THROUGH THE ROOF

How can the architectural element – the roof – mediate climatic conditions in a New Zealand context and produce a more efficient, culturally relevant and tectonically expressive building?

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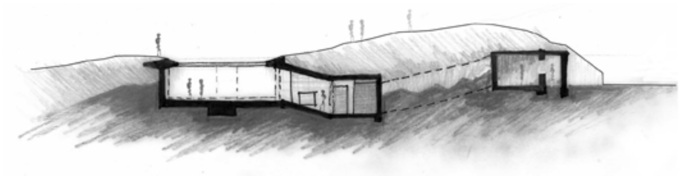
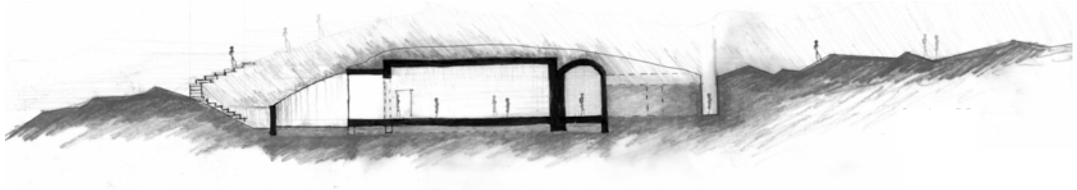
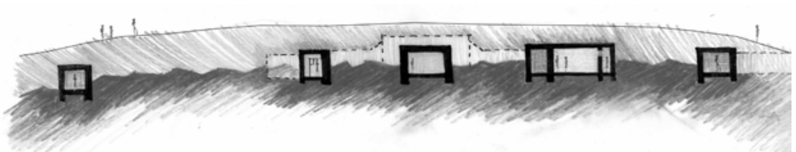
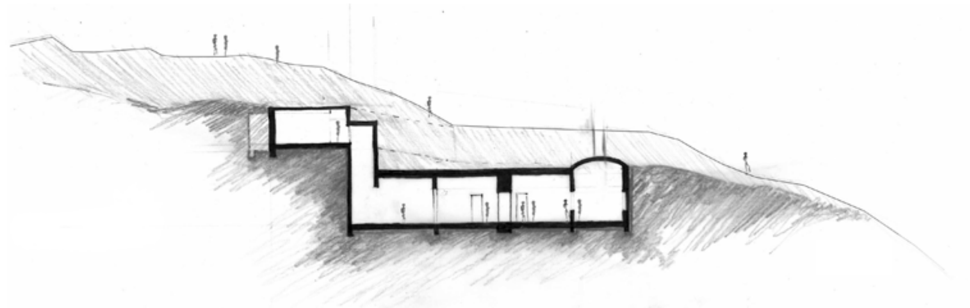
A Research Project submitted in partial fulfilment of the requirements of the degree of Master of Architecture Professional. Unitec Institute of Technology, 2014.

Figure 1.1. *Lake Taupo Aerial View*

Abstract

The architectural element – the roof – is the subject of this research project. Whilst the roof serves a strong practical function by providing physical shelter, it also serves certain 'felt' functions. Rich in symbolic meanings, the roof has been employed across a variety of cultures and times, to give importance to spaces below. It has also been suggested that the roof helps establish a 'sense of place', as it is the element that separates sky and ground. This sky-ground relationship will be explored further throughout this project, thus introducing an underlying metaphysical theme. The issue placelessness remains topical in New Zealand amidst trends towards more globalized architectural practices, and where buildings of a modernist style are in abundance. These modernist buildings favor a universal language, over local expression.

The project is located within the Taupo Domain, an area rich in local history and contextual issues. This abundance of local issues offers various avenues for design and an expression of this place will be architecturalised through the design of a tectonic roof. Research findings will help develop a brief for the design of a Taupo Art Center which celebrates local art works and supports local artists.

Acknowledgements

I would like to sincerely thank Jeanette Budgett, Christoph Schnoor and David Chaplin for sharing your knowledge with me, for your encouragement and your critiques, Brendan Smith and Peter McPherson for being so generous with your time, and the members of the Taupo Active Arts Group who have helped enrich this project by sharing local insight. Thank you to my friends and family who have shared this journey with me, and finally my parents Peter and Debra Mount, for being so patient and supportive with me and to whom I am incredibly grateful.

Figure 1.2 Sections through the North Head tunnels, Auckland.

1.0 Introduction

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1.1 Project Background

The roof is the symbolic element that separates man and sky, so it inevitably has strong significance in the way people experience space. Sky and ground, a relationship that is referenced in many religious and mythical teachings[1] and one that inspired the writings of philosopher Martin Heidegger, will be an underlying theme throughout this research. Christianity frequently references "heaven and earth"[2] and the Maori myth of Rangi and Papa[3] also supports this reoccurring theme, which transcends cultures and time. Throughout history, architects of sacred or religious buildings harnessed this powerful relationship by giving special treatment to the roof. Renaissance churches combined arches, vaults and domes and began to blur the boundary between roof and wall, creating what appears as a more seamless transition of weight forces between the roof and column. These roofs were detailed with ribbing, coffering, and took expressive forms of various vaults. There is also an abundance of examples from various styles that use similar techniques and/or contain elaborately decorated ceilings which further suggest a universal appreciation of the innate relationship between man and sky, throughout history. The characteristics of this roof may hold symbolic significance, particularly when the pitch of the roof moves from a flat surface to a pitched one.

Christian Norberg-Schulz has already addressed Modernism's lack of sensitivity to the human spirit.[4] It seems no coincidence that typical Modernist design principles rejected the pitched roof, opting for a flat roof and ceiling, thus effectively reducing the expression of the roof. The flat ceiling generally reduces the expressive quality of the roof structure above by making it unseen from the inside. The flat roof also has a minimised effect of both centering and creating individualised spaces. The Modernist treatment of the roof is arguably still observed in architecture schools. Students know all too well that a roof can be considered last during the design process and when time becomes scarce it is common for students to opt for a flat roof because at an undetailed level, it is the easiest and least complex option. Similarly, commercial and high rise buildings seem to disregard the roof for reasons of scale, where it is usually too removed from sight at street level to be of any significance. Residential architecture may display a pitched roof; however it is also common practice to employ a horizontal, painted ceiling which downplays the presence of a pitched roof from the inside. For these reasons, the pitched roof is still largely underutilised as a tool for creating richly articulated interior spaces that have the ability to evoke delight in the hearts of people experiencing a building.

Architectural historians commonly accept that buildings in their earliest form, existed almost entirely as a stand-alone roof. This can be seen when considering a building in its most primitive form as one that exists of only a roof, perhaps held up on minimal pole supports. It is much easier to accept this as a type of building, than one that is enclosed by walls and no roof. Heidegger acknowledges this in his connection between the German words for "house" and "hat"[5], where the roof is seen as the hat which protects the body below it. This image of a roof held up on minimal poles is seen throughout history and over a wide variety of cultures. Charles Moore explains:

> "The roof is summarized by the canopy. For all of human history, aediculas – delicate pavilions with four columns and a canopy above – have been symbolic houses for Christian saints, Hindu gods,

1 A. Seidenberg, "The Separation of Sky and Earth at Creation III," *Folklore* 94 (192): 192, 193, accessed October 15, 2013, http://www.jstor.org/stable/1260492.

2 The opening verse of the Bible commences with "In the beginning God created the heaven and the earth." (Genesis 1:1), "The Bible," (The Official King James Bible Online).

3 In Maori mythology Ranginui (sky father) and Papatuanuku (earth mother) were originally embraced and shared divine children, who eventually split them apart by physical force, allowing light to shine on the earth, A. Seidenberg, "The Separation of Sky and Earth at Creation Iii," *Folklore* 94, no. 2 (1983).

4 Christian Norberg-Schulz, *Genius Loci: Towards a Phenomenology of Architecture*. (New York: Rizzoli, 1980), 189-190.

5 Barbara Burren, Martin Tschanz and Christa Vogt eds, *The Pitched Roof* (Zürich: Niggli, 2008), 37.

> Jewish newlyweds, Egyptian pharaohs who virility was being extended, and more recently bands and bandstands and householders in their garden gazebos."[6]

Moore's description of the early aediculas emphasises the universal importance of the roof throughout history. These structures not only housed spaces which were protected from environmental conditions, but they also held symbolic importance, suggesting something of civic and/or personal importance below. The roof speaks about structure, necessity and creative ingenuity; more so than any other architectural element, hence it should be both celebrated and expressed. Perhaps Marc-Antoine Laugier's *Essay on Architecture* still holds some relevance today, despite its intended application into a Classical discourse. His argument for the correct design of Classical buildings and his promotion of the image of the Primitive Hut suggest the promotion of an architecture focused on essential features to hold up a roof structure. He also offers insight into the relationship between the columns holding up a roof and adjacent walls. He explains:

> "The parts that are essential are the cause of beauty, the parts introduced by necessity cause every license, the parts added by caprice cause every fault… Arches are faulty: Because they require massive piers and imposts which, baked against columns, take away the air of lightness which is the main beauty of columns and make the whole structure look heavy."[7]

Laugier's continues to explain that "the column must be free standing so that its origin and purpose are expressed in a natural wall".[8] His advocating for Classical architecture which celebrates necessity and expresses individual elements provides a platform for a discourse on recent developments in the way the roof is expressed. Recent architectural projects have blurred the distinction between what is considered wall and roof. For example, the Southern Cross train station in Melbourne is composed of an undulating canopy, held up by monumental columns that branch out at the top. The angular connection between the steel space frame roof and the monolithic steel encased concrete columns, appears to be a seamless in form, thus blurring the line between what is considered 'wall', 'vertical support' and the 'roof'. The blurring of these two elements make it difficult to define what is considered as roof in contemporary architecture, and is something that will be explored throughout this project.

6 Donlyn Lyndon and Charles W. Moore, *Chambers for a Memory Palace*(Cambridge: MIT Press, 1994), 127.

7 Marc-Antoine Laugier, *An Essay on Architecture*, trans. Wolfgang and Anni Herrmann(Los Angeles Hennessey & Ingalls, 1977).

8 Ibid.

1.2 Aims and Objectives

This research project aims to explore the role of the roof in the context of New Zealand. As a young multicultural nation, there is a less developed vernacular style, and an abundance of buildings with a modernist flavour. New Zealand's exhibition at the 2014 Venice Biennale, led by David Mitchell, presented a New Zealand architecture of "posts and beams and panels and big roofs"[9] and suggested this was the influence of our Pacific location. This research project discussed specific local conditions, and explores how these conditions may be manifested through the design of a large roof. Whilst this project pursues a closer relationship between roof and context, it is not suggesting that there is only one type of roof appropriate for the local conditions. It does, however, explore how site context can assist in the production of more energy efficient and culturally relevant buildings.

The research project will inform and be informed by the design of a roof, which responds to various contextual issues relating to the chosen site. From this design, an evaluation can be formulated which addresses the research question.

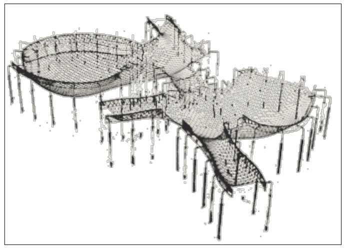
9 John Walsh, "New Zealand Institute of Architects Launches New Zealand Exhibition at 2014 Venice Architecture Biennale," New Zealand Institute of Architects Launches New Zealand Exhibition at 2014 Venice Architecture Biennale, 'last, 'accessed' 12 July, 2014, https://www.nzia.co.nz/news--media/new-zealand-institute-of-architects-launches--new-zealand-exhibition-at-2014-venice-architecture-biennale.aspx

1.3 Scope and Limitations

What is considered a 'roof' in this research project? Some recent buildings have blurred the distinction between elements, by use of more fluid forms. In this project, the roof will be considered as the upper boundary of the building, including: roof cladding; structure; and ceiling. This sandwiched roof panel will be explored for its architectural potential.

1.4 Research Question

How can the architectural element – the roof - produce a culturally relevant and tectonically expressive building in a New Zealand context?



2.0 Research Background

2.1 Roof and Structure

2.1.1 The Evolution of Structure and Structural Expression

Technology associated with various structural roof systems and their subsequent construction, has developed significantly over thousands of years. Developments in technology combined both new construction materials and new structural systems. The two parallel each other throughout history and give rise to new formal solutions, which seem to trend towards creating lighter and larger buildings.

Early roof structures made use of whatever materials were available (mud, sticks, stones), and were generally small and followed more pure geometries. Their smaller sizes saw them used most often in a residential setting, occasionally for smaller gatherings, for storage of grain and oils and for producing bread and ceramics.[10] The New Stone Age saw the introduction of new tools, and an increased use of stone, dry bricks and metalwork. These new tools led to the construction of the Great Pyramid of Cheops in Giza, ca. 2589 – 2566 BC.[11] Each side of the base measured around 230 meters and reached a height of 147 meters,[12] demonstrating considerable advancement in construction knowledge. The mystery surrounding their construction and design however makes it difficult to locate them within this discussion. Use of stone in construction was common in the rest of the Mediterranean region – particularly Mesopotamia, Phoenicia and Egypt – where flat roofs were formed by either stone slabs or parallel beams laid on top of each other, in a post and lintel arrangement.[13] Around this time, stone was also used as a tile cladding over timber framed structure.

Developments in the use of stone as a structural material resulted in an increased use of arches, making use of the variety of locally available stones.

10 Gyula Sebestyen, *Construction: Craft to Industry*(London: Spon Press, 1998), 16.

11 Ibid.

12 Britannica, “Pyramids of Giza,” (6 February, 2014).

13 Alfonso Acocella, *Stone Archtiecture: Ancient and Modern Construction Skills*, trans. Alice Fisher and Patrick John Barr, 1 ed.(Lucca: Lucense, 2004), 476.

Although the Egyptians had shown evidence of using the arch as early as 1400 BC, its application throughout Europe was seen predominantly in utilitarian structures. Developments in the use of stone arches and subsequent vaults are important to this discussion because they led to the discovery of the dome. The second most important contributor to the development of the dome was the Roman discovery of the volcanic sand, pozzolana, for the making of concrete.[14] The structural capabilities of this concrete allowed curved roofs, domes and vaults. Variations of the standard dome, where a circular dome rests upon a circular drum below, are seen in a multitude of buildings but most commonly in churches. Square or other multi-sided plans challenged designers for new solutions, as did the issue of light entry and the prospect of buildings having several domed roofs. All of these advancements were made possible by the material capabilities of this new concrete material.

A notable variation to the traditional use of arches, vaults and domes, was the development of ribbing on the underside of the vault, adding strength and visual clarity to the interior by masking what were seen as unclean joins in the groin vaults. The exploration of ribbed vaults also facilitated greater spans and heights. Between the Romanesque and Gothic periods pointed arches were more frequently used because of the structural problems caused by circular arches, which exert a thrust outward as a result of their weight and require heavy walls with a wide section below them. Structural developments in the Gothic style incorporated buttresses, and later: flying buttresses, which met the vaults at critical points, allowing the walls to be opened up with larger windows, thus making the roof appear lighter. Further Gothic advancements saw the use of the timber hammerbeam truss, which was capable of spanning greater distances than the traditional truss and offered an alternative to the vault, although this system still exerted thrust outward.

With the Industrial Revolution came the emergence of iron and steel in the

14 Ibid.

field of architecture. As was the case with stone arches, the use of steel in earlier days was found in buildings with little civic significance such as bridges, factories and packing houses.[15] Steel, ushered in various structural systems and allowed the development of long span technologies because of its hardness and tensile strength, particularly in comparison to the spanning capabilities of traditional timber, concrete or stone. It did not warp, bow or twist in the same way as timber and was lighter in weight. The roof forms created from early steel exploration often displayed gables and vaults, however, these traditional forms could include large amounts of glass, introducing a unique spatial quality in these buildings. The use of steel as reinforcing in concrete encouraged a much more exploratory approach to the creation of architectural forms, and allowed longer spans than concrete was previously capable of. Examples of reinforced concrete buildings from this time include the exhibition hall of CNIT in Paris, and the Brynmawr Rubber Factory in Wales, both of which used thin concrete shell roofs in experimental forms.

Figure 2.1 A. Interior of the Blue Mosque, 1616. B. Exeter Church Cathedral, ca. 1400.

15 Arne Petter Egen and Bjorn Normann, *Steel, Structure and Architecture* (New York: Whitney Library of Design, 1995), 16.

Throughout the 20th century, various structural systems and types were employed in architecture. The possibilities appeared limitless, as singular systems can be used in conjunction with other systems to give a desired outcome. While this freedom creates delight for many architects, many buildings do not appear to have any structural logic. There is a tendency for some architects to design forms and consult the engineer later, to find a structural solution to the chaos they have created. This approach has robbed many buildings of two valuable opportunities. Firstly, they often fail to visibly express their structure, which can contribute to the architectural richness and meaning of a building. Secondly, they fail to utilize structural logic through the form finding process, and often end up creating exuberant forms which are both costly to construct and difficult to resolve structurally, thus taking time, money and unnecessary effort. Structure offers patterns, tones, rhythms and other visual interest, which could be harnessed. Form finding, through the application of structural logic and the use of structural analysis, can produce inspiring results which utilize the material properties of structural members, reduce the time and efforts for the engineer, and produce visually appealing results. A well-considered structure may enter a dialogue about nature.

Engineer, Cecil Balmond discusses the relationship between the natural world and structure, more specifically 'structural rhythms'.[16] He proposes that the natural world was first understood (and still is) through witnessing and interpreting rhythms in the environment: the rhythmic cycle between night and day, the rhythm of a heartbeat, or the ripples, waves and tides of the ocean.[17] For example, a faster heart beat might suggest danger is near, an increase in the rippled effect of the ocean might tell fishermen to return to shore because a storm is coming. Balmond explains this strong bond between natural context and people:

> "We knew our death and how the soul shuffled its coil with nature. We had no personal identity but were one with the heavens and the animals and the earth." [18]

16 Cecil Balmond, *Cecil Balmond* (Tokyo: A + U Publishing Co. , 2006).

17 Ibid.

Balmond argues that all people read the rhythms of nature and suggests that this enhanced the relationship between people and their natural surrounds. He applies these same principles to the way people read rhythms in structure. Pier Luigi Nervi says:

> "No one could feel a sense of tranquil aesthetic enjoyment in a space whose walls or whose roof gave the sensation of being on the verge of collapse, even if in reality, because of unseen structural elements, they were perfectly safe."[19]

This implies knowledge exists within all people that makes them capable of reading structures and making a judgement, even if it is just to determine whether it is safe to pass under them. Exploring structure can change the atmospheric quality of a space greatly, especially if the architect is intending to create drama in a building or wants to create a peaceful relaxed environment. Abrupt changes in a structural rhythm may also suggest a change in the building, perhaps a threshold to a new space in the building. A well-considered structure is embedded with historically rich layers of man's developments and is universally significant. Perhaps it is worth expressing in architecture, as not to rob a person of the delight and experiential richness that comes from reading a structure.

18 Ibid., 17.

19 Pier Luigi Nervi, *Structures*, trans. Giuseppina and Mario Salvadori(New York: McGraw-Hill Book Company Inc. , 1956).

2.1.2 Four Approaches to Structural Exploration

Pier Luigi Nervi : Reinforced Concrete

Pier Luigi Nervi's[20], work is driven by his love for *ferro-cemento* which he describes as "magic" and praises it as being "able to create "melted" stones of any desired shape, structurally superior, because of their tensile strength, to natural stone".[21] His work explores the potential of the material, seeking a greater synthesis between the design of architecture and structure. This is seen in his expression of ribbing and vaulting on the underside of the roof, grand columns and buttresses which are both functional and sculptural and his elegant proportioning of these structural elements.

Nervi's explanations of the early stages of the design process are often less detailed than his theoretical discussions however the process usually involves an attention to strict programmatic requirements, particularly for issues of dimensions and access. For example, the design brief for his famous air hangars would have had clear dimensional requirements depending on the size, number of planes to be housed, and the circulation of the aircraft in and out of the hangar. The ribbing and vaulting used, allowed for greater spans with the ferro-cemento, and removed the need for internal columns, whilst external buttresses helped counteract the outward thrust. His hangars maximised the use of pre-fabrication, reducing the labour required on-site, and ultimately reducing time and costs associated with construction. This would have also had significant design implications.

Nervi explains his use of experimental model analysis to test his structural design, as he explains the benefit of physical testing over theoretical calculation. The process involves constructing a scaled model, made of the same material, or one with similar properties. Experimental stress analysis is undergone on these models by inducing stresses to the models and measuring its load capabilities. Whether or not this process was repeated several times during the design of one particular building, or whether the testing ever saw Nervi make changes to his individual designs before they were built is unclear. He has explained however, that he examined the earlier hangars during and after completion, and that his discoveries about how they had performed over time influenced his later designs for other buildings.[22] The buildings he produced using this approach have a unique character to them. They appear light, elegant and graceful and inspire designers in terms of the potential uses for reinforced concrete.

Figure 2.2. *Pier Luigi Nervi, Aircraft hangar, Orvieto 1935.*

20 Pier Luigi Nervi was an Italian architect and engineer, producing notable buildings between the early-mid 20th century.

21 Nervi, *Structures*, 29.

22 Ibid., 64-93.

Konrad Wachsmann : Mass Production

Konrad Wachsmann's[23] greatest architectural legacy was his innovative use of light modular steel tube sections, forming large steel space frames, a response to a brief for a US Air Force hangar. While the space frame was not a new idea[24], it had not yet made its way into the field of architecture. His system combined modular steel sections into equilateral triangles, and then into pyramidal forms, increasing stability. The modular sections were joined through a spherical chromium steel joint, which allowed the connection of up to 20 steel tube members.[25] The hangar that this system was intended for initially required housing for six large aircraft, calling for a long span roof and an open column-free floor plan. The proposed roof displayed a double cantilever, allowing aircraft to freely circulate below, whilst displaying a remarkably light mystic quality and an architectonically expressive structure.

Figure 2.3. *Konrad Wachsmann's Air craft hangar for the U.S. Air Force, ca. 1960.*

23 Konrad Wachsmann was a German modernist architect, living active around with mid twentieth century.

24 Alexander Graham Bell had been documenting his experimentation with the space frame model, Bjorn N. Sandaker and Mark R. Cruvellier Arne P. Eggen, *The Structural Basis of Architecture*(New York: Milton Park, 2011), 210.

25 Ibid.

Eladio Dieste : Thin Shell Brick Roofs and Catenary Curves

The free standing barrel vault and the Gaussian vault, by Eladio Dieste's[26], have been accredited for having "a lightness, a mysterious case, a concise simplicity, something like dance without effort or fatigue."[27] The former innovation comes from its rejection of conventional heavy walls, using spans and cantilevers that were unprecedented in brick structures. The roof here can be thought of as cantilevered beams, rather than vaults and are held in place by pre-tensioned steel supports, connecting to a central street beam. The Gaussian vault was based on the barrel vault, but reduced the span to depth ratio, whilst allowing diffused light to enter into large buildings through the roof, illuminating the underside of the vault. The vault utilised the structural superiority of catenary curves, composing a series of catenary arches, increasing and decreasing in height to create the undulating roof surface.

The design processes used by Dieste relied heavily on mathematic calculations, an uncommon approach, requiring a strong knowledge of engineering. Antonino Gaudi's work with masonry catenary curves preceded Dieste's, although he created his forms through model making, relying less on mathematics.

He would hang wires with weights attached, to derive complex vault forms, notably those at Colonia Guell.[28] Modern technology offers computer modelling software, aiding the process of catenary curve design and subsequent testing of structural capabilities. This said, the role that physical modelling plays in focusing the architects mind on the properties of specific materials to explore an appropriate formal response remains an invaluable tool.

Figure 2.4.. *Dieste's free standing barrel vault for the Barbieri & Leggire Service Station Salto, Uruguay, 1976.*

Figure 2.5. *Gaussian vault by Dieste for the Julio Herrera y Obes Hanger, Montivideo 1979.*

26 Eladio Dieste, a Uruguayan architect and engineer, produced notable works between the mid-late twentieth century.

27 Eladio Dieste: Innovation in Structural Art p. 14

28 Oliver Tessman, *Collaborative Design Procedures for Architects and Engineers* (BoD, 2008), 60.

Frei Otto : Tension Structures

Frei Otto[29] explored the potential of tensile structures, using membrane claddings. His early works produced a series of pre-stressed fabric forms, creating small roof shelters. These fabric forms followed simplistic geometries. For example, the Temporary Bandstand at the Federal Garden Expo in Kassel stretched the fabric over two high points and two low points.[30] Complexities in form paralleled the development of steel cable nets, to which a pre-stressed membrane could be attached, rather than using the membrane or cables alone, thus permitting greater spans. Architectonic forms seem to result from an experimental approach, realising the seemingly unlimited potential of tension structures. Otto's forms were governed once again, by the spanning and structural capabilities of the material, which determined column placement, and dimensions in the x, y and z axis.

Multihalle in Mannheim applied principles of tensile structures to a timber gridshell. The form, conceived by hanging a net from specified points, appears to be derived from a pre-determined floor plan. The hanging net is subject to tension forces, almost exclusively from any other forces and moments.[31] Hanging purely in tension, the efficiency of this structure is undeniable and when inverted to create a roof it becomes held up through compression. The design process involved both physical and computational models to analyse and optimise structural performance.

The resulting form uses catenary curves, increasing structural stability and allowing for thinner timber slath members, ultimately reducing the cost of the project.[32] The building span reaches 60x60m, a remarkable feat for a timber structure and whilst it may seem like an unusual and eccentric roof form, it fulfils the brief which called for "a light, airy construction to harmonize with the landscape of flowers, trees and artificial hills".[33] The organic form sits harmoniously in the garden landscape, while establishing a well-balanced relationship to the very linear floor plan arrangement below.

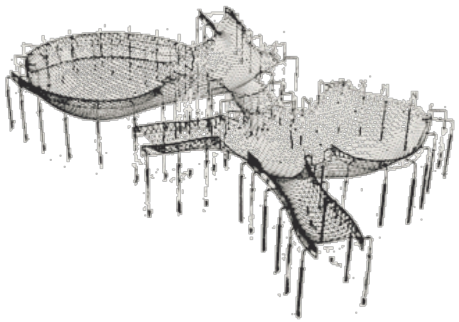


Figure 2.6. *Gaussian vault by Dieste for the Julio Herrera y Obes Hanger, Montivideo 1979*

Figure 2.7. *View through the entrance to the Munich Olympics Stadium, 1972. A tensioned steel net establishes a roof canopy*

29 Frei Otto is a German architect and engineer who has produced many works from the mid twentieth century, until the present time.

30 Rudi Scheuermann, *Tensile Architecture in the Urban Context*(Oxford: Butter worth-Heinemann, 1996), 2.

31 Tessman, *Collaborative Design Procedures for Architects and Engineers* 62.

32 Princeton University: Department of Civil and Environmental Engineering, "Mannheim Multihalle," Mannheim Multihalle, 'last, 'accessed' 6 July, 2014, http://shells.princeton.edu/Mann1.html

33 Ibid.

***Figure 2.8**.Multihalle, Mannheim, 1975.*

2.2.1 Tectonic Expression of the Roof

Tectonic theory emerged as a 19th century discourse, which dealt with the expression of structure in architecture and favored detailing. This expression brings structure into the realm of art with tectonic theorists often discussing the "poetics of construction" and celebrating the process of *making*. Eduard Sekler explains:

> "Through tectonics the architect may make visible, in a strong statement, that intensified kind of experience of reality which is the artist's domain – in our case the experience of forces related to forms in a building. Thus structure, the intangible concept is realised through construction and given visual representation through tectonics."[34]

Here, Sekler explains the process of bringing a conceptual idea into the visual realm; making the intangible, tangible. This implies a structural system or idea is in fact not made a reality until construction is considered because through construction buildings are brought to reality. The intangible ideas Sekler refers to generally refers to are physical forces such as gravity, thrust, tension or compression. However, it has been suggested by other theorists that both social and cultural forces fall into this category also. Mitchell Schwarzer discusses this issue in relation to Karl Bötticher's theory of tectonics:

> "Like the aestheticians, he (Bötticher) accepted that the essence of architecture lies in functional needs and constructive forces. But he did not concur with the sublimation of these utilitarian aspects to artistic transcendence. Instead, Bötticher argued that art must refer back to utility and external nature. His proposal for the artistic symbolism of building forces established a linguistic aesthetic of architecture: a harmony between building and human culture brought about through the mediation of artistic ornament. Here we recognize Bötticher's concept of representation."[35]

Here, Bötticher acknowledges how functional and utilitarian issues require a tectonic response, and how these needs relate specifically to social and cultural concerns. Furthermore, Kenneth Frampton's discussions on tectonics imply that buildings also construct culture, implying a 'chicken and egg' type relationship between the two, where the former both influences and, is influenced by, the latter. David Leatherbarrow, in discussion of Frampton's *Studies in Tectonic Culture* states that "Frampton presents a hermeneutics of thoughtful construction- the construction of buildings which in turn construct culture."[36]

How do digital design processes relate to the issue of tectonics? As has already been mentioned, the increased focus on digital design has given rise to new architectural forms, resulting in an overall unease about the appropriateness of parametric software in the design process, particularly in regards to the issue of tectonics, seen in Frampton criticism of Gehry's work as being only "interested in plasticity, and whatever makes it stand up will do - he couldn't care less".[37] There is certainly less physical contact between designer and building material when working digitally, as opposed to say physical modelling. Parametric design however, relies on inputting material properties into algorithms, which can act as the generator of forms. Gaudi's catenary arches were once conceived through hanging metal chains, but now can be modelled in a similar manner parametrically. Attention to

34 Eduard Sekler, "Structure Construction Tectonics," (1987), http://610f13.files.wordpress.com/2013/10/sekler_structure-construction-tectonics.pdf.

35 Mitchell Schwarzer, "Ontology and Representation in Karl Bötticher's Theory of Tectonics," *Journal of the Society of Architectural Historians* 52, no. Sep. 1993 (1993): 267.

36 David Leatherbarrow, "Studies of Tectonic Culture: The Poetics of Construction in Nineteenth and Twentieth
Century Architecture by Kenneth Frampton; John Cavareview," *1* 56 (1997): 100.

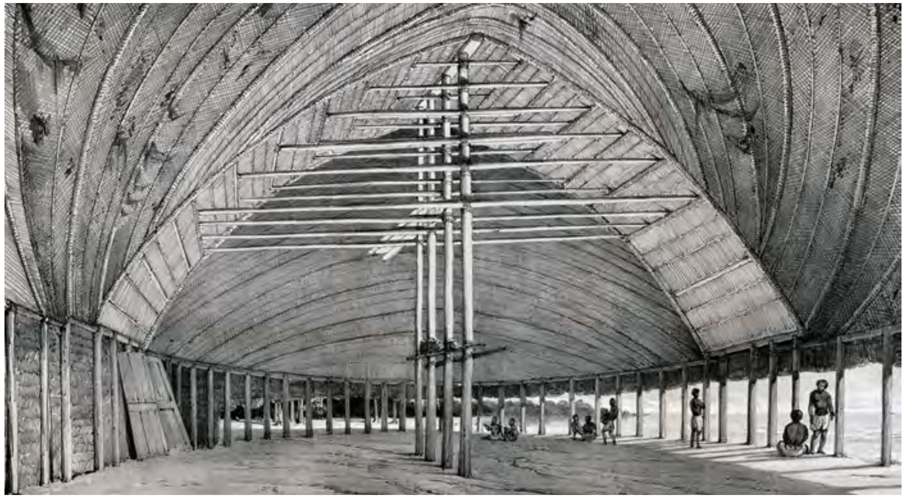
37 Stan Allen and Hal Foster Kenneth Frampton, "A Conversation with Kenneth Frampton," *October* 106(August 2003): 51.

material properties however, does not ensure attention to the expression of construction details. In discussion on the relationship between architecture and memory, Mark Wigley adds to this topic by by arguing that the expanding digital realm threatens the need for physical buildings at all:

> "Buildings are at best fragile images, props in heterogeneous publicity campaigns. Digital archives have taken over the role of storing memory from solid structures. Collective memory is diffused across an invisible electronic landscape rather than concentrated in singular monumental objects."[38]

Although not directly speaking about tectonics, Wigley's argument for the digital realm promoting architecture as "fragile images" highlights an important issue, where the act of *making* is threatened, which has significant implications for tectonics. Whilst tectonics promotes expression of construction and appreciates the tangible building, digital architecture may have a tendency to prefer imagery as the realized product of a building. On the other side of the argument, the digital realm offers advantages to the construction of buildings through BIM technology, greater efficiency in pre-fabrication and offers opportunities for new construction methods such as 3D-printing. However, if new types of construction are made possible, how might these new methods relate to local traditions of building?

How does tectonic expression manifest itself in New Zealand's local architecture? Gottfried Semper's *Four Elements of Architecture* acted as a catalyst for discussion on tectonics. The four elements discussed are hearth, roof, enclosure and mound. He distinguishes between heavy mass elements as stereotomic and the light framed roof and walls as tectonic elements, arguing this elemental typology as having rich history in the origins of architecture and the art of construction. This simplified western architectonic type conflicts with early architecture throughout the Pacific, preferring light organic forms of tectonic expression over heavy masonry construction in the west, exemplified by the Samoan fale, held up on light poles and left relatively open to the elements. New Zealand's location and history of early Pacific migration lend itself in many ways to this construction preference. Mike Austin advocates that the origins of Pacific architecture are a result of a lifestyle absorbed by coastal activity,[39] both in frequent marine migration and in daily activity. Through this he suggests a different origin to both the fale and other variations of this architectonic type throughout the pacific. Austin states that "The architectures of the Pacific are thoroughly imbricated with the technologies, mythologies and aesthetics of movement".[40] Construction techniques such as lashing and weaving are used similarly in boat construction, producing similar forms and aesthetics.



Figures 2.9. *Samoan Fale, displaying a light and flexible quality.*

38 Mark Wigley, "The Architectural Cult of Synchronization," *October* 94 (Autumn 2000): 31.

39 Mike Austin, "Pacific Island Migration," in *Drifting: Architecture and Migrancy*, ed. Stephen Cairns(New York: Routledge, 2004), 226.

40 Ibid., 227.

2.2.2 Precedent Study – Enric Miralles' Santa Caterina Market

How might tectonic expression manifest itself in a building with specific local issues? Enric Miralle's refurbishment of the Santa Caterina Markets offers a good precedent for the way tectonic expression can visualise a structural idea, whilst responding to a culturally rich context. The marketplace was built in 1848 and is the earliest market in Barcelona, making it historically significant. The redevelopment continued the market tradition, incorporating imagery of fruit and vegetables in the mosaic roof tiling, visible from the tall surrounding buildings, a contextual response. Miralles tells us that the project sought to blend the old and new structure.[41] This appears to be achieved firstly by preserving the existing function and external masonry walls, and secondly by contrasting the structural rhythm of the two, highlighting the regular rhythm in the original elevation, as seen in figure 2.

The large undulating roof canopy is partially supported by three steel trussed beams which span 42m across the building[42], cutting in and out of the canopy below, exposing them at various moments and adding to the building's playful expression of structure. Below these beams sit a series of irregular vaults. This irregularity is expressed throughout the entire structure, seen in the spaghetti like steel columns out front, which rest on unsymmetrically twisted concrete columns. Furthermore, a series of timber panels of various geometries flank the exterior façade, positioned somewhat erratically. The playful expression of this structure is a good example of tectonic expression and how it can be used to convey an idea. Here it is used to enter a dialogue about old and new structures in Barcelona, adding both a playful atmosphere and a dynamic to the lively market place.

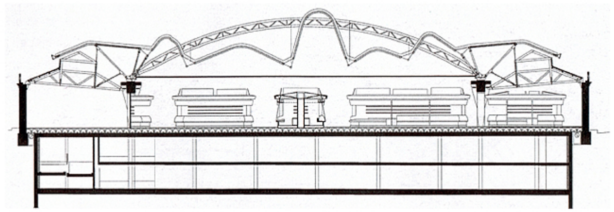


Figure 2.10. *Section through the Santa Caterina Market showing the justaposition of structural elements.*

Figure 2.11. *A. Entrance to the marketplace. B. The view down onto the mosaic tiled roof, seen by the surrounding buildings.*

41 Enric Miralles, "Santa Caterina Market Renovation: Conceptual Memory," Santa Caterina Market Renovation: Conceptual Memory, 'last, 'accessed' 4 September, 2014, http://www.mirallestagliabue.com/project_cm.asp?id=59

42 thearchie, "Market of Santa Caterina, Barcelona," Market of Santa Caterina, Barcelona, 'last, 'accessed' 4 September, 2014, http://thearchie.com/en/mercado-de-santa-caterina-barcelona/

2.2.3 Precedent Study – Peter Stutchbury's Hangar Flying Museum

Peter Stutchbury's Hangar Flying Museum in Cessnock uses tectonics to express something about the function of the building, this time in a modest and minimal manner. The building houses a collection of historic war fighter planes in a rural airport setting[43]. Stutchbury explored their theatrical nature, creating a building with drama to enhance the visitor experience. The built form is reminiscent of an aeroplane wing, held up with four curved vault trusses and cantilevered 12m. These trusses are bolted into the concrete slab floor, providing a structure which is both practical and poetic and allows an uninterrupted floor area. A suspended walkway cuts through the museum, held up by steel tensioned cables connected to various points acts as a viewing platform, adding to the tectonically expressed drama. From the exterior, reference to aircraft wings becomes more obvious as the profile of the light sheet metal is made visible and more easily understood, displaying its light malleable quality and thin profile.

Figure 2.12. *A selection of views of Stutchbury's Hangar Flying Museum in Cessnock, 2009*

Figure 2.13. *Four curved steel trusses provide the roof frame for the building and create a dynamic and theatrical space.*

43 Ewan McEoin and Michael Nicholson Brit Andreson, *Under the Edge : The Architecture of Peter Stutchbury*(Brooklyn, N.S.W.: Architecture Foundation Australia, 2011).

3.0 Roof and Local Context

3.1 Roof and Connection to Place

While there appears to be a universal use of the roof for shelter, adaptations to the generic concept can be seen around the world, as regional vernacular adaptation. These adaptations make use of different forms and local materials, resulting in collections of local buildings as having certain common features, which contributes to the local *character* of a place, as Norberg-Schulz refers to. This *character* is believed to establish both meaning and belonging for local communities, and the local built environment contributes to this. Recent developments in detailing and other technologies however, have allowed for almost any combination of form and material. This trend towards globalization, away from local traditions is seen in the iconic works of architects such as Gehry or Hadid, where each building appears to have a strong resemblance to one another, regardless of their different locations around the globe, resulting in buildings which lack a strong connection to place.

This connection to place is described by Neil Leach as having the ability to achieve a "sense of belonging"[44] and "identity"[45]. Scientific research further supports the importance of this connection, seen in studies into how environmental cues affect daily rhythms in humans, referred to as a circadian rhythm, 'circa' meaning about and 'dies' meaning a day.[46] These rhythms are found in all areas of nature. "Rhythmical fluctuations occur not only at an environmental level but also at every level of nature's organization",[47] meaning they are found in humans, other living organisms and also in nature. Biological, social and behavioral factors are a selection of some of the factors subject to these rhythms experienced by all people. For example, because of the limitations of human eye sight, we are generally diurnal creatures, a behavior informed by the presence of light and dark cycles, external to the human body, thus sleeping at night when our vision is less capable. Similarly, we tend to eat at regular times during daylight, which in turn affects renal excretory rhythms. This research is most easily understood by considering the phenomenon of jetlag, where the body must regulate its rhythm to align with a new environment. Complex systems of interrelated biological processes are still in early stages of discovery however this research concludes that some biological rhythms are endogenous (internally controlled), and some are exogenous (externally controlled), thus supporting the idea that the human relationship with specific places is important at a cellular level also.
A connection to a place relates to more than just physiological and biological issues however. Norberg-Schulz explains:

> "Man-made places relate to nature in three basic ways. Firstly, man wants to make the natural structure more precise. That is he wants to *visualize* his "understanding" of nature, "expressing" the existential foothold he has gained...A natural character is for instance translated into a building whose properties somehow make the character manifest. The purpose of symbolization is to free the meaning from the immediate situation, whereby it becomes a "cultural object", which may form part of a more complex situation, or be moved to another place."

44 Neil Leach, "Belonging: Towards a Theory of Identification with Place," *Perspecta* 33(2002): 129.

45 Ibid., 130.

46 D.S. Minors and J.M Waterhouse, Circadian Rhythms and the Human (Elsevier Science, 2013). 2.

47 Ibid., 1.

This suggests that when a building embodies characteristics from its surroundings, the designer has understood the surrounding context, translating into a building which may embody significant meaning and symbolism, thus showing a deeper understanding and adding to the richness of the building.

How does 'digitalization' in architecture position itself within this discussion? The seemingly endless possibilities for form through digital design have given rise to curvaceous and complicated forms, often referred to as 'blobitecture'. The issue is further complicated by the development of certain architect's 'iconic' styles, which are seemingly applied to projects throughout the world. This raises questions relating to the extent in which context played a role in the creation of these forms, if at all, and has evoked criticism about the 'alienating' quality of such buildings. It has been suggested that the act of constructing these buildings offers an opportunity to express local conditions, since construction requires detailing specific to site. In this sense, a generalized building type could be applied to multiple locations, whilst still establishing some connection to each. How might this building connect to a desert ground compared to a rocky coastal ground, and how might this connection be expressed? Similarly how might temperate climates be mediated as opposed to say a hot arid climate, and how might this be expressed in the building? Or finally, how might the collective qualities of a place be addressed through the design of a roof?

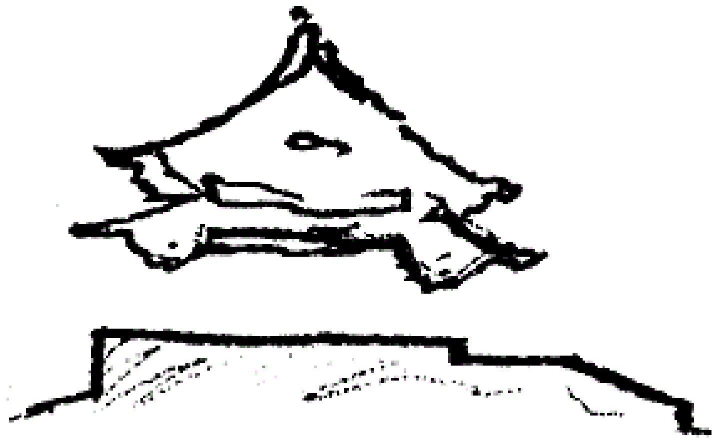


Figure 3.1. *Jorn Utzon's sketch of a Chinese Roof*

3.2 Roof and Climate

3.2.1 Expression of Local Climate through a Roof

A fundamental part of the roof's relationship with local context is how it mediates the unique climate of the given site. Traditional roof forms vary between regions, suggesting the designers and builders of each region understood the conditions of that specific place. A flat roof was commonly found on residential dwellings throughout the hot eastern region of the Mediterranean[48], where precipitation is at a minimum and the shedding of water is not as critical. Alternatively, a gable, or hipped roof may be found throughout the United Kingdom and other parts of the world that experience higher levels of precipitation and snow loads. Materiality can also suggest locality by signifying what is available and by giving clues to other local conditions. For example, a building made entirely of timber suggests local ground conditions that support the growth of trees. There is likely a reasonable rainfall in the area and fertile soils to produce timber for construction. Secondly, materiality can give clues as to a place's likely temperate. Hot arid climates will often utilize materials with large thermal mass to store radiant heat during the day, preventing it from directly entering the rooms below and then releasing it at night when temperatures drop. Complicating the issue of materiality however, is a discussion on whether materials must be **sourced** locally or whether imported materials can still give reference to local issues.

New Zealand's roof forms have experienced Maori, Pacific and Colonial influence. The typical Maori roof often displayed an A-frame, or gable, constructed as a post and beam running lengthwise, with rafters placed above. This framing was then covered by either rushes, bark or thatch cladding, and utilized local timber for structural framing.[49] Because nails were not available, weaving commonly held elements together. The interior of the wharenui (meeting house) was lavishly decorated in carvings, weaving and painting, and depicted things from important family lineage to imagery about nature and reproduction, thus showing an interpretation of the world around.
Early European settlers occasionally brought pre-fabricated elements such as windows with them, but generally made us of local materials such as timber framing and claddings varied from fern fronds, reeds and sheets of bark to canvas and longboards, usually displaying a pitch between 30-45° to effectively shed rain.[50] Corrugated iron (steel), became available as early as 1843 in New Zealand, imported from Britain and often auctioned at ports.[51] Because it was both strong and cheap, it became widely used. This roof cladding became the most commonly used until the 1980's, where aluminium coated steel products surpassed, because of their superior corrosion resistance. This is still a very commonly used material for residential projects and comes in a variety of profiles. Timber framing was the preferred construction method for European settlers also and was commonly joined without nails. Although nails were around by then, they were expensive, so mortise and tenon joints were commonly used.

Gable and hipped roof types are still commonly seen in residential buildings however flat roofs made a feature post ca. 1990. These flat roofs however, are generally regarded as a contributing factor for New Zealand's leaky homes crisis, which reportedly cost around $11.3 billion to remedy[52], thus further arguing the importance for climate appropriate architecture. Flat roofs, with little or no eaves are problematic in New Zealand where frequent rain, high wind speeds and horizontal rain is experienced, as they provide little protection at important junctions
At a simplistic level, allowing local conditions to influence architectural design offers further advantages by encouraging efficient use of energy in systems required for heating, cooling and ventilation; reducing transport costs from

48 Acocella, *Stone Archtiecture: Ancient and Modern Construction Skills*, 476.

49 Te Ara Encyclopedia, "Story: Building Materials," Story: Building Materials, 'last, 'accessed' 4 September, 2014, http://www.teara.govt.nz/en/building-materials/page-1

50 Ibid.; ibid.

51 Ibid.

52 The New Zealand Herald, "Leaky Homes Will Cost $11.3b to Fix - Report," Leaky Homes Will Cost $11.3b to Fix - Report, 'last, 'accessed' 21 September, 2014, http://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=10617051

importing distant materials and by supporting local economy. Strategies for designing a climate-specific roof have been developed over thousands of years, firstly as modest houses to shelter against water, snow, wind and sun, and more recently as highly complex mechanical systems. A roof is now expected to do far more than simply protect from rain, snow, wind, and sun. Modern day roofs are capable of activities that range from: collecting rainwater; housing PVC and solar HW panels; displaying wind turbines, utilizing green roof planting for insulation and extended landscape areas; and complex ventilation and lighting strategies which are particularly important for big buildings with deep floor plans.

***Figure 3.2**. Carrying a roof, Congo ca. 1900-1915*

***Figure 3.3**. Hut of a Toda Tribe, India, constructed from local stone, bamboo and thatch.*

***Figure 3.4**. A Maori wharenui, on display in the Auckland Museum.*

3.2.2 Precedent Study – Renzo Piano's California Academy of Sciences Building

Renzo Piano's California Academy of Sciences building incorporates complex environmental systems. The building's programmatic requirements demanded this as it houses: a planetarium; rain forest; large aquarium; exhibitions for several biological collections; and research labs which require controlled conditions, amongst other climatically demanding spaces. This novel programme, combined with the enormous scale of the building (the green roofs covers 2.5 acres[53]) has incredibly large demands on mechanical systems for heating, cooling and ventilation, also requiring large quantities of water and electricity. It was therefore imperative that the building could not only contribute to its own running costs, but give something back to the surrounding environment from which it would otherwise act parasitically to.

The environmental system used in this building utilizes the roof to create an efficient machine. The roof is treated as an extension of the landscape, housing a blanket of around 1.7 million specially selected native plants.[54] This effectively insulates the roof, helping reduce mechanical heating and cooling requirements, whilst also contributing to the surrounding ecology by attracting local wildlife.[55] Furthermore, these native plants don't require any additional watering. The undulating form responds to the programme on the floor plan below. The two large curves hover above both a planetarium and rainforest, giving some hierarchy to these two attractions. They also encourage the movement of hot air up toward the highest point, where skylights are positioned and automatically controlled to open and close, helping to naturally cool these spaces. These strategically placed skylights also bring natural light into the deep floor plan, reducing the requirement for artificial lighting. Furthermore, photo sensors in the roof register when natural lighting has reached critical levels and will increase artificial lighting only when needed.

53 ArchDaily, "California Academy of Sciences: Renzo Piano," California Academy of Sciences: Renzo Piano, 'last, 'accessed' 18 July, 2014, http://www.archdaily.com/6810/california-academy-of-sciences-renzo-piano/

54 Ibid.

55 Ibid.

The roof also houses 60,000 photovoltaic cells, which are believed to supply around 213,000 kWh annually,[56] thus reducing the building's reliance on the grid and utilising the roofs direct connection with the sun. The overall architectural expression has produced a building which appears to blend in with its surrounding landscape. The undulating roof plane references the hilly terrain in the distance and offers a unique visitor experience.

Figure 3.5. *Skylights let light in to the rainforest within the building.*

56 California Academy of Sciences, "Green Architecture Fact Sheet," Green Architecture Fact Sheet, 'last, 'accessed' 12 August, 2014, http://www.calacademy.org/newsroom/releases/2008/green_building_facts.php

Figure 3.6. *A sectional drawing, showing the relationship between roof curves and the spaces below.*

Figure 3.7. *The green roof helps the building to blend into its landscaped surrounds.*

3.3 Roof and Ceiling

3.3.1 Exploring the Relationship between the Roof, the Ceiling and Spatial Qualities

The relationship between the terms 'roof' and 'ceiling' provide an interesting platform for a discussion on the nature of a roof covering. 'Roof' is usually used to refer to the upper external boundary, while a 'ceiling' is what is seen whilst inside the building. This distinction is clear if a suspended ceiling is present. When one is not, the terms can be used interchangeably to describe the same composition of elements, thus establishing a solid-void relationship between the two terms, where the roof is seen from the exterior as an object (a solid), and the ceiling is viewed from the interior (void) space. These two elements can either work together, or they can oppose each other. When roof and ceiling differ in shape, secondary spaces are formed between the two. These spaces may be used as attic space for storage, to house services in medium to large scale buildings and to act as a thermal barrier between interior space and the roof cladding above, reducing heat loss through the roof in cold climates. Distinctions between the two elements need not arise from a change in geometry, but can be established through changes in materiality, varied structural systems, or by allowing different types of lighting to pass over each surface. The different treatment of these two elements was a characteristic seen in many examples of Baroque architecture, where the external context required a different architectural treatment to the internal, an issue widely debated at the time.

The qualities of both the roof and ceiling pose enormous architectural potential in terms of the perceived arrangement of spaces below. A roof can either define a series of individual spaces below, each room as defined on the plan may have a distinct roof, thus establishing individuality. Alternatively, a roof can encapsulate several spaces, dissolving boundaries between them by providing one seemingly inclusive covering. In a public building this may suggest more freedom to wander throughout, or suggest a collective meeting of different groups with a common purpose. Furthermore, exposing the roof and giving special attention to this element often symbolizes an important space, as seen throughout vast examples of religious, civic and political buildings throughout recent centuries and cultures alike. The symbolic meaning may differ between buildings between issues such as wealth, power or to demonstrate sophisticated technology, or in religious buildings it may even represent heaven itself. When a roof takes on a symbolic quality, it suggests a surpassing of the mundane.

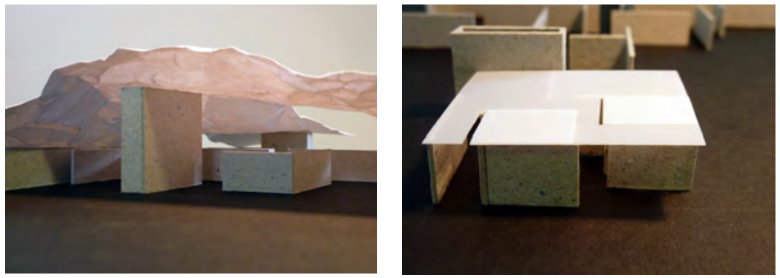
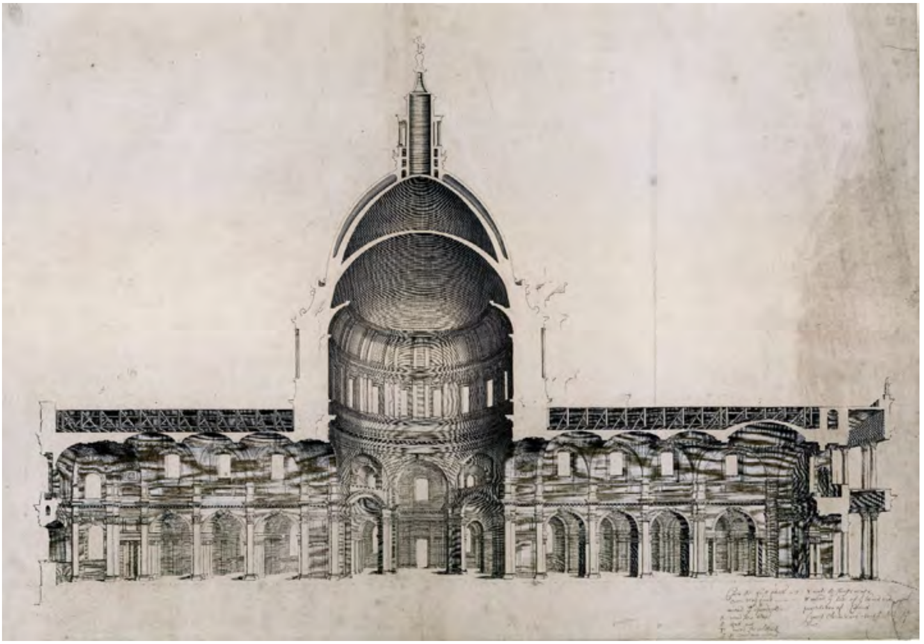
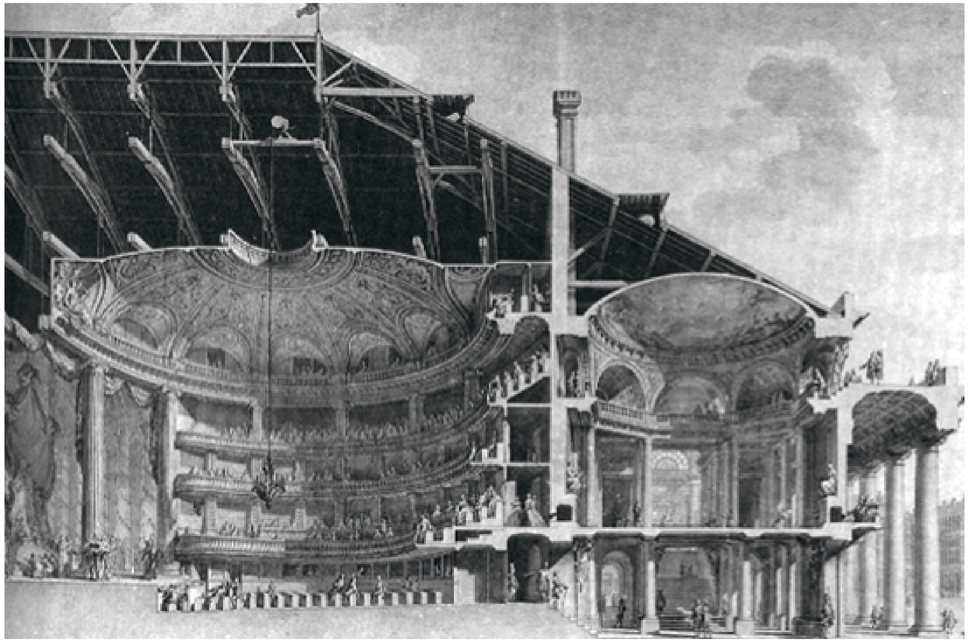


Figure 3.8. *Explorative models use Mies' Brick Country House as a starting to point and consider the way in which a roof can act to 'gather' or 'individualise' multiple spaces.*



Figures 3.9. *Sir Christopher Wren's Baroque style drawing for St Paul's Catherdral,. The central dome differentiates between the upper roof boundary and the dome and the dome below. The remaining section of the building shows a timber trussed gable roof sitting above a vaulted ceiling throughout the remaining section, thus establishing a different appearance of form between views of the interior and exterior.*



Figures 3.10. *A surviving drawing of the original Odéon-Théâtre de l'Europe, by Charles De Wailly and Marie-Joseph Peyre, 1782, establishes a radically distinct roof and ceiling difference.*

3.3.2 Explorative Modelling - Farnsworth House and Form

A process of experimental models explored the relationship between the roof and floor element of the Farnsworth House. This building was chosen for its Modernist treatment of the roof. The straightforward geometry, structure and configuration of floor plates make it a good starting point to explore the effect of the roof on the space below.

Figure 3.11. *Mies van der Rohe's Farnsworth House, Illinois, 1951*

From Left to Right:

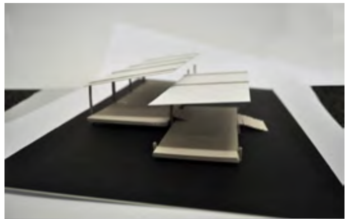
Figure 3.12. *Two gables clearly defining the two floor plates and acts as powerful imagery of 'house' and 'hut', suggesting shelter and perhaps a feeling of homeliness. The gable end has an opportunity to frame a view outdoors, whilst the change in scale of the two roofs establishes a hierarchy.*

Figure 3.13. *Two shed roofs, parallel to each, suggest an inclination outdoors, facing out to the entrance.*

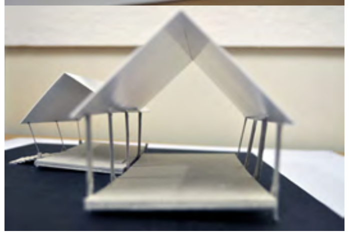
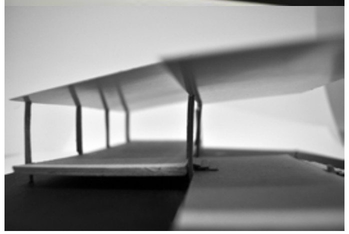
Figure 3.14. *This curved roof establishes a center within, best seen in the image on the right. One might feel 'held' within this space, perhaps as though they have reached a destination. There roof also recalls Pacific architecture, suggesting that the roof can have a symbolic function also.*

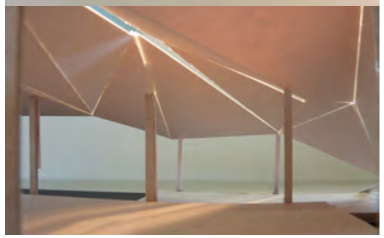
Figure 3.15. *The butterfly roof here hovers lightly above the floor. From inside, the angled roof planes direct the eye up and outward, away from the interior, whilst differentiating between the two floor plates by implying a threshold where the two angles meet.*

Figure 3.16. *This multifaceted roof adds an element of drama into the space. The roof surface falls in multiple directions, creating a dynamic form and seaming together the two floor plates that sit below.*



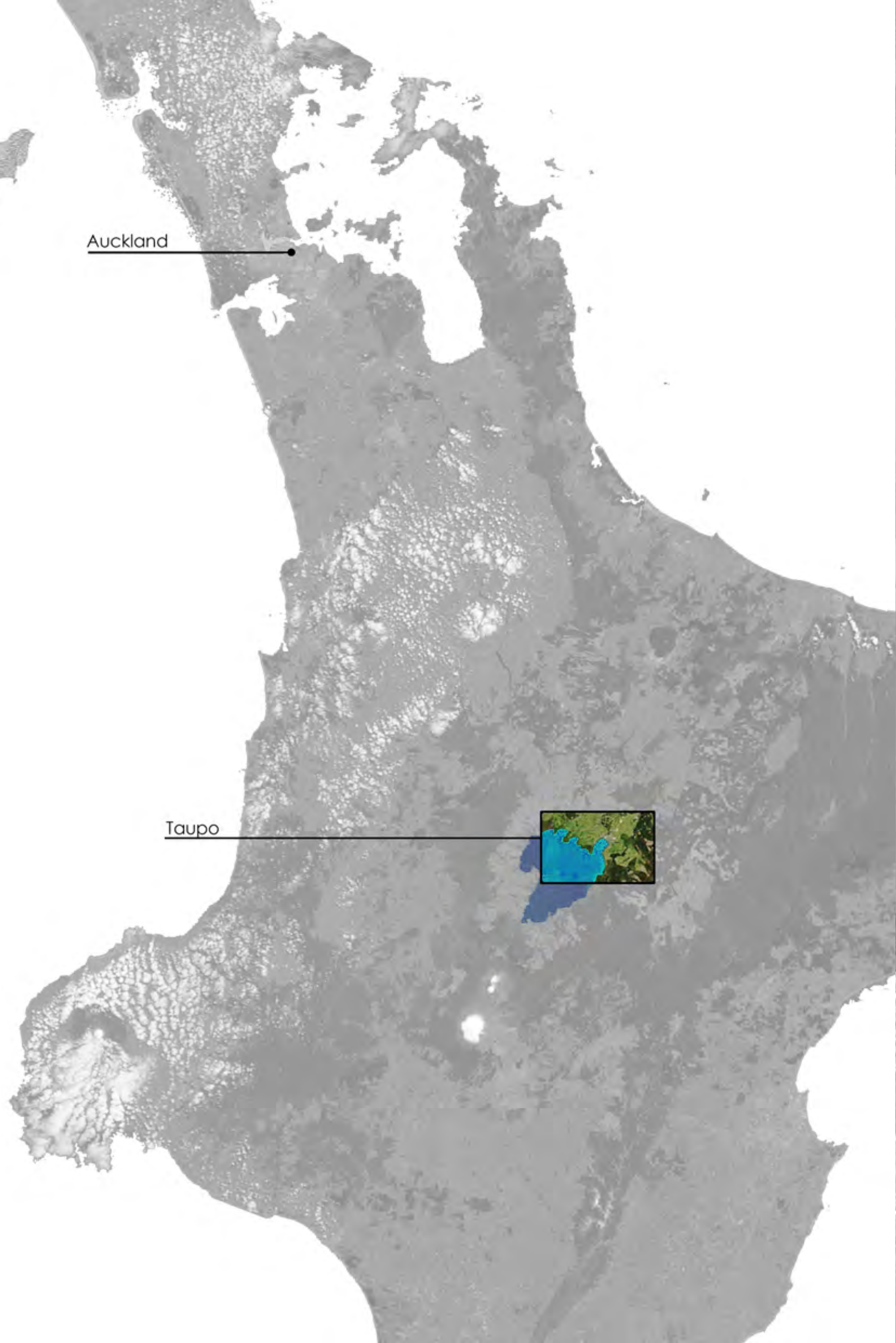
4.0 Design Process

Phase One

4.1 Site

4.1.1 Site Selection

The chosen site has an abundance of contextual issues that the roof can respond to: topographically; historically; culturally; and climatically. The site is located at the meeting point of Lake Taupo and the Waikato River. The area along the eastern embankment of the river is declared a public domain.
The topography of the Taupo region has been shaped, particularly the Oranui eruption ca. 26,500 years ago,[57] which formed the large caldera which eventually filled with water to form the lake. The life of the town has strong links to both the lake and the Waikato River, seen in the close proximity of many important buildings to the water's edge and the abundance of boats and water-based activities enjoyed by both locals and tourists. The site itself was once a pumice dam, which enclosed the lake and encouraged the formation of the land around water's edge to take on its beach-like appearance, as seen today. The site was most likely submerged under water until the dam was broken and the water level fell. The water level now remains fairly consistent with app. 1-2m fluctuations throughout the year and is regulated by water control gates a short distance down the river.



57 Geoff Hicks and Hamish Campbell, *Awesome Forces: The Natural Hazards That Threaten New Zealand*(Wellington: Te Papa Press, 1998), 35.

Figure 4.1. *Site location within the Taupo Domain, adjacent to the Thermal Explorer Highway.*

4.1.2 Historical Context of Taupo Domain

The site's location in the Taupo Domain (also known as Tongariro Domain) has important implications for the design. The word domain gives rise to ideas about the public quality of the land and its repository nature. The word domain is defined as both "complete and absolute ownership of land" and "a sphere of knowledge, influence, or activity".[58] The type of ownership of 'domain' land usually depends on the governing body of the place, be that a government, monarchy or otherwise. This has deep historical roots from the french words demeine and demesne,[59] which refer to land ownership of a lord,[60] and also the latin words dominium and dominus,[61] also meaning land ownership, particularly through political power.[62] More recently, 'public domain' suggests public ownership of land, however the term is somewhat misleading, as these areas of land are generally still owned by government or the crown. The use of the land however, gives greater certainty about the public quality of the domain, clearly visible throughout the history of the Taupo Domain. The domain is not commercially owned, as the rest of the Taupo town center appears to be, and it does not support privatisation, which is something worth protecting and enhancing. The site has both a rich history of use by Maori, as a military base and more recently as a site for a variety of community based activities. The change in use of the Taupo domain demonstrates this can be broken down into three distinct time periods: Pre-1869; 1869-1885; and post-1885.

Firstly, pre 1869 Maori occupied this land, and although there is little documentation on this, there is evidence of several important Maori tracks running through the land.[63] Various paintings and sketches show further signs of activity taking place.[64] An important use for this site was that it was the crossing point of the Waikato River, a journey taken via waka. European settlers, developed this crossing by erecting an overhead cable, to help ferry the canoes safely against the strong current. Early postal services took advantage of this system, bringing mail down through Oranui, and along the western edge of the river, finally crossing over into the township. In 1869, it was reported that there were Maori living in the area, and no European buildings.

The period 1869-1885 saw the domain used for European military purposes, a response to the Maori Land Wars, with some of the earliest buildings recorded in the domain being the magistrate's court and a Maori whare. In 1871, military set up the first buildings here, including accommodation for 32 men, boat sheds, and later, officers' quarters, stables, and a magazine made of pumice block walls and a corrugated iron roof to hold weapons and ammunition.[65] This small addition is still seen on site today and is Taupo's oldest building at around 120 years old.[66] In 1872, the government purchased the surrounding land, which made up the remainder of the domain. In 1875, the complex was complete with the addition of a guardroom, cookhouse and an orderly room, of which timber was utilised from the local Opepe Bush.[67] The area was given the name Tapuaeharuru, translated as 'the place of resounding footsteps', a result of the pumice ground below appearing hollow and giving off an echo, but perhaps also in remembrance of the many Maori paths that lead through the site also. [68]

In the coming years several buildings were added and later removed or recycled for a different use. Taupo's first school was established along the

58 Merriam Webster, "Domain," Domain, 'last, 'accessed' 7 August, 2014, http://www.merriam-webster.com/dictionary/domain

59 dictionary.com, "Domain," Domain, 'last, 'accessed' 7 August, 2014, http://dictionary.reference.com/browse/domain?s=t

60 "Demesne," Demesne, 'last, http://dictionary.reference.com/browse/demesne

61 "Domain".

62 Merriam Webster, "Dominium," Dominium, 'last, 'accessed' 7 August, 2014, http://www.merriam-webster.com/dictionary/dominium

63 RJL Guppy's map of Taupo, 1857, Taupo District Council, "Tongariro Domain Management Plan," Tongariro Domain Management Plan, 'last, 'accessed' 13 June, 2014, https://www.taupodc.govt.nz/our-council/policies-plans-and-bylaws/reserve-management-plans/Documents/Tongariro%20Domain/Tongariro-Domain-Management-Plan4-5-6-7-8.pdf

64 As shown by a sketchby Travers and a painting of Tapuaeharuru in 1864 showing Poihipi's pa by WilliamFox (Alexander Turnbull Library).

65 Council, "Tongariro Domain Management Plan" 11.

66 Ibid.

67 Ibid.

68 Barbara Cooper, *The Remotest Interior*(Tauranga: Moana Press, 1989), 8.

southern border of the domain, but later relocated. A community hall opened in 1881 and was later converted in a courthouse,[69] until the courthouse was moved into a new building next to the police station, still within the domain. Other buildings that have featured over time (some still remaining), include a library, post office, council offices, information center, event centre, campgrounds, a memorial hall, public toilets, a museum, and various club rooms that were erected around the southern end of the domain. In more recent times, there has been a shift towards utilising existing buildings and also establishing various premises for various clubs from the community. These include the bowls, tennis, yachting, senior citizens and various arts clubs.

The area has become a repository of both stories and artefacts relating to the people of Taupo, throughout different periods of time. Further enhancing this idea is the abundance of memorials that have featured in the domain: a memorial hall was erected post World War Two; various memorial plaques are located under specific trees around the domain; there are also three totara trees which are themselves a memorial to the late New Zealand prime minister, Norman Kirk.

69 Council, "Tongariro Domain Management Plan" 12.

The very public nature of the domain has several important implications for any building that is placed within its boundaries, particularly one that is significant in size. An important is pedestrian access, and preserving access to important features in the domain, particularly the water. A focus on walkways would also reference the Maori paths which crossed through the domain. Another requirement is for the building to respond sensitively to its natural surrounds, and to not appear imposing on the landscaped quality of the domain, imposing implications on scale. Finally, it is important the building be flexible enough to accommodate changing programs and various club groups. This would support future developments to the township, and encourage efficiency by consolidating club group buildings. It is important that the public nature of this site be emphasised, for its political and social importance. The roof will have a 'gathering' function here, in which various ideas, activities and community groups are collectively gathered into one building, or perhaps more poetically, under one roof.

Figure 4.2 *Site Analysis diagrams (Left to Right): Viewshafts, Vehicle Access and Parking, Pedestrian Circulation, Implied Zones and Uses of the buildings within the domain.*

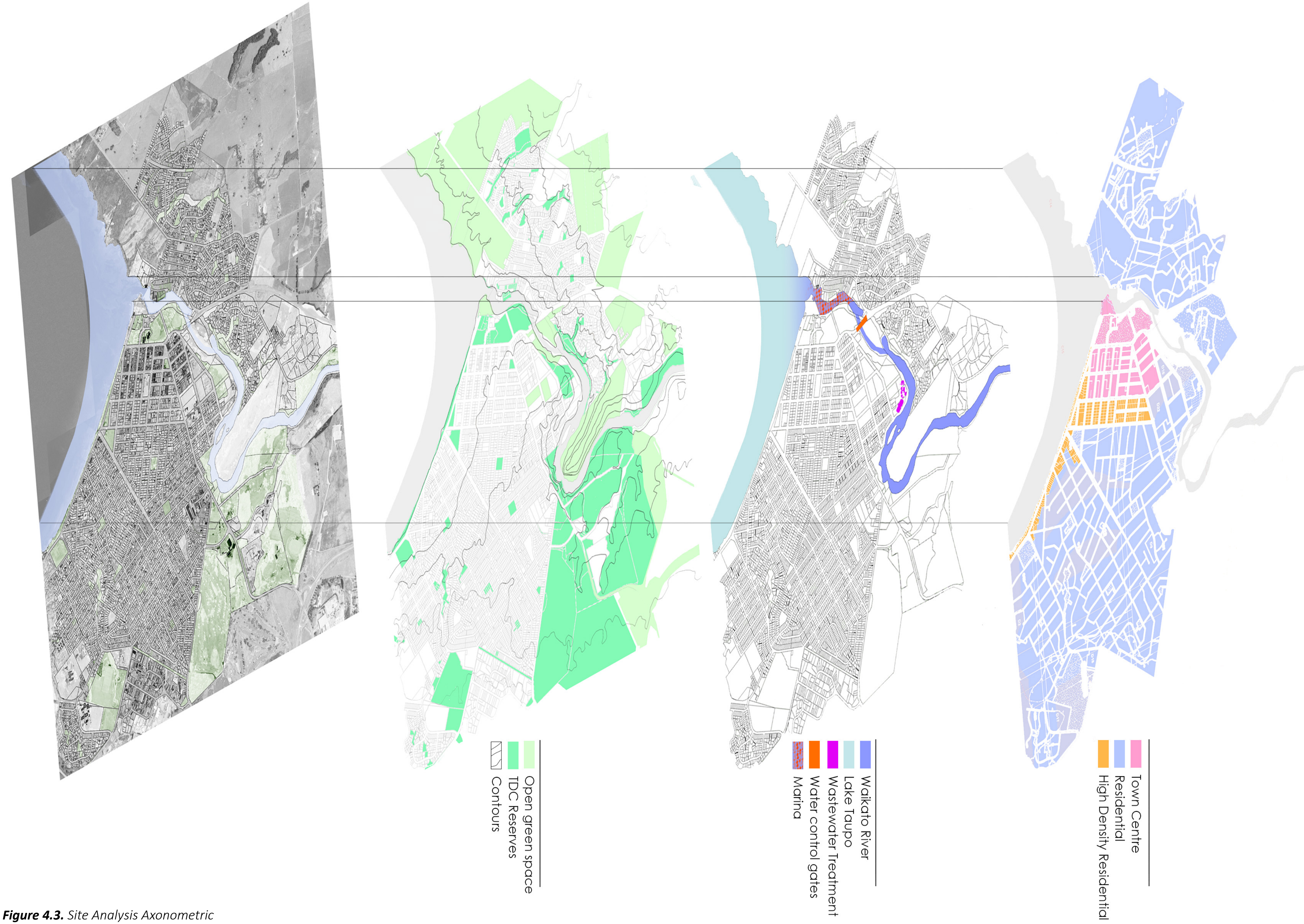
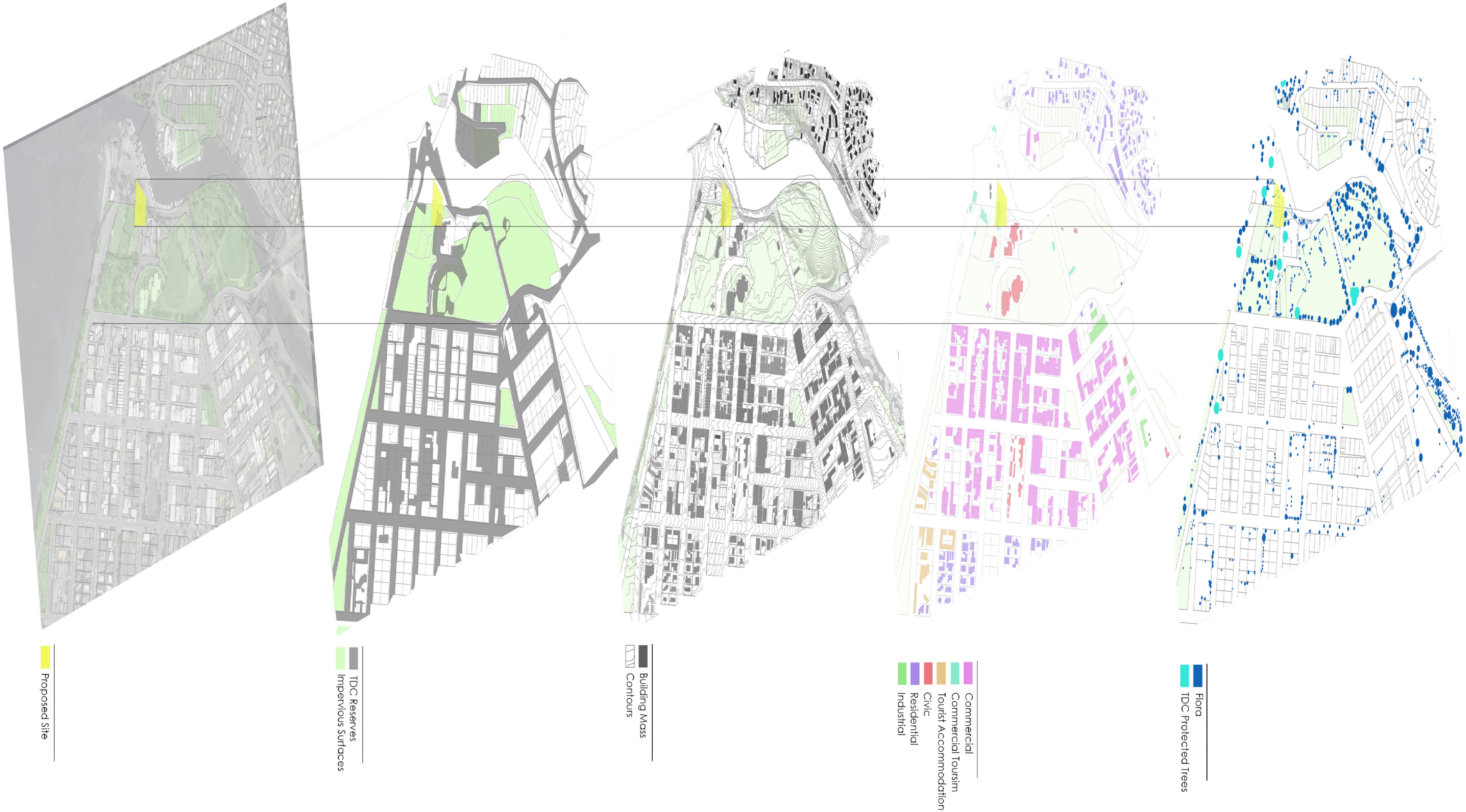


Figure 4.3. *Site Analysis Axonometric*



Proposed Site
TDC Reserves
Impervious Surfaces
Building Mass
Contours
Commercial
Commercial Toursim
Tourist Accommodation
Civic
Residential
Industrial
Flora
TDC Protected Trees

1
2
3
4
5

1.

2.

Top Left to Bottom Right:

Looking up the Waikato River towards the site

Approach along Story Place

View of the site from the water

Seating area in the Rose Gardens

View up the Waikato River from the site

3.

4.

5.

Figure 4.4. *Site Analysis*

4.1.3 Climatic Conditions of Taupo

Taupo is renowned for its cold winters and for having mild summers. Its location north east of Tongariro Park attracts many tourists who pass through on a ski trip, or find accommodation in Taupo. This location is however responsible for its cold winters. Average monthly temperatures range between 9 - 19°C between winter and summer,[70] with a record low of -6.3°C and a high of 33°C.[71] The average rainfall is 1102mm and it has been known to snow on several isolated occasions. There is also a large amount of geothermal activity which happens below the earth's surface; unfortunately this is not the case near the chosen site, which could have been utilized for heating the building.

4.1.4 Considerations of the Buildings in the Taupo Domain

This project proposes the removal of two buildings: the old Active Arts Center in the northern end, for reasons already discussed; and the Taupo Women's Club on the chosen site, both shown in red. The Taupo Women's club is currently only used several times a week, and whilst it sits on a prime civic site it offers no relationship to surrounding domain and acts as an eye-sore. Flexibility in the proposed building will however ensure the club group is accommodated.

70 NIWA, "Average Rainfall and Temperatures," Average Rainfall and Temperatures, 'last, 'accessed' 19 August, 2014, http://www.niwa.co.nz/sites/niwa.co.nz/files/sites/default/files/images/map_taupo-g.jpg

71 "Climate Summaries," Climate Summaries, 'last, 'accessed' 14 August, 2014, http://www.niwa.co.nz/education-and-training/schools/resources/climate/summary

Figure 4.5. *Sketched analysis of buildings within the Taupo Domain.*

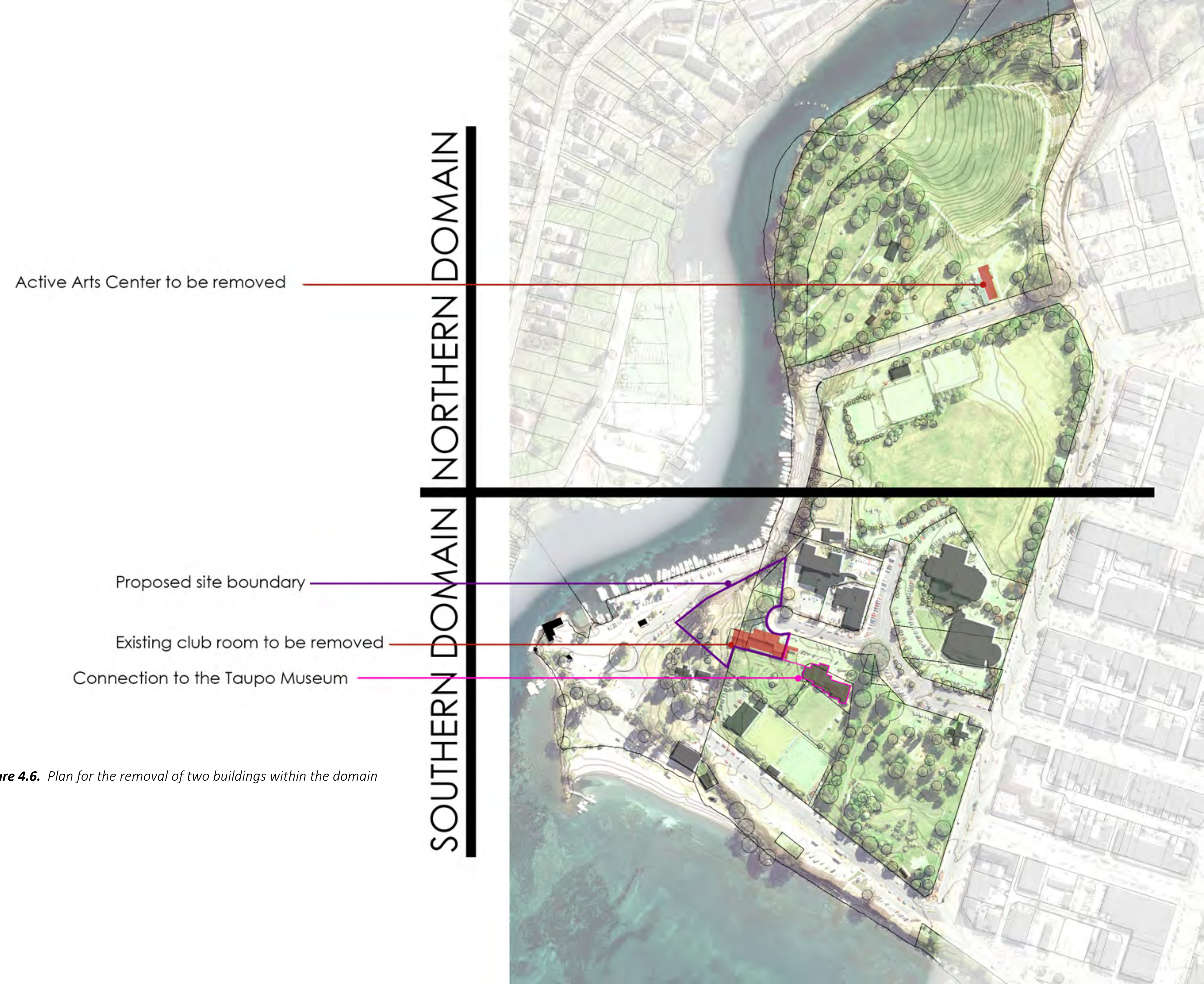


Figure 4.6. *Plan for the removal of two buildings within the domain*

4.2 Programme

4.2.1 Programme Selection

Programmatic considerations are crucial to this project because of the public quality of the domain, demanding a building which majority of the community will appreciate and have access to, thus making a strong political and social statement that the Taupo Domain is a *public* domain and serves to the public. It is also important that the project offers a variety of implications for the design of a roof, particularly in terms of environmental systems. It has been noted on several occasions in the Tongariro Domain Management Plan, the immense public support for enhancing the arts culture in the park. [72] Part of this arts development includes the expansion or relocation of the existing Active Arts Center. [73] The Active Arts group currently offers art classes and workshops, which take place in three small studios. They also host the 'Art in the Park' market each Saturday, adjacent to the water to sell their work[74], although several members of the group have communicated via email that they would value a permanent indoor gallery space. This presents an opportunity to propose a new art center, which would allow the existing building in the northern area to be removed, and encourage preservation of the landscaped area of the domain. An art center requires focused attention of environmental systems in the form of lighting and ventilation to ensure art works are viewed and stored safely.

The Taupo community could also benefit from some type of large, flexible community space, which could take the form of a simple roofed outdoor area where informal activities could take place. There are currently many activities in the domain that have no sheltered area to make use of (see Appendix 1). These activities include markets, home shows, and sporting events which supporters gather for. Taupo winters are cold and wet however, making outdoor events difficult. Community halls have had a strong presence throughout New Zealand, particularly in smaller towns post WWII, often described as "living memorials"[75]. Bill Mckay describes these community centers as being more programmatically rich than the traditional *country hall*. He explains that "a community center was more of a complex that could support a variety of events: social, cultural, political, educational and recreational."[76] The typical community hall consisted of: a gable roof with a square or stepped façade; a front door facing the street; a stage at the rear; and a kitchen to one side.[77] These simple amenities provided great flexibility in the use of these halls for a variety of activities. This project will incorporate the basic amenities of a stage and a kitchen though, as these have been a proven success.

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72 Council, "Tongariro Domain Management Plan" 17., p.17, 21, 22.

73 Ibid., 2-3.

74 A Market held every Saturday morning during summer in Colonel Roberts Reserve, a five minute walk from the domain. itravelnz, "Art in the Park Taupo," Art in the Park Taupo, 'last, 'accessed' 5 July, 2014, http://www.itravelnz.com/event/art-in-the-park.html

75 Bill Mckay, "Living Halls: The War Memorial Community Centres," in *Living Halls/ Fiona Jack*, ed. Gwynneth Porter(Auckland: New Plymouth: Clouds: Govett-Brewster Art Gallery, 2011).

76 Ibid., 78.

77 Ibid., 80.

4.2.2 Outline of Space Requirements

Art Center Functions

- Sculpture Gallery
- Painting Gallery
- Workshop : Painting
- Workshop : Weaving
- Workshop : Pottery/ Sculpture (with kilns and an outdoor Raku firing pit)
- Arts Collection Library
- Learning/ Conference Room
- Lots of Storage
- Office/Admin
- Licensed Café/ Restaurant
- Book/Craft Shop

Flexible Community Space

- Kitchen
- Staged Area
- Outdoor Seating

Figure 4.7. *Various activities within the Art Center*

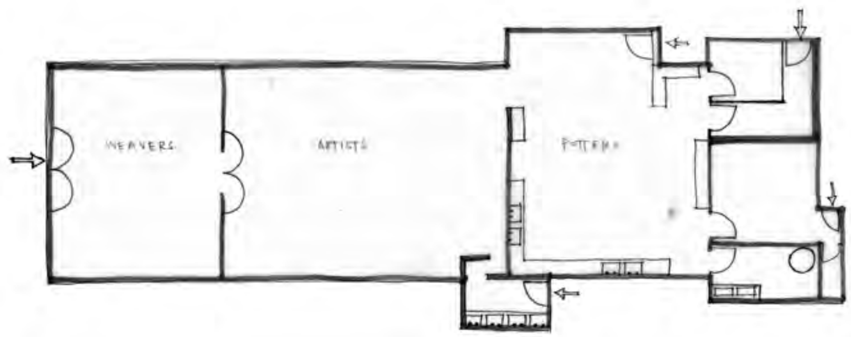


Figure 4.8. *Diagrammatic floor plan of the existing Taupo Active Arts Center building*

4.2.3 Theoretical Discussion of Art Museums

Art Museums enter into a complex discussion about the relationship of the architectural form and the art held within. Should the architecture reflect, respond to, or enhance the ideas of the art in some way, or should the architecture serve primarily as a backdrop for the art? There are several well-known examples that support the former argument; such as Gehry's Guggenheim, or Libeskind's new wing for the Denver Art Museum. There has been much criticism that these exuberant forms outshine the work on display. Hal Foster describes this as "a gigantic spectacle-space that can swallow any art, let alone any viewer, whole."78 In contrast Renzo Piano's designs for art museums tend to be much quieter in nature, achieved through his use of simple geometries, clear rhythms, and neutral tones. Whilst they are quieter, they are still incredibly beautiful buildings.

One important factor in establishing an architectural intent for the design of these buildings has been the type of art on display, and whether or not it is a permanent collection, or whether the space needs to cater for changing collections. The proposed center will need to cater for changing collections, an appropriate approach for a small town, which is likely to experience future growth and see new artists emerge in the years to come.

The Taupo art center offers an opportunity to express the character and values of the place, whilst providing more neutral gallery spaces, to avoid competition with the work on display. A design opportunity also exists to explore the potential of the roof and ceiling, where the roof is viewed from outside and can be far more expressive, and a ceiling can reduce the roofs drama in gallery areas, where required. It may also be feasible to propose some gallery spaces where an expressive roof is made visible or partially visible. As Donlyn Lyndon says "keep the myth up off the floor", where she suggests "letting spaces develop extra interest and meaning without clogging the arteries of function". 79 Here, the main function will be to allow circulation and promote the viewing of the art on display.

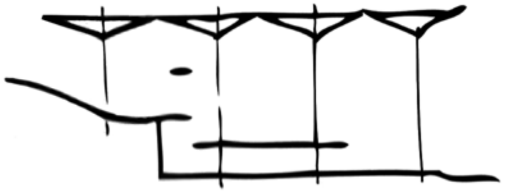
78 Hal Foster, *Design and Crime: And Other Diatribes* (Londson: Verso, 2002), 37.

79 Donlyn Lyndon nd Charles W. Moore, *Chambers for a Memory Palace*(Cambridge: MIT Press, 1994), 135.

4.3.4 Art Center Precedent Study 1 – Auckland Art Gallery

How can a local Art Center respond sensitively to its rich natural surroundings, through the design of a roof? Auckland Art Gallery's 2011 extension, located on the outskirts of Albert Park, required architects FJMT and Archimedia to respond to the park's rich landscape quality. The approach used here was to *blend* in, achieved in part by the extensive use of timber. The height of the kauri roof canopy responds to the slope of the land on which it sits, seen in the architect's earlier sketches, forming spaces between roof and ground. The canopy stands tall next to the neighboring trees, resting upon slender tapered columns, appearing as an effortless feat against gravity. The design seems to support Laugier's argument for the correct design of a roof,[80] a disengagement of columns and walls, also referencing a tree-like "stand alone" quality. External glass curtain walls dissolve the perimeter enclosure, thus inviting the public to enter in, whilst maintaining a strong visual connection to the park when indoors. The use of glass also allows the eye to see the canopy on the opposite side of the building, helping it to read as continuous canopy, aiding circulation through the interior, with floors inserted below, establishing various "parts of a whole". Different spatial qualities are also achieved (see appendix). For example, the atrium achieves a sense of grandeur through the dramatic vertical displacement of the floor from the roof, whilst more informal spaces like the café appear to hug the canopy more closely, creating a more intimate environment. This variation in spatial qualities enhances the visitor experience, and the building starts to become a piece of art to be experienced in conjunction with the collections on display.
The architects appear to have made a conscious effort not to overshadow the art on display by creating a more neutral appearance in the gallery spaces. Gallery walls are painted white and in some areas the timber canopy and is partially concealed by a suspended white ceiling which also holds artificial lights, thus playing out the tension between the two contrasting types: the white box approach and the expressive approach.

80 Laugier, *An Essay on Architecture*, 14.



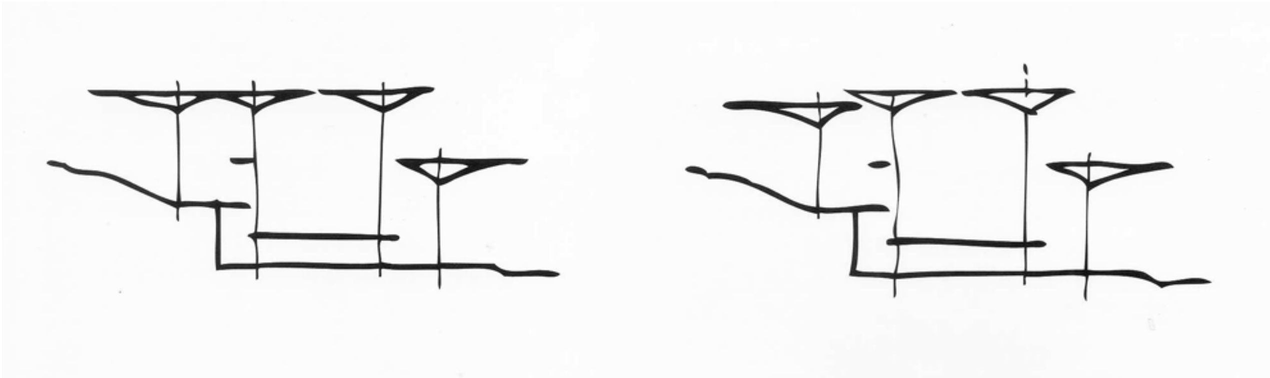


Figure 4.9. *Architect's early sketches for a roof canopy*

Figure 4.10. *Entrance to the extension of the Auckland Art Gallery, along Kitchener Street*

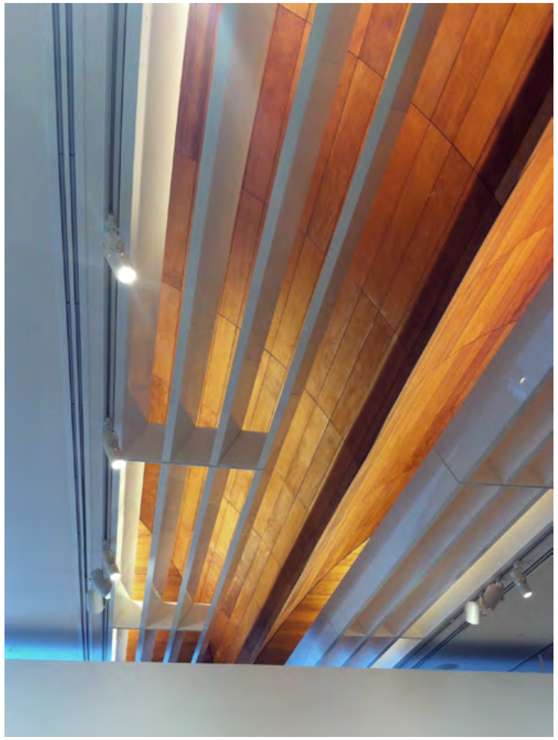


Figure 4.11. *A flat suspended ceiling houses white louvers, reducing the drama of the timber roof and housing artificial lighting*

• Tree-like columns in a landscaped site • Variety of roof heights • Roof and ceiling shift

3.3.5 Art Center Precedent Study 2 – The Beyeler Museum

Renzo Piano's design for Ernst Beyeler's Art Museum is located within the park-like grounds of a historic villa in Switzerland. The site, rich in landscape features, hosts several trees which are centuries old, influencing Beyeler's brief for an art museum "immersed" [81] in the surrounding greenery, whilst also being naturally lit. This was addressed through the design of a lightweight roof, engineered to control light and temperature.

Minimal steel supports hold up the roof, allowing the use of a multi-layered system of angled opaque glass sun shading, flat double glazing, operable louvers, a glass ceiling and a second ceiling in perforated metal[82], over which a white fabric is stretched to ensure an even distribution of light[83]. Thus, the roof provides both sufficient lighting on dim winter days, and allows control of shading on brighter summer days. Whilst reliance on natural lighting has not always been conventional for displaying art, the strategy has been celebrated for its changing ambiance in the gallery space, allowing works to be viewed in differing conditions, whilst bringing the architecture to life. The roof's lightweight quality is further expressed by contrast with the four main walls, which are heavy in mass and appearance, and large in dimensions (127m x 4.8m)[84]. The ends of these walls are met by large windows, looking out over the green surrounds. Piano stated in an interview that "enjoying art is a personal matter. It's made up by contemplation, silence, abstraction".[85] This building offers a silent quality to its interior spaces through a subtle colour palette, regular and rhythmic geometries, a connection to green space outside, and the uplifting quality created by the dreamy glow of the light roof above.

• Roof controls diffused light • Orthogonal Geometries • Large picture windows

Figure 4.12. *Beyeler Museum elevation view*

Figure 4.13. *Interior gallery space, naturally lit through the roof*

81 Renzo Piano Building Workshop, "Beyeler Foundation Museum," Beyeler Foundation Museum, 'last, 'accessed' 23 August, 2014, http://www.rpbw.com/project/38/beyeler-foundation-museum/

82 Arup, "Beyeler Foundation Museum," Beyeler Foundation Museum, 'last, 'accessed' 25 August, 2014, http://www.arup.com/projects/beyeler_foundation_museum.aspx

83 Workshop, "Beyeler Foundation Museum".

84 Ibid.

85 Martin C. Pederson, "Mixing the Sacred and the Profane," Metropolis,Mixing the Sacred and the Profane, 'last, 'accessed' 23 August, 2014, http://www.metropolismag.com/December-1969/Mixing-the-Sacred-and-the-Profane/

3.3.6 Art Center Precedent Study 3 – Kimbell Art Museum

Louis Kahn's Kimbell Art Museum shows how an art museum can successfully bring light into a gallery space through the roof without distracting from the works displayed, and being a beautiful piece of art in its own right. The building houses three individual gallery spaces on the north, south and east, a restaurant, an auditorium, a shop and a lobby with an information desk.

From the outset, the design focus was on natural light, and creating a space that was not overpowering,[86] seen in Kahn's selection of cycloid vaults over semi-circular vaults, connected in a rhythmic manner to establish a series of spaces underneath. Light enters through plexiglass skylights, extending along the apex of the vault, made possible by steel post tension rods. Hanging directly below the skylights, are reflective aluminum *wings*, diffusing harsh direct light into the spaces below and illuminating the arch to express the light grey and lavender tones of the concrete. Kahn's subtle material palette here combines concrete, travertine and white oak, further creating an interior which does not overpower the works on display. Reference to exterior spaces, is established through the design of the open portico along the western façade, where the arched roof is held up on two concrete columns and faces out over a pool of water. Selective windows also frame views out to the landscaped outside.

• Light illuminates the ceiling • Light ceiling reflectors • Subtle material tones

Figure 4.14. *Kimbell Art Museum. Aluminium 'wings' brings diffused light into the gallery space through the roof*

Figure 4.15 *Kimbell Art Museum. Portico facing out over the water*

86 Kimbell Art Museum, "Kahn Building," Kahn Building, 'last, 'accessed' 1 August, 2014, https://www.kimbellart.org/architecture/kahn-building

5.0 Design Process

Phase Two

5.1 Design Prospects

5.1.2 Roof and Hierarchy

This initial exploration took the form of a ‘stegreif’ exercise, where an impromptu form was created quickly using 3ds Max. The roof responded to a diagrammatic floor layout and a simple concept was employed where spaces with greater social importance were given hierarchical importance through an exaggerated verticality. Although intended as a multifaceted surface, rather than a curved one, the curved central space appears effective at defining the central space as important, and establishing an inward focus, focusing attention to any public activities happening within. More consideration is also required regarding the formal geometry of this roof, to avoid an un-necessarily complicated building.

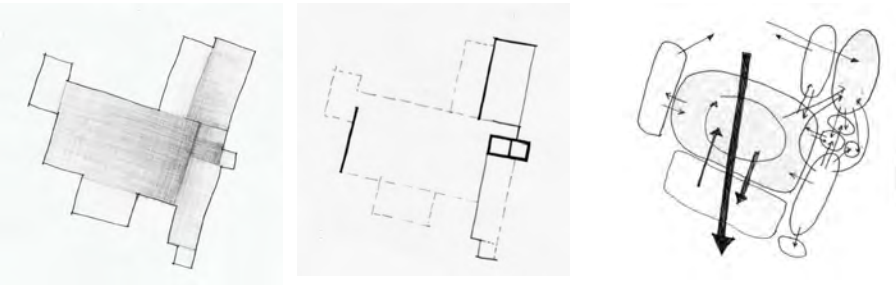


Figure 4.16. *Diagrammatic floor planning exploring light entry, privacy and circulation*

Figure 4.17. *Sectional exploration of hierarchy in the roof*

Figure 4.18. *Diagrammatic floor planning, on site model*

Figure 4.19. *Initial considerations for a roof on site*

5.1.3 Form Finding and Materiality

This exploratory excercise responds to earlier research on the relationship between structure and architecture and the relationship between materiality and form. Here, a roof form is created through manipulating a piece of 100gsm A4 paper. A grid is applied to both the upper and lower sheets of paper so that the forms can be more easily translated into a computer or a technical drawing later, allowing for a much more explorative approach. After cuts and folds are made into the paper, it is twisted and bent loosely, to allow the material properties of the paper to influence the resulting forms. This approach inspires endless formal solutions and it could be expected that all potential forms would express the same light malleable quality of the paper if the same approach were used, where the paper is only lightly touched in the manipulation process. Whilst paper cannot translate into construction easily, the process used here could be applied to a more appropriate material.

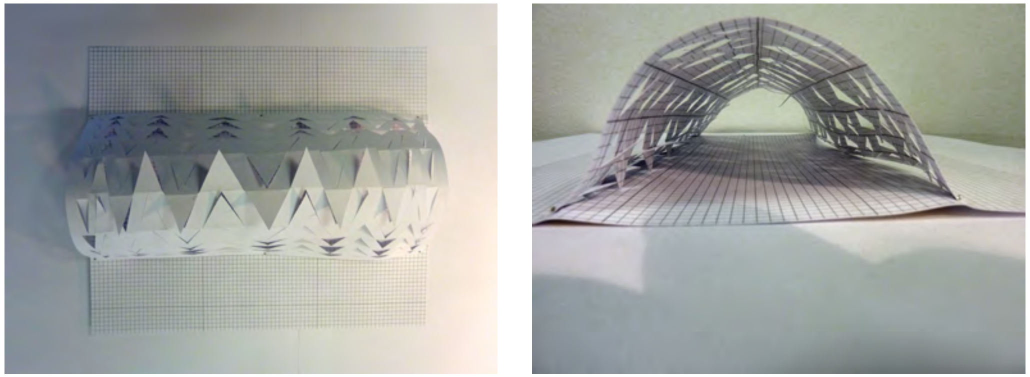


Figure 4.20. *Explorative models*

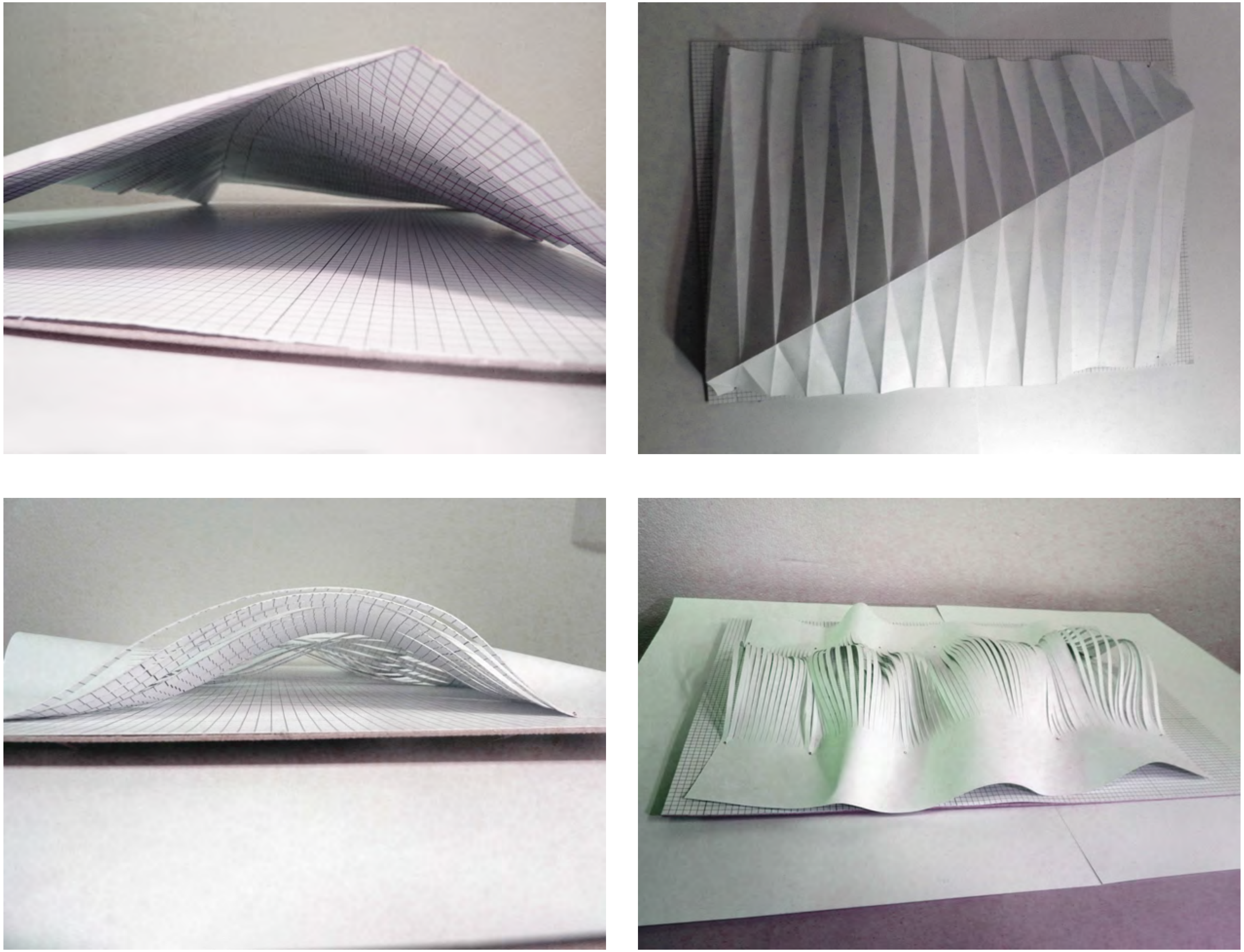


Figure 4.3. *Form finding exploration using a grid system*

5.2 The Project

5.2.1 Developing the Floor Plan

The site, currently acts as a main pedestrian route, connecting Story Place and the township along HeuHeu Street, down to the water. Two boundary conditions exist at each end of this pathway through the site: one quite formal and the other, more informal. The former meets Story Place and houses many civic buildings: the courthouse, police station, museum, library and the Great Lake event center. Some sort of formal arrival space is called for along the street edge relate to its context. This space could take the form of an atea and act as a gathering point for the street, for which there is currently none clearly defined. The formality of this walkway dissolves towards the western end of the walkway, where it opens out over the peninsula, houses seating looking out over the marina. A small café and a bustle of activity from various boating activities also take place. The roof will need to respond to these two conditions, whilst maintaining a cohesive whole.

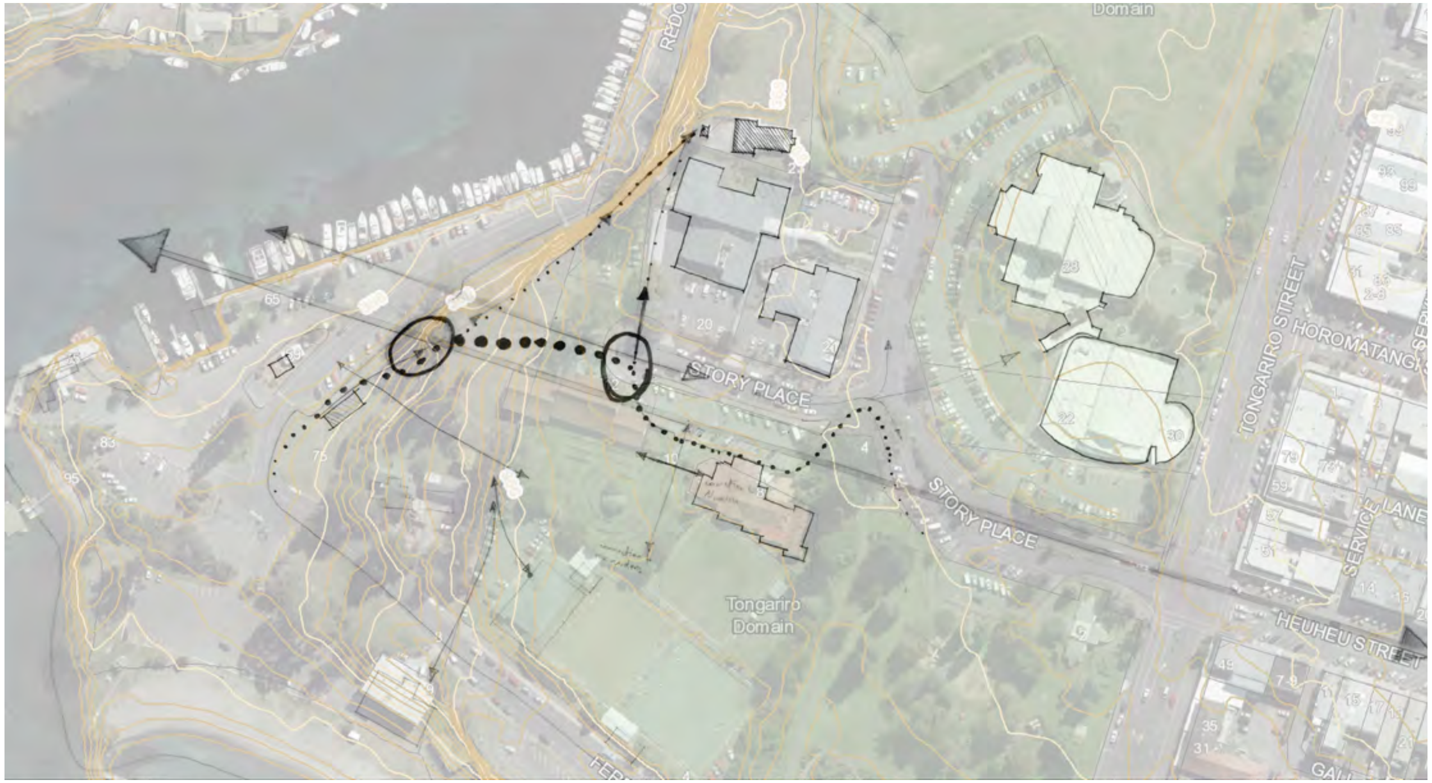


Figure 4.21. *Site planning diagram exploring circulation around the site. A design opportunity presents itself to enhance this pedestrian route the design of circulation in the building.*

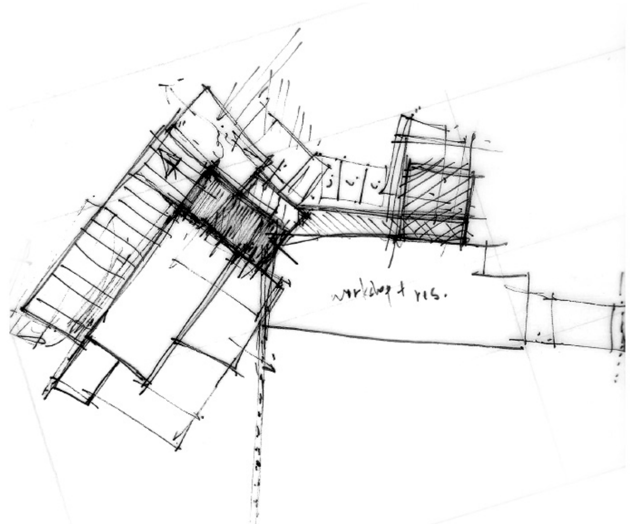


Figure 4.22. *Floor planning, explores the relationship between interior and exterior. The plan needs breaking up along the north to bring more light in and encourage public connections*

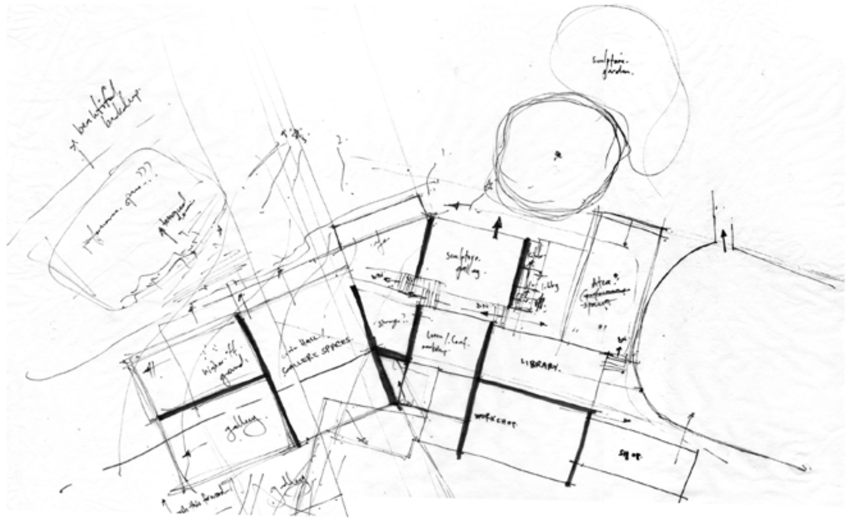


Figure 4.23 *Axis responds to Story Place and the Waikato River. Heavy load bearing walls could act as an acoustic barrier between activities. Awkward spaces are leftover where the two axis meet.*

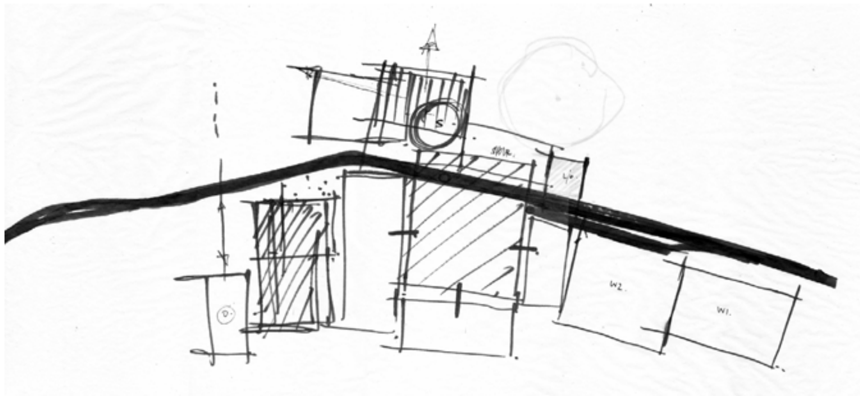


Figure 4.24. *A central walkway enhances the path through the site. Primary spaces connect to the walkway, with secondary onces attached on, where privacy/security are required*

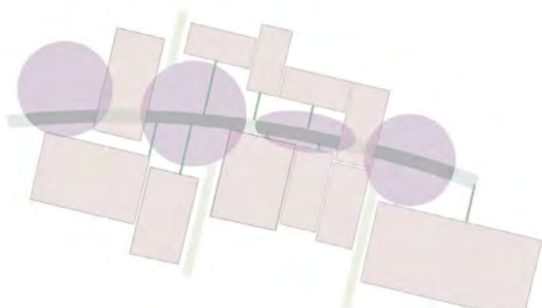


Figure 4.25. *Diagram of spatial configuration. This arrangement allows independent use of spaces, increasing flexibility*

5.2.2 Developing the Floor Plan - Structure

A structural grid of regular 3 meter intervals was imposed along the x-axis (red) The grid along the y-axis (blue) sits at various meter intervals and responds to the requirements for space sizes, decided upon after visits to two art centers of a similiar scale: The Mairangi Bay Arts Center and Ponsonby's Art Station. This uniformly spaced structural grid frees us exploration for the roof, an advantage already established in the exploratory paper models.

Figure 4.11. *Structural Diagrams: Grid layout, Location of load bearing walls and columns. Perimeter columns are maximised to give the appearance that they are holding up the roof and enhance the light tectonic quality of the roof. Load bearing walls are distributed as evenly as possible throughout the plan for stability and are placed strategically in areas where an acoustic barrier is required.*

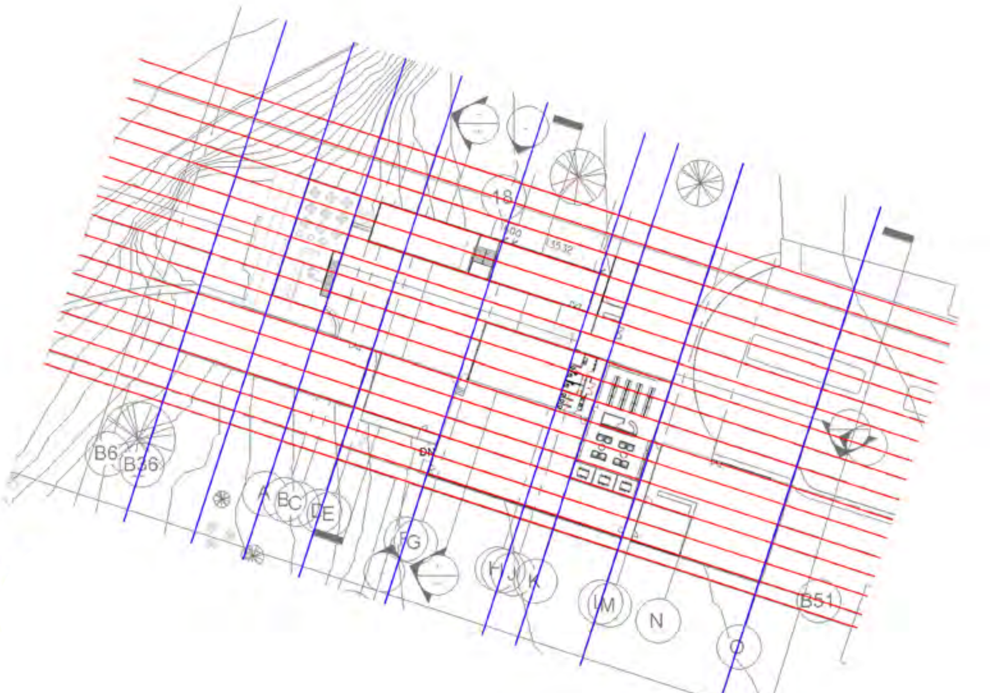
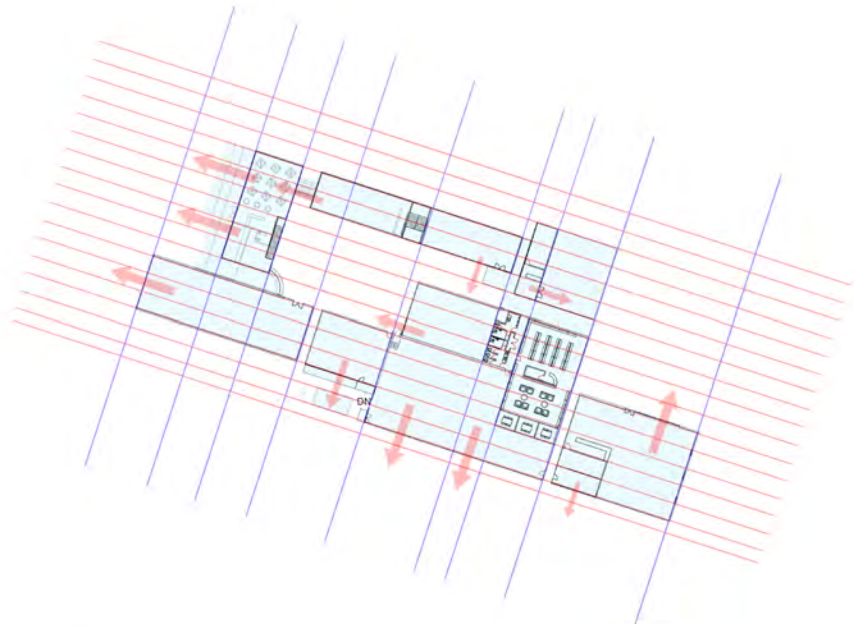
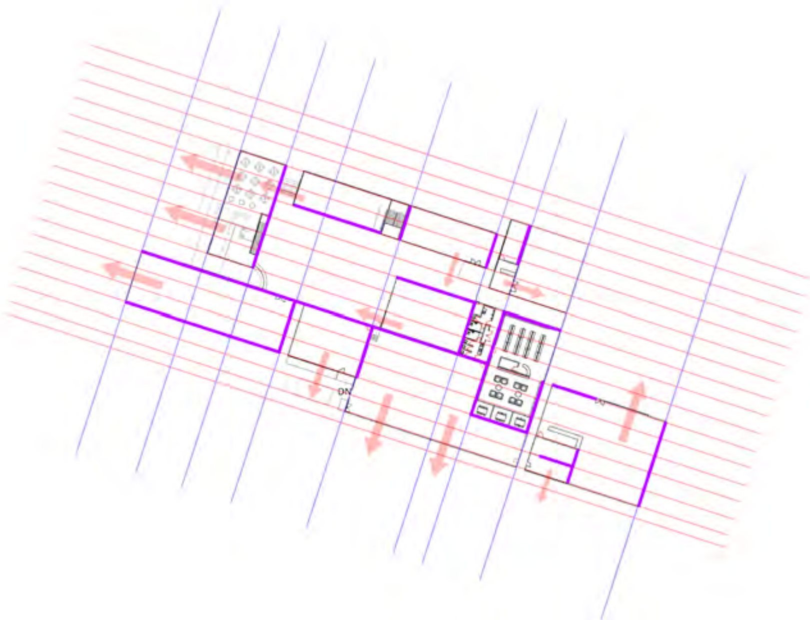


Figure 4.26. *Floor planning and structural grid layout*





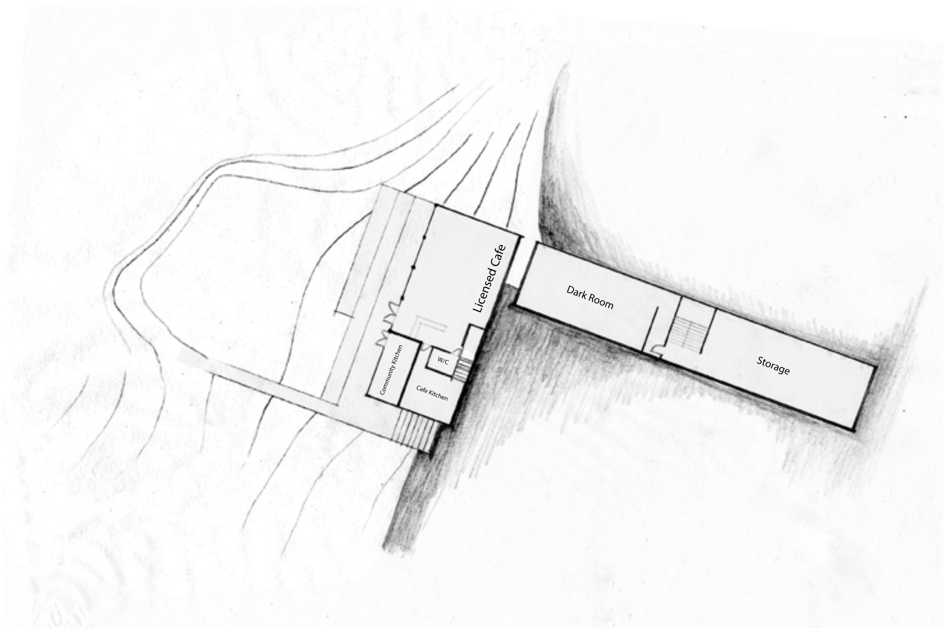


Figure 4.27.(Left) *Lower Ground Floor Plan, housing a dark room, shared storage facilities, and a licensed cafe and public kitchen next door, looking out over the water.*

Figure 4.28 (Right) *Upper Ground Floor Plan, defines both internal spaces and public circulation through the center. Four main public spaces are established with importance given to the central space which is sheltered from the cold south westerly winds which pass over the Lake and through the site.*

Floor planning development: Establishing four main public spaces along an axial route at ground level. Spaces are arranged to maximise natural lighting and views outdoors. Workshops are galleries are given preference along the Southern edge, to allow windows to frame views without any direct light enty, something that is crucial to spaces for viewing art. The bookshop, cafe, offices and weaving workshop are placed along the north to utilise natural lighting and heating as these areas aren't restricted to diffused light.

Workshops and galleries are able to operate independent of eachother, whilst having shared access to the library, toilets, storage and public kitchen. This accommodates for various groups and allows for future changes to user groups as this issue was identified in the document as being a cultural trend within Taupo.

Figure 4.29 (below) *Four main public spaces are established. 1. An Atea space 2. a 6m wide thoroughfare which could double up as market space with stalls either side, a central space to host activities outlined in Appendix 2 and a small ampitheatre, maximising the natural land*

5.2.3 Taupo's Caldera Volcano

Perhaps the most pertinent contextual issue in Taupo, is the violent Oranui caldera eruption, around 26,500 years ago,[87] although the lake's irregular shape tells us that more than one eruption has taken place here. More recently, the volcano erupted around 1800 years ago and is considered the most violent eruption in the last 5000 years, although not as colossal as Oranui.[88] The volcanic area is believed to have begun erupting around 300,000 years ago and is considered by volcanologists to be both the 'most frequently active' and the 'most productive' of its kind.[89] This 'productivity' comes in the form of rhyolitic pumice which is expelled during an event, a highly vesicular rock, giving it its high porosity and ability to float. This unique rock is found bobbing along the water's edge of the lake and is present in the soil around most of the Taupo region. The site was also quite recently a pumice dam, before it was broken through, creating the mouth of the Waikato River, thus going to show the abundance of this rock in both the immediate and surrounding Taupo context.

These models explore the vesicular structure of the pumice. These models started with a configuration of balloons and had plaster poured over them, allowing the liquid mass to take form through the forces of gravity and friction with the balloons.

Figure 4.30. *Typical cloud patterns of a caldera eruption*

Figure 4.31. *Pumice rock floating in water, a frequent sight along the edges of Lake Taupo*

87 Campbell, *Awesome Forces: The Natural Hazards That Threaten New Zealand*, 35.

88 Les Molloy and Roger Smith, *Landforms: The Shaping of New Zealand*(Nelson: Craig Potton 2002).

89 Ibid., 42.

Figure 4.32. *Plaster and balloon modelling, exploring the light vesicular structure of the pumice rock*

5.2.4 Materiality of Project

The material used in the project includes both timber and pumice. The early structures built in the domain were created from these two materials, as already mentioned in reference to Taupos oldest building: a military magazine located in the domain, made of pumice block walls and a timber framed roof. Timber can be both locally sourced and also gives rise to traditional architectonic types of both Pacific and Maori buildings. Pumice will be used as an aggregate in both the floors and some walls. Its light vesicular structure makes it difficult to use structurally, however it will increase the R-value of the concrete, an advantage during cold Taupo winters.

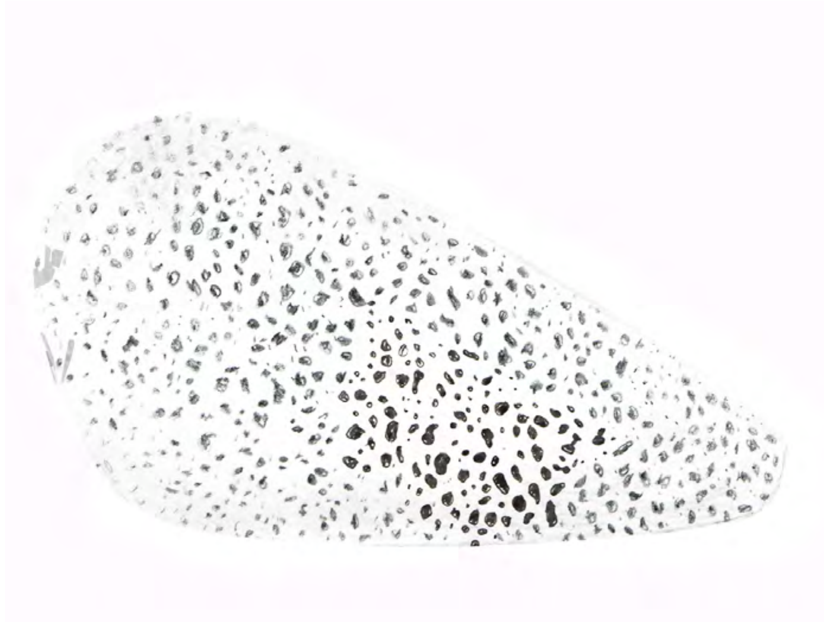


Figure 4.33 Sectional sketches through pumice roof

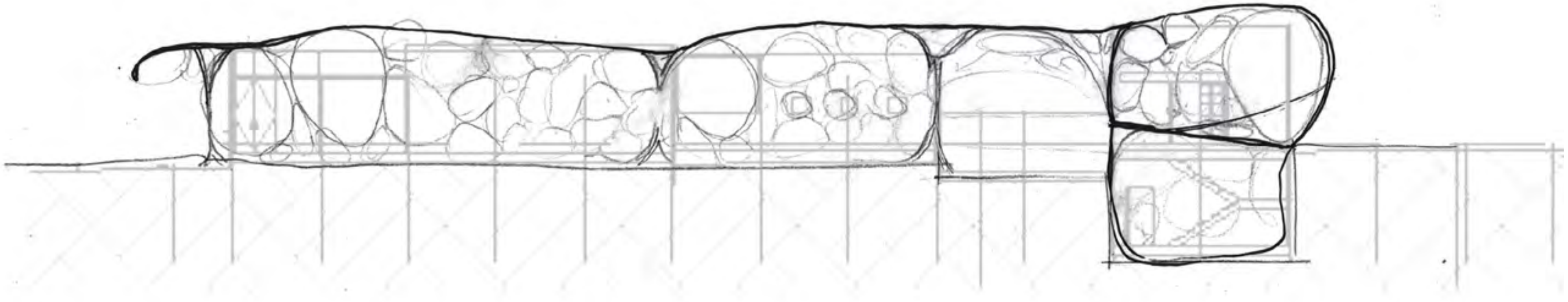


Figure 4.34. *Sectional exploration of the pumice structure and the form the building. It is important that the building doesn't become a piece of 'blobitecture' however.*

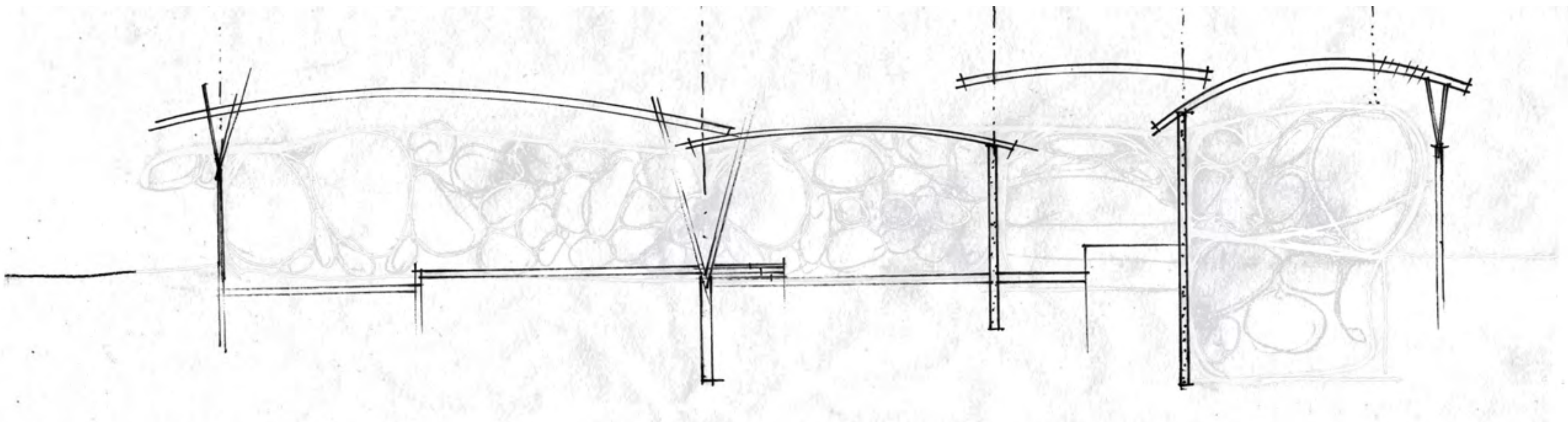


Figure 4.35. *Sectional exploration. Cellular, light, floating roof.*

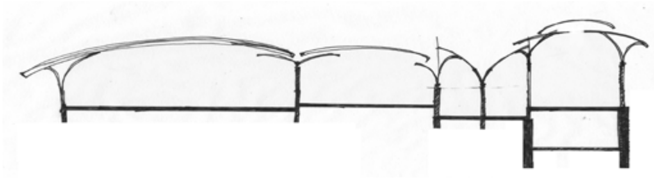


Figure 4.36. *Sectional exploration. Column connections*

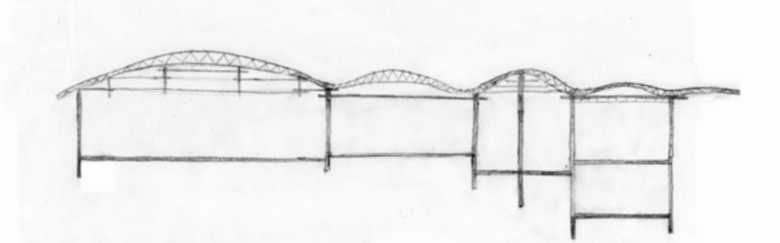


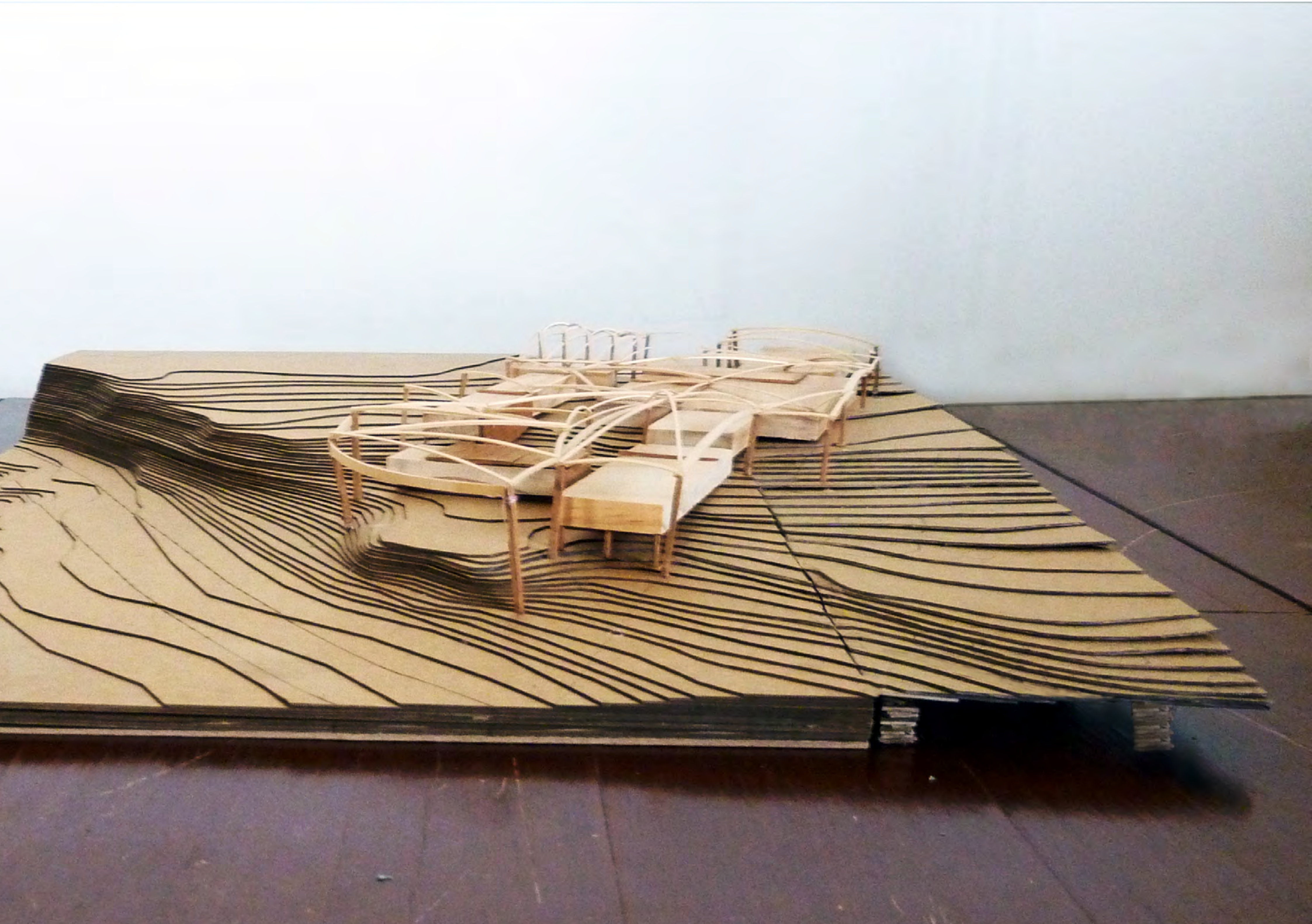
Figure 4.37. *Light steel space frame roof takes a curvacious form, while a rigid concrete frame below expresses qualities of Pacific architecture.*

5.2.5 Explorative Modelling : Stereotomic and Tectonic

Explorative models combine an understanding of the light, flexible and organic architectonic roof forms found throughout the pacific, as previously discussed, with the vesicular cellular structure of the pumice rock. The model creates pockets of spaces below the roof, intended to establish a similiar quality of enclosure or containment within each cell to that of the pumice rock, whilst mainting a light fleixble quality. The stereotomic is referenced through solid timber massing of spaces, however this is misleading as it reads as a series of spaces with flat ceilings and is not the intent. This model also highlights the conflict between using equal proportions of stereotomic and tectonic qualities if this model is to promote the light tectonic of the pacific. Heavy mass walls will be used more selectively.

The vertical columns are also struggling to withstand the outward thrust, suggesting heavier columns, angled or cantilevered columns may be more efficient and stable.

Figure 4.38. *Modelling of a roof, exploring the tectonic light roof, and stereotomic mass below.*

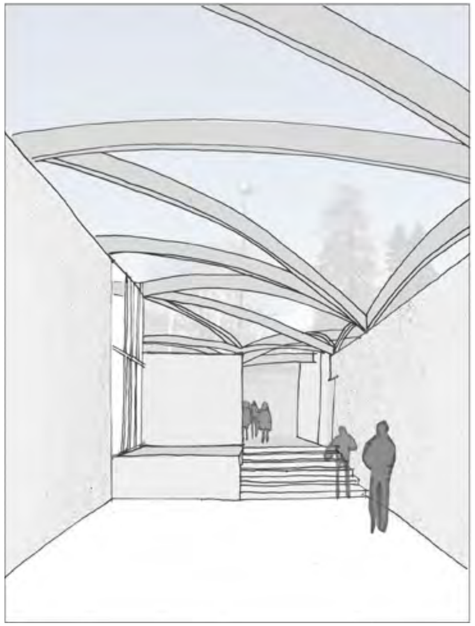


5.2.6 Exploring Public Circulation

Figure 4.39. *Serial Vision drawings*

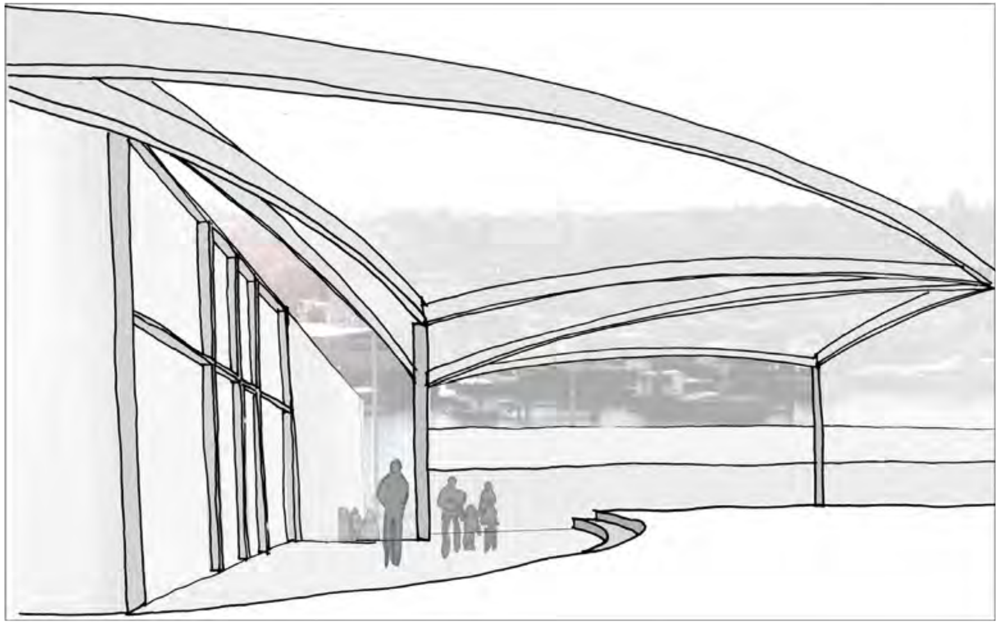
1 Approach from Story Place

A more formal and controlled geometry is used here to reference the civic quality of Story Place and the associated formal quality. The Atea space to the right of this image serves as an entrance-way and as gathering space. The local Maori presence is acknowledged here as this a feautre present in a lot of Maori buildings and it also allows cultural activities to take place within the building by offering a 'welcome' space



2 Thoroughfare looking back toward

Story Place, could be used to host the various markets (see appendix 1).



3 Main space, looking down to the water

Curving members span in different directions here and create a somewhat chaotic roof. More attention is needed. This space should be an inviting place for gatherings.

4 View back up to the main public space, facing away from the water.

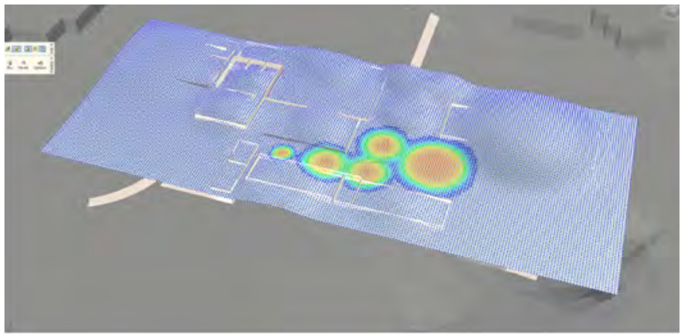
There is an opportunity here for the roof to enhance the threshold between walkway and the central social space. Further attention is needed.

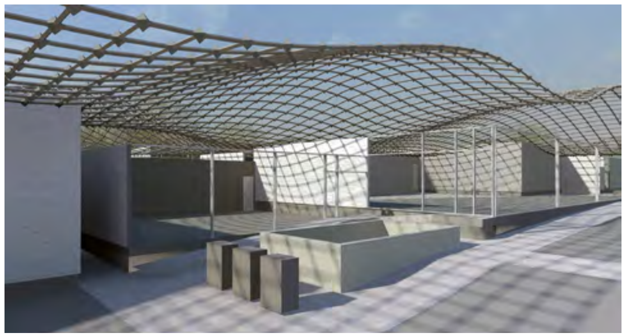
5.2.7 Developing the Roof as a Surface

Here, the roof is developed into a more gently curved surface, whilst still mainting the 'cellular pockets' below. This helps the roof to read as one continous element, as one that 'collects' or 'gathers' the community spaces below. It also helps the building read as having less perceived boundaries by reducing the abrupt changes in curvature that were present in the previous model This helps increase the 'public' quality of the building, where individual spaces are not privatised and where the public realm is defined within the central walkway, but not so much so that it appears to be controlling visitors and limiting community members from having access to roam freely through the building.

Design developments were made through computational modelling. The model switched between 3DS Max, Revit and Sketchup, to take advantage of the benefits of each. Each programme offers the advantage that the roof can be manipulated in perspective view, allowing a greater understanding of the experience of the space inside when making decisions.

The irregular rhythm of curves along the elevation lines is slightly overpowering however when viewed en-masse and gives away the delight of the interior before one even enters inside. Perhaps Renzo Piano's treatment of a flat perimeter edge to the roof in the California Academy of Science's building could help re-establish some order here.





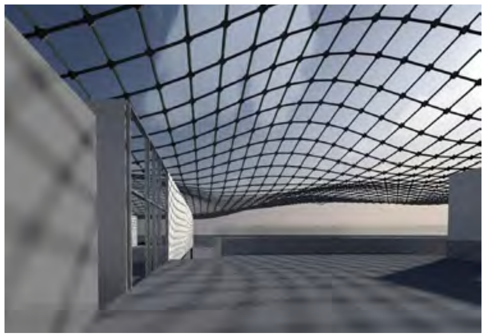


Figure 4.40. *(Left) A flat grid surface is constructed over the plan and then manipulated to form 'cellular pockets' below. Circles radiate from a center, at a specified gradient and are then raised to any given height. A general principle of one circle per space (as defined in floor plan) is used. This rule is broken however, through the central thoroughfare, particularly the more narrow passage. A series of circles creates a more dynamic spatial quality and encouraging movement.*
Figure 4.41. *(Center) View into the sculpture workshop, with an outdoor Raku firing pit and kilns. The roof needs to allow smoke to pass through.*
Figure 4.42. *(Right) View inside the central public space. The roof needs to create a greater 'loft' here. A higher roof is required.*

Figure 4.43. *Lineal movement of the building, with the curved roof defining a series of spaces.*

Figure 4.44. *Lineal quality of the building, contrasts the curved roof*

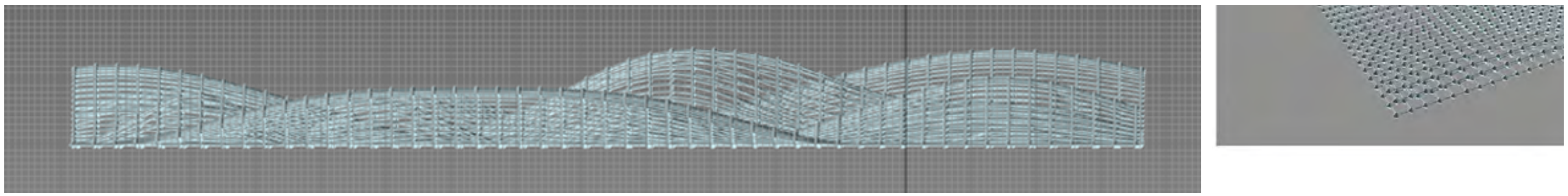


Figure 4.45. *The roof surface is conceived as a series of nodes and lathes, forms a grishell structure. The grid is then manipulated into a series of undulations which hover above spaces defined by the floor plan.*

5.2.8 Serial Vision Studies

The central thoroughfare (far left) begins to add contrast to the rest of the roof's light quality. This space is entirely internalised and acts as a transition between Story Place and the central social space. A heavy sculptural concrete column sits centered in the space, with a convex roof above, and heavy mass walls surrounding it, tightening and condensing this space. The apparant heaviness of this space encourages its use as a thoroughfare, whilst also acting as a contrasting palette refresher between the street edge and the central social space.

A greater loftiness is achieved in the central space through an increased vertical dimension.

The gridshell provides a framework for different ceilings, claddings and treatments of the roof to be explored, in relation to the different thermal and felt requirements for each space.

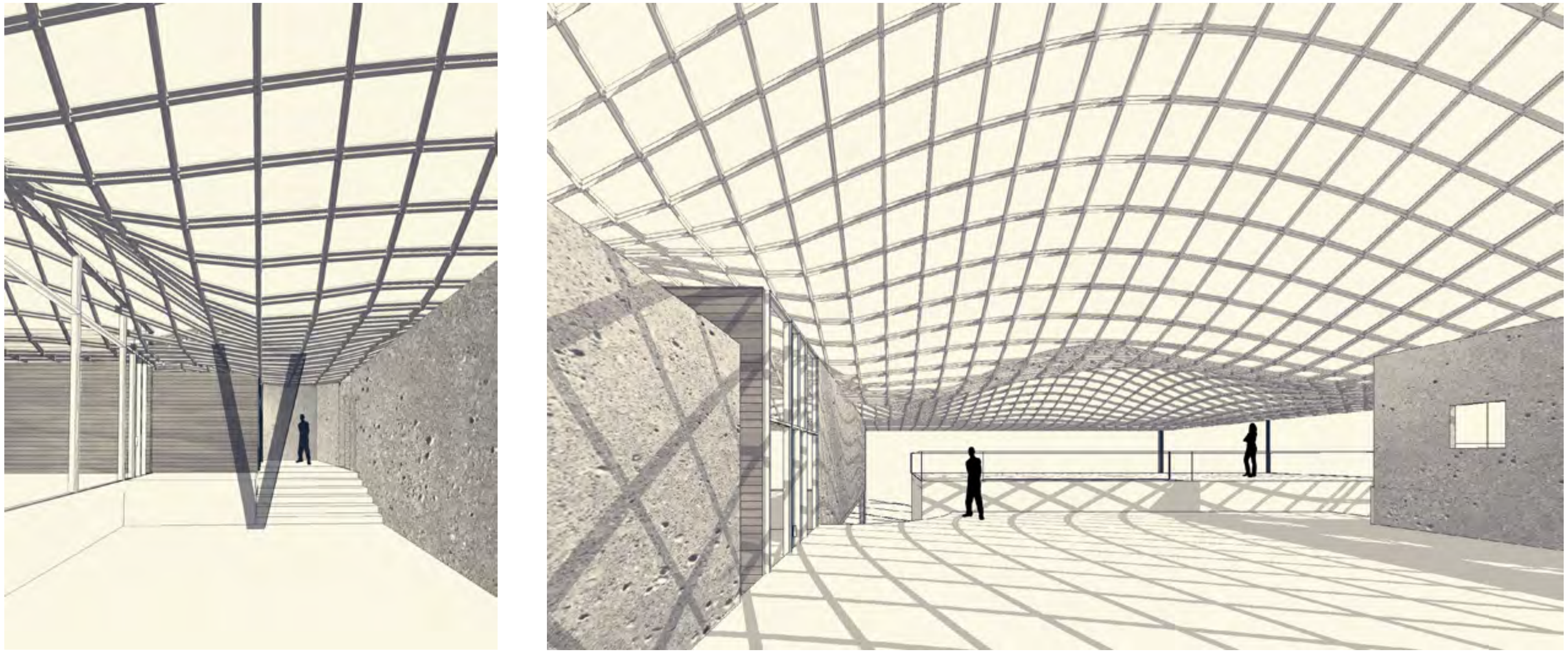


Figure 4.46. *(Left) Public circulation (Right) View towards the water from inside the main social space*

The perimeter edge of the building is left flat, to establish order and a difference between the perceived exterior and interior qualities of the building, adding an element of surprise and discovery to the building. This rule is broken over the atea space however where the roof edge has a concave curve to it, thus marking an entrance and establishing some grandeur to this space. It is marked as important in comparison to all other perimeter spaces. The angled columns shown here are connected to the concrete floor slab via steel pin joints, thus enhancing the qualities of lightness and flexibility through tectonic expression. Heavy foundations will be required, concealed below the ground here to prevent uplift from the roof.

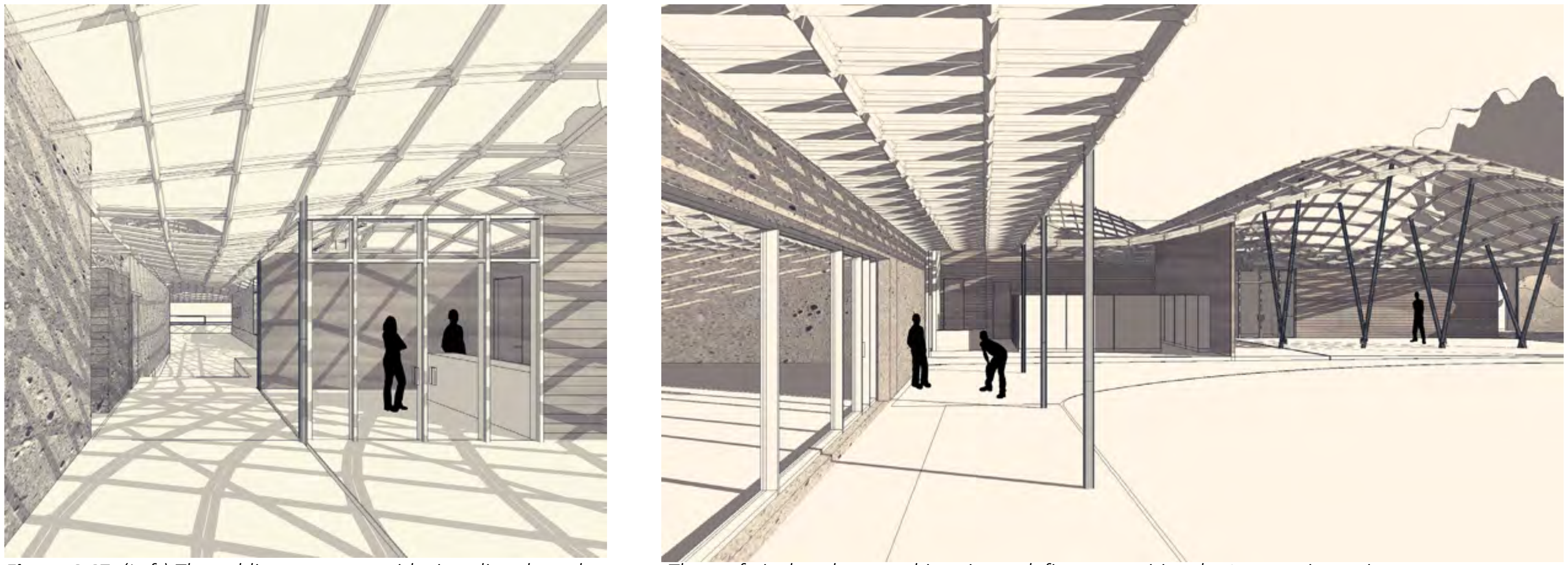
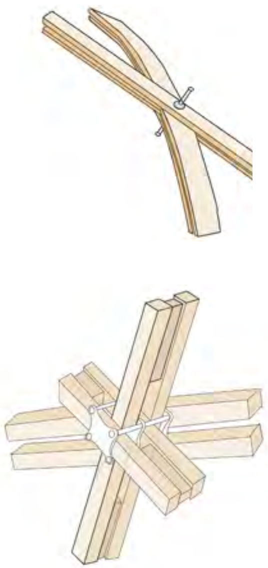


Figure 4.47. *(Left) The public accessway, with view directly to the water. The roof pinches down at this point to define a transition, better seen in section. (Right) Approach along Story Place*

5.2.9 Tectonics and the Roof Sandwich Panel

Gridshell construction uses a series of lathes, connected at node points. The double curvature of these roofs gives it its strength and make it capable of long spans with relatively small lathes, usually made from steel or timber, for their tensile properties. These roofs are constructed either by first connecting them and then lifting them up into position, or by laying them on top of a formwork. Tectonic connection at the node offers a point for architectural expression. Steel connections are commonly used and need to allow for deformations in the timber lathes post-construction. A survey of current detailing took place. A decision was made to use the system on the right, in figure 4.48 as it gives reference to the weaving traditions of Maori construction. Furthermore, it appears to have the least visible requirement for steel connectors, hence giving rise to a similiar quality to Pacific and Maori tectonic forms which used no nails or steel and relied on interlocking methods of timber construction such as lashing and weaving



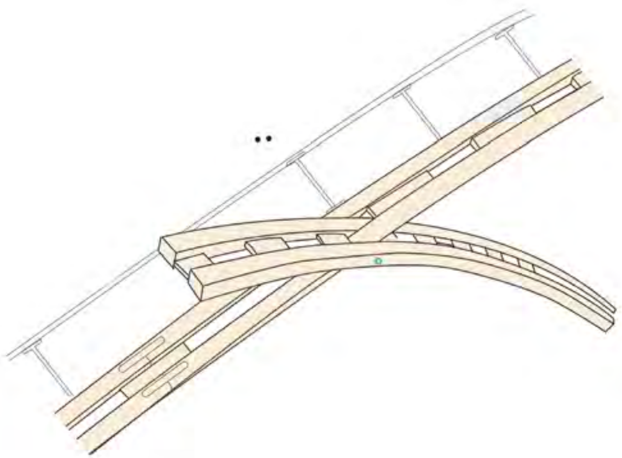
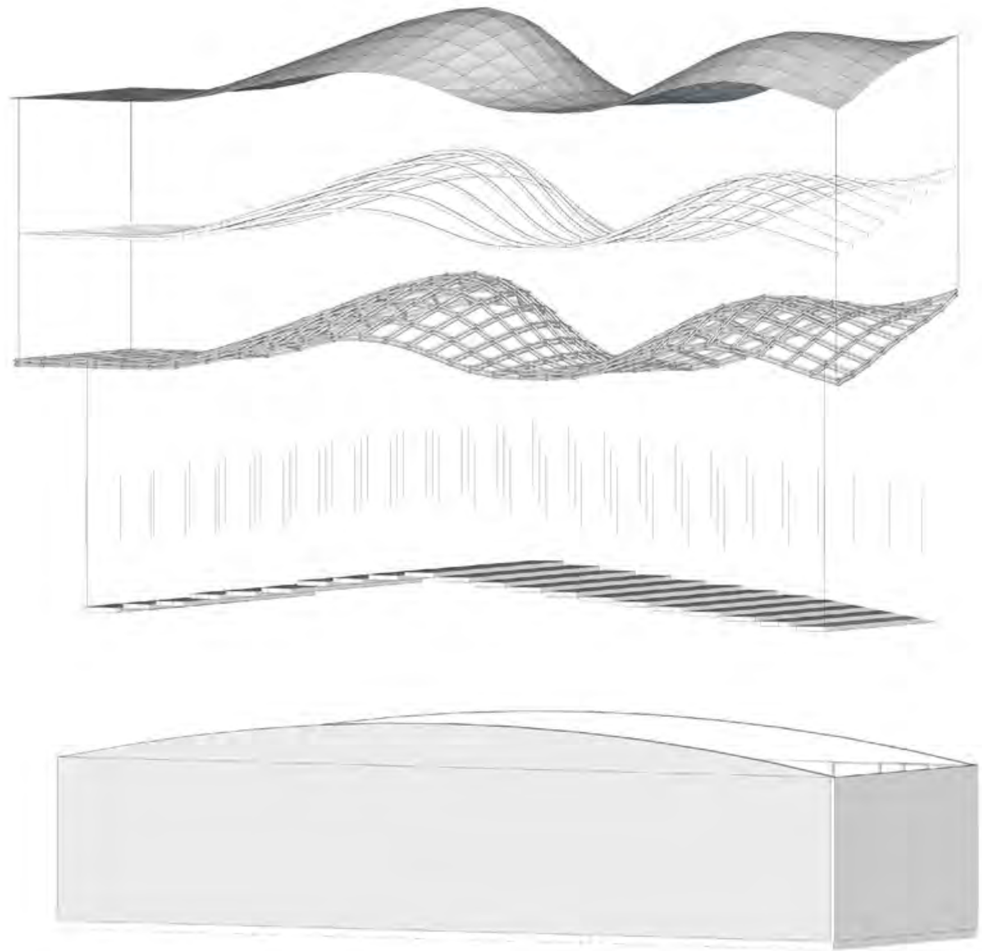


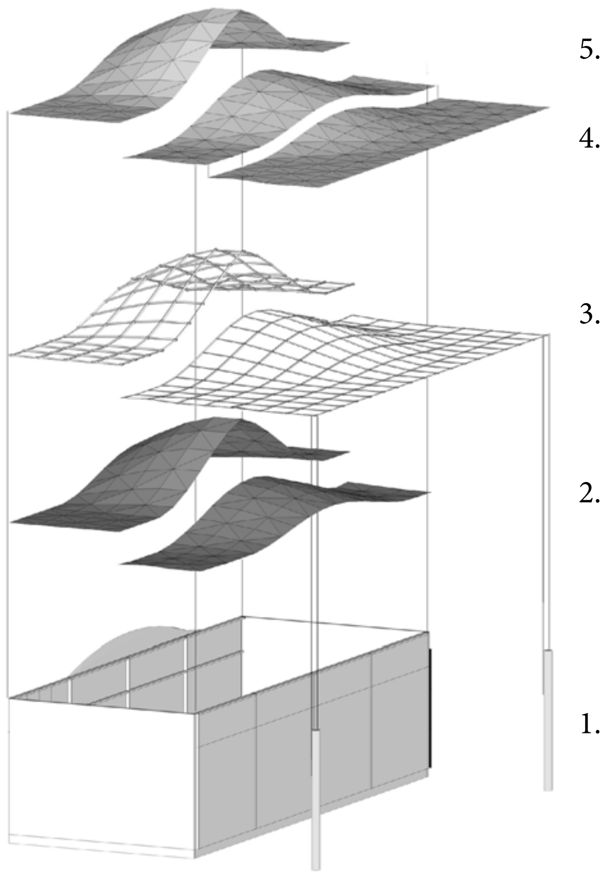
Figure 4.48. *Tectonic detailing of the gridshell roof*

Figure 4.49. *Exploded Axonometrics*



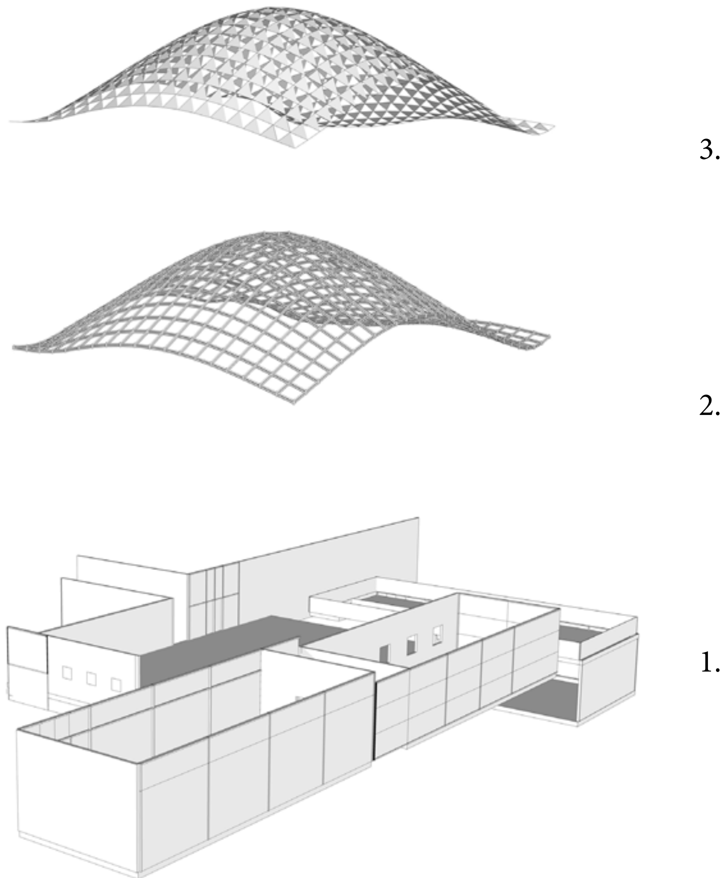
PAINTING GALLERY

1. Concrete mass walls (inward focus)
2. Suspended cables to support ceiling
3. White, wide louver panels run along the short section. (Gentle curve in one direction, simple geometry)
4. Double layer gridshell structure
5. Steel ribs run along the long section, following the gridshell (provides connection for ETFE panels)
6. ETFE panels (cladding and even distribution of light)



SCULPTURE GALLERY

1. Concrete mass walls (inward focus)
2. GRC concrete panels to cover the underside of the gridshell. The surface is smoothed over with concrete to create a rich textural surface.
3. Double layer gridshell structure is split through the middle. The southern section is raised, establishing windows facing north and bringing in diffused light by illuminating the underside of the roof.
4. ETFE cladding along the external overhang (continuity along roof)
5. GRC cladding sits above the gridshell, establishing a double layer roof with an insulation layer. This cladding is not visible from any point on site



MAIN SOCIAL SPACE

1. Surrounding walls
2. Double layer gridshell
3. Rainscreen operable louver panels, angle out toward north-west, bringing in light during the day and allowing the beautiful light from the sunsets along the the west, over the water, to pass through and hit the underside of the roof.

5.2.10 Roof Sections

Floor plates are stepped to follow the specific topography of the site and to create a changing relationship between roof and floor. Walls are not connected to the underside of the gridshell, clerestory windows will exist in this space in between. The strict horizontality of the walls contrasts the roof form and actually enhances the flexible and light quality it possesses. Furthermore, because the curves don't form perfect domes, the walls would all experience different curvature, and could produce an uncomfortable space. Glazing in this upper section minimises any changes in curvature between the surrounding walls. Large overhangs also ensure greater protection against the climate, particularly against rain, horizontal rain in winds and provides shading against the summer sun, thus helping keep the building cooler and removing direct light from the art spaces.

The section opposite develops various compositions of the roof sandwich panel. Operable polycarbonate rain screen louvers sit above the gridshell throughout the main social space, leaving both elements visible and adding to the visual interest of the space. This provides shelter from the rain and light to penetrate into the space. Hot air will also be able to pass through louvers when opened in summer, as the hot air will travel upward naturally, reducing the need for cooling. A suspended ceiling in the painting gallery draws inspiration from the Auckland Art Gallery and helps minimise the drama of the roof in a space where the art is the focus, whilst allowing artificial lights to be positioned. ETFE panels are attached above the gridshell to ensure an even distribution of light

The workshops incorporate a double layer membrane, for added insulation .

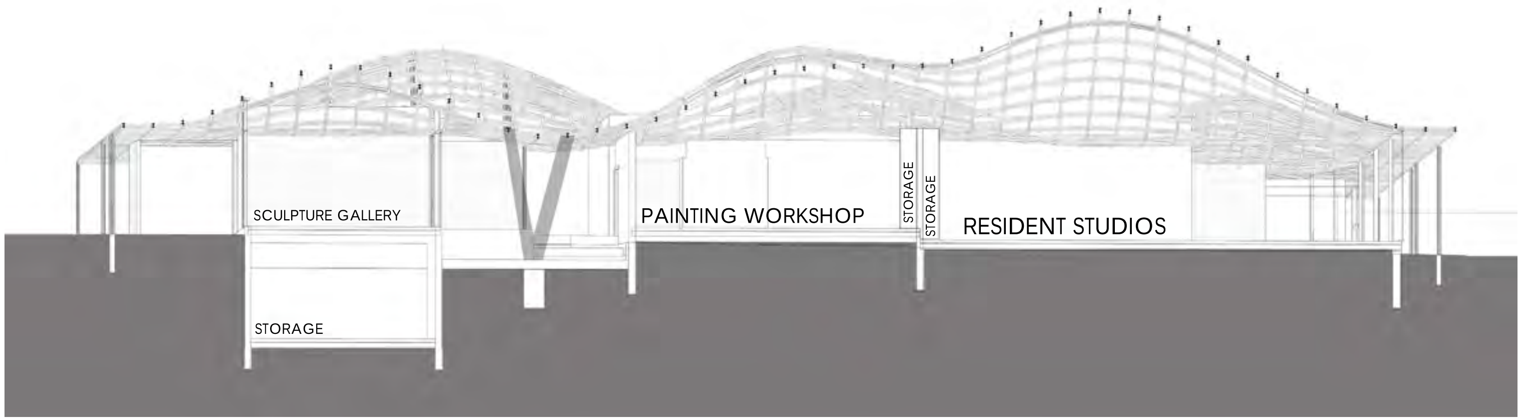


Figure 4.50. *Sectional Drawing*

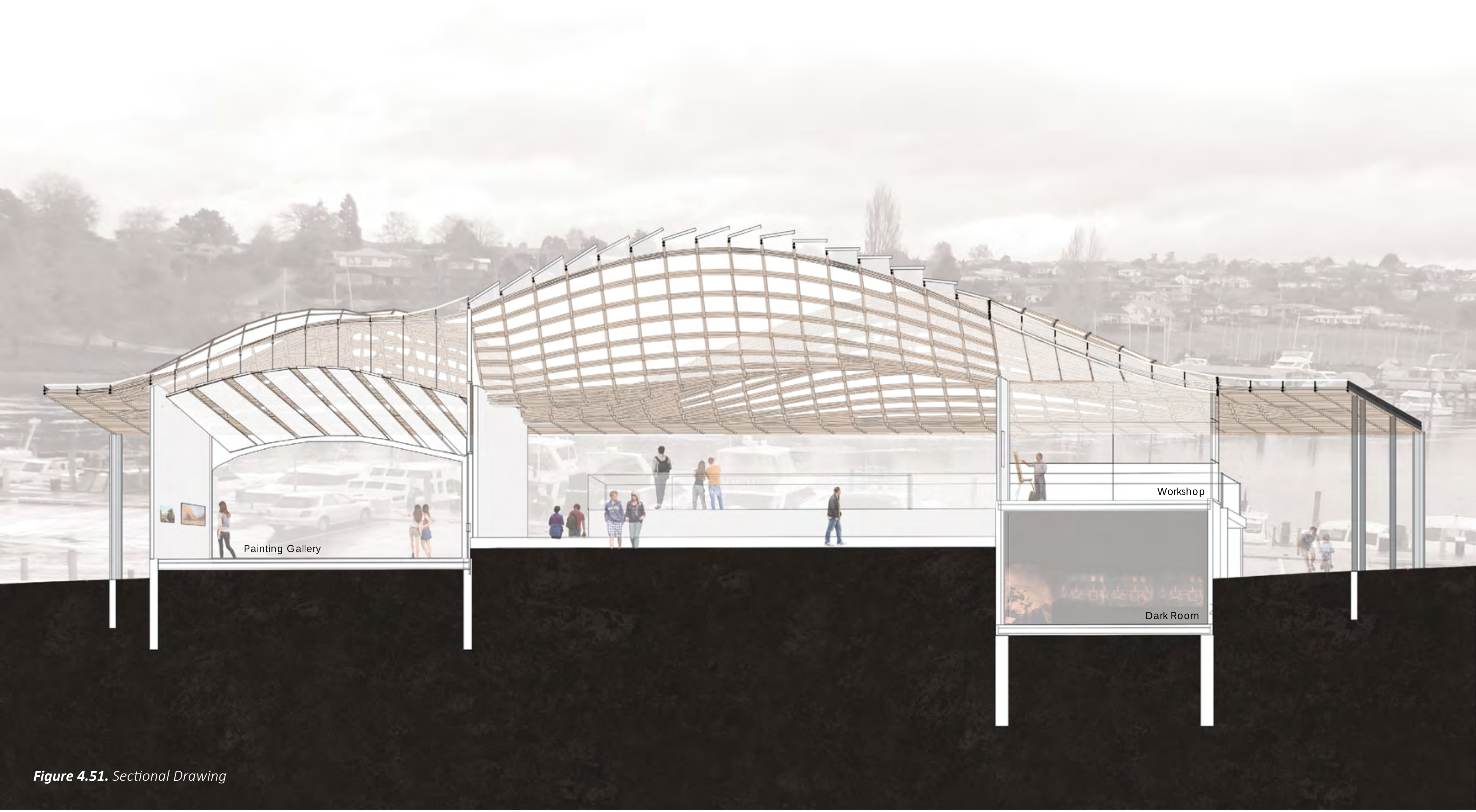


Figure 4.51. *Sectional Drawing*

6.0 Conclusion

6.0 Critical Appraisal

The purpose of this project was to explore the role the roof plays in establishing a connection to a place. What has become increasingly obvious throughout this research is the complexity involved in such a connection. Places have a seemingly infinite number of qualities and attributes. These attributes relate to each other and are not easily summarised into words. These inherit complexities raised questions throughout the design process of what characteristics were important to this particular place. The main characteristics selected for this project were topography, volcanic activity, Maori and European heritage, a connection to the water, a local culture of changing club groups and the landscape quality of the domain. These attributes were prioritied after many site visits, time spent in Taupo, speaking with locals and reading literature on the history of the town. It must be said however, that it cannot be concluded without any doubt that this building can induce feelings of connection to Taupo for any person who might experience it. This feeling of connection to a place is subjective to every individual. What this project offers however, is a process for design which takes inspiration from selected contextual issues and uses them to guide the design of a building.

The building is site specific in that it enhances established circulation routes through the domain and establishes physical and visual connections to significant areas on site: the rose gardens, the historic magazine to the north of site and a connection to the water. Spaces for the art center were situated strategically on site to utilise natural lighting, and to react sensitively to the current circulation of the site. The Taupo domain is a very public place, hence it was important that public life was not only preserved, but also enhanced. Providing various roofed spaces for public activities responds to this, where the roof protects from the rain. Circulation is guided by the form of the roof, where concave surfaces suggest a space where activity takes place and where one might linger, convex surfaces suggest the opposite and are used to encourage movement. This gently curving roof however, does not establish harsh confronting boundaries however, encouraging the perception of the building as being open, public and freely accessible to the public. A hierarchy of concave surfaces responded to a previously designed plan. This hierarchy was given based on perceptions of what was important to the building. Emphasis was given to public spaces, based on research findings which supported this quality as most important. Combined, these efforts create a more culturally relevant building.

Tectonic expression of the roof was explored through timber modelling and sketching and takes influence from Pacific and Maori construction. A timber gridshell was decided for the roof structure as it holds a flexible light quality and responds to the richly landscaped quality of the domain. Attention was given to create tectonic joints which enhanced the appearance of a 'light and flexible' roof. This included pin joints at columns columns and light steel connections at the nodes of the gridshell.

The roof encompasses an enormous variety of architectural issues; hence an in-depth investigation into every issue could not fit within the scope of a yearlong project. This research project, however offers an overview of issues, thus suggesting further areas for research. A more focused investigation into the relationship between digital processes and local context could be useful, as might a project specifically focused on the notion of a 'working roof', developing the relationship between environmental services and the roof. The enormous potential for different design avenues, relating to the roof, gives weight to the argument that the roof is of fundamental importance to architecture.

7.0 Bibliography

Acocella, Alfonso. Stone Archtiecture: Ancient and Modern Construction Skills. Translated by Alice Fisher and Patrick John Barr. 1 ed. Lucca: Lucense, 2004.

ArchDaily. "California Academy of Sciences: Renzo Piano." Accessed 18 July, 2014. http://www.archdaily.com/6810/california-academy-of-sciences-renzo-piano/

Arne P. Eggen, Bjorn N. Sandaker and Mark R. Cruvellier. The Structural Basis of Architecture. New York: Milton Park, 2011.

Arup. "Beyeler Foundation Museum." Accessed 25 August, 2014. http://www.arup.com/projects/beyeler_foundation_museum.aspx

Austin, Mike. "Pacific Island Migration." In Drifting: Architecture and Migrancy. Edited by Stephen Cairns. New York: Routledge, 2004.

Balmond, Cecil. Cecil Balmond. Tokyo: A + U Publishing Co. , 2006.
"The Bible." The Official King James Bible Online.

Brit Andreson, Ewan McEoin and Michael Nicholson. Under the Edge : The Architecture of Peter Stutchbury. Brooklyn, N.S.W.: Architecture Foundation Australia, 2011.

Britannica. "Pyramids of Giza." (6 February, 2014).

Campbell, Geoff Hicks and Hamish. Awesome Forces: The Natural Hazards That Threaten New Zealand. Wellington: Te Papa Press, 1998.

Cooper, Barbara. The Remotest Interior. Tauranga: Moana Press, 1989.

Council, Taupo District. "Tongariro Domain Management Plan." Accessed 13 June, 2014. https://www.taupodc.govt.nz/our-council/policies-plans-and-bylaws/reserve-management-plans/Documents/Tongariro%20Domain/Tongariro-Domain-Management-Plan4-5-6-7-8.pdf
dictionary.com. "Demesne." http://dictionary.reference.com/browse/demesne

———. "Domain." Accessed 7 August, 2014. http://dictionary.reference.com/browse/domain?s=t

Encyclopedia, Te Ara. "Story: Building Materials." Accessed 4 September, 2014. http://www.teara.govt.nz/en/building-materials/page-1
Engineering, Princeton University: Department of Civil and Environmental. "Mannheim Multihalle." Accessed 6 July, 2014. http://shells.princeton.edu/Mann1.html

Foster, Hal. Design and Crime: And Other Diatribes Londson: Verso, 2002.
Herald, The New Zealand. "Leaky Homes Will Cost $11.3b to Fix - Report." Accessed 21 September, 2014. http://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=10617051
itravelnz. "Art in the Park Taupo." Accessed 5 July, 2014. http://www.itravelnz.com/event/art-in-the-park.html

Kenneth Frampton, Stan Allen and Hal Foster. "A Conversation with Kenneth Frampton." October 106 (August 2003): 35-58.

Laugier, Marc-Antoine. An Essay on Architecture. Translated by Wolfgang and Anni Herrmann. Los Angeles Hennessey & Ingalls, 1977.

Leach, Neil. "Belonging: Towards a Theory of Identification with Place." Perspecta 33 (2002): 126-33.

Leatherbarrow, David. "Studies of Tectonic Culture: The Poetics of Construction in Nineteenth and Twentieth Century Architecture by Kenneth Frampton; John Cavareview." 1 56 (1997): 98-100.

Mckay, Bill. "Living Halls: The War Memorial Community Centres." In Living Halls/ Fiona Jack. Edited by Gwynneth Porter, 65-85. Auckland: New Plymouth: Clouds: Govett-Brewster Art Gallery, 2011.

Miralles, Enric. "Santa Caterina Market Renovation: Conceptual Memory." Accessed 4 September, 2014. http://www.mirallestagliabue.com/project_cm.asp?id=59

Moore, Donlyn Lyndon and Charles W. Chambers for a Memory Palace. Cambridge: MIT Press, 1994.

Moore, Donlyn Lyndon nd Charles W. Chambers for a Memory Palace. Cambridge: MIT Press, 1994.

Museum, Kimbell Art. "Kahn Building." Accessed 1 August, 2014. https://www.kimbellart.org/architecture/kahn-building

Nervi, Pier Luigi. Structures. Translated by Giuseppina and Mario Salvadori. New York: McGraw-Hill Book Company Inc. , 1956.

NIWA. "Average Rainfall and Temperatures." Accessed 19 August, 2014. http://www.niwa.co.nz/sites/niwa.co.nz/files/sites/default/files/images/map_taupo-g.jpg

———. "Climate Summaries." Accessed 14 August, 2014. http://www.niwa.co.nz/education-and-training/schools/resources/climate/summary
Normann, Arne Petter Egen and Bjorn. Steel, Structure and Architecture. New York: Whitney Library of Design, 1995.

Pederson, Martin C. "Mixing the Sacred and the Profane." Metropolis. Accessed 23 August, 2014. http://www.metropolismag.com/December-1969/Mixing-the-Sacred-and-the-Profane/

Scheuermann, Rudi. Tensile Architecture in the Urban Context. Oxford: Butterworth-Heinemann, 1996.

Schwarzer, Mitchell. "Ontology and Representation in Karl Bötticher's Theory of Tectonics." Journal of the Society of Architectural Historians 52, no. Sep. 1993 (1993): 267-80.

Sciences, California Academy of. "Green Architecture Fact Sheet." Accessed 12 August, 2014. http://www.calacademy.org/newsroom/releases/2008/green_building_facts.php

Sebestyen, Gyula. Construction: Craft to Industry. London: Spon Press, 1998.
Seidenberg, A. "The Separation of Sky and Earth at Creation Iii." Folklore 94, no. 2 (25/10/2013 1983): 192-200.

Sekler, Eduard. "Structure Construction Tectonics." (1987). http://610f13.files.wordpress.com/2013/10/sekler_structure-construction-tectonics.pdf
Smith, Les Molloy and Roger. Landforms: The Shaping of New Zealand. Nelson: Craig Potton 2002.

Tessman, Oliver. Collaborative Design Procedures for Architects and Engineers BoD, 2008.

thearchie. "Market of Santa Caterina, Barcelona." Accessed 4 September, 2014. http://thearchie.com/en/mercado-de-santa-caterina-barcelona/
Walsh, John. "New Zealand Institute of Architects Launches New Zealand Exhibition at 2014 Venice Architecture Biennale." Accessed 12 July, 2014. https://www.nzia.co.nz/news--media/new-zealand-institute-of-architects-launches--new-zealand-exhibition-at-2014-venice-architecture-biennale.aspx
Waterhouse, D.S. Minors and J.M. Circadian Rhythms and the Human Elsevier Science, 2013.

Webster, Merriam. “Domain.” Accessed 7 August, 2014. http://www.merriam-webster.com/dictionary/domain
———. “Dominium.” Accessed 7 August, 2014. http://www.merriam-webster.com/dictionary/dominium

Wigley, Mark. “The Architectural Cult of Synchronization.” October 94 (Autumn 2000): 31-61.

Workshop, Renzo Piano Building. “Beyeler Foundation Museum.” Accessed 23 August, 2014. http://www.rpbw.com/project/38/beyeler-foundation-museum/

7.0 List of Figures

Figure 4.15 Kimbell Art Museum. Portico facing out over the water (Source: http://devries-designdiary.blogspot.co.nz/2011_01_01_archive.html).

Figure 4.30. Typical cloud patterns of a caldera eruption. (Source: http://www.dailymail.co.uk/sciencetech/article-1350123/Worlds-largest-volcano-Yellowstone-National-Park-wipe-thirds-US.html).

Figure 4.31. Pumice rock floating in water, a frequent sight along the edges of Lake Taupo (Source: https://www.flickr.com/photos/studavidson/5061953513/).

8.0 Appendix

APPENDIX 2
9/3

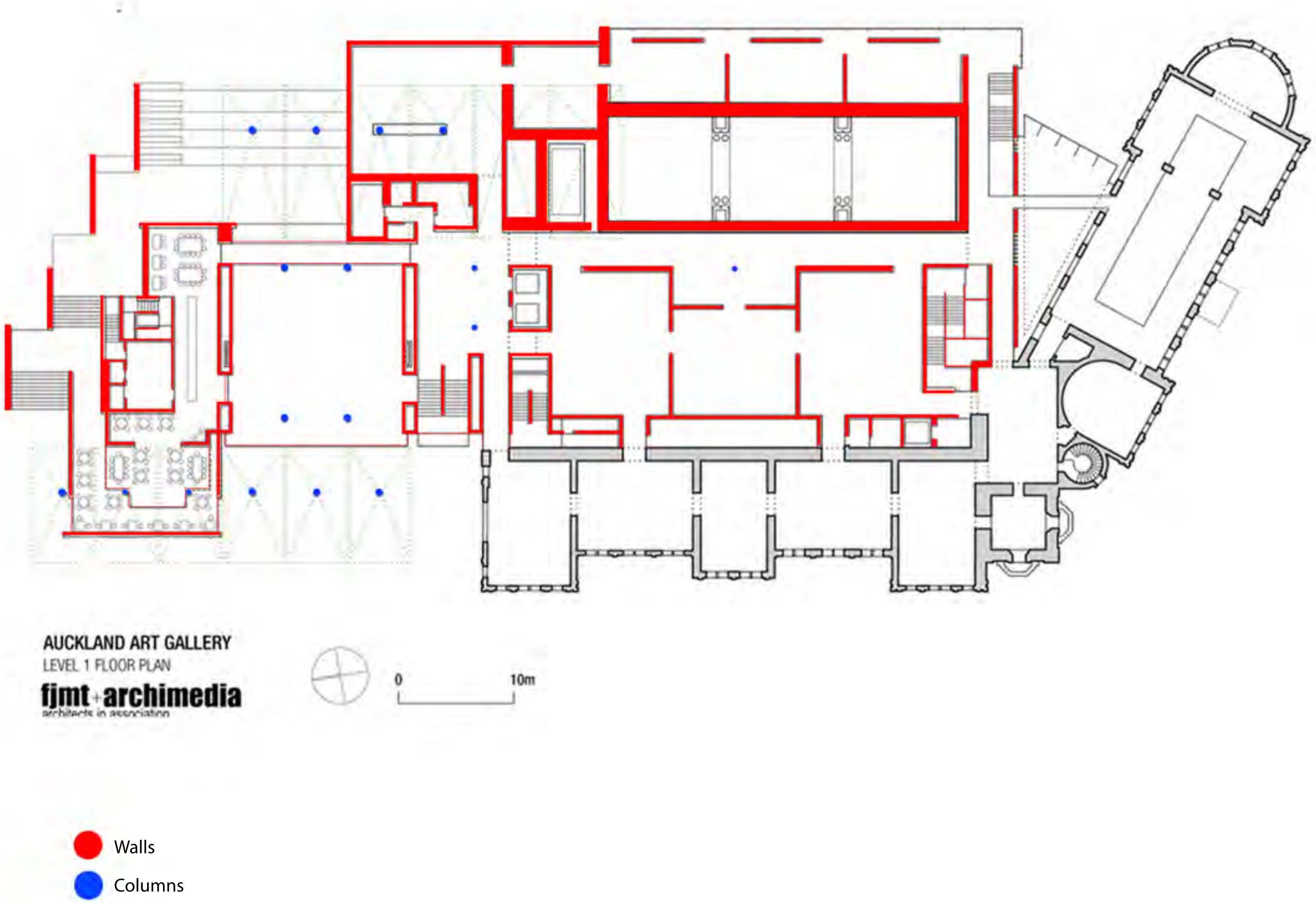
Tongariro Domain Bookings 2004

Event	Month	Days
Mahons Amusements	January	18
Dogs Are Fun Day	January	1
Harriers	January	1
Lake Taupo Arts Festival	February	25
Innovation Story Roadshow Trust	February	8
HSV Car Club Display	February	1
Cortina Car Club Display	February	1
Harriers	February	2
Guides NZ	February	1
Great Lake Relay	February	2
Ironman	Feb/March	13
V Cinema Circus	March	1
Highland Pipe Band	March	2
Playcentre Fun Day	March	1
Teddy Bears Picnic	March	1
Kiwanis Run for Fun	March	1
Home Show	March	9
Mustang 40th Anniversary Pony Run	March	1
Jowett Car Club display	April	1
Tinkers & Traders	April	6
Hikoi to Parliament	April	1
Roadshow Trust	May	9
Maui Caravans	June	1
Levene Half Marathon	July	1
Crater to Lake Multisport Challenge	August	1
Adventure Education Display	August	1
Whirling Bros Circus	September	6
Gypsy Fair	September	4
Tinkers & Traders	October	5
Maui Direct Motor Home Display	October	1
Merry-go-round	October	3
Fly Casting Demo	November	1
Mountview Primary Outdoor Education Day	November	1
Lake Taupo Cycle Challenge	November	4
Xmas Carnival	December	2
Café Awareness Campaign	December	1
Birthright	December	1
Carols by Candlelight	December	1
Mahons Amusements	December	13
New Years Eve Concert/Celebration	December	1
TOTAL		**154**

+ VARIOUS CAR DISPLAYS

Table 1

1. *Taupo Domain record of annual activities*



2. *Analysis of Auckland Art Gallery's extension floor plan, displacing columns and walls*

***3.** Analysis of the Auckland Art Gallery building's changing relationship between roof and floor level, creating a variety of spatial qualities*

8.0 Appendix

Final Drawings

Lower Ground Floor
1:200

1. Shared Storage
2. Shared Kitchen
3. Cafe Kitchen
4. Licensed Cafe
5. Photography Dark Room
6. Art Storage

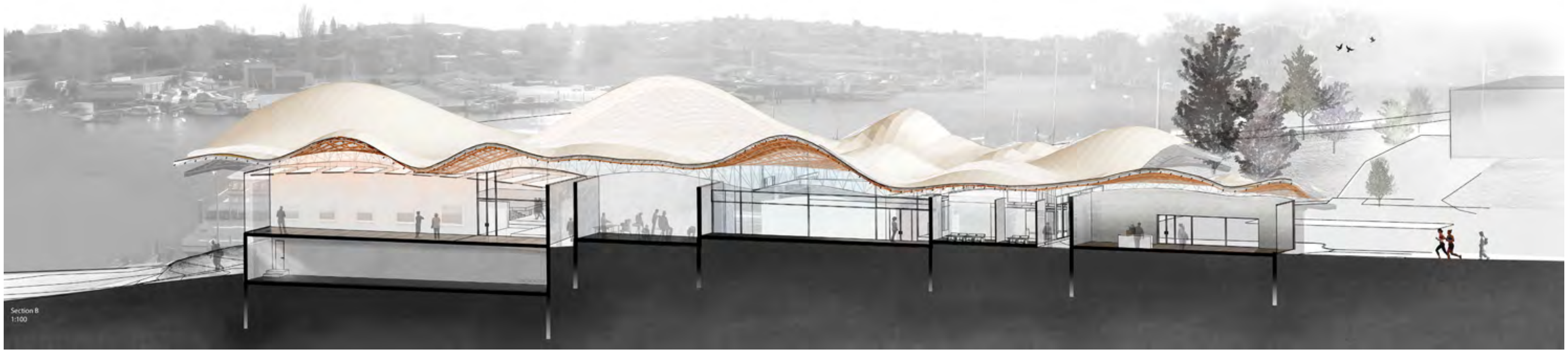
Upper Ground Floor
1:200

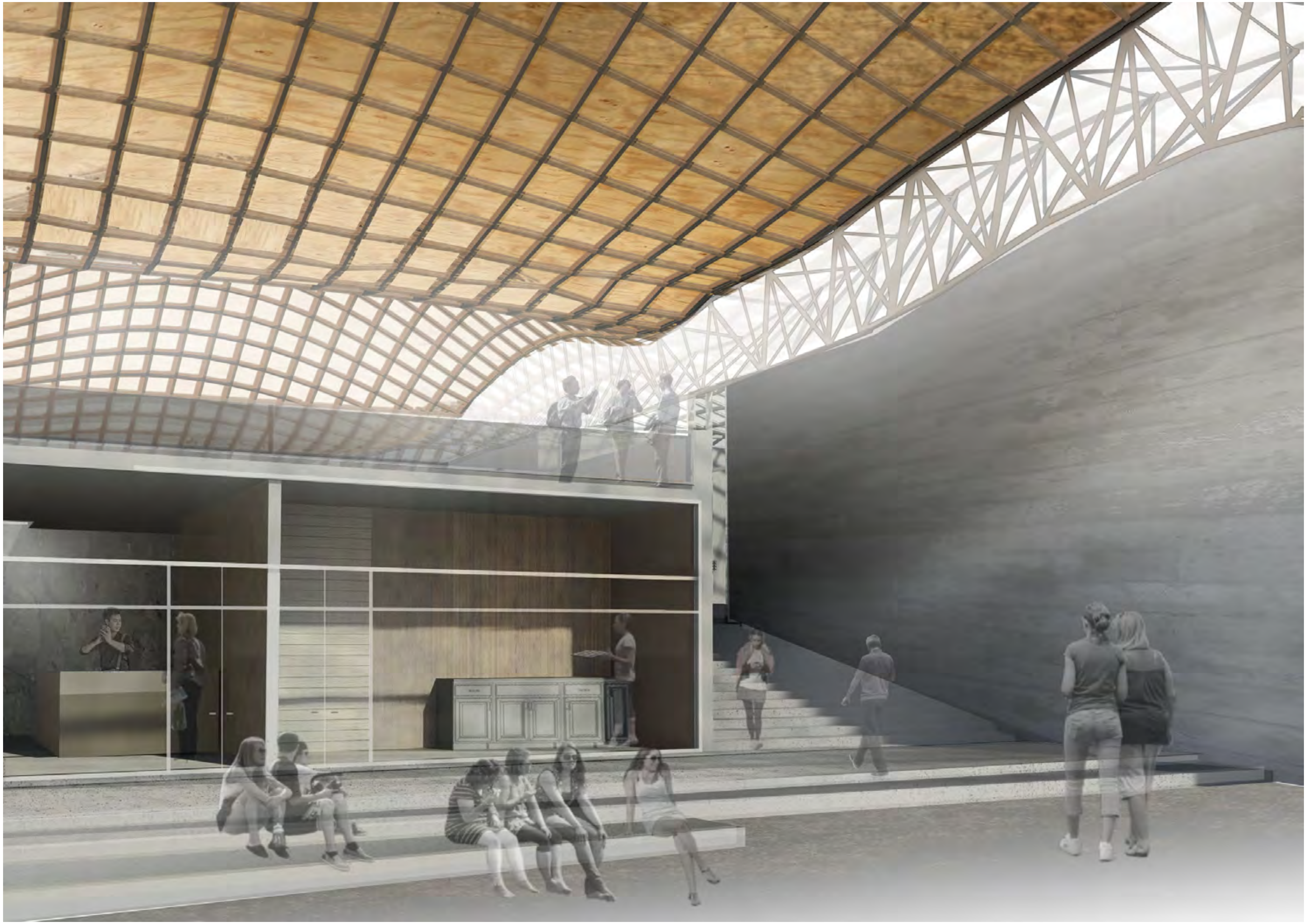
7. Painting Gallery
8. Weaving Workshop
9. Sculpture and Pottery Workshop
10. Sculpture Gallery
11. Resident Artist Studios
12. Painting Workshop
13. Admin
14. Visitor Info
15. Library Storage
16. Art Collection Library
17. Study Rooms
18. Storage
19. Staff Kitchen
20. Craft and Book Shop

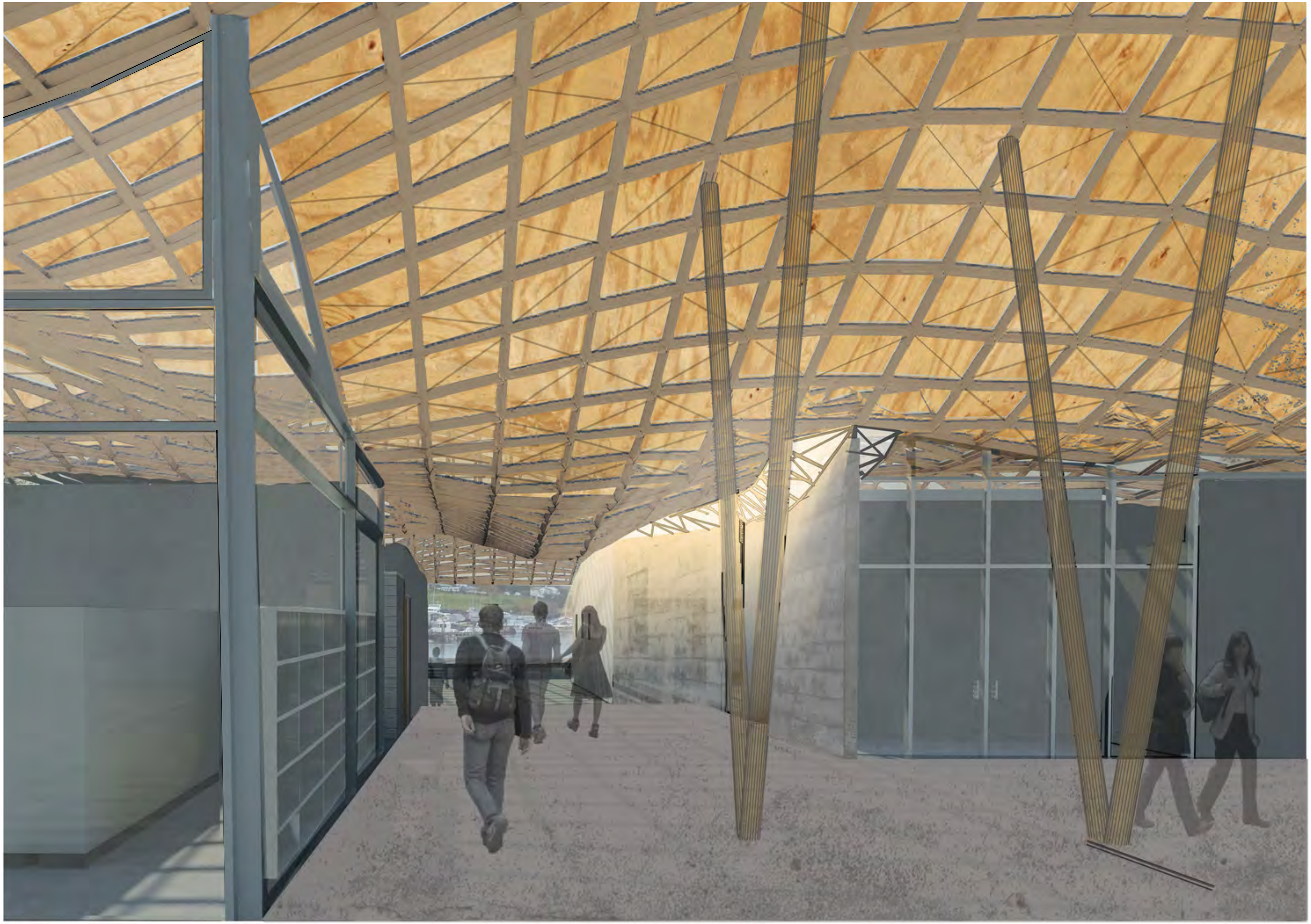
East Elevation
1:200

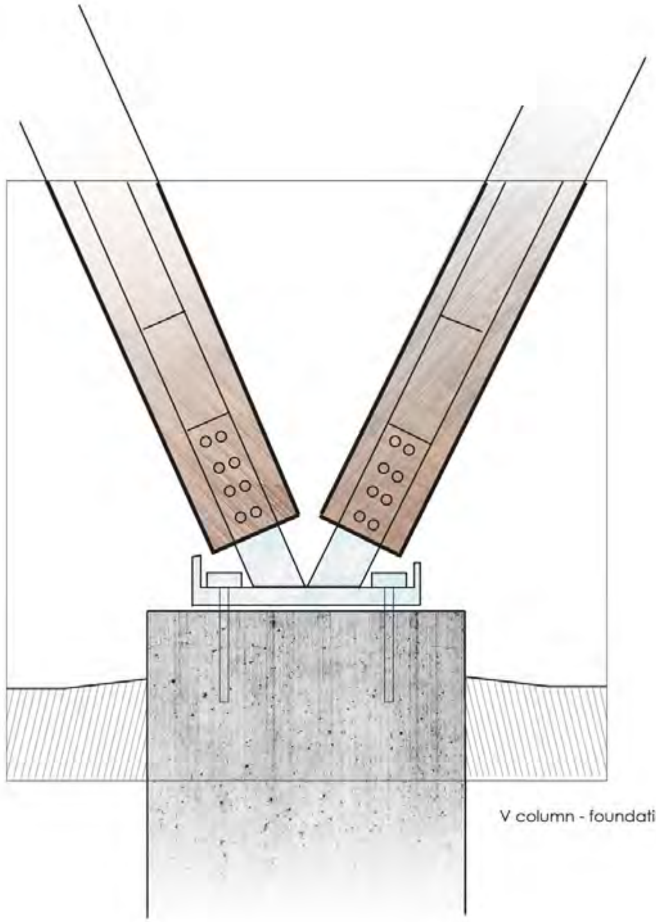
North Elevation
1:200


Section A
1:100

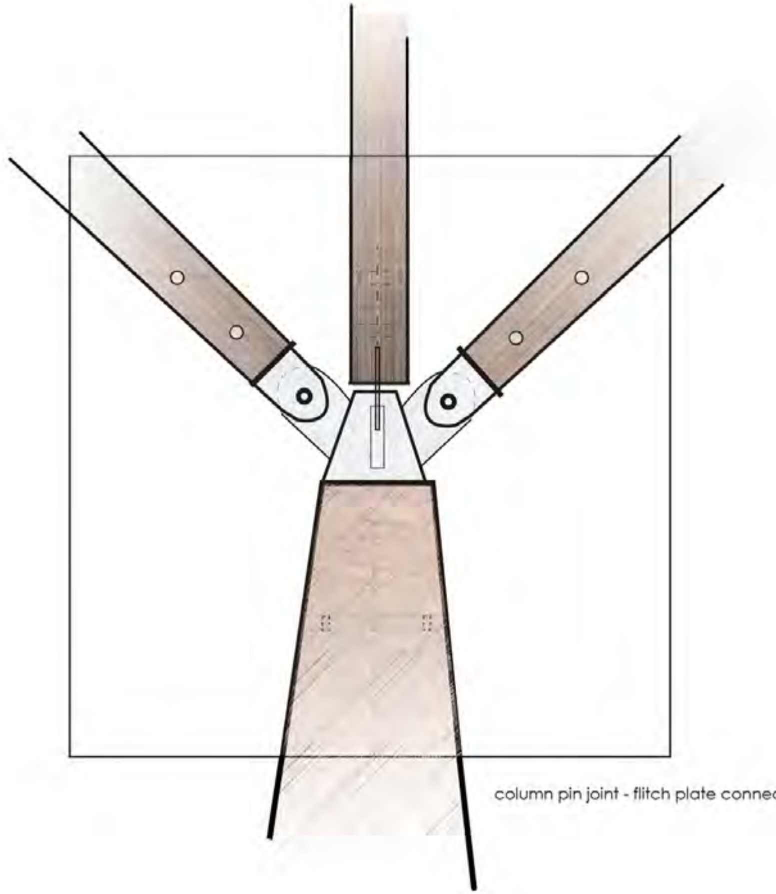

Section B
1:100



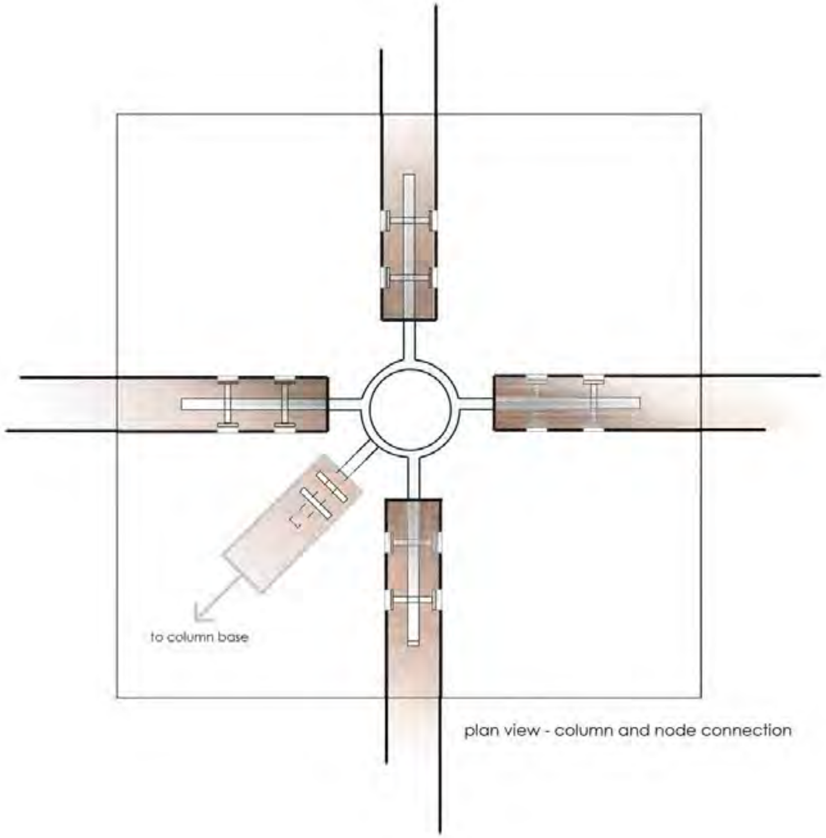




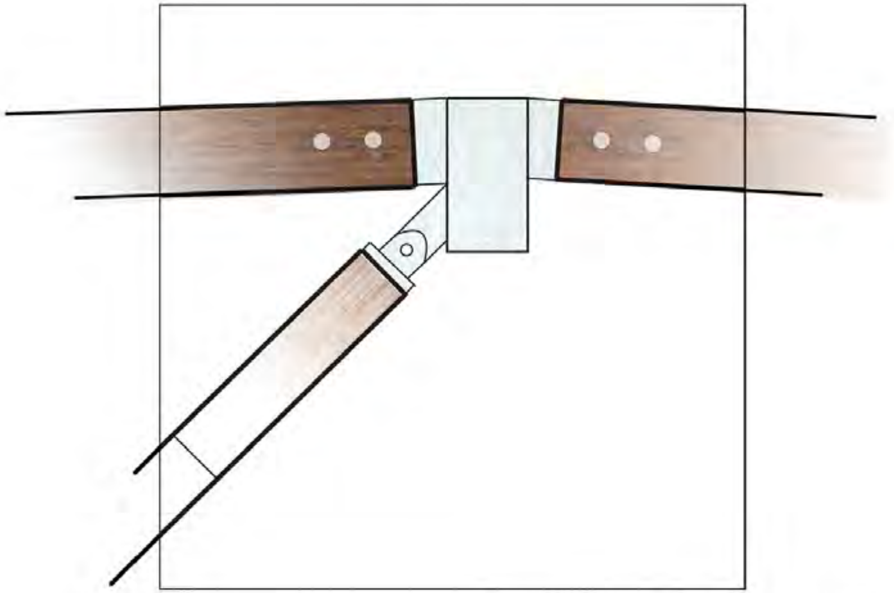
V column - foundation connection



column pin joint - flitch plate connection



plan view - column and node connection



elevation view - column and node connection