Pavilions and Parameters

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Abstract:
The pavilion has been a part of that architectural landscape for many centuries taking on many different forms leading to the very definition of the pavilion and the role it plays in the architectural discourse uncertain. There are many examples of pavilions appearing in the modern architectural environment. Well known examples like the Serpentine Gallery Pavilion showcase the pavilion typology and invite architects to take on the challenge of representing the pavilion within a modern context. With many theorists see the pavilion as a platform for experimentation in the architectural profession, this project aims to explore the pavilion, identifying the elements that form the basis of the pavilion. Critically examining the role it serves in the architectural discourse and attempting to identify key design criteria that make up this otherwise ambiguous typology. Aiding to the architectural profession this research sheds a light on the crucial importance the pavilion plays and shows how architects can take full advantage of pavilion commissions. Using parametric design processes the project will attempt to see how the elements that make up that pavilion can be parametrised and used to design a pavilion structure. The project will engage directly with a real-life pavilion design that has the intention of being constructed and erected over the 2018/2019 summer period. Acting as a case study it will inform the design of a new pavilion that embodies the characteristics of the pavilion, and ultimately validating the pavilion within the architectural discourse.
8.0 Appendix ................................................................. 77
9.0 Table of Figures ......................................................... 85
10.0 Bibliography .......................................................... 96
1.0 Introduction:

1.1 Background of the project:
Pavilions have been a part of the architectural profession for a long time. Initially as war tents for Roman legions, taking the name papilonem which when translated from Latin means butterfly. This name was chosen due to the small stature and light nature of which the pavilion touches the ground. This was also due to the temporary nature of the pavilions themselves, lasting only for a short time before moving to a new location. The next major transition of the pavilion came with the beginning of exhibitions from the 1800s onward. International exhibitions allowed for architects and even countries to display architecture and culture through these pavilions. These exhibitions have now become the way that modern pavilions are displayed to public. Many competitions have been centred around the pavilion. Providing an avenue for architects to freely express design, often becoming a catalyst for experimentation. Many architects test technology through pavilions, some adopting methods of parametric and algorithmic design to achieve the complex forms that can often be unachievable within a standard architectural project. Parametric design is a way in which architects can use external parameters to influence design and let them define form and construction within a project.

Advances in digital design technology have grown rapidly throughout the world at a rate that is becoming increasingly hard to keep up with. Architects are having to learn skills that were once considered out of their scope of work. Fabrication technologies such as 3D printing, laser cutting, and CNC machining are becoming industry standard, forcing collaboration between more and more industries to design, create and build. International exhibitions in which pavilions and follies are displayed provide opportunities for digital technologies to be tested and prototyped. Current architecture could almost be described as lacking theory or perhaps too much theory applied with a lack of cohesiveness. As technology has developed, architects have continually found ways in which they can make use of the new tools available and be able to incorporate them as into the design process.

1.2 Outline of the Project
The project is to be an event pavilion for the Waiheke Headland Sculpture on the Gulf art and sculpture festival. The HSOTG festival is a Bi-annual event that invites artists and architects to produce sculpture to be displayed on the main headland of Waiheke Islands Matiatia Bay, the passenger ferry inlet. At the commencement of each festival a series of temporary tents are erected as the start and end of the walk. These tents host a mixture of activities, including, art gallery for local artists to display and sell their art, ticket stands, toilets, bar and catering and a display area for major event sponsors. Within a small space there is a mixture of activities, with it being the centre of the festival it should be a building that represents the sculptural nature of the festival. This pavilion design will be influenced by another pavilion design that will be done at the same time. This pavilion is referred to as Tall Hut. Tall Hut is a project conceptualised by Moller Architects for the 2019 HSOTG festival. The Tall Hut project will require personal involvement and will be documented and analysed as a case study and will look at what makes it a pavilion, as well as the use of parametric design within the project.

1.3 Aims/Objectives of the Project
The aim of this project is to find an understanding of the role of architectural pavilions, the history behind them and the benefit they provide to the architectural profession. Using the Pavilion as an opportunity to explore parametric design tools. Assisting design and prototyping of Tall Hut for the 2019 HSTOG pavilion will act as a case study for the design of the main event pavilion. The project will aim to validate why we as architect’s design sculptural pavilions and chose to put them on display at international exhibitions like the Serpentine Gallery Pavilions, Venice Biennale and Exposition Universelle. Examining what defines a pavilion and the characteristics that are evident among examples. Themes of homologation and experimental design approaches can be seen in pavilion structures; therefore, similar ideas will need to be carried over in to personal design of the event pavilion.
1.4 Research Question
What role does the pavilion serve to the architectural discourse?

- How can a parametric approach be used to develop a pavilion design?

1.5 Scope and Limitations
The research project will assess the past and current understandings of what a pavilion is, looking at various precedents and evaluating the Tall Hut case study on findings from precedent studies and literature. Using parametric and algorithmic design tools the project will be used to explore how they can be used in different stages of the design and construction process. The project will only encounter design and testing of the two pavilions. The possibility of working in association with technicians, fabricators, manufacturers and external consultants will provide greater opportunity to test and prototype design outcomes. The pavilion will require a structural engineering understanding in order to test the full extents of materials and structure. Consultation with an engineer may be required to achieve the best results for prototyping and testing.

- The project typology is specifically a pavilion type. The depth of requirements i.e. weathertightness, inhabitability, will remain undetermined until the beginning stages of the design process.
- The project is not specifically challenge engineering and structure but attempt to enhance and abstract using parametric design tools.
- The project will not be specifically looking in to the international exhibitions and their formation, although, the role of the exhibition will have to be recognised in reading and analysis.


1.6 State of Knowledge in the Field
If one were to define what a pavilion is they would struggle to find a set definition of this elusive building typology. There are many texts that talk of pavilions past and those built in today’s architectural landscape. Pavilions have been seen by some as artefacts of architectural history and it could “even be possible to trace a history of architecture’s leaps into new tasks, new experiences, and new formal, spatial and structural experiments by following the meandering path of pavilions.” Professor Barry Bergdoll suggests that the pavilion has always been the experimental building type for the architectural profession. Other theorists describe it as a ‘prototype’ of many different purposes and agendas. When Andrea Phillips critiqued the Serpentine pavilions, she said that “these temporary buildings are stages for the prototyping of a different kind of acting that mixes the requirement to participate with a lack of physical and somatic investment in public life.” With the factors that make up the pavilion being so undefined and elusive it could be said that the pavilion genealogy is constantly changing and never static. “It is a single unchanging type; in fact it is not a type at all. The pavilion is not only an amorphous thing, adapting to several forms and functions, but it is also responsive to changes in its geographical and historical environments.” Pavilions are interpreted in many different ways, with theorist unable to define a building typology that is constantly changing and the public being left to make their own conclusions about what the pavilions they interact are meant for.

If the pavilion is to be considered a prototype of architecture being a structure with no programmatic requirements; being mostly a decorative test site that showcases small scale engineering with design experiments. Then it would require creative innovation from the current building industry. When looking at the current building industry we can see that much of what architects and

engineers design is straightforward and uses proven components, materials and techniques. To bring forward the construction industry we need to prototype in order to push the construction industry to keep up with the advancing fabrication technologies. However, few designers actually make and/or prototype. Possibly due to lack of opportunity or lack the skills and knowledge. Architectural exhibitions can provide a means for architects to express and test new materials and techniques in a formal outcome. Towards the beginning of the 1930’s countries were beginning to represent themselves with new and modern constructions. Opposing the traditional historic representations that were originally displayed at exhibitions. These new modern pavilions allowed architects to test their countries latest innovations. The process of making and testing allows designers to creatively adapt more common materials, products and techniques in order to best engage with the more mainstream building industry.

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2.0 Design Methodology

For the research project, one of the most important tasks is to define what a pavilion really is. This is through examining previous arguments and precedents as well as thorough design exploration. Defining the characteristics of a pavilion is an integral part of research and is necessary when approaching the design of a pavilion. The characteristics of a pavilion can be used to develop a brief aiding in the design process. With this research project there is integrated involvement with a real-world design and build project. This project is set to be the design and build of a sculptural pavilion for a bi-annual art and sculpture festival. Working directly within the team will allow for first-hand analytical understanding of the design process of complex structure. Rapid prototyping at various scales both digitally and physically will be a necessary and beneficial task in realising complex forms. The benefits of digital and physical prototyping have been widely recognised by many architects and theorists. As John Thornton mentions in his essay fabrication research, if you can test design before committing it to the contractual process, you can afford to be more ambitious. Continual testing between multiple disciplines, for example the engineer, architect and builder, allows for multiple scenarios to be tested allowing for fewer uncertainties to arise. Using the findings from the design process of the Tall Hut pavilion the development and design of a new pavilion will occur. Material and tectonic findings from the Tall Hut case study will enable better refining of a subsequent design. When designing the new pavilion, it will be important to evaluate a concept objectively. This is especially important when matters of buildability are vital. Due to the nature of a pavilion it can be easy for an architect or designer to become heavily invested in their concept or idea. Real world factors play a large role in the design process and need to be acknowledged. Constant evaluation against reality is required to ensure that a well-developed design is produced where each element is considered and the role that it plays in the whole. The use of a parametric design approach to the pavilion is a key factor for this study, it will allow for workflows to be easily created and transferred between documents and programs. When using a parametric approach BIM information will be embedded within the model. Information like quantity surveying and building capacities will play an important role in project procurement to avoid delays and deliver on time. The BIM aspect and 3D modelling will be carried between the two projects. The value of quantity surveying within any project is substantial but more so for the research project where subsequent factors are used as parameters. This is especially evident in the design of pavilions where the reliance of benefactors for funding plays a large role in the success of a project.

The project will be conducted within a plugin for Rhinoceros 3D called Grasshopper. This plugin is for designers who are exploring new shapes using generative algorithms. Being a graphical interface, it allows for designers to easily produce generative designs without prior knowledge of programming or scripting. Creating multiple scripts within a file will allow for all the conceptual and development scripts to be kept together and referenced at later dates. Another important aspect of the project will be the process of collaboration. Collaborative discussions that happen within the Tall Hut project will be used to provide insight to the many factors that make up a pavilion design. With fortnightly meetings being held between the architect, engineer and Unitec will identify the key aspects and stages of a project. Observing the role that model making plays within the process as well as the incorporation of parametric design will help validate their roles within industry.

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9 Anderson and Anderson, Prefab Prototypes, 11.
3.0 Context Research/Literature Review

3.1 Pavilions and follies: the origin and meaning behind them.

The origin of the term Pavilion dates back to the ancient Roman empire where the term papilio in Latin or 'butterflies' in English was used to describe portable structures that would be setup in military campaigns. The reasoning behind the butterfly labelling is because the structure are light to the touch on the ground, resting only for a short time before being folded away and taken to a new location. Sometimes ornamental in look, to show power and wealth, they once again represent the decorative nature of the butterfly spreading its elaborate patterns when resting on the ground. The term papilio was later adapted by the French becoming papillon and later pavilion. Pavilion has been used to describe many buildings and structures, used almost loosely for everything from small experimental material structures to large scale buildings that represent countries in international exhibitions. One factor that does stay true to the pavilion is the element of it being temporary. The timeline of temporary is variable it can range from days to months or years, in the context of the Serpentine Pavilion, a well-known pavilion programme in London, it means the few months of summer. However, at a point in time pavilions were not seen as temporary. Throughout England and France in the 18th century pavilions were signs of wealth and status. Scattered around private gardens, they often adopted more traditional architectural eras. Many of these pavilions still stand in these gardens made from heavy stones, almost opposing the original definition of the pavilion. It wasn’t until the building of the Royal Pavilion in Brighton, 1823, did the public become exposed to such extravagant designs and the pavilion took a turn to becoming public oriented. With the modernisation of architecture came the imminent change of the pavilion, the structures became theatrical, experimental, spectacles of art and architecture. The aspect of the brief lifespan of the pavilion became an aspect that plays to its advantage, its lack of permanence opens up avenues for exploration and experimentation. As Barry Bergdoll put it, “Lack of permanence has often been a trampoline for invention. It might thus even be possible to trace a history of architecture’s leaps into new tasks, new experiences, and new formal, spatial, and structural experiments by following a meandering path of pavilions.” Pavilion has now become catalysts of change, there limited budgets, freedom for design without limitations and limited consequences. To define a pavilion would be an impossible task as there is no specific design style or function that can be tied to it. Rather there are terms that fit the pavilion, terms such as, temporariness, experimentation, sculptural, public.

A building type that is closely connected with the definition of the pavilion is the folly. The two definitions can often be seen trading places when it comes to define certain structures. Derived from the French term folie (madness) these buildings were often seen as expressions of ego, eccentricity or foolishness. Follies are more permanent in design and placement and were more common place in English and French gardens than the pavilion. “The folly fellowship, an English preservation organisation, states that follies were built for pleasure before purpose.” The folly has traditionally been the purposeless structure that populated English gardens. However, the folly has become more attuned to its context. The Contemporary folly is now actively engaged with nature rather than serving as a detached decorative moment, encouraging users to engage by altering the ways in which we perceive them.

The connection to surrounding and environment is an important connection in both pavilions and follies, whether it be a direct site reference or a more complex

17 Moskow and Linn, Contemporary Follies, 8.
18 Moskow and Linn, Contemporary Follies, 8.
social and contextual connection. Pavilions and follies are often dictated by the environment that the designer is in, this could be the digital environment that is constantly changing around architects and designers. For example, the Serpentine Pavilions designed by Toyo Ito (2002) and Alvaro Siza (2005). Ito’s design chose to use a parametric approach to create the, what may appear as a random line layout. He used the pavilion as an opportunity to experiment with new geometric algorithms to structure and organise space.19 Siza’s pavilion was influenced by taking a modern approach to a long span roof which is often through bold gestures of dominating elements.20 Instead he chose to use a light weight material and alternative construction method to create the long span timber pavilion.

The history of the pavilion has been chequered with many interpretations of what it should be, and all can fall under the scope of a pavilion. To define the term pavilion is almost an impossible task. Many authors, theorists and architects have done so. Pavilions have had a “mixed history regarding the dialectics of use and usefulness, temporariness and fixity, sociability and elitism.”21 But to somewhat define what the pavilion is in current time would be to say that they are “stages for the prototyping of a different kind of acting that mixes the requirement to participate with a lack of physical and somatic investment in public life.”22

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20 Tomoko, From Control to Design: Parametric/Algorithmic Architecture, 46.
3.2 Parametric design and computation as a tool

Parametric design has been around for a long period of time within the architectural discourse. But it wasn’t until the late 1980’s and early 1990’s that some architects began to make the move to parametric design. Architects were no longer designing “the specific shape of a building but building a set of principles encoded digitally as a sequence of parametric equations by which specific instances of design can be generated by simply varying the values of parameters.” Architects can go a step further to develop equations in which parameters X, Y, and Z for example can be manipulated and represented in 3D geometry. A modern example of how parameters can be used in design appears in the British Museum, London, UK, designed by Foster + Partners. There were 3 equations that were used to construct the roof structure of the great court, from a rectangular to a circular boundary, while maintaining singularity of curvature.

\[ z = \frac{(1-\frac{x}{a})(1+\frac{x}{a})(1-\frac{y}{b})(1+\frac{y}{b})}{(1-\frac{x}{a})(1+\frac{x}{a})(1-\frac{y}{b})(1+\frac{y}{b})} \]

\[ r = \sqrt{x^2 + y^2} \]

\[ z = \frac{\left(1-\frac{x}{a}\right)}{\left(1+\frac{x}{a}\right)} \left(1-\frac{y}{b}\right) \left(1+\frac{y}{b}\right) \left(\frac{c}{a}-1\right) \]

\[ \lambda = \frac{\lambda_0 x}{\lambda_0 (x+y)} + \frac{\lambda_0 y}{\lambda_0 (x+y)} + \frac{\sqrt{\lambda_0 x^2 + \lambda_0 y^2}}{\lambda_0 (x+y)} + \frac{\sqrt{\lambda_0 x^2 + \lambda_0 y^2}}{\lambda_0 (x+y)} \]

Figure 2: Equations for British Museum Roof Geometry

Parametric design could be described as a tool or way for designing. Parametric design has been used for many years by architects and designers. Put simply parametric design is a way of designing that has infinite predetermined design outcomes. Parameterising factors allows for regulation in a design, parameters can be as simple as the dimensions of a vertical or lateral member to the interpolation of statistical data. Designing through parameters allows for quick and easy changes to be made without the need for mass remodelling.

Conventional architectural design can require many reworks with small changes sometimes resulting in consequent delays in other areas. Set-backs like these can limit exploration and in turn restrict design. Parametric design can also be labelled as algorithmic design, using scripting languages to allow architects and designers to go beyond the factory set limitations of design software. “Algorithmic design does not eradicate differences but incorporates both computational complexity and creative use of computers. For architects, algorithmic design enables the role of the designer to shift from architecture programming to programming architecture.”

Design parametrically requires a different thought process, Robert Woodbury states them as; conceiving dataflow, dividing to conquer, naming, thinking with abstraction, thinking mathematically and thinking algorithmically. Understanding the intended concept is necessary for algorithmic design, using algorithms to produce creative outcomes is difficult and can stunt design progress. Therefore, restricting algorithmic design to a tool for modelling, not a method of design.

Successfully using parametric design as a tool for exploration alongside traditional design methods allows for a more through and thought out design. Enabling fast editing and alteration of design outcomes to fit the original design intention without time-consuming major remodelling. Parametric design also assists prototyping, using parametric design tools such as Rhinoceros 3D’s Grasshopper produces multiple digital prototypes at the click of a button. Being able to transfer vital programmable design data gives ease of opportunity for


multiple design outcomes. Digital prototypes serve an essential role in the design process. Using parametric tools to develop digital prototypes requires an understanding of how to construct the individual elements of structure. Breaking each element down to its separate elements or as Robert Woodbury put it “dividing to conquer” and “thinking with abstraction.” Similar to a typical construction methodology, as a designer needs to “divide the design into parts, design the parts and combine the parts into an entire design, all while managing the interactions among the parts.” Using grasshopper to generate a digital prototype allows for the extraction of quantity surveying data making the transition from digital to physical prototyping as seamless as possible. Staggering the scale of prototypes is essential to ensuring a steady pace of development.

Starting with smaller scales such as 1:10 or 1:20 allows for overall form to be understood and a basic understanding of how elements would be joined together. Larger scales such as 1:2 or 1:1 are used to test connections and construction methods. All forms of prototyping act more as an “instrument than an artefact. It is not designed as an original from which all subsequent copies will stem, but rather as the first term of an evolutionary process.” The evolutionary process with its working difficulties “offers the designers vital insight and understanding into how they might take a next tentative step forward.” Combining parametric design tools and prototyping allows designers to develop designs that test creativity and construction.

Figure 3: The Three eras of CAD: smart geometry

27 Woodbury, Elements of Parametric Design, 24-35.
4.0 Precedent Studies

4.1 Introduction:
There are many different types of pavilions, with literature being able to only identify so much. Dealing with the pavilion it is important for the process of the project to identify what pavilion types there are as well as the metrics that define a pavilion. History has shown that the pavilion has taken many forms. From starting of as tent structures made purely to accommodate specific functions. Transferring to the English gardens the pavilion took on a more permanent role, with many of these structures falling under historical protection in today’s environment. After public adoption of the pavilion exhibitions brought about the event pavilion. This could be seen as the main pavilion type that is defined in the modern architectural environment. There is however, one more type that is seen in architecture and that is the sporting pavilion. This pavilion type strays the furthest from original applications. For the purposes of the project, focus will be placed on the event pavilion.

Focusing on the event pavilion there are different timeframes that the event pavilion can fall under. These are the fixed, the seasonal or semi fixed and the festival or event pavilion which has the shortest timeframe, suggesting that the assumed short timeframes of the pavilion are more complex and contradictory. Each timeframe aspect can play a large role in the pavilion design often defining the extremities of which a pavilion can be designed. These timeframes will be explored in with the precedent studies to see how it was factored into a pavilion design.

4.1.1 Metrics of a Pavilion
From literary research and background knowledge of the pavilion landscape the following aspects were found to define the pavilion. Timeframe is one of the first defining factors of that produce the pavilion. The next defining element is experimentation. Experimentation and timeframe are two core aspects of the pavilion with each building off each other. Two further defining aspects of the pavilion are visual engagement and narrative. Pavilions are often seen as eccentric design and if one were to be cynical about them, they could be considered the creative industries billboard. Visual engagement is what draws visitors to the pavilion, with narrative keeping the visitor engaged and within the design. A final aspect of the pavilion is function fluidity. Pavilions are rarely designed for specific functions, with designs often allowing for a range of functions to take place within. All of these elements will define the metrics that the pavilions within the project will be defined by.

35 Hirsch “The Pavilionization of Architecture,” 57

4.2 Evolver Folly
Alice studio, Ecole Polytechnique Federale De Lausanne
Lake Stelli, Near Zermatt, Switzerland

Evolver is a pavilion folly that is located on the edge of Lake Stelli in Zermatt, Switzerland. This structure is designed to allow visitors to engage with and observe the panoramic views of the surrounding landscape in a new and responsive way. The skeleton is made of twenty-four wooden trusses that act as structural rings and allow the route to rotate for a continuous 720°. Voids in wooden slats make the interior of the structure completely open to the weather. Larger openings along the structure allow for uninterrupted views across the surrounding mountain ranges.

Its close connection with its location and its purpose is altering the way in which hikers that approach the structure perceive the surrounding environment.

Evolver was a project that drew in visitors with visual engagement, with extravagant design Evolver stood out among its mountainous context. This project also had narrative as its design lead visitors on a journey that made them engage with the environment. The design called for experimentation as with a remote location prefabrication was required to enable transportation options. Lastly the time frame of the building is a permanent one. This design was never intended to be built for a temporary period which takes away from the aspects of the pavilion. Evolver was built to serve a specific function, engaging the visitor with the environment. This limited it to this function only with there being little to no opportunity for different functions to take place.


40 Moskow and Linn, Contemporary Follies, 57.
41 Design Boom, “Alice Studio: Evolver”
4.3 Serpentine Gallery Pavilion 2005
Alvaro Siza & Eduardo Souto De Moura

This highly complex pavilion was designed by Architect Alvaro Siza and Eduardo Souto De Moura in associated with engineer Cecil Balmond. This is a large column-less timber structure where a rectangular grid of crossing beams provides a self-supporting structure. From is a fairly regular shape in plan with an undulating roof structure. Siza took reference from the early 1920’s barrel vaulted roofs from Germany, with his structure acting as an evolution of these original structures. Although Siza’s design looks simple in construction it required lengthy calculations on the engineer’s side to make work Each joint being unique can provide many complications in construction. However, with appropriate software the architect and engineer were able to provide the desired outcome. Using appropriate and collaborative software, complex geometry is able to be achieved with the architect’s original design intention. The pavilion is a large structure with a total floor area of 380 square meters, with a 22-meter span in length and 17-meters in width and maximum height of 5.4-meters. Made up of 427 unique timber beams, the structure was constructed from one corner, expanding out and across to its diagonal corner, this form of assembly was adopted due to the reciprocal nature of structure.

The architect wanted to make sure that the timber was exposed in the design and make it seem like a continuous structure to reference to the trees that surround the serpentine pavilion and those that occupy Kensington gardens and Hyde Park. The pavilion was hugely successful, with its open plan it was able to host a variety of activities and programmes such as the traditional café that occupies most of the serpentine pavilions as well as hosting films, plays and seminars for the public. This gives the pavilion function fluidity and not tying it down to serve a specific activity.

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43 Hobson, “Serpentine Gallery Pavilion by Siza and Souto de Moura,”

44 Tomoko, From Control to Design: Parametric/Algorithmic Architecture, 46.

45 Tomoko, From Control to Design: Parametric/Algorithmic Architecture, 46.
4.4 Warka Water Tower 2

Architecture and Vison, Ethiopia

This project was designed with the intent of being a water collection tower for remote villages in Ethiopia which don't have access to fresh clean water. Water would collect on the stretched mesh overnight and drip feed in to a collection tank at the base of tower. Sitting at 10m high with a base diameter of 4.2m it allows for a more efficient collection of water at a greater volume. The structure was made from split bamboo allowing it to be extremely light and with the entire structure weighing a total of 60kg. This meant there was no need for any cranes or scaffolding to be placed on site, which is almost impossible to have access to in such remote locations. The tower was constructed in multiple prefabricated sections, built on the ground beside each other it allows for each section to be stacked on top one after another. With the structure being so lightweight the issue of it being too weak to withstand wind loadings arises, to combat this there are tie downs that hold the structure to the ground. These tie downs were spread in a 12m radius around the tower.

There are many similarities between the Warka water tower and the Mollers pavilion design. A lot of the methods of construction used in the water tower will be referenced and adapted in the pavilion design and construction. The Waiheke pavilion will have to be constructed in multiple sections however some of them will have to be not only split vertically but also around the ring. The stacking allows for far more off-site prefabrication and quality control can be closely checked at ground level before being stacked. The traditional lashing of the tower will also be adapted to the Tall Hut tower. The lashing connection method has been widely used with almost every bamboo structure around the world and has been proven to work effectively.

Figure 7: Completed tower and render of the tower within a remote village

Figure 8: The tower being constructed in modules then lifted in to position

4.5 Serpentine Gallery Pavilion 2002
Toyo Ito & Associates, Architects. Cecil Balmond (Arup)


This serpentine gallery pavilion was used as an opportunity for architect Toyo Ito to experiment with algorithmic architecture. Taking an algorithmic approach to his design, he wished to create seemingly random and chaotic array of lines that cross over one another creating random geometry transferred between roof and walls. The first step of the design process was to attempt to develop a rule that would create the complexity required. Different approaches were taken on how the square plan could be subdivided. A cartesian approach was considered but wouldn’t give the desired effect for the design. The chosen method became as Ito put it the $\frac{1}{2}$ to $\frac{1}{3}$ method. This is where a line is drawn from a half point to the nearest one third point of the next line, essentially creating a square with corners cut off. This process was then repeated seven times to create the lines of the structure.

Figure 9: Interior of the pavilion

Figure 10: Rule applied to consecutive squares

Personal examination of the Serpentine pavilion designed by Toyo Ito provides an insight in to how algorithmic design can be used to generate pattern and structure for a pavilion design. Using algorithmic design for a pavilion allows for a designer to create complex geometry with easy and clarity. Being able to easily make changes to form and structure without the need for laborious measures of re-modelling. Using parametric programs is one method of how algorithms can be used to influence design. This can also be done manually, dividing and controlling the algorithmic process at each iteration.

47 Tomoko, From Control to Design: Parametric/Algorithmic Architecture, 36.
48 Tomoko, From Control to Design: Parametric/Algorithmic Architecture, 37.
4.6 The Tote
Serie Architects
Mumbai, India, 2011

The Tote in Mumbai is a restoration of colonial era buildings set within the Mumbai Race course, serving as an event space. The architects aimed to represent the on-site rain trees through the structure. The architects achieved this through using structural trees to support the roof structure. The structural trees were designed using an L-system tree simulation. Branches were extended or trimmed to meet with the planar surface of the ceiling. Using a L-system to create the structure the architects were able to achieve an accurate representation of the trees that surround the building. The method in which they created the L-system was creating the individual branch structures in a 2D format then arraying around a point and altering the L-system for each direction to align with key structural lines within the roof structure.

Although the L-system had created a suitable tree system it was still a very raw geometric form. Once the architect had established the form, they went on to refine the smoothness of the curve by creating curves between branches giving an element of elegance to an otherwise raw and natural shape. Examining complex algorithmic and parametric architecture shows how architects can apply a programming language to building design.


4.7 Findings from literature and Precedents

From the precedent studies and literature examined in this section some conclusions can be made about the role that pavilions serve in architecture as well as what defines the pavilion. An analysis of parametric design, how it works and examples of the different ways it has been implemented into pavilion design can also be made.

4.7.1 Pavilions:

From the literature it can be understood that history of the pavilion is a long one. Spanning across the architectural profession, and constantly adapting to architects and requirements of the time. As Barry Bergdoll says in “The pavilion and the expanded possibilities of architecture,” “It might thus even be possible to trace a history of architecture’s leaps into new tasks, new experiences, and new formal, spatial, and structural experiments by following a meandering path of pavilions.”

In a traditional sense the pavilion has been a way for architects to express and experiment within architecture. Temporary timeframes of a pavilion can disrupt peoples understanding of architecture. Looking at how the term pavilion is used in today’s environment adds more uncertainty than clarity. A pavilion is used to describe a multitude of buildings. “It is commonly used to describe a freestanding or temporarily attached buildings used solely for the purpose of viewing things/people – sport, art, social engagements.”

Pavilions are becoming increasingly harder to define, however, for the purposes of the project it is important to define a set of metrics that can be used to define the pavilions in this project, these were the timeframe, experimentation, visual engagement, narrative and function fluidity as set out in 3.1.1. Pavilions are seen by architects as opportunities of expression and experimentation. This means key developments in architectural knowledge can be made and must be taken advantage of to benefit the industry. As Bergdoll states “If the Barcelona Pavilion marked a high-water mark of spatial experimentation in architecture, subsequent decades witnessed the emergence of the pavilion as a laboratory of new structural experiments.”

Each precedent showed an element of either temporariness, experimentation or both. The two Serpentine Gallery Pavilions designed by Toyo Ito and Alvaro Siza both serve a brief life span, being initially intended in lasting on the site for only three months before being deconstructed again, these could be labelled as seasonal or semi-permanent event pavilion. It presented an opportunity to briefly display architectural design advancements to the public acting as visually engaging pavilion design. This finding draws an encouragement for the subsequent pavilion design to push the limits of architecture in its current state and use the result as an invitation for others to push the boundaries of design.

The Evolver folly and the Warka Water tower were two examples of how pavilions made in remote location can serve very specific functions rather than having function fluidity but still required experimentation of form and structure. The need for the Warka Water tower was to provide water for remote African village. Hence, it was designed and built in such a way that accommodate that. The evolver folly sits somewhat on the other end of the spectrum experimentation. Being designed only to help the occupier experience the environment around them. Requiring the designers to experiment the way in which building structure can influence the way visitors interact with the building.

The final precedent, the Tote was a design that looked experimental design specifically using parametric and algorithmic processes. Using L-System algorithmic design the architects were able to create a structural tree system that is derived from the trees on site. The two serpentine pavilions also show experimentation by adopting parametric and algorithmic approaches to creating form and structure. To compare the serpentine pavilions with the Warka tower, both have opposing uses. One to benefit humanity and the other to experiment for high end design. However, they both aim to push the boundaries of preconceived notions of their intent. For example, the Warka tower could have simply used a well to collect water but using advanced design, it was able to discover new methods that achieve the function to a higher standard. Therefore, the pavilion design will not focus on the purpose of the pavilion but how the

pavilion give opportunity to discover innovative ways to achieve the function fluidity.

The value that pavilions make to architecture is they allow for architects to disrupt the norms of design.57 Allowing for new interpretations of how we experience space, how we negotiate structure and how we treat material. Opening opportunities for discussion for where architecture is now and where it may be heading. The collaboration of disciplines that occurs within the small timeframe of the pavilion amplifies the creative process making all parties think outside the box to create an expressive and complex form.

4.7.2 Parameters
There are many texts that can describe what parametric design is and the role it serves but parametric design is a vast category that has many elements that comprise the field. Discussions in literature focus on how parameters can be used to influence design, and aid in the overall design process. Parametric design is by no means a new concept, however, the constantly evolving nature of it is new. Starting off with a lot of manual scripting, an architect would need to almost take on the role of a programmer to create the forms they desire. With programs like Rhino’s Grasshopper and Autodesk’s Dynamo providing easy to use graphical user interfaces, parametric design is now more approachable.

The newfound ability for architects to model complex forms can be applied to mass componentry for design efficiency. The subsequent pavilion design will utilise software beyond its current uses to understand how far the architect’s role in digital modelling can go.

Within the precedent studies it could be seen in three cases that parametric or algorithmic design approaches had been taken. In Alvaro Siza’s 2005 pavilion a parametric approach was taken. With it being a shell-like structure, each element was reliant on each other for support. When using parametric design, any changes made to one member will have subsequent effects on every other member. This will either be harmonious or an obstruction to the pavilion design as it causes changes to be cohesive in the entire design. For Toyo Ito and Serie Architects an algorithmic approach was used. They used algorithms to generate patterns from a set of rules and were repeated through iterations, Parametric is about flow but algorithmic design is for form generation, allowing architects to use predetermined rules to influence key form finding processes.

Regardless of whether an architect takes a parametric or algorithmic approach, the advantages can be seen throughout the entire design process. It enables quick conceptual design all the way to fine detailing. Collaboration between disciplines becomes easier as controlling factors can be scripted in and accounted for.

4.7.3 Learning Taken Forward
From the Literature and precedents, it has been established that two key characteristics make a pavilion unique. The temporary lifespan and the desire to experiment. It was found that the experimental element of the pavilion is drawn from the fact that they have temporary lifespans. Interaction with the user has also been identified though the aspects of visual engagement, narrative and function fluidity. Each playing a key role how the pavilion is perceived within the public realm. These factors are going to be used to critically analyse the Tall Hut project as well as form a basis for a brief of a new pavilion design. Understanding how these factors have been represented in design choices within Tall Hut and the new pavilion design will aid in determining if they can in fact be considered pavilions. It was found that the use of parametric and/or algorithmic design tools are found within pavilion designs, showing that these tools can be used to explore both form and structure. This can be explored within the two pavilion designs that take place in the project, allowing to build on the factor of experimentation within the pavilion landscape. The elements of parametric and algorithmic design can also be used to explore the temporary aspect of the pavilion. The pavilion will draw from the way precedents approach parametric design for efficiency and be temporary by providing the ability to adapt to various sites.

5.0 Headland Sculpture on the Gulf

5.1 Introduction to HSOG – programme
The Headland Sculpture on the Gulf festival is a local sculpture festival located on Auckland’s Waiheke Island. First started in 2003 and now in its 8th year the festival attracts upwards of 40,000 visitors within a three week period making the festival a great opportunity for artists and architects to display work. With the introduction of the festival pavilion in 2017 it provided the opportunity for local architects to put forth proposals for pavilion designs. The aim of the sculpture festival is to engage with local, national and international visitors as well as collaborating with artists and local community to create a distinctive art experience. This project will directly focus on the pavilion aspect of the festival, looking a previous successful example as well as the design of two further designs; the new proposed pavilion for 2019 conceptualised by Moller Architects and a new event pavilion to host the services of the festival.

5.1.1 Stevens Lawson Gateway
The 2017 pavilion was design conceptualised by local Auckland firm Stevens Lawson Architects. Originally intended for the New Zealand exhibit at the Venice biennale. The gateway pavilion was designed to represent a dissolving wharenui, a traditional Maori building, that morphs from building to landscape as one moves around the structure. This project was realised through a team of students from Unitec Institute of technology and with the assistance of Holmes Consulting for engineering input. This project is well known as there was personal involvement within the project, playing a key role from the beginning stages of Unitec’s involvement. The gateway pavilion was successfully funded and supported and was a resounding success for the festival as well as the students involved in the project.

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5.2 Introduction to Moller’s Tall Hut
Tall hut is a design produced by local Auckland architecture firm Moller Architects. Designed as a competition entry for a local sculpture festival, Headland Sculpture on the Gulf, located on Waiheke Island in Auckland’s Waitemata Harbour. The project is intended as a main pavilion for the festival, with it acting as the start and end point of the festival. Tall Hut is depicted as a celebration of its surroundings and traditional construction techniques of the pacific. Representing the shape of a volcano and cloaked in a woven hessian design. Original design requirements dictate that the pavilion only be erected for the period of the festival. The design of the intended pavilion seems to have an almost purposeless demeanour which can be a major factor when it comes to project realisation. With it having a life cycle only initially intended for the period of the festival its second life cycle is undetermined. In order to fund the project benefactors and possible buyers of the pavilion would be needed. This factor of budget meant for the architects the pavilion would need to have a longer life span than three weeks. This meant altering the design of the pavilion and its structural layout, thus initiating design development of the Tall Hut Pavilion.

5.3 Personal Role in the Project
The Research presented in this paper will look at the personal involvement within the Moller Architects’ Tall Hut design. Aspects not completed by the author will have been completed or assisted by the architects or engineer. Using Grasshopper, a plugin for Rhino3D, allows for communication of design changes through various iterations. Rhino is the parent program used for 3D modelling however the Grasshopper plugin enables the use of scripts for parametric design. Upon the initial design of the HSOTG pavilion by the architect, several structural design options were proposed and parametrically modelled. This enabled fast alteration in structure and form. Parametric modelling in Grasshopper allows for information to be processed with ease and for data outputs to be read in real time. For instance, a grasshopper script was quickly created to establish how many occupants the pavilion will be able to hold, once again with variable data outputs that change according to structure size.

Figure 15: Tall Hut concept
5.4 Form Finding Through Parameters

The initial concept was designed by Moller Architects, with the name the Tall Hut, the form of the structure is an elliptical chimney like shape with a 13m X 10m base tapering to an off centre 2.5m X 2m ellipse at the top, with the overall height of 12m. Using Grasshopper to generate the overall chimney shape allowed for possible alteration in terms of size and shape. With infinite possibilities using a script to control initial from allows that architects to finely tune the from. This initial form generation in grasshopper was done by the engineer, providing the parameters of the top and bottom rings as well as the front curve. Curves lofted together form a surface from which the basis of all parameters is drawn from. From here divisions can be made through the structure at any given point in order to obtain specific data for manipulation. Changes made to this script would result in flow on changes to structural options that are derived from this initial surface. The advantage of creating the form with controllable parameters means that as design progresses potential necessary criteria such as people capacity or building height restrictions set by local council can be controlled by simply moving number sliders across to account for these requirements.

Figure 16: Script creating an ellipse through points and two radii

Figure 17: script created similar to top ellipse
Figure 18: Script generating two rails (left) and manipulating the rail front rail to the curvature of a graph (top right) and sweep to create form (bottom right)
5.5 Initial structural concepts
The initial concept was designed by Moller Architects, with the name the Tall Hut, the form of the structure is an elliptical chimney like shape with a 13m X 10m base tapering to an off centre 2.5m X 2m ellipse at the top, with the overall height of 12m. Much of the initial concept was based around the artist involved with the sculpture. The artists’ involvement is to create a patterned cloak that covers a portion of the structure. After an initial meeting with the architects and engineers a series of multiple structure options were quickly modelled. These ranged from the most economical and structurally sound options to options that help portray the architects spiralling intentions of the design.

![Figure 19: Option 1](image)

The image shown above was the most efficient option in both money and structure. However, it was the least preferred option as it limited the curvature of the design and carried no spiralling movement which was essential to the architect’s original design intentions. Being simply made from horizontal and vertical members it required the least amount of timber or steel and would be the quickest to assemble on site. Members made of timber or steel would be bolted on site using specially fabricated brackets.
Figure 20: Option 2

The second option was a diagrid system that work on divisions of ten for each layer. Going in both directions the structure is very strong, however, it requires the most number of members, therefore the highest weight and cost. This was the strongest of the outcomes and provided an aesthetic that the architect found had enough of a spiralling motion.

Figure 21: Option 3

This option was a single directional diagonal quad system. Most preferred by the architects it portrayed the spiralling upward motion drawing the occupier’s eyes upwards. However, the structure does not work as the way it is designed is that it would collapse upon itself, therefore it was not recommended by the engineer for a final solution.
5.6 Refining the Diagrid:
With form now established, the next step is to parametrically create the diagrid. Splitting the form vertically with a variable number of planes allows for section lines to be gathered at varying heights and subsequently divided with a variable number of divisions. The two variables mentioned are crucial in deciding the structural aesthetic of the design. Increasing the number of vertical divisions will create a structure that follows the curvature of the original form however it also increases the density and distract from the spiralling motion that the architect intended. Subsequently, increasing the number of divisions in each ring will emphasise the architects’ spiralling motion but increases the weight loading making the structure too heavy to support itself and would be financially out of reach. A balance had to be found between the two variables and ultimately the combination found between, a balance between aesthetic, functionality, weight, structural stability, and cost.

Figure 22: Script to determine No. of rings used to divide the initial form and create structure
Figure 23: Script for the creation of diagrid lines, dividing structure rings and spanning curves between points
5.7 Developing the Joint:
Once the Desired structural layout had been decided the next step was to develop a joint. A series of simple curves now been generated from the various divisions, with each curve having a start and end point, it allows for precise node points and their vector coordinates to be recorded.

![Figure 24: Resolved Structural Layout](image)

The nature of the joint was that every node intersection had either four or six unique connections meeting at a single point. This produces a large amount of complexity to the design. A joint style had to be established that would allow for this series of unique connections to be secured and be strong enough. A precedent was found that provided the desired aesthetic and was shown to be a possible suit for the strength required from the joint.

![Figure 25: Joint that was used as a precedent for design](image)

This precedent was sourced from a geodesic dome made entirely out of timber members and steel joints. The reason for this joints success is because it is a geodesic dome with a continuous angle and member weight loading on specific joints is spread throughout. A quick 3D model joint in a similar style was made for one of the connections of the Tall Hut design.

![Figure 26: 3D generation of joint prototype](image)
This design provided the desired aesthetic for the architects; however, the structural integrity of the joints had not been calculated or tested. With the desired aesthetic chosen for the joint, the move to make all of them in Grasshopper was made to get quantity surveying numbers and overall weights for engineering and transportation purposes. The joints could have been individually modelled in Rhino the same as the original 3D model prototype however that process could have taken several weeks and a further several weeks for detailed drawings to be produced. By producing them in Grasshopper it allows for drawing time to be reduced and for larger amounts of information to be gathered with ease. Beginning the process designing the joints in Grasshopper the separate elements of the joint had to be modelled and scripted, those being the pipe section in the centre and the plates that connect the timber beams to the centre pipe. For the pipe the first step was to gather the node points of each connection and find the centroid of the ellipse. From here two rings were made to create the internal and external diameter of the pipe and then extruded both inward and outward along the axis derived from the centroid and node points. With the pipe there are 3 variables that can be altered the two circle diameters change the pipe size and material thickness, and the length of the pipe. The harder stage was creating the individual plates of which all were unique to each joint. The first stage of this process was to get the gather the lines that make up the diagrid and have them separated all in to their individual pieces. The lines were then split at equal lengths from each node point. In order to do this easily a sphere was created at each node point with the desired distance that the plates will extend to from the nodes. Once a trimmed axis line had been made for the plates the next stage was create a variable rectangle and extrude it along the axes forming the base shape of the plate. From here these plates were trimmed against the pipes at each node to produce the cutting curves. Although the process to program the plate joints in Grasshopper took longer than individually modelling a single joint. The process of designing it with variable parameters meant that the shape and size of all members can change according to engineering requirements.
This was the first exploratory model of the Tall Hut Waiheke pavilion. Simply made using laser cut ply wood and sting, it provided a quick way of understanding how this structure may be built. This model was beneficial in understanding how the front curve sweeps down to the ground level. The string used in the model helped tie the rings together and set them at the appropriate spacing that was needed. Also discovered with this model is the importance of vertically locating members that fix ring spacings.
Taking the tall hut model making to the next step, a test was made to see how steam bending would work within a structure. This model proved to be successful as it achieved the spiralling motion that the architects were seeking. Problems arose though when it came to modelling the bottom section of the tower. With steam bending being able to meet all the node points, it would be a desirable option, but the pieces used would be too short and have to meet within mid-air. This would be a problem that would come when it comes to the full construction. The process of steam bending full size bamboo in the final build is too time consuming and labour intensive.
Figure 34: Entire tower model

Figure 35: Base of the tower looking upward
Figure 36: Inside of tower from top

Figure 37: Diagrid system
This final model was that last made for the Tall hut pavilion. This was the most successful of all the options made by the architects and engineer. Made at a 1:20 scale the model was used to test construction methods and structural integrity. This simplified tower was designed to have the same conical shape as the original Tall hut design with the ‘tail’ cut off. The model was made from plywood rings and bamboo skewers. With no steam bending required, the construction of the whole tower took very little time to construct. Vertical members were cut and placed first locating the rings in the entire structure. Diagonal members are then added afterwards allowing for a one ring buffer before the second layer of the diagrid is added. Once all the elements were added the structure became very strong and dimensionally stable. This ease of construction could be carried into the full-scale build allowing for elements of prefabrication and quick on-site assembly. Straight members can be pre-cut, packaged, and labelled for on-site construction. Producing cut lists from grasshopper can ensure that each piece is cut to specific length and labelled appropriately.

Figure 38: 1:20 model
## 5.9 Findings from Tall Hut

Successful development of the Tall Hut pavilion project required a collaborative relationship between multiple disciplines. Much like in a typical architectural project where an engineer and builder would be involved, this project had a similar workflow. The collaborators of this project were:

- Moller Architects
- Unitec Institute of Technology
- Holmes Consulting
- Bambusero
- Areez Katki
- Cave Urban

With many parties being involved with the project, it was important to keep a constant form of communication between all parties. Regular meetings were set at 2-week intervals in order to keep design progression moving forward. These meetings were beneficial in terms of design process. However, at some stages progress would get halted due to another party. Quotes were one of the many setbacks for design progression in the project. Due to waiting on subcontractors for cost estimates, it was unsure if the project could continue within the budget or if it were over and the design needed to be reconsidered. Another setback for progress was the engineering input. In a standard architectural design project an engineer would be directly working with the designers. Within this project it was similar, however, the work and time spent on the project was done pro-bono by the engineers Holmes Consulting. This meant the project was not as high a priority as any of their other clients would be and therefore the calculations and results would be delayed.

An important aspect of the collaboration process is cohesive file use if not program use. There were advantages within this project as each three key parties: the architects, the engineer and myself, were all using the same program. This allowed for models and information to be easily transferred. The programs used were Rhinoceros 3D and parametric modelling plugin Grasshopper.

Grasshopper was used entirely to create the structural designs. Each party had the original file from which grasshopper would reference from. Therefore, scripts could be made by all parties and be easily implemented into another script. Colour coding would be used to identify each collaborator’s different inputs and calculations.

![Figure 39: Colour coded scripts in Grasshopper](image)

Unfortunately for the Tall Hut project it was cancelled due to a series of issues. These issues were that there was resolution of material, structure, approach and total budget. These issues were all linked and brought the project to its eventual standstill. Although bamboo had been chosen as the building material, it had not been completely confirmed as it was dependant on a structural layout confirmation. Another factor regarding the bamboo was where it would be sourced from. A Bali supplier available would introduce time constraints that would be associated with importing and customs control. An alternative New Zealand supplier was available but this supplier would come with higher costs and the consistency of the bamboo could not be confirmed. The end structural
layout in fig 40 had been suggested by the engineer but calculations had not been made pertaining to its rigidity. With changes to the structure being made so often, a construction approach was unable to be confirmed. This was important as a defined construction approach can allow for prefabrication and reduce on site building costs. Finally, all the unresolved factors lead to an uncertain total budget. With so many vital aspects of the project being unconfirmed, and a rapidly approaching deadline, it was unlikely for the project to proceed with the time left available. As with many architectural projects overall cost, running cost and building longevity play a large influencing factor. The choice of bamboo, although a cost effective and light material, does not provide the building longevity for a large monetary investment. Providing a potentially five to ten year life cycle and regular cloak replacements would make the Tall Hut a costly pavilion for a private owner.

It can be easily said that Tall Hut was a temporary structure because of the short time the festival was held. Literature and precedents showed that short time frames can and should be used to the advantage of the designer. A highly conceptual design from the architects provided grounds for design exploration but their technical skills required delegation of modelling to myself. This can cause delays as tasks need to be spread across more people than the ideal. There was design exploration that took place within the project that would accommodate to the timeframe, one of these was the matter of prefabricating the structure. These elements were continually looked at throughout the project and when the major re-design occurred, many of the challenges that provided design exploration were eliminated. Removing the ‘tail’ of the design meant that the structure was turning in to a more traditional tower. Applying the same structural system meant that project was no longer as complex as once before and that the need for design experimentation was beginning to diminish. Although all the changes to structure required their own level of exploration the fact remained that the more the structure changed the closer it came to more standard building practice, losing the experimental essence that a pavilion holds. From the beginning Tall Hut was visually engaging. Initial renders showed a tall tower that contrasted the flat site that it was situated on drawing visitors in before they step foot on the island. Initial structural concepts provided an engaging interior that drew the eyes up upon entering. With design changes that came within the project it became less visually engaging both on the interior and exterior with the removal of the tail. The narrative of the pavilion has always remained the same with the Maori cloak being represented in the artwork cloak that would wrap the entire structure. The final factor of function fluidity was present within the pavilion, providing an open interior space and not being specifically designed to house certain functions meant that the project could be used for a multitude of activities. Overall the Tall Hut failed to achieve the ideal of a pavilion as it did not provide a clear expression of design exploration and visual engagement. Two of the key metrics that the pavilion is judged against. More practical factors played the deciding role of the project going through showing that cohesion and resolution is a defining factor in project success.
Figure 40: Rendered representation of the final state of Tall Hut

Figure 41: Original Tall Hut Interior
6.0 Personal Design Development

6.1 Introduction:
This section will focus on the design of a new pavilion that facilitates the administrative activities of the Headland sculpture on the Gulf festival. Separating the design into two sections; the roof and base design an investigation will see how they were design and the parameters that were used to influence them.

Building on the findings from the Moller Architects pavilion design and the historical research of the Pavilion, the final design will be a culmination of the design development and contextual research. The pavilion design will use its location as its main design drawing element, using aspect like terrain, fauna and flora to reference from. With the pavilion being located at the site of the HSOTG festival the environment that surrounds it is the coastal area of Matiatia Bay. Using the origins of the pavilion being referenced from Papilio, the butterfly, the design draws on the New Zealand Red Admiral Butterfly or Kahukura in Maori. Translated from Maori it becomes the Red Cloak, this once endemic butterfly has reportedly disappeared from the Auckland region. The pavilion will incorporate various aspects of the Red admiral butterfly. Another design influence derived from the butterfly will be in its connection to ground. The original pavilion was given the butterfly reference due to its light touch to the ground while also only staying in a chosen location for a short period of time. By incorporating this it means that the pavilion design will have to be movable, being able to be disassembled and rebuilt in various locations. Suggesting that there should be no permanent building components that require an in-situ building approach. With the HSOTG festival being located on Waiheke island the coastal climate acts as another influence. The main sculpture area of the festival is easily located from the ferry ride in and is a focal point for the festival. The terrain at the top of this headland will inform the form and shape of the roof structure. The headland walkway is also scattered with the Native Pohutukawa tree, a tree which has a bloom that occurs during the sculpture festival. The main structure of the design will reference the overarching branches of the Pohutukawa, reaching and touching the ground, spreading as they extend to the ground. This arching nature will be carried through to the main structural system that supports the separate roof component. One final influence of the design comes from the contemporary understanding of the pavilion. Modern pavilions have often been about experimentation whether it be material or process. This idea is carried through to the design of the pavilion. The design process for the Tall Hut can be broken into two main stages, the first was when the structure was to be made either from steel or glulam members and the second was when the design was returned to a bamboo construction. Separating the new pavilion in to two elements makes allows for the two main design stages of tall hut to be explored in the elements, the base and the roof. This has led to the base Pohutukawa section of the pavilion to be constructed using one of the methods explored in the initial design stage, and the roof section to be in the chosen bamboo construction form the second phase of design.

Parametric design tools will be utilised within the personal pavilion design to explore design further than was in the Tall Hut pavilion. The use of parametric design also allows for different influences to be combined in a cohesive design. For example, the influences from the red admiral butterfly and topographical influences from the site can be integrated through scripts. Throughout the Tall hut design process, many grasshopper scripts were created to visualise and test design options. The most effective scripts in terms of structure, aesthetics, and efficiency can be carried across and used for the new pavilion design. Using scripts allows for easy interconnectivity between 3D design files requiring only to change the original source of data. To test and validate the advantage of parametric design within the project the final scripts used in the new pavilion design will be applied to two different sites. This exemplifies the temporary nature of the pavilion design and the experimentation required within a pavilion design. Showing that a parametrically designed pavilion can be applied to different locations producing ever changing outcomes.
This model was designed and made to test a quick modularisation method that allowed for infinite alternative designs, with pieces being added and subtracted from one another. This model allows for quick form finding and can also allude to possible methods of connection that allow for movement between panels. Limitations of this model however, are that variance in tolerance makes some forms out of reach and certain movements along some axes difficult to achieve. For example, the disc allows for movement along the direction it faces but not perpendicular as this will provide a force against a piece. Further development of this concept would be to establish a more flexible jointing system to allow movement in all directions.
This exploratory model was one of the first tests of jointing. The model was based on a traditional Japanese jointing method called Igeta-shikuchi. What was found with this model was that the pieces were susceptible to cracks. Due to fragility, the structural stability can be compromised. To make this joint as strong as possible, it would be recommended to use a much harder timber than the engineered timber that was used for this test as the strength of the grain can aid in overall strength. The joint also introduces a level of accuracy that must be achieved for its success. This may be a disadvantage as there is no room for error.
6.3 Roof design:

6.3.1 Topography
The shape of the roof structure is drawn from the context of the site. Following the curves of the main sculpture area of the HSOTG festival the roof is a scaled version of this exact site. This area is vital to the sculpture festival and is easily identifiable from the passenger ferry ride in to Matiaitia Bay. The roof of the design draws from the learnings of the second main design phase of the tall hut pavilion. Made almost entirely out of bamboo, it shares similar ratios of bamboo to plywood to that of the bamboo redevelopment of Tall Hut.

Once the location from where the roof shape was confirmed the next stage was to extract the data of the location. Gathering GIS data meant that the site could be recreated with height intervals of 0.5m. A grasshopper script was then created to analyse the entire Matiaitia Bay in terms of overall gradients and angles. The colours seen in fig 50 indicate the slope of the headlands on each side of the bay and show the relatively flat nature of pavilions construction site in comparison to the gradients of the roof site abstraction.

Figure 48: Matiaitia Headland

Figure 49: Matiaitia Headland

Figure 50: Land Gradient Analysis
Examining the site closer gives a better understanding of the way it flows (fig 51). The top of the headland provides a smooth and gentle gradient change taking a saddle formation. The edges of the cliff face however are easily identified as indicated by the quick colour gradient change to red. The advantage of using grasshopper to analyse the topography was that it allows for all items of data to be collect, and possibly used as a design influencer at later stages.

Figure 51: Topographical gradient analysis

Once the form of the roof was established the structure for it had to be developed. Using the diagrid system of the tall hut pavilion the roof draws on that from that. Although the Tall Hut pavilion has three bamboo components, the vertical pieces, and the cross members that go in two different directions. The roof will use only the two crossmembers to create the diagrid system. The plywood rings used in the tall hut will also be carried over, however, in the form of ribs running longitudinally across the roof. These ribs act as a locator and structural tie for the overall roof piece, taking the role of the vertical and horizontal members from the Tall Hut pavilion. With holes that go through them they locate key nodes for the bamboo structure, similar to the notches taken out of the plywood rings in the tall hut pavilion.

Figure 52: Roof Structure

Moving down from the plywood diagrid comes a truss system. The creation of this truss system comes from research in bamboo building. Although there are more traditional uses of bamboo construction where canes would be lashed and woven together the use of bamboo within truss systems has been widely used. Trusses can be used in situations where there is a high load on the roof.
All the connections that occur at bamboo joints will be lashed using traditional methods. The reason for this is it allows for the strengths of the bamboo cane to be utilised. Despite bolting appearing to be a more effective form of connection. The process of drilling in to the bamboo undermines its structural capabilities. If drilled and bolted, the cavity within the bamboo would need to be filled with a mortar and possibly steel plates to take the load, making it an overall timely and costly option.

Figure 53: Examples of bamboo roof truss construction

Figure 54: Examples of traditional lashing techniques
6.3.2 Kahukura the Butterfly

Moving to the final stage of the roof uncovers the roofing material. This too was established from the Waiheke Tall Hut pavilion and played a key role in describing the design narrative. For Tall Hut, the design that was produced on the canvas depicted the patterns that could be seen on a Maori chieftain’s cloak. The design of the pavilion for Matiatia bay will draw from the origins of the word pavilion meaning butterfly and particularly from the New Zealand Kahukura butterfly. The Red Admiral has a distinctive look with mainly black wings that have distinctive red markings on them. These red markings will be emulated on the pavilion roof, however the shape of them is derived from the site. The Red markings in fig 55 are created from the contour lines of the Matiatia bay both north and south. Taking the top contour (the top of the headland) and the bottom contour (coastline) and filling the space between them with the same shade of red from the Red Admiral butterfly.

![Image of roof pattern design derived from the Matiatia headland](image)

The material chosen for the roof is a combination between hessian and PVC fabric. This is the same combination of materials for the Tall hut pavilion. The hessian gives a more natural look to the design helping integrate between the natural nature of the bamboo canes and the PVC fabric. The PVC fabric acts as a waterproof layer that adds a layer of protection to the occupiers of the pavilion.
6.4 Base Design

6.4.1 Pohutukawa

The base design of the pavilion has been derived from the Pohutukawa tree, a New Zealand native tree that is commonly found in coastal areas. The reason for using the Pohutukawa as a design influence is because the site on which the pavilion will sit has two Pohutukawa trees that sit either side of the site. One being a very large and well-established tree and the other being a small and fragile tree.

The Pohutukawa was chosen not only for its site relevance to the site but also to its overall connection to the theme of the pavilion and the festival itself. Being native to New Zealand, it also calls for a strong connection to sacred Maori site.

The technical design details of the base were established from the earlier design phases of the Tall Hut pavilion design. This was when the structure would use complex and unique steel joints that would connect up to six axes multiple times. Although this structural and construction technique was found to be too complex for tall hut, applied to a more structurally sound form could provide a more buildable solution.

Creating the joint connection was the most complex scripting that was needed to be done by Grasshopper. There are multiple ways in which a script can be set up; first is creating a script to design a specific element without much opportunity for change. The other is creating a script that allows for easy modification and embedded data to be easily extracted. Scripting in the first way is similar to that of standard 3D modelling, which can be a laborious task if changes are needed to be made. However, it has advantages in later stages of design development as it can be used to finely define and ‘tune’ a joint or similar detail. The second modelling style provides greater opportunity for a designer to explore various design options. Unfortunately, this does make scripts far more complex as there are a greater number of commands and calculations being processed at the same time. For the pavilion design, the joint design was adapted from the Tall Hut pavilion. The reason for using a parametric approach is that it allows for the designer to focus on a single element like the joint and then apply it to an entire design, preventing the need for repetitive remodelling. Through parametric design the architect is able to visualise specific elements throughout an entire design as well as

A script was created in which data is extracted from any grid-like structure. It draws from curves and points created. Each joint is specific to every node connection with the start and end points of curves providing those points. After all the points are created, duplicate points would need to be culled to ensure too many geometries are not created. A sphere is then created and used to cut the curves that created the structure. A sphere is used as it provides a uniform distance from each point, regardless of any angle that curve enters the sphere at.
This sphere plays an important role as it controls the size of the joints, an essential tool when it comes to the engineering phases of design. From this point frames are created perpendicular to the cut lines and in turn boxes are created. The size and shape of the plates is easily controlled to once again easily meet engineering requirements. The way in which the joint script has been created allows for it to be used in many different applications as well as be easily modified to meet engineering requirements.

Now that a joint script has been created, the structure is free to take on any form it wishes and be able to adapt to the engineering requirements. The first iteration of the base design has been derived from hyperbolic paraboloids. The reasoning behind this is because of its high strength properties. The shortcomings of the Tall Hut pavilion were that it was designed in such a way that load was not evenly spread through its members, making it want to collapse on itself. The parabolic shape of the structure allows for load to be more evenly spread.

A parabola was initially explored in its original state having equal length sides, creating a symmetrical curve shape. The form was then taken and applied in a 3-dimensional format. This allowed for an exploration of how parabolic structures can manipulate 3-dimensional space, dependent on which members lines are referenced and divided. Further developing the lines can be done by setting certain parameters to them. For instance, to increase the smoothness of the curves the number of divisions could increase, however, this refinement becomes almost exponentially less effective the more divisions that are created. The length and angle of the line is another parameter that can greatly control the form of the shape.

The advantage that this script provides past the those associated with design is that it can be used to calculate detailed quantities. With the joint made from steel, a material priced on weight, a tonnage can be calculated making the quoting process faster for the architect, builder and supplier. The joint exploration enables the temporary aspect of the pavilion to be achieved. With a universal joint system the structure is easily assembled as well as allowing for the pavilion to be changed in terms of design. Changing lengths of members or layouts of trees to represent a different site and context.

Figure 58: Grasshopper script used to create joints, scripts separated into sections to reduce computing load
Figure 59: 2D and 3D parabolic curve used to create conceptual form
Figure 60: First initial concept generated form parabolic curves
The initial concept developed from the parabolic curve provided a strong visual concept. However, it lacked relevance to the Pohutukawa tree in its current state. The concept was taken further in the development process where it was given size and dimensionality. The parabolic curves provide a suitable test for applying a joint script from one design to another. To do so the curves of the parabola would have to be lofted into a 3D surface then divided into an appropriate structural layout. For the initial stages of design development, a diagrid system was chosen as it was most like that of the Tall Hut pavilion. Possibly allowing ease of transfer between scripts.

6.4.2 Connection Development

The next stage was to apply the script to create the individual lengths or the timber members as they can be known as. The creation of the pieces is done in a similar way to that of the joints with the exception of using the long cut lengths from the sphere intersection or the outside curves. From there the process is simply creating a referencing a perpendicular frame to the geometry and extruding a square geometry along the axis of the associated line. From here the joint script can be applied and Boolean subtractions can be made from the timber pieces that allows for bolting plates to slide in to place and bolt holes to be drilled.

Figure 61: Script to create the diagrid system

Figure 62: Timber members script

Figure 63: First stages of the grasshopper generated joint
The joints displayed on the left are quick initial joint concepts being generated from grasshopper script, they are in still somewhat of a raw form requiring further development. The joints on the right however are refined and tested joints, both providing their own strengths and weaknesses. The bridge joint (top left) provides secure fastening to all timber members and with the use of a ball node it allows for multiple angles to enter the joint without too much difficulty. However, it means that each joint is unique and must be custom fabricated. The tree joint (bottom right) allows for angle modification meaning joints can be mass assembled and no unique pieces while also being able to securely lock in angles and transfer load to supporting members. Within the new pavilion design, a new joint will need to be designed to allow for minimal unique pieces and effectively distribute load similar to that of the tree joint.
6.5 Current design analysis

The current design of the pavilion is lacking a cohesion. The roof element of the design has the delicacy the pavilion requires. Referencing from the site and the case study of the Tall Hut pavilion the roof harmoniously references the site. The base of the design however does reference well enough to the Pohutukawa trees that are on the site. The parabolic nature of the base design lacks connection to the simple and natural roof structure. With largely complex joints that are all unique to each joint it would require large amounts of documentation to construct the pavilion in its current state. Through the next design development stage, the project examines adapting the joint system to a more universal system that can be mass made but uniquely adjusted to fit geometry. The next stage will look at using an L system similar to that of The Tote in Mumbai (page 14).

Figure 68: Overall pavilion concept
6.6 L-Systems used for design

Lindenmayer systems or as they are more commonly known L systems, were originally conceived as a mathematical theory for plant development. When used and applied to graphical interfaces users can simulate natural growth patterns. For example, the nature in which a snowflake is formed or the growth of a tree. The way that L-systems can be used in architecture is to be able to generate structural trees, an efficient structural alternative to the standard structural column. An example of an L-system generated structure is The Tote designed by Serie Architects in Mumbai, India (page 14) Due to using the L-system method of tree generation the designers were able to create more of a natural tree-like structure rather than a more staged and artificial tree structure. The L-system will be used to better represent the Pohutukawa within the base design being able to abstract the branching structure. Starting with a more accurate tree representation the script will be developed into a more appropriate structural and architectural system.

A program used to create L-System was a plugin called Rabbit for Rhino’s Grasshopper. This plugin was developed to simulate biological and physical processes, with the function of creating L-systems. Using the multiple inputs of the grasshopper components a user can create multiple iterations through simple command changes. The way in which L-Systems work is through assigning specific characters with specific functions. With rabbit these were predetermined by developers.

- **F** move forward at distance L(Step Length) and draw a line
- **f** move forward at distance L(Step Length) without drawing a line
- + turn left A(Default Angle) degrees
- − turn right A(Default Angle) degrees
- / roll left A(Default Angle) degrees
- \ roll right A(Default Angle) degrees
- * pitch up A(Default Angle) degrees
- \* pitch down A(Default Angle) degrees
- / turn around 180 degrees
- J insert point at this position
- * multiply current length by \*dL\* (Length Scale)
- \* multiply current thickness by \*dT\* (Thickness Scale)
- \? start a branch(push turtle state)
- \} end a branch(pop turtle state)
- A/B/C/D\_, placeholders, used to nest other symbols

**Figure 70: Alphabet of the L-system**

For an L-system to take place it first needs an axiom. This is the starting point of all growth within the system. From there a rule or set of rules is needed. These rules are what help determine the growth patterns of the geometry. The final
input for the L-system is the number of generations, this determines the extent of growth to be simulated.

To translate the above input into a geometry requires an input called a turtle. This input applies the rules dictated by the L-system to a 3D output. Defining parameter such as the step length and scale.

To translate the script in fig 69.

The axiom: 3X line length 15.43 (46.29) ending with output A

Production Rules:

Output A= Multiply current thickness (not applicable), Multiply current length twice by length scale 0.9 (default), Create Branch B, rotate four times the set angle 34.04° (136.16°), Create Branch B, rotate four times the set angle 34.04° (136.16°), Create Branch B.

Output B= Pitch down set angle 34.04°, move forward three set distances 15.43 (46.29), Create output A, Create a point.

Typically after working through multiple test iterations of the L-System the next task is to create a L-system structural tree that shares similar growth parameters to the that of a Pohutukawa Tree. From there it can be adapted to fit the loading and placement requirements of the pavilion roof.

Figure 73: Quick analysis of tree on site

When looking at the nature of where the tree splits apart, its base section or axiom is relatively short in comparison to the main branches that stem from it. Long branches then grow from there at a distance that could be estimated at three times the length of the axiom. Before starting the traditional tree growth phase of progressively smaller branches leading to leaves.
Creating a 3D tree structure for with an L system does not provide the level of detail and customisation needed to adapt to the existing roof from. The next step taken was to produce a 2D L-system where individual tree trusses can be made and adapted to the form. This can be done by changing angle incrementations and creating new rules. The 2D systems shown in figure 73 show how the modification of rules can allow for a more structured tree branching system that can be used to support the roof. Allowing to script alteration can eliminate the need for existing trusses.

Figure 74: L-System development into trusses
With a script made for the branch structures materiality can be added. The example in figure 74 shows if the structure were to be made out of a 40mm steel circular hollow section (CHS). Using grasshopper allows for different scripts to be applied, changing the shape and section of the constructive material. With an adaptable script the branches are able to be arrayed around a central point spanning with each branch being able to be adjusted to reach key structural points. With the possibility of changing scripts to allow for different layouts it means that multiple iterations can be made of structure systems.
Figure 77: Different Possible tree layouts
These computer generations show how the different layouts drawn in figure 76 look in a 3D sense. Each providing layout provides different layers of branch density. The branch density may be a factor to be explored. Helping correlate between the two Pohutukawa trees that define the site. Adding more tree structures toward the far end of the pavilion creating a denser canopy feeling within the pavilion.
Figure 82: Densified option 1

Figure 83: Densified option 2
Figure 84: Revised design
6.7 Design Summary and Taking the Design Further

The new pavilion design had both successes and downfalls. It was able to achieve the successful implementation of parametric design processes that help exemplify the elements of a pavilion. Challenges were faced when developing a joint system that allowed the pavilion to be reassembled without the need for unique pieces but rather joints that are able to adapt to the desired structure. This was overcome by altering the script derived from the Tall Hut pavilion. Another challenge that arose was the lack of cohesion and connectivity between the roof and base structures. To overcome this, a new parametric design tool was introduced, the L-System, this allowed for a further abstraction of the Pohutukawa site influence as well as adding an element of further experimentation within the project. This provided the envisioned design intent however further refinement of the building elements will be needed to make the design flow between all elements.

With the method of how the pavilion is to be constructed confirmed. Using a L-System for a structural foundation on which to support a lightweight bamboo roof. The new pavilion was scripted with the intention of referencing from elements of the site. Using the topography of the Matiatia headland to create roof from. Abstracting the branching structure of the Pohutukawa to create a structural system that defines the interior space of the pavilion and returning the red admiral butterfly to Auckland through an interpretation of cladding. To test the pavilion design in terms of how parametric tools have helped represent its temporary and exploratory elements the parametric script will be applied to two other sites. The script will be used to create a new pavilion form that takes on a new representation of its site. The two sites chosen will have elements that contrast the original HSTOG festival location. This is to ensure that the pavilions will take on a new shape that represents their unique environments. The reasoning behind producing two more pavilions is to show how incorporating a parametric design approach within a pavilion can encourage the exploratory nature of the pavilion as well as providing the architect with opportunities of design and structural exploration.

Potential sites that will produce alternative pavilions are featured on the following page.
Figure 85: Aotea Square

Figure 86: Silo Park

Figure 87: Arataki Visitor Centre, Waitakere Ranges

Figure 88: One Tree Hill
7.0 Conclusion

This research project examined the pavilion and the role that it plays within the architectural discourse while also exploring ways that parametric design can be applied to a pavilion project. The project identifies the pavilion as a stand-alone building that serves as a catalyst for experimentation within the architectural discourse. Previous definitions of a pavilion were often blurred, but through literature and precedent examination as well as design exploration it was discovered that pavilions play a very important role in architecture.

The literature studied within the project allowed for an understanding in parametric design and the role that pavilions play within the architectural discourse. Literature placed the origins of the pavilion being derived from the Latin word papilionem when translated means butterfly. Tracing the history of the pavilion follows its transition from the regal English gardens to the international expositions that rule the culture of modern architecture. The modern pavilion has now become a catalyst for experimentation within architecture. The experimental platform of the pavilion validates the Tall Hut pavilion and design exploration that took place within the project. Literacy insight into parametric design explains how the parametric design process benefits design by allowing formal control. Parametric design has allowed for branching in to the fields of digital fabrication, using scripting language to translate in to machining language, allowing for smooth transitioning between design and production. The scripts developed within Tall Hut produced information that was used directly for the subsequent pavilion. This opportunity of script and information sharing can be beneficial to the architecture field where typical projects do not provide opportunity for this type of exploration. Developments made within one project can be directly translated and further explored and tested in ongoing designs.

Once an understanding of pavilion design and parametric design was established, the next step was to examine the case study’s design process. Playing a key role within the Tall Hut allowed a first-hand perspective into whether it fits the definition of a pavilion. The Tall hut can be considered a pavilion because of its temporary nature, but also in its form of experimentation. The Tall hut being made from bamboo at first would not seem highly experimental from a parametric and computational standpoint as it is a common material that has been used for centuries. However, it was the use of traditional jointing techniques with modern parametric design which test the capabilities of design. The abilities of parametric design allowed for the inclusion of material constraints to be integrated in design. If this had not been done the design would require far more consultations with the engineer than had been done. By integrating downstream factors into the design process, the designing team are able to predict structural outcomes. This resulted in a technically complex design in a traditional context. The Tall Hut however, can also be considered a folly. This is due to the connection to site and the way in which the Tall Hut can help the occupier appreciate the environment they are in. Isolating the sky through the top and when the sun sets, framing the stars.

The cancelation of the Tall Hut allowed for an examination into how and why the project failed to be built. Failing due to unresolved issues pertaining to material, structure, building approach and budget, each unresolved element affected the next. As with any architectural project the lifecycle or lifespan of the building must be considered. This is especially important for the pavilion as its sites are often temporary, only being able to be occupied for short periods of time. Therefore, designing for multiple purposes and for relocation is of large benefit to the pavilion. The subsequent pavilion design successfully achieved this by encoding a method that allows for building transformation according to the site. It was found that scripts taken directly from the case study could be used to alter the form as data changes. Using conventional design processes, developing a design to fit for a new site may be a laborious task. The parametric design allowed for immediate changes with physical data instead of interpretation.

The collaborative practices seen in the Tall Hut project realised a need for better communication in building information. Ensuring scripts could be transferred across files and refinements in script complexity help make the parametric process smoother. Downfalls to the collaborative process however is that if a smooth line of communication and workflow is not established, work can sometimes end up being repeated by different parties or in some cases forgotten about leading to delays that set a project behind. Ensuring the creative thought is carried through cross disciplinary processes is important to the design of a
pavilion. With a pavilion being a platform for experimentation all parties must be able to think outside of the box when approaching design challenges. Stagnating design can lead to collaborator wanting to stick to what they know and not push boundaries.

The original intention of the new pavilion was to adapt the styles and construction methods of the Tall Hut, however, some methods were not suitable. This meant that scripts had to be redefined to be made usable across all designs. The roof of the design ties in to the site and the methods of construction found in the Tall Hut pavilion in its bamboo design stages. However, when it came to the base design using a similar system to the Tall Hut pavilion proved to have a lack of connection between the roof and base. This prompted a re-design of the base elements. Re-designing the base allowed for another opportunity of exploration. Using L-systems allowed for a bigger leap into parametric and algorithmic design. Examining precedents that have used L-systems and coming up with structural tree concepts led to a base design that fits to the design narrative of the new pavilion. Using the L-system showed that parametric and algorithmic processes can be used generate structural references and context. Exploring ways in which a system originally used to re-create natural growth patterns can be used to create structural elements within a pavilion design. This ties in to the underlying themes of what makes a pavilion, with experimentation be a core element of pavilion design.

The new pavilion design achieves a better resolution than the Tall Hut project to fit the needs of the Sculpture on the Gulf festival. The design draws directly from the site and adapts methods that allow use of the pavilion to adapt all around the island and more. The pavilion successfully showcases the sculptural qualities through the topography of the location that draws visitors to the festival. The lifespan of the pavilion is only for the duration of the festival itself, being disassembled at the completion of the festival. However, having no permanent infrastructure means that it can be re-located and moved to serve other purposes before being reassembled at the beginning of the next festival. By incorporating a parametric design approach, it also allows for the pavilion to be adapted to different locations. The script uses information directly from site data to reflect it in the design. For example, the topographic data of a different site can be used to change the roof form. This provided the design narrative of a pavilion that is able to adapt and abstract from its site. This narrative engages visitors enabling for them to made more aware of the environment that surrounds them by looking at structure and from. It is the structure and from that is a visually engaging aspect of the pavilion. Abstracted tree structures make the pavilion stand out from landscape drawing visitors to interact with whichever function may be taking place with the pavilion. This means that with a single script various pavilions can be generated to suit each designer and the site. A pavilion that is not fixed to a permanent site means that the architect is constantly being provided the opportunity for exploration, adapting scripts to interact with new environments.

A Pavilion design that is able to adapt means that it has the element of function fluidity. The new pavilion design provides an open and engaging space that can be programmed by the used to cater to their needs all while not effecting the overall structure and from of the pavilion. Alongside each reassembly of the pavilion, there is opportunity for new artwork to be used on the roof canvas. This will constantly change the nature of the pavilion. The parametric process has allowed for multiple design influences like the Red Admiral butterfly, the Pohutukawa and the site topography to all be referenced within a single cohesive design. Pushing the creative boundaries of the architect by adding layers of complexity within a project.

The design of the new pavilion has explored experimentation using different parametric design tools to reference various contextual design inputs. The platform of the pavilion is what provides the opportunity for experimentation as within standard architectural projects it is rare that much experimentation can be done. Therefore, using parametric designs tools like scripting and L-systems the architect can push the limits of design. The scripts produced within the new pavilion design are not only applicable to the pavilion designs. But utilising the opportunity of experimentation architects can test non-standard methods that can go on to further use within the industry. If architects begin to take full advantage of both the pavilion and the parametric design tools the field would be able to grow at a much faster rate, encouraging constant creative thought. The pavilion becomes the trampoline for change within not only the architectural industry, but all parties involved within pavilion design.
8.0 Appendix

Figure 89: New Pavilion scripts used to create all elements
Figure 92: Diagrid Structure Script that controls step numbers and creates bamboo members as well as boundary plywood roof structure.

Figure 91: Truss Script that spans the width of the pavilion and made into bamboo members.
Figure 94: Joint Script used in creating the initial concept 3D model

Figure 93: L-system script where parameters define a 2D tree simulation
Figure 95: Timber structure script that is generated by the diagrid system curve system, sizes of members are manipulatable and can be calculated in quantity.
Figure 96: SOTG development script
Figure 97: SOTG form generation script

Figure 98: SOTG beginning definition of base form

Figure 99: SOTG initial frame concept

Figure 100: SOTG people capacity script

Figure 101: SOTG initial structural system concepts
Figure 102: SOTG steel member generation and structural feet script

Figure 103: SOTG steel member and structural feet continuation

Figure 104: SOTG plate joint geometry script

Figure 105: SOTG form refinement and regeneration
Figure 106: SOTG CAD data extraction script

Figure 107: SOTG structure refinement and analysis

Figure 108: SOTG structural ring definition

Figure 109: SOTG node generation on structural rings

Figure 110: SOTG creating diagrid and refined structural members
Figure 111: SOTG creation of door script

Figure 112: SOTG structural refinement

Figure 113: SOTG waffle support structure part 1

Figure 114: SOTG waffle support structure part 2

Figure 115: SOTG waffle support structure part 3
Figure 127: Pavilion Floor Plan

Figure 128: Short Cross Section

Figure 129: Join Axonometric

Figure 130: Waiheke Pavilion Render
Figure 135: Arataki Site Contours

Figure 136: Silo Park Pavilion Render

Figure 137: Silo Park Site Contours
9.0 Table of Figures

All non credited figures sourced from author.

Figure 1: Timeline on the history of the pavilion
https://sites.google.com/site/cumilatedperformancetask2012/
https://www.pinterest.nz/pin/76435367977442209/?lp=true
https://commons.wikimedia.org/wiki/File:Garden_pavilion_in_Rogau.JPG
https://en.wikipedia.org/wiki/Burgh Castle
https://www.medistorehouse.com/historic-england/historic-images/1850s-1860s/crystal-palace-interior-dp004613-440908.html,
Figure 2: Equations for British Museum Roof Geometry Reproduced from Brady & Terri Peters. Inside Smart Geometry: Expanding the Architectural Possibilities of Computational Design. Hoboken, New Jersey: John Wiley & Sons, 2013 ......13
Figure 3: The Three eras of CAD: smart geometry Reproduced from Peters, Brady & Terri Peters. Inside Smart Geometry: Expanding the Architectural Possibilities of Computational Design. Hoboken, New Jersey: John Wiley & Sons, 2013.........................14
Figure 4: Evolver in summer and winter (Credit: Alice Studio) Reproduced from https://www.decoist.com/2011-03-02/evolver-by-alice-studio-spiraling-structure-in-the-mountains/..................18
Figure 6: Corner entrance to the pavilion (Credit Sylvain Deleu)
Figure 7: Completed tower and render of the tower within a remote village Reproduced from https://yourstory.com/2014/11/warkawater/ .....................20
Figure 8: The tower being constructed in modules then lifted in to position Reproduced from https://www.csindy.com/coloradospriings/arturo-vittoris-warka-sculptures-gift-a-functional-solution-for-water-woes/Content?oid=3572704..............................................20
Figure 9: Interior of the pavilion Reproduced from https://www.dezeen.com/2015/09/03/movie-serpentine-gallery-pavilion-2002-toyo-ito-cecil-balmond-arup-julia-peyton-jones..................................................21
Figure 10: Rule applied to consecutive squares........................................21
Figure 11: Interior of the Tote Reproduced from http://www.serie.co.uk/projects/269/the-tote#6 ..................................................22
Figure 12: Axonometric of design elements Reproduced from http://www.serie.co.uk/projects/269/the-tote#6 ..................................................22
Figure 13: Gateway Pavilion Reproduced from http://snap361.net/ig-tag/HSOTG ..................................................27
Figure 14: Gateway Pavilion with other sculptural pieces Reproduced from https://www.stevenslawson.co.nz/projects/gatewaypavilion/.........................27
Figure 15: Tall Hut concept Reproduced from https://www.mollerarchitects.com/sculpture-on-the-gulf.................................................28
Figure 16: Script creating an ellipse through points and two radii........................29
Figure 17: script created similar to top ellipse ........................................29
Figure 18: Script generating two rails (left) and manipulating the rail front rail to the curvature of a graph (top right) and sweep to create form (bottom right) ......30
Figure 19: Option 1..................................................31
Figure 20: Option 2..................................................................32
Figure 21: Option 3 ..................................................................32
Figure 22: Script to determine No. of rings used to divide the initial form and create structure ..................................................33
Figure 23: Script for the creation of diagrid lines, dividing structure rings and spanning curves between points .................................................34
Figure 24: Resolved Structural Layout ..................................................35
Figure 25: Joint that was used as a precedent for design Reproduced from https://www.archdaily.com/891857/geodesic-dome-with-worlds-largest-
Figure 54: Examples of traditional lashing techniques “Building with Bambo: Design and Technology of a Sustainable Architecture.” Basel, Switzerland: Birkhauser, 2012. 42.

Figure 55: Roof pattern design derived from the Matiatia headland.

Figure 56: Small Pohutukawa located at the site.

Figure 57: Large Pohutukawa tree located at the site.

Figure 58: Grasshopper script used to create joints, scripts separated in to sections to reduce computing load.

Figure 59: 2D and 3D parabolic curve used to create conceptual form.

Figure 60: First initial concept generated form parabolic curves.

Figure 61: Script to create the diagrid system.

Figure 62: Timber members script.

Figure 63: First stages of the grasshopper generated joint.

Figure 64: Grasshopper generated joint concept.

Figure 65: Early Joint Prototype.

Figure 66: Bridge Joint concept “ROPPE Bridge.” Last Modified Spetember 20, 2011. //www.grasshopper3d.com/photo/roppe-bridge-16

Figure 67: Tree joint system Po-Hung Chiu, “The Structure of L-System,” (Masters, University of Cincinnati, 2015), 33.

Figure 68: Overall pavilion concept.

Figure 69: L-System script with controlling axiom rules and generation influencing length and scale parameters.

Figure 70: Alphabet of the L-system Reproduced from https://morphocode.com/2d-branching-structures-with-rabbit.

Figure 71: L-system tree generation.

Figure 72: Large tree analysis.

Figure 73: Quick analysis of tree on site.

Figure 74: L-System development into trusses.

Figure 75: Massed Tree Structure.

Figure 76: Three Branches arrayed at a point.

Figure 77: Different Possible tree layouts.

Figure 78: Layout 1.

Figure 79: Layout 2.

Figure 80: Layout 3.
Figure 81: Added density to floorplan ................................................................. 66
Figure 82: Densified option 2 .............................................................................. 67
Figure 83: Densified option 1 .............................................................................. 67
Figure 84: Revised design .................................................................................... 68
Figure 85: Aotearoa Square
Figure 86: Silo Park
Figure 87: Arataki Visitor Centre, Waitakere Ranges
Figure 88: One Tree Hill
Figure 89: New Pavilion scripts used to create all elements ............................ 77
Figure 90: New Pavilion total script ................................................................. 78
Figure 91: Truss Script that spans the width of the pavilion and made in to bamboo members .......................................................... 78
Figure 92: Diagrid Structure Script that controls step numbers and creates bamboo members as well as boundary plywood roof structure ............. 78
Figure 93: L-system script where parameters define a 2D tree simulation .... 79
Figure 94: Joint Script used in creating the initial concept 3D model .............. 79
Figure 95: Timber structure script that is generated by the diagrid system curve system, sizes of members are manipulatable and can be calculated in quantity ... 80
Figure 96: SOTG development script .............................................................. 81
Figure 97: SOTG form generation script .......................................................... 82
Figure 98: SOTG beginning definition of base form ........................................ 82
Figure 99: SOTG initial frame concept ............................................................ 82
Figure 100: SOTG people capacity script ......................................................... 82
Figure 101: SOTG initial structural system concepts ..................................... 82
Figure 102: SOTG steel member generation and structural feet script .......... 83
Figure 103: SOTG steel member and structural feet continuation ................. 83
Figure 104: SOTG plate joint geometry script ................................................ 83
Figure 105: SOTG form refinement and regeneration ..................................... 83
Figure 106: SOTG CAD data extraction script ............................................... 84
Figure 107: SOTG structure refinement and analysis ..................................... 84
Figure 108: SOTG structural ring definition ................................................... 84
Figure 109: SOTG node generation on structural rings .................................. 84
Figure 110: SOTG creating diagrid and refined structural members ............. 84
Figure 111: SOTG creation of door script ....................................................... 85
Figure 112: SOTG structural refinement .......................................................... 85
Figure 113: SOTG waffle support structure part 1 ......................................... 85
Figure 114: SOTG waffle support structure part 2 ......................................... 85
Figure 115: SOTG waffle support structure part 3 ......................................... 85
Figure 116: Final Model .................................................................................. 86
Figure 117: Final Model .................................................................................. 86
Figure 118: Final Model .................................................................................. 86
Figure 119: Final Model .................................................................................. 86
Figure 120: Final Model .................................................................................. 87
Figure 121: Final Model .................................................................................. 87
Figure 122: Matiatia Bay Contours ................................................................. 87
Figure 123: Matiatia Bay Headland Contours ................................................ 88
Figure 124: L system Generaton ................................................................. 88
Figure 125: L system Axiom, Rules and Trees ................................................. 89
Figure 126: Cross Section ................................................................. 89
Figure 127: Pavilion Floor Plan ................................................................. 89
Figure 128: Short Cross Section ................................................................. 89
Figure 129: Join Axonometric ................................................................. 89
Figure 130: Waiheke Pavilion Render ......................................................... 89
Figure 131: Waiheke Pavilion Render ......................................................... 90
Figure 132: Waiheke Pavilion Render ......................................................... 90
Figure 133: Waiheke Pavilion Render ......................................................... 90
Figure 134: Arataki Pavilion Render ........................................................... 90
Figure 135: Arataki Site Contours ............................................................... 91
Figure 136: Silo Park Pavilion Render ......................................................... 91
Figure 137: Silo Park Site Contours ............................................................... 91
Figure 138: Exploded Pavilion Design ......................................................... 92
Figure 139: Tall Hut Design Progression ..................................................... 92
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