linings	Internal finishing and trim	Fit out
Untreated Sawn (Non-native)	31.1	440.2	324.7	0.0	0.0	27.8	9.3	18.5
Native timber (Untreated)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Treated Sawn (non-native)	1026.7	3163.4	1447.2	1226.3	1389.6	4678.6	2317.8	0.0
Prefabricated (precoated element)	220.2	1603.7	0.0	0.0	0.0	222.3	889.0	0.0
Engineered Product (treated)	0.0	698.5	1102.9	763.8	198.8	1124.6	368.6	280.9
Engineered product (untreated)	375.8	1687.2	195.4	0.0	69.5	387.8	111.1	666.8
Pallets	20.0	1605.6	450.0	150.0	1263.9	724.5	157.4	18.5

Table Appendix C.2 : Site Two timber waste profile by stage (kg)

	Foundation	Wall framing	Midfloor framing	Roof framing	Cavity and cladding	Roof cladding	Internal wall linings	Internal finishing and trim	Fit out
Untreated Sawn (Non-native)	0.0	11.6	34.9	0.0	0.0	0.0	23.5	0	0
Native timber (Untreated)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
Treated Sawn (non-native)	74.4	148.8	148.8	148.8	148.8	74.4	47.0	11.75	0
Prefabricated (precoated element)	0.0	0.0	0.0	0.0	93.0	0.0	29.4	17.625	11.75
Engineered Product (treated)	0.0	46.5	0.0	0.0	0.0	0.0	35.3	21.15	14.1
Engineered product (untreated)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	23.5
Pallets	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0

Table Appendix C.3 : Site Three timber waste profile by stage (kg)

	Foundation	Wall framing	Midfloor framing	Roof framing	Cavity and cladding	Roof cladding	Internal wall linings	Internal finishing and trim	Fit out
Untreated Sawn (Non-native)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
Native timber (Untreated)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
Treated Sawn (non-native)	0.0	45.0	0.0	67.5	67.5	0.0	0.0	0	0
Prefabricated (precoated element)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15	0
Engineered Product (treated)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
Engineered product (untreated)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
Pallets	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0

Appendix D Regression analysis

To understand how accurate the visual assessments of the skips were, eight skips of timber waste were selected to be included in sort and weigh audits. Using the data collected from the sort and weigh and comparing this to the visual data collected of the same skips a least squares linear regression was used to understand the relationship between data. The analysis gave a R^2 value of 0.641, meaning that approximately 64% of the variance in the visual data (dependant variable) can be explained by the sort and weigh data (independent variable). The p-value is 0.006 for the relationship between visual and sort and weigh data. This means, as the p-value is less than 0.05, there is a statistically significant relationship between the visual and sort and weight data. This gives some confidence in that the visual data is representative of the actual weights of the skips.

The least square linear regression statistical test established that there is a statistically significant relationship between the sort and weigh, and visual data. To further understand this relationship, confidence intervals and predication intervals have been calculated. Figure Appendix D.1 shows the relationship between the visual and sort and weigh data. There is a positive linear relationship between the sort and weigh and visual data. The confidence and prediction intervals are shown in Figure Appendix D.1. The confidence interval shows 95% of the timber data mean will fall between in the two orange lines. The prediction interval which is demonstrated by the red lines on the figure show 95% chance of the next observation falling within these lines.

The predictive interval has a polynomial fit with a 95% chance of new values varying between 19.76% and 21.19% from the mean. The confidence interval also has a polynomial fit with a 95% chance of the mean varying between 2.62% and 8.08%. This shows that where materials have a greater percentage of the composition, the confidence in the accuracy of the material composition decreases.

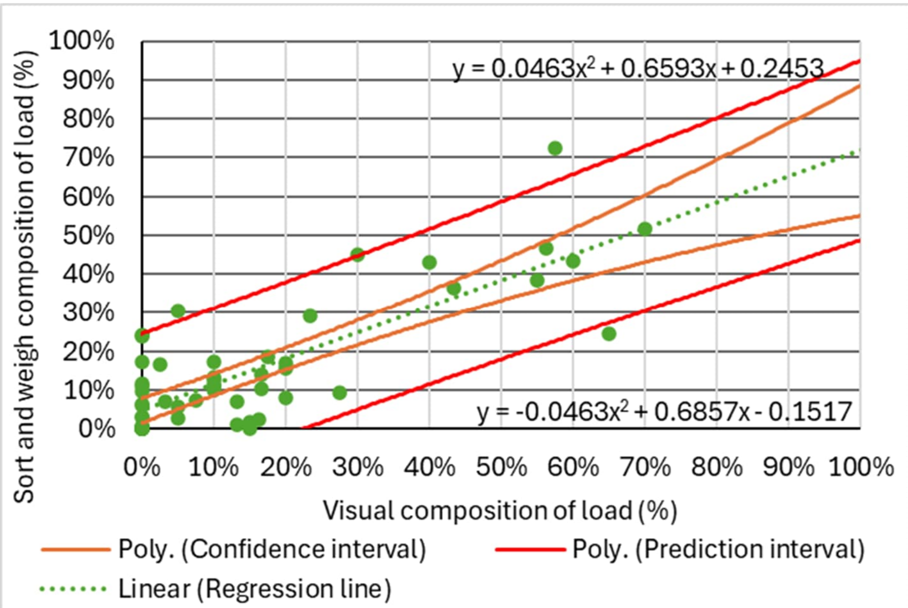

Figure Appendix D.1: A scatter plot comparing visual and sort & weigh data for Site One.

Appendix E Carpenters focus group thematic coding

Appendix E Table 1: Carpenters focus group

Question	Response overview	Mentions	Commentary
Timber material management in construction			
From your perspective and experience what timber types are most wasted in construction?	Framing timber	4	Framing timber had the highest response among focus group participants. All agreeing that this was the most wasted timber type in construction. Formwork was mentioned three times.
	Engineered timber - e.g., LVL	1	
	Formwork	3	
	Weatherboards	1	
	Packaging timber	1	
	Packaging material - e.g., dunnage	1	
	None	1	
From your perspective and experience what stages of construction does most timber waste come from?	Framing	2	One participant commented, "I don't think there's one stage that's worse than the rest."
What timber material management methods have you witnessed / been instructed to undertake?	Using leftovers/off-cuts for dwangs or nogs	2	The data suggests that residential construction has greater capacity and will/culture for reuse of materials. This can be dependent on time, however. If time poor, reuse may not be prioritised. In commercial construction, there is less capacity for reuse as buildings generally more bespoke. One participant commented, "When I first started my time as a labourer, it was about learning what pieces carpenters thought were useful. So I was just like, oh, chuck it away. They're like, No, it's the size of your forearm that's a keepable piece."
	Depends on space	2	
	Firewood	2	
	Reusing on other sites	3	
	If timing is tight, dispose	2	
	Depends what else is happening on the job	2	
	Stockpile on site	2	
	Dispose if unusable	1	
	Try to donate	1	

Question	Response overview	Mentions	Commentary
	Take it to the next job (if residential)	2	
Would you say when you started out that this was similar practice, or have you seen a change?	Yes	2	Respondent also noted that this was out of the ordinary. And it was also noted that commercialised sites look for reuse opportunities at the start of the project, but by the end, when there are less opportunities to use off-cuts etc., this shifts to disposal. One participant commented, "Well actually I'm the opposite, at my very first job was with an old guy who was really old school we made all of our own frames as well in residential, which is a bit different now. He was the same he was like, keep everything that's a usable length for like nogging and stuff."
	No	2	
What do you think has driven that change?	Cost increases *for construction as a whole*	4	Noting the mixed views above on reuse onsite, it could be assumed that both cost and onsite personalities have an impact on reuse of materials.
	Timber prices	3	
What do you think about our use (New Zealand's use) of timber in construction?	Improved	2	General and genuine acknowledgement of wastage within the industry. A sense of a lack of alternatives in situations where time and space are key pressures. One participant commented, "Its improved, its definitely improved. I think people realize how much money that has been wasted. I think that's the thing. That's also people are understanding the management of plans now too, so they plan it better."
	Design specifications	1	
	Influence by other factors, e.g., time and space	3	
	Increased understanding/awareness	1	
Have you seen an increase in a deterioration of the quality (of timber)?	Yes	4	Consensus across the group that timber quality has declined.
Any other influencing factors to what's creating waste on site?	Knowledge/intelligence	3	There was an interesting discussion re: labourers on site who often dispose of new materials as waste. Opportunity for education?
	Mistakes	1	
	Over ordering	2	

Question	Response overview	Mentions	Commentary
Even like further outside of say, your control is carpenters.	Supplier fault	1	Over-ordering was also spoken about, generally to provide for contingency as opposed to my mistake.
	Poor design	1	
Timber material management in deconstruction			
If you have worked on deconstruction projects (these include traditional demolition projects) what timber material management methods have you witnessed / been instructed to undertake?	Remove nails/screws	3	Removal of nails was the most discussed theme, however there were comments regarding the length of time it takes to deconstruct elements of builds which makes the job longer and less exciting.
	Disposal	1	
What do you think the drivers are for these methods?	Heritage	1	Good discussion around deconstruction vs. demolition, noting that deconstruction is more time consuming and costly, and often materials are damaged and unusable. Quality of material and individuals wanting to take specific materials for themselves are key drivers.
	Quality of material, e.g., native timber	1	
	Materials are damaged	4	
	Not charging the client for deconstruction	1	
End of life options / opportunities			
What is the most common end of life option for timber waste on sites you have worked on?	Disposal	1	Participants noted a range of end-of-life pathways for timber waste and other types of waste including mirrors (stolen), furniture (taken home). Interesting comment re: employers not minding because it saves them money on tipping.
	Take home	4	
	Firewood	3	
	Give to someone	1	
	Stolen	1	
	Stockpile on site	1	
What infrastructure and/or initiatives (that you are aware of) are available in your region to support extending timber life or recovery of timber?	Reuse on site	2	Interesting commentary re: inmates at the prison being keen to reuse materials on site for their horticultural activities. Donations were to kindergartens (offsite) and prisons (onsite). Potential opportunity to have a 'Free to Take' pile?
	Donate onsite	1	
	Donate offsite	1	
	Requests	3	

Question	Response overview	Mentions	Commentary
			One participant commented, "Most people actually come to us asking for stuff."
Does your organisation have any practices implemented (or pending) which will prolong the life of timber in the construction sector?	Opportunity for South Island to have same programs the North Island has.	1	A North/South divide was noted in access to recycling programs. There was a view in the room that in cases where there were practices to prolong the life of materials, these were through to be extreme, that people doing these things were the exception, not the norm. One participant commented, "What I think would be great is for there to be a way to recycle treated timber in the South Island. I know that in the North Island they burn it at Golden Bay cement. But if there was a way to kind of chip it up and turn it into a structural MDF board or chipboard that could be used in buildings. Like that could be cool."
	Precise design	1	
	Don't know	1	
What are the challenges/barriers that limit timber extending its life? Please be specific with types of timber and the individual challenges.	Cost too high	1	One participant commented, "So it really comes down to who's running the job, sometimes you see a lot more good practices on one site than another."
	Depends on onsite management	3	
When the timbers leaving site in the skip, do you actually know where it's going? What what's happening to it?	There's no treated timber recycling	1	It was noted here that attitude has much to do with recycling and what happens on site, as well as held beliefs. Also, end-of-life for timbers once in the skip doesn't seem like a consideration as primary work is of higher importance. One participant commented, "I never bother to ask the question. We're interested to know but it's not like we're thinking about it every time it leaves the site."
	No	1	
	Haven't asked	1	
	Haven't considered	1	
What other timber products would you say are also	Contamination	1	Note that the North Island vs South Island issues arose again in this question. There was also a discussion around sawdust and how this can be reused or sent to piggeries.
	Mould	1	
	Chipping	1	

Question	Response overview	Mentions	Commentary
challenging, in terms of reuse or extending the life of?	Sawdust	1	One participant commented, "It's how much people are willing to invest towards it, and for a country that prides itself on being green, you know, how much investment are we putting back into it."
	Lack of investment	2	
	Opportunity for South Island to have same programs the North Island has.	1	
Final review			
At which stage in a construction project do you see the biggest opportunity for reducing timber waste?	Design	4	Agreement between the group on design and planning, with an emphasis on design.
	Planning	4	
At which stage in a deconstruction/demolition project do you see the biggest opportunity for reducing timber waste?	Whole time	1	
	Beginning	2	
	Joinery	1	
At which stage in a project do you see the biggest opportunity for extending end of life for timber?	Onsite	1	
	After framing	1	
	During framing	1	
Which timber materials are the biggest issues / areas of concern?	Treated timber		
	Chipboard		

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