The image displays two architectural drawings of a building frame. The top drawing is a section view labeled 'Section of the Frame AB. (1 in 100)'. It shows a gabled roof structure with various structural members labeled with letters (a, b, c, d, e, f, g, h, i, j, k, l, m, n, o, p, q, r, s, t, u, v, w, x, y, z). The roof is supported by a series of vertical columns. The ground level is indicated by a hatched line. The bottom drawing is a ground plan view labeled 'Ground-plan of the frame. (1 in 100)'. It shows the footprint of the building, with a central rectangular area and a smaller rectangular area to the right. The drawing is overlaid with a grid of dashed lines. A semi-transparent black box with white text is centered over the ground plan, reading 'ARCHITECTURE VIA A C E H'.

*A 120-Point thesis submitted to the Victoria University of Wellington
in partial fulfilment of the requirements for the degree of Masters of
Architecture (Professional)*

2017

*Victoria University of Wellington
School of Architecture (or School of Design)*

Architecture

via

Aceh

- a proposal for seismic innovations to timber structures -

by

Jared F. Hubbard

For Rhykah and Sebrin in the hope they take inspiration to
achieve every goal they set for themselves.

And for Avinash and Michael, for everything they have done.

Acknowledgments

First, my thanks with sincere gratitude goes to my supervisor, Professor Regan Potogaroa whose encouragement and sense of adventure pushed me to achieve this goal of submitting a Masters thesis.

Special thanks to Dr. Ir. Mirza Irwansyah, Dr. Ir. Izziah and Syiah Kula University.

Finally to my two families; the first my parents, Darice and Darryl Hubbard and sister Sarnia Hubbard, without whom I wouldn't have even started. The second, my friends who without I could not have finished.

Thank you.

“We have two families in life. One we're born with that shares our blood. Another we meet along the way that's willing to give its life to us.”

- Mark Frost

Abstract

There are many swaths of land that are deemed unsuitable to build on and occupy. These places, however, are rarely within an established city. The Canterbury earthquakes of 2010 and 2011 left areas in central Christchurch with such significant land damage that it is unlikely to be re-inhabited for a considerable period of time. These areas are commonly known as the 'Red Zone'.

This thesis explores redeveloping on volatile land through innovative solutions found and adapted from the traditional Indonesian construction techniques. Currently, Indonesia's vernacular architecture sits on the verge of extinction after a cultural shift towards the masonry bungalow forced a rapid decline in their occupation and construction. The 2004 Indian Ocean earthquake and tsunami illustrated the bungalows' poor performance in the face of catastrophic seismic activity, being outperformed by the traditional structures. This has been particularly evident in the Rumah Aceh construction of the Aceh province in Northern Sumatra.

Within a New Zealand context an adaptation and modernisation of the Rumah Aceh construction will generate an architectural response not currently accepted under the scope of NZS 3604:2011; the standards most recent revision following the Canterbury earthquake of 2010 concerning timber-based seismic performance. This architectural exploration will further address light timber structures, their components, sustainability and seismic resilience. Improving new builds' durability as New Zealand moves away from the previously promoted bungalow model that extends beyond residential and into all aspects of New Zealand built environment.

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Introduction

This thesis is broken into two parts to explore how overseas vernacular architecture can inform the seismic design of timber structures in New Zealand beyond the scope of NZS3604: 2011.

The first half explores the precedent of construction, the Rumah Aceh, and how to assimilate its form and construction method into a New Zealand context. The second half explores how this new method of construction can be used to help re-establish an architectural presence on Red Zoned land in Christchurch which at the time of the research was the primary example of land unsettled by earthquakes in New Zealand.

The Canterbury earthquakes of 2010 and 2011 were a stark reminder that New Zealand is highly susceptible to earthquakes. Large areas of land were severely damaged due to dramatic ground failures, primarily caused by liquefaction, to the extent that remediation to the structures upon it was considered uncertain. These areas were soon after declared a 'Red Zone' and regarded as unsuitable to develop in the short and mid-term futures (MacDonald & Carlton, 2016). Inevitably this has left a large amount of vacant land in and around the city centre, a consequence and reminder of a devastating event.

However, in this absence exists the opportunity to build back better (Johnson & Olshansky, 2016). Often with the loss of structures come the loss of identity and place (Zakariya & Ujang, 2014) as the sense of 'place' cuts across geographical forms, communities and physical structures. 'Place' is where people create meaning to give a sense of identity and the loss of the built environment threatens that identity.

While 'Blueprint 100', introduced in 2011 by Warren and Mahoney through a competitive process, suggested 16 anchor projects and a wider scheme to regenerate the central business district, large suburban areas and pockets of land near the Avon

river closer to the city centre remained 'retired'. Thus, the wider Christchurch community has since began regaining a sense of identity, some communities connected with Red Zone sites remain without a sense of place, their identity waning (Dalman, 2014).

This could be said for Ngai Tahu the local iwi of the Canterbury region. As the original settlers of the land the iwi hold a strong sense of place and identity to geographical aspects such as Otakaro, better known as the Avon River. Despite that the iwi holds little representation in the visual aesthetic of the city that more reflected the English Colonialism prior to the earthquakes (Keene, 2013). While emphasis has been placed on the Otakaro/Avon River Precinct in the redevelopment plan, highlighting its importance in cultural history, less focus has been on the proposed cultural centre that would have anchored the values and set a distinct visual presence within Christchurch for Ngai Tahu. By employing the first half of this thesis as a proposal to re-establish a presence on retired land the 'forgotten' anchor project will serve as a program to show its validity within a New Zealand context.

PART ONE

I

- A LITERARY REVIEW -

Building Codes are continually amended and refined to improve seismic resilience of New Zealand buildings. Historically amendments are made following a natural disaster which highlights the shortcomings of current building practices when collapse or severe damage to buildings result.

This pattern has occurred repeatedly since regulated building practices were implemented across New Zealand in 1935 as a direct result of the 7.9 (ML) earthquake that devastated much of Napier in 1931 (Wolfe, 2013). At this time many countries, upon realising various imported typologies' inability to response to similar seismic events due to their construction methods, had already begun to develop modern earthquake designs (King, Gutierrez, 2004).

More recently, significant developments to the New Zealand Standards were made following the 2011 Christchurch 6.3 (ML) earthquake. Resulting in the latest adaptation of NZS: 3604 regarding 'non-specifically engineered timber framed structures' amended to better reflect the natural environment and locations on which we build (Standards New Zealand, 2011). This included improved earthquake hazard maps, earthquake zone classifications and the introduction of soil classification considerations, as some soil profiles are likely to amplify the seismic waves by several orders of magnitude which drastically affect the structures intensity of shaking during a seismic event (King).

Fig 1.01
CHRISTCHURCH CBD
FOLLOWING 2011 CANTURBURY
EARTHQUAKES

These amendments improved the seismic resilience of New Zealand timber framed housing. However, they are over 80 years old and based on a sparse number of seismic events. Furthermore, they adopt, perhaps understandably, the need to anchor the building to the ground. They focus on ‘force reduction factors’ rather than designing for earthquake forces in their entirety assuming a level of inelastic behaviour to dissipate seismic energy (Langenbach, 2010).

While logic prepares us to think that modern construction techniques should be regarded as preferable (Ortiz-Palacio, Ibanez, Lopez-Ausin, & Porres) previous papers have argued, with convincing evidence, that there could be lessons taken from vernacular architecture, as selected vernacular buildings have reportedly outperformed current ones (Sassu, n.d, Langenbach, 2010, Gutierrez, 2004, Gautam, Prajapati, Paterno, Bhetwal, & Neupane, 2016)

Vernacular buildings have been around much longer and just like their contemporary cousin they have been developed after disasters, but instead over hundreds of years and many more seismic events. They demonstrate a wide variety of approaches rather than a singular tactic.

This longevity inherently links the built context with the social and religious strata of the culture as much as the physical requirements posed by the environment (Gutierrez, 2004). The resulting vernaculars are highly developed response praised by architects, engineers and cultural anthropologists as being extremely effective solutions to the needs of their dwellers. Buildings are only modified as a result of persistent and extraordinary circumstances. (Gutierrez, 2004) The question ‘Could selected vernacular seismic exemplars be used and adapted to the current New Zealand context?’ should be considered as a viable exploration of building resilience.

Fig 1.02
POST TO BEAM AND
FOUNDATION TO STRUCTURE
CONNECTIONS AS SHOWN IN
NZS3604: 2011
ILLUSTRATING RIGID JOINTS
AND TYING BUILDING TO
GROUND ➡

New Zealand's seismic vernacular heritage appears to be sparse. Maori, New Zealand's indigenous people, had little over 750 years to progress a vernacular prior to European arrival (Memmott & Davidson , 2008, SSTaylor, 1966). This is a significantly shorter period than many indigenous cultures. The vernacular culminated in a variety of post and beam buildings. Smaller dwellings such as sleeping houses which is typically simple in both design and construction, consisting of two primary posts erected to support a singular ridgepole. The roofing and walls were a framework of saplings fastened to the primary structure with vines, overlaid with thatch and secured additionally with two horizontal poles running the length of the roof on either side. (Taylor, 1966). While forms varied and developed over time, the use of lightweight materials on rammed earthen foundations was the primary structural resilience against seismic activity¹.

In the event of an earthquake these small timber structures were ductile enough to flex and under extreme duress collapse without killing the occupant. After a collapse the structure could easily be reconstructed and elements replaced, honouring the Maori philosophy of built forms having a life cycle and respecting Ruaumoko, the Maori God of earthquakes (Gutierrez, 2004). These events ensured community engagement during reconstruction and the transfer of skills to the next generation. (Memmott & Davidson , 2008) It is to be noted that 'Resilience' within this framework refers to the ability to quickly and easily rebuild as opposed to longevity, as is the incentive of contemporary New Zealand building culture (Standards New Zealand, 2011).

It is therefore perhaps more apt to explore a vernacular example that does embody our current expectation of 'resilience' such as the Rumah Aceh from Indonesia.

¹ Primary architectural forms of high importance such as Maraes involved larger structural elements making them heavier and less able to benefit from the resilience installed in smaller dwellings.

2

- THE DEVELOPMENT OF A METHODOLOGY -

This chapter details the research and design framework for the study. It explains suitable methodologies and theories adopted to achieve the objectives stipulated by the study. The structure of this chapter is as follows; firstly setting out the method of researching the main precedent of the study, the Rumah Aceh. Secondly, exploring methodologies that will research the Rumah Aceh's ability to be assimilated into a New Zealand context, and finally outlining a design framework that will guide form making to achieve a resolved design alliteration as a response to the research question.

2.1 Researching the precedent

After consideration of the objectives of the study, the research question, scope and limitations it was deemed appropriate to adopt both a qualitative and quantitative methodology when concerning the understanding of the main precedent of the study, the Rumah Aceh. Researchers use the qualitative approach to explore the behaviour, perspectives, experiences and feelings of people, interpreting these to understand the subject with critical thinking (Groat and Wang).

As this research is based on understanding the Rumah Aceh's reaction to seismic activity it is imperative to have the experiences and knowledge of those who interact with them on record. This can be achieved by visiting the precedent in person and employing six undergraduate architecture students from Syiah Kula University to guide and assist in translating 1:1 'semi structured interviews' with the occupants reflecting a more quantitative researching approach. With the intention of yielding insights on the history of the house, the occupant's perceptions of their homes, changes made both physically and socially and their experience of their homes throughout seismic events.

By collecting material from 10 selected examples of traditional Aceh architecture it is possible to quantify qualitative data and formulating well-rounded conclusions. The use of a qualitative approach in this sense could be further distinguished as one of ethnographic fieldwork. As this method is often defined by its reliance on observation (Groat and Wang)

While collecting data between several approaches is dissimilar in method they are not mutually exclusive and together will provide pragmatic advantages by recording both perspective and pattern responses (Driscoll, Appiah-Yeboah and Salib)

This methodology's ability to establish credibility to a design by investigating ideas with a high degree of control has lead it to be considered one of the best methods available to researchers (Beaumont, Bang and Eriksen). However experimental research has been widely criticised mostly for its accuracy in representation.

Typically an experimental method is used to separate ideas and test them. This can be accomplished many ways and with the advancement of technology is no longer restricted to just physical models.

The turn to technology and, in particular simulation programs, allows the early and rapid testing of designs.

As these programs have developed, less precise information is needed to yield useful information. This has allowed the focus to lie on testing the degree of appropriateness or performance of the design over learning new computer programs. In this way the near instantaneous results can be used to rapidly advance or justify forms, structure and materials (Achten).

Alternatively physical prototyping is a known embodiment of design research, but it also goes beyond theory and opens new ways of seeing opportunities, setting examples and precedents that in turn are preparation for future design. (Koskinen, Zimmerman and Binder)

Plainly it is testing the hypothetical theories. Consequences are predicted from this methodology and the results are then comparable to real world situations.

In the case of this study a hypothesis on the way the structure of the Rumah Aceh responds to seismic loads will need to be tested to show its capabilities. This can be done both digitally and physically to show different elements of the structures response. Following this the data collected can be analysed to allow further understanding of the response of the structure during a seismic event.

2.3 A design framework

In setting a design framework the practise of form making is grounded in reason. It formalises the reflective process in so much that it gives something to reflect against. This allows for critical assessment, comparability and evaluation through sketching and digital modelling, weaving between problem and solution (Hauberg).

Following Christopher Alexander who introduces an approach to design in his work 'The notes on the synthesis of form' defined the method of design as;

"The process of inventing physical things which display new physical order, organisation, form in response to function"

Alexander explains that this definition is equally applicable to both the process of unselfconscious and self-conscious design. These terms can also be defined as engineered and non-engineered.

Concerning vernacular design, or as it is being defined here as - unselfconscious design, building skills are first learnt informally; they are then built upon through tradition. Whereas the self-conscious is arguably worse off as it does not base its design off the success of its predecessors. This is because with the arrival of self-conscious design the stability of tradition that is the foundation of the vernacular disappears in favour of architectural expression (Gutierrez).

However it is within self-conscious design that today's architecture is based. Thus it is faced with the process of developing form and in order to solve complex problems. In an attempt to resolve this Alexander advocates a logical, objective approach to design in which form fits context by addressing a set of design requirements (Stenson).

Alexander sets out that form is composed of intention and materiality. The first represents the ideal conditions while the second is the resources fit for purpose. These two often conflict as the first seeks the 'ideal' while the latter is holding down the process in reality. The creation of form is the balance and compromise between the two however, both cases concern the combination of form

and context. This is relevant when translating the Rumah Aceh into New Zealand contexts as the Rumah Aceh form is a product of its materiality while New Zealand architecture often sources materials to best fit the desired form.

Further exploring form or intention as Alexander refers to it, borrows from the Roman architect Vitruvius who defined three requisites for any successful architectural work, Venustas, Firmita and Utilita, which can be translated as beauty, durability and convenience or which Gutierrez redefined as firmness, service and delight, these three terms, form the foundation to reach intention (Gutierrez).

- Firmness represents the structure which itself can be further broken into three terms; Strength, Stiffness and Stability.
 1. Strength to withstand loads and actions acting upon the form.
 2. Stiffness to keep displacement and internal deformations under tolerable limits while requesting specific loads and actions.
 3. Stability; to be able to hold its original equilibrium position after disturbance.
- Service can be best described as program and its ability to perform without hindrance to both context and form.
- Delight consists of aesthetics which may be considered as a fundamental component involving both the form and its context as the beauty cannot be judged in isolation but as it relates to its surroundings.

Visually represented Alexander's theory is three nodes on an equilateral triangle as all are equally important.

This model is then shown as a three-dimensional tetrahedral where Gutierrez includes economy as the third node to the foundation which is equal to firmness and service relating the cost of materials and upkeep.

Fig. 2.02
 DIAGRAM CHRISTOPHER
 ALEXANDER'S DESIGN
 FRAMEWORK AS DESCRIBED BY
 GUTIERREZ

While materiality and all that is associated to it regarding shape, constructive technology and dimensioning, and detailing as described by Gutierrez in this model, is a corner stone of this research. The intermediate step of considering economy is disregarded as it has minimal influence on the research question and is outside the scope of this thesis. The 'node' of economy is acknowledged in the understanding of the Rumah Aceh being a vernacular construction as a product of its circumstance and immediate environment. This is disregarded in a New Zealand context to keep the scope of the research focused on timber construction.

The resulting model is Stella Octangula, a combination of all influence, which leads to intention of form.

Alexander's design theory was initially based on Cartesian rationalism for solving design problems. Problems are broken into their smallest components. Each component is solved separately and then synthesized into a grand solution (Jutla). This now represents a performance-based approach and emphasised that the design of a form is defined by the context, it is historically, culturally and geographically dependent. When evaluating the adequacy of a design it is essential to consider the particular historic, cultural and socio-economic and physical conditions of the context. Design is intended to fit form to its context. Form is an important part of the design over which designers have control but it is imperative to remember that context is also part of the design which puts demands on this form (Grabow, 1983)

This framework first established by Alexander and later redefined by Gutierrez will serve as the framework to this thesis output.

3

- A FIELD TRIP -

Rumah Aceh, or Aceh house, is the ingenious dwelling of the Aceh Province located at the Northern most point of Sumatra, Indonesia. This paper limits the scope of Indonesian vernacular examples to the Aceh region as, much like New Zealand, Aceh is under constant threat from seismic activity. Both regions are located at the meeting point of tectonic plates and share a recent history of devastating seismic events.

Fig 3.01
NEW ZEALAND TO INDONESIA,
ALONG A SHARED TECTONIC
PLATE ➡

3.1 A strategy

A research trip to Banda Aceh in May of 2016 allowed for the exploration of the Rumah Aceh's seismic resilience in person. With support from Syiah Kuala University, a research team was assembled and assisted in conducting a study in Lubuk, an inland settlement where many occupied examples of the vernacular architecture remain.

Ten vernacular houses in an inland settlement of Lubuk were identified to be documented. At each dwelling the students introduced the occupant to the study and in pairs completed an interview following an interview guide written by the researcher (Kajornboon). These were completed and recorded in Bahasa and later translated to English by the students.

The goal was to understand the occupant's perceptions on the Rumah Aceh and its success, in their view, as their primary dwelling whilst gaining knowledge on the structure and construction process. This was aided by visual documentation of the buildings. The gathered data aids to visually assess the primary elements that provide seismic resilience. This is understood by prior established construction principles (King).

These interviews served as a foundation for further observation and documentation of the original structure, modern additions, and annotated dimensioned plans, also completed with the assistance of the students.

Fig 3.02
 ACEH REGION, SUMATRA
 BANDA ACEH AND LUBUK

3.2 Findings

Rumah Aceh's are timber post and beam structures, which are erected on flat rocks or concrete plinths without foundations. Typically built 2.5 – 3 meters above ground with variations ranging as low as 0.5 meters. The structure consists of 4 posts across, creating 3 bays, clearly outlining the front, middle and rear of the house. The middle section is typically elevated 0.5 – 0.75m above the back and front rooms. The length varies depending on the size requirements and can be amended by adding additional bays.

Rumah Aceh's in Lubuk did not escape the urbanisation process and all 10 houses surveyed have incorporated various aspects of modern housing. This development began as local perception of housing and was altered with the change of living needs and improvement of amenities that became available (Ly, 2012). Such modernisation often included; living spaces on lower levels to accommodate older family members, as well as modernised kitchens and bathrooms. This was accomplished by enclosing various portions of the bays underneath the original structure with clay brick and concrete render construction.

Earthquakes such as the 2004 Indian Ocean Tsunami presented the masonry structure as the most affected. It has been suggested this resulted from the limited understanding local people and builders have on how to properly create safe dwellings with new materials given their inelastic properties and unfamiliar construction methods (Tuan Anh & Van Giai Phong, 2014).

Changes to the original Rumah Aceh are limited to the removal of internal columns to provide space below and above, altering the way internal spaces are divided. It is important however, to distinguish that it is simply a variation within a given order, a manifestation of unselfconscious design. The case studies provided show that adaptations to modernize the Rumah Aceh do not involve adjustments to the construction of the original structure. This suggests that in an earthquake the primary structure, due to its unique seismic resilience, would continue to survive even if the newer addition were to fail and collapsed below it.

Fig 3.03
STUDY OF ACEH VERNACULAR
BY DR. C. SNOUCH HURGRONJE
1906

(SEE PP. 34. ET SEQ.)

This architectural drawing shows a cross-section of a building's foundation and lower levels. The basement is labeled 'a Raised Basement' and contains several columns labeled 'b' and 'c'. The ground floor has columns labeled 'a' and 'b'. The roof is shown with a series of horizontal lines. The drawing includes various annotations such as 'B', 'A', 'B', 'C', 'Y' on the left and 'B', 'A', 'B', 'C', 'Y' on the right, and '17 C.M.' and '28 x 28 C.M.' near the columns.

Rumah Acehs surveyed date from the early to mid 20th Century and typically been occupied by a single family for generations, often built by parents or grandparents of the current residents. This gave weight to individual's accounts of seismic experience within their Rumah Aceh's and their knowledge of the buildings history. Of those interviewed, the 2004 Earthquake was the most recalled event experienced. While many admit to fleeing their homes they all returned stating they felt safer in their Rumah Aceh's which suffered no structural damage but were weary of their brick and concrete addition where cracking was visible.

Ignoring the modern brick additions, the Rumah Aceh's show the same construction techniques as documented by Dr. Hurgronje during his research in 1891, 'The Archenese' (Hurgronje, 1906). This suggests construction methods have been deemed sufficient by those who have occupied them for generations. This is supported by the fact of a new Rumah Aceh that has recently been constructed in Lampulo, a riverside community outside of Banda Aceh. This illustrates two elements that are crucial to the Rumah Aceh's seismic resilience: The lack of foundations and the construction joints that form the frames of the post and beam structure. The shape generated is of ideal proportions to resist lateral force of seismic events.

Primary construction joints between posts and beams are made entirely from wood and without nails. While other wood construction details have often promoted the need to create a ridged joint, the Rumah Aceh beams slide into the post with ease. The joint is then packed with a wooden wedge to create a sufficiently stiff structure. In the event of a sizable earthquake the forces acting on the structure will force the wedges to loosen allowing greater elasticity between individual members of the joint. This in turn dampens the vibrations and dissipating the energy through regular lateral force distribution.

Timber and similar organic materials are valuable for seismic resistance as they have the capacity to resist high tensile forces, they are especially vulnerable to fungi and xylophagous insects (King). Whilst raising the building off the ground gives a level of protection its ability to easily replace individual elements as they rot or come to harm make the Rumah Aceh particularly resilient.

Fig 3.04
 ACEH MUSEUM
 HOUSE OF CUT NYAK DHEN

c.1914 ►

Fig 3.05
 RUMAH ACEH DEWLLING,
 LAMPULO

c.2015 ►

Fig 3.06
RUMAH ACEH STUDY
DWELLINGS 01-10
ELEVATIONS AND PLANS AS
OBSERVED AND DOCUMENTED
ON SITE
1:200

01

02

06

07

03

04

05

08

09

10

Fig 3.07
RUMAH ACEH STUDY
DWELLING 04
PLAN + ELEVATION WITH
PRIMARY (PINK) AND
SECONDARY BEAMS (BLUE)
IDENTIFIED
1:100

Fig 3.08
RUMAH ACEH STUDY
DWELLING 04
VISUAL DOCUMENTATION

Fig 3.09
RUMAH ACEH STUDY
DWELLING 05
PLAN + ELEVATION WITH
PRIMARY (PINK) AND
SECONDARY BEAMS (BLUE)
IDENTIFIED
1:100

Fig 3.10
RUMAH ACEH STUDY
DWELLING 05
VISUAL DOCUMENTATION

0 1 2 3 4m

Fig 3.11
RUMAH ACEH STUDY
DWELLING 09
PLAN + ELEVATION WITH
PRIMARY (PINK) AND
SECONDARY BEAMS (BLUE)
IDENTIFIED
1:100

Fig 3.12
RUMAH ACEH STUDY
DWELLING 09
VISUAL DOCUMENTATION

The easy replacement of individual elements is only achievable because the joints facilitate an easy disconnection between its various elements. This allows post and beams to be removed and replaced with little disruption to the rest of the structure. This is aided by the building not being tied to its foundations as the posts rest instead on concrete plinths. This allows the building to be lifted and supported by bamboo scaffolding when primary elements are temporally removed.

The Rumah Aceh is easily constructed on various soil types due to its lack of foundations. Despite the Rumah Aceh not being tied to the ground, it is able to resist lateral wind force by the sheer weight of the structure. The lack of foundations also helps dissipate lateral seismic forces by being able to shift when under extreme seismic stress. In the most extreme circumstances the Rumah Aceh can slide off the plinths, drastically damping vibrations. Following this, the structure can quickly be corrected through community engagement or 'Gotong royong' in a similar aspect of Maori resilience, however, this only happen as a last resort rather than a primary defence.

The overall shape is a direct result from the physical properties of the timber posts and beams assembled into the replicated bays, which obtain full advantage of their major strengths by retaining structural symmetry. This is a key element that is essential for proper earthquake behaviour (King). The Bays can be classified into two categories: The earlier style, where the middle section is raised, and the later style, where the floor is level across the front, middle and rear of the house, called 'santeut'. One of the houses included in this study adapted their Rumah Aceh to the later style to create more spacious interiors. While this affects the way the post and beams fit together across the front, middle and rear of the house, it does not appear to have an adverse effect on the seismic resilience or rather the occupants and craftsman's involved in its construction are confident of its structural integrity. This suggests that the construction joints can be used in a multitude of ways to develop variance in form.

Fig 3.14
THE IDEAL EARLY MODEL
RUMAH ACEH FOUNDATION
SET OUT
1:100 5 ▲

Fig 3.15
THE IDEAL EARLY MODEL
RUMAH ACEH ELEVATION
1:100 ▼

Fig 3.16
THE IDEAL EARLY MODEL
RUMAH ACEH PLAN
1:100

Fig 3.17
THE IDEAL EARLY MODEL
RUMAH ACEH ELEVATION
1:100

Fig 3.18
THE IDEAL LATE MODEL RUMAH
ACEH FOUNDATION SET OUT
1:100
Fig 3.19
THE IDEAL LATE MODEL RUMAH
ACEH ELEVATION
1:100

Fig 3.20
THE IDEAL LATE MODEL
RUMAH ACEH PLAN
1:100

Fig 3.21
THE IDEAL LATE MODEL
RUMAH ACEH ELEVATION
1:100

Fig 3.22
THE IDEAL EARLY MODEL
RUMAH ACEH PERSPECTIVE ▲

Fig 3.23
THE IDEAL LATE MODEL
RUMAH ACEH PERSPECTIVE ▲

4

- ASSIMILATING CONTEXT -

After arriving back in New Zealand from Banda Aceh the question of how one nation's vernacular can be placed within another's without replication and respecting both nations' differences in design and lifestyles, needed to be addressed.

An argument can be made that New Zealand's first inhabitants arrived through a migration pattern that had crossed the Aceh region. Thus a connection between both vernaculars could be drawn, however, New Zealand has long since moved into its own modern housing archetype.

A range of overseas precedents have always influenced New Zealand architecture. Settlers arriving in the early 19th Century replicated the Georgian architecture, which was popular in England at the time. Since then architecture has followed the trends of the major overseas movements, drawing from Edwardian, Arts and crafts and Early 20th Century American styles respectively. It was not until the Modernist movement that New Zealand architecture began developing forms in direct response to local precedents, conditions and ways of life (Gatley). It can be said that from this movement onwards, with the introduction of mono-pitched roofs, exposed timber posts, beams and rafters, a new New Zealand vernacular arose. More recently there has been a shift towards clean lines, large areas of glass and minimalist detailing which still embodies and reflects 'kiwiana' celebrating local materials, sites specific details and culture.

At this point it is essential to experiment with form and structure, breaking away from the Rumah Aceh's rigid form. The modular rectangular forms that, while an asset during a seismic event, do not reflect New Zealand's developing aesthetics. In doing this, connections between elements that do not work with unique forms, need further development to assimilate within a New Zealand context.

To do this three pieces of architecture are selected to represent the modern New Zealand style. The structural skeletons then reformed, employing the methods of construction of the Rumah Aceh, 'forcing' the construction method into the designs. In doing so, a disconnection between the Rumah Aceh's traditional form and its construction method is forged and extends the ideas of form making through adaptation and development of details.

This experiment explores how the 'essence' of the construction method can be maintained yet modernised to suit the desired architectural forms. Retaining the factors, which have proven to be essential for earthquake design.

4.2 House One

Home of the year winner 2011 by Bull O'Sullivan architects design 'Harvey Family Home'

Fig 4.01
HARVEY FAMILY HOME BY
ARCHITECT BULL O'SULLIVAN

Fig 4.02
HARVEY FAMILY HOME PLAN ▲

Fig 4.03
HARVEY FAMILY HOME AS
RUMAH ACEH CONSTRUCTION ▲

Fig 4.04
HARVEY FAMILY HOME AS A
RUMAH ACEH PERSPECTIVE

Fig 4.05
PRIMARY BEAMS IN RED
SECONDARY BEAMS IN BLUE
COLUMNS IN YELLOW

Fig 4.06
AREAS OF CONFLICT BETWEEN
DESIGN AND CONSTRUCTION
METHOD

4.3 House Two

2013 NZIA local Award for architecture by Wendy Shacklock Architects design 'Macalister Onetangi House'

Fig 4.07
MACALISTER ONETANGI
HOUSE BY WENDY SHACKLOCK
ARCHITECTS ▲

Fig 4.08
MACALISTER ONETANGI HOUSE
PLAN ▲

Fig 4.09
MACALISTER ONETANGI
HOUSE AS RUMAH ACEH
CONSTRUCTION ▲

Fig 4.10
MACALISTER ONETANGI
HOUSE AS A RUMAH ACEH
PERSPECTIVE ▲

Fig 4.11
PRIMARY BEAMS IN RED
SECONDARY BEAMS IN BLUE
COLUMNS IN YELLOW ▲

Fig 4.12
AREAS OF CONFLICT BETWEEN
DESIGN AND CONSTRUCTION
METHOD ▲

4.4 House Three: Under Pohutukawa

Home of the year winner 2012 by Herbst Architects
design 'Under pohutukawa'

Fig 4.13
UNDER POHUTUKAWA BY
HERBST ARCHITECTS ▲

Fig 4.14
UNDER POHUTUKAWA PLAN ▲

Fig 4.15
UNDER POHUTUKAWA AS
RUMAH ACEH CONSTRUCTION ▲

Fig 4.16
UNDER POHUTUKAWA AS A
RUMAH ACEH PERSPECTIVE ▲

Fig 4.17
PRIMARY BEAMS IN RED
SECONDARY BEAMS IN BLUE
COLUMNS IN YELLOW ▲

Fig 4.18
AREAS OF CONFLICT BETWEEN
DESIGN AND CONSTRUCTION
METHOD ▲

4.5 Exploring detailing solutions

Having forced the structure into the three architectural precedents revealed several key areas that are further explored to be resolved in sketch detailing.

Fig 4.19
SKETCH CONCEPT AND
DEVELOPMENT OF MULTIPLE
PRIMARY BEAMS TO POST ▲

Fig 4.20
CONTINUED SKETCH
DEVELOPMENT OF PRIMARY,
SECONDARY AND BEAM
CONNECTIONS ▲

Fig 4.21
SKETCH CONCEPT OF PRIMARY
BEAM TO POST CONNECTION ▲

5

- TESTING -

Modelling the frames of the Rumah Aceh to understand the structure's movement during an earthquake provides better insight into the performance of the construction technique. This will then allow a more appropriate and realistic adaptation into a New Zealand context as the limits or parameters to the architecture's form will be more fully realised.

As was observed during the research field trip to Banda Aceh, the Rumah Aceh's are not tied to the ground. This was seen as a structural advantage during a seismic event as the building has greater movement and elasticity.

Additionally if the structural columns were to slide from plinths on which they are placed the vibrations are increasingly dampened, as mentioned in chapter three (Standards New Zealand).

Banda Aceh sits near the equator between the Tropic of Cancer and Capricorn, a region of light and irregular wind broken by the occasional thunderstorms. New Zealand on the other hand has stronger winds being located in a region known as the 'roaring forties'. The lack of landmasses to serve as windbreaks surrounding

New Zealand adds to the often extreme winds (McGann). This has led to a focus on tying structures to the ground to prevent uplift and structural damage from wind forces. For this reason it is beneficial when testing the structure the foundations are modelled as a pin joint, fixed to the ground with the ability to move with realistic freedom. This gives greater legitimacy to the structure being assimilated into a New Zealand context.

Below: Area under line in 5.01 is equal to the darker grey rectangle in 5.02 and 5.03. Where the spacing between Delta 1 and Delta 2 shows ductility. Diagram illustrates increased ductility between 5.02 and 5.03

Fig 5.01
BASIC FORCE V. DEFLECTION
GRAPH FOR EARTHQUAKE
RESPONSE ▲

Fig 5.02
EXPECTED DEFLECTION GRAPH
OF TYPICAL NZS 3604:2011
TIMBER STRUCTURES ▲

Fig 5.03
EXPECTED DEFLECTION GRAPH
OF RUMAH ACEH ▲

5.2 Digital testing

Fig 5.04
SCREEN SHOT OF
ANIMATION PRODUCED BY
SAP2000

SAP2000 is a digital program used for structural analysis and design. It has the advantage of calculating the deflection of the structure when under seismic stress. Taking into account materials of the structural members, the yield values and the connection joints between one another.

In this simulation the late style Rumah Aceh was modelled, having a single continuous level flooring along the length of the structure. The model was simplified to a two-dimensional model of a short cross section. This revealed the three moment resisting frames or bays typical of the Rumah Aceh. This allowed for results to indicate the level of deflection that may occur when subjected to the equivalent standard approach to loads determined by NZ1170 (Standards New Zealand)

The result was an exaggerated animation that determined that at its peak the level of deflection was around 80mm. This is important to understand within a design as separation of structures to avoid butting is imperative to minimise damage.

5.3 Physical testing

To further test the structures ability to be an appropriate method of construction in New Zealand, a physical model of one of the bays was constructed at 1:1 scale. This not only allowed for a greater study of the physical capabilities but a visual understanding of the stresses placed on the structure. Physical testing also allowed for a better modelling of the wedge connection between the members that was unable to be achieved fully in SAP 2000.

The single bay modelled was based on the same 'idealised' Rumah Aceh structure used in the digital modelling. This frame was then placed within a beam crusher to simulate its characteristics as a supporting frame and to simulate the live and dead loads that would be acting on the frame. This was achieved by placing two cylindrical pins and packing boards between the beam of the model and the top of the supporting frame until the beam was deflecting 3-4mm mid-span as measured by a laser measuring tape.

The wedges, a key element of the joint between the Rumah Aceh's beam and column, are tightened until the beam is level and rigid against the column. The rigidity of the joint is assured by giving the wedge an additional hit with a soft mallet. The base of the columns was fixed with a bolt to the supporting frame as to not allow the model to slip as lateral force was applied. It is important to note that this joint still allowed movement in both directions

Following this lateral loading was applied by wrapping a strap around one side of the supporting frame and back around the models column above the beam. A power cell was placed against the column of the model at this point. To give additional support to the power cell a lead piece was packed between the back of the cell and the strap. The power cell measured the forces placed on the frame as the strap was tightened against it using a pull down ratchet.

Results are measured by recording the force applied to the power cell through lateral loading in comparison to the movement of the models columns to the supporting frame. The left side marked at D1 and the right at D2. As the supporting frame is fixed this method allows the

measuring of deflection. In having the bi-directional framing axially and laterally loaded bracing units for this frame can be calculated.

ELEVATION

Fig 5.05
SPECIFICATIONS OF
MODELLED RUMAH ACEH
FRAME

PLAN

SECTION

◀ Fig 5.06
RUMAH ACEH FRAME
ERECTED IN BEAM CRUSHER

Fig 5.10
LEFT: STRAP PULLING
FRAME SIMULATING LATERAL
LOAD WITH POWER CELL ▶

◀ Fig 5.07
CYLINDRICAL PINS
ON PACKING BOARDS
SIMULATING LIVE AND
DEAD LOADS

Fig 5.11
TOP RIGHT: FRAME SITTING
INSIDE BEAM CRUSHER
SHOWING STRAP WITH
PULL DOWN RATCHET ▶

◀ Fig 5.08
POWER CELL PLACED
AGAINST COLUMN AND
SUPPORTING LEAD PIECE

Fig 5.12
MIDDLE RIGHT: FOOTING
OF FRAME SECURED
TO BEAM CRUSHER AT
FOOTING WITH SINGLE
BOLT ▶

◀ Fig 5.09
TIMBER WEDGES BETWEEN
CLOUMN AND BEAM

Fig 5.13
LOWER RIGHT: VISIBLE
LEANING OF FRAME
FROM SUPPORTING BEAM
CRUSHER AFTER LATERAL
LOADING HAD BEEN
APPLIED ▶

5.4 Findings

Fig 5.14
SERIES DOCUMENTING
MOVEMENT OF WEDGES AS
LATERAL FORCE IS APPLIED
FROM 110 - 190 KGS

Forces applied where restricted due to load testing capabilities. It was decided for health and safety reason to end the testing at 190kg lateral force.

KGs	D1 mm	D2 mm	Visual observations
0	8.55	2.137	No Change
90	17.15	2.125	No Change
90	32.98	2.109	Stressed side showing signs of compression under wedge
130	35.94	2.107	Slight movement in both wedges noticeable
110	45.22	2.236	Wedges continue to moves slightly
100	53.61	2.091	Wedges move moderately
140	59.07	2.087	Wedges move moderately
180	65.03	2.086	Movement noticeable, compression under wedge significant
190	73.97	2.075	Wedges continue to move noticeably outward
190	82.68	2.063	Wedges still hold beam in place but have significantly moved

Converting the results into bracing units to compare against New Zealand's current standards.

$$\begin{aligned}
 &180\text{kg} \times 9.81 \\
 &= 1800 \text{ N} \\
 &= 1.8 \text{ Kn} \\
 &1.8 / 0.05 = 36 \\
 &36 \times 3.6 / 2.5 \times 1.5 = 80 \text{ BU per Frame}
 \end{aligned}$$

Therefore under NZS 3604 the frame is roughly equal to 80 bracing units on a 2.1 by 2.1 moment resisting frame or 40 bracing units per meter squared would be anticipated. A higher bracing unit would be expected if load testing had continued as columns hardly showing any signs of stress while continuing to take the lateral load applied at the beginning of the test. These results in comparison to P21 BRANZ testing show that the frame performance is the equivalent to, or above, current practise. In knowing this the wind and seismic zone in NZ are now comparable and applicable to the construction method (Shelton)

5.5 Developing details

Following the testing, details to form a ‘toolbox’ of construction can be generated that will inform design, building on sketched concepts from chapter four. It can be observed that this method of construction is multiverse in that its ability to span greater widths or carry higher loads is achieved by scaling all elements proportionately.

Fig 5.15
RAFTER TO COLUMN PLAN

Fig 5.16
SECTION : RAFTER TO
COLUMN DETAIL

Fig 5.17
ELEVATION : RAFTER TO
COLUMN DETAIL

Fig 5.18
ELEVATION : RAFTER TO
COLUMN DETAIL

Fig 5.19
BEAM TO COLUMN PLAN

Fig 5.20
SECTION : BEAM TO
COLUMN DETAIL

Fig 5.21
ELEVATION : BEAM TO
COLUMN DETAIL

Fig 5.22
ELEVATION : BEAM TO
COLUMN DETAIL

Fig 5.23
COLUMN TO FOUNDATION
PLAN

Fig 5.24
SECTION : COLUMN TO
FOUNDATION DETAIL

Fig 5.25
ELEVATION : COLUMN TO
FOUNDATION DETAIL

Fig 5.26
ELEVATION : COLUMN TO
FOUNDATION DETAIL

Fig 5.27
ISOMETRIC SECTION
OF DEVELOPED
CONSTRUCTION METHOD ➡

Fig 5.28
SECTION OF DEVELOPED
CONSTRUCTION METHOD ➡

PART TWO

6

- APPLYING TO A NEW ZEALAND CONTEXT -

Previous chapters have established the developing architectural methods, structural integrity and ability to be integrated within modern New Zealand designs.

This chapter addresses a specific problem through an architectural alliteration using the first half of this thesis as its method of design.

The Canterbury quakes of 2010 and 2011 caused significant structural damage to the Central Business District (CBD) and surrounding suburban areas.

Much of which was later declared a 'Red Zone' and subsequently retired from development. Large portions of this land lies the Avon River which holds cultural significance to the local iwi, Ngāi Tahu. Previously they used the rich food and resources in this area known as Mahing Kai, drawing strong connections between the land to knowledge, practices and customs that prior to European arrival were essential to everyday identity and lifestyle.

A proposed 'Te Puna Ahuree Cultural Centre' was to be one of the 16 anchor projects planned to rejuvenate the CBD and acknowledge the iwis significance. 'Blueprint 100' shows that the plan was to develop a cultural centre which...

"...Would reflect New Zealand's evolving identity, integrate with the Avon River precinct, and provide an inspiring and interactive facility to showcase and celebrate Ngai Tahu, Maori and Polynesian traditions..."

The proposed 'Te Puna Ahuree Cultural Centre' however was one of two anchor projects that had no definitive time line and is yet to have work begin.

The proposed location for this project was near Victoria Square on Cambridge Terrace. This site was used as an early trading post between the first Europeans and Maori. It would be more apt however to appropriate the 'Avon loop', a large swath of land near a site known as O-Tautahi, more commonly called 'the bricks' which was one the first settlements on the Canterbury plains following the arrival of European settlers.

6.2 Site analysis

Fig 6.01
WIDER CBD AREA SHOWING
RESIDENTIAL RED ZONE
AROUND AVON RIVER
1:10,000 ▲

Fig 6.02
CHRISTCHURCH CBD.
INDICATING AREAS AFFECTED
BY HIGH AND MODERATE
LIQUEFACTION
1:10,000

Fig 6.03
CROSS SECTION OF
CHRISTCHURCH CBD SHOWING
RANGE OF SOFT SOIL TYPES

Fig 6.04
WARREN AND MAHONEY
BLUEPRINT 100

Fig 6.05
 CHRISTCHURCH CBD
 BODIES OF WATER AND MAORI
 SETTLEMENTS PRIOR TO
 EUROPEAN ARRIVAL
 1:10,000

Fig 6.07
PROPOSED SITE AS SEEN FROM
GOOGLE EARTH ▼

Fig 6.08
WIND STUDY OF SITE

Previously the area was the meeting point of three bodies of water making it a common spot for ceremonial and cultural activities prior to European arrival (Kipa). Following the settlement of Christchurch, a map from March of 1850 shows the development of this land into botanical gardens. On the 1st of August 2005 the sites significance was recognised as holding high cultural importance with Ngai Tahu by erecting three carved pou (poles) signifying the three waves of migration to Christchurch. By this time the 'Avon loop' across the river had developed into mixed residential and commercial zone.

Following the Canterbury Quakes the residential lots in this area were designated as part of the 'Red Zone' and cleared of infrastructure and retired from future development. The Commercial buildings also were cleared and 'Blueprint 100' reappropriated the site as a future green space for the city, ultimately returning to a botanical garden as it was in 1850.

By using this space to place the proposed cultural centre to test the investigated construction method will show its ability to be built on soft soils that have otherwise been disregarded by current New Zealand acceptable solution. Additionally, it repurposes the space in a much more culturally appropriate way and utilises the land beyond green space.

Fig 6.09
ONE OF THREE POU AT
THE SITE

Fig 6.10
SITE PRIOR TO
EUROPEAN ARRIVAL

Fig 6.11
FIRST MAP OF
CHRISTCHURCH 1850 ▲

Fig 6.12
SITE OF MIXED
RESIDENTIAL AND
COMMERCIAL 2008 ▲

Fig 6.13
SITE FOLLOWING
EARTHQUAKE 2011 ▲

Fig 6.14
PROPOSED
DEVELOPMENT TO SITE
IN 'BLUEPRINT 100' ▲

Fig 6.15
LANDMARKS SET OUT BY
BLUEPRINT 100
1:10,000

Fig 6.16
 LANDMARKS SET OUT BY
 BLUEPRINT 100 INCLUDING
 PROPOSED SITE
 1:10,000

6.3 Developing a brief

The archetype of a 'cultural centre' is one that fosters a community's relationship within its own and other cultures. Going beyond a link to 'heritage' and facilitating a creation of recognisable 'identity' (Bone, 2009). To accomplish this it is imperative that the values of Nāgī Tahu are reflected in the program. Additionally the architecture itself should respond to the site's cultural heritage and recent geological state. This further links it to Nāgī Tahu who are invested in ecological and environmental remediation alongside culture, education and community.

In talking with Maire Kipa, Iwi reliance researcher, it was said;

"When papatūāuku moves as she has it may have been Ruaumoko – the God of earthquakes but it's her that is affected – so we have to figure out how she settles back down again" (Kipa)

By employing the researched and developed construction method the resulting architecture will sit on top of the land, leaving a 'soft footprint' rather than an invasive foundation system to anchor the structure as is currently required. This works towards the iwi's interests in allowing the land to resettle in a more respectful and natural way.

Programs included in a cultural centre should additionally foster the other key values of education, culture and community.

These values are translated and facilitated in physical spaces, through:

Education:

- Lecture hall
- Meeting rooms and classrooms

Culture:

- Gallery spaces
- Artist studios
- Museum spaces
- Performance spaces

Community:

- Social spaces

This is formalised into a more rigid brief of 12 spaces which as a programmatic starting point provides a base to design a form around using the adapted construction method.

- [01] Lecture hall
 - for education and large meetings
- [02] Meeting rooms
 - of various sizes to be rented out as needed to the public
- [03] Performance space
 - for shows and events
- [04] Cafe
 - to be a place for community engagement
- [05] Kitchen
 - to support the cafe and catered events
- [06] Gallery
 - for works of art produced by the iwi
- [07] Museum
 - to educate visitors on the history of the iwi and the significance of the site
- [08] Artist studios
 - two on site artist studios that are able to be used by artists to encourage further exploration of culture in mixed media
- [09] Artists in residence
 - temporary accommodation for the artists using the studio spaces if needed
- [10] Reading room
 - for public engagement in iwi and local publications
- [11] Accesses to river
 - to reconnect the public to the local environment and highlight its importance and significance regarding history and iwi culture
- [12] Supporting spaces
 - offices for managers and workers

Fig 6.17
ARTIST IMPRESSION OF
PROPOSED TE PUNA AHUREA
CULTURAL CENTRE

7

- DESIGN DEVELOPMENT -

This chapter employs the historical context and site analysis set out in chapter six while maintaining the construction methods learned and developed in 'Part One'. Chapter seven begins to explore through sketched development how the two are joined in design to arrive at an architectural resolution for the Te Puna Ahurea Cultural Centre.

7.1 Form Development

Fig 7.01
PROPOSED SITE WITH LINES
OF AXIS BETWEEN THE AVON
RIVER, THE SITE OF POU AND
ACCESS ROADS ▲

Fig 7.03
SKETCHED MASSING OF FORM EXPLORING
FILLED IN SPACES BETWEEN OF AXIS
AND GUIDELINES WHILE CONSIDERING
SIGNIFICANCE OF THE HISTORIC THREE
WATERWAYS JOINING TOGETHER ▲

Fig 7.02
CENTRE OF SITE IDENTIFIED
WITH GUIDELINES DRAWN TO
CONNECT TO RIVER AT POINTS
IDENTIFIED IN FIG 7.01 ▲

Fig 7.04
INITIAL ASSIGNMENT OF
PROGRAM CONSIDERING FLOW
AND MOVEMENT THROUGH
FOR, PROGRAM AND SITE ▲

Fig 7.05
DIAGRAM OF PROGRAM
RESTRICTED BY FROM IN
GREATER DETAIL

Fig 7.07
DETAILED AND HEAVILY
CONSIDERED MOVEMENT OF
SPACE, SITE AND PROGRAM IN
RELATION TO FORM ▲

Fig 7.06
FURTHER EXPLORATION OF
MOVEMENT AND CONNECTION
OF SPACES

32.5 per mshl.
145. / 2.
50
45
2.5
97.5

Fig 7.08
CONSIDERATION OF FORM IN
LONG ELEVATION

Fig 7.09
CONSIDERATION OF FORM IN
SHORT ELEVATION

Fig 7.11
SCALED FORM ON SITE
EXPLORING PLACEMENT AND
CONNECTIONS TO RIVER ▲

Fig 7.10
 FIRST FORMALISED FLOOR
 PLAN TO SCALE ▲

7.2 A reflection

Emphasis is placed on the architectural relationship to context with particular regard to historical, environmental and cultural aspects. Employing Alexander's methodology to guide the process of form making; as was laid out in chapter 2.3: 'A design framework' a form begins to take shape as dictated by the various axis and guidelines that are ordered by the site. These imaginary plains that both cut across and radiate from the central point of the site create abstract geometric patterns when overlaid.

By including shapes as 'positive' and excluding others to remain as 'negative' this allows for spaces in which to dwell while others remain to move through and around. Thus a more organic shape emerges as seen in figure 7.03.

The selection of areas to be 'positive/spaces to dwell' is based on the historical context of the site. Prior to colonial intervention, three bodies of water converged near this area. This was a point of many ceremonial and sacred rituals for the local Maori (Kipa). The form, while based on the geometric patterns of the axis in figures 7.01 and 7.02, begins to fragment and be guided by the idea of three forms converging into one moving South West to North East across the space.

This gives a core form in which to begin the organising of spaces regarding the program. Figures 7.05-7.07 show the exploration of space planning to accommodate the functional needs as described by the brief. The space requirements can be split between the three core values of Ngai Tahu;

- [01] Education
 - Museum
 - Lecture theatre
- [02] Culture
 - Art studios
 - Artists in residence
 - Gallery
 - Performance spaces
- [03] Community
 - Meeting rooms
 - Reading rooms
 - Café

Each can occupy a wing of the architecture on the South West side, which in its form is representational of the three bodies of water coming together. On the North East side where the architectural form blends into one solid shape, the programs can intersect and cross over another, representational of connection between the values and the importance of all three being connected rather than separate. The central space becomes more negative than positive, meaning a point of circulation space activated by movement and informal activity.

This exploration is formalised and scaled in figure 7.11 that shows a clear floor plan of the conceptual design. While the form remains based off the original guidelines and axis, the shape now has more clearly been defined by the core concept and compromised by the functionality of the program.

Here we can clearly see the central space, the proportions based off a Marae, acting as a point of circulation and informal entrance. This space can be used as a performance stage with the audience on the north lawn or altered to hold a more casual event. The walkways that extend from this space pull the occupant towards the river on elevated walkways facilitating engagement with the site.

Considering the emerging design with regards to the construction method, as laid out in 'Part One' of this thesis, it is more beneficial for a structure of this size to be fractured and broken apart to reduce damage to the forms as they will move during an earthquake. This would also make better use of the site as is shown in figure 7.10

Furthermore the need to consider more structurally symmetrical shapes to drastically reduce seismic forces is imperative to the success of the architecture. This does not mean the shape of the structures should be exactly symmetrical but rather the structure should facilitate the additional movement if they are not. Where elements cannot be moved further away, such as the connecting walkways, there should be a level of sacrifice to them. By using a modular system these can be replaced in the occurrence of a large seismic event while the primary forms remain preserved.

8

- DEVELOPED DESIGN -

Chapter eight is the result of the previous two chapters of design exploration. It exists to show an example of an architectural response that can be developed using the techniques of Part One. While the research of the construction methodology can be seen as the primary output of this overall document, chapter eight is the evidence of its effect in design.

Fig 8.01
RESOLVED FLOOR PLAN

- 01. CENTRAL HALL
- 02. STUDIOS
- 03. ARTISTS IN RESIDENCE
- 04. PERMANENT EXHIBITION
- 05. PUBLIC RESTROOMS
- 06. READING ROOM
- 07. MEETING ROOM
- 08. CAFE
- 09. KITCHEN
- 10. GALLERY
- 11. LECTURE HALL
- 12. ADMIN OFFICES

Fig 8.02
MEETING ROOM
AND READING ROOM
STRUCTURAL MOCK UP ▲

Fig 8.03
MUSEUM WING
STRUCTURAL MOCK UP ▲

Fig 8.04
ARTISTS WING
STRUCTURAL MOCK UP
INCLUDING STUDIOS AND
ARTISTS IN RESIDENCE
ACCOMMODATION ▲

Fig 8.05
MEETING ROOM AND
READING ROOM PLAN ▲

Fig 8.06
MEETING ROOMS AND READING
ROOM SECTION ▲

01. READING ROOM
02. MEETING ROOM

Fig 8.08
SECTION THROUGH MAIN
HALL WITH EXAMPLE OF
BEING USED AS A STAGE
FOR MUSIC PERFORMANCE
WITH AUDIENCE ON NORTH
LAWN ▲

Fig 8.09
EXTERIOR RENDER LOOKING
BACK BETWEEN TWO WINGS OF
THE MEETING ROOMS AND THE
MUSEUM ▲

Fig 8.10
EXTERIOR RENDER SHOWING
FAÇADE OF THE ARTIST WING
AND MAIN STAIRS LEADING TO
THE CENTRAL HALL. ▲

Fig 8.11
EXTERIOR RENDER OF THE
COLUMNS AT BUILDING
HIGHEST POINT ON STAIRS
LEADING TO CENTRAL HALL.

9

- CONCLUSIONS -

The conclusion of the design set out in chapter eight shows a viable 'human centric design' through a creative approach. It is tailored to the environment rather than imposed upon it unlike the current standards developed from colonialism.

This approach to design is embraced by ideo.org who illustrates their method of design in the three clear stages of inspiration, ideation and implementation. This sets out a clear and concise way to section out how this research was completed and applied to answer the research question.

Inspiration is the thought prescribed to being open to new and creative solutions such as employing a foreign vernaculars principle of seismic design to a modern New Zealand context. Thus resolving the issue of maintaining safely the longevity of new timber structures in the face of a nation susceptible to earthquakes.

The opportunity to research the primary precedent, the Rumah Aceh, in person gave exclusive documentation of a wide variation of occupied examples. This provided significant information to advance this research beyond anything possible from an exclusively text based investigation. This overseas study gave the design process that followed a high level of legitimacy when being applied to ideation and its development phase. Processing what was learnt to a full understanding of its capacity. In this instance, ideation was founded in analysing and evaluating the construction method that allowed the Rumah Aceh to remain seismically resilient and thereby a valid inspiration for seismic design.

It was through assimilating the Acehnese construction method into a New Zealand context that forced the issues of joint detailing to present themselves. This initiated a conceptual phase of detailing for a New Zealand context based off the precedents' core principles.

These conceptual details were then advanced through prototyping. This 'testing' ultimately provided a well-grounded and well-evidenced basis of documentation showing the construction methods' success. It concluded in a stripped back detail 'tool kit' of construction joints to implement in the design of a New Zealand timber structure.

Finally implementation is achieved by placing the resolved ideas in a 'real world' situation thereby measuring its success.

At the time of this research the Canterbury earthquakes of 2011 were the most recent example of wide spread damage especially to the inner city resulting in the demolition of buildings and retirement of land from redevelopment due to heavy liquefaction. With the likelihood of further seismic movement this land, known as the Red Zone, is of too high a risk to place structures under our current standards due to the soft soils. While current solutions do exist to build on such areas, they are highly expensive and hugely invasive to the land with deep foundations and ridged joints making them uneconomical and overly stiff to cope with larger seismic forces.

By selecting a site within the Red Zone this body of work has shown that overseas vernacular architecture can inform the seismic design of timber structures in New Zealand beyond, but interestingly connected to, the scope of NZS 3604:2011.

Furthermore, by selecting the Te Puna Ahurea Cultural Centre as the program of design, this thesis has explored aspects of social complexities of an early colonial city. Previously it unfairly represented the indigenous population in its architectural landscape and has now faced and arguably failed in its redevelopment plan to right a significant wrong. This can be attributed to the debates over land rights regarding the significance of the newly retired land that holds personal, cultural and historical significance to Ngai Tahu.

However, regardless of the site's condition and likelihood of further earthquakes, the developed research methodology that 'Part One' of this thesis illustrates a way to occupy and bring significance back to such examples of damaged and now unoccupied land in a respectful and appropriate way.

In many ways this follows Conklin's argument that architectural design is constrained by the environment and the 'laws of science' (Conklin). Neither New Zealand's susceptibility to earthquakes, proclivity towards timber structures nor the laws of science is at any risk of changing. Therefore to improve seismic resilience in timber architecture the scope of acceptable solutions must be expanded to include innovative solution such as the one presented in this research. Joining the key priorities of design; longevity,

preservation and respect for context in an elegant way. Thereby going beyond addressing the physical demands of the structures as dictated by the seismic implications and becoming a vessel to aid social complexities.

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Appendix

SCHOOL OF ARCHITECTURE AND DESIGN
TE WĀHANGA WAIHANGA-HOAHOA
139 VIVIAN STREET, TE ARO CAMPUS, WELLINGTON
PO Box 600, Wellington 6140, New Zealand
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www.victoria.ac.nz/fad/

Performance of local housing in Banda Aceh. Interview questions and guide.

1. How long have you and your family lived in this house?
2. How long have you and your family lived in this area?
3. How many people live in your household?
4. How many members stay at home for the longest time every day?
5. How do you socialise with your neighbours/ communities?
6. What do your friends say about your [redacted] house?
7. Are you satisfied with it?
8. What do you like most about your house?
9. [redacted]
10. Why have you decided to stay/move out of your previous house?
11. What would you change to improve the current layout of your home?
12. How has the structure of your house changed since you first moved in? / LAYOUT?
13. How have the materials of your house changed since you first moved in?
14. How many months/years did it take to build your house?
15. Who contributed to building the house?
16. Have you experienced an earthquake at home?
17. When was the earthquake?
18. If you were home, did you feel safe?
19. Was anything damaged?
20. What can you tell me about how your house was built?
21. Have you done any additions/ preparations to the house to prepare for an (another) earthquake?

• we are trying to find out the advantages and disadvantages of the Rumah Aceh house.

House - 2

2.

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Performance of local housing in Banda Aceh.
CONSENT TO INTERVIEW

This consent form will be held for 5 years.

Researcher: Jared Hubbard, School of Architecture and Design, Victoria university of Wellington.

- I have read the Information Sheet and the project has been explained to me. My questions have been answered to my satisfaction. I understand that I can ask further questions at any time.
- I agree to take part in a (Visual documentation/audio) recorded interview.

I understand that:

- I may withdraw from this study up to four weeks after the interview, and any information that I have provided will be returned to me or destroyed.
- The information I have provided will be destroyed immediately after the research is finished.
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Signature of participant:

Name of participant:

Date:

Contact details:

House - 1

1

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House - 4

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Date:

Contact details:

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Performance of local housing in Banda Aceh.
CONSENT TO INTERVIEW

This consent form will be held for 5 years.

Researcher: Jared Hubbard, School of Architecture and Design, Victoria university of Wellington.

- I have read the Information Sheet and the project has been explained to me. My questions have been answered to my satisfaction. I understand that I can ask further questions at any time.
- I agree to take part in a (Visual documentation/audio) recorded interview.

I understand that:

- I may withdraw from this study up to four weeks after the interview, and any information that I have provided will be returned to me or destroyed.
- The information I have provided will be destroyed immediately after the research is finished.
- Any information I provide will be kept confidential to the researcher and the supervisor. I understand that the results will be used for a Masters report and a summary of the results may be used in academic reports and/or presented at conferences.

- My name will not be used in reports, nor will any information that would identify me.

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[Redacted signature area]

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