Unpredictable Verticality

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[Paradigm of a Vertical City]

by

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[*A dedication to* ' The Future ']

Preface

A curiosity about the combination of science, technology and architecture coupled with the fascination of architecture portrayed in movies were the motivation for this thesis. The architecture within movies that depict elements of verticality within them has always been a fascination, raising the question whether mankind could one day subjugate the skies to the point where verticality becomes a norm in the architecture of our everyday lives.

This research is a personal exploration on the ideology of verticality, merging ideologies from different, seemingly unrelated aspects into a consolidated viewpoint of what I envision that verticality could be in architecture.

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Firstly, thank you to my supervisor Simon, for your support and encouragement to this thesis, even through those moments of long introspections.

To dad, for the many long chats that helped me framed my mindset of how to put my thoughts into words.

Garry, thanks for letting me use the laser cutters on overtime over and over and over again.

Last but not least, to the many friends I have had conversations with regarding my thesis: your insights have been valuable in one way or another.

[ABSTRACT]

With the densification of urban cities, our urban concrete jungles are populated by self-supporting and monolithic building blocks such as high rises and skyscrapers, connected only by the ground plan that they sit on. Although the buildings of today's cities are getting taller, the architecture of today's cities is still being developed on a two-dimensional template, where ground is the base plane and tall buildings remain independent to one another. This has created a segregation between the claimed internal spaces of our built environment and the public domain of architecture within the vertical realm of our urban fabric.

This thesis speculates what vertical architecture of the future could be like if we challenge the conventional perception of our claimed vertical space, proposing an alternative while exploring the idea of a three-dimensional urban fabric. The research also encapsulates exploration of future technologies that may aid in the feasibility of this type of vertical architecture.

Utilizing a design-led research approach, design experiments were employed to explore different ideologies surrounding futuristic alternatives in approaching vertical architecture. The research explores the proposition through design experiments of three different scales, namely, an installation exploring connectivity through abstraction, a 'mid-scale' vertical residence and a vertical city at a public scale. This research was predominantly influenced by the theoretical works of Yona Friedman, Nat Chard, Lebbeus Woods and Cedric Price. Their works were analyzed and merged to generate a hybrid concept for an alternate utilization of vertical space.

OPPOSITE

Fig 0.02. **The Burj Khalifa**

Standing at a height of 829.8m, the Burj Khalifa stands as the tallest building in the world since its completion in 2009 (Burj Khalifa).

[RESIDENTIAL SCALE]

Handwritten notes and diagrams in Chinese characters, likely describing architectural concepts or construction details.

[PUBL]

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CHAPTER 01

INTRODUCTION

I am interested in the prospect of provoking the conventional perspective of verticality, seeking to expand the alternatives for vertical utilization. Verticality in architecture is not a foreign concept, however, there seems to be a disconnect between the conventional vertical architecture of today and the futuristic vertical architecture portrayed in the media (such as movies).

This research puts forward the question: How can the utilization of verticality play a role in dissolving the boundary between public and private to facilitate the progression of a three-dimensional urban fabric?

With the advancement of architecture reaching new heights, it is easy to become complacent with the way we utilize verticality in architecture – just build it taller. It can be generalized that the tall buildings we build today are monolithic and individualistic, planned for a specific program with no ability for architecture to adapt. Although programs of certain tall structures have considered the concept of mixed-use, the current progression of vertical architecture still conforms to mere stacking of space to utilize vertical heights. This design-led research seeks to develop an alternative method to the utilization of vertical space, narrowed down to seeking out human unpredictability and the untapped potentials of technology.

OPPOSITE

Fig 1.01. **A-City: Sector 1576N, Quad 2NR** 1987
The A-City Project by Lebbeus Woods investigated the relationship between technology and patterns of life.

Fig 1.02. **The Stacks - Ready Player One 2011**

The vertical architecture found within the universe of Ready Player One, where homes are stacked above one another on metal frames.

{ Methodology }

“Trial-and-Error could possibly be the way to architectural innovation.”

- Yona Friedman

This thesis applies a design-led research approach, as suggested by Jane Rendell that “in much design research the process operates through generative modes, producing works at the outset that may then be reflected upon later” (117). She states that “a practice that questions the context and/or reflects on its own methods may produce new knowledge” (144).

This research is developed through a design process structured into three design experiments of different scales, each increasing in scale and complexity in sequential order. Each subsequent experiment builds on from the former, introducing new and more complex ideas. Perry Kulper supports this methodology as he states that “interests can be derived through graphic exploration, breeding latent and unpredictable opportunities, then visualized and capitalized upon towards design speculations” (Kulper 59). The experiments, in order of sequence, are:

- Installation
- Residential Scale
- Public Scale

Through the model iterations, this research focused on two key challenges: verticality and unpredictability (of the interaction of architecture due to human behavior) (Friedman and Hans 12). Unpredictability is approached as an abstract thought, stemmed from Friedman’s teachings that architecture can never really be predictable but rather a given set of guidelines to use (Friedman and Hans 14).

The focused methodology of the thesis was that of modelling in order to solve the problems that arose. Rendell states that “design research should be driven by the logic of ‘application’ and the need to solve problems” (118). The models were constructed as a test for a particular idea which were then reflected and analyzed through the drawings and photography.

Fig 1.03. **Installation** *1:1 Scale*

Fig 1.04. **Vertical Dwelling** *Residential Scale*

Fig 1.05. **Unpredictable Verticality** *Public Scale*

{ Thesis Structure }

The structure of this thesis is a chronological order of experiments that uses a design-led research approach to the investigation. This thesis encapsulates seven chapters that document the thesis investigation.

Chapter 1

Introduction

Chapter 2

Literary Context: Unpredictable Verticality – establishes the standpoint for the theoretical context of unpredictable vertical architecture, acting as an observer and consolidator of information.

Chapter 3

Case Studies – investigates four case studies that have key elements that influenced the thesis. Included are the works of Yona Friedman, Nat Chard, Lebbeus Woods and Cedric Price.

Chapter 4

Experiment One: Installation – investigates the abstract idea of fluid connections between architectural space in three-dimensional verticality in a 1:1 scale installation, conceptualizing on the interaction between the aspects of ‘public’ and ‘private’.

Chapter 5

Experiment Two: Vertical Dwellings – investigates the architectural framework of a residential dwelling in ‘The Vertical City’, developing its potential architectural design language.

Chapter 6

Experiment Three: Unpredictable Verticality – explores a speculative framework for vertical architecture on a public scale, developed as a guideline that is open to interpretation.

Chapter 7

Conclusion – summarizes the body of work with regards to the impact of the research on the discipline. A critical reflection identifies the successes and limitations of the design outcomes.

CHAPTER 02

LITERARY CONTEXT

- Verticality
- Public and Private
- The Politics of Urban Air
- Boundaries between Public and Private

This chapter records the theoretical background for the foundation of inquiries pertaining to verticality. First, it addresses the issues pertaining to the conventional perspective of verticality. This is followed by the clarification of ‘public’ and ‘private’ aspects of architecture, the two abstract principles used to frame the circumstances of conventional vertical architecture. Analysis of certain architectural projects coupled with architectures portrayed in media is then used as a basis for establishing design strategies and concepts that can be adapted into a new form of approach towards vertical architecture. The chapter concludes by addressing how representations of vertical architecture in media can communicate a new perspective of vertical architecture.

OPPOSITE

Fig 2.01. **Nine Reconstructed Boxes** 1999

One of Lebbeus Woods’ many experiments regarding the radical reconstruction of architecture in a post-war urban setting.

Verticality

The idea of effectively utilizing vertical spaces have intrigued many architects and designers alike. Building higher is mainly done to increase the effective use of a given building footprint, especially when an increase in population density calls for the housing requirements to be more dense as one gets closer to the center of the city.

As the building scale increases from a residential house to a commercial block, to a high rise building and eventually a skyscraper, these different typologies still have one thing in common - they are all still connected only to the ground with a single channel linking it to other built forms. The programs within these built forms are merely stacked one above the other, stretching only as high as it was planned where the ground still acts as the only medium by which the different buildings are interconnected.

Most architectural builds of today that utilize vertical heights are pre-planned and designed from the start with any design changes limited to the finer details of the build. This creates architecture that is predictable and resistant to change. Inasmuch that we can tear down a small building on the ground to build something new, it should be the same for architecture built in the vertical. Yona Friedman considers this the emergence of 'soft or softer architecture' - architecture that can adapt to the our ever-changing needs (Friedman, "Pro Domo" 73).

Public and Private

To explore soft architecture, one of the focus of this thesis is exploring how architecture can use verticality to shift the spectrum of what we define as public and private within our built environment in the vertical. To understand this, it is helpful to establish a standpoint of what the terms 'public' and 'private' used in this thesis mean. The term 'public' is used to describe places in which are openly accessible - places that the individual has freedom to inhabit. This is architecture that serves the people, which includes but is not limited to, places such as streets, beaches, gardens, even libraries and theme parks.

'Private' on the other hand, is used to describe built forms that have an apparent 'off-limits' perception ingrained into them, usually coming with an authoritative entity. This includes houses, farms, properties, mansions, castles, office towers and so forth which usually comes with limited ownership.

However, ownership is not necessarily limited to the private. On the contrary, aspects of architecture that is opened to the public can also be seen to be 'private' - for example a museum which is publicly accessible yet its exhibits are considered to be private. This is where politics draw the boundary between the two, dictating the behavior of its inhabitants.

Boundaries between Public and Private

This thesis seeks to blur the boundaries of the public and private realms of architecture in verticality; or to put it in other words, to shift the boundary between the public and private away from the ground plane, allowing this ‘boundary’ to inhabit vertical space, making it harder to pinpoint.

An example of blurred boundaries of vertical space can be seen in Sou Fujimoto’s 2013 Serpentine Pavilion (Fig 2.02), where the boundary between layers seemingly disappears from the naked eye. The transparent surfaces further enhance the blurred threshold of the build, requiring careful attention to the descending of the terraced seating as it ‘merges with the classical structure of the gallery’, suspending visitors in the space between architecture and nature (Martin). The same concept is also seen in Fujimoto’s House NA, a glass house with staggered platforms and transparent walls. Although the few walls that exist are made of glass, they are still able to make space secure even without adding privacy (Frearson).

This type of staggered architecture in the vertical can be foretasted in the chase scene of the 2016 movie ‘Total Recall’ (Fig 2.04). In the scene, the protagonist is chased by his double agent ‘fake’ wife. As the scene unfolds, they run through a series of residential houses suspended in the vertical. The scene shows the two

Fig 2.02. 2013 Serpentine Pavilion 2013
The pavilion designed by Sou Fujimoto invoking the sense of a blurred threshold.

Fig 2.03. House NA 2013
House NA by Sou Fujimoto, a pile of stacked boxes interconnected with one another that allows free movement within its loosely defined program.

characters jumping from rooftop to rooftop, with occasions where they run through the dwellings of unfortunate inhabitants, shooting guns and leaving a trail of chaos and destruction. One can ask, where are the boundaries between buildings?

Another example of blurred boundaries can be found in the movie *Upside Down*. The setting in this movie boast a duality of worlds of the protagonist and : One whose gravity points up and the other points down (Fig 2.05). In this movie, Up and Down is akin to Public and Private. Even though there is a clear separation of the characters from both worlds, there is no definite line to be drawn as to where the separation lies between worlds as the boundary of both the Up and Down worlds have intersected at so many different levels.

The Privatized Vertical

There are movies that directly portray verticality in their media, and the problems associated with building high, such as *Judge Dredd* (2012), *High-Rise* (2015) and *Skyscraper* (2018).

In *Judge Dredd*, the plot revolves around a drug cartel that monopolizes a self-contained vertical building. When a judge responds to bring the cartel down, he must fight his way up to the top. In *High-Rise*, the injustices of a crumbling society in a high-rise becomes the center plot, where the protagonist fights with others to climb the societal chain within the building while witnessing the chaos of a crumbling society. In *Skyscraper*, the story focuses on the attempt of a terrorist group to seize control of a soon-to-be-finished, state of the art skyscraper and the endeavors the protagonist (a hired security for the skyscraper) had to go through to secure the building. It can be seen that a privatized vertical city poses a myriad of problems as seen in the plots of these movies.

The Politics of Urban Air

Naturally, there will be difficulty in changing the negatively stigmatized perspective of how vertical architecture is perceived, partly due to the politics that governs the progression of architecture. In their paper 'Getting off the ground: On the politics of urban verticality', Graham and Hewitt writes that 'the majority of critical urban writing emerging over recent decades has neglected the vertical qualities of contemporary processes of urbanization', that 'we contend that a notable *horizontalism* tends to still dominate analyses of contemporary urban space within such traditions' (73). Although our cities have come to include buildings that get built higher and higher, the maps we use to represent them on paper still remain two-dimensional, focusing on the horizontal with little regards to how we represent verticality. Graham and Hewitt conclude that much needs to be done to move beyond conventional approaches which are, in Klauser's descriptions, 'almost exclusively based on two-dimensional planar metaphors' (73).

Conclusion

In reality, there is a bottleneck on the conventional perspective of vertical architecture. Inasmuch as the architecture in movies provide a platform for which one can freely explore verticality, there is still a considerable gap for reality to catch up. This research sets in motion a discussion of alternatives to the vertical discourse.

TOP

Fig 2.04. **Total Recall** 2016

A glimpse of the architecture in the Total Recall Universe, where architecture exist above other architectures.

MIDDLE

Fig 2.05. **Upside Down architecture overview** 2012

The setting of Upside Down portrays a universe with dual gravity; One points up, the other points down. At moments in space, the architecture of both worlds interact with one another.

BOTTOM

Fig 2.06. **Interior of an office in Upside Down** 2012

Within buildings, citizens of both the Up world and the Down world interact with one another.

CHAPTER 03

CASE STUDIES

-
• Yona Friedman	- Ville Spatiale	1960
• Nat Chard	- Instruments of Uncertainty	2011
• Lebbeus Woods	- Terrain Project	1999
• Cedric Price	- Fun Palace	1961

This chapter records the exploration of four different provocative architectural projects regarding utilization of space, with focus on ideas adaptable for vertical space coupled with the uncertainty of the future. First is the analysis of Yona Friedman's ideology of an elevated city with the flexibility of design autonomy. This is followed by unpacking Nat Chard's design-led research project of didactic instruments teasing out indeterminate qualities of architecture. Next, the evaluation of sketch projects turned physical models of Lebbeus Woods provides the framework for the design of an alternative vertical architecture. Finally, the exploration of an influential project by Cedric Price on the effects of technology towards architecture gives an indication of how technology can aid vertical architecture.

OPPOSITE

Fig 3.01. **Instrument Eight**

Part of a series of Nat Chard's Instruments of Uncertainty in collaboration with Perry Kulper. Chard's Instruments investigates the conditions of indeterminacies by catapulting medium such as paint to test the contingent spatial conditions generated.

[VILLE SPATIALE]

Yona Friedman's Ville Spatiale is a concept that consists of a space-frame structure where built forms, being suspended within the space-frame, would occupy. These built forms are not constrained in shape, but is let free for the user to insert his own 'emotional fantasy' into those voids. Friedman intended architecture to break away from the 'shoe box' architecture - architecture built to be filled by programs of the user. Friedman proposed Ville Spatiale as a 'transparent shelf' of which these self-designed shoe boxes would inhabit (Friedman, "Pro Domo" 49).

Unpredictability of Trial and Error

Ville Spatiale is Friedman's developed concept of his precedent ideas of mobile architecture which revolves around the process he calls 'merzstrukturen', where the home of the individual is built out of randomly found parts, having the power to determine the design of their own dwellings (Friedman, "Pro Domo" 49). Friedman states that the real architect and urban planner is the individual user of the city. He explains that a city has its own 'hardware' and 'software' where the 'software' is dictated by human behavior. Given the same 'hardware', two cities will be different because of the 'software', which is of unknown quantity and predictability (Friedman and Hans, 12). Ville Spatiale hence advocates the user to implement a trial-and-error approach to

designing without financial fear or security risk, allowing 'software' to influence 'hardware'(49).

Inference

Through Ville Spatiale, Friedman demonstrates how architecture can be realized in the vertical above an existing city without taking the design aspect of architecture away from the individual. Friedman's drawings and models on Ville Spatiale are as provocative as they are conceptual. The key idea acquired is that architecture, when extrapolated to the vertical, does not need to lose the design voice of the individual.

Fig 3.02. **Merzbau** 1932
Kurt Schwitters' Merzbau was the basis behind Friedman's concept of mobile architecture. It was the experimentation of anti-rationalism, subverting new forms the instant that they came into being ("The Merzbauten: Influence").

TOP

Fig 3.03. Ville Spatiale 1959

One of many of Yona Friedman's sketches on Ville Spatiale, a concept of an elevated, freeform city suspended in the air through the usage of space-frames.

BOTTOM

Fig 3.04. Extension du Centre Georges Pompidou circa 1977

A superimposed sketch of the Ville Spatiale on the Centre Georges Pompidou, a project with an indirect inspiration from the principles of Ville Spatiale.

[Instruments of Uncertainty]

Nat Chard has an interesting take on the indeterminate qualities of architecture. As an artist and academician on top of being an architect, Chard employs the creation of didactic drawing instruments in a performative installation to extract the concept of uncertainty. This defies the conventions of architectural drawings that Chard calls ‘production drawings’ – drawings which allows the same thing to be understood in the same way by others. He describes that with interpretation, the drawings becomes static and the life of the drawing ends (Chard, “Drawing Indeterminate” 35).

Drawing Uncertainty

Through a series of didactic drawing instruments, Chard questions how the indeterminate condition becomes possible in architecture. The instruments he created uses paint (initially light) as a medium for drawing, teasing out the indeterminate qualities of splatter (Chard, “Fathoming” 46). It is interesting that the occurrence of a splatter is predictable but the indeterminate is how the splatter will occur. It is in this ‘how’ that Chard forms the basis of his inquisition.

Inference

Chard’s investigation in the act of making the drawing focuses on the emergent rather than the outcome. By manipulating the things he can control, he states that the tension between being in control and out of control gives a helpful measure of uncertainty (Chard, “Fathoming” 58). By re-iterating the experiments with each subsequent experiment containing a different element or variable, Chard is able to isolated the specific qualities of indeterminacy he is studying. This case study provides a guideline as to how one can manipulate the unpredictable outcome by manipulating the variables one can control.

OPPOSITE TOP

Fig 3.05. **Instrument Seven**

Using a catapult to throw paint towards drawing pieces.

OPPOSITE MIDDLE

Fig 3.05. **Instrument Five**

Different iterations of instrument five, built to receive thrown paint from other instruments.

OPPOSITE BOTTOM

Fig 3.07. **Instrument Six**

Produces ‘floating shadows’ that are captured by a stereoscopic camera.

[Terrain Project]

Lebbeus Woods' focus was centered on the emergence of radical architecture that did not seek to replace that which was lost through war. He states that any attempt to restore the fabric of old cities is mere folly, calling any attempts to replace that which was lost as '... a parody, worthy only of admiration of tourist' (Woods 15). Terrain Project by Woods is part of a series of experimental projects conducted through sketches that developed around this idea. Woods was exploring the notion of architecture that is able to conceive 'new types of spaces', dynamic forms that are a product of a response to rapidly changing contemporary urban cultures and environments (Woods, "Terrain Project").

Inference

The personal interpretation of Lebbeus Woods' Terrain Project lies in the undefined boundaries of where the model ends. The frame is only there to frame a portion of what could extend on into infinity. Although Terrain Project only shows the indeterminate conditions of a thickened two dimensional space, it can be extrapolated into three dimensions. Sketches like 'Same Difference' also allows for an abstract interpretation of a three-dimensional Terrain Project, starting an investigation into the paradoxical coexistence of individualism within the unpredictable and ever-growing architecture of globalism.

The Unpredictable Terrain

Woods' Terrain Project sketches are provocative in the idea of architecture having an identity. He writes, "one of the main problems in the present age of globalism and individualism is how to reconcile—and sustain—their paradoxical coexistence." (Woods, "Same Difference"). In his sketches for 'Same Difference', one can see the global gesture of short, straight lines drawn across the image, yet observe that there are moments of individualism with no two similar moments (Fig 3.08).

Fig 3.08. **Same Difference** 2009
One of Lebbeus Woods' sketches investigating the paradoxical coexistence of the present age of globalism and individualism.

Fig 3.09.

Fig 3.10.

Fig 3.09 - Fig.3.10. **Terrain Project 1999**
Physical model of Lebbeus Woods' ideology of generating 'new spaces'.

[Fun Palace]

Fun Palace was a socially interactive machine concept that adapted to the social and cultural shifts of its time and place. The idea was that with the correct usage of technology, the public had a new sense of unprecedented control over their environment. It was a 'laboratory of fun' where the building would respond to the needs of the individuals and activities that would take place inside it (Glynn). The essence of Fun Palace was that of continual change, allowing for multiple and indeterminate uses.

Technology 'Is' Architecture

The Fun Palace was the realization of the long unfulfilled promise of Le Corbusier's claims of a technologically informed architecture, a 'machine for living'. It was designed to be a scaffold/framework of sorts, enclosing a socially interactive machine where the users were able to manipulate the space by using the cranes to assemble prefabricated walls, platforms, floors, stairs, and ceiling modules - a virtual architecture that merges art and technology (Mathews 75). Price believed that technology should serve

the public, allowing for the avoidance of conventional architectural practices that try to 'get it right the first time', resulting in 'the safe solution and (a) dull practitioner' (Price 54).

Inference

The idea taken from this precedent is that technology plays a role in allowing architecture to adapt to time and place depending on the variables that it receives. It is a spectacle of a three-dimensional matrix where bits and pieces are stuck here and there, invoking constant activity but would never reach completion. Technology supports the creation of architecture, therefore technology itself is architecture. This precedent shows that there is potential for architecture to evolve hand in hand with future technologies not yet discovered.

TOP

Fig 3.11. Fun Palace Perspective 1961

Perspective sketch demonstrating the usage of the technology to adapt space for different programs within Fun Palace.

BOTTOM

Fig 3.12. Diagram usage of Fun Palace

A diagram created to illustrate the guidelines of the usage of Fun Palace.

CHAPTER 04

EXPERIMENT PHASE ONE

– *Installation* –

- Aim
- Method
- Process
- Design Outcome
- Conclusion

The first of three design experiments was aimed at investigating the concept of unpredictable geometries in relation to generating architectural forms of complex shapes in three-dimensions. This was done in the form of an installation piece, designed and constructed at a 1:1 scale.

OPPOSITE

Fig 4.01. **Installation Design Outcome**

Elevation perception of a perspective image.

TOP

Fig 4.02. **Concept sketch of an elevated community**

AIM

Influenced by the idea in Lebbeus Woods' Terrain Project and his pursuit for generating 'new spaces', the aim of this installation is to conceptualize a framework of which three-dimensional geometries could inherently interact with each other to produce new architecture.

METHOD

The experiment is conducted by merging key ideas of precedented works to dictate a design that would inform the exploration of unpredictability of complex forms within vertical architecture. The idea is that by

merging main ideas from different sources, new hybrid ideas will emerge, leading to the conceptualization of new architecture.

Architectural elements and ideas from precedented works are extracted and analyzed through drawings without scale to generate a design language. From the drawings, the process of model making is used to explore the realistic applications of the abstract ideas in physical form. Magnetism and its influence to the form generation of new architecture is also investigated within the exploration, allowing for the extraction of the abstract idea of unpredictability to be expressed in physical reality.

Fig 4.03. **Digital Manipulation**
Superimposed images of modules to investigate module form generation.

PROCESS

- Abstract Sketch Drawing
- Module Form Generation
- Phenomenon Analysis – Magnets
- Module Material Selection
- Module Manipulation:
 - Cluster
 - Stretch
 - Collapse

[Abstract Sketch Drawings]

Sketches such as (Fig 4.04) incorporates the visual form of Lebbeus Woods' 'Terrain Project' with Yona Friedman's idea of free form-generation of space in 'Ville Spatiale'. It visualizes the idea of an expanding pattern formation without a rigid grid system, forming a series of elevated platforms that are interconnected through vertical and horizontal elements to generate a dynamic architectural built form. These sketches conceptually investigate verticality with ideas of incorporating modern engineering technology as a platform to allow user control over the built environment.

Fig 4.04. Concept sketch of form expansion

Using the pattern of boxes with horizontal and vertical lines, the sketch investigates the abstraction of a growing architectural community.

Fig 4.05. Concept sketch of space generation

Investigation of the potential usage of interspatial spaces created within the form.

TOP

Fig 4.06. Concept sketch of ground detachment

Investigation on the conditions emerged from detaching architecture away from the ground plan.

(Top right, mini plan sketch)

BOTTOM

Fig 4.07. Concept sketch of vertical structure and shelter

Investigating the interaction of elevated architectural forms with the ground, simultaneously looking into the boundary conditions of space.

[Module Form Generation]

The idea of a module was conceived to create a platform by which expansion of the architectural form could be proposed in smaller segments. After producing a generated set of module drawings inspired by the abstract sketches (Fig 4.08), the drawn forms were abstractly modelled with cardboard to test the forms generated (Fig 4.09, Fig 4.10). Each modules consist of six to eight pieces, joined together to approximate the sketches produced.

RIGHT

Fig 4.08. **Concept sketch of module form generation**

OPPOSITE TOP

Fig 4.09. **Cardboard modules**

Initial module mock-up representing architecture space.

OPPOSITE BOTTOM

Fig 4.10. **Cardboard modules**

Expanding the number of modules to increase the number of potential outcomes.

[Phenomenon Analysis - Magnets]

It was crucial that the modules were able to be attached together yet have the flexibility of modification. Magnets were used to allow temporary forms to be created, yet allowing for the flexibility of reiteration. Small neodymium magnets were experimented with to allow the cardboard modules to attach to each other with a temporary but strong connection.

OPPOSITE LEFT

Fig 4.11. Neodymium magnets

Testing of the properties of small neodymium magnets. The North poles were marked with a dot for easy identification. A test was conducted on the repulsion of similar poles. The outcome was that it would attach to each other by the sides at the cost of a weaker bond.

OPPOSITE TOP RIGHT

Fig 4.12. Attaching magnets to modules

A neodymium magnet attached to the middle of a surface on a module. Magnets were used sparingly due to the limited amount available.

OPPOSITE BOTTOM RIGHT

Fig 4.13. A module with magnets attached

Reflection

The interaction between modules were tested with the magnetic points to identify the abstract forms generated. The forms generated resembles that of Woods Terrain Project, but now has the added variable of uncertainty pertaining to its form.

Due to the small size of the magnets used, the connections between the magnets are affected by the weight of the module, occasionally causing the links to marginally separate (Fig 4.16).

OPPOSITE TOP LEFT

Fig 4.14. **Complete cardboard composition**

Cardboard modules attached to one another via magnets

OPPOSITE TOP BOTTOM LEFT

Fig 4.15. **Attachment closeup**

Two opposing poles will create a successful, strong connection between modules.

OPPOSITE TOP RIGHT

Fig 4.16. **Collapsing module**

With weak connections due to the small magnet size, the modules would sometimes not hold its connected shape.

OPPOSITE BOTTOM

Fig 4.17. **Magnet connections**

A magnet connection that is about to detach from each other under the weight of the cardboard.

As the magnets were glued at random on flat surfaces of the modules, the connected modules occasionally could pivot around its connected axis, rotating until it was obstructed or the center of mass of the module was lower than the point of connection due to gravity.

The polarity of the magnets affected the way the modules interacted as the magnets were glued to the modules. The magnets could not all have the same polarities facing up as similar polarities repel. The modules only had stable connections at points with an opposing polarity while having weaker link at points with similar polarities.

OPPOSITE

Fig 4.18. **Intentional Collapse**

A post collapsed composition of cardboard modules is able to maintain due to the magnets.

TOP

Fig 4.19. **Magnet Rotation**

Due to each connection having only one node of attachment, certain modules with one node of connection can freely rotate about the node's axis.

BOTTOM

Fig 4.20. **Opposing poles**

Certain nodes that have similar poles get connected with a weaker magnetic connection.

[Module Material Selection]

As the cardboard modules had limitations in the different configurations they could generate, the material of the modules were replaced with magnetic metal. With the change in material, the configurations that can be generate by the models are no longer limited as the magnets are not limited to a specific point on the module but can be stuck onto any portion of the module surface.

A sheet of ferromagnetic metal was cut with a metal cutter into small pieces of undetermined sizes to simulate the many different possible outcomes of a user-centered architecture that

is not preplanned. The only criteria of the pieces cut are that one side must be cut at an angle, simulating the existence of a guideline (Fig 4.23).

The pieces were soldered together using silver solder to create a couple of unpredictable modules, each with approximately four to six pieces, just like the modules made with cardboard.

TOP LEFT: Fig 4.21. **Metal sheet cut into smaller strips**

TOP RIGHT: Fig 4.22. **Strips are cut into small pieces**

BOTTOM LEFT: Fig 4.23. **Preparation of edges for soldering**

BOTTOM RIGHT: Fig 4.24. **Soldered modules**

Magnet Connection

Due to the small size of the magnets, multiple magnets were used to connect the module pieces together. This also allowed the pieces to remain rotatable while maintaining a stable attraction.

TOP

Fig 4.25. Multiple magnets

Due to the small size of the neodymium magnets, multiple magnets were used to increase the strength of the connection.

BOTTOM

Fig 4.26. Rotatable connection

The metal and magnet combination allows the pieces to have a strong bond while still allowing for rotational movement.

[Composition 1 - CLUSTER]

[Design]

The first of three concept iterations are modules which were attached together while trying to reduce the amount of gaps in-between, forming a cluster. This iteration investigates the concept of architecture that expands in a cluster surrounding a node.

As the modules do not have a uniform unit of measurement, the modules had to be attached at angles that would allow sufficient attraction

from the magnets. This allows organic orthogonal forms of architecture to appear, creating a stronger sense of soft architecture given the hard nature of metal.

The denser parts of the composition can be interpreted as programs sited within an interesting form of architecture, with moments of release where pieces extend outwards.

Fig 4.29.

Fig 4.30.

Fig 4.31.

Fig 4.32.

Cluster composition close up
Taken from different angles and orientation

OPPOSITE TOP

Fig 4.27. **Cluster composition perspective overview**

OPPOSITE BOTTOM

Fig 4.28. **Modules used in the Cluster composition**

Fig 4.33. Cluster composition detail

[Inference]

An interesting observation is that the model is visually dense at certain angles but less dense in others. Although the model was put together while trying to reduce the amount of gaps that appear in the model, the geometry of the modules still generated significant gaps that can be interpreted as interesting spaces in-between.

Fig 4.34.

Fig 4.35.

Fig 4.36.

Cluster composition perspective view

Taken from different angles and orientation

[Composition 2 - STRETCH]

[Design]

The second concept iteration is to test the modules in a chain formation, investigating their attraction as the composition stretches longer and longer. This iteration represents building forms that extend away for the cluster.

Even though more magnets were used for every connection, there is a limit to the magnetic strength. It is observed that the composition

can only self-sustain about four modules before the chain twists and then disconnects.

Due to the forms of the modules extending in all three axes, the chains created by the composition do not visually look like a chain as some parts of the modules rotate back onto itself.

Fig 4.39.

Fig 4.40.

Stretch composition close up
Taken from different angles and orientation

Fig 4.41.

OPPOSITE TOP

Fig 4.37. **Stretch composition perspective overview**

OPPOSITE BOTTOM

Fig 4.38. **Modules used in the Stretch composition**

Fig 4.42. **Stretch composition detail**

Fig 4.43.

Fig 4.44.

Stretch composition perspective view
Taken from different angles and orientation

[Inference]

The composition visually looks more narrative as there is a visual flow in the model. The difference in the form density of the model also gives it a contrast of possible functions of the model. When the model was handled in certain ways, the model would twist under the weight of the modules but still maintained connection.

[Composition 3 - COLLAPSE]

[Design]

As the second concept iteration showed moments when the composition would collapse on itself under its own weight, the final concept iteration investigates the forms generated when this is purposely done.

It is observed that the modules predominantly underwent rotation rather than detachment, partly due to the constant attraction of the magnets.

The modules were attached together and then handled to allow the composition to collapse on itself until a stable form was achieved.

Fig 4.47.

Fig 4.48.

Fig 4.49.

Collapse composition close up
Taken from different angles and orientation

OPPOSITE TOP

Fig 4.45. **Collapse composition perspective overview**

OPPOSITE BOTTOM

Fig 4.46. **Modules used in the Collapse composition**

Fig 4.50. Collapse composition detail

Fig 4.51.

Fig 4.52.

Fig 4.53.

Fig 4.54.

Stretch composition perspective view
Taken from different angles and orientation

[Inference]

The model maintains a stable form after collapsing under the initial weight of the joints and obtaining support from its neighboring modules, becoming more varied in the orientation by generating forms that are a lot more angled and rotated.

Interestingly, the reconnection of modules when it collapses depicts what an adaptive architecture could be like.

DESIGN OUTCOME

The installation is an interactive piece intended for the observer to interact and play with. The tactile feel of the modules would dictate how the observer would attach them together. The nature of the material permits free range of imagination as to where magnets are placed and modules attached, constrained only by the success of the attachment between modules.

The installation can be changed and manipulated as the observer sees fits, having no definite rules to how it is to be used. The concept of magnetism allows for an indefinite amount of module composition where no two composition is ever the same.

OPPOSITE

Fig 4.55. Series showing the iteration with the installation

By using magnets, the smaller modules can be attached together to create a larger composition. There is no definite rule pertaining to how it is to be attached, only guidelines governed by the rules surrounding magnetism.

Fig 4.56. Installation model

TOP

Fig 4.57. **Installation model perspective view**

BOTTOM

Fig 4.58, Fig 4.59. **Installation composition perspective view**

Taken from different angles and orientation

OPPOSITE

Fig 4.60. **Final composition detail**

CONCLUSION

The installation is designed to be abstract as to investigate the idea that vertical architecture can deviate from the typical stacking of space above one another.

Until the modules are pieced together, the outcome of the installation will not be known. This investigates how non-orthogonal forms that intertwine with each other in all three axes are able to create a blurred boundary of space. Each module is representative of the unpredictable nature of the architecture formed by the individual who has control over its design outcome while the composition represents the community of which the individual is a part of.

The process of soldering the metal pieces together was a challenge as inadequate knowledge of maintaining

optimum temperature of soldering led to less than satisfactory handling of the heated material. Although the pieces were soldered with adequate strength, the crude handling of these small pieces resulted in pieces of the modules that were not soldered neatly at the edges. This led to the modules not having perfect alignments with one another. Although this is considered as an unplanned outcome, the outcome shows that an unpredicted result can lead to a sublime of architectural forms. Despite the modules not joining neatly together, it becomes an example that unique architectural spaces can be generated by unorthodox geometries.

OPPOSITE

Fig 4.61. **Module Collage**

Using digital programs, the modules were extrapolated to simulate a composition that is larger than the what the physical model can achieve.

CHAPTER 05

EXPERIMENT PHASE TWO

– *Residential Scale* –

Fig 5.05. Vertical architecture sketch

- Investigation 1: *Settlement Module*
- Investigation 2: *Host Core*
- Site
- Investigation 3: *Circular Tower Core*
- Investigation 4: *Residential Module*
- Conclusion

The second experiment looks into architecture that is not grounded. As architecture moves into the vertical, there will be a separation between the built form and the ground plane. As such, alternatives to a 'ground plane' is required.

Developing on the abstract idea of magnetism in architecture, the designs in this experiment aims at developing a potential architectural language that seeks new forms of a ground plane while incorporating the unpredictable nature of a user-centered design approach to vertical architecture. Although the designs closely relates to parasitic architecture, it has clear separation of ideas that allows it to not be defined as such.

OPPOSITE

TOP: Fig 5.01. **Settlement Module**

TOP MID: Fig 5.02. **Host Core**

BOTTOM MID: Fig 5.03. **Circular Tower Core**

BOTTOM: Fig 5.04. **Residential Module**

SETTLEMENT MODULE

- Aim
- Method
- Settlement Cluster Enlargement
- Reflection

[Aim]

To simulate the growth pattern of a community that expands over time in an existing build while gathering information on how unpredictable architectural forms can come together to be an architectural whole.

[METHOD]

As working with metal and magnets in the previous test had its challenges, the modules of this experiment were made out of 3mm Medium-Density Fiberboard(MDF), digitally modelled and precisely cut with a laser cutter, then glued together.

This investigation aids in understanding how architecture can expand in the vertical by conducting a documented series of compositions. The idea of the investigation is to test the form generation of a linear development of architectural forms, simulating a growing architectural community.

OPPOSITE

Modules for composition investigation

These modules were premade for the composition investigation to simulate a user-centered design architecture that was designed before being added to the community. This abstractly simulates the expansion of a vertical community.

Fig 5.06.

Fig 5.07.

Fig 5.08.

Fig 5.09.

Fig 5.10.

Fig 5.11.

Fig 5.12.

Fig 5.13.

Fig 5.14.

Fig 5.15.

Fig 5.16.

Fig 5.17.

Fig 5.18.

Fig 5.19.

Fig 5.20.

Fig 5.21.

[Settlement Cluster Enlargement]

A composition series was documented, with each sequential composition adding one additional module. The compositions were documented in isometric view as well as the four elevation views.

The initial compositions were still quite grounded, having majority of the module faces touching the ground. By composition 4, the modules gained elevation off the ground. Composition 5 started to get saturated at concentrated parts of the model, with 6 and 7 having little difference.

OPPOSITE

Documentation of cluster composition

This table shows a linear progression of the cluster composition with each composition having one extra added module. The composition was then documented in all four elevation views.

Isometric

Fig 5.22.

Composition 1

North View

Fig 5.23.

East View

Fig 5.24.

South View

Fig 5.25.

West View

Fig 5.26.

Fig 5.27.

Composition 2

Fig 5.28.

Fig 5.29.

Fig 5.30.

Fig 5.31.

Fig 5.32.

Composition 3

Fig 5.33.

Fig 5.34.

Fig 5.35.

Fig 5.36.

Fig 5.37.

Composition 4

Fig 5.38.

Fig 5.39.

Fig 5.40.

Fig 5.41.

Fig 5.42.

Composition 5

Fig 5.43.

Fig 5.44.

Fig 5.45.

Fig 5.46.

Fig 5.47.

Composition 6

Fig 5.48.

Fig 5.49.

Fig 5.50.

Fig 5.51.

Fig 5.52.

Composition 7

Fig 5.53.

Fig 5.54.

Fig 5.55.

Fig 5.56.

[Reflection]

The compositions documentation show that there is potential in creating interesting space within an unpredictable sequence of addition. However, due to the slender nature of the modules, the conceptual space observed requires a minimum of two modules to frame the space.

As the modules comprise of tectonically flat pieces, there is difficulty in speculating habitable spaces within the model. For now, the spaces within the model can only be speculated to be open-air architecture.

LEFT
Composition 7 West View Detail (Fig 5.56.)

OPPOSITE TOP
Composition 4 Isometric (Fig 5.37.)
This composition gives the illusion that the composition is growing taller in height.

BOTTOM LEFT
Composition 5 South View (Fig 5.45.)
This composition visualizes the extension of the architectural form away from the main node.

BOTTOM RIGHT
Composition 2 West View (Fig 5.31.)
Even though it is one of the earlier compositions, it looks similar in density to some of the later compositions.

Image Manipulation

An interesting epiphany is that the rotation of the images led to a whole different perspective. The shifting of what is perceived as the ground plane creates a different perspective how the image is viewed. The perception of gravity being still in the downward direction gives a sense that the model is suspended in the vertical. This becomes visually similar to a render of a concept parasitic architecture that latches on to the Hoover Dam (Fig 5.58).

TOP

Fig 5.57. Change of Perspective

As the composition was documented with no site on a monotone background, a shift in perspective occurs when you manipulate the images. This image of composition 5 north view has been mirrored and rotated.

BOTTOM LEFT

Fig 5.58. Parasitic Vertical Upside-Down Casino

Stephen Sobi's suspended Casino that latches on to the Hoover Dam

OPPOSITE

Fig 5.59. Analysis of Composition 5 North View

OPPOSITE

Fig 5.60. **Host Core model perspective overview**

TOP LEFT

Fig 5.61. **Plan sketch of tower core**

The idea of a tower core dedicated to provide structure and support.

TOP RIGHT

Fig 5.62. **Host Core model plan**

BOTTOM LEFT

Fig 5.63. **Elevation sketch of tower core**

The module surfaces would circle the tower core as the tower core provides the structural support.

HOST CORE

- Aim
- Method
- Settlement Cluster Enlargement
- Reflection
- Tectonic Plate to Intersecting Volumes

[Aim]

Initially, the modules were to be suspended over the ground. However, in the last test with the settlement clusters, it was concluded that the modules needed a host to attach themselves onto.

[Method]

Using black card, a mock-up of a square tower core was made. A couple of modules were then attached to the core to test the interaction between the modules and the core. Three modules were used, with each module attached to one of the four surfaces of the square tower core (Fig 5.60).

[Reflection]

Having something to latch onto aids the model in having a backbone. However, similarities with parasitic architecture starts to emerge. Parasitic architecture is defined as architecture that is not built for the addition of structures.

But, what if it were built for the addition of structures? Stephane Malka's parasitic 'plug-in' extension extends the facade of the host building to improve the performance of the building (Fig 5.65). The idea of a plug-in facade becomes intriguing, having a tower core that is designed to receive the modules while providing the structure and support.

OPPOSITE TOP

Fig 5.64. **Host Core model perspective**

OPPOSITE BOTTOM

Fig 5.65. **Attachment diagram**

The host core model is made by attaching a module unit to one side of the tower core. Due to the formation of the modules used, one core was left without an attached module

RIGHT

Fig 5.66. **Stephane Malka's 'plug-in' extensions**

This parasitic architecture is a facade extension that improves the performance of its host building. The adaptable idea here is that of a 'plug-in' architecture.

[Tectonic Plate to Intersecting Volumes]

Within the modules that have been experimented with thus far, the pieces that constitutes it can be described as tectonic plates that do not intersect. The spaces visualized within these modules have been vaguely defined by imaginary planes created by these tectonic plates.

Inspired by the design idea of Peter Eisenman's Guardiola House (Fig 5.69) which uses intersecting volumes and voids of a cube to create the form of the house, the modules were reiterated to be designed with volumes rather than non-intersecting tectonic plates.

With the aid of digital programming, the plates of the digitized modules were given thicknesses to simulate space for programs to inhabit. A prototype model was then created for better analysis. For better visualization of the space inside, certain faces of this model are omitted to be able to view the interior spaces of the volumized module (Fig 5.67).

Mini-reflection

The volumized modules create interesting interior spaces that are not the conventional orthogonal interior space. As there is a lot of verticality within the interior, therein also lies the question of vertical circulation and access.

OPPOSITE

Fig 5.67. **Volumized module model perspective**

TOP LEFT

Fig 5.68. **Host core perspective**

TOP RIGHT

Fig 5.69. **Digital volumization of modules**

Using digital software, the individual pieces of a module was given thickness.

BOTTOM LEFT

Fig 5.70. **Guardiola House 1988**

Peter Eisenman's Guardiola House is the result of operations that manipulate (rotation, displacement, superposition, shift) a basic geometrical figure: the cube.

SITE

- Site Criteria
- Mini-conclusion

[Site Criteria]

As the vertical architecture in this thesis aspires to be adaptable and functional on a city scale, it is important that the site chosen functions more as a testing ground than a final site location. As the vertical architecture of this thesis is planned to be a network of architectures and not solely one building, there must be an abundance of these site locations strewn across a city that is readily convertible in the future.

A car park building lot fits this criteria well as these buildings are built as a means to cater for the increasing population of cars traversing in the city. Increase in the number of cars has brought with it problems that plague the cities such as traffic jams and grid locks. As major cities worldwide such as Copenhagen, Paris and even parts of China are taking actions to move from cars to bikes within its city center, it will not come as a surprise to see other cities following suit (Garfield). With a strong action to reduce the number of cars, it can be forecasted that car-parking facilities may become obsolete in the future, allowing for their reuse.

With the increase in the number of cars produced out of necessity to satisfy the modern day transportation needs, architecture has naturally conformed to the ideology of a car-

driven city. However, this is prone to change. There is a scene in *Captain America: The First Avenger* (2011) where Howard Stark, a businessman inventor, exhibits a prototype car that hovers (Fig 5.71). In *Total Recall* (2012), we get a glimpse of what cars that operate on magnetic levitation is like (Fig 5.72). Fast forward a couple of years and we see real-life developments such as the hover bike that stems from the recent popularization of the miniature quadcopters and even jetpacks that can propulse a human (Fig 5.73, Fig 5.74). Although these inventions are currently in the prototyping phase with the potential to become public in the coming years, these ideas of taking transportation into the third spatial dimension changes the way we see transportation, which will consequently alter the architecture of the city. This is another reason why car-park buildings are a prime location for testing the idea of this thesis - because it is an infrastructure that has the biggest affect when cars no longer become the center of the city's infrastructure.

OPPOSITE TOP

Fig 5.71. Captain American: The First Avenger 2011

Howard Stark, a businessman inventor shows the prototype car that hovers above the ground. It is not a flying car, but a car that doesn't touch the ground.

OPPOSITE MID

Fig 5.72. Total Recall 2012

Chase scene shows a network of cars that hover with the usage of electromagnets. The protagonist takes advantage of this by disengaging the electromagnets to escape pursuers.

OPPOSITE BOTTOM LEFT

Fig 5.73. Colin Furze rides his hoverbike 2016

Colin Furze, a stuntman inventor builds a hoverbike in his own backyard.

OPPOSITE BOTTOM RIGHT

Fig 5.74. Richard Browning flies his jetpack 2017

Richard Browning, CEO of Gravity Industries is developing a jetpack that can allow a person to fly individually.

[Mini-conclusion]

For easy testing and site access, a car-parking facility in Wellington City is used as a testing grounds for the thesis. It approximates 50 metres by 30s metres in dimension, located along the bustling street of Cuba, situated on the outskirts of the City's CBD. The site is chosen because of its potential for a vertical city hub as well as its relative proximity to a couple of other potential, underused, land plots nearby.

OPPOSITE

Fig 5.75. **Carpark buildings around Wellington City**

TOP

Fig 5.76. **Chosen carpark lot**

The site chosen is currently an open parking area just off Cuba Street, one of Wellington's liveliest pedestrian streets.

BOTTOM

Fig 5.77. **Carpark lot size**

The site approximates 30 metres in width and 50 metres in length and sits at the corner of an intersection. The two dots represents another parking lot and an underused park.

CIRCULAR TOWER CORE

- Aim
- Method
- Reflection

After the host core test (Fig 5.78), it was deemed ideal to make the core a part of the vertical architecture design rather than having the modules take on a parasitic nature, latching on to other buildings as a base host.

During the host core test, each module was dedicated one surface to be attached. To increase the number of attachable surfaces, the tower core was developed as a circular core to increase the number of tangent points available for modules to attach to.

TOP LEFT: Fig 5.78. **Host core perspective**

TOP RIGHT: Fig 5.79. **Sketch of a circular tower core**

The square tower core was converted into a circular core to increase the number of tangent surfaces that modules can be attached on.

MID: Fig 5.80. **Sketch developing the idea of how the modules would attach to the tower core**

The sketch investigates the distribution of air space for the non-orthogonal modules to inhabit.

BOTTOM: Fig 5.81. **'Dynamic Towers'**

An 80-storey tower proposal in Dubai that features rotating levels – an inspiration to the circular core idea.

OPPOSITE: Fig 5.82. **Tower core investigation sketch**

The sketch investigates the interaction between tower cores via a connecting bridge. It also investigates the distance one can build from the tower core.

[Aim]

With a circular core, the number of tangent points on the surface increases. It is therefore necessary to establish how the modules are to be attached to a curved surface while experimenting with the interaction of modules that are stacked above one another.

[Method]

To experiment with the curvature of the tower core, a circle is divided into 24 segments. Column pieces are then erected on these 24 points, with holes on the columns pointing outwards away from the center.

Rather than using complex volumized modules, a couple of simple curved modules were made to simulate the potential occupiable air space. These simple modules have hooks on the top to allow their attachment to the perforated columns of the modelled tower core.

OPPOSITE TOP

Fig 5.83. **Circular tower core perspective overview**

OPPOSITE BOTTOM

Fig 5.84. **Circular tower core detail**

TOP LEFT

Fig 5.85. **Module sizing**

Each module size differs in the number of segments it occupies.

TOP RIGHT

Fig 5.86. **Tower core columns**

Structural frames were arranged in a radial pattern to resist lateral movement of the tower core in all directions.

BOTTOM

Fig 5.87. **Module walls and column template**

The module walls have a hook at the top to allow it to slide into the holes on the column, holding it in place via gravity.

[Reflection]

The modules for this experiment showcases a potential working framework for architecture of different sizes to occupy vertical space, allowing for an unprecedented freedom of occupying air space.

The connection between the module and the tower core was maintained in a circular fashion to test if circular surfaces could become viable. This proved to be mildly difficult, but could be of interest for further investigation.

Albeit difficult, it was interesting to see that the modules could be attached to the tower core from the inside (Fig 5.89) showing that there is potential for the modules to occupy the insides of the tower core.

OPPOSITE

Fig 5.88. **Series of module attachments to tower core**

TOP

Fig 5.89. **Module attached to the interior**

RESIDENTIAL MODULES

- Aim
- Method
- Modelling
- Reflection

[Aim]

As modules created thus far have been basic prototype shapes, this test aims to create a set of modules that is visually habitable. This test hopes to push the boundaries of how vertical architecture is perceived and designed.

[METHOD]

Drawing upon the influence of Lebbeus Woods' drawings such as *High Houses* (Fig 5.97), an initial set of residential drawings were sketched and developed. These drawings were then emulated in modelling form using yellow styrofoam as the bulk form generator, detailed with balsa wood, black card, metal wires, laser-cut MDF pieces and textured brown card.

Fig 5.90

Fig 5.91

Fig 5.92

Fig 5.91 – Fig 5.96. **Series of residential module sketches**

These sketches investigate form generation that incorporates all the knowledge gained from previous tests.

OPPOSITE TOP

Fig 5.97. **High Houses** 2010

One of Lebbeus Woods' sketches that investigates dwellings that were elevated on beams welded from end to end, occupying air space.

Fig 5.93

Fig 5.94

Fig 5.95

Fig 5.96

[Modelling]

The drawings were enlarged to a 1:250 scale and printed on paper. Using a styrofoam cutter, thick styrofoam was cut to size to make up the shape of the drawn images of the residential modules. The pieces were then glued together and reinforced with pins.

Human figurines were used to visualize the potential of habitation within these modules more realistically.

TOP

Fig 5.98. **Module model mass**

The base material used were styrofoam, balsa and blackcard.

BOTTOM

Fig 5.99. **Semi-completed residential model**

OPPOSITE

Fig 5.100. **Collection of residential dwelling models**

Fig 5.101

Fig 5.102

Fig 5.103

Fig 5.101 - Fig 5.107. Series of residential module models

These models are built using the residential sketches as guidelines. The process is reflective of the unpredictable outcome of a user-centered architecture.

Fig 5.104

Fig 5.105

Fig 5.106

Fig 5.107

Fig 5.108. Collage of residential module sketches

This collage depicts a speculative connection between residential dwellings in regards to the tower core.

[Reflection]

The residential modules generated showcases a sense of the unpredictable architectural styles that the individual user-centered design is able to conceive. By generating a basic set of guidelines, the user is free to design as he so chooses, taking the design and putting it in the hands of the unpredictable human (Friedman, "Pro Domo" 15).

CONCLUSION

The speculative design of the residential dwellings attempts to provide guidelines to alternative ways of building in the vertical. The restraint from producing any detailed drawings as to keep the design decision in an indecisive state allows the design to be up for interpretation, but can be frustrating at times as there can be a multitude of design outcomes.

As the design developed, the discourse was that elements and ideologies from other conceptual works started to emerge within the thinking process of the design. One such example is the similarity between the design and the ideology of the metabolist movement, predominantly the idea of 'pluggable modules' within a megastructure (Fig 5.III). The rebuttal to this similarity is that the metabolist movement proposed an architecture to the individual that was already set - capsules designed and planned for the usage within the system of the metabolist city making the design of the city predictable (Fig 5.IIO). The research design proposes a vertical city where the architecture

LEFT

Fig 5.I09. **Residential dwelling detail**

OPPOSITE TOP

Fig 5.IIO. **Nagakin Capsule Tower**

The world's first capsule architecture to be built having similar concepts of pluggable units, but were never fully realised.

OPPOSITE BOTTOM

Fig 5.III. **City in the Air 1961**

One of many designs proposed during the era of metabolism, Tange Kenzo's City in the Air proposed megastructures that tower over the city as a solution to the rapid economy growth and shortage of usable land.

is not defined by the architect, but rather by the user who will inhabit the architecture.

The production of physical models allowed for the understanding that there is a potential for architectural forms to have no relations to a ground plane while avoiding the production of square box architecture.

Time permitting, it would be interesting to further investigate architectural forms of programs that are not residential such as commercial and public to get a tacit understanding of how the concept of an expandable, user-centered architecture can be realistic in the vertical.

CHAPTER 06

EXPERIMENT PHASE THREE

– *Public Scale* –

“Unpredictable Verticality”

- Tower Core Section
- Final Design Outcome
- Reflection

The third experiment is a continuation of experiment phase two and looks into further developing the framework for a working vertical city on a public scale, consolidating the knowledge of previous design experiments.

Developing the idea of a tower core that houses individual architecture, the designs in this experiment aims at investigating the interaction between the public and private architectural builds.

TOWER CORE SECTION

- Aim
- Method
- Reflection

[AIM]

Consolidating the idea of magnetism from experiment one and the tower core idea of experiment two, a section of a tower is designed. This investigation aims to develop the interaction between the residential module (private) and the tower core (public). This test also aims to incorporate the idea of magnets back into the design process to inject the idea of an adaptable architecture.

OPPOSITE

Fig 6.02. Tower core section overview

TOP

Fig 6.03. Tower core section perspective elevation

The section is representative of a segment of a full tower core as represented by the elevation of the section.

[METHOD]

A section of the tower core was designed and built at 1:250 scale. The tower core was divided into 12 segment, each at 30° from the center point. A two layer, four segment model was built to test the interaction of a module with its horizontal and vertical neighbouring bays. The tower core also had exterior bays as well as interior bays. Each bay consists of a space frame with a hole at each corner for a magnet. A duplicate frame was made to simulate the connection of the modules to the tower.

OPPOSITE TOP

Fig 6.04. Tower frame detail

The magnets on all four corner have to be of the same facing polarity, while the opposing module frame must be of the opposing polarity.

OPPOSITE BOTTOM

Fig 6.05. Tower core plan

This image shows the attachment of a unit module. The module used is a mock-up module for the purpose of testing in this experiment.

TOP

Fig 6.06. Tower core side elevation

The elevation shows that the module does not necessarily need to be contained within the boundaries of each floor level.

BOTTOM

Fig 6.07. Tower core front elevation

Reflection

With the simple idea of magnetism, a single module is able to be freely placed in any of the tower bays. As the magnets are on all four corners, the module was able to be rotated as well. It is observed that verticality, in essence, is a series of planes for vertical habitation.

The 'bay' concept gives a rough guideline as to the boundary one is able to design/build. However as the mock-up module was built, it did not necessarily fit into a definite boundary. This shows that there is a requirement for a mutual interaction between the built forms of two adjacent bays, both horizontally and vertically.

In the exterior bays, as the module is built further outwards, the horizontal air space available increases. This is, however, an opposite case with the interior bays, as the space available for built forms overlap. Therefore the exterior builds will have to rely on mutual agreement as to who builds on the interstitial zone, while it is more beneficial for the interior to be considered one big circular consolidated air space.

OPPOSITE

Fig 6.08. Tower core interior

With magnets, the mock-up module could easily be attached to the interior of the tower core. However, the size of the module needs to be regulated, as the allocated air space size per bay is smaller on the interior than it is on the exterior.

FINAL DESIGN OUTCOME

- Tower Core Shape
- Tower Levels
- Modelling
- Magnetic Dwellings
- Dwelling Interaction
- Vertical Strata
- Technology in Architecture
- Tower Interior
- Building a city
- Reflection

[Tower Core Shape]

As the circle is a strong base geometry with symmetry, there is potential for the shape of a circular tower core to be manipulated. As concluded from experiment two investigation three, there is potential for the interior to be used as additional surface area for modules to attached on, creating a center 'courtyard' in the middle. Sections of the tower could be cut out as in Fig 6.10, opening out the center space. Fig 6.15 shows sections of the core that could be moved from its center point, expanding the area of the interior courtyard. Here, is it also shown with connectible layers for further options in vertical circulation (Fig.6.14).

The final shape that was brought forward was the circular core with a section cut-out (Fig 6.13), which was deviant from the full circular tower core but still maintaining its center axis.

Using digital modelling software, a detailed prototype tower core was developed, sized to fit into a typical carpark building lot with a maximum width of 30 metres (Fig 6.16). The core is 27 metres in diameter to allow a buffer within the carpark size.

The tower is supported externally with conceptual portal frames that align radially from the center. The width of the curved floor plates are approximately seven metres with radial stairs modelled to give an estimation of the circulation.

TOP: Fig 6.09 - Fig 6.15. **Tower core shape iteration**

OPPOSITE

Fig 6.16. Digital tower section

The final tower core section was designed digitally - divided into three floor segments of nine metres each; each segment has three, three-metre high sub-floors totalling 27 metres in height per section.

[Tower Levels]

Each floor segment is prototyped at nine metres with sub-floors every three metres to allow consideration for vertical space allocation in the vertical sense. Nine metres is an estimation for a vertical architectural building of two to three levels.

TOP

Fig 6.17. Residential dwelling to tower core section

This illustration depicts what the section of a module connected to the tower core may look like. The ground plane of the vertical dwelling is no longer horizontal, but vertical.

OPPOSITE

Fig 6.18. Latitudinal tower core section

The tower core is a repetition of the 27-metre high tower section

[Modelling]

A 1:250 tower core model consisting of three tower core sections is modelled, totalling a scaled height of 81 metres. The columns of the tower cores were modelled as triangular portal frames that provided structural stability with the least amount of material used. Holes were cut out of the columns to allow bracing beams to be attached to support the modelled floors.

TOP

Fig 6.19. Tower support columns

Long triangular columns were lazer cut and glued together. The triangular shape allows maximum structure integrity for the least amount of material used.

BOTTOM

Fig 6.20. Modelling guards

Placeholder guards were made to ensure that the positioning of the columns were accurate in relation to one another.

OPPOSITE

Fig 6.21. Progression model detail

Fig 6.23

Fig 6.24

Fig 6.25

Fig 6.23 - Fig 6.25 Tower core occupation

The figures help to visualize the occupation of the tower core.

OPPOSITE

Fig 6.22. Tower core detail

The tower core shows floor segment of nine-metres, repeated in the vertical for modules to attach to, inhabiting vertical air space.

[Magnetic Dwelling]

Magnets were reintroduced to the dwelling models made in experiment two, allowing them to be connected to the final iteration of the tower core model. Two magnets were attached to the back side of the dwelling models while a magnetic metal wire was glued to the perimeter of the tower. This allowed the dwelling modules to be attached to the magnetic wire.

OPPOSITE

Fig 6.26. Dwelling on tower close up

TOP LEFT

Fig 6.27. Magnets on dwelling model

Two magnets were attached to the corners of the dwelling model. The polarity of the magnet did not matter too much as both polarities would be attracted to the metal wire.

TOP RIGHT

Fig 6.28. Magnetic wire

A 3mm copper-coated steel wires were used to line the perimeter of the tower core. The wire also provide stability to the tower model.

MID

Fig 6.29. Attaching the dwelling module

BOTTOM

Fig 6.30. An attached dwelling module

The magnets allow the model to be attached to the tower core, with the flexibility to be rearranged

[Dwelling Intertaction]

The dwellings are tuned to ensure that there are no clashes with each other. This is akin to having a mutual agreement between one dwelling and another.

OPPOSITE

Fig 6.31. All dwelling modules attached in a row

TOP

Fig 6.32. Side elevation of dwellings

Although it is arguable that there is a boundary that defines the air space of where one can build, those boundaries can become blurred, allowing the dwelling modules to interact architecturally with one another vertically.

Fig 6.33. Birds-eye view of tower core and dwellings
Looking from above, there are obvious gaps in between the dwellings where architecture can be varied, with some of the builds potentially utilizing the shared interstitial space between.

Fig 6.34. **Tower collage**

This collage gives an idea as to how the tower would look like as a fully occupied tower. This is only a speculative image as the tower does not necessarily have to be fully occupied in every bay.

Fig 6.35. Interaction between dwelling
Unpredictable verticality seeks to blur the boundaries between the public and private. The open-plan architecture allows the inhabitants of the architecture to interact with one another, allowing private boundaries to be redefined due to the emergence of a public interaction.

Fig 6.36. Dwelling and tower interaction

Not all the bays of the tower need to be occupied with an architectural build; rather, it becomes interesting as the experience of a city evolves from two-dimensional to three-dimensional, allowing for the appreciation of the top (roofs) and bottom (floors) of an architectural build.

Fig 6.38

Fig 6.39

Fig 6.40

[Vertical strata]

A vertical strata system allows the distribution of vertical space to the individual to produce architecture as he/she sees fit. Like having a landed property, the vertical bays can be segregated or amalgamated to allow architecture of different sizes and forms to occupy vertical space. This allows for architecture to take on a variety of scales. This creates potential for what Friedman describes as ‘soft architecture’ and ‘soft city’, where the urban pattern can become adaptable (Friedman, “Pro Domo” 73).

The tower is not limited to just residential dwellings but can cater for all other forms of public and private architectural builds such as office blocks, shopping malls and vertical gardens.

OPPOSITE

Fig 6.37. Sketch of a larger dwelling/ commercial build

The sketches done in experiment two, investigation four focused on single family residential dwellings. In theory, this should be able to be scaled up to builds of larger scales and sizes.

TOP

Segregation and Amalgamation diagrams

Fig 6.38. Segregation of bays for individual builds

Fig 6.39. Amalgamation of adjacent bays for bigger builds

Fig 6.40. Segregation and amalgamation to cater for large builds

[Technology in Architecture]

During the installation of the public scale tower core, it was interesting to be able to rotate the floor plates as the tower maintain its strong circular geometry.

Initially, this was speculated to be tower floors that could expand as needed by the programs of the architecture that inhabits the tower. This led to the inquiry of how the tower could be expandable, becoming a 'living architecture'. The solution was the development of a crane system that would aid the tower in its expansion.

With the aid of a tower crane, the tower core can theoretically expand further upwards. The crane is not centered in the middle of the tower, but circulates on a circular track around the building. This gives it the crane a bigger range of motion around the tower.

OPPOSITE

Fig 6.41. Dwelling on tower core overview

TOP

Fig 6.42. Rotation of floor plates

Playing with the floor plates that were not stuck to the frame gave insight to technologies that can be implemented into the design.

MID

Fig 6.43. Plan sketch of tower crane

BOTTOM

Fig 6.44. Elevation sketch of tower crane

Fig 6.46

Fig 6.47

Fig 6.48

The adaptable tower

An integrated tower crane opens up possibilities for the vertical city to be adaptable to change. Just like the motion of snapping the magnetic modules of the tower model, the tower crane would similarly detach a dwelling to shift it to another bay, allowing for a variable and shifting vertical urban fabric.

OPPOSITE

Fig 6.45. Digital model of an integrated tower crane

Technology is the key in allowing architecture to become adaptable. An integrated tower crane allows for the tower to change according to the requirements of the situation.

TOP

Technological aided adaptation of architecture

Fig 6.46. Focused architectural dwellings

Fig 6.47. Dwellings shifted with the help of the tower crane, vacating bays for development.

Fig 6.48. Vacated bays allow the construction of larger builds

{ Tower Interior }

Due to the overlapping nature of the air space in the interior of the tower, it is concluded that it would be more beneficial if the inner bays were conglomerated as access to the center air space. The central space can be developed into programs such as (but not limited to):

- Vertical Public Parks
- Public Gardens
- Elevated Open Stage
- Schools/ Education Facilities etc.
- Vertical Carparks

OPPOSITE

Fig 6.49. Digital model of tower interior cut out

The consideration of the tower center not as multiple segments of air space, but as one large air space for large builds.

TOP

Fig 6.50. Sketch of a commercial size building section

The core can be utilized as a large central space that houses programs such as a malls or gardens that stretches over multiple floor segments.

1st year period 2nd year period 3rd/4th year period 6th-8th year period 10th year period

[Building a City]

This vertical framework for a vertical city is designed to be able to sustain a gradual growth allowing the architecture to remain adaptable to the requirements of the urban fabric. As an individual tower expands to a certain mass, a second tower can be erected to distribute the density of the urban fabric. As towers grow to a certain height, horizontal connections can be made to link the towers together, creating connection in between buildings in the air.

OPPOSITE

Fig 6.51. Render of a tower core with connections to other towers
The towers in this render is unoccupied as to keep it in a state of unpredictability. The tower is to be built upon by the unpredictable outcome of a user-centered design, where the user is its best architect and urban planner (Friedman, "Pro Domo" 49).

TOP

Fig 6.52. Series of city growth over time
This is a speculative timeline of the implementation of the unpredictable vertical city. The tower can be built small, then expanded when more build space is required. The joining of towers allow for a varied connection of circulation within the elevated urban fabric.

[Reflection]

The speculative design of the vertical city challenges one to rethink the possibilities of verticality rather than being conformed with what has already been established. There are still issues that haven't been resolved and until then, it puts the feasibility of the scheme at risk.

One such area is the feasibility of building buildings that are cantilevered. Inasmuch as technology supports architecture, architecture can only progress so far without the development of technology. Today, with research on materials such as graphene and Carbon Nanotubes (CNT), its usage as a viable building material isn't too far off in the future. CNTs are organised structures of carbon at the atomic level that, when made, is stronger than steel by magnitudes in terms of its density to strength ratio. This allows cantilevered building to be able to sustain its own weight better than cantilevers made in steel allowing for longer spans. However, the research of today is still limited to the creation of small quantities, but its usability in construction is hopeful in the near future. With this to look forward to, the architecture of the unpredictable vertical city becomes a viable alternative to conventional vertical habitation.

OPPOSITE

Fig 6.53. Network of a vertical city

The sketch represents the potential for the vertical city to become a network of interconnected towers. As a new tower gets erected, it is possible to be connected to other towers in the network, creating a three-dimensional urban fabric not conformed to the grids established by the urban fabric on the ground below.

RIGHT

Fig 6.54. Double Walled Carbon Nanotubes

This lightweight material could allow structures of the future to be lighter, allowing possibilities of cantilevering architecture to become the norm.

As for circulation within the tower, the design has only been speculated as a couple of flights of stairs. The reason for not specifying any other modes of vertical circulation such as elevators is because the future of vertical transportation is prone to change in the near future. Aside from the change in transportation as discussed in chapter five, the way we commute within our buildings may also be subjected to change, taking for example the movie *Meet the Robinsons* (2007). In the movie, we are introduced to the future city where people are travelling in bubbles (Fig 6.55) and although the idea is a farcry from reality, it is possibly applicable to the unpredictable vertical city. Technology nowadays are developing the quadcopter to deliver parcels (Fig 6.56) and won't be long before the idea becomes feasible that buildings no longer require elevators because drones become a daily part of the commuting life.

Another future possibility that may change the way the future operates in the vertical is the development of exoskeletons, as depicted in Neill Blomkamp's 2013 sci-fi movie, *Elysium*, which shows us the potential of an exoskeletal suit (Fig 6.57). As a dying man, the exoskeleton suit aids the protagonist to seek revenge on the society that

oppresses people like him. Adapting the ideology of the exoskeletal suit providing aid, it may one day be a possibility that exoskeletons become a daily part of life as they aid with what the human body is unable to do (Fig 5.58). This would result in the ability to climb flights of stairs with ease, becoming a simple, plausible solution to the vertical circulation. This is why the circulation of the tower was only modelled with flights of stairs as it may also be the only mode of vertical circulation we need.

The crane design is a speculative representation of a method that allows the tower to become adaptive in its architecture. As today's technology has allowed us to encounter the emergence of robotic arms with six axes (Fig 6.59), there could be a change in the way the crane of the unpredictable vertical city would operate, allowing for a bigger diversity of architectural form construction.

Inasmuch as the realm of drone flying has provoked the policy makers of air space usage, policies regarding the usage of vertical space will definitely have to be considered in the future. Given more time, it could be an interesting aspect of vertical architecture to explore to make the design of the unpredictable vertical city a reality.

OPPOSITE TOP LEFT: Fig 6.55. **Bubble transportation**

Bubble transportation as seen in Meet the Robinsons (2007). A bubble is created around the user at ground level, and is popped at the level you are going to.

OPPOSITE TOP RIGHT: Fig 6.56. **Drone delivering parcels**

Places like Singapore are testing the viability of automated drone delivery services

OPPOSITE LEFT MID: Fig 6.57. **Elysium 2013**

Futuristic exoskeleton depicted in the movie is surgically connected to the brain for better response. We may still be far off from a neural aided exoskeleton, but the exoskeleton itself is realistic progress.

OPPOSITE BOTTOM LEFT

Fig 6.58. **Progress of today's exoskeletal suit**

OPPOSITE BOTTOM RIGHT

Fig 6.59. **A 6-axis Kuka robot**

Fig 6.6o. Unpredictable Verticality

// 6 - Public

Fig 6.61. Point of perspective
The vertical city is an alternative way to view the ground plane.

[INSTALLATION SCALE]

Installation Scale Model

[RESIDENTIAL SCALE]

Residential Scale Model

VERTICAL CONTINUITY

How can the relationship of verticality play a role in determining the connectivity between public and private in building the program of a residential urban space?

How can the relationship of verticality play a role in determining the connectivity between public and private in building the program of a residential urban space?

How can the relationship of verticality play a role in determining the connectivity between public and private in building the program of a residential urban space?

[PUBLIC SCALE]

[DESIGN OUTCOME]

Fig 6.62. Thesis presentation

CONCLUSION

The literary context established a viewpoint of the future of verticality, allowing for an inquiry as to how the boundary between 'public' and 'private' aspects in vertical architecture can be blurred, allowing for an inquiry regarding the unpredictable future of vertical architecture. The questions asked include 'how can architecture cater for the user-centered design of the individual?', 'how does the architecture of the vertical change, now that it has no ground plane?', 'how can future technologies affect the way we approach verticality?' and 'how can we implement these findings to the modern day scenario?'

These enquiries were then explored through four case studies, each pertaining to a different aspect of the enquiry, to establish a position by which an exploration of the merger of these ideologies can generate a new hybrid ideology pertaining to vertical architecture. These ideologies were investigated through a series of experiments conducted at three different scales of increasing complexity. The experiments were not site specific as the experiments were conducted in view that it could be adapted to a myriad of sites. The first experiment, an interactive abstract installation that established an understanding of generating indefinite architectural forms through modularity and magnetism provided the framework of how 3D architecture forms can interact with each other in three spatial directions while providing the architectural language that is used throughout the research. The second experiment inquired into the

design potential of architectural forms that are not connected to the ground plane, establishing a framework where architectural forms are able to interact with each other through the concept of an architectural backbone - the tower core. Finally, the third experiment brought together elements established from the previous projects, consolidating them into a functioning concept while establishing guidelines for a functional vertical city. The final design is intended to be a provocative design that is open to interpretation.

[Critical Reflection]

The final design outcome of this research has been successful at establishing a framework of how verticality is utilized in architecture while still maintaining the authority of architectural design in the hands of the individual. This form of speculation allows for the spatial boundaries of the vertical realm to be reconsidered, provoking the conventional approach to verticality. The design has successfully provided a solution to creating a three-dimensional urban grid, blurring the boundaries between public and private in regards to vertical air space. Time permitting, it would be beneficial to investigate other forms of spatial boundaries, such as the boundary between architectural builds and the tower itself - merging architectural builds to become one with the tower.

The concept of magnetism has been a major asset in establishing a standpoint of how architecture

can adapt in the vertical. The qualities of magnetism is still yet to be fully understood as it is one of the elements that can defy gravity. It has provided the understanding of applying concepts of technology into architecture, showing that technology can be a driving force in shaping the way architecture is conducted and perceived.

This thesis has been a platform that has allowed me to gather ideas from different sources, reflecting on them and adapting them into my viewpoint of how verticality in architecture can be. It is not easy to change other's perspective on verticality, but this thesis challenges one to have an open mind to the possibility of verticality being the future of architecture.

This thesis also acknowledges that technology plays a huge role in the future of architecture, be it in the physical of establishing a three-dimensional urban fabric or in blurring the boundaries between the public and the private. Technology is an integral part of architecture and must not be separated, for in separating them, architecture becomes stagnant.

[Concluding Statements]

There are many ways that verticality in architecture can be occupied. Understanding that there is more ways that one is the first step in breaking free of the rigid conventional perspective on verticality. Verticality no longer

has to be just spaces stacked upon spaces, but rather a whole dimension in which architectural forms can be expressed.

I hope this thesis will become an eye opener to a whole new perspective on the world of verticality.

Fig 6.63. Author post presentation 2018

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