ARCHITECTURAL DESIGN MANAGEMENT IN WELLINGTON

ATTITUDES AND BEHAVIOURS OF ARCHITECTS TOWARDS CONSTRUCTION WASTE

BY

TANVI BHAGWAT

A thesis
submitted to the Victoria University of Wellington
in fulfilment of the requirements for the degree of
Master of Building Science

Victoria University of Wellington
(2019)

Architectural Design Management in Wellington

Attitudes and Behaviours of Architects Towards Construction Waste

Tanvi Bhagwat
300362221
BILD591

Table of Contents

List of Figures

List of Tables

Acknowledgements

This thesis was made possible by the joint effort of several individuals who have helped me along the way to completion. I owe the biggest share of thanks to Dr Nigel Isaacs, my supervisor, who was always willing to listen to my ideas no matter how far they deviated from the topic. His constant attention to detail has resulted in this study being as meticulous as it is.

Dr Vincente Gonzalez and the work of his students at Auckland University were also very strong motivators for this study. His inputs on the subject of construction and design management, and his experiences of working with the New Zealand industry are invaluable.

Mr. Roman Jacques and his work in the field of construction waste were both a major guidance for this thesis to take the form it did. His support during the process of this study is highly appreciated.

Victoria University has been a second home through this process. Its library facilities provided ease of access to essential literature from New Zealand as well as the rest of the world. IT staff were also very kind and patient when approached for queries on software. For the university's investment of time and effort in each student, I am very grateful.

My last note of gratitude goes to my parents, who listened to all my ranting and raving with nothing but love and support; to my friends who were often asked to read my work with a critical eye and did so without complaint. They kept me going in my times of doubt and were always encouraging.

I dedicate this thesis to the large body of researchers in the field of lean construction and design management, who have constantly been building on each other's work and have been labouring relentlessly towards improving industry standards since the 1980s.

Abstract

Previous New Zealand waste management studies have focused on the waste generated from construction activities. However, international research suggests about a third of the overall waste generated originates in the design phase. Internationally lean design management claims to reduce the waste produced by inefficient design practices. In New Zealand the literature reveals that the application of lean principles is still in a fledgling state, and even where they are used, waste minimization is not a business priority. This leads to the question: can lean design management be used by construction projects in New Zealand to reduce waste in the design phase? This paper investigates the attitudes, experiences and expectations towards construction waste minimization of a selection of architects using a semi-structured questionnaire. It was found that Wellington-based architects can be broadly classified into 3 categories of lean awareness—high, medium, and low. The medium group, largest in number, comprised architects who identified waste as a problem, but cited post-construction recycling and reuse as their preferred approach to waste minimization. This group notably had 20-25 years of experience in the industry, and related material reuse to residential construction only.

Keywords: lean design, architectural management, waste minimisation

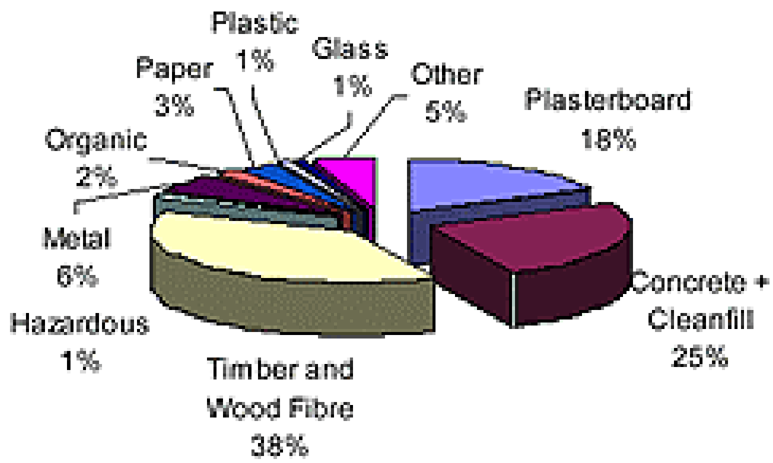

Figure 1: *Typical composition of waste sent to a NZ landfill site shows that timber, concrete, and plasterboard are the major waste products.* ***Source:*** *(Inglis, 2007)*

Chapter 1:
Introduction

> *Dearest multiple gods that have swarmed in from the sky, land, sea.*
> *On the seat you left, I sit like a garbage god, and do you or don't you know*
> *that I wait for the green truck heading to the landfill like the dearest dirtiest loftiest god*
> *who has long endured till now because of its hunger for humans?*
>
> *- Kim Hyesoon, "All the Garbage of the World, Unite!"*

An estimated 50% of New Zealand's total waste output comes from construction and demolition sites (Inglis, 2007). 17-19% of material products—including packaging—that are ordered to a typical building site in New Zealand are expected to be disposed of as landfill (Storey, 2008). Over the years, several attempts have been made by the New Zealand building industry to deal with construction waste. Most were focused on "end of the pipe" reuse or recycling of leftover material off-cuts (Rose, 1999; Burns, 2001; Hanne & Boyle, 2001; Jaques et al., 2001). It is, however, noteworthy that these measures were confined to on-site sorting, volume monitoring, staff education, and ultimately recycling of material.

Figure 1 shows the typical composition of waste sent to a NZ landfill site, with timber being the largest contributor at 38%. John and Buchanan (2013) reported that in New Zealand, treated timber will continue to be directed to landfill for at least the next 15 years because of the lack of technology and economic benefits to reuse or recycle it.

On the legislative front, the Waste Minimisation Act of 2008 made provisions to levy a tax on the amount of waste sent to landfill by weight. It may be said that it is cheaper to dispose of waste to landfill sites than to recycle it (Rose, 1999). Particularly on commercial projects, if the profit far outweighs the penalties there are no apparent incentives to recycling construction waste.

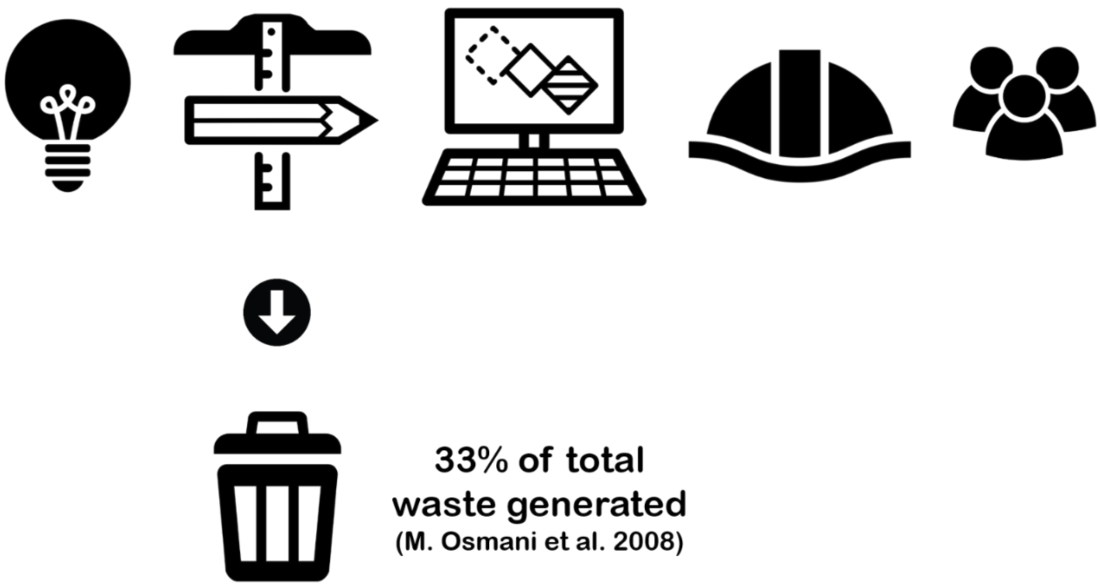

Figure 2: *A third of the C&D waste of a project rises from design ineffeciencies.*
Source: *Author's image.*

The focus must then shift towards waste reduction. Research suggests that up to a third of the waste generated throughout a construction project originates in the design phase (Osmani et al., 2008; Liu et al., 2011). As **Figure 2** portrays, from project initiation to end use, the design stage has been recorded to produce a third of the total C&D waste on a project. This is a significant figure and raises the question: what strategies could be implemented in the design phase to minimize construction waste? One possible option is "Lean Production".

Studies have reported that the application of architectural design management could potentially reduce waste, and afford improvements to time, cost, quality and value for the client (Jacomit & Granja, 2011; Pasquire & Salvatierra-Garrido, 2011). But the measure of its implementation and success in New Zealand architectural practices is yet unknown.

1 Scope of Work

This thesis investigates Wellington architects' familiarity with the concept of design management in construction projects, and its application to prevent waste generation.

Osmani et al. (2008) stated that from a design perspective, any activities or resources that can be eliminated from the process without diminishing value for the client are considered waste. Other studies found that decisions taken in the design stage strongly reflect on the quality of the building in the construction stage (Mazlum & Pekeriçli, 2016). Design changes, complexity in designs, detailing errors, unclear specifications, and miscommunication are major sources of on-site waste that is created in the design phase. It was further revealed that ineffective design management accounted for inefficiencies in the design process (El. Reifi & Emmitt, 2013a). A detailed discussion of these studies is presented in **CHAPTER 2**.

Similar research in New Zealand reported architects' beliefs that the focus of the design process does not lie in waste minimization, and that material waste is mainly generated due to inefficient work on construction sites. Overall, it found that architects' view of the design process was doing "what the client wants" rather than establishing a dialogue between the two parties. This was despite some responses pointing out that clients were largely unaware of the nuances of the design and construction processes (Jaques, 1999).

Since these findings, no new research on the topic of waste minimisation **in the design phase** has been published in New Zealand. It is then well within reason to hypothesize that architects' attitudes towards construction waste minimisation have greatly changed over the last two decades. This hypothesis is held on the following assumptions--

1. The Jaques (1999) study report may have positively informed a significant portion of the construction industry, which in turn may have brought a change in the way designs are produced.
2. The creation of the New Zealand Green Building Council in 2005, and its enthusiastic promotion of waste minimisation, may have bridged the gap between action and inaction.

The aim of this thesis was to explore if lean design management can be used by construction projects in New Zealand to reduce waste in the design phase. The method chosen to do this is to investigate current practices and attitudes of the NZ architectural and design industry towards waste minimisation. Specifically, interviews with industry professionals were designed to examine aspects of client briefing, information flows, iteration in design, and architectural competency. Because research was constrained to be completed within 12 months' time, the focus was on architectural firms based in the city of Wellington. The criteria for selecting participants are detailed in **CHAPTER 3**.

Because of their focus on the construction phase of projects, previous New Zealand studies in waste minimization have only collected responses from contractors and subcontractors. While their inputs often impact the design of a project, studying their attitudes towards waste management in design is outside the scope of this study.

2 Research Questions

The primary purpose of this study was to understand architects' attitudes to waste minimization in the design phase. Because of earlier studies claiming that architectural design management strategies would aid the process of waste reduction, the research question can be summarised as

> *Can lean design management be used by construction projects in New Zealand to reduce waste in the design phase?*

To answer this question, it was important to answer the following questions—

1. *What is architectural design management?*
2. *How has it been implemented by architectural practices in other parts of the world?*
3. *What design management approaches have architectural teams implemented in New Zealand?*
4. *How do these management approaches reflect the attitudes of architects to waste minimization?*

Questions 1 and 2 were answered by conducting an extensive literature review on architectural design management, and attitudes towards waste in the construction industry. The process and findings of this review have been reported in **Chapter 2**. Questions 3 and 4, however, remained largely unanswered, which made it necessary to design an analytical research methodology.

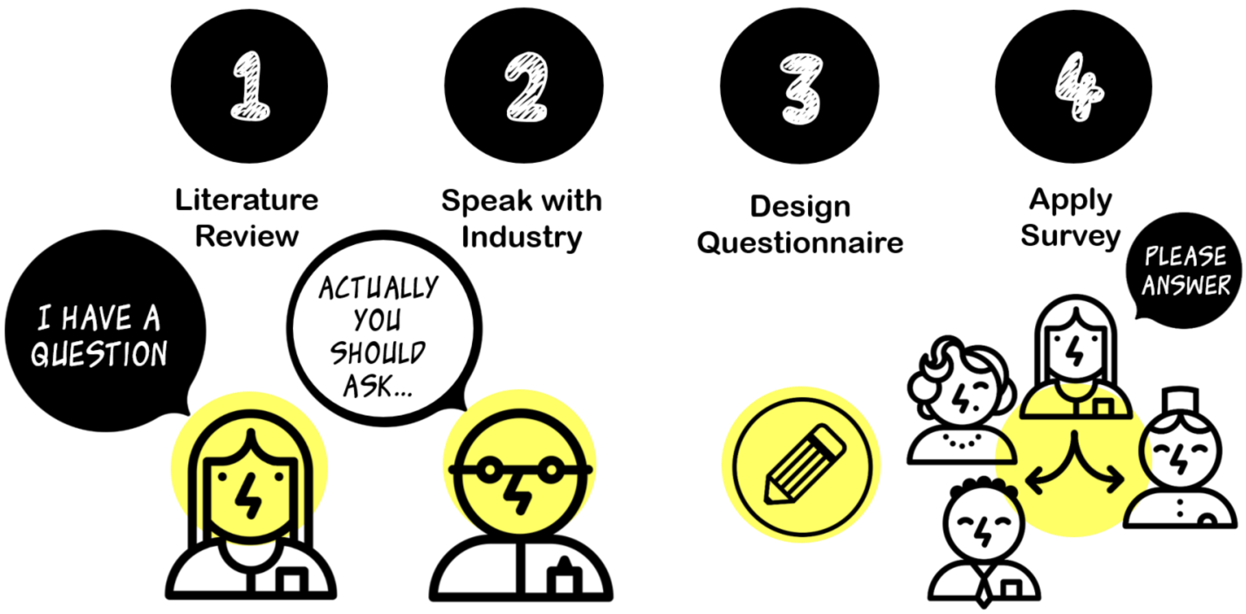

Figure 3: *Overview of the study.*
Source: *Author's image.*

3 Structure of the Report

Because of the investigative nature of the questions, this study took the support of semi-structured interviews conducted with industry professionals. The creation of the interview questions was carried out in 4 stages, as shown in **Figure 7**.

The first stage took support from the literature review to understand the attitudes of industry professionals towards construction waste in other parts of the world. From these readings, a list of design waste-related issues was identified. The second stage was to gain insight into design management from New Zealand researchers. They were asked about their experiences studying construction waste and architectural management in New Zealand. Their inputs helped refine the questionnaire and, to a degree, the direction of the study. **CHAPTER 3** details the core of the methodology—an interview designed to engage architects in a discussion of design management. Consequently the terminology of the interviews needed to be architectural, or at least recognizable by professionals in the New Zealand construction industry. Six questionnaire trials were conducted with members of academia and those with experience in research design. These trials informed the order of the questions and their phrasing. As Iarossi, (2006) stated, "Four criteria should be followed when wording any question: it must be brief, objective, simple, and specific."

The responses generated from these interviews were first recorded on an audio device, then transcribed for later analysis. A qualitative analysis was conducted with the help of NVivo 11 for Windows. **CHAPTER 4** reports the results of this study, providing conclusions from the analysis. It also makes suggestions for future research and provides recommendations for the New Zealand industry to improve their waste minimization strategies.

Each chapter ends with a set of conclusions drawn from the information presented, with **CHAPTER 5** presenting the overall results of this thesis and their limitations. A reflection on the research question is provided, and a comparison of literature with findings from the analysis is presented to create an overview of the entire study process. This report is brought to a close with a bibliography of cited works and an appendix containing various documents such as memoranda from the Victoria University Human Ethics Committee, correspondence with thesis participants, and the interview questions.

Chapter 2:
Literature Review

Chapter Overview

Because construction is a labour-intensive industry, the attitudes and behaviours of project participants are a presiding factor in waste generation (Begum et al., 2009). As understanding local architects' attitudes towards waste management and reduction was a primary intention of this thesis, an international literature was used to create a global picture for comparison. Osmani et al. (2008) found that from a design perspective, any activities or resources that can be eliminated from the process without diminishing value for the client are considered waste. Literature has estimated that about a third of the waste generated in the construction of a building can be traced back to the design phase of the project (Liu et al., 2011).

In order to answer the research questions, it was necessary to consider design management and its application in other parts of the world. To do so, this chapter examine the existing literature on the subject. It is an introduction to architectural design management, clarifying the meaning of the term and its association with the practice of waste minimization. In the course of research, lean design management emerged as a widely adopted solution to reduce waste created in the architectural design process (Deshpande et al., 2011; Emmitt, 2011; Kpamma & Adjei-Kumi, 2011; Tribelsky & Sacks, 2011). International studies, as well as New Zealand's efforts at adaptation and implementation of such an approach are also discussed here.

Although New Zealand research has maintained a primary focus on on-site waste sorting, in the past there has been **only one** study conducted on design and procurement approaches and how they reflect waste minimisation culture. Because of the nation's geographical location the rate of development of both ideology and technology in the construction industry has been at a relatively slower rate (Fuemana et al., 2013). The use of design management approaches in New Zealand to improve productivity and reduce waste has been noted; their successes and failures have also been reported. This chapter presents a summary of the same. The literature review was instrumental in informing the course of this study, particularly in the formulation of a methodology. Segueing into the next step, this chapter concludes with a summary of the aspects that were carried forward.

1 Systematic Review

From the outset it was clear that a large amount had been published on construction and design management, so a careful selection of relevant literature was important. To achieve this, a systematic review approach was adopted. Systematic reviews are common in the field of medicine, using an eligibility criteria to recognize and evaluate publications pertaining to the research question (Moher et al., 2015).

A search strategy was established based on Preferred Reporting Items for Systematic Reviews and Meta-Analyses[1] (PRISMA), which is a set of guidelines for conducting systematic research reviews. The primary source of literature was the Victoria University of Wellington library database, which yields results ranging from books, theses, journals, conference proceedings, and technical reports, to magazine articles and websites.

1.1 Search Strategy

At the beginning of the process, general websites were excluded from the search to maintain the reliability of results.

A search for electronic literature was conducted on construction and design management journals such as *Journal of Construction Engineering and Management*, *Architectural Engineering and Design Management*, *Construction Innovation*, *Waste Management*, *Architectural Management in the Digital Arena*, and *Engineering,*

[1] http://www.prisma-statement.org/Default.aspx

Construction and Architectural Management. Search terms such as “attitudes to waste”, “architects and waste”, “design management”, “construction waste management”, “waste management in New Zealand”, “waste reduction in design”, and “architectural management” were used. The recurring appearance of the terms “lean construction” and “lean design management” led to including searches of these phrases in conjunction with “waste management”. Authors of previous New Zealand studies were also contacted for their feedback on conducting research in the subject of construction waste management, and for advice on methodology. Of the many results, only studies published in English were selected.

Figure 4: *The process followed when conducting a systematic review, and the outcomes of the same.* ***Source:*** *Author's image.*

Additionally, conference papers from the Management in Construction Research Association (MiCRA) Postgraduate Conference, Association of Researchers in Construction Management (ARCOM) Conference, International Group for Lean Construction, and the WasteMINZ Conference were evaluated for their relevance.

When searching for New Zealand studies, technical reports constituted a large proportion of the search results. These were all published by the Building Research Association of New Zealand (BRANZ), which was considered as a credible source of research data.

Lastly, the search also produced books and theses on related subjects. These were included in the evaluation process, as represented in **Figure 4**.

1.2 Study Records

Zotero[2], a citation software, was used for information management. Extracted data from the searches was classified into four categories of "New Zealand", "Architectural Design Management", "Architects' and Waste", and "Lean Design Management".

The search strategy produced 102 results. The preliminary screening method was identification by title, followed by a further narrowing down by the relevance of their abstract. Next, the studies were grouped by applied methodology, which ranged from randomized controlled trials and comparative studies, to simulation and social media polls. The first independent round of screening was conducted by the author.

For the second round, the reason for selecting or rejecting the study was discussed the research supervisor. This process filtered the results down to 39. The bibliographies of these selected studies had multiple overlaps, from which a further 3 studies were added for review. At the end of this process, a total of 42 studies were used for the systematic review.

[2] https://www.zotero.org/

1.3 Eligibility Criteria

All New Zealand studies were selected for review. These were mainly conference proceedings and study reports. Magazine write-ups were eliminated as they did not cite sources for their information.

Of the studies on attitudes to waste, only those with randomized controlled trials were selected provided their sample sizes were larger than 40. Six studies reporting responses from post-design/construction stages were selected. These 6 studies included questions related to waste transference from design to later stages. Simulation studies were rejected firstly as they only dealt with material waste and secondly because they provided very little information on the software. The social media cases and workshop approaches were rejected because of the lack of reported sample definition.

A search on the term “construction waste management” often yielded results for studies on lean construction while “architectural design management” also found lean design management research. Because literature on these topics was largely theoretical, the selection was limited to only case studies reporting the adaptation impact of lean design management on live projects.

A lot of literature claimed that Building Information Modelling’s (BIM) capability to simulate construction waste before it is created, is useful in waste minimization. However, Domingo, Su, & Egbelakin (2015) reported that BIM is not a commonly used tool in the building industry of New Zealand. In practices where it is used, waste minimization is not the priority. Because of this report’s findings, studies related to BIM were excluded.

Of the books that were found in the search, 3 were selected for their direct relevance to the research question. These books covered subjects such as architectural management (Emmitt, 2014), design brief definition (Blyth & Worthington, 2002), and information exchange within the design team (Emmitt & Gorse, 2006).

2 Construction Industry Waste

A look into previous attempts at waste minimisation in New Zealand afforded cognizance of previous studies in the field. Rose (1999) highlighted that there are two aspects to waste production in construction— construction waste, which is leftover material waste on site; and construction industry waste, which causes the creation of construction waste. The study reflected on options for waste minimisation by introducing the concept of incentivised reuse and recycling for the industry. Higher landfill charges and an education regimen for construction industry practices were proposed.

While the Waste Minimisation Act of 2008 was an attempt at discouraging landfill dumping, its effectiveness is questionable, as discussed previously. Secondly, few efforts have been made at educating the industry of the environmental impact of construction waste. Initiatives such as Resource Efficiency in Building and Related Industries (REBRI) and Greenstar Building Rating Tool have been sincere efforts at promoting material efficiency on site.

REBRI is an online waste management guide that targets site foremen and workers by encouraging them to consider what they can do to minimise waste at construction sites. It suggests the matching of material sizes to room sizes to reduce cutting, and also calls for initiatives to segregate, measure, and repurpose inevitable material offcuts. Inglis (2007) tested the efficacy of REBRI on live construction sites by comparing the process costs of ordering, storing, and disposing excess materials on two distinct sites—one having implemented the REBRI waste management plan, and the other not. A 21% cost saving was reported on the REBRI site. This was made possible by the practice of source separation (Hanne & Boyle, 2001), wherein waste materials were to be stored in separate bins, and an observation of the same would be indicative of what could be reused, and what portion would have to be disposed. It was reported that under the REBRI management plan approximately 56% of the construction waste by weight was diverted from landfill, including timber, steel, cardboard and plasterboard.

Despite such a success, it was noted that the source segregation method would only be effective dependant on availability of space on site, support from the site management team, and co-operation from subcontractors.

While REBRI and source separation were easy to implement on smaller projects (Hanne & Boyle, 2001; Inglis, 2007) Greenstar is a step towards waste minimisation measures for large commercial projects. As the New Zealand equivalent of green building rating systems such as BREEAM and LEED, Greenstar facilitates the reuse of old building components on commercial, industrial, and educational projects, awarding points for the same ('Green Star v3', 2015). In 2007, Wellington City Council required all new office buildings had to achieve a minimum rating of 4 stars on the Greenstar rating scale (Storey, 2008). While this seems like a large step towards the positive, it is important to note that aiming for a Greenstar rating is an expensive process, with no existing research showing obvious benefits of such an extensive investment.

Despite these calls to reduce waste in the construction industry, the application of such strategies and their influence on waste generation remains unmeasured and their acceptance, questionable.

Table 1 summarises various attempts at studying waste minimisation in New Zealand. It is noteworthy that no new studies have been conducted on the subject in recent years, and therefore makes it important to look at international literature and the advances made in other countries on the subject of construction waste reduction.

Reference	*Discussion Topics*
(Rose, 1999)	• Unique projects call for unique waste management schemes • High staff turnover rates hinder training • Fragmented industry with no influencers
(Burns, 2001)	• Despite clear incentive, no waste reduction measures adapted • Recycling industry is under-utilised • Focus on commercial gains overpowers lack of action • No infrastructure exists for recycling waste materials
(Hanne & Boyle, 2001)	• Site separation affords 50% reduction of waste by volume • Separation is inexpensive, effective, low-risk and non-evasive applicable to all sites • Largely dependent on space availability, ease of access by workers and trucks
(Jaques et al., 2001)	• REBRI heavily promoted by trade and online media (e.g. BRANZ website) • Demonstration trials held in Wellington sites • Updated regularly to introduce recycling operators
(Inglis, 2007)	• REBRI easily applicable to all sites • Inclusion of waste management plan is necessary in contract documents • Major construction companies translate practices over to all their sites • Councils providing education through workshops can be influential
(Storey, 2008)	• Local government authorities responsible for running landfills, and government action aimed at prolonging lives of landfill sites • Waste minimisation voluntary, and no systems exist to meet targets of waste minimisation. Construction waste low on priority list

Table 1: *Summary of New Zealand literature on waste minimisation.*

2.1 Reuse and Recycling—Why Not?

The use of recycled or "green" materials and the effective reuse of old building components is one way of dealing with construction material waste. These are, at least in Singapore, known to cost significantly more than ordinary materials (Hwang & Tan, 2012). The use of these resources not only includes the procurement costs, but also consequent research and certification costs. It is then reasonable to believe that the implementation of such ecologically sustainable techniques on site results in additional expenses, which may discourage clients and contractors from their acceptance.

Construction waste also ultimately translates into a financial cost for clients (Kulatunga, et al., 2006). But in the context of New Zealand, material reuse and recycling is a more complex matter than a designer making a simple economic suggestion to a client. The New Zealand Building Code is internationally unique in that it assesses buildings on an additional code clause of durability. Structural and façade elements are required to have a life of at least 50 years (Ministry of Business, Innovation and Employment, 2017). A previously common design practice of alternative specification, or substitution of building products with those that "looked the same", experienced decline as a consequence of this regulation (Haberecht & Bennett, 1999). While the code clause may have improved building performance, the ripple effect has been that recycled materials are not specified because they are uncharted territory—the inherent properties of recycled materials are unknown to the designer, and often no current standards exist to test such products for strength, resistance to moisture, and durability.

Finally, in a scenario where a developer utilizes recycled building materials and building systems, the ultimate benefits of such construction practices are only experienced by the end-user of the scheme. Hwang & Tan (2012) opined that all other participants of a project have no final profit from sustainable practices, even though they have invested their time and money on it. So from a business financial perspective, there may be no merit in material reuse or recycling.

This finding leads to taking a step back from the problem of material waste, and looking at the aspect of project stakeholders' attitudes towards waste minimisation.

Country	*Paper*	*Methodology*	*Respondents*	*Findings*
Sri Lanka	(Kulatunga et al., 2006)	Survey	Estimators	• Profits and overheads highest priority, waste is lowest. • Actual waste is always much greater than waste allowance.
UK	(Osmani et al., 2008)	Survey by Likert rating scale	Architects	• Waste is not a priority in the design phase. • Waste is a consequence of construction, not design.
UK	(El. Reifi & Emmitt, 2013b)	Survey	Architects	• Design brief process was found to have maximum inefficiency • Very few architecture firms use design management.
Malaysia	(Begum et al., 2009)	Survey and logistic regression	Contractors	• Most surveyed contractors exhibit a positive attitude but negative behaviour. • Firm size, training regimens, past experiences, are directly proportional to positive attitude and behaviour.
Palestine	(Al-Sari, Al-Khatib, Avraamides, & Fatta-Kassinos, 2012)	Survey	Contractors	• In the absence of regulation, behaviour is dictated by economic benefit. • Firm size, education is inversely proportional to positive attitude and behaviour.
China	(Li, Tam, Zuo, & Zhu, 2015)	Theory of planned behaviour (TPB)	Architects and structural engineers	• Design training is more important than awareness of design waste generation. • Designers feel limited social pressure (clients, managers) to reduce waste.

Table 2: *A chronological list of international studies of construction industry professionals.*

2.2 Attitudes and Behaviours

Due to the scarcity of New Zealand studies on attitudes and behaviours towards waste management, attention was directed to international research. ***Table 2*** provides a summary of significant international studies. The most significant and consistent result is that because businesses are profit-oriented, and local legislation does not incentivize material reuse or recycling, waste management is not high on the project priority list.

2.2.1 Early Design Stages

It is critical that early design stages experience monitoring and control because the progress in these stages is intangible. As Freire & Alarcón (2002) noted:

> *"(...) lacking physical deliverables such as drawings, it is difficult to measure the amount of work completed and remaining on any given task, and consequently in the project as a whole (...) To make matters worse, projects are increasingly subject to uncertainty because of the pace of technological change, the rapid shifting of market opportunities, and the inability to keep pace with relentless pressure to reduce time and cost."*

Kulatunga et al. (2006) noted that if designers were to pay greater attention to clients' requirements and to the detailing of drawings in the design phase, rework could be avoided in the construction phase—thus minimizing waste. However, architects are of the opinion that clients are principally responsible for late design changes and consequential rework in the construction phase (Osmani et al., 2008; Mazlum & Pekeriçli, 2016). Oftentimes clients, who are not well-versed with the processes of architectural design, tend to project unrealistic expectations onto the design brief. They are also likely to rush the project along without spending enough time on concept development or value definition, which results in last-minute re-designs (El. Reifi & Emmitt, 2013). Such events would lead to the project running over the stipulated time and budget. As Hansen & Olsson (2011) reported, the later changes are made to designs, the costlier and more difficult to execute these changes becomes. At the root of these inefficiencies is vagueness in the content of the client's brief and difficulties associated with securing their approval between consecutive design stages.

Mazlum & Pekeriçli (2016) echoed that rushing through a project left very little scope for co-ordination between design and construction trades to completely evaluate the project and gather all the necessary information. Design is an iterative process (Kpamma & Adjei-Kumi, 2011) and forgoing that progression would give unsatisfactory results in terms of project value. It is important to note at this juncture that a stringent design schedule would also leave no scope for management to advise their staff on waste management strategies, creating a gap between adaptation and implementation of waste minimisation philosophy (Kulatunga et al., 2006). Another observation that must be highlighted is that, in a "buyers' market" it would be difficult for consultants to enforce their decision when clients are not co-operative or open to any suggestions that sounds new to them (Mazlum & Pekeriçli, 2016). For example, clients may prefer to work with a particular contractor they have positive experiences with from past projects, despite contrary suggestions from the procurement officer and architects.

From the findings of these studies, the twin issues of miscommunication and poor client awareness stand out. Clients that are unacquainted with the commissioning and procurement process tend to contribute greatly to a poorly developed design brief. Additionally, these issues were encountered by studies of architects in different parts of the world. Therefore, one may take it to mean that the problem is not specific to a particular economic or social canvas, and can be applied to the global construction industry.

2.2.2 Unaware Design Team

The contexts of these international studies are very different. Some concentrated on cities with a large amount of construction activity (Begum et al., 2009; Al-Sari et al., 2012; Li et al., 2015), while some others focused on a national phenomenon of waste production (Kulatunga et al., 2006; Osmani et al., 2008). Different groups of stakeholders were surveyed in every study, and different methods of data collection and analysis were employed. Despite these variants, a general lack of interest and investment in front-end waste minimisation was the common theme in all the international studies.

Li et al. (2015) strongly echoed all others in that graduates were given little to no training in environmental awareness. There was no insistence from clients or team managers to make an effort at waste minimisation in the design phase. Osmani et al. (2008) added that a firm's environmental certification did not reflect environmental awareness; ISO 14001 accredited firms were found to be as uninformed as those that had no such accreditation or staff training. A negative attitude towards waste reduction is also made apparent by the industry resigning themselves to thinking "waste is inevitable" (Osmani et al., 2008) or that "waste is unavoidable junk" (Kulatunga et al., 2006). This notion consequently assigns a low value to waste management in design and on-site: despite a common awareness of methods such as source separation and repurposing, they are not exercised (Begum et al., 2009).

Lack of regulations or support from governing bodies is another repellent to dealing with construction waste. Al-Sari et al. (2012) stated that because of the ongoing conflict in the surveyed region of Palestine, there is no priority for waste management and thus no regulatory initiatives from local authorities. This has led contractors to dispose waste to private dumpsites, open land, or to the sides of public roads. At the other end of the spectrum, Begum et al. (2009) found that the levying of heavy taxes on landfill usage has led contractors to dump their waste illegally. The commonality in both cases is that there is no initiative from either public or professional fronts to reduce, reuse, or recycle.

2.2.1 Information Exchange

While the external factor of undecided clients is commonly cited by architects to be a deterrent, there are several internal issues within a design team that can obstruct waste minimisation as well. Osmani et al. (2008) pointed out that inexperienced design teams can make detailing or specification errors, which leads to alteration(s) on site. Later on in the project's life cycle, these specification errors could become apparent in the deconstruction of a building as well, when the materials cannot be reused or recycled despite their original potential.

Design and management competencies have a major influence on client satisfaction. Amos-Abanyie et al. (2014) noted that designers' teamwork abilities, coordination, and leadership qualities produce higher client approval than contractual compliance. This highlights the necessity for architectural firms to hire graduates with not only a high level of design competency, but also the ability to improve on their management skills. The issue of clashes in architectural design and architectural management arises from the fact that educational institutions do not acquaint architecture students with time and budget limits (Emmitt, 2014).

An unfamiliarity with construction processes and equipment required on site creates confusion around constructability (El. Reifi & Emmitt, 2013). In dealing with these issues the waste that is produced from over-specification and under-preparation slips to the bottom of the priority list. This creates a situation where the design phase is wanting for more time allocated to design processes rather than to problem solving. Findings of their study on design inefficiencies mirrored other papers in other regions, and are portrayed by **Figure 5**.

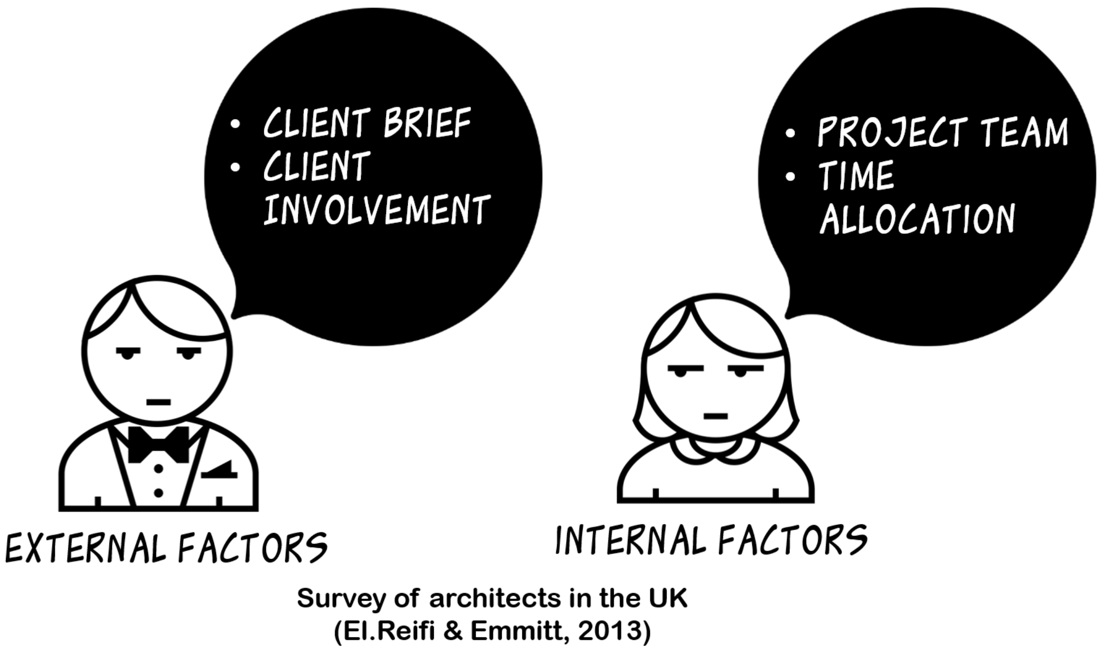

Figure 5: *Synopsis of inefficiencies in the design phase as noted by El. Reifi & Emmitt (2013).* ***Source:*** *Author's image.*

2.2.2 In New Zealand

Jaques (1999) conducted a survey of architects, quantity surveyors, and contractors based in Auckland to understand their attitudes towards waste management. The focus of the study was trained on procurement and design practices and the management principles implemented within the framework of these two realms, to help reduce waste. The study reported the following conclusions.

1. Architects to not consider waste minimisation a priority for the design phase, and believe that any waste generated in the construction process is produced due to the actions of the contractor on site. This is in keeping with the findings of international studies discussed in the previous sections.
2. Architects have expressed the belief that incentivizing waste minimisation during the design phase would encourage clients to consider including waste minimisation within contract terms.
3. Contractors hold the belief that modularization or standardization of room and material sizes will reduce waste on site. The international studies discussed in the previous section have reported on waste minimisation measures taken in the design phase, but they do not cover this aspect.

A lack of interest in waste minimisation was reported against clients by the respondents in this study. It is, however, unclear how often the option of waste reduction or minimization was put forth to the client at design stage. The study also made it clear that as a means of conforming to the client's needs, architects would rather follow a client's instructions than suggest waste management alternatives that they may be more aware of due to their technical knowledge.

Where design software is concerned, in 1999 a parallel but unrelated study found that 46% of the construction industry used CADD in their design work. There is reason to believe that technological advancements in the last 18 years place this number much higher, and the importance placed on design software may also be greater. The significance of this observation is in the fact that Jaques (1999) also reported that architects had very little belief in CADD to reduce waste with 63% respondents from the

Auckland region not agreeing with its contribution to minimize waste. Electronic drawings were also not very commonly shared with contractors. In light of these findings, this thesis would be remiss to ask the same question of architects—are the same drawings and information shared with contractors at pre-construction stage?

Prefabrication was also met with indifference from the survey respondents, according to the 1999 study. The study informed that prefabrication was viewed as a cumbersome process by architects. They were of the opinion that it led to a much longer design process with too much time spent on working with present sizes and compromises made on fixtures and opening locations. Standardized design was seen as curbing of creativity. This is in conflict with the observation that contractors believe these processes to be essential in waste reduction.

In review of this study, it is important to state that questions around these aspects can still be asked to understand the industry's current attitudes and behaviours towards waste. Borrowing from the hypothesis and from the literature review, this thesis aimed at questioning a sample of architects (from another region of New Zealand) about their design practices and how they perceive waste generated by activities in the design phase.

Cause of waste	
Familiarity	General lack of awareness about reducing waste among the design team. Environmental benefits of material management are considered to be inconsequential in relation to other building activities which generate profit.
Design	Acts or omissions by the designer that result in waste on site. Design changes made while the construction is ongoing, are a major source of waste. A designer's lack of experience with project complexity can also lead to waste by over-specification.
Motivation	Absence of significant incentivized contractual procedures for stakeholders to follow. Waste minimisation requires investment of time and effort for no apparent benefits, in relation to other building activities which generate profit.
Co-ordination	Architects believe that waste is a consequence of construction activities on site and that design does not produce waste. Lack of communication with clients on the design brief, and miscommunication between trades.

Table 3: *Summary of findings on industry attitudes and behaviour to waste.*

New Zealand and international studies have both shown parallels in that there is a lack of training and motivation among design professionals where waste management is concerned. **Table 3** encapsulates these parallels, suggests that these factors directly influence the creation of material waste on site, and leads us towards looking for a solution to these issues.

Several papers in this section noted the role of an architect in reducing waste from the construction project. The requirement for a strong client brief, consistent design quality, and clear information flows was highlighted by Kulatunga et al. (2006) and El. Reifi & Emmitt (2013). The management of waste during design has been covered by literature under the term *architectural design management*. There is a belief within literature that design management is the key to reduced waste and improved value for the client (Freire & Alarcón, 2002; Tzortzopoulos & Cooper, 2007; Emmitt, 2014; Novak, 2014). To understand the meaning of architectural design management, a literature review of significant studies was conducted, and is reported in the following section.

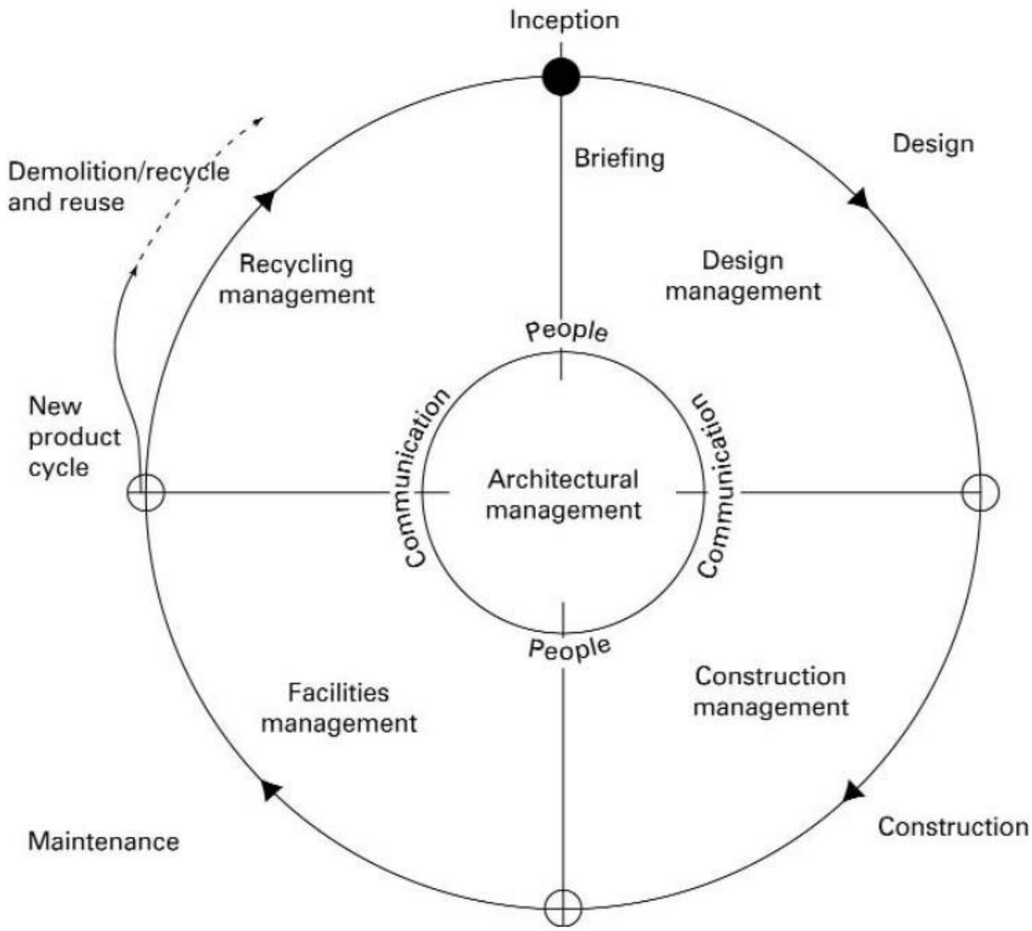

Figure 6: *Currently accepted model of architectural design management.* ***Image source:*** *(Tzortzopoulos & Cooper, 2007)*

2.3 Defining Architectural Design Management

Literature describes design management as a set of management practices dedicated to improve the processes of design, innovation, and quality in construction projects (Emmitt, 2011). In this discussion, competency of management is always separated from competency in design and innovation. As such, architectural design management is the connection between design processes, and the overarching controls that enable these processes to run smoothly. As Emmitt (2016) clarifies,

> *"The search for an understanding of how people perform complex cognitive activities has been the underlying principle of design research for the past four decades (...) the trend is towards a more pro-active stance to the management of design information and an attempt to manage those charged with producing that information."*

Historical studies in the field have thrown distinct spotlights on office management and project management. This difference has been closed by more recent works on the subject (Deshpande et al., 2011; El. Reifi & Emmitt, 2011, 2013; Emmitt, 2014) as these aspects are now seen as connected. The organizational structure of a firm and the individual skills of designers exert a combined effect on project performance. This combination has highlighted 'hard' activities of design development as well as 'soft' activities like interactions within the design team and communication with the client. With this, literature has directed the debate towards the entire project lifecycle which encompasses the process of design (systematic design and decision-making) as well as the product of design. Architectural design management no longer considers design as an independent front-end process, it now considers all the stages that succeed it as well. It also takes into consideration the communication networks within a project and the skills required to achieve a successful project. **Figure 6** is a representation of this model.

This shift in focus has further led to the development of management concepts that define and guide the process of design management. The following sections will discuss both these sets of literature in detail.

2.3.1 Information Flows

The origin of the term "design management" has its roots in encouraging architectural involvement in the business aspects of design (Emmitt, 2014). Over time, the definition has taken on a meaning that is unique to individual participants of the design process, with no more than their individual perception of the term for guidance. However, the advent of new technology and new workspaces such as Building Information Modelling (BIM) changed how designs were processed until recently. Alharbi et al. (2015) made an attempt at producing a definition that could uniformly be accepted by the industry:

> *"Architectural management is the strategic management of the architectural firm that assures the effective integration between managing the business aspects of the office with its individual projects to design and deliver the best value to all stakeholders."*

The key word "value" is important, as several studies have reported on value creation in the design phase. In the previous section it was pointed out that untimely client changes have often resulted in waste. Thyssen et al. (2010) however, strongly stated that ineffective value management of architectural designs would result in unhappy clients that do not agree with the proposed designs and demand changes throughout the process. This demand is brought on by uncertainties that clients face when they are unclear about the *whys* and *hows* of the design. Emmitt & Gorse (2006) call it a defence mechanism, and draw attention to the idea that value holds different meaning for different stakeholders. To mould the project in one's own values while rejecting another's values would lead to contradictory actions, and consequent dissatisfaction for the end user: the client. Coupled with the finding that designers aren't always co-located and are involved in other projects at their firms, a breakdown in communication between parties would obviously not deliver the best value to a client.

Thus, late client-ordered changes and expensive rework on projects can only be avoided by a good briefing strategy (Blyth & Worthington, 2002). Additionally, the raising of a client's needs to the highest importance would require an alignment between various project participants such as the architects, the consultants, the contractors etc. (Thyssen et al., 2010) While different contract and procurement methods are followed for every project, maintaining a strong communication link between the design, construction, and end use groups throughout the duration of the project is necessary for successful execution and value realisation.

To summarise, the creation of a client brief should define product values and the design team must adapt the design brief to their process values. The research has made several attempts to illustrate this by providing suggestions of better management of information at different stages of the design. The flow of information between project stakeholders is highlighted by Tribelsky & Sacks (2011) and information is alluded to "the designer's raw material". They note that if information flows in a project were assessed similarly to production batches, one finds concurrent issues in the two concepts. Echoing Thyssen et al. (2010) they report that the inefficient flow of information during the initial phases of a project can cause various forms of waste in later stages of construction. Rework follows wherever design has proceeded based on outdated versions of other designers' drawings because newer information was withheld or not forthcoming. Waiting for information leads designers to shift their attention to other projects, incurring the waste of renewed 'setup' times for familiarization with what was done earlier when work on a project is resumed. As a result, the overall program of the project is completely reorganised and overheads bloat the initial budget. In terms of value, design iterations based on incorrect or late information become negative iterations and design options that should've been explored are never discussed.

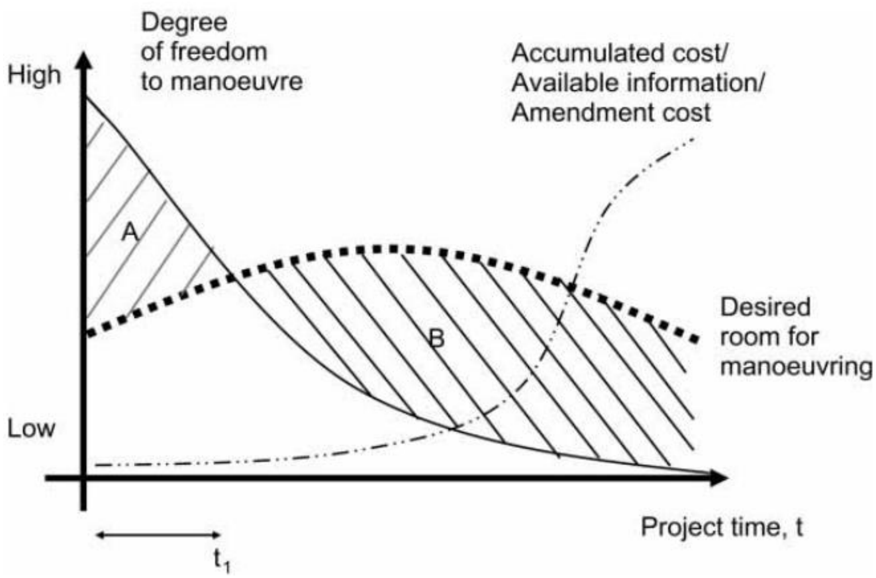

Figure 7: The later a design is changed, the costlier and more time-consuming the act becomes. **Source:** (Hansen & Olsson, 2011)

2.3.2 Layering of Designs

Hansen & Olsson (2011) support the idea that client changes and variability related to the refocusing of a project can be dealt with by dividing the project in several "layers". They note that because various layers of a project are interlinked, decisions taken in one stage influence all succeeding stages. Unlike in manufacturing, historical practice in construction puts quality down to how well the product conforms to the design documentation rather than how well suited the product meets the end user's needs (Emmitt, 2014).

Project design layering comes from the production concept introduced by Tribelsky & Sacks (2011)—large batch sizes cause bottlenecks in the production line. In a production system, situations where the occurrence of large batch sizes, long cycle times, flow bottlenecks, accumulation of work in process inventories etc. were found, the was a coinciding poor quality in the production line. Some of these issues can be identified in flows of information in the detailed phase of architectural design as well. Such variances are smoothed out in the planning stage to ensure a continuous production flow.

By taking measures in a way that the project is several flexible components, design layering provides a conceptual method to accept information in small "batches", process it, and use it on gradual stages of a project. Most of the costs and much of the quality in a construction project are locked in long before construction launch, and therefore the design process will be crucial not only to 'do things right' but also, more importantly, to 'do the right things'.

Figure 7 illustrates the costs generated the later changes are made to the design. Design management strategies with a focus on minimizing waste and maximizing value should, therefore, be applied as early as possible in the building process.

The idea of layered design is illustrated through a case study. Using hospital design as an example Hansen & Olsson (2011) showcase two hospitals that were constructed with a layered design philosophy. Of note was the second case study where each section of the project (base build, internal layouts, interior design) was handled by a different design firm. This ensured that the design brief was translated and consequently the designs conformed to the ideas of the client. The paper also notes that coordination between these different design stages was made easy by involving all design teams throughout the process, and following a handover process between each stage.

This suggestion seems to be grounded in industry facts, as Freire & Alarcón (2002) noted. Construction is the realisation of the design brief and the client's requirements but it is the design phase that extracts these requirements and feeds them into the construction process. It is the role of an architect to establish a dialogue with the client and tease out the brief, giving it definition and clarity through iterations. As the design gains more exactness, other consultants such as project managers, structural engineers, services engineers, consultants for acoustical and fire design etc. may be added to the team depending on the scope of the project. These additional members make design decisions that are interdependent on each other's proposals. As Emmitt & Gorse (2006) pointed out, the design development stages on projects with multiple consultants are bound to experience clashes in opinion and personality. Coupled with budget and schedule limitations, and the possibility that information in the design brief may not be as complete as the design team believes, their coordination process requires monitoring and control.

Over-design is another issue discussed by Emmitt (2014), which follows from the desire to avoid the need to deal with additional or changed design requirements that may be communicated only late in the design process. Understanding the flow of information between project participants is useful in determining the effectiveness of design management.

The link between the quality of design, design documents, and the amount of waste and rework during construction itself is well established in literature. Tribelsky & Sacks (2011) found that the quantity of rework is inversely proportionate to the quality of information flow between designers. As stated above, the design and construction stages are very deeply linked in that intangible concepts and translated into visual information as drawings and 3D models, which is further translated into tangible structures on site. Blyth & Worthington (2002) noted that such important stages of translation and design are hardly scrutinised or standardised. One of the main challenges in the design and construction process is that neither all of the required information may be available nor the necessary decisions made in order to finalize the design (Hansen & Olsson, 2011).

To summarise, assigning higher importance to the briefing and conceptual design stages and managing the flow of information would produce better-informed decision making through to the completed building. Facilitating a greater synergy between design, manufacturing and construction teams will in turn create significant potential to deliver value throughout the whole process. This can only be done when a well-outlined design management plan is in place (Blyth & Worthington, 2002; Thyssen et al., 2010; El. Reifi & Emmitt, 2013b).

2.3.3 Design Brief as Production Cycle

One strategy for reducing the need for information processing is the creation of self-contained tasks (Emmitt & Gorse, 2006). Self-contained tasks may be achieved by modularization of the design, by use of standardized components or clarified interfaces related to both design and organization. Modularity can enable projects to cope with uncertainty because individual components do not have a critical role. Repeating this discussion are the findings of El. Reifi & Emmitt (2013). They suggest that the briefing process preceding the design stage is often the point where design teams fall short in understanding client requirements due to ineffective information flow from client to architect, poor communication from architect to design team, and poor decision-making.

There are two schools of thought about the briefing process in the construction industry. According to El. Reifi et al. (2013) the first school believes that the design brief should be static when client requirements are established, collected, identified, agreed, fixed and eventually delivered as a final design brief. The other school sees briefing as a dynamic process which starts at project inception and develops through the design stage, eventually completing before construction. A large portion of designed waste originates at briefing due to lack of surety in whether the briefing process should be fixed or dynamic (El. Reifi et al., 2013).

2.3.4 Designers' Skill

Another key to unclear or unresolved client briefs lies in architects' design competencies. Tzortzopoulos & Cooper (2007) noted that experienced designers do not focus on the problem, preferring to chase after a solution instead. In this chase, design iterations and exploration of value fall to the wayside. The process monitoring required during critical points of progress—such as concept to preliminary, or developed to detailed design stage—are often replaced by compromise or improvisation to keep up with the project schedule (Freire & Alarcón, 2002). This is accompanied by lack of communication between the design team and their client, consequent missing information or poor documentation, overwork on the part of drafting technicians or graduates, clashes between the designs of multiple consultants, and decisions that are not fully considered. This increases complexity and risk in designs and produces inconsistent information between different aspects of design. This is a particularly significant finding as other literature has noted the direct proportion between architects' design competency and client satisfaction (Amos-Abanyie et al., 2014).

Literature from around the world has echoed Emmitt (2014) by insisting that architects must accept the role of design managers in the project delivery system, and prepare for such a role to be created by promoting training and education in the field. Since client satisfaction is a big measure of successful projects, management of designs emerges as an important necessity. Tzortzopoulos & Cooper (2007) summarise this role by stating,

> *"(…) design managers need to have technical skills, looking at design as a sequence of activities based on a rationalized approach to a technical problem; cognitive skills, approaching the skills and limitations of the individual designer; and social skills, looking at how designers interact with other stakeholders and how this influences teamwork and value generation."*

Ling (2003) found that project managers select architects based on their experience level and design skills, not on how much they are likely to charge. Additionally, good technical know-how that supports the constructability of designs was stated to be a significant quality in a designer, from a project manager's perspective. This provides a clue as to the qualities a design manager must possess to lead a project towards success.

The methodology took note of these discussions and designers' skill level played a major part in the creation of the same.

To summarize previous literature, the role of a design manager has been described as project management (Alharbi et al., 2015), value management (Thyssen et al., 2010), organizational management (Novak, 2014), and BIM management (Sacks et al., 2009) There is no single, standardised view or definition of what design management must be, and none of the above approaches have a connection to construction waste minimisation. In the search for this connection, a range of literature was found on the subject of lean design management. The following is a summary of this literature based on the most recent and significant international studies.

2.4 Defining Lean Design Management

Lean design has been described as the application of lean production principles—the elimination of waste and non–value adding activities—to design in the construction industry. Lean production has helped achieve significant waste elimination targets in the automobile industry (Salem et al., 2006). Created by Toyota in the 1980s, it underlined the need to produce more with less (i.e. less time, less cost, less effort, less space.) Lean design takes a page from this book, and introduces three main aspects to the design process: conversion of inputs to outputs, flow of information represented as design, and design as value generation for the client (Alarcón, 1997; Freire & Alarcón, 2002).

Lean considers any production system to be made up of two main activities: **flows and conversions**. Conversion activities are the primary source of value addition to a process, while flow activities do not generate any value; they connect conversions together. The application of Lean methodology to construction processes has shown improvement by either reducing the time spent on or eliminating non-value-adding flow activities them completely (Salem et al., 2005). Conversion activities, on the other hand, are streamlined and made more efficient.

Lean design management differs from traditional management wherein all activities within a production cycle are seen as flow and conversion activities, thus differentiating between value and non-value adding work. This distinction lends to the control and improvement of both, consequently improving the design product and reducing waste. The defence for a lean approach to design management is presented by Freire & Alarcón (2002) who state,

> *"(...) the conversion view is not especially helpful in figuring out how not to use resources unnecessarily or how to ensure that customer requirements are met in the best manner. The conversion view is effective for management, but not for improvement."*

Literature has pointed out that the conversion view only defines three aspects of design processes—the amount of design documentation produced, the amount of unnecessary work reduced, and that client satisfaction has been achieved. The consequence of such a view has led to fragmentation within the design process in that certain tasks are considered more important than others, taking the effort away from intangible progress through information flow and directing it at tangible conversions (Tilley & others, 2005). Invisible rework is produced from such a fragmented practice, and the ultimate goal of providing value to the client is forgotten in the scurry to manage the rework.

Realigning the process of design management to include information flows and exchanges would reduce waste by decreasing the time spent on retrieving missing information, time spent on testing the design on incomplete information, time spent on designing to assumptions, and time spent on conveying information effectively within the design team (Freire & Alarcón, 2002). This means that the design phase must coordinate with the construction phase by including the contractor and manufacturers while the designs are still being developed.

On the subject of value, lean design management agrees that defining the design brief to encapsulate the client's requirement is necessary (Arleroth & Kristensson, 2011). Additionally, it states that the briefing process requires improvement to reduce loss of value when information is withheld, forgotten, or misinterpreted. Several authors have led the discussion of design management towards the concept of lean design but found that a lean approach to design briefing has not yet been developed. El. Reifi et al. (2013) proceeded to detail out a conceptual model for the same by defining three questions that grant transparency to the briefing process,

1. *Is the process value producing the desired product value?*
2. *If not, why is the process not producing value, and which specific process requires fixing?*
3. *What is it about that specific process or task that needs changing?*

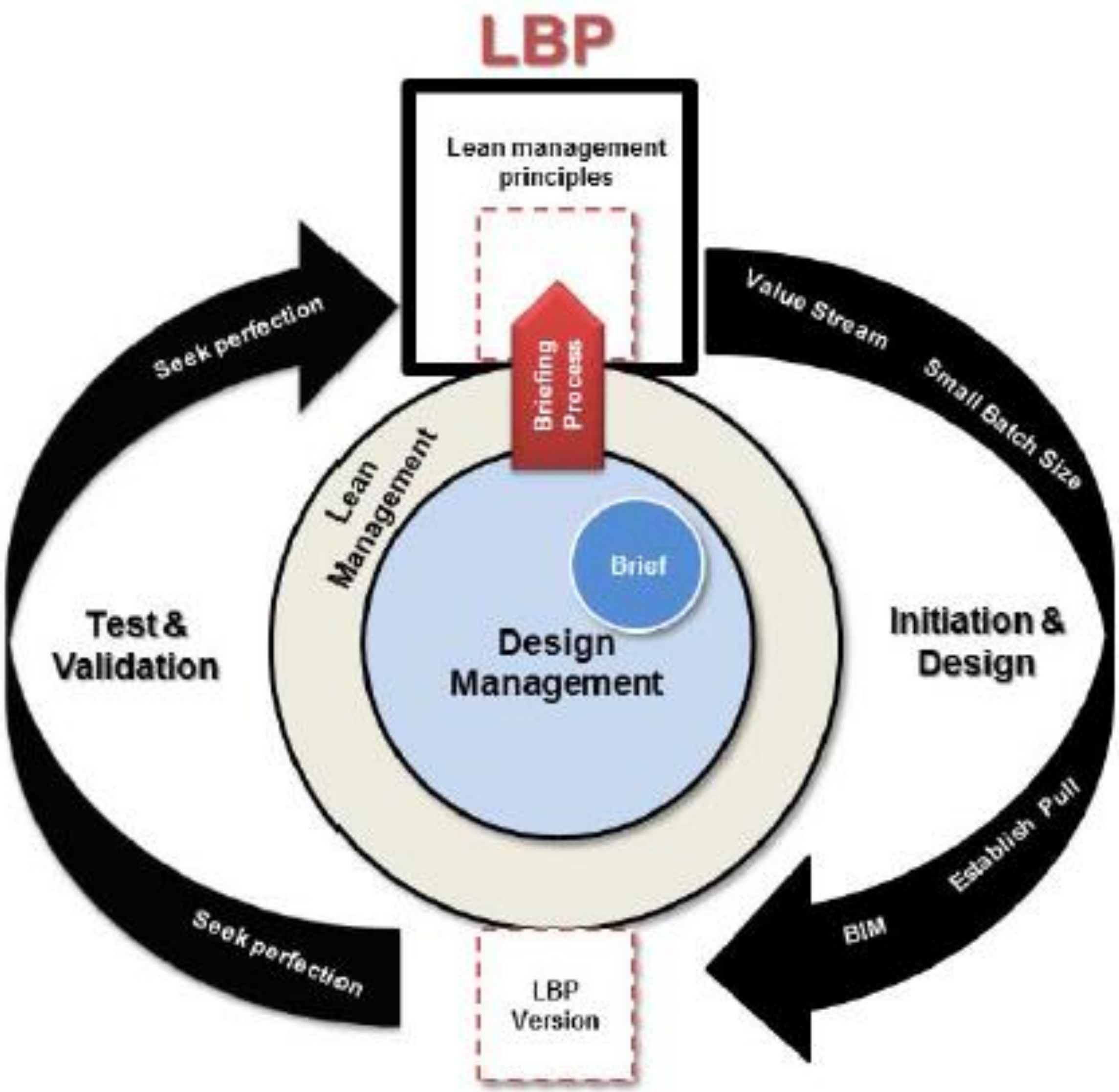

Figure 8: *Conceptual model of the Lean Briefing Process (LBP).*
Source: *(El. Reifi et al., 2013)*

The lean briefing model is highly dependent on the skills of the management team and therefore requires them to be trained and capable of executing Lean concepts in practice. It consists of 2 stages as shown in **Figure 8**—the initial stage identifies the project objectives and constraints. This stage is known as the initial brief. The second stage of development, the project brief, uses the initial brief to create a detailed project definition from which a design can be created to meet the client's requirements. This process does not seem very different from a usual briefing process. However, the two main aspects of lean briefing process that set it apart are: the initial brief needs to be very clear from the start; and the project brief is organized in phases which are aligned with the development of the design from inception to construction.

Value also relates to the quality of the product, and how well it performs. Understanding this value is made possible by including the end-user in the design process. In commercial or residential projects, a discussion around spaces and whether they are sufficient or satisfactory for their function is important. To achieve this, lean design management agrees on producing design iterations to ensure conformance to the design brief (Tilley et al., 2005).

In summary, the normal design process involves conversions, flows, as well as value generation. While these aspects exist as a combination within the design phase, lean design management attempts to separate the performance of these aspects so they are independent of each other, and attempts to improve them by standardisation. As a result, preceding and succeeding tasks are not affected by inefficiencies in one independent link of the whole process. The major influence of lean design management is extending control to the flow and value aspects, thus subjecting them to systematic management.

2.4.1 In New Zealand

From the literature review it was found that lean has been implemented in New Zealand at the construction stage. It is most commonly applied as the last planner system (Sadler, 2011). Other tools are used less frequently, but only when management personnel are aware of these tools. The research found contractors claimed that the industry did not see merit in standardisation or waste minimisation because construction is exclusively one-of-a-kind projects. Participants of the study perceived waste minimisation in relation to local legislation and green building rating credits, rather than as a prominent feature of lean principles and philosophy, or of their own design ethos.

Fuemana et al. (2013) found that the productivity of New Zealand's building sector is lower in comparison to other countries in part due to its geographical isolation, some four hours by plane from its nearest large neighbour. Other factors include stunted innovation, existing regulations, current procurement practices, and current management capabilities in construction. Their research uncovered that construction industry management exhibited a range of experience and training in terms of lean construction, but only a few contractors had involved designers and clients in their progress meetings. This was also exhibited by the interview wherein few designers included contractors in design meetings. This leads to the belief that although the construction industry may see benefit in collaborative design work, they do not implement it due to clients' choice to "stick with the familiar" as one participant noted.

Beyond research, attempts at implementing lean construction are few and do not appear to have been very successful. Constructing Excellence in New Zealand[3] is a cross-sector organisation, marketed as a source of advice for professionals and clients. It claims to have targeted benchmarking of waste reduction and value improvement since 2005, but the results of this service are publicly unavailable. The organisation also hosts conferences and management training programs annually, but they focus on the last planner system and are only held in one region of New Zealand. The Lean Construction

[3] http://www.constructing.co.nz/Services/Constructing-Excellence/Lean-Construction

Institute of New Zealand[4], on the other hand, was an initiative by a senior lecturer at Auckland University. With the goal of increasing lean awareness, the institute's mission was to be an intermediary between the industry and academia for knowledge exchange. However, it was revealed that industry professionals expressed an initial interest in participating, which ultimately disappeared.

As a closing note to this chapter, it should be remarked that two of the four research questions have been answered within this chapter. Specifically:

> What is architectural design management?

The search to answer this question led the literature review towards the concept of lean design management. Lean has been described in the past as a tool to reduce waste by improving design and production processes. It encompasses a philosophy of businesses producing more with less (less time, less cost, less effort, less space). This philosophy is absorbed into all processes within an organization, by the people who control these processes. Lean provides the tools to examine a process, identify the prevalent inefficiencies, pin-point the cause of these inefficiencies, and solve the problem with management strategies. If this approach were applied to design, the inefficiencies in how designs are produced could be found and fixed. This thesis aims to search for these inefficiencies if they exist.

> How has it been implemented by architectural practices in other parts of the world?

The work of Hanne & Boyle (2001), Jacomit & Granja (2011), and Pasquire & Salvatierra-Garrido (2011) has been discussed previously. Layered designs draw a link between lean thinking and flexible design solutions. First and last value provides an insight into design management and its view of building whole lifecycle. Target costing focuses on the client's quality requirements against cost-driven development. This chapter leads towards forming a method of investigation based on findings from literature.

[4] http://www.leanconstruction.co.nz/

Chapter 3:
Methodology

Chapter Summary

The primary purpose of this study is to understand a selected group of architects' attitudes to waste minimization in the design phase. It aims to investigate the perception of design management in building design and construction projects. To perform such an investigation, this study took the support of a semi-structured interview conducted with industry professionals. In the preceding chapters it was established that this study would also try to answer the following research questions—

1. *What is architectural design management?*
2. *How has it been implemented by architectural practices in other parts of the world?*
3. *What design management approaches have architectural teams implemented in New Zealand?*
4. *How do these management approaches reflect the attitudes of architects to waste minimization?*

The literature review in **CHAPTER 2** revealed a number of publications from New Zealand, and elsewhere, on issues of construction waste minimization. This was useful in answering questions 1 and 2.

However, questions 3 and 4 remain unanswered. Because of the investigative nature of the questions, it was decided that the creation of a questionnaire directed at industry professionals would obtain the most information. This chapter is the detailed documentation of the design and execution of the data collection phase of the study. It includes a narrative of the method of questionnaire design, respondent selection, and the instruments used to complete the interviews. It also provides details of assumptions, required ethical procedures, and study limitations.

To gain a good understanding of the management and coordination issues faced by design and construction teams on a project, a live case study was selected as a foundation to build up the research methodology. Hegde (2015) explained that case studies are instrumental in demarcating “a frame of reference and a definition of the situation”. While the literature review revealed the general causes of waste in design, a single case study in New Zealand pertaining to inefficient design management highlighted the complications of attitude and behaviour towards waste. This case study was conducted in Wellington, and a summary of the data collection method is provided.

The case study was used to gain as complete as understanding of inefficient design management as possible. But the primary investigative focus of this thesis was architectural practices and their design methods. The interview questionnaire was designed for face-to-face exchanges with architects. Potential participants were identified, sent invitations detailing the subject of study and specifics of the interviewing process, and then interviewed. Their answers contributed to this study as experiences of design management implementation in New Zealand, and are reported in the following section.

At the end of this chapter, a project timeline indicating major milestones is presented to give a better chronological understanding of methodology implementation.

Figure 9: *Triangulation of various data collection methods adopted in this study.*
Source: *Author's image*

1 Research Design

1.1 Triangulation

Triangulation is the use of multiple methodologies for data collection. This tactic improves the definition of the research question by exposing different aspects of it (which may be opposing), and leading to other questions that could be answered by future researchers (Hegde, 2015). It could also improve the accuracy of judgement and eliminate biases if various methods are used to answer the same question. **Figure 9** is a graphical representation of the triangulation methods adopted in this study.

The literature review was conducted to understand the meaning of architectural design management. It revealed the construction industry's attitudes and behaviours towards waste minimization in New Zealand and other parts of the world. It helped recognize that the local building industry's stance on construction practices is different due to its geographical location (Fuemana et al., 2013). Also of note is the fact that the New Zealand study of architects' attitudes was conducted nearly twenty years ago and several technological advances have been made since then. These blind spots were dealt with by identifying a live case study of a construction project. The case study brought forth specific issues of design management between different stakeholders. It also illustrated the depth of each trade's involvement in the design phase of a project. However, an architect's perspective was missing from this case study, and waste management wasn't overtly emphasized in the discussion. The knowledge gap was filled by creating an interview questionnaire that would specifically address these lacking points.

1.2 Phenomenology

Phenomenology was initially developed as a philosophical approach that focused on "lived experiences" of study subjects (Connelly, 2010). The outcome of data collection in phenomenological studies is usually in the form of observations or stories of the persons being interviewed. Participants share their judgements and perceptions of a particular subject, and analysis is conducted on their responses. While it has enjoyed a status of popularity in nursing research, lately management studies have been stretching towards more phenomenological approaches (Hegde, 2015). The human aspect of design management for waste minimisation could not be ignored on this study, which led to it assuming a phenomenological construct.

So that architects' experiences in design management could be highlighted by this study, they were asked open-ended questions on aspects of design management underlined by the literature. Their "lived experiences" in the design phase, and their recollections of design management on specific projects, drew attention to how it is implemented in New Zealand projects and whether it focuses on waste minimisation. While international research has adopted a statistical research method to gain a national overview of attitudes and behaviours towards waste (Osmani et al., 2008; Al-Sari et al., 2012) this phenomenological study of New Zealand architects directed its questions at a small and purposeful sample set. As Connelly (2010) stated,

> *"The phenomenon is studied in fewer people, but in more depth than would be possible in a survey or other type of research. The purpose of this kind of research is to become deeply involved in the data and therefore the phenomenon."*

Data was also collected from a live project case study conducted in New Zealand. From this case study, a set of themes pertaining to design management were identified that would require further inquiry. These themes were translated into questions, enabling a comparison of the responses received. Quotations from the case study as well as from interviews helped accentuate the lived experiences of industry professionals. It was observed that respondents found it easier to articulate on specific projects, rather than abstracting their answers. Wilson (2015) stated that lived experiences are mainly tacit in nature, pertaining to emotions. To extract the actual experiences, or the *whats* of a situation, asking the right questions and a deep analysis of the data is necessary. The following sections illustrate in detail, how this was achieved.

1.3 Qualitative Analysis

The literature review showed design management is a broad subject. The literature review also provided the realization that a study of this nature could not be represented in the form of statistical or mathematical terms. This necessitated the need to create a qualitative research methodology. In order to understand its specific effects on and in relation to waste management, certain features of architectural design management were identified from the literature and the case study. These were translated into questions for studying in detail.

Qualitative analysis has historically been associated with research in the field of sociology and anthropology. Jankowicz (2013) however, found that management studies, among other areas of social and organizational research, have seen an ascending interest in qualitative methods since the 1980s. Research on construction management, too, has traditionally relied on quantitative analysis. Most of the popular studies published on the subject of design management also report their findings as statistical data. The argument to such a methodology is that it is “inward looking and self-referential” (Dainty et al., 2000). Behaviour-related aspects of design management cannot be faithfully conveyed by statistical data, and require more room for interpretation. While quantitative analysis answers the what, when and where of a subject matter, qualitative research looks for the why and how of it (Silverman, 2009). In this, qualitative analysis is not as rigid or literal as quantitative analysis, and is more holistic i.e. it tries to look at the bigger picture. It uses methods such as participant observation, historical studies, ethnographic studies, structured and unstructured interviews, focus groups, case study methods, and action research. These various methods in turn lead the focus to aspects such as language, signs, emotions, body language etc. of the participants (Hegde, 2015). The drawback of this methodology is that it can be time consuming and thus, it usually requires a smaller sample size or number of cases. This was echoed by the construct of phenomenology, and taken into account when designing the methodology for a study of architectural practices in New Zealand.

There has been dissent in terms of the generalization potential of qualitative analysis. Yin (2013) says the following about qualitative analysis as a rebuttal:

> *"Qualitative research can be generalized. Analytic data can be generalized to some defined population that has been sampled, but to a theory of the phenomenon being studied, a theory that may have much wider applicability than the particular case studied. In this, it resembles experiments in the physical sciences, which make no claim to statistical representativeness, but instead assume that their results contribute to a general theory of the phenomenon"*

A possibility of generalizing data with qualitative analysis in construction management was explored by Dainty et al. (2000). They claimed that ethnographic research in construction, while difficult in its data collection and lengthy in its analysis procedure, marginally improves in potency with computer-aided analysis. It makes the process transparent, and provides access to deeper implications of a response. Taking cues from this, the semi-structured questionnaire featured in this study is its main method of data-collection. Its responses were evaluated through a qualitative analytical approach, with the help of NVivo 11 (QSR International) which is a computer software used for analysing rich text data.

Another aspect of the designed questionnaire was the inclusion of a rating scale, shown in **Table 4**. Participants were asked to rank the impact of various design phase-related issues on design cost and schedule from a scale of low or no impact (1) to very high impact (5).

	Impact on design cost					Impact on schedule				
	1	2	3	4	5	1	2	3	4	5
Inflexible building code										
Inexperienced team										
igh staff turnover										
Complexity in designs										
Design software issues										
Strict budget limits										
Unavailable HR										

Table 4: *5-point measurement scale to discern the effects of various issues highlighted by literature.*

This helped reveal the most serious issue(s) architects face during the design phase. It also created a basis for comparison between responses, so that trends and outliers of design management could be identified. To limit the respondents' predispositions towards these issues (Iarossi, 2006), they were asked to answer specifically based on their own experiences.

2 Constructing the Questionnaire

2.1 Influence of Literature Review

As noted at the start of this chapter, the literature review provided an in-depth look at the current practice of design management in other parts of the world, its connection to waste reduction, as well as architects' attitude to waste minimization. This answered some of the supplementary questions that would ultimately lead to answering the research question:

Can lean design management be used by construction projects in New Zealand to reduce waste in the design phase?

To specify, the aim of the methodology is to answer the remaining supplementary questions:

1. *What design management approaches have architectural teams implemented in New Zealand?*
2. *How do these management approaches reflect the attitudes of architects to waste minimization?*

To answer the rest of the supplementary questions, it was necessary to develop a methodology to explore the attitudes and behaviours of New Zealand architectural practices identified as.

Design has historically been a linear process (Kpamma & Adjei-Kumi, 2011) This process treats the client, designer, consultants, and contractors as links in a chain. Beyond sharing the most basic information, there is no integration between these links. This means that the current briefing and internal communication processes may not be as robust as they need to be for the client's tacit requirements to become explicit in the design. Tribelsky & Sacks (2011) added that designers are usually juggling between several projects at a time to support the business's aim of maximizing profits. This inefficient management of workloads may also be a result of inefficient information flows during initial project stages. Large quantities of information transferred at one instance can increase the complexity of the project. Long wait times for important information can permit a shift in designer's attention to other projects. Withheld information that resurfaces can entirely re-organise a project and be a major cause of

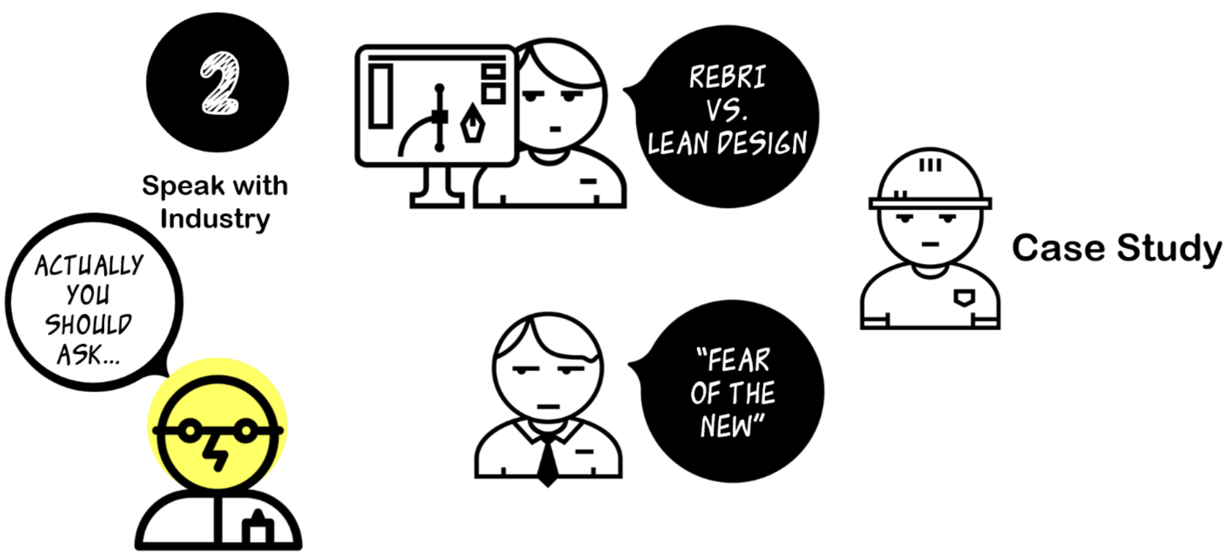

Figure 10: *Interactions with the industry prompted the need to identify a live New Zealand case study.* ***Source:*** *Author's image.*

rework. To accommodate a strict program and budget limitations, design teams often rush a project without subjecting it to iterative development (Hansen & Olsson, 2011).

Consequently, waste minimisation and value maximization are forgotten. The focus of the design team remains on simply completing the project in the given timeframe with a given budget. Amos-Abanyie et al. (2014) reported that design and management competencies have a major influence on client satisfaction. They noted designer's teamwork abilities, coordination, and leadership qualities produce higher client approval than contractual compliance.

The aim of the questionnaire, was to examine the four main cues identified as being at the root of inefficient construction industry waste minimisation: **client briefing, information flows, iteration in design,** and **architectural competency.**

Interactions with the industry noted that REBRI is the only commonly known tool for waste minimisation. How REBRI compares against Lean Principles is discussed in the literature review.

However, Gonzalez (2016) highlighted other concerns with regards to adaptation of new ideas or systems for waste minimisation. They argued that organisations currently promoting the use of lean construction have "ignored the detailed literature that addresses the extent to which lean methods are applicable beyond the unique production context". Literature on Lean Construction on the other hand states that the lean principals are ideally applied to the management of dynamic projects. This further reinforced the need for opinionated data responses as opposed to statistical ones. These issues were addressed by observing site operations in a live New Zealand project as a case study (**Figure 10**).

2.2 Case Study

Access to the case study was provided during a 4-month student internship program with a project management firm based in Wellington. From June 2013 to August 2016, the firm was a stakeholder in a major infrastructure project, and their involvement provided the background information required to successfully conduct the case study.

This case study was an observational field study organized, with the approval of those present, as part of a “Lessons Learned” meeting during the close-out of the project. Meeting participants included the client, the project managers, the commissioned designers, the specialist consultants, health and safety advisors, facilities managers, and the construction team. The meeting was conducted to review some of the organizational issues encountered during the project, and to improve the planning process for future construction work of a similar scale. Each stage of the project was addressed by the respective project stakeholder, with the stages being initiation, design, execution, monitoring and control, and closeout. At the end of the meeting, the participants were asked to express their overall positive and negative experiences during the project. The case study is summarised in the next chapter, according to the different project stages discussed at the lessons learned meeting.

2.3 The Interview

The interview questionnaire consisted of 2 parts. The first was a list of questions that attempted to get an overview of the architect, their firm, and their most notable projects. This introduction was designed to help categorize the respondents and whether they had been engaged in overseas projects. Since Fuemana et al. (2013) stated that New Zealand’s geographic isolation may have a direct effect on its building practices, there is good reason to test if contact with overseas design and construction groups may have activated a knowledge exchange for architectural firms.

As mentioned in a previous chapter, this study hypothesized that the inception of the New Zealand Green Building Council may have brought forth an improvement in the industry's attitudes towards waste minimization. To test this hypothesis, participants were asked about their firms' affiliation with environmental accrediting bodies.

The second part of the questionnaire consisted of 21 questions, further subdivided into 4 sections. These questions were designed to identify how design management is used by architectural practices in New Zealand. The 4 sections mimicked the stages presented in the case study—initiation, planning, execution, monitoring and control. Through this division of the interview into stages, it was easy to direct the respondent from concept design to construction drawing phases of the design process. It also helped reveal the phases that produced the most amount of waste.

The questions were initially drafted on the basis of the preliminary studies of literature and the case study. This first draft then underwent multiple modifications, and through the questionnaire trials, which are detailed in the next section. The final product of these exercises was then submitted to Victoria University's Human Ethics Committee.

Upon Committee approval, the selected participants were contacted by email, and invited to contribute their answers to this study. At the interview, all participants were asked the same questions, and were encouraged to elaborate the open-ended ones. The responses were collected on a personal audio device, and then transcribed for analysis. All interview-related files were assigned codes in keeping with the guarantee of anonymity. Besides the researcher, only the supervisor had access to any written or recorded data. Participants were assured that all collected data, and all copies, would be destroyed after 2 years.

Participants were encouraged to ask queries and clarify any doubts they may have had about the interviews. This was done once through the invitation email, and another time at the end of the interviews.

Invitations avoided using words such as study, research, and thesis. This is because there was a risk of such words demotivating the potential respondents from accepting the invitation to contribute (Iarossi, 2006). Beyond this, no effort was made to affect the objectivity of the participants.

The interviews were conducted face-to-face, at a location of the interviewee's choice. Although there is the possibility of response bias working its way into such a setting, Bennink et al. (2013) insisted that:

> *"There are several advantages to collecting data using face-to-face interviews: visual, oral, and even nonverbal communication can take place; longer questionnaires can be examined; it is easy to obtain long and complete sentences as answers to questions; item nonresponse is relatively low; the presence of an interviewer makes a respondent's reading and writing abilities irrelevant; and the interviewer can help with difficult questions"*

2.4 Questionnaire Trials

The questionnaire survey was designed to engage architects. Consequently the terminology it used had to be architectural, or at least recognizable by professionals in the New Zealand construction industry. In order to ensure there were no discrepancies in the language of the questionnaire, a series of trials were conducted with members of academic staff and people with experience in research design. These trials also informed the order of the questions, and their phrasing. Some trials were conducted with those who have a history of New Zealand industry experience. Their responses foreshadowed several responses the final questionnaire gathered.

2.4.1 Trial Summary

2.4.1.1 Trial 1 – *logic of the questionnaire*

The first trial was conducted with a research expert from New Zealand who had a good understanding of various expressions used by the industry. They also had a very good grasp on commonly employed contracts and procurement methods. This trial was essential in incorporating several major changes and in understanding the "logic of the questionnaire". The order and flow of questions was put up to scrutiny. Repetitive questions, or questions that may not have a very useful response were selected to be omitted. As a result of this trial, corrections to the usage of certain words were made, and multiple phrases that the participant did not understand were highlighted for correction.

2.4.1.2 Trial 2 – *architectural language*

The participant of the second trial was a member of academia, and also an architectural consultant. Because of their involvement with academic research, their understanding of technical vocabulary used in the questionnaire was very high. They were also able to answer, as well as suggest, improvements to questions related to contracts and client briefing methods. The primary advantage of this trial was the introduction of commonly used architectural terms and language. The phrasing of each question still required clarification and each was amended appropriately. Overall, the survey functioned with a much higher response rate to its questions from this trail because of the improvements it received after the first.

2.4.1.3 Trials 3 & 4 – *simpler English*

Interviewees 3 and 4 had a limited understanding of and experience in the New Zealand construction industry. However, they were very well-versed with architectural language. These trials interestingly highlighted some of the more verbose phrasings of the questionnaire. These confused the participants, and hindered their willingness to answer. These phrases were simplified. It was also observed through these trials that inexperienced respondents may not be able to answer questions about contracts and client briefing, which advised careful participant selection.

2.4.1.4 Trial 5 – ***open-ended questions***

Trial 5 was also conducted with a researcher and practicing architect. The most significant realization of this trial round was that the questions were close-ended. While other trials had yielded descriptive answers despite this fact, trial 5 indicated it may not always be the case. With this in mind, the questions were changed to be open-ended where possible. The flow of questions was also changed so each question would naturally lead to the next.

2.4.1.5 Trial 6 – ***New Zealand terms***

The final trial was informative in changing some of the terms used in the questions because of their common use in New Zealand. It was found that by this stage, the questionnaire was easily comprehensible to a person with no industry experience, and a basic understanding of architectural jargon. There were also no requests for clarification, no confusion over the meaning of a question. This trial was significant in confirming the usability of the questionnaire.

At the end of the questionnaire trial period the survey was reviewed once more, before applying for Human Ethics Approval. An application for approval was submitted on, and suggestions were received from the board with respect to the leading nature of the questions. This aspect was improved upon, and an approval was received on 17th August, 2016. The memo of approval is in the Appendix.

3 Participation

3.1 Sampling

The study population was architectural professionals in the building design industry. Findings from the literature review and the case study both revealed that design management should be the responsibility of those with many years of experience. Senior architects and design managers are responsible for implementing the company's ideals at project level. They are best positioned to know what management techniques are used during design and how they adapt and use new techniques (Sadler, 2011). Because of this, the sample was filtered to architects with a professional experience spanning greater than 15 years.

The time constraints of this study also decided the region of participant selection to be Wellington, based on ease of access. The architects were selected off of the New Zealand Registered Architects' Board website which lists currently registered architects, the number of years they have been registered, and their region of practice. The 20 selected practices were based in the Wellington region, and each selected participant had 17-35 years of experience in a wide spectrum of building typologies. Their businesses ranged in size from micro (1-5 employees) to small-sized firms (20-25 employees).

Potential participants were sent an introductory email with basic information about the study, and the VUW Ethics Committee required participant information sheet detailing the subject of the questionnaire, the time it would take to complete it, where and how it would be conducted. It was made clear that their participation was voluntary, and that they were allowed to end the interview at any point of its duration. They were also assured of anonymity in the recorded information, and subsequent report and any conference or other paper. No incentives were offered for participation. Documentation of this process is provided in Appendix.

The first invitations to participate in the study were sent out on 7 September 2017. Twenty potential participants were contacted.

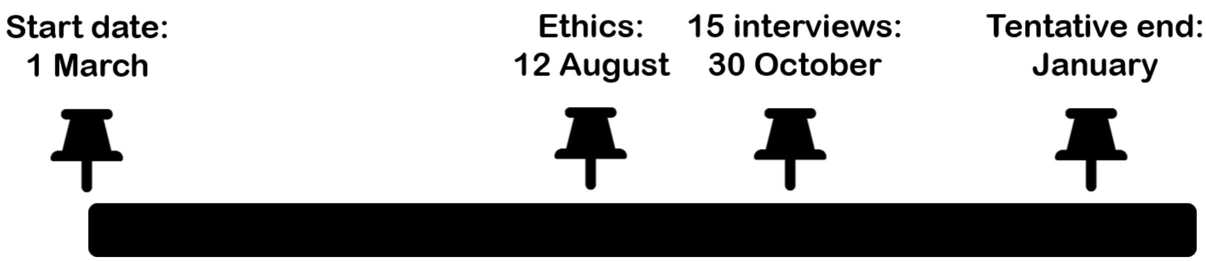

Figure 11: *Timeline of methodology execution.* ***Source:*** *Author's image.*

3.2 Interview

Each interview was conducted with a timeframe of 30mins in mind, however most were extended into 40-50 min mark with a few stretching to around 90mins. Most participants provided well-detailed responses and understood the questions as they were intended to be understood. Outside of the interview structure, additional questions were asked in such a way as to help the respondents elaborate some answers. At the end of each interview, every respondent was asked “Are you familiar with Lean Design Management?” Every response was recorded, and later played back and transcribed for analysis.

The collected data was full of information that need coding and categorizing. This helped uncover patterns and outliers in the responses, and to identify them with concepts presented in the literature review. Although certain issues related to design management were already identified through the literature review, and through the case study, it was believed that an analysis of the responses would turn the focus on other issues so far undisclosed to the study. Codes were developed for generic phrases repeated between multiple respondents, which highlighted common themes in the responses. Codes were also assigned to terms that were unique to each participant.

Table 5 summarises the interview code allocated to each participant (beginning with "P"), their area of expertise, the company size they worked in, their years of experience and their current position. The coding sheet linking the interviewee name and interview code is held securely and will be destroyed with the detailed interview records as noted earlier.

Code	Area of Expertise	Company Size (people)	Experience (years)	Position Held
P1	Commercial	1-5	26	Director
P2	Residential/Commercial/Public	10-15	27	Director
P3	Health Care	5-10	29	Director
P4	Residential	10-15	28	Sr.Associate
P5	Residential/Commercial/Institutional	10-15	28	Director
P6	Residential/Commercial	1-5	30	Director
P7	Sports Facilities	15-20	18	Director
P8	Commercial/Institutional/Industrial	20-25	15	Sr.Associate
P9	Urban Planning	15-20	17	Advisor
P10	Seismic Resilience	20-25	20	Director
P11	Residential Renovation	1-5	25	Director
P12	Residential/Public	1-5	29	Director
P13	Residential/Commercial/Product design	5-10	15	Director
P14	Residential/Health Care	1-5	19	Director
P15	Residential/Commercial	20-25	35	Director

Table 5: *Expertise, experience, and position held by respondents*

Chapter 4:

Analysis

Chapter Summary

As discussed in the previous chapter, the process of data collection was split between the case study and an interview with industry professionals. Several overlaps exist between the content of both processes, however the case study primarily focused on repercussions of design inefficiencies on the construction phase. While the interviews discussed design management aspects such as creation of a client brief, information flows between stakeholders, designing in modules and considering prefabrication etc. Data extracted from both methods has been summarised and presented in this chapter.

Of the 20 architects invited to participate, 15 (75%) consented to be interviewed, 2 refused citing a change in profession or unavailability, and 3 did not respond. The first interview was conducted on 8th September and the last was held on the 27th of October. This chapter reports the analysed data collected through these 15 interviews with architects in the Wellington region.

The analysis was carried out on transcribed responses of the interview participants. The transcripts were imported as data sources into the software and each transcript was first individually coded using the NVivo software. The codes were created manually, by rereading the transcripts. All coded data was categorized into 14 different nodes, or themes discussed throughout the interviews. Because the same questions were asked of each participant, these themes were uniformly covered by each respondent, in varying degrees of detail. For clarity during data analysis, the nodes were labelled according to the subject matter of the coded text e.g.: "briefing" or "early contractor involvement".

These nodes were then analysed for common trends or unique answers by creating a data matrix for each node. The matrix consisted of case nodes (the participant number) as column data, and theme nodes (subjects covered in a response) as row data. This made comparing or drawing parallels between multiple respondents easy. At the next step, all matrices were then aligned next to each other to highlight connections between different nodes or themes.

The following is an elaboration of data housed in these 14 nodes, as well as data collected from the case study. Additionally, the written contents of this chapter are helped by visualization in the form of relationship diagrams. Analysis of the data helped compare the lived experiences between different case nodes. However, rich text data is difficult to compare by itself, and thus comparisons were visualized through comparison diagrams. Similarly, case nodes with common responses were clustered together and presented in diagrammatic form. All images were generated on the NVivo software platform and imported into this report.

1 Analysis 1: Case Study

The following is a summary of the case study, resulting from discussions around the meeting table on the different project stages.

1.1.1 Project Initiation

At the start of the meeting the client noted that the contract had set out the scope of work and persons responsible for delivering it. However, unforeseen circumstances during the course of the project caused the originally commissioned architects to pull out of the project, leaving the team with an incomplete design. The fees, time, and effort spent on the design process until that point could be interpreted as waste since the design was never completed or built. Due to a stringent project schedule, the responsibility then fell on the contractor to complete the design work for construction. Although this was a major and sudden addition to the scope of work on the contractor's part, the contract was modified to "achieve the objective" rather than "complete the project". Uncertainty also prompted the project manager to amend the contract to be priced as a cost reimbursement. According to the standard contract terms (Standards New Zealand, 2013), under such a contract the client covers the contractor's expenses, including profit overheads. This motivated the construction team to aim for innovation and cost savings.

1.1.2 Design Stage

The client explained that the architects had led them from the design brief through to concept design before removing themselves from the project. Upon introducing the contractor into the design stage, not only were the previous designs scrapped, any value recognition and concept design definition work was also ignored in favour of what the contractor assumed was the right design solution. Although the end result was a built product that far exceeded the client's expectations, it was noted that the client wanted to be part of the planning process and wanted to offer their inputs to the design. In response to this, the contractor pointed out that the client's in-house engineering team did not have the technical know-how to provide the required design support. In the end, the participants agreed a design manager should have been present so as to accommodate a dialogue between two parties. Any person in such a role would have also facilitated staging of the design phase rather than the design team completing 100% of their deliverables before consulting the client.

The project managers suggested early contractor involvement as a possibility to be explored in future ventures. Early contractor involvement on a construction project allows contractors to offer their suggestions on the design proposal and opens the process out for identifying constructability risks (Snijders, 2010). In an ideal situation, the construction team's on-site experience keeps other trades aware of cost and time expectations. It also helps different stakeholders to familiarise with each other and acts as a team building exercise (Emmitt & Gorse, 2006).

1.1.3 Execution Stage

All parties agreed that a good rapport between the various stakeholders meant that there was an openness in team communication. Positive relationships among the design team ensured easy access to advice between team members. Design meetings progressively boosted the client's confidence in the contractor, however in discussion the client still maintained that a design manager should have been present to carry out inspections of site work. Because of this insistence, it was agreed that someone with a long history of experience in similar construction work would have been the best candidate for the role. A person contracted in such a role would have to be adept at identifying risks and providing useful advice so the project realigns with its critical path.

Further, several issues surfaced from a lack of coordination with consultants. Primarily, there was no construction methodology supplied to the contractor for specialist installations, and site work was more "guess work" than a structured program. The absence of a clerk of works, or similar monitoring authority on site was felt strongly when major variations were ordered, inflating the price of the project. Quality assurance checks were required, and no specific team members were assigned the role, leading to confusion and major delays. These issues led back to the problem of a redrafted contract that did not clearly outline roles or create opportunities for quality management. Consequently, the contractor was overtasked and underpaid.

The project manager suggested in the future the definition of roles in terms of time rather than cost, would avoid misallocation of price.

1.1.4 Monitoring and Control Stage

A pressing need for risk management became more and more apparent in this stage of the project. Due to the nature of infrastructure projects, the scope of work often involves construction activities during facility operational hours. This heightened risk was identified as an aspect that required vigorous monitoring. The consultants mentioned that they had learnt from previous stages, and specialist installations in high risk zones were given exceptional attention to reduce errors. Extensive pre-planning, and scheduling of works in off-peak hours helped deal with the foreseen problems. The consultants also noted that a carefully selected team of highly skilled workers made the job easier by eliminating uncertainties.

Additionally, the last day of each work phase was assigned for quality assessment, so that any divergences observed in the installations could be dealt with before moving on to the next phase. Because of this reverse engineering tactic, any complications that arose during this stage were dealt with comfortably without disrupting the rest of the program. All stakeholders agreed that this stage saw continuous improvement with every work phase.

However, from this experience, the issue of inefficient resource allocation was also brought forward. Because the riskiest work was undertaken by the best workers, all other parts of the project suffered major setbacks due to shortage of experienced personnel.

1.1.5 Close-out Stage

Despite the upheavals faced by the design and construction team through the process, the client was very satisfied with the overall result. The most commonly mentioned positive aspect from around the table was that notwithstanding the large risks overtaken by installation teams, all works were carried out safely and with no major mishaps. There was also an echoing of “good communication” and “good trust” within the gathering. This positive relationship was noted as an important key to knowledge exchange between project stakeholders.

The project manager made an insightful note that in most cost reimbursement contracts, the contractor does not give precedence to design innovation. It was surprising, then, that innovative design remained a strong driver on this project through the interferences the program faced. As an additional advantage, the cost savings because of the innovative design were enormous.

The negative feedback was centred on a need for a more structured design management plan. Because of the absence of one, there were many incidents on site that could have been avoided by more careful planning. While there was an openness within the team to learn from their mistakes, by the time protocols for risk mitigation were put into practice, that phase of work was already completed. A strong communication link kept knowledge exchanges congenial, however the designs provided incorrect material specifications and did not factor in the equipment available on site for the scope of work. As a result, material deliveries were delayed and a lot of time was spent on the maintenance of fabrication equipment.

This case study highlighted waste in the form of time, effort, costs, and the overarching issue of uncertainty stemming for an unsteady initiation phase. The discussion within this case study, the marked absence of an architect’s perspective, and the lack of a dialogue around waste management was identified as the knowledge gap. This gap was filled by creating an interview questionnaire that would specifically address these lacking points.

2 Analysis 2: Interviews

2.1 Classification of Respondents

This section explores the different attitudes of the interviewees, looking for common issues in order to best categorise them. The "nodes" mentioned below are a result of text coding and classifying carried out with the help of NVivo 11 software. They have been used here to gather together the responses. The node numbers are mentioned in the order they were discussed by the participants, under the design phase they are related to. The key features of the interviews have been briefly summarised at the end of the chapter in **Table 5**.

2.1.1 Node 9: Lean Design Management

This node was used as primary means of categorizing the respondents. This was done for ease of understanding the trends in architects' attitude towards waste, and differentiating the results from architects' behaviour towards waste, which is discussed under the other nodes. To record observations on the attitudes of architects to waste, each participant was asked the question "Are you familiar with the term Lean Design Management?"

The high awareness group (20% of the sample – interviewees P1, P6, P10) had a common history of working in the UK. They knew the basic principles of lean construction terminology, and acknowledged that information flows were the weakest link in the design process.

The medium awareness, and most populated, group (47%), had more than 25 years of experience. Despite not being familiar with lean terminology, they understood the concept of construction waste. However, their experiences with waste minimisation were limited to residential projects where timber was ordered to the right amount, and off-cuts reused. Some participants claimed that waste reduction was a subconscious phenomenon that occurred during design, but all cited examples of waste management were limited to recycling. P11 was conscious of material sizes, controlling the design scale, and using sustainable products. But since clients are driven more by cost than sustainability, they are not always receptive to "green" materials.

The low awareness group (33%) had an experience level of 15-20 years. This group neither knew about lean design management, nor considered waste reduction a priority in the design process. On being offered a clarification, P14 dismissed lean as a production tool that would be difficult to adopt in construction. P13 stated that the contractors their firm worked with used material upcycling strategies on site but these practices were not regular, only reflexive to material availability. However, value creation for the client was important to them, and they mentioned taking several measures to ensure that the client was happy with the design solution presented to them.

This classification into 3 distinct awareness groups (high, medium and low awareness) was further analysed for behaviour in the design phase. The following is a summary of responses to the interview questions, classified by design stages.

2.2 Concept Design Stage

Questions at the concept stage were related to the initiation and development of the design brief. Participants were asked to describe the briefing process, the number of meetings it took, and who was involved in the process besides the client and the architect. Most responses to this section were fairly aligned to be common, with outliers only being mentioned as anecdotes from one-off projects.

2.2.1 Node 1: Design Brief

Most respondents stated that the client brief is dynamic and continuously changes through the stages of the design process. Respondents P2, P10, P11 and P15 mentioned that their firm had established briefing strategies that defined value for the client at the conceptual sketch stage. P13 uniquely answered that design briefs were made static at the start and any future changes were "not allowed". This meant that solutions were heavily controlled to be right the first time. P1, P6 and P12 had a common response to how soon design decisions are made through the project: they all insisted that their projects were preceded by an initial period of research, which included macro (have similar projects been done before?) to micro-level questions (colours and textures) P11 said they like to mull over a decision before they present it to the client because in their eyes, “the first answer is not always the right answer”. P12 echoed this by stating that they would be very weary of hastily made decisions, and like to give the client time to think about a proposal, as well.

There were a small number of issues on which there was consensus from all the interviewees. This included the belief that every project is unique, as the phrase “depends on the (scope of the) project” appeared repeatedly on answers regarding briefing, design meetings, and design team structure. P4 and P6 stated that a client’s needs drive the project, but the terms of engagement set out early on must be very particular about alterations. Because large changes in later stages of design are costly and time-consuming for all stakeholders, architects highlight these costs at the start.

P15 summed up the pre-design phase as “the design brief is a live document that is audited at every stage, and updated at every stage” where the design is “challenged” at every step to confirm if it still stands in the positive when compared to the client’s brief, and what the client initially wanted. They did, however, note that the brief itself is also changing and so a dynamic design brief runs alongside a dynamic design while client and architect try to match the contents of each. The effectiveness of the design meetings lies in asking whether the designer and the client are the right match for each other, and then asking what the client is requiring to be designed. P8 echoed that the design brief is first drafted as a list of requirements from the client’s side and then takes on an architectural language once the architect enhances it by their knowledge. It is then a back-and-forth between the two parties to come to a coinciding idea and design.

P1 implied that architects provide the best professional guidance to the client in terms of highlighting the value of the project, by “enabling the vision” of the client. P2 revealed a system of in-house value engineering sessions. Smaller firms such as P11 and

P14 also showed their familiarity with the term “value engineering”, but did not have related experience beyond attending study workshops on the subject. In their eyes, value was built with design details, suggesting that the more detailed documentation a project has, the more satisfied a client might feel about the project. P3 and P5 mentioned “costing exercises” implying that value is associated with budget and these exercises are a way to contain the design within “what (the client) can afford”.

Despite concept stage being stated as the point of maximum interaction with the client and absorption of information, design iterations were not discussed detail. P13 noted that it was seen a waste of time to “go down a path that will lead to nothing”. P12 noted iteration as something that occurs when a client doesn’t particularly understand a proposal the first time, or does not realise the cost implication of the first option.

While all respondents assigned importance to the concept phase by stating that it was very necessary to create an outline of the client’s requirements at the start of the process, their responses were usually around the questions they asked of the client or the information extracted by other consultants (e.g. the geotechnical report). The practice of iteration, how many were explored and in how much detail, was not mentioned explicitly in any responses. This may be a limitation of the interview itself.

P4 was unique in highlighting that the designer must be problem-focused and not solution-focused to define the problem with the current setting, and to explore the best solution to the same.

2.2.2 Node 7: Design Decisions

As noted previously, most architects stated that they make design decisions as soon as possible. P7 illustrated that at the end of every stage of design a report of the development is presented with the reasons for each decision made within that stage, and cost implications. The client must sign these off before the architect can move on to the next stage. This takes the idea of a briefing dialogue to the next level where control of the project is passed between client and designer at every milestone.

Another approach was highlighted by P6 and P9 which can be summarised as: “we make decisions tentatively, but we’ll most likely make the best decision we can and move forward,” which implies that decisions do not hold the project back and a general program is always adhered to. P14 reiterated this in their answer when they noted that an overarching schedule dictates the project and deviations from it may be acceptable to residential clients, but commercial ones do not consent to delays.

P11 pointed out that most of the important design decisions are made early on for their projects as obtaining resource consent is a major part of progressing to the next step of design. Because of the exactness that a design proposal must attain before resource consent, there is very little room to manoeuvre through the project, or change things externally (form, volume, sizes etc.), so decisions become more focused on internal layouts and furniture.

P12 stated that clients are often more excited about discussing joinery and layouts while the architect tries to work out construction details. This lends to a mismatch in how the project grows for different parties.

2.2.3 Node 10: Modular Design

In a consensus, respondents explained that since most residential projects are currently refurbishment projects, there is very little room to work in design modules or employ material prefabrication. P3 pointed out that truss manufacturing is the biggest prefabrication industry in New Zealand, working to standard sizes, materials, fixing and spacing. P4 added that even in a new build situation, other forms of prefabrication or modular design are difficult to adopt in the residential design sector because they are usually one-off projects. New Zealand also makes it difficult to plan for prefabricated elements to be transported to site as the cost implications would be very high. P9 notes that prefabrication is considered as an option when there is a possibility for the site works to produce too much annoyance for the neighbouring properties. P1, however said that sizes prescribed on the design do not always get translated to the actual material, with the product often being imperfectly sized, causing differences of several hundred millimetres in the final dimensions of the project. P2 and P3 were involved in prefabrication projects for community skill-building exercises, where the very act of prefabrication was allowing the setting up of industries. These projects did, however, come about because of the very reason P4 cited for lack of popularity for prefab construction—sites that are too difficult to access.

P1 pointed to the fact that New Zealand practices used the imperial measurement system until 1969. The change from imperial to metric may not have been industry-wide immediately, which causes issues when ordering materials from suppliers to match existing buildings around this time period. They went on to clarify that this phenomenon is not limited to suppliers within New Zealand and ordering material from Europe has become difficult because of the cost implications of wrongly-sized materials not be returnable.

P1 also reported experiences from projects where structural engineers would not budge on their decision of bringing in monolithic steel frame members or prefabricated concrete structural members to site. While these decisions may have been valid from a structural engineering standpoint, their validity in terms of value to the client, and the absence of exploration of alternatives, was similarly highlighted by the case study.

2.3 Preliminary Design Stage

Questions under the preliminary design stage covered subjects like software applications, design changes, and quality management. This stage produced a variety of answers for each aspect, and particularly highlighted the relationship between an architect and their client(s), how architects perceive clients and the changes they are required to make through the design process.

2.3.1 Node 3: Reason for Design Change

The consensus on commercial and government projects was that the brief is very well defined early on. P3 and P5 agreed in that the concept design stage in such projects is dedicated to feasibility studies and negotiating the design. In other words, the design sees much more development in this stage than later, as far as commercial and public sector clients are concerned. P8 noted the reason for design change to be strict budgets and very stringent timeframes. P1 and P3 also noted this similarity with community group or NGO clients, who need to raise funds for the project and are very firm about costs and schedules.

Designs tend to experience the most changes in the developed design stage. Respondents unanimously stated that the most common cause of changes was budget limitation. This is because the concept design is made more spatially robust in the developed stage. Considerable change in client briefs later in the design is extremely uncommon. However, it was noted from the examples participants provided of these rare occurrences, that they were all commercial projects. Because of the nature of their projects, P9 cited “big picture” influences such as climate change or economic and political change as causes for design change. Their response provided an overview of how designs deal with change: “some changes can be dealt with technical solutions, some others you just have to wait and see.”

2.3.2 Node 4: Clients' Changes

P1 and P11 both mentioned that clients tend to see potential in every idea that is put forward by the designer. It is, however, very difficult to make them decide on any one idea and move to the next design item. P12 especially noted that when clients do not recognize the right option on their own, they have to be led towards a certain direction by the design team. The average number of briefing meetings held with the client ranged from 2-3 for every respondent. Some outliers existed where P2 reported a project where the brief was very well defined from the start, and no meetings were held until construction stage. On the other end of the spectrum was P9 who said that as many as 20 meetings were held on their current project, because of the large group of stakeholders it would impact. Typically the client is asked for a written brief of their requirements, and typically on residential projects the architect would visit them in their current home to understand how they live as per P5's response. P7 insisted that it was important to get the client's signature on consecutive design stages, as a form of approval. P13 uniquely noted that their designs do not allow any room for client changes. P15 noted, "it is important that the client plays their part when making design decisions. If they don't, then there's an issue for the designer."

Converse to this line of thought are the responses about unforeseen reorganisation to the project because of the client's decision to redesign. Some respondents such as P2 had never experienced client changes, but had a clarity for the decisions that would be necessary to make in such a situation. P4 stated that the scale of projects they work on made it easy to cope with the changes as long as the cost of the change is manageable. Unforeseen changes that lead to unforeseen developments on site often require a complete redesign. P6 explained that a client's unfamiliarity with the design and construction process leads to difficulty for the design team. They said, "what looks like a simple change for a client may actually take quite a lot of time to work through and process a new set of drawings. Some clients are more problematic in that aspect. Some clients love changing things." P8 highlighted the need to manage the process as it is not profitable for a firm to allow design changes with every project. P10 referred to adaptability and flexibility, but noted that the underlying concept and the size of the change are a reflection of ease of redesign. P12 related an incident when a client decided to change the site of the project late in the design process. This seems to be another echo of clients' general lack of understanding of the design process. P14 also focused on the fee aspect of the change stating, "if they change their brief it's outside of your control (...) it's costly to make changes but we've got that fairly covered with our engagement letter"

2.3.3 Node 5: Clients' Knowledge

P1 and P3 were consistent in pointing out that clients don't often know what is right for the project, however the design process is led by client's prerogative. P2 and P6 reported cases where the client had ordered changes to the design when the project was already on site. P2 justified it by saying the decisions must allow the designs to be reconciled with the costs. P3 noted on the subject of standardized design processes that the client often does not know about these terms and will not ask for modularization or prefabrication. However they also spoke of commercial projects where the clients know their business goals really well and know how they would achieve it through architecture. In those cases the project runs smoothly. P4 reported that the client doesn't understand procurement procedures. On the subject of building consents they said, "you really have to try to placate your client and explain the situation but also do everything you can to encourage whoever's not delivering to deliver." P5 added to this by noting that clients has very unrealistic expectations for the outcome of the design process. They base their expectations off of magazine photos and precedent images. The participant stated that, "those are difficult because often the particular site or requirements or budget or scope or climate don't reasonably respond to what they want." On the effectiveness of communication, P7 mentioned that some clients find it easier to react to SketchUp walkthroughs and Revit models, while others do not understand 3D images and need a solid model to work with. P9 followed this by revealing that clients may not always know what they want, or have an idea of what they want their structure to be but cannot express it. In their words, "we need to be good at listening, reading between the lines, have some patience. Our role is to look beyond what the client wants and see the bigger opportunity." P11 noted that their clients' unfamiliarity with resource consenting issues and quantity pricing leads to them advising their clients about making changes before pricing and consenting is considered.

2.3.4 Node 6: Design Costs

The most commonly cited cause for design changes was a client's budget. P6 and P13 commonly stated that client's unrealistic expectations were curbed at the start of the process, which is during the concept design phase. This kept a close check on the design brief and the design itself from being "inflated to dream-like proportions" in the words of P5. It is noteworthy that other respondents, particularly P3, had very different experiences wherein even as late as the documentation phase, there were multiple subtractions or alterations to the design so it would fit within the budget. In their words, "(the clients) have a number in their minds that they are sometimes hesitant to reveal, but it is there." This withholding of information may be the cause of late changes in the design.

It is equally possible, as reported by P8, that the client may change their mind on a whim, which is difficult for the designer to deal with on an emotional level.

2.3.5 Node 11: Design Quality

Issues of design quality were dealt with in various ways, with P3 stating that their designs were peer-reviewed within the firm. They stated that another director of the firm or senior designers are given the opportunity to review each design at documentation stage and illustrated it by saying, "it's amazing what another pair of eyes can find."

P10 described a well-defined quality assessment regimen where designs are assessed internally at 10%, 30% and 90% completion. The project is subjected to audits by an independent technical auditor. P9 also described a similar process in that 30%, 60% and 90% are considered major points of design discussion and peer-review. The design also undergoes testing by creating dialogues with clients and end users where the proposal is put forward and described in detail, and receives comments from an audience. Additionally, they noted that communication with other consultants and team members is important for design quality.

Several respondents mentioned building consents as an additional process of quality monitoring, wherein construction documentation undergoes scrutiny from territorial authorities to ensure that designs comply with codes and standards. P8 and P13, on the other hand, perceived the question as doubting the quality of their work, rather than the monitoring of said quality. When asked, they could not define the term "design quality". P13 clarified by saying, "There is no degrees in the quality that we deliver (...) you have to adapt to that, to not accept a project if it is under the standard in which we think we produce. That doesn't mean the project at all, it means people."

P14 represented another version of this response by noting material selection as an exercise in quality management. To them, finding the right material at the right price is a form of monitoring the quality of the final constructed project.

On the aspect of communication, while the participants themselves were very clear in construing their responses, and in clearly laying out the process of design briefing and the development that follows, it is difficult to know if these skills are shared by the cross-section of their firms. The composition of the design team itself shows that designers with experience are often shadowed by graduates—P3 described a residential project a graduate assisted them on, and noted how steep the learning curve was due to the complexity required by the design. The transference of skills through this practice, and the training regimen for graduates outside of project experience, was not investigated by the interviews. In hindsight, this was identified as a limitation.

2.3.6 Node 13: Design Software

On the subject of new recruits to the design team, the only requirement highlighted by respondents was the ability to use Revit. All respondents said that knowledge of commonly used design software was a must for recruitment. This, they claimed, was another measure of quality management. Participants were also of the opinion that the architectural market currently faces a severe skill shortage, pointing to the possibility that the current graduate pool does not meet the requirements of hiring firms. There is a grey area around the specific requirements graduates must meet. While this was not explored in detail by the interview, the subject of software itself was inquired upon.

Many respondents stated that they first work on concepts by hand, citing difficulty in using software. In general, once a certain level of information clarity has been reached between the client and the architect, these designs are transferred onto a soft model by technicians. This may be ArchiCAD or Revit. P4 explained that the conversation between these two versions was usually via hand-written mark-ups on printouts of the soft model.

Some participants such as P2 and P6 differed in that they had replaced hand drafting with SketchUp models. P3 stated that in certain cases the site itself had to be modelled extensively on a software, while P1 revealed that for challenging retrofit projects, the design team resorted to point-cloud scanning. P11 stood out in their response by stating that they tend to try new software once in a while as a skill improvement challenge, but otherwise completely hand-draft all their work because the scale of their projects does not require exploration of forms and detection of clashes.

2.4 Developed Design Stage

Questions under the developed design stage delved further into relationships within the design team by asking questions on the configuration of a design team, team meeting schedules, causes for project delays, and human resource issues. This section once more provided common responses. The aspect of information flows was discussed under this section and industry-wide human resource issues were revealed.

2.4.1 Node 12: Design Schedule

One of the recurring responses to issues of time delays was that the processes of obtaining resource and building consents take too long. All participants were of the belief that codes and standards by themselves do not add to the project cost or schedule, as they are considered knowledge any designer must have. However, respondents believed that the processing officers of territorial authorities add time delay by asking for too much clarification. P8 revealed that a completely different set of design drawings are prepared for building consent assessment, with more information and project specification than in detailed design documentation. This may be because the consented documents are to be kept on the construction site for the foreman to access at all times. It is, however, questionable as to the similarity of these documents with those sent out to tender.

P3 interestingly responded that the building consent process, to them, is another method of design quality assessment as “it is amazing what a second pair of eyes will notice”. P14 on the other hand, seemed to consider the consenting process as a constricting set of compliance rules that leave no space for architectural creativity.

Time-poorness on the client's part was cited as a reason for limited exploration of value in designs. P14 said "the analysis happens outside of the client meeting but getting clients to talk about anything for half an hour to an hour is really difficult." Respondents that have had previous experience working with commercial clients have stated that it is a lot easier to define the design brief in these cases, as a management team outlines clearly the opportunities and constraints of the project. The end use goal is also much clearer in these cases. P3 pointed out that commercial design teams try to push for earlier project deadlines as the client's business may undergo broad economic changes, some which may be unfavourable for the construction project.

Contrarily, residential clients often take months to "make up their mind", and these projects are put on the backburner for other projects. P2 stated that clients in these cases will have a rough idea of what they would like, but they do not commit to making decisions until the project is under construction. P7 said that visual support to the design process (3D and scaled models) prove to be very helpful in times of client indecision because clients do not read 2D architectural drawings the way professional designers would be expected to. P1 echoed this line of thought, going a step forward by suggesting 2 versions of documentation must exist throughout a project—one for the design team, another for discussions with the client, with the second usually in the form of a Revit model.

2.4.2 Node 14: Design Team

Most respondents stated that the design team was briefed on the project after the concept stage. P14 provided insight by stating "I need to understand what the project costs are before I get someone involved." This is extended to the external team of stakeholders as well, as P11 noted the architect must understand the project and everything it entails before they can instruct someone else.

P1 and P8 stated that on projects that the firm wins by bidding, the team is briefed from the start of the project. Some respondents like P3 and P4 noted that the design team within the architectural office is very small and can be out together as soon as the client has supplied the first brief, however P3 went on to state that the team members would be expected to have their own understanding of the written brief produced from meetings with the client. P5 clarified that on residential projects there is often only 1 person on the job. On bigger projects there is a lead designer with one or two assistants. P6 (2 persons) and P13 (4 persons) had common answers in that there is always a fixed number of people working on a project at any given time. The structure of this team was elaborated by P7, where they stated that a director or senior associate is involved in every project with assistance from a graduate. The workload is divided between these two persons until documentation stage when technicians are introduced to the project and a team of as many as 6 can be working on a big commercial project at a time. P12 had a variant of this response in that the design is led by one experienced architect, and other members are introduced at preliminary design. P4 interestingly added the client to the design team, justifying it by stating that the dialogue established between the client and the designer is important. P10 were unique in noting two distinct roles for project design and project management.

2.5 Construction design Stage

At the construction stage, participants were asked about the intersection the design team with the construction team. There was a spectrum of responses on the subject of interactions with builders and subcontractors. The general overview of this stage was that projects often lack continuity in terms of them changing hands within construction firms. Architects also revealed that they would prefer to work selectively with only experienced builders.

2.5.1 Node 2: Constructability

P1 noted that the access to the site and the ease of building a proposal were the most important aspects to consider for buildability. They also echoed issues highlighted by the case study in that materials, their application on site, the related equipment required, their procurement lead times, are all important to discuss beforehand so that there are "no surprises on site". P2 mentioned again that the final design should be acceptable to the client, and meet their parameters for cost, time, and quality. P4 stated that keeping the designs predictable and "familiar to the builder" made it easy for project completion on the stipulated budget and schedule. Radical design solutions take too long to manoeuvre through in terms of constructability, and are often adapted for something simpler on site anyway. They did, however, point out that design work assumes perfect situations whereas realities on site often lead to varying levels of change to the proposal. P3 markedly pointed towards gathering as much information about the site as possible. In their experience, contaminants and unknown hazards found during excavation are known to often hold up the building process than anything else.

P1 also mentioned that architects' experience of on-site risk assessment is very limited in comparison to construction teams. This is one of their reasons for preferring to have a contractor on board from day one. They noted, "You'll want a contractor who has had good experience so that they can know all the things that can trip you up and someone who's quite vocal, who'll say their piece". Another advantage of such exchanges, they said, was the point that whole-of-life assessment of the design is easier to make when construction and post-construction teams (maintenance etc.) are more involved in the design meetings. Because the architect only has one perspective of the whole situation, several assumptions are made in order to complete the project. P4 interestingly said "the architect and the client, that's the design team".

P2 had a different perspective, saying it is very important to maintain continuity in the project—persons who start the project must see it through to the end. Because ECI (Early Contractor Involvement) projects in their experience have not offered that continuity, they found that the site foreman decided to take things their own way, throwing a lot of the design meeting decisions wayside.

2.5.2 Node 8: Early Contractor Involvement (ECI)

About early contractor involvement, most participants had positive things to say about such practice. But only P11 claimed that they sought contractor inputs in the design phase for all their projects. The rest explained that if the client did not demand it, they would not engage a contractor during the design phase. All respondents believed that clients "don't know how much they don't know (about the industry)"

The lack of the contractor's involvement in the design phase was highlighted by all respondents stating that ECI is something they find beneficial, but cannot implement either because the client already has someone in mind, or the PM (Project Manager) drafts the contract in a manner that does not allow for ECI. P5 and P9 both stated that ECI is sometimes avoided because the contractors who are involved in the design phase expect to be tendered the construction works as well. P2 notes that this would be an ideal situation as continuity is necessary for the discussions during design meetings to materialize on site. However, the contractor may decide to quote higher overheads and P and G (Preliminary and General) rates if they are certain of being given the job.

P3 illustrated a different scenario where the tendering process is carried out earlier and the job is awarded to a contractor based on the specific requirements entailed by the design, rather than the cost of construction. In this case, it is possible to have a contractor on board from the beginning of the design process, all the way through completion. P11 noted that they follow a similar process for every job, since they work primarily in residential retrofitting work, and the constrictions set by existing site conditions are easier to manoeuvre through because of the inputs of the post-design team.

P1 pointed out that architects and designers are not always aware of the health and safety risks associated with site work, which makes the presence of the contractor during design meetings much more valuable. P10 stated that the regulations around health and safety have seen a recent update from the territorial authorities around the country, which has made it much more difficult to design with freedom. P6 also stated that too much cost is associated with safety-proofing sites with unnecessary measures that hinder movement and cause delay to the construction process, rather than aiding it.

2.6 Summary

Table 6 provides a brief summary of the issues discussed in this section. For each node number it give a description heading, the section number and key point(s).

Node	Description	Section	Key Point(s)
1	Design Briefing	2.2.1	Design briefs are live and continuously changing until the drawings themselves do not earn clarity.
2	Constructability	2.5.1	There is no consensus at to what helps the project's constructability. Answers ranged from traditional material specification, to health and safety, to designing to codes and standards.
3	Reason for Design Change	2.3.1	The most common cause behind changes was the client's budget. However, these changes were not always about reducing the scope of the project, they may also encompass including earlier concepts that were rejected.
4	Clients' Changes	2.3.2	Clients are the largest stakeholders in any project, with changes demanded by them ranging from positive definition for the designs, to confusing iterations that lead to rework.
5	Clients' Knowledge	2.3.3	The client's knowledge was commonly criticized by all respondents, highlighting that the project suffers from unrealistic demands, withheld information, and lack of realization of design implications.
6	Design Costs	2.3.4	Design costs are usually made clear at the engagement stage, with variations and rework being charged on hourly rates. Most respondents noted resource consent procurement as being the most difficult and expensive process.
7	Design Decisions	2.2.2	Design decisions are always made as soon as possible, with only few respondents stating they "like to mull over it". Respondents also said that clients often take months to make certain decisions which leads them to move on to other projects.

Node	Description	Section	Key Point(s)
8	Early Contractor Involvement	2.5.2	ECI was noted to be beneficial by every respondent. However, experiences were mixed in that some had very rarely employed a contractor, while others had a practice of bringing the contractor team on board before construction documents were produced.
9	Lean Design Management	2.1.1	The awareness level varied, with some knowing various aspects of it and employing it in their office management systems, and others commenting that it is a production industry tool that could not apply to construction.
10	Modular Design	2.2.3	Some respondents had previously dabbled in modular design and noted that it was for projects with difficult access. Meanwhile, others knew of the concept and said it seems like a positive move ahead but difficult to implement for Wellington terrain.
11	Design Quality	2.3.5	Design quality was interpreted in multiple different ways, with some respondents commenting on technical quality, and others on workmanship. Various management methods and checklists were mentioned by each.
12	Design Schedule	2.4.1	The program set at the start of a project was the main guidance tool for most respondents. Residential projects were noted to not have very strict schedules but commercial ones would push to follow the program vehemently.
13	Design Software	0	Although Revit was mentioned as the most commonly used tool, most architects noted that they begin the concept design by sketching their ideas out. Interestingly 3D models were noted to improve visualisation for the client, but concept stage was dedicated to absorbing the most amount of information.

Node	Description	Section	Key Point(s)
14	Design Team	2.4.2	The design team was described in detail by some respondents, and as a general guideline by others. Commonly, there is a clear hierarchy in within this team. Team briefing was usually done after the key players had a defined understanding of the client brief. Meetings were noted to be held periodically and often informally within an office. Not much was said about teams being a source for iterations, but offices with multiple branches often exchanged resource.

Table 6: *Key points discussed in the interviews, and their corresponding nodes.*

Chapter 5:
Discussion and Conclusions

Chapter Summary

This chapter is a discussion on the contents of the analysis of text data. The literature review had formed a canvas for understanding concepts such as architectural design management, and attitudes towards construction waste. Data collection provided a glimpse into the New Zealand industry where these matters are concerned. To maintain a connection with the analysis process, this chapter is a mirror of the previous one, in that a discussion is presented on the individual nodes introduced in the previous sections. For clarity, **Table 6** is a summary of the key points noted for every node. As part of the bracketing process described in the methodology, there was a necessity to divide these two chapters into separate accounts to create a distance between the actual situation within the industry and the comments that can be made from relating this data back to the literature review.

This chapter presents deductions made from the data collected, and their connection to key aspects of the literature review. As such, it is a link between the literature and the analysis and discusses the current state of architectural design management in practices within Wellington. Additionally, it presents recommendations based on the literature and aspects covered by respondents as important issues that need addressing for better management of designs. At the end of the chapter, a collective conclusion is reported, bringing the conversation back to a previous New Zealand study of attitudes and behaviours towards construction waste. Parallels are drawn between the studies and how these relate to the initial research question of this report is also clarified. Several questions are raised based on the findings of the analysis chapter to pave the way for future research in the subject. Limitations of the study are also discussed.

	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	N12	N13	N14
P1	Green	Green	Green	Yellow	Yellow	Green	Green	Yellow	Green	Yellow	Green	Yellow	Yellow	Green
P2	Yellow	Yellow	Green	Yellow	Yellow	Green	Green	Yellow	Yellow	Green	Green	Yellow	Yellow	Yellow
P3	Red	Red	Green	Green	Red	Green	Green	Yellow	Yellow	Yellow	Green	Yellow	Green	Red
P4	Red	Yellow	Green	Yellow	Red	Yellow	Green	Red	Yellow	Red	Green	Red	Green	Green
P5	Yellow	Yellow	Green	Green	Red	Yellow	Green	Yellow	Yellow	Red	Green	Red	Yellow	Yellow
P6	Green	Yellow	Green	Green	Yellow	Green	Green	Green	Green	Green	Green	Red	Yellow	Green
P7	Green	Yellow	Green	Green	Yellow	Red	Green	Yellow	Red	Yellow	Green	Red	Red	Yellow
P8	Green	Red	Yellow	Green	Yellow	Green	Green	Yellow	Red	Yellow	Red	Yellow	Yellow	Green
P9	Green	Green	Green	Red	Yellow	Green	Green	Yellow	Red	Red	Green	Red	Green	Red
P10	Green	Green	Green	Yellow	Yellow	Green	Green	Yellow	Green	Green	Green	Yellow	Yellow	Green
P11	Green	Yellow	Green	Red	Green	Red	Green	Green	Yellow	Red	Green	Yellow	Red	Green
P12	Yellow	Green	Green	Green	Yellow	Green	Green	Green	Yellow	Red	Green	Yellow	Red	Yellow
P13	Red	Yellow	Red	Red	Green	Red	Green	Green	Red	Green	Yellow	Green	Green	Green
P14	Yellow	Green	Green	Yellow	Yellow	Green	Green	Red	Red	Red	Green	Yellow	Yellow	Green
P15	Green	Red	Yellow	Yellow	Yellow	Green	Green	Yellow	Yellow	Yellow	Green	Yellow	Yellow	Green

Table 7: *Responses of each participant to each node. The colours denote positive (green), negative (red), or neutral (yellow) responses.*

The following sections present conclusions of each node response, with some nodes combined due to the results of the data collection process. In **Table 7** the responses to these nodes by each participant are recorded based on positives and negatives against the key points recorded in **Table 6**. For example, under N3, the key point raised by respondents was that the client's budget influenced design changes. Responses to Node 3: Reason for Design Change are recorded as positive ("the budget is the most common cause behind design changes") for most participants, negative for P13 (they practice a very strong control over the design and do not allow for changes) and neutral for P8 and P15 (they reported reasons besides the budget for changes in design) This table is a graphic representation of the case node vs theme node matrix produced on NVivo from the analysis process. In the following sections, each node is discussed with reference to the literature review, the findings of the interviews, and a conclusion drawn from both.

2.6.1 Node 9: Lean Design Management

Shadowing the literature review are the findings of the interviews wherein participants displayed a wide range of awareness of lean principles and their application to design management. The question inquiring after awareness revealed 3 distinct groups with striking commonalities within them.

The high awareness group could hold a discussion about lean construction and design management by covering several key aspects like control of information flows, value improvement, and prioritising waste as a by-product of design. These respondents shared a common denominator in having overseas work experience. They held a positive belief that lean design management is the way forward for New Zealand construction. However, their high awareness did not necessarily translate into their behaviour, with only one respondent implementing lean within the workplace because of their company's organizational policies.

At the other end of the spectrum the low awareness group stated that waste is not a priority for the designer, as design is about exploring value for the client and providing high quality design solutions. However, like the high awareness group, P13 was an outlier in this group. While waste was not dealt with directly in their designs, they aimed to recycle materials from old structures on every retrofit project. They also selectively work with builders who specialise in material upcycling.

The medium-awareness group followed this thought in describing waste as a product of site operations or poor material choices. Decisions and actions in the design phase did not have a presence in their discussions of waste, and lean was condensed to being a tool that requires implementation at the construction end. Interestingly enough, while this group did not use any lean terminology, some of their responses did reflect implementation of lean to their practices. This exposes the variation in attitude and behaviour in the studied sample, and the correlation between level of awareness and contrasting behaviour.

It is also important to note that design management is not a specialized role that exists distinctly from the creative processes in a project. Architects are required to perform the duties of a design manager alongside performing the duties of their own profession. Their work requires them to manage the design process, coordinate with the construction team, as well as producing designs that embody the requirements of the client and reflect the brief through drawings. This reflects overwork and may be a reason why architects are hesitant to implement management principles. It is understandable that solo practices, or firms with 1-5 employees may find it difficult to achieve this. However this trend is also noticed in larger firms with 20-25 employees specializing in design.

It is reasonable to conclude from the above that the concept of architectural design management is still at a fledgling state, at least in the region of Wellington, with no standardized view across the spectrum of design practices in the industry.

2.6.2 Node 1: Design Brief and Node 7: Design Decisions

Creation and definition of the design brief is an important stage in the design process. To quote Oyedele & Tham (2005),

> *"It is the starting point for the generation of the design. The architect's precision in taking a brief will reflect their ability to understand the client's corporate objectives, forethought and consideration of users' requirements, thereby identifying and prioritizing project objectives, analysing the design concepts and requirements and ensuring design conformance to owners requirements."*

The literature review found that design practices are often confused about whether the brief must become static after a point or remain dynamic until construction documentation stage. The interviews revealed a mix of responses where the design brief remained fluid until different stages of development.

However, answers to other questions revealed a contradictory practice. Designs do not always go through the iterative cycles which literature reports as positive. Respondent designers held 3 briefing meetings on an average before a client brief is deemed explicit enough to move on from concept design to the next steps. This is further reinforced by the fact that preliminary design was noted as the stage when designs went through the largest amount of change. It is reasonable to believe that the level of detail is only one reason behind these changes, and that another aspect of it could be linked to the client not fully understanding the implications of design proposals made in previous steps. One participant constantly pointed to this occurrence throughout their interview. Another stated that it is quite obvious the client will come with a written brief when they commission projects.

Where design decisions are concerned, architects seem extremely possessive of the ability to tap into the client's emotional requirements from a space. One respondent stated that they prefer not to have a project manager on their projects, because in their eyes the addition of one dilutes the client's requirements to "numbers and tick boxes". Architects generally prefer to make decisions for the client by presenting themselves as "emotional interpreters." Interestingly, some respondents have also noted their averseness to including other consultants in early design meetings from early stages because they do not want these other consultants to drive the project.

In conclusion, the briefing process in the Wellington construction industry is not standardised. Architects assign varying degrees of importance to the process of briefing, with some who constantly addressed the brief through their process while others seemed to isolate the brief to the concept stage and move on. It seems that findings of international literature on the subject could be applied to New Zealand as well, in that the client's requirements are not always seen as pivotal to the process, thus client satisfaction cannot always be guaranteed at the end of project delivery.

2.6.3 Node 2: Constructability and Node 14: Design Team

The literature review notes that constructability and interaction between the design and the construction team go hand in hand. The respondents had varying ideas of constructability, with some noting the choice of materials as being the most important aspect of design, and others stating functionality of the designed space. Unique answers included health and safety, good documentation, and building to codes and standards. The case study held the key on this point where it highlighted the necessity to discuss materials and site equipment before construction documentation. In the particular studied case, on-site mishaps, delays, and cost overruns could have been avoided by reducing uncertainties around site operations.

Additionally, the points raised on design team capability feed into this discussion. While the design process is led my architects with experience, they are often assisted by graduates or draft-persons who may not have the technical abilities of the lead architect or project director. Consequently, they may not fully understand the implications of specifying certain materials or construction methodologies. Because a majority of the design documentation work is done by graduates and technicians, it seems imperative that they be exposed to site operations and construction processes. To quote one participant, “(the graduates) may know how to draw it, but they don’t always know what to draw”. In such a scenario, the interaction of design and construction phases can be seen as important.

To conclude this section, it must be pointed out that the participants noted health and safety hazards are an unknown to them. Yet, the frequency of contractor involvement in the design process was very low. One respondent emphasised the reason as lack of continuity in human resource. Similarly, inexperienced team members providing a large amount of work based on assumptions seems to lend a likelihood for rework. While continuity issues may be a difficulty that must be overcome, the problem of missing or incorrect information between project phases and the risks it entails seems equally important to address.

2.6.4 Node 3: Reason for Design Change and Node 6: Design Costs

Cost plays a large role in changes to the design, according to the responses. It is interesting to note that while many pieces of literature discuss better ways for the design to conform and respond to the client brief, the interviews found that the main reason why designs are changed is the client's budget. Design iterations were not mentioned in any detail by the participants, however several anecdotes from the interviews deal with having to adjust the design to fit within the client's affordability range. It seems as if an integral part of the value development that must occur within the concept stage of the project is later subjected to compromise by sizing the project down, or reducing the scope, or in some cases redesign. Only one interviewee mentioned that "we don't work with (those) clients" who demand too many changes. This response may have been a reflection of the control they exercise on their designs.

Other responses lend to the belief that clients are reluctant to reveal their budget at the start of the project, which is withheld information. Additionally, it seems that design exploration is a very small part of the whole process, and ultimately the client receives what the architect can manage to deliver within the stipulated budget. One interviewee revealed that there were several projects they had designed that did not get built as a consequence of this process.

The findings of this node can be concluded by saying that design to project cost may **act** as the most important factor in design processes, but it may not necessarily **be** the appropriate response to a design problem. It is reasonable to believe that a client's expectations are not simply cheap and fast construction; the exploration of value must come from iterative processes. One respondent argued that if the answer is right the first time then there will be hardly any iterations. This seems unlikely as every project is unique and years of design experience may not always be sufficient to solve a unique problem.

2.6.5 Node 4: Client Change and Node 5: Client's Knowledge

The view that every project is unique also clashes with the view that some respondents expected all clients to have an equal level of knowledge about construction and procurement practices. They also assumed clients would have a "good" design brief from the start, implying that it is favourable if the client knows what they want from the beginning of the process. Clients who did not have very clear briefs were occasionally implied to be difficult to work with and meetings or discussions with them are time-consuming. In line with this is the fact that very few client briefing meetings are held to reach an explicitness in the brief. Only one participant stood out in recognizing that their clients have often never had any experience dealing with architects or builders and therefore require guidance in the process.

To conclude, it seems that the brief development stage is not recognized as design work, when in fact it is the framework that holds the project together. Most participants implied that if the client had their way, the brief would never be settled. It seems impractical to expect clients to know how the design brief should be created, when it should reach its definition and how it should be translated to drawings. One participant stated that it is the job of the architect to listen, ask questions, interpret, and converse with the client on the creation of this document. According to the literature review, this is the key to value management, but the participants' behaviour seems to hold a negative correlation with their attitude towards this subject.

2.6.6 Node 8: Early Contractor Involvement

Projects with ECI were noted to have a mixed response from the participants. Because of the nature of these projects, the contractor is allowed a greater say in design work than in traditional tendered contracts. The literature review revealed design-build projects as being well-managed and providing a better performance in terms of cost and schedule. While some participants noted that their interaction with contractors reduced health and safety hazards, and fed improvements into the methodology of architectural details that are difficult to execute, a majority of them mentioned that the option to employ ECI on a project rests with the client.

These responses imply that although architects may see a benefit in ECI, and have had good experiences working with contractors in the design phase, it is the prerogative of the client as to who they would want to build their structure with. Usually, it was revealed, that decision is based on the tender price, with the lowest bidder usually winning the contract. From the discussion of other nodes such as design quality and reasons for design changes, it seems that in most situations cost is the ultimate deciding factor on several aspects of the project, from who should build it, to how it should be built, to what should be built. The most important point to note in conclusion of this node, is how it is contradictory to Node 5—architects believe that clients are naïve when it comes to construction processes of design and procurement, yet allow the client to have a large amount of control over said processes.

2.6.7 Node 11: Design Quality and Node 13: Design Software

The literature review found a discussion of different aspects of quality. Thomson et al., (2003) noted that quality in the construction industry is associated with the skill of the designer, which is technical quality. Other studies have noted functional and architectural quality as being of paramount importance in the design phase (Emmitt, 2014; Alharbi et al., 2015). They note that in the majority of projects it is not the procurement route that gives poor quality but the quality of the client's brief — whether a design team is able to deliver a quality project, depends to a great extent on the quality and clarity of the client's brief. If the final version of the brief does not sensitively and comprehensively reflect and fulfil client aspirations, then the result will be a dissatisfied client and thus an unsatisfactory building.

Responses from the interviewees on design quality were by far the most varied and the most interesting. Some noted that reviewing the drawings internally or with the help of a peer-review is the most effective way of monitoring the quality through development stages. Other respondents said that designers were expected to adhere to modelling checklists when working on drawings. Two participants stood out in interpreting the question as an attack on their workmanship quality. This lends to the belief that there is no consistent idea of what architects think of the term "design quality" and their definitions, if they have any, are subjective to the scale of projects they work on or the size of their firms. It must be noted that these checks on design quality were all internal organizational, or technical, or architectural measures against poor quality designs.

One respondent stood out in saying that their office's use of BIM ensured that everyone within the design team worked to a particular protocol, and this protocol was carried into the work of other consultants. Where one federated model was used, there is the possibility of less rework and fewer clashes in structure and services occurring. This addresses functional quality as well as the other types described by literature.

It may be valid to conclude from these responses that a standard set of quality management principles is necessary for industry-wide use. This is because architectural drawings would have a level of detail and quality distinct from drawings produced by other consultants. Similarly, information in construction drawings would be very different from information provided by interior fit-out design drawings. So that these different trades can communicate seamlessly with one another, a standard drawing practice and a standard software may help reduce confusion and inconsistencies in design information. This does not seem like a very difficult issue to deal with as most practices in New Zealand already use the same software for their design work.

2.6.8 Node 12 Design Schedule

A majority of respondents stated that their projects do not always finish on time. The idea of a fixed program does not exist on residential projects. However, on commercial projects there is a strict set of limitations on both budget and schedule. The architects responded that any delays are caused either by weather conditions such as high wind and heavy rainfall, or due to unforeseen site conditions. Contamination discovered on sites during excavations, or the presence of asbestos on retrofitting projects is a hindrance to program milestones being met. One also noted the client's "interference" in the project as a time delay. Participants claimed that clients like to think about design proposals for a long time, but expect the designer to come back to them within unrealistic timeframes. One summarised it by saying, "Architects overpromise and under-deliver. We don't always understand how long it will take, or what the process needs. Sometimes there's too many projects and too little people. It's quite common." On the other hand, another participant uniquely mentioned that they only work with contractors who can deliver the project on the promised time.

These responses reveal another raft of deviations where no set idea of design schedules and deadlines exists. It may once again be concluded from this node that participants believe cost is the most important aspect of the design process. Schedules are compulsory to follow only when business goals are necessary to be met. Coupled with the observation that iterations in design are not explored and adequate time is not spent on communicating with the project stakeholders, architects seem to rush through their projects as fast as they can because an inordinate amount of time is being spent on another part of the design process. This is reinforced by the general response that resource and building consent processes were reported to take more time than is necessary. While they may be essential parts of the process, if they are not as efficient as they need to be, the program is affected.

2.7 Conclusions

The research question "can lean design management be used by construction projects in New Zealand to reduce waste in the design phase?" has not been completely answered as most of the aspects studied under design management have no standard answer through the cross-section of architectural practices. There are limitations to this study in that it was only carried out within the city of Wellington. However, some striking conclusions have been made through the process and can be summarised as follows:

1. In comparison with the Jaques (1999) study, conducted some 18 years ago, waste management in construction projects is still assigned a low priority. The more significant finding is that a majority of architects relate waste reduction with residential projects, as exhibited by the responses of the interviews. While concepts such as lean design management are slowly being adapted and recognized by the New Zealand industry, the uptake is too slow because of very little contact with innovation on the global scale.
2. Echoing the 1999 study, prefabrication and standardisation is still seen as a niche market and a novelty process, reserved for clients who specifically ask for it. The process is seen as costly, and difficult to implement in New Zealand terrain, unless it is for large scale construction that has a ripple effect of supporting communities and regenerating cities. Hidden under these responses is the fact that most new timber-framed homes in New Zealand are fitted with prefabricated trusses.
3. Another parallel between both studies is the common rhetoric of clients' lack of awareness about design and construction practices. While architects identify the issue, the majority of them do not guide their clients towards prioritising waste minimisation through the design process. This and the above findings pose important questions about the future of waste minimisation in New Zealand, and the building industry's inertia in adopting new ideas or systems of management.
4. Besides these findings, the interviews lent an observation that cost is seen as a primary decision-making factor in construction projects, schedule is mostly

important in commercial projects, and quality does not have a standard definition. Design refinement is largely dependent on the budget of the client, while a quality management process like building consent assessment has been reported to be time-consuming and a non-value adding activity.

5. There is very little cross-trade communication between design and construction. A minority of architects have established a process of early contractor involvement on all their projects, reporting cost and time saving as benefits of following the process. Interestingly, architects who do not employ ECI on their projects also see a benefit in it. Cross-trade communication within design practices is positive between architects but may not necessarily be so between architects and other consultants.

In light of these conclusions, it is important to state that more research is required into the subject of design management within the New Zealand construction industry.

2.8 Future Work

- The exploration of attitudes and behaviour towards waste in smaller cities of New Zealand may give a more complete picture of national trends on the subject of waste minimisation in design.
- International studies have provided insight into the attitudes and behaviour of architects, as well as surveyors, project managers, contractors, and clients in different parts of the world. This can be an avenue for future work in New Zealand as well.
- Post-earthquake Christchurch and, recently, Wellington have seen several buildings be condemned to demolition because of their lowered safety standards. The implication of such large-scale demolition work on the waste stream is an important point to discuss. The down-cycling of demolition material may present an opportunity for future work.

Chapter 6:

Appendix

Ethics Approval Memorandum

TE WHARE WĀNANGA O TE ŪPOKO O TE IKA A MĀUI
VICTORIA
UNIVERSITY OF WELLINGTON

Phone 0-4-463 5480
Email susan.corbett@vuw.ac.nz

MEMORANDUM

TO	Tanvi Bhagwat
COPY TO	Nigel Isaacs
FROM	AProf Susan Corbett, Convener, Human Ethics Committee
DATE	17 August 2016
PAGES	1
SUBJECT	**Ethics Approval: 23228** Lean Design Management in New Zealand

Thank you for your application for ethical approval, which has now been considered by the Standing Committee of the Human Ethics Committee.

Your application has been approved from the above date and this approval continues until 28 February 2017. If your data collection is not completed by this date you should apply to the Human Ethics Committee for an extension to this approval.

Best wishes with the research.

Kind regards

[redacted]

Susan Corbett

Convener, Victoria University Human Ethics Committee

Email Correspondence with Participants

Dear X and Y

I am a Master of Building Science student at Victoria University of Wellington. I am currently working on a thesis which aims to investigate the implementation of environmental design management principles in New Zealand.

I would like to invite you to participate in a survey consisting of questions relating to design management. Upon receiving your agreement to participate, this interview will be held in a space of your choice, whether in your private office or a café. It will last for a maximum of 30 minutes. Your responses will be recorded on an audio device, and then later written up and analysed. You will be free to stop the interview or pause to ask me questions at any point during this time. A short discussion will follow the survey to review your responses to the interview. For more details, please see the attached Participant Information Sheet.

This questionnaire has been approved by the Victoria University Human Ethics Committee, Ethics Approval number: 23228.

If you have any further inquiries or information you require to aid your response, please feel free to contact me through a replying email or call me on my mobile number, specified below.

Sincerely

Tanvi Bhagwat
Master of Building Science Candidate
Victoria University of Wellington
PH: 021 064 2804

Participant Information Sheet

TE WHARE WĀNANGA O TE ŪPOKO O TE IKA A MĀUI
VICTORIA
UNIVERSITY OF WELLINGTON

Lean Design Management in New Zealand

INFORMATION SHEET FOR PARTICIPANTS

Thank you for your interest in this project. Please read this information before deciding whether or not to take part. If you decide to participate, thank you. If you decide not to take part, thank you for considering my request.

Who am I?

My name is Tanvi Bhagwat and I am a Masters student in the Building Science programme at Victoria University of Wellington. This research project is work towards my thesis.

What is the aim of the project?

This project deals with construction waste minimisation in the design phase of the project. It aims to study and understand current design management strategies in the New Zealand building industry. This research has been approved by the Victoria University of Wellington Human Ethics Committee *[provide approval number]*.

How can you help?

If you agree to take part I will interview you in a public place, such as a café. I will ask you questions about design management. The interview will take 30 minutes. I will audio record the interview and write it up later. You can stop the interview at any time, without giving a reason. You can withdraw from the study up to two weeks after the interview. If you withdraw, the information you provided will be destroyed or returned to you.

What will happen to the information you give?

This research is confidential. I will not name you in any reports, and I will not include any information that would identify you. Only my supervisors and I will read the notes or transcript of the interview. The interview transcripts, summaries and any recordings will be kept securely and destroyed 2 years after the research ends.

What will the project produce?

The information from my research will be used in my Masters thesis. You will not be identified in my report. I may also use the results of my research for conference presentations, journal articles, and academic reports. I will take care not to identify you in any presentation or report.

If you accept this invitation, what are your rights as a research participant?

You do not have to accept this invitation if you don't want to. If you do decide to participate, you have the right to:

- choose not to answer any question;
- ask for the audio recorder to be turned off at any time during the interview;
- withdraw from the study up until two weeks after your interview;
- ask any questions about the study at any time;
- receive a copy of your interview audio recording;
- read over and comment on a written summary of your interview;
- agree on another name for me to use rather than your real name;
- be able to read any reports of this research by emailing the researcher to request a copy.

If you have any questions or problems, who can you contact?
If you have any questions, either now or in the future, please feel free to contact either:

Student:

Name: Tanvi Bhagwat

University email address:
bhagwatanv@myvuw.ac.nz

Supervisor:

Name: Nigel Isaacs

Role: Supervisor

School: School of Architecture and Design

Phone: 04 463 9745

Nigel.Isaacs@vuw.ac.nz

Human Ethics Committee information

If you have any concerns about the ethical conduct of the research you may contact the Victoria University HEC Convener: Associate Professor Susan Corbett. Email susan.corbett@vuw.ac.nz or telephone +64-4-463 5480.

Design Management in New Zealand
Interview Questions

Part I
Participant Information

Respondent's name: ________________________ (optional)

Company name: ________________________

Company size: ______ (number of employees)

Position held: ________________________

Area of expertise: ________________________

Qualification: ________________________

Experience: ______

HQ: ________________________

Service provided:	Residential	☐	
	Commercial	☐	
	Industrial	☐	
	Other	☐	Please specify ______________________
Business source:	Government	☐	
	Other Government	☐	
	Private	☐	
Overseas:	Yes	☐	Please specify ______________________
	No	☐	
Environmental accreditation:	Yes	☐	Please specify ______________________
	No	☐	

Part II

Initiation – Concept design to Preliminary design stage

1. At what point of the design process is the client brief in its most explicit form?
2. How often are client meetings held to reach that explicitness in the brief?
3. When is the design team briefed about the project?
4. Is modular design considered at the concept design stage?
5. Does design work start immediately after the first client briefing session?

Planning – Preliminary design to Developed design stage

6. What software applications are generally preferred for design projects?
7. At what stage does the design experience the most amount of changes?
8. What are the most common causes behind these changes?
9. How is design quality monitored through the different stages?
10. When there is a considerable change in client requirements, how easy is it to change the design to suit the new requirements?
11. How are these changes reflected in the time and cost of the project?
12. How often does the design team meet during a project?
13. Who does a design team typically consist of?

Execution – Developed design to Detailed design stage

14. Are design decisions made as soon as possible?
15. What percent of design is completed at contractor procurement stage?
16. What percent of design is completed before construction begins?
17. What happens in the event of delays caused by human resource?
18. Are all projects completed on schedule?

Monitoring and Control – Construction design stage

19. How common is Early Contractor Involvement?
20. How common is it for the design team to consider prefabrication?
21. What does a design team typically consider as "most important" in terms of constructability?

Bibliography

Alarcón, L. (1997). *Lean Construction*. CRC Press.

Alharbi, M., Emmitt, S., & Demian, P. (2015). What is architectural management? Towards a pragmatic definition. *Engineering, Construction and Architectural Management*, *22*(2), 151–168. https://doi.org/10.1108/ECAM-05-2014-0068

Al-Sari, M. I., Al-Khatib, I. A., Avraamides, M., & Fatta-Kassinos, D. (2012). A study on the attitudes and behavioural influence of construction waste management in occupied Palestinian territory. *Waste Management & Research*, *30*(2), 122–136.

Amos-Abanyie, S., Ayebeng Botchway, E., & Kwofie, T. E. (2014). The Relationship between Level of Architect's Professional Competencies and Client Satisfaction Level. *Engineering Management Research*, *3*(2). https://doi.org/10.5539/emr.v3n2p10

ARLEROTH, J., & KRISTENSSON, H. (2011). Waste in Lean Construction. *A Case Study of a PEAB Construction Site and the Development*.

Begum, R. A., Siwar, C., Pereira, J. J., & Jaafar, A. H. (2009). Attitude and behavioral factors in waste management in the construction industry of Malaysia. *Resources, Conservation and Recycling*, *53*(6), 321–328. https://doi.org/10.1016/j.resconrec.2009.01.005

Bennink, M., Moors, G., & Gelissen, J. (2013). Exploring Response Differences between Face-to-Face and Web Surveys: A Qualitative Comparative Analysis of the Dutch European Values Survey 2008. *Field Methods*, *25*(4), 319–338. https://doi.org/10.1177/1525822X12472875

Blyth, A., & Worthington, J. (2002). *Managing the Brief for Better Design*. Taylor & Francis.

Burns, P. (2001). Waste minimisation in the construction industry. Presented at the WasteMINZ Conference 2001, New Zealand: Sinclair Knight Merz Ltd.

Connelly, L. M. (2010, April). What is Phenomenology. *Nursing*, *19*(2), 127–128.

Dainty, A. R. J., Bagilhole, B. M., & Neale, R. H. (2000). Computer aided analysis of qualitative data in construction management research. *Building Research & Information*, *28*(4), 226–233. https://doi.org/10.1080/096132100050073689

Deshpande, A. S., Filson, L. E., Salem, O. M., & Miller, R. A. (2011). Lean techniques in the management of the design of an industrial project. *Journal of Management in Engineering*, *28*(2), 221–223.

Domingo, N., Su, M., & Egbelakin, T. (2015). Use of Building Information Modelling in Construction Waste Source Reduction. In *The Australasian Universities' Building Educators Association Conference*. Sydney: Royal Institution of Chartered Surveyors.

El. Reifi, M. H., & Emmitt, S. (2011). Lean design management: exploring perception and practice. *Architectural Management in the Digital Arena*, *46*, 1105.

El. Reifi, M. H., & Emmitt, S. (2013). Perceptions of lean design management. *Architectural Engineering and Design Management*, *9*(3), 195–208. https://doi.org/10.1080/17452007.2013.802979

El. Reifi, M. H., Emmitt, S., & Ruikar, K. (2013). Developing a Conceptual Lean Briefing Process Model for Lean Design Management. In *IGLC 21* (pp. 329–338). Brazil.

Emmitt, S. (2011). Lean Design Management. *Architectural Engineering and Design Management*, *7*(2), 67–69. https://doi.org/10.1080/17452007.2011.582337

Emmitt, S. (2014). *Design Management for Architects*. John Wiley & Sons.

Emmitt, S. (2016). The construction design manager – a rapidly evolving innovation. *Architectural Engineering and Design Management*, *12*(2), 138–148. https://doi.org/10.1080/17452007.2015.1136519

Emmitt, S., & Gorse, C. (2006). *Communication in Construction Teams*. Routledge.

Freire, J., & Alarcón, L. F. (2002). Achieving lean design process: Improvement methodology. *Journal of Construction Engineering and Management*, *128*(3), 248–256.

Fuemana, J., Puolitaival, T., & Davies, K. (2013). Last Planner System-A step towards improving the productivity of New Zealand construction. In *Proc., 21th Annual Conf. of the Int. Group for Lean Construction (IGLC-21), International Group of Lean Construction, Fortaleza, Brazil*.

Gonzalez, V. A. (2016, May 16). Lean Construction and its Awareness in the New Zealand Building Industry.

Green Star v3. (2015, August). Retrieved 26 July 2016, from https://12253-console.memberconnex.com/Attachment?Action=Download&Attachment_id=228

Haberecht, P. W., & Bennett, A. F. (1999). *Experience with durability assessment and performance-based building codes*. BRANZ.

Hanne, S., & Boyle, C. (2001). *Source separation of construction wastes in New Zealand*. Thesis, School of Engineering, Auckland University, Auckland, New Zealand. Retrieved from https://www.wasteminz.org.nz/wp-content/uploads/SOURCE-SEPARATION-OF-CONSTRUCTION-WASTES-IN-NEW-ZEALAND.pdf

Hansen, G. K., & Olsson, N. O. E. (2011). Layered Project–Layered Process: Lean Thinking and Flexible Solutions. *Architectural Engineering and Design Management*, *7*(2), 70–84. https://doi.org/10.1080/17452007.2011.582331

Hegde, D. S. (Ed.). (2015). *Essays on Research Methodology*. New Delhi: Springer India. Retrieved from http://link.springer.com/10.1007/978-81-322-2214-9

Hwang, B.-G., & Tan, J. S. (2012). Green building project management: obstacles and solutions for sustainable development. *Sustainable Development*, *20*(5), 335–349. https://doi.org/10.1002/sd.492

Iarossi, G. (2006). *The Power of Survey Design: A User's Guide for Managing Surveys, Interpreting Results, and Influencing Respondents*. The World Bank. Retrieved from http://elibrary.worldbank.org/doi/book/10.1596/978-0-8213-6392-8

Inglis, M. (2007). Construction and Demolition Waste–Best Practice and Cost Saving. *SB07 New Zealand*. Retrieved from http://www.cmnzl.co.nz/assets/sm/2260/61/057-INGLISMahara.pdf

Jacomit, A. M., & Granja, A. D. (2011). An Investigation into the Adoption of Target Costing on Brazilian Public Social Housing Projects. *Architectural Engineering and Design Management*, *7*(2), 113–127. https://doi.org/10.1080/17452007.2011.582334

Jankowicz, A. D. (2013). *Business Research Projects*. Springer.

Jaques, R. A. (1999). *Construction Site Waste Generation – The Influence of Design and Procurement in Auckland* (No. 88) (p. 34). Auckland: BRANZ.

Jaques, R. A., Mittermuller, P., & ARC, A. R. C. (2001). *REBRI and the Easy Guide to Reducing Construction Wastes*. BRANZ. Retrieved from http://www.wasteminz.org.nz/wp-content/uploads/EASY-GUIDE-TO-REDUCING-CONSTRUCTION-WASTES.pdf

John, S., & Buchanan, A. (2013). Review of End-of-life Options for Structural Timber Buildings in New Zealand and Australia. Retrieved from http://www.ir.canterbury.ac.nz/handle/10092/10296

Kim, H. (n.d.). ALL THE GARBAGE OF THE WORLD, UNITE! (poem) - Kim Hyesoon - South Korea - Poetry International. Retrieved 1 April 2017, from http://www.poetryinternationalweb.net/pi/site/poem/item/17521/poem_org_video_left/poem_english/0

Kpamma, E. Z., & Adjei-Kumi, T. (2011). Management of Waste in the Building Design Process: The Ghanaian Consultants' Perspective. *Architectural Engineering and Design Management*, *7*(2), 102–112. https://doi.org/10.1080/17452007.2011.582333

Kulatunga, U., Amaratunga, D., Haigh, R., & Rameezdeen, R. (2006). Attitudes and Perceptions of Construction Workforce on Construction Waste in Sri Lanka. *Management of Environmental Quality*, *17*(1), 57–72.

Li, J., Tam, V. W. Y., Zuo, J., & Zhu, J. (2015). Designers' attitude and behaviour towards construction waste minimization by design: A study in Shenzhen, China. *Resources, Conservation and Recycling*, *105*, 29–35. https://doi.org/10.1016/j.resconrec.2015.10.009

Ling, Y. Y. (2003). A conceptual model for selection of architects by project managers in Singapore. *International Journal of Project Management*, *21*(2), 135–144.

Liu, Z., Osmani, M., Demian, P., & Baldwin, A. N. (2011). The potential use of BIM to aid construction waste minimalisation. Retrieved from https://dspace.lboro.ac.uk/dspace-jspui/handle/2134/9198

Mazlum, S. K., & Pekeriçli, M. K. (2016). Lean Design Management – An Evaluation Of Waste Items For Architectural Design Process. *METU JOURNAL OF THE FACULTY OF ARCHITECTURE*, *33*(1), 1–20. https://doi.org/10.4305/METU.JFA.2016.1.1

Ministry of Business, Innovation and Employment. (2017, January 1). Acceptable Solutions and Verification Methods for NZBC Code Clause B2 Durability. Ministry of Business, Innovation and Employment. Retrieved from https://www.building.govt.nz/assets/Uploads/building-code-compliance/b-stability/b2-durability/asvm/b2-durability-2nd-edition-amendment-9.pdf

Moher, D., Shamseer, L., Clarke, M., Ghersi, D., Liberati, A., Petticrew, M., … Stewart, L. A. (2015). Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. *Systematic Reviews*, *4*(1), 1.

Novak, V. M. (2014). Design management of sustainability values: a learning organization perspective. *Architectural Engineering and Design Management*, *10*(3–4), 218–232. https://doi.org/10.1080/17452007.2014.896782

NVivo 11 for Windows | QSR International. (n.d.). Retrieved 15 December 2016, from http://www.qsrinternational.com/nvivo-product/nvivo11-for-windows

Osmani, M., Glass, J., & Price, A. D. F. (2008). Architects' perspectives on construction waste reduction by design. *Waste Management*, *28*(7), 1147–1158. https://doi.org/10.1016/j.wasman.2007.05.011

Oyedele, L. O., & Tham, K. W. (2005). Examining architects' performance in Nigerian private and public sectors building projects. *Engineering, Construction and Architectural Management*, *12*(1), 52–68.

Storey, J. B. (2008). *Construction materials stewardship the status quo in selected countries: CIB W115*. Wellington: Centre For Building Performance Research, Victoria University of Wellington : International Council for Building Research Studies and Documentation (CIB), Working Commission W115: Construction Materials Stewardship. Retrieved from http://cibworld.xs4all.nl/dl/publications/pub318.pdf

Thomson, D. S., Austin, S. A., Devine-Wright, H., & Mills, G. R. (2003). Managing value and quality in design. *Building Research & Information*, *31*(5), 334–345. https://doi.org/10.1080/0961321032000087981

Thyssen, M. H., Emmitt, S., Bonke, S., & Kirk-Christoffersen, A. (2010). Facilitating Client Value Creation in the Conceptual Design Phase of Construction Projects: A Workshop Approach. *Architectural Engineering and Design Management*, *6*(1), 18–30. https://doi.org/10.3763/aedm.2008.0095

Tilley, P. A., & others. (2005). Lean Design Management: A New Paradigm for Managing the Design and Documentation Process to Improve Quality? In *13th International Group for Lean Construction Conference: Proceedings* (p. 283). International Group on Lean Construction. Retrieved from https://search.informit.com.au/documentSummary;dn=565373967910593;res=IELENG

Tribelsky, E., & Sacks, R. (2011a). An Empirical Study of Information Flows in Multidisciplinary Civil Engineering Design Teams using Lean Measures. *Architectural Engineering and Design Management*, *7*(2), 85–101. https://doi.org/10.1080/17452007.2011.582332

Tzortzopoulos, P., & Cooper, R. (2007). Design management from a contractor’s perspective: The need for clarity. *Architectural Engineering and Design Management*, *3*(1), 17–28.

Wilson, A. (2015). A guide to phenomenological research. *Nursing Standard*, *29*(34), 38–43.

Yin, R. K. (2013). *Case Study Research: Design and Methods*. SAGE Publications.