EXPRESSIVE SPACE

Engaging the architectural experience between the tectonic and stereotomic

Master Thesis Explanatory Document

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Acknowledgements

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Abstract

“The art of architecture studies not structure in itself, but the effect of structure on the human spirit.” - Geoffrey Scott

The essence of architecture is the construction of structures, defining space. Space cannot exist without the assembly of structures and components, coming together in a unique manner that will delineate how said space exists. This relationship can frequently be lost and disjointed, structure becomes a burdened necessity and removes itself from a space's quality. This project explores how tectonic and stereotomic expression can enrich and define the spatial qualities in architecture. Through exploring the qualities of tectonics and stereotomics, the project develops how these ideas can not only generate spatial qualities, but enrich them.

“The best architecture is that whose ornamentation cannot be divorced from the structure” – Viollet-le-Duc
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1.0 Introduction

1.1 Research Question

How can the juxtaposition of tectonics and stereotomics create and enhance the spatial qualities of architecture.

1.2 Outline of Project

This thesis aims to explore tectonic and stereotomic expression in architecture and how it can manifest spatial qualities. The engagement of people with how built form is structured, formed and withstands forces is an important factor in architecture and this project aims to contribute to the existing knowledge of tectonics and stereotomics; adding a more spatial component.

Architecture expresses notions of emotion, form, space and physically built structures. An important aspect of how these emotions, forms and spaces are manifested are through the structure of architecture, because without structure, there can be none of the former. In structure, there are forces which act upon it, these forces enable the structure to take certain shapes and to hold and be constructed in a certain manner. This project deals with how forces can create form and specifically elaborate and express forces through the form of structures. Furthermore, how this expression can compose and enhance space, because space is what is inhabited by people and one of the defining functions of architecture.

The human body also deals with forces, forms and structures on a daily basis; it constitutes how we move and function and hence also displays tectonic characteristics. The architectural program will hence be tested using an anthropomorphic exploration of the body and how it can develop architectural tectonics, further evolving the relationship between people and built form.

1.3 Aims and Objectives

This thesis proposes to design through structure and construction. Using both a conceptual and pragmatic process, the aim is explore and produce how expression of structure and construction can enhance and create architectural space.

The first objective is to explore and investigate how different forces can produce different forms and structures, and how this can be expressed both visually and physically. Furthermore, the aim is to explore the relationship between expression of structural members and how it can generate and compose spatial qualities. This is to subsequently be tested through the application of a program and an architectural project.

The two notions of tectonics and stereotomics apply to structure and construction, therefore the intent is to research and develop the different qualities of space these two ideas produce, how they differ and can be used together to generate architectural space.

Beginning with the joint, the progression into how expressing structure in spatial terms can enhance and make the beauty of the space. The tension between tectonics and stereotomics is to be explored and develop what experiences lie between the two.
1.4 Scope and Limitations

This project deals predominately with expression of structure and hence the core emphasis is on this expression and maximising design potential; thus is not limited to any legal requirements set by the New Zealand Building Code or a monetary budget. However the student acknowledges sound understanding of construction principles and adheres to this in a responsible manner.

1.5 Methodology

Research through Existing Knowledge

This was carried out in two parts, literature and precedent study. The former was used to identify the important and relative theoretical positions relating to tectonics and stereotomics. The latter analysed and critiqued examples of architecture which again, bore relevance to the research question. These precedents were also analysed according to the theories found in literature. Through this research, a basis of knowledge relating to the question is used as an aid to develop the project.

Research through Design

While the existing knowledge informed and guided decisions through the design process, the process itself was used as a research to develop ideas and furthermore, the project solution. The nature of the research question involved the use of drawing, physical model making and digital model making to realise certain design decisions which in turn, was research in itself, subsequently leading to further design decisions.
2.0 Existing Knowledge

2.1 Defining the Scope of Tectonic

Tectonics is the phrase used to describe an aspect of architecture which demonstrates its construction or craft in its built form. There are many interpretations including the art of joining, the poetics of structure and construction, and the ontological effects of built form.

The word tectonics derives from the Greek word, tekton, which signifies carpenter or builder; also relates to the Sanskrit word of Taksan, also referring to the craft of carpentry and the use of an axe. Through Greek literature it evolves and adopts its poetic connotations where the carpenter assumes the role of the poet in script by Sappho. Overtime the term adopted a more aesthetic connotation as quoted by Adolf Heinrich Borbein –

Tectonic becomes the art of joinings. “Art” here is to be understood as encompassing tekne, and therefore indicates tectonic as assemblage not only of building parts but also of objects, indeed of artworks in a narrower sense…tectonic tends toward the construction of making of an artisanal or artistic product.

From his analysis on dwelling in the ‘Four Elements of Architecture’, Gottfried Semper classified built form into two separate procedures of tectonics of frame, which are lightweight, linear components, assembled to encompass a spatial field; and stereotomics, which consist of compressive mass and volume, formed through the piling up of heavyweight elements; this can be brick, clay, mortar and concrete.

Kenneth Frampton states Semper was hesitant and undecided between the symbolic expressivity of construction itself; or a symbolic elaboration of the cladding, irrespective of the underlying structure. Frampton elaborates on this and states the ontological differences of the two terms. He claims the tectonics of frame is light and tends towards the sky; whereas the stereotomic mass is heavy and tends to embed itself deeper towards the earth. This symbolic reference he summarises to sky and earth.

Expanding on this tectonic analogy by Frampton, we can place the human experience of built form somewhere between the earth and sky. We are neither embedded in the ground, yet not free from the forces of gravity to float towards the sky. There is a certain tension between grounded elements and their polar opposite frames which lead toward the sky.

4 In a natural sense, without the aids of aviation and other forms of flight.
A building’s connection to the earth is just as important as its presence above the earth; articulating this connection between the sky and earth, heaviness and lightness to create a space for human experience is tectonic.

Tectonic and Stereotomic have significant etymological connotations however their distinction between light and heavy reflects a more general differentiation in terms of materiality. Wooden construction displays a more tensile representation in terms of basketwork and framing, whereas stonework, brickwork and later reinforced concrete convey a compressive and heavy characteristic.

The distinction between tectonics and stereotomics can also vary through time, culture and place and climate. The earthwork and stereotomics of a traditional Japanese house are restrained to mere boulder footings; whereby the stereotomics in a traditional Algerian construction, the walls extend to become floors and roofs made up of the same material.
Filigree Construction vs. Solid Construction

Filigree construction is a structure of slender members consisting of horizontal or vertical members, assembled to form a planar or spatial lattice, whereby the load bearing and enclosing functions are fulfilled by different elements. It consists of voids and requires a further step of ‘enclosing’ to define space. The definition of interior and exterior space is done by secondary elements. The term itself is actually defined as “ornamental work of fine (typically gold or silver) wire formed into delicate tracery,” but has been used to describe structures of slender members and tectonic construction principles.

Solid construction consists of heaviness and compactness. In contrast to filigree, it is primarily massive, and comprises of layers of stone or modular prefabricated materials, or a solidified material cast in a mould. Solid construction can create defined spaces as their load bearing and enclosing functions are identical.

Filigree construction (tectonics) and solid construction (stereotomics) categorize two archetypal construction systems and all subsequent construction forms can be derived from these two. However their boundaries are ever so blurred today as almost anything is feasible with a number of composite and artificial materials.

Load bearing and ‘heavy’ structures can be created artificially while also, heavy materials can be used to create lattices. These terms thus provide not only historical connotations, but a reference to illustrate ‘how’ a building is constructed, ‘why’ and ‘what’ it generates.
2.2 The Role of the Detail

The scope of tectonics is varied as mentioned, although a significant aspect is whether the expression of it be construction, structure and forces are from the overall forms or the specific details and joining of components. Vitorio Gregotti maintained that “detailing should never be regarded as an insignificant technical means by which the work happens to be realized. The full tectonic potential of any building stems from its capacity to articulate both the poetic and cognitive aspects of its substance.” Gregotti argues in that details and technical constraints such as weatherproofing and structure sometimes dominate a process which then leads to formal attributes to fall into place and generate a piece of architecture. He states that the tectonics derive from how a building’s substance holds poetic characteristics and how people relate to it psychologically and physically. This scope of thinking is relating tectonic expression more with space and how a building as a whole can convey tectonics.

Opposing this thought, Macro Frascari states “…the detail expresses the process of signification; that is, the attached meanings to man-produced objects.” Furthermore stating, “Details are much more than subordinate elements; they can be regarded as the minimal units of signification in the architectural production of meanings.” Frascari expresses how details are much more than lesser important aspects of construction; and although their size may be diminished in overall scale, they are significant in the meanings and representations they illustrate.

It is interesting to compare these two schools of thoughts. Gregotti’s take not letting details and minor technical components overtake the architectural process is rebutted by Frascari’s idea of the details itself expressing meaning and being much more significant than their scale allows them to be. Both involve the idea of expression, however at different scales.

Louis Kahn states “The joint is the beginning of ornament. And that must be distinguished from decoration which is simply applied. Ornament is the decoration of the joint.” Simply worded, he explains how ornament is not a tacked on façade or components added for aesthetic beautification, but rather the joint is where ornamentation in architecture begins.

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10 Ibid
2.3 Expressive Forces

Eduard Sekler demonstrates that tectonics needs to be separated from construction and structure; which it is usually associated with. He defines “construction” connotes of something put together consciously, while “structure” refers to an ordered arrangement of constituent parts. He further explains how structure is a system or principle which is arranged to cope with the forces that work on a building, such as columns and beams, arch, vault. Construction refers to the realization of the principle, which can be solved through a number of materials being put together or fastened in a number of methods.

When a structural concept has found its implementation through construction, the visual result will affect us through the expressive qualities of the play of forces which correspond to the arrangement of these structural parts in a building. It cannot be described in terms of construction and structure alone. These qualities which demonstrate the expressive relation of form to force, is tectonic.

The focus of this thesis is how architectural space can be enhanced and composed by the expressiveness of forces, through the form of structure and construction.

Carles Vallhonrat defines tectonics by three fundamental principles of the physical world; gravity, structure of materials and the assembly of those materials. How these principles are dealt with governs the way they appear and how they form spaces. He explains how gravity ‘forces us to bring loads down, or up and then down’. This understanding and how we deal with this has not drastically changed over the years. Gravitational loads are either transferred down a column or wall, or through the middle of a span with a beam, lintel, arch or slab. Due to gravity and our understanding over the physics behind it, we may be limited to certain structures until advancements in engineering find methods around it. However, these will only alter the path that the forces are directed, as inevitably, the gravitational force on earth will always be present and constant; thus inevitably all grounded structures must transfer its loads downwards.

Vallhonrat comments on the aqueducts by Gustav Eiffel and suggests “...we wonder if anything so dramatic as those structures has extended our understanding of gravity since the turn of the century”. The entire structure is visually expressing the forces of gravity, which also echoes Sekler’s idea of ‘making visible’ the forces through form.
Vallhonrat also discusses material properties and how they can be tectonic. Concrete can be expressed by two main methods; either simply using the natural behaviour of concrete which is poured or cast in formwork to create certain shapes; or be reinforced to extend its structural capabilities. The former restricts the forces and loads the material can carry, while the latter, reinforced with steel cages can emphasise linear geometry and equate concretes behaviour with that of wood and steel. He further states to visualize the truth behind the surface, X-Ray vision would be necessary to see the full extent of forces displayed within. Technical drawings illustrate this but to an average observer, it is the form. “It is the form that makes art. The miracles must be miracles of form.”

Figure 2.3.1: Garabit Viaduct, Gustav Eiffel (1882-84)

16 Ibid
2.4 Tectonics and Space

The emotion a person feels in a space can be derived from this expression of force, in the form of the space. This relationship between tectonics and space is not a sum, or linear equation, but an experience. Tectonics conveys the expression of forces through form, structure and materiality; all of which can be used to generate space. This space then expresses an emotion onto the viewer.

Louis Kahn states how tectonics in architectural space is so critical. The manner in which a building is made and built should be displayed and celebrated – and it is this which makes a space architectural.

“A building is like a human. An architect has the opportunity of creating life. It’s like a human body – like your hand. The way the knuckles and joints come together make each hand interesting and beautiful. In a building those details should not be put in a mitten and hidden. You should make the most of them. Space is architectural when the evidence of how it is made is seen and comprehended.”

Figure 2.4.1: Tectonics // Space Sketch

Andrea Deplazes illustrates the relationship between construction and space using a Potter as a metaphor. The Potter models a vessel with both hands, inside and out in order to reshape the mass of clay into hollow space. Between the outside and inside, lies architectural matter; a boundary or transition between inside and out. “This is the paradox of architecture: although ‘space’ is its first and highest objective, architecture occupies itself with ‘non-space’”\(^\text{18}\) The material limiting the space influences the outwards and inwards. The character of the architectural space therefore depends on how things are done, and the constructional and structural realisation of the materials used in building.

Manfred Sack states “Again and again there is the sensuality of the material – how it feels, what it looks like: does it look dull, does it shimmer or sparkle? Its smell, is it hard or soft, flexible, cold or warm, smooth or rough? What colour is it and which structures does it reveal on its surface?”\(^\text{19}\) He observes how architectural space is perceptible firstly in a physical-sensual manner. By walking through a space, our senses are alerted by the appearance of the materials, the manner in which we touch the materials, the smell of the materials and the sound which resonates from walking through the space. In terms of tectonic expression, all of these attributes can be reflected on the structure of a building. The material of the structures, how they are articulated and the spaces they generate are all responsive of the physical-sensual experience of a person in the space.


\(^{19}\) Ibid
The table [right] illustrates this relationship between the physical characteristics of space and the sensual perceptions one experiences in a space. The physics of space outline the physical entities which exist in architecture. Each noun has a number of adjectives which constitute the physical component in a specific manner. For example, a material such as concrete can be heavy, flat, monolithic and constructed in a geometrical manner which dictates a certain size.

The physiology of perception is how our senses and emotions react and relate our perceptions of the physical objects. For example we may see a space a certain colour, feel that it is rough and dry and smells earthy. Therefore the relationship between these two tables is reciprocal. Without physical entities, there is nothing we can perceive, Vice versa, must perceive physical entities to distinguish them apart. For example, our perception of a lightweight timber cube in a field of grass differs from a heavy, smooth sphere in a urban street corner. Tectonics and stereotomics can both be influenced by this relationship and their qualities can use this table to further enrich an enquiry.
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<td>Stereotomic, homogenous</td>
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2.5 Precedent Study

The Highway Church in Florence by Giovanni Michelucci shows tectonic and structural expression through his articulation of columns and arches which are unorthodox in comparison to generic churches. The striking columns which fly across the spaces demonstrate the load that the concrete curved roof disperses through them, and into the ground. These structural components are significantly visible to the viewer; indicating that the expressiveness of them are important in showcasing the beauty of those components. Michelucci demonstrates the tectonic through this expressiveness and almost organic use of members. It appears as if the members are like a hand, stretching out from the ground walls to hold up the roof with fingers.

[Fig. 2.3.2] Figure-ground sections illustrate the effect of the structural members on the spatial configuration of the church. The manner in which they are articulated create variation of spaces that not only create difference spatial configurations, but also scale and forms between each main column. The structure here illustrates how it physically forms different spaces.

[Fig. 2.3.3] is a drawing that intends to illustrate the tectonic and spatial relationship of the space. The exaggerated dark etchings act as a negative graphical notion to convey how the structural components of the building (in positive white) are such an integral part of the space. The strutting beams and columns are visually seen to be distributing the forces from the walls and roof, towards the ground. This demonstrates Sekler’s idea of tectonics as a display of forces with these members visually forming the forces being distributed by the curved roof. However although it conveys tectonics in Sekler’s manner, it has strong stereotomic qualities through its use of heavy materials. Concrete and stonework are the primary materials and haven’t been used in a typical stereotomic manner.
The concrete roof in fact displays Frampton’s tectonic idea of ‘towards the sky’. One of the reasons the space is successful as this treatment of a stereotomic material in a tectonic manner creates dramatic spatial qualities.
Enric Miralles displays a more poetic notion of tectonics in this work with strong notions of compression and tension referenced from an archer's bow. The section illustrates the structural system of raking columns in tension, pulled outwards like the string on a bow to support the roof planes extruding skyward, indicating notions of flight. This not only shows the conceptual methodology Miralles used to design this building, but how the expression of forces is evident in the built form. The variations in column sizes, thick and thin are important gestures which make visible the tension and compression loads acting on the building. These different gestures heighten our awareness of the constant physical forces which the building resists. These gestures of pulling and tension gives the occupant a sense and feel for these resisting forces and thus illustrate how tectonics has influenced the spatial quality.
Frampton’s analysis of sky and earth is evident in this example. The heavy, stereotomic mass of brickwork and concrete in the centre has a grounded notion; while lighter steel columns and roof are articulated skyward. This separation and tension is evident between the space as you experience the polar opposite forces from the two different elements.

Miralles also demonstrates stereotomics and perhaps, is more evident than traditional tectonic frame as the roof elements are not light weight. The presence of stereotomics is illustrated through the use of heavy materials and structures [right] in the circulation spaces and the vertical elements dividing exterior from interior. Concrete and brick clearly define spaces while also extending into the roof planes. This can be seen as a tectonic treatment of stereotomic elements.
This drawing focuses on highlighting the spatial atmosphere created by the tectonic components. Again, the dramatic nature of the raking columns is highlighted, which forms the visual dominance of the indoor/outdoor space. Drawing into the internal spaces, the columns rake across downwards and create spaces of their own by forming routes and obstacles for people to manoeuvre through the space. This almost sculptural treatment of the columns allows a greater interaction with the space and thus, forms the spatial qualities of the area.
[Left] Figure 2.5.10: Archery Centre Elevation

[Above] Figure 2.5.9: Drawing of Archery Centre, Barcelona
Louis Kahn’s Indian Institute of Management in Ahmadabad, India has a strong sense of material and structural tectonic expression, especially evident in the buildings arches and entrance thresholds. An arch is in pure compression, the compressive stresses push outwards on either side of the arch, downwards towards the base. In most cases, the arch can hold its own structure itself. However, as the height of the arch decreases, the outward thrust increases and in order to prevent the arch collapsing, the thrust needs restraining. Kahn has expressively done this using concrete ties as illustrated. In certain cases, it seems the arch structure could hold itself, however in others [Fig. 2.3.9], the shallow height of the arches would collapse. As a visual consistency, Kahn has tectonically expressed these compressive forces through the use of concrete ties in the building. The viewer is immediately able to perceive the material characteristics, structural system and the forces the building is resisting. [Fig 2.3.7] illustrates in certain cases, tectonic expression is more of an aesthetic statement.
The drawing illustrates the strong visual expression of the concrete ties between the arches. Both materially and structurally, it visualizes the compressive forces pushing out from the arch. Kahn also uses space and light to highlight this tectonic expression through dark voids behind this threshold.
Stadelhofen Station by Santiago Calatrava demonstrates tectonics in an open space yet still holds the qualities of expressiveness through its tectonics. The concrete deck which forms the promenade above and also the shelter for the station at platform level is supported by the raking steel pylons with struts in three directions. These pylons run the course of the station and form the main structural component in the station.

The drawing [Fig. 2.5.17] highlights the tectonic expression in the train station. The raking pylons are seen to be supporting the large concrete deck above and the formal composition conveys a heavy mass being directed downwards. The mass of the concrete structure is also seen to be held up by the pylons in an almost anthropomorphic manner. The pylons can be seen to convey a human form pushing up a large mass and this immediately suggests the essence of force as we can relate to holding a large weight ourselves. Heinrich Wolfflin states, “Architectural form thus comes close to human organization and gains the capacity to express anything that can be said through the relation of the human limbs to the human body...”

Whether by intention or not, we may see this comparison and thus conveys a stronger expression of form as we can relate it to our own body's structure.

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Robert Vischer and Harry Francis Mallgrave, *Empathy, Form, and Space: Problems in German Aesthetics, 1873-1893*, (Santa Monica: Getty Research Institute; 1994), 172
Figure 2.5.17: Steel Pylon Study

Figure 2.5.18: Stadelhofen Station Sketch
2.6 Concluding Statements

This project asks the question of how tectonic and stereotomic expression can influence, compose and enhance spatial qualities in architecture. The survey of the existing knowledge has highlighted specific attributes relating to this question which have addressed key areas, techniques and ideologies which can be explored in this project.

Frampton highlights the idea of lightweight, tectonic frame which shows notions towards the sky with stereotomics consisting of heavy mass, showing notions of earth. However the ideologies of Sekler, Gregotti, Vallhonrat and Louis Kahn state tectonics are an understanding of construction, materials and how they come together, and how they express it through form, space and meaning. Through the survey of precedents it is evident that perhaps stereotomics can also display expressive qualities which are not ‘grounded’, yet they all echo the characteristics of the said ideologies.

The characteristics of anthropology were evident in certain precedents, may it be through intention or our visual perception; the notions of our human body were surfaced through the study. Robert Vischer states, “How the body, in responding to certain stimuli in dreams, objectifies itself in spatial forms. Thus it unconsciously projects its own bodily form - and with this also the soul - into the form of the object.”21 Thus, by purpose or our mere cognitive response to form, we can reference built works to the human body. This project will look at this relationship as a conceptual and programmatic basis to explore the tension and experience between tectonics and stereotomics.

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3.0 Project Development

3.1 Program

3.1.1 Physical Rehabilitation:

Orthopaedic Therapy

Through the exploration of tectonic expression, one of the emerging qualities is of the anthropomorphic nature; and the similarities and relationships between expression of structure, and the human body. The program of orthopaedic therapy aims to engage the rehabilitation and recovery of people, with the tectonic expression in architecture. The anthropomorphic aspect of tectonics will appropriately be influenced by the program of the building, thus physical rehabilitation in orthopaedics will be used as a catalyst to test this tectonic expression in architectural space.

Orthopaedics concerns the musculoskeletal system of the human anatomy, which is defined as relating to muscles and the skeleton. The system involves: muscles, bones, joints, bursa, ligaments and tendons. Orthopaedic therapy manages and treats disorders and injuries relating to the musculoskeletal system, and also rehabilitates post orthopaedic surgery. This type of therapy is commonly structured as an out-patient clinical setting. The treatment consists of post-operative joints, injuries, amputations and other conditions.

Aquatic Therapy:

The primary branch of orthopaedic therapy this project will engage with is aquatic therapy. Aquatic therapy is a form of physical therapy performed in water, and uses the resistance of water instead of weights. The benefit of this form of therapy is the number of properties in water. Buoyancy assists in supporting the weight of the patient, which decreases weight bearing and reduces the forces placed on joints. Aquatic therapy can increase range of motion, muscle strength and improve; balance, endurance and relaxation.

3.1.2 Brief

The application of the thesis question is a building which facilitates the physical rehabilitation of patients in the orthopaedic branch of physical therapy. The facility will be structured as an out-patient, clinical rehabilitation format with no on-premise surgery. The function is to provide physical therapy for orthopaedic patients and specialize in aquatic therapy. Patients will comprise of a number of issues relating to orthopaedics, including: post-operative, athletic and sports injuries, amputations, physical disabilities, other orthopaedic conditions such as arthritis.
3.1.3 Spatial and Functional Requirements:

Specific Therapy:
- Aquatic Therapy Specialist Pools (4x2.5m) x 4 min
- Changing rooms (male and female)
- Swimming Pool (25m x 5-6 lanes)
- Outdoor/indoor adaptable spaces for therapy
- Reception and Waiting Area

Administration and Staff:
- Offices for admin staff and therapists

Common and Shared Spaces:
- All areas of the building will need to be accessible for disability.
- Bathrooms
- Outdoor spaces

Services:
- Maintenance and Pump room for pools (approx. 25sqm)
- Equipment storage
3.2 Existing Knowledge

The thermodynamics of water holds therapeutic properties through its ability to retain heat capacity, which is 1,000 times greater than an equivalent volume of air. Water is an efficient conductor, hence it has a greater ability to retain heat and transfer heat energy. These thermal qualities with the specific temperature of water aids in water rehabilitation as it can easily deliver it to the immersed part of the body.

The versatility of water allows a range of temperatures to serve different therapeutic requirements. Cold plunge pools with a temperatures ranging from 10°–15°C are used for athletic training, as it decreases muscle pain and speeds overuse injury recovery. Typical therapy pools have temperatures ranging between 33.5°–35.5°C, which allows longer immersion durations and in water activities to produce therapeutic effects without chilling or overheating. Hot tubs and spas range from 37.5°–41°C which does not allow for active exercise.

The volume and level of water is also a contributing factor in aquatic therapy. These attributes are essential as it will affect the architecture and the design of spaces, depending on levels of water. Depending on the type of injury, the type of exercise and depth of water varies. Acute injuries typically start at non-weight bearing depths and progress towards weight bearing. Shallow water

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22 Bruce E. Becker, Aquatic Therapy, "Scientific Foundations and Clinical Rehabilitation Applications", PM&R, 1, no. 9 (2009), 864
therapy using closed kinetic chain exercises\textsuperscript{23} allows the waters’ buoyancy to aid in the counterforce. Deeper water exercises typically are open chain\textsuperscript{24}, along with horizontal exercises such as swimming. The ability of water to damp the force of movement due to the viscous properties of water allows weight bearing exercises at different levels and the depth of water chosen can be adjusted for the desired off-loading of the body.

Types of Exercises

Aqua running is a form of running in the water which is used for not only conditioning during rehabilitation, but also used to supplement regular training for athletes. The importance of aqua running is it not only improves cardiac and pulmonary performance, but also minor muscle groups, ligaments, tendons and joint due to the elimination of weight bearing. Due to this, and the added resistance from water, all muscle groups require effort to produce the same movement on land. Aqua training is not seen as a replacement for land-based running, but rather a supplement or for rehabilitation. In terms of this project, pools for aqua running and high cardiovascular exercises would require a separate pool due to both temperature and size. To replicate running, a linear based pool is ideal, with a depth whereby the water level is at shoulder level with the mouth comfortably out of the water without cervical spine extension.\textsuperscript{25}

Many exercises require therapists in the water with one-on-one therapy with the patient. This includes spinal rehabilitation which, due to the viscosity of water, allows much better stabilization. The different sized pools must therefore accommodate for a therapist in water.

\textsuperscript{23} Physical exercises performed where the hand (for arm movement) or foot (for leg movement) is fixed in space and cannot move
\textsuperscript{24} Open chain exercises are exercises that are performed where the hand or foot is free to move.
\textsuperscript{25} Andrew J. Cole, \textit{Comprehensive Aquatic Therapy}, (Philadelphia: Butterworth Heinemann, 2004), 139
3.3 Site

3.3.1 Location

The site is located on Rendall Place, Eden Terrace in Auckland. It occupies properties 7 to 25 on the lower end of the street and sits adjacent to Basque Park. The site is predominately vacant with a small outlet store in lightweight construction on the southern end. A semi demolished concrete structure existed in early 2013, but has been recently demolished to make way for a proposed apartment block. A residential building is also situated adjacent to the park and towards the end of the year, a subsequent second building is under construction. These are variables which have occurred during the project and thus the site will be treated as per March 2013.

Significantly north orientated, Basque Park allows the site to be fully open from the north and majority of the east which enables vast solar exposure throughout the day. The considerable, gradual slope of just over ten meters opens up a number of opportunities in terms of the exploring research ideas. Both tectonics and stereotomics can benefit from the sloping topography.
Figure 3.3.4: Site Context Panorama
3.3.2 Criteria

The following lists the reasons for choosing this site:

- Location was an important criterion in catering for an orthopaedic therapy facility as it is easier for patients to travel to a central location whereby limiting travel times for patients commuting from further ends of the city.

- Distance from public transport is a key factor. Many patients without cars need to be able to access the facility with ease and this site is 500m from Mt Eden Train Station (6 minute walk). The bus stop is also 180 meters away on New North Road (3 minutes’ walk).

- Community and public integration is another criterion. Basque Reserve is a well-populated park throughout the week, being used by not only residences from the surrounding apartments but also throughout the day by people on their breaks from work. This site has 2 boundaries which border the reserve and integration with the park is possible.

- Outdoor/indoor spaces are also important. This site, again with its vast aspects towards the park opens up opportunities for this.

- The site is predominately vacant. A semi-demolished, concrete structure sits in the center of the site with an asphalt car park at the lower end. This allows minimal demolition of existing structures.
Figure 3.3.5: Aerial view of site and immediate context.
Figure 3.3.10: Site Context
4.0 Development of Tectonic and Spatial Relationships

4.1 Phase I: Conceptual Investigation

"How the body, in responding to certain stimuli in dreams, objectifies itself in spatial forms. Thus it unconsciously projects its own bodily form and with this also the soul into the form of the object."26

The design process is initiated by exploring the anthropomorphics of swimming. Aquatic therapy involves a vast number of exercises however the core principles in swimming consist of the four main strokes. The process begins with this because our bodies also display tectonic qualities; we have been constructed in a certain arrangement and our body moves and behaves to forces on earth accordingly. The strategies in this investigation are intended to develop forms and shapes based off the human body using drawing techniques to highlight the forces acting upon us during swimming.

26 Henry Francis Malgrove, "Empathy, Form, and Space: Problems in German Aesthetics, 1873-1893", (Chicago: Getty Center, 1994), 92
These drawings begin to explore the anthropomorphic qualities of swimming and how forces act upon the body through the stroke cycle. Although the strokes have no set position, I have chosen the positions in which they are at opposites to determine the motion and movement of the body through the stroke cycle. These drawings highlight the position of the body (blue) and the forces acting on the water as the body moves through (red). Butterfly illustrates a strong pulling movement from the arms while the legs illustrate a reciprocating, vertical motion.
I chose Breaststroke as the other stroke as it is significantly different in technique compared with Butterfly. This illustrates a more elastic, horizontal compression and springing action from the arms; while the legs are again in a vertical motion, however from the pivot point of the knees.
These drawings now further develop from the former and begin to architecturalize and delineate forms and lines through the motion of the body and the forces acting upon it. Again, the two different strokes create different forms while using the same drawing technique as a base medium. The two different colours are used to show the many positions of the body through the stroke cycle. Using lines extruding from points of major joints and pivots, the aim was to illustrate this movement of swimming and highlight the movement and form of the body in a more graphical and architectural manner.
The breaststroke drawing shows a more dynamic form due to the different style of the stroke; the number of joints and pivots is evident and is conveyed through forms created from the linear etching. From a tectonic perspective, these drawings based off an anthropomorphic diagram illustrate the forces acting on a body, through form, and how structural parts of the body are articulated in water. The butterfly stroke also illustrates Frampton’s theory of the frame, extruding skywards, which can be seen through the free and outward expressing form above the water plane.
4.2 Phase II: Initial Concept Exploration

[1] explores the geometric composition of the previous drawings by connecting points of pivot and using a red tone to indicate forces of tension. This highlights certain points of strong expression and force whereby the form looks to be held together in tension, compared to floating in the water. [2] explores how a tensegrity structure could be implemented, using rigid poles for the limbs and connecting them through tension cables.
These drawings begin to explore tectonic expression and how they can compose space using the swimming stroke drawings as a conceptual and formal driver. The sections use the breaststroke leg movements to generate forms and begin exploring methods of conveying not only structure, but the display of forces.

[1] illustrates a basic stereotomic form, heavy in mass, grounded towards the earth. Using this as a basis, the drawings develop the strokes into forms. [2] uses only stereotomics - a heavy mass which forms a sculptural structure. [3] Explores Semper’s theory of ‘tectonic frame’ and Frampton’s idea of ‘towards the sky’. The lighter elements extend upwards while the ‘hip and body’ remain grounded and heavy. [4] Also uses lightweight elements towards the sky but a tensegrity structural system which has the elements in constant tension and compression and ‘floating’ above. These drawings all explore the basic notions of tectonic expression however, do not fully convey the forces acting upon them through the forms. The forms seem static, held up in tension by wires. In terms of how the tectonics compose spatial qualities, these drawings are only beginning to encase space through the structure. ‘Qualities’ are not evident and [2][3] are lightweight, with defined space not clear.
The models now begin to explore the structural components in three dimension and explore how their physical composition convey not only tectonic expression, but how they generate and compose space. This model conveys the structure of the main pool area with a composition of timber, concrete and tension cables creating a spanning, cantilever structure over the width of the pool. The form was developed from the initial stroke drawings, however not literally conveyed into structure. The idea of the leg posture and different position of joints was developed into this form. The intent of expression of forces, I believe is successful through the tension cables which hold the longer span. This force is seen to be pulled up, and then down towards the angling concrete columns into the ground.

This one structure is then repeated along the length of the pool. The model does however highlight the sculptural quality of it. The lightness and openness is not enclosed, which conveys the pool as more outdoor space.

Figure 4.2.4: Exploration Model
Further developing this form, the drawing expands on the notions of stereotomic mass and tectonic frame; while extending how the expression of forces can be clearer. Instead of the heavy mass being grounded, it is seen to be ‘floating’ and touching the ground. This retains the heavy mass towards the ground while also creating a sense of lift and expression upwards. The formal shape of the mass continues upwards but with a change in materiality and mass, to a lighter ‘frame’ which forms over the space. Smaller connections between the elements convey not only the joints of the human body, but also again, expressing the tension that holds these elements together.

This model expands on the previous drawing intending to expand on how the tectonic elements would be constructed and built. The lighter elements consist of a timber frame with a steel structure connecting the entire frame to the concrete pylon. Aesthetically, the expression of forces in the bent vortex at the top is prominent as it holds heavier forms on either side. However the pylons do not have enough grounding, and do not express enough expression towards the ground. The heaviness is lacking and the structure seems to mimic that of a sea-saw. Also, grounding or enclosure is lacking on the right side of the model. Whether it be glazing or solid structure, the spatial qualities in this model are slightly more defined however, still quite lightweight and open.
4.3 Phase III: Planning and Spatial Development

Developing the plan and program will allow the development to explore which spatial qualities and functions the question can be applied to. The initial planning places the main spaces on three axis’ running through the site with therapy at the north end and the main, shared pool in the centre. The site has a constant sloping topography; the design thus accommodates this with the two main spaces (Therapy Pools, Lap Pool) located at either ends where the gradient is lesser. The steeper middle section is used as the entrance and primary circulation between the two, a valley which separates the two spaces. The initial focus and exploration of ideas will be through the Therapy Pools.
Initially the plan arranges the therapy spaces in a linear manner, dividing each pool into separate cubicles. However this creates small, congested spaces with privacy thwarted by the circulation corridor. [2] Splits the space with changing rooms to allow separation between group therapy sessions and individual. [3] has a more direct circulation however creates a bottleneck, which is solved by creating circulation through the changing rooms [4]. Developing this plan further, the smaller therapy pools have retained privacy, yet still open using curved walls on specific edges to achieve this. The changing rooms are situated in a more intimate ‘mass’ within the overall form as privacy and warmth is a necessary quality in those spaces.
The purpose of these models was to test methods of casting which can be used in the construction of the aquatic pools. Using plaster as the casting material and card as the mould, it was used to replicate concrete casting which is done using a similar technique with timber and concrete used in place.
These drawings investigate the design of the therapy pools. In usual aquatic therapy facilities, the pools are bought fixtures which are merely placed in rooms. These drawings explore how the therapy pools can provide the function of the pool while incorporating stereotomics into the ground. The sections illustrate the massing 'cut-out' of the ground plane which places massing according to types of activities undertaken in the pool.
4.4 Phase IV: Initial Developed Concept

The design progresses from a conceptual form exploring stage, to a development of spatial qualities and how tectonic expression can create this. Using the shapes and forms generated from the swimming diagrams to create structures in the building through sectional drawing. The main structure comprises of a steel portal frame supported on angled, concrete columns. The purpose of this is to illustrate Frampton’s idea of tectonics and the balance between heavy stereotomics and light tectonics. “The first implies load-bearing masonry and tends towards the earth. The second implies the dematerialized A-Frame and tends towards the sky and translucence.” Our experience lies between these two elements and thus the design incorporates the combination of these two elements. The rectangular ‘massing’ of the changing rooms is constructed from brick, again using Semper’s grounding of the earthwork to enforce the idea of heaviness and privacy in those spaces.

Figure 4.4.1: Section through Group Therapy Pool

Figure 4.4.2: Section of Individual Therapy Pool
The curved forms are used to generate different spatial qualities and scale in space. Section [1] demonstrates the manner in which the open space dips down to a more intimate space as the person enters the therapy pool. Using structure, the space follows the movement of people through the pool to generate a more enclosed spatial quality.

Using tectonic expression through a combination of structure, material and scale; this section illustrates the different spatial qualities that are created with them. Changing rooms in pools are intimate spaces with a journey of experiences and activities that take place through them. The ‘box’ is orientated towards the north; north-east to gain as much solar exposure possible, and the concrete and brick construction provides high thermal mass. This is to generate more natural heat that can be dispersed throughout the day. Especially for people exiting the pools and coming to the changing rooms, a warm enclosed environment is comforting and inviting thus a combination of these materials and lower height in space creates these qualities. Privacy is also an important criterion, with changing and showering activities; views in are blocked but views out through slits in the wall and roof allow not only light, but apertures outside.

Critique feedback suggested there is not enough focus on the aspect of tectonic expression, due to the concentration on program and addressing the needs for function. Comments specifically regarding the roof and column structure and questions regarding the shape, materiality and structure. It was suggested to focus more on the connection between roof and column, the ground and the actual roof structure. The models earlier in this document were distinctive and the project could possibly further explore those models and how it can be incorporated in these spaces with greater complexity.
Figure 4.4.3: Section through Changing Room
4.5 Phase V: Detailed Tectonic Exploration and Development

Expanding on critique feedback which suggested further exploration and interest in the earlier conceptual models; the design develops the existing therapy spaces. Feedback suggested the lack of expression and disjointedness of the roof structure, thus these drawings incorporate the earlier conceptual models in the form of a roof and column structure. Immediately this illustrates a more tectonic expression; the timber roof structure is cantilevered over the space with tension cables fixing it down to a concrete column. Compared with the earlier section, this demonstrates more of Sekler's idea of illustrating forces. The tension forces are evident through the cables and as it is cantilevered, the floating nature of the roof provides a more dramatic expression. The expression of this structure is also creating the envelope for the interior space, something which was lacking in the former drawings.
“Architecture is an art because it is interested not only in the original need for shelter but also in putting together spaces and material, in the meaningful manner. This occurs through formal and actual joints.”

Through the design development it has arisen that although this project deals with the spatial relationship between tectonic expression, the detail does need to be addressed. As Frascari states, the actual joints and manner in which they are put together becomes the art. It is critical for the expression of joining materials that is tectonic. These sketches illustrate how the tectonics of frame (the spanning roof structure) connects to the stereotomic mass of the grounding columns. The recessed cut in the concrete provides a more elegant finish with the timber sliding and the supporting piece fixed on top. Having the flushed timber also provides a stronger connection structurally, and also visually as the two materials are visually in unison.

Fig. 4.5.4 illustrates a long section through the therapy pool spaces. The main roof structure (Fig. 4.5.3) has remained throughout the design progression and thus types of spaces it generates remains similar as you progress through the building. The roof structures were based off the idea of leg movements and positions of a swimmer in water; thus the aim now is to evoke movement in the building as well. The structures now ‘move’ as you move through space by freezing different moments of a swimming stroke. Formally, this is used to generate different spatial qualities by adjusting the size and scale of space created from the roof structure. The shared group pool uses the roof structure to be in a higher position, creating a larger, more vertically open space below. This is due to the more communal nature of this space. However the individual therapy area requires a more intimate and private space, and thus a lower roof structure allows for this.
One of the primary tectonic components of this project is the roof and column structure of the therapy building, which provides the base envelope of the building. The issue is weather-sealing of the structure and how it will separate inside from out. The two drawings illustrate the main structure in relation to the wall and roof with a copper, sculptural gutter used in between. This allows the expression of water drainage to be expressed inside the building as well as out; and materially it forms the junction between roof and wall. However the issue is the placement of the outer structure which interrupts the continuity of the gutter and creates issues of weather proofing. Perhaps the location of these needs to be reconsidered in order for the building to be sealed.
Figure 4.5.7: Main Structure Perspective
Re-configuration of roof structure to column in order to allow the building to be weather sealed.

Figure 4.5.8: Roof to Column/Wall Development
Figure 4.5.9: Roof Structure Bay
Figure 4.5.10: Roof Structure Joint Development
The exploration of tectonic expression continues into the development of the joining of the roof’s structural elements. As Marco Frascari stated, “the detail expresses the process of signification; that is, the attaching of meanings to man-produced objects.”

The process of developing this joint is not merely at a functional level, but also signifying the attachment of two planes. The initial concept was derived from a person moving through water and thus the joint continues to use anthropomorphic references to develop the detail; mimicking the knee joint.

The joint begins with simple steel rods and explores methods where steel plates can be used to provide a stronger connection which is also visually indicative of two parts of the structure, joining together. [6] Incorporates the tension cable which is used to suspend the roof structure from its supporting arm.

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The development of the roof joint is further applied to the entire roof-to-wall structure. The upper supporting arm is fixed to the concrete column by slotting the supports into the concrete. The arm is fixed also through tension cables which allow the arm to support the lower roof structure. This allows the roof to be ‘floating’ and cantilevered, allowing no need for support on the opposite end.

The structure intends to apply many ideas of tectonics; the tension cables illustrate the forces required to hold up the roof while the lightweight nature demonstrates Frampton’s ‘tectonic frame’.
Figure 4.5.13: Roof/Wall/Column Structure Development
Investigation One: Changing Rooms

These drawings and models develop the changing room sub-building illustrated in Fig. 4.4.3 (p. 61) earlier. The design at that stage displayed basic stereotomic qualities, however was possibly ‘too heavy’. The roof was a large, flat mass which made it difficult to have natural lighting and ventilation. Also, the form was not ‘expressive’ enough; it consisted of one material, one type of surface and no depth in form manipulation.

Now the development aims to manipulate the structure to allow light in specific areas and also ventilation in the shower areas. The use of stereotomics in this area is that it provides more of an intimate spatial quality through its heavy materials (concrete and brick). In contrast with the light frame in the main building which is used to create vast, open spaces. These structures are more enclosed and thus, provide a more sensual space.
Initial changing rooms space from Fig. XXX illustrating space and light penetration. Limited in spatial expression and natural light.

Exploring manipulation of roof planes to create different spatial configurations and light apertures.

Further manipulation of roof planes to create different spatial configurations and light apertures.
The concrete roof expresses tectonic qualities through its compression cables which tie it to the foundations. This gives the intention of the building’s roof physically opening at the centre to allow light and ventilation into the spaces. The curved surface of the shower space is again, enforcing the relationship between the body and building, as the curves compliment the body’s natural forms.
Figure 4.6.4: Changing Room Development Section

Figure 4.6.5: Changing Room Development Section
Manfred Sack discussed how the character of architectural space comprises not only of the structural composition, but also the material make-up and the sensuality of the materials used. The changing rooms are a significantly different spatial quality compared with the pool areas and thus, stereotomics and materiality are used to generate these qualities.

The use of concrete formwork in the showering area is to highlight the raw nature of that environment with such a raw material, yet finishing it so “the formwork boasts skin-like smoothness, with formwork joints looking like the seams of a tent, which lends the exposed concrete a visual quality devoid of any ‘heaviness’.” The skin of the building’s users is the most exposed in the shower and ones sensuality relating the smoothness of ones skin to their immediate surroundings is what the space aims to achieve.

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Ibid, 57
Figure 4.6.7: Changing Room Development
Figure 4.6.8: Perspective from Basque Park
Figure 4.6.9: Building Cross Section
Within the changing room, the actual changing of clothes is one of the most utilised spaces; acting as a transition between people entering or exiting the facility. The intent is to use stereotomics techniques to define space however the ceiling plane was previously under utilised.

“The ceiling plane, as in the case of the base plane, can be manipulated to define and articulate zones of space within a room. It can be lowered or elevated to alter the scale of a space, define a path of movement through it, or allow natural overhead light to enter it.”

Using Ching’s ideas on planes, these drawings explore means to create dynamic spaces in the changing areas by pushing the physical and visual boundaries.

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With a flat plane [1], the limits of the defined space are visually established; as the corners convey the force is distributed down the walls. This also creates a static space as the experience is between two flat planes. [2] aims to break the plane by introducing glazing for natural light. However the space becomes significantly vertical due to the edges now being less defined. [3] and [4] alters the form into an arch. This creates a large space due to the corners being less defined. [5] implements an inverted arch to create a more intimate space. Although the corners are defined, they disappear into the corners as the ceiling projects downwards. [6] Implements glazing across the length of the space to introduce natural lighting which would fall as the curve falls away. In terms of expression, this also enforces a visual impact on people in the space. The ceiling is supported on opposite ends and due to the glazing, the effect of the ceiling would appear ‘floating’ between the two walls.
Feedback suggested the curved suspended ceilings [See Fig. 4.4.2, p. 59] were ‘disjointed’ from the structure and overall tectonic expression. The curves were merely suspended from the roof frame above and seemed ‘tacked’ on.

The therapy pools display stereotomic qualities through their subterranean, grounded nature. Expanding on this notion, these sketches and models explore how stereotomics, rather than tectonic frame can generate the structure and space of the pools. Whereby the suspended ceiling hung from above, the latter now grows out of the ground and uses the idea of stereotomics to generate space. The variations explore enclosed spaces while also taking into consideration the space generated on the outside.
Figure 4.6.13: Therapy Pool Development Models
4.7 Phase VII: Developed Design

The developed design now incorporates the different elements of the building and explores the relationship between tectonic and stereotomic.

This drawing illustrates the view looking from the larger, group pool down towards the individual pools. The intent is for the tectonic frame to create the overall, enclosing space while the smaller stereotomic elements enclose smaller spaces.

The tectonic frame however needs more development. The primary structure is evident yet the interior finish of the ceiling needs attention. Rafters need to be fixed to allow the ceiling to span and this could also elaborate of the tectonic expression.

The planning of the building now moves the therapy areas to the east of the site. This is because the boundary is larger, thus providing more area where the west lacked. Due to the topography of the site, it also provides an entry level without the need of level changes. This is important as building needs to be accessible by wheelchair.
Figure 4.7.2: Interior Perspective looking down towards therapy pools
The idea is the stereotomic pools sit within the greater tectonic space, which allows the characteristics of each to govern the spatial qualities within their respective spaces.

The individual therapy pools which are subterranean retain stereotomic qualities that extrude out from the ground. The brick walls create semi-enclosed spaces which provide privacy within the greater building. Apertures in the walls give the patient in the water views out, while still retaining visual boundaries with two other walls.

The concrete arch above each pool is again, allowing stereotomics to create a more intimate space within the pool by arching down as the patient steps into the pool.

Issues regarding the structural requirements for the arch need to be addressed. Clearly the effect is to have it ‘floating’ above the water however it needs structural support.
Figure 4.7.4: Interior Perspective of Therapy Pool Area
The stereotomics of the project still require further development, specifically in the aquatic therapy spaces. The choice in brick as the primary material for enclosing the pools do not emphasise stereotomics and ‘grounding’ strongly enough. The brick walls seem disjointed from the ground plane and visually; the space conveys itself in three elements - frame, wall, ground. The presence of one in the space is disjointed from the tectonic frame and almost obstructed by the brick walls.

These drawings [Left] explore different possibilities in using stereotomics to define the smaller pools. [1] shows the earlier brick and concrete structure which although defines the pool strongly, creates a lot of negative and unused space around it. [3] and [4] tone back on creating whole sub-spaces and instead, use stereotomics through walls and level changes to create subtle space definitions. This uses the tectonic frame of the whole building to act as the top vertical plane while the stereotomics create subtle divisions.

Figure 4.7.5: Therapy Pool Development
Figure 4.7.6: Base plane manipulation

With the removal of high walls from the smaller pool spaces, it compromises the privacy. In order to still maintain privacy yet not divide the space drastically, the base plane is manipulated. Ching states, “the degree to which spatial and visual continuity is maintained between an elevated space and its surroundings depends on the scale of the level change.”

Drawing [1] has no manipulation, thus a constant visual continuity which allows no privacy between the group pool and individual pools. [2] Introduces an elevated plane which does disrupt the visual continuity but still exposes the individual pools. [3] implements vertical, part-height walls which disrupts this visual continuity and furthermore, [5] implements a further drop in level to create greater privacy. This allows all to look out towards Basque Park yet separating visual continuity between pools.
Manfred Sack states discussed the importance of material by stating, “Is it hard or soft, flexible, cold or warm, smooth or rough? What colour is it and which structures does it reveal on its surface?” While this has been addressed thus far, it has only been explored as one entity. Concrete was chosen for its stereotomic characteristics, yet this can further enhance the sensual experience by exploring the surface of the structure. The images on the left illustrate the different surface finishes of concrete. As the therapy area is exposed to bare skin, the treatment of these surfaces is important. Exposed aggregate [Fig. 4.7.10] would not be ideal for the pool surface and surrounding areas as the aggregate can be harsh on the skin; but perhaps be suitable for the circulation and main floor areas as the aggregate can provide natural grip which is required in a wet area.

Light sandblasting [Fig. 4.7.12] can reveal a smooth, sand-textured finish. This can also be

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appropriate to provide grip on the floor surface, however possibly a bit rough for inside the pool. In-situ concrete with smooth formwork [Fig. 4.7.8] would be most suitable for inside the pool and also the surrounding walls. The smooth finish provides a comfortable surface for the skin and feel smooth against the body. As exercises are performed against the pool walls, a smoother surface would provide a more pleasant experience.

Formwork can also be used to introduce textures and shapes to the surfaces. [Figure 4.7.9] demonstrates how timber formwork can impose its own surface onto the concrete. Using this technique, the surface of the pool walls impose triangulated cuts [Fig. 4.7.13] to not only create a visual pattern, but also provide hand grips. The patients can use these to support themselves in the water. Rather than implementing ‘stuck on’ aluminium or plastic rails, the construction and structure of the architecture is contributing to the spatial and functional quality.
Developing on this, the design now retains concrete as the primary material and structure for the pools. Using changes in floor levels and lower dividing walls, the space is more open and allows a clearer relationship with the tectonic frame. The concrete walls still retain the privacy between each pool and allows people to manoeuvre through the building with these walls acting as a passage. The stereotomics are significantly more defined. The forms are almost part of the landscape and topography which emphasises their relationship to the ground; and these qualities demonstrate a more stereotomic space.
Figure 4.7.16: Therapy Pools
5.0 Conclusion and Critical Appraisal

This project explored how tectonic and stereotomic expression can create and enhance the spatial qualities in architecture.

Firstly, explicit exploration and representation of these two ideas were pursued. The direction and methodology that was used allowed the project to pursue itself in a manner which firstly analysed literature and precedents, and subsequently applied the findings to the chosen architectural project of an Aquatic Rehabilitation Facility. Due to the two aspects of tectonics and stereotomics, the design process led down two paths. Early on, as the chosen project was Aquatic Therapy, anthropomorphic representation was chosen as a conceptual design starter. This was used to generate forms and explore the tectonic forces acting upon the body while swimming. This resulted in a rather literal and clumsy representation of swimming strokes being represented in form. Also, the design was predominately space orientated, and the structure was there to fill the envelope only.

The design thenceforth proceeded away from mere corporeal representations and towards exploring the tectonics and expression of the structural components. These strategies then evaluated the design against the literature findings and further developed them accordingly. The main theories of Frampton’s, ‘between earth and sky’; and Eduard Sekler’s, making visible forces through form were achieved. Through model

Figure 4.7.17: Plan
making and drawing, the main space of the therapy building was developed through tectonic exploration of the roof plane. However, the tectonic exploration became limited to this roof structure. Constant development explored not only compression and tension forces in the roof structure, but Frascari’s idea of signifying the detail; this led to a detailed development of the roof and column structure which became the core structure of the building. The anthropomorphic representations became slightly ambiguous. The formal characteristics represented swimming strokes in a metaphorical manner, however was deconstructed to explore the structure in a more tectonic approach. The manner in which the roof fluctuates vertically along the length of the building to evoke the movement of legs during a swimming stroke remains ambiguous. This is merely an analogy and not evident unless pointed out.

The second strategy was to explore stereotomics. Again, this became limited to certain parts of the building which subsequently developed to be the core focus of the project. Unlike the tectonic investigation which was more direct, the stereotomic investigation took two paths. One dealt with the subterranean and spatial qualities of the therapy pools, while the other explored the showers and changing room facilities. The former developed more in accordance with traditional stereotomic characteristics such as grounding, heavy mass and repetition of massing units. It developed into a Frampton orientated design with the tectonic frame above, and stereotomic mass below. The latter implemented tectonic qualities of expression into stereotomic structural elements by creating spaces using heavy, stereotomic materials and structures. These spaces used no lightweight frames, but rather implemented stereotomics in a tectonic manner. This ambiguity between the two stereotomic investigations generated rather more interesting interpretations and outcomes for the building as it illustrated how stereotomics can be manipulated in a tectonic manner. The natural progression of the project leads the focus purely towards the aquatic therapy building and while the design planning considered other areas and spaces, the focus retained on the therapy areas and changing facilities; as this provided the most content relating to the research question. The design successfully showed how the exploration of the two theories can enrich design at a detailed and spatial level.

The final design outcome, together with its documented process, illustrates how a building can be enriched through detailed exploration and development of its structure and construction. It shows how structure can in fact delineate spatial qualities and that a detailed, design outcome can be more successful than a large architectural gesture of mass. The project highlights the importance of detail, expression of structure, understanding of construction and material, and how these physical components can affect the physiology and characteristics of architectural space.
Finally the question of where this enquiry could further develop? Foremost, the methodology can be further applied to the greater scope of the architectural project, expanding past the therapy areas into the larger lap pool, consultation spaces and entrance area. These different functions will offer different spatial requirements, thus the tectonic and stereotomic enquiry can explore those in a similar manner to which this project addressed. The enquiry could also choose an alternative architectural scheme to test the thesis against. The chosen scheme of aquatic therapy resulted in an anthropomorphic orientated solution which influenced the tectonic and stereotomic exploration. It would be interesting to see what solutions would arise out of a different scheme, which would further contribute to the knowledge of the importance and richness of tectonics and stereotomics in architecture today.
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8.0 Appendix A

1. Roof Structure Section

- Roof Support Arm
- Glazing (operable skylight)
- Pre-cast concrete wall panel
- In-situ concrete column

3. Exterior

5. Interior

6. Tension cable system to support roof
Zinc roof cladding on plywood substrate, fixed to purlins on exposed rafters.
3. Detail of Roof Structure

- Tension Rod/Cable
- Flashing
- Roof Frame
- Joist hanger to fix rafters to roof framing
- Exterior

Zinc Roofing
- Purlins
- Plywood substrate doubling as ceiling
- Internal Gutter on lower end.
- Turnbuckle/similar to fix cables to rod
- Glazing between framing
- Rafter
- Interior

3. Detail of Roof Structure
4. Detail (Plan) of Roof to Column Structure
5. Detail of roof support arm to concrete column.
Concrete in-situ column
Pre-cast concrete wall panel
Gutter fixed to wall with aluminium flashing
Roof frame fixed to concrete column
Glazing
Aluminium joinery fixed roof structure
Exterior
Interior
6. Gutter to exterior wall detail
EXPRESSIVE SPACE

Engaging the architectural experience between the tectonic and stereotomic
Main Entrance from Rendall Street
View from Basque Park

Approach from Rendall Street
Individual Therapy Pool Area
1:20 Model of Roof Structure Bay. (Plaster, Cedar, Steel, Stone)
1:20 Model of Roof Structure Bay. (Side Elevation)

Tension Cable to Column Fixing.
1:20 Model of Roof Structure Bay. (Front Elevation)

Roof Structure to Column Detail