

# Modular DIY architecture :

by Phillip Howat

How might a modular building block system be created to satisfy regulatory requirements for the revival of do it yourself to New Zealand Architecture?

A Research project submitted in partial fulfilment of requirements for the degree of Master of Architecture Professional from Unitec Institute of Technology, 2015

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## PREFACE

“Do-it-yourself (DIY) behaviours encompass a broad spectrum of activities such as home remodelling, automobile repair, gardening, and consumption-directed projects such as handcrafting furniture”<sup>1</sup>

New Zealanders are known for their ‘Do-it-yourself’ attitudes. Many normal New Zealanders have designed and invented products that have become household items<sup>2</sup>.

Do it yourself remodelling and renovation used to be common practice in New Zealand architecture. The practice of do it yourself is controlled by the activity. Building laws have been enacted, and rightfully so, meaning that no unqualified person should attempt building work without the proper paper work or skill set. This ensures people’s safety and also that the quality of workmanship is high.

Through consideration to those who wish to continue the do it

yourself attitude, a modular component will be developed to create a rejuvenation of the do it yourself spirit.

It is not so much what we are building, but how. If the how we build is simplified to require less knowledge, many may attempt to do it themselves.

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1 Wolf, M., & McQuitty, S. Understanding the do-it-yourself consumer: DIY motivations and outcomes. (2011), 154-170.

2 Bill Gallagher, as a New Zealand farmer, inventor, manufacturing engineer, businessman and commercial fisherman, who developed the electric fence in 1936-1937

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## I.0 Introduction

## 1.1 PROJECT OUTLINE

Architects are trained to think, to envision, to design and to give solutions. Residential architecture is more than just designing spaces or objects – their needs to be more consideration given to the way we build and to the people whom we are building for<sup>3</sup>.

It is not hard to prove that architecture; those in the lower income bracket rarely use good architecture and architects. So how might architecture change this and bridge the gap? Experimenting with the way we build, to benefit the intention of residential architectural is to design, think, and to have innovative vision as an architect.

Looking into many aspects of design, one would say design

adapts and grows with time, for the better. All you need to do is consider the life of a car. Affluence and position in society could be easily attributed to possessions, one being the fact that your family owned a car. Fast forward to the present day in the western world, everyone owns a car and they all have the same basic function. The only variable is given to the value and quality of car, which differs from family to family. Smart design coupled with technology has now given the ability to produce high-quality, cheap cars which anyone can own<sup>4</sup>. This can be seen as a common trend over the design and production of various commodities. Architecture though, seems to have done the opposite, content in focusing on issues of aesthetics. Man used to have the ability to build a house to give shelter to his or her

family. Though the size and scale of the house promoted status, it did not take away the fact that one could build one's own house. There was simple methodology involved in the design and construction of houses, giving opportunity to many to build. Now regulations and building governing bodies have created such a complex set of rules and high standards, which has meant that the New Zealand "do-it-yourself" mentality has faded away from consciousness. Unlike the design and development of the car, architecture traditionally has seen good design the privileged of those who can afford it. How do we bridge this gap? Designing smarter, and simpler.

Designing essentially is to create a smarter, more useful option that will have maximum impact on those who use it; in the same way the development of the car affected society.

This project will show the relationship between manufacturing

parts to benefit architecture, researching the possibilities of introducing manufacturing techniques to a modular architecture system, and how they can assist or not assist architecture construction.

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<sup>3</sup> After the Meltdown, "Where does Architecture go From Here", 'accessed' 19 October 2014, <http://www.archdaily.com/226248/after-the-meltdown-where-does-architecture-go-from-here/>

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<sup>4</sup> Timberlake, James, and Stephen Kieran. *Refabricating Architecture*. New York, USA: The McGraw-Hill Books, 2004

## 1.2 RESEARCH QUESTIONS

How might a modular building block system be created to satisfy regulatory requirements for the revival of do it yourself to New Zealand Architecture?



### 1.3 AIMS AND OBJECTIVES

The aim of this design project is to investigate and develop an architectural modular system that can give an individual the ability to alter or extend his or hers own built environment. This system must consider a variety of possible user groups and their different building abilities. Thought will also be given to keeping the construction process as simple as possible, through consideration of current architectural detailing. The resulting modular system will also incorporate elements of sustainability, as the intention is to create a system that does not add to the waste stream generated by the construction and demolition industry, but in fact to remove waste. The finished component will be used in many situations, giving its application flexibility. The basic "block" will be available to anyone to build anything from a structural wall

to a garden shed, its simplicity will be its strength. To have a modular system that is not only constructible, but also de-constructible, will have further uses, especially with the likes of disaster relief and war-torn areas. Creating an object that has many uses and applications will also see a decrease in waste within the construction industry



## 2.0 Define Project

## 2.1 RESEARCH PROBLEM

There are many possible reasons why there is an opportunity to design a concept for a building system. This design project will touch on a few issues: sustainability and construction environmental effects. The main focus, will to be to offer a building system that caters to the high demand for houses in New Zealand. Increasing population and high construction costs have all caused an unprecedentedly large increase in the average house price. This situation has triggered undue pressures on New Zealand's building industry, as there are not enough houses being constructed to keep up with the demand. For many, the need for a larger home, as a result of a growing family, is combated by the constant rise of house prices. Auckland is a great example of how prices of housing are rising at a relentless rate. The National Business Review states that in a six-year period houses have risen by 52%, and when adjustments are

made for inflation, that still equates to a 37.8% increase. In November 2008 the median house price was \$435,700. Now, five years later in 2013, sales figures show that the median price has increased to \$664,100, an increase of \$228,400 <sup>5</sup>. As a consequence this has seen Auckland continue to sprawl and get larger and larger, as many struggle to find property where they can live. For those on minimal standard incomes, with children, the availability and ability to own, build, or renovate are becoming more a dream than a reality. Is it naive to say that architecture has become more and more elitist and that those in the lower socio-economic sectors are being forced to live in rather disappointing, poorly designed homes

Pressures like this may benefit from developing a mass-produced housing system, which would help curb these issues, or possibly a system for the re introduction of 'do-it-yourself' to

New Zealand.

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5 "Auckland house prices continue their relentless rise." By Alister Helm. <http://www.nbr.co.nz/article/auckland-house-prices-continue-their-relentless-rise-dc-150592>. (2014)

## 2.2 PROJECT

There is so much consideration when it comes to scale, materiality, form and all other architectural visual and spatial concerns, that the process of construction is nearly forgotten. Architecture School teaches construction in a limited sense and there is limited push or desire from students to experiment with construction within architecture. The “star architect” label can be seen as the pinnacle position of an architect, though it is rarely reached<sup>6</sup>. Notions of fame and notoriety of peers, wanting to be the next big face and named architect, drive current day architecture students. More importance is placed upon what is being designed<sup>7</sup>, concern with pushing boundaries of aesthetics, and architectural intent rather than a concern for pushing boundaries of

architecture as a whole, including the fabrication and the construction of the object.<sup>8</sup> Architects are possibly more focused on appearance, while the engineers go beneath the surface to create a system of construction<sup>9</sup>. The world of architecture has grown, but with growth comes consequences. It has become more wasteful, disposable, splintered and specialised, while process engineers are dissolving integration between thinkers and makers. Hundreds of years ago, the master builder held all intelligence, part architect, part builder, part engineer, generating forms of architecture that came from a single person, a single mind, body, heart and hand<sup>10</sup>.

But as an architect, there must be some social obligation to push architecture as a whole, construction, environmental and aesthetic. Architects will carry the same status that once was

held by the master builder; architect, part innovator; part environmentalist.

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6 Rodeš, Anja "The Museum after the 'Bilbao Effect'," in Proceedings of the Society of Architectural Historians, Australia and New Zealand: 31, Translation, edited by Christoph Schnoor (Auckland, New Zealand: SAHANZ and Unitec ePress; and Gold Coast, Queensland: SAHANZ, 2014), 321–330.

7 Timberlake, James, and Stephen Kieran. Refabricating Architecture. New York, USA: The McGraw-Hill Books, 2004

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8 Le Corbusier, C-E. Translated by Frederick Etchells. "Towards a New Architecture." New York, Dove Publications, Inc, 1986

9 ibid

10 ibid

## 2.2.1 LE CORBUSIER AND MODERNISM

European avant-garde architects such as Le Corbusier were the architects that began pioneering the idea of mass-produced parts. Modernism began to emerge in the early 20th century, with the likes of Le Corbusier, Walter Gropius and Ludwig Mies van der Rohe becoming prominent figures with established reputations. After the Second World War, mass-produced architecture began to be implemented to meet the high demand for housing. Roughly 15% of the urban population was living in poverty<sup>11</sup>.

Seeing the link between building elements and building construction, Le Corbusier wanted to

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<sup>11</sup> Jeremiah, D. (2000). *Emergency, Economy and Modernisation: 1940-1953*. In: *Architecture and Design for the Family in Britain, 1900-70*. Manchester: Manchester University Press. pp. 123-163.

connect industry and technologies to begin mass-producing house elements. There was a belief that by industrialising architecture, building elements would be made precisely, cheaply and be of a high quality. Simplifying architecture to elements in the way cars, planes and ships were constructed meant that many elements could be produced in advance to supply the demand<sup>12</sup>.

The Model T Ford was used as the aesthetic exemplar for modern architecture, declaring that they wished to build houses like Ford built cars. Le Corbusier was always looking for new ways of construction to compete with the high demands that were inflicted by the war:

Le Corbusier's ideas of a simple construction methodology were echoed by Fredrick Winslow Taylor's (1856-1915) principles of production efficiency. Taylorism (as it was called) was the idea that all objects could be analysed, disassembled, reassembled and

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<sup>12</sup> Le Corbusier, C-E translated by Frederick Etchells. "Towards a New Architecture." New York, Dove Publications, Inc, 1986



figure 2.1 Model T Ford factory, assembly line construction of the Model T ford, showing efficiency of construction through small parts.

optimised to be mass-produced. The work was to be carried out by unskilled workers who would need training to assemble the objects for production.

Le Corbusier drew inspiration from Henry Ford, who believed the cost of automobiles could fall if production time was reduced<sup>13</sup>. If architecture could address these qualities, reducing production time would eventually lower the cost. After Ford had created automobiles with certain specifications, he began to standardise production. Standardising everything from engine to screws meant that factories could use assembly lines to achieve mass-produced cars.

Le Corbusier's ideas of housing standardisation and industrial production were envisioned with the housing project in Pessac, France.

The heart of Le Corbusier housing design was that the prototype of the house, the basic units and

13 Gartman, David, "From Autos to Architecture: Fordism and Architectural Aesthetics in The Twentieth Century" Princeton Architectural Press, 2009

elements, standard plane, composition, and housing type all could be simplified for efficiency and ideally, for mass production<sup>14</sup>.

Cité Frugès, Pessac, France, was France's attempt at social housing. Initially, 135 houses were planned, but it was downsized to 50, which were delivered in 1926. Six types of standardised plans offered 75-90 metres squared, which offered all amenities of a house.

The houses still look modern by today's standards, but this revolution in design and style meant that they struggled to gain acceptance. This social experiment in a way failed. The houses, when new, had no personal input from the architect, leading the houses to have no personal feel<sup>15</sup>.

These houses were possibly ahead of their time, and Le Corbusier was aiming for perfection in design, not leaving room

14 Le Corbusier, C-E. Translated by Frederick Etchells. "Towards a New Architecture." New York, Dove Publications, Inc, 1986

15 Le Corbusier's Cité Frugès: "Timelessly Modern and Back in Fashion" <http://en.paperblog.com/le-corbusier-s-cite-fruges-timelessly-modern-and-back-in-fashion-607149/> accessed Jan 2015

for renovation or individualisation, eventually labelling the Cité Frugès a failure. The occupants have renovated many of the original houses, over time. This proves that by building the simple walls supporting the roof, the buildings were easy to reconfigure as a family expands.

Now close to 90 years old, these houses still look modern, and are being recognised as early modernism rather than a "miscarriage of modernism and the arrogance of its architects"<sup>16</sup>.

Le Corbusier was arguably ahead of his time, not only with thinking but also design, and this experimental housing project in Pessac estate is testament to this

16 Huxtable, Ada Louise "Architecture View; Le Corbusier's Housing Project, Flexible Enough to Endure". New York Times (Published: March 15, 1981)

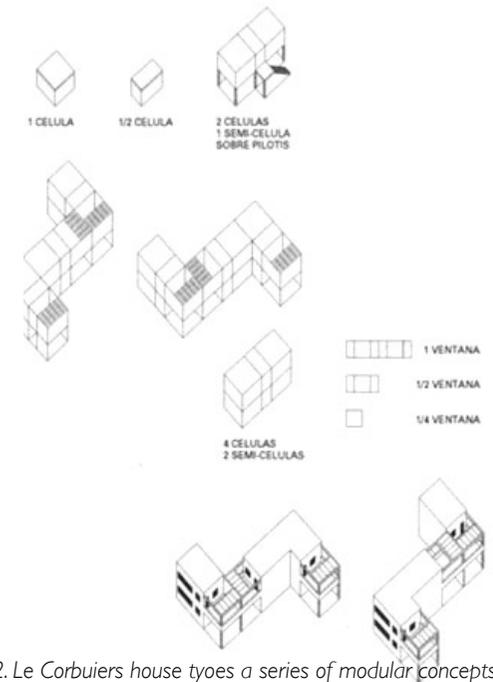


figure 2.2. Le Corbuier's house types a series of modular concepts



*figure 2.3 Houses of Cité Frugès, that are still standing today, and with maintenance over time, still look modern*



## 2.2.2 RETHINKING ARCHITECTURE

James Timberlake says, in *Refabricating Architecture*, if an architect were to wake after an 80-year sleep, all would appear different yet is in fact the same. Appearance still triumphs over substance, and architecture still takes years to design and build<sup>17</sup>. Architecture has developed, but the same issues are around that faced Le Corbusier in the 1930's. In nearly 90 years since Modernism, there are few truly new materials, features, and processes that have become commonplace. Construction methods, especially materiality, have not changed significantly. Materials that have been used for decades still dominate construction methods currently. With the building industry under constant scrutiny (council regulations), the introduction of new methods in construction is frowned upon in

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17 Timberlake, James, and Stephen Kieran. *Refabricating Architecture*. New York, USA: The McGraw-Hill Books, 2004

favour of tried and tested methods. Concrete and timber are commonplace in residential architecture, with steel construction now occurring not only in commercial but gaining a foothold within the residential sector. But these traditional methods are time-consuming and costly, keeping the cost of construction high. Modular, prefabricated systems are a way to mass-produce a product, lowering the cost, making it for less and less<sup>18</sup>.

Image has becoming an obsession, while failing to focus at process. This has led generations of architects to overlook transfer technologies and transfer processes. They argue that the time has come to re-evaluate and update the basic design and construction methods that have a stranglehold on the building industry, skilfully demonstrating how contemporary architectural construction is a linear process, in both design and construction. If a linear process can be created, Modernism architecture can be replicated faster and more simply. The automobile,

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18 *ibid*

shipbuilding, and aerospace industries encourage this thought and, as with Le Corbusier, there must be an effort to learn how to incorporate collective intelligence and non-hierarchical production of structures and or components<sup>19,20</sup>. It's not hard to show that these industries have proven to be progressively economic and efficient, and through process they yield a higher-quality product. The production of buildings has stagnated because it is based on methods and practices that still exist from the nineteenth century. The transfer they envision is the complete integration of design with the craft of assembly, supported by the materials scientist, the product engineer and the process engineer, all using tools of modern information science as the central enabler.

Kieran Timberlake puts his ideas about streamlining the design

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19 *ibid*

20 Le Corbusier, C-E. Translated by Frederick Etchells. "Towards a New Architecture." New York, Dove Publications, Inc, 1986

build process to test these theories, constructing a unique house, featuring an adjustable double-skin facade. Located on Taylors Island, off the coast of Maryland's Chesapeake Bay, Loblolly House utilises a new, more efficient system of construction, through the use of building information modelling (BIM) and integrated component assemblies. To keep the impact on the site to a minimum, the house was manufactured off-site and lifted into place. Many parts were collapsed into a few dozen prefabricated cartridges and blocks, and simply put together on location.<sup>21</sup>

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21 Timberlake, James, and Stephen Kieran. *Refabricating Architecture*. New York, USA: The McGraw-Hill Books, 2004

## 2.3 EXISTING CONSTRUCTION

Building culture in New Zealand is based on techniques and methodologies used in fabricating our architecture, has remained rather unchanged. The construction industry in New Zealand has gone through some hard times. Auckland's leaky houses epidemic and Christchurch earthquakes, are two examples of the cost of poorly designed and constructed architecture. Though there has been an interest in experimenting in new construction methods, traditional techniques still remain constant. To create a concept for a new way of building, researching and understanding existing techniques will help develop a solution for all issues found.

### 2.3.1 TIMBER

Timber construction is the predominant form of building in New Zealand.

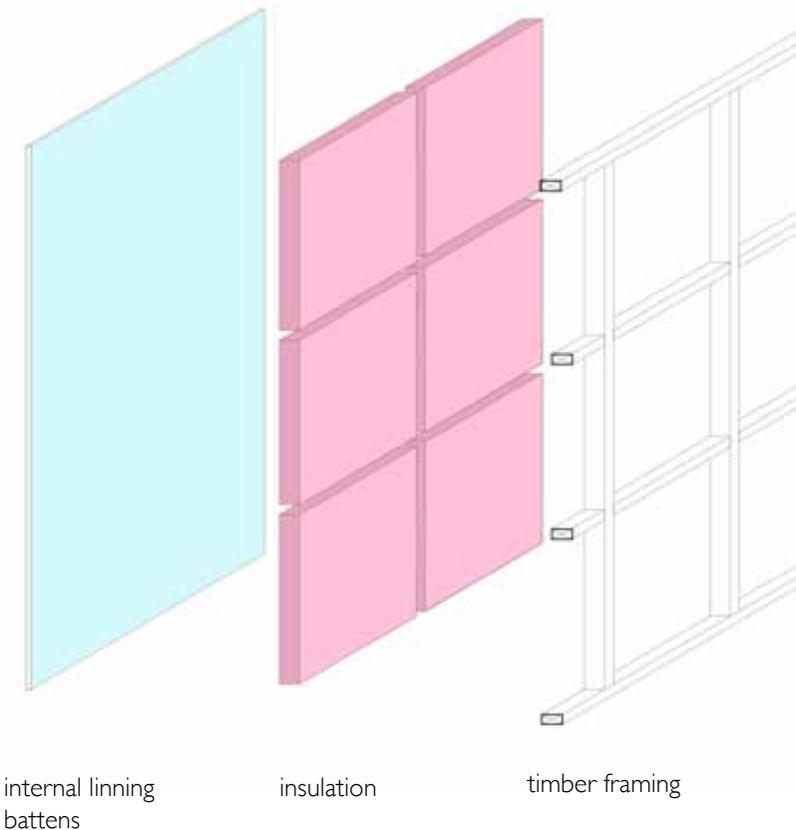
This is due to having an abundance of this resource, and it being a naturally renewable resource. It is lightweight in singular form, while having an excellent strength-to-weight ratio. It is flexible in construction, easily adaptable to various design features, while also giving the opportunity to adjust on site if there is an adjustment to the design. Timber is still the major form of construction also for its traditional status. We have predominately built with timber; been taught to construct in timber; and it generally seems to do the job correctly, so why change?

Timber, though renewable, is not reusable. In events like an earthquake, or even a renovation, timber is generally scrapped and not seen as being salvageable. Timber construction as a whole is a rather wasteful practice.

Timber-framed walls are constructed with a framework

consisting of vertical timber studs between a horizontal timber bottom and top plate, with nogs to give strength and stability. These nogs also create fixing lines for both the internal and external faces of the wall, giving variable methods of cladding that can be fixed at certain heights. Frames are generally prefabricated off site, by a pre-nailer and transported to site in large pieces. Once the frames are on site, they are positioned on a floor structure, as per the location on the plans. The bottom plate is first nailed down to the floor structure. Timber has a warp variance. It can bend and buckle over time due to its exposure to heat or moisture, and also can be slightly changed in the transport stage of construction. This means that the bottom plate has to be straightened to create a strong straight line. Once the bottom plate is straight, the next step is plumbing the vertical frames.<sup>22</sup>

<sup>22</sup> Timber framing – rapid and reliable [http://www.branz.co.nz/cms\\_show\\_download.php?id=da1eb1a5451c97b258c199dfabf24615b72e7647](http://www.branz.co.nz/cms_show_download.php?id=da1eb1a5451c97b258c199dfabf24615b72e7647)

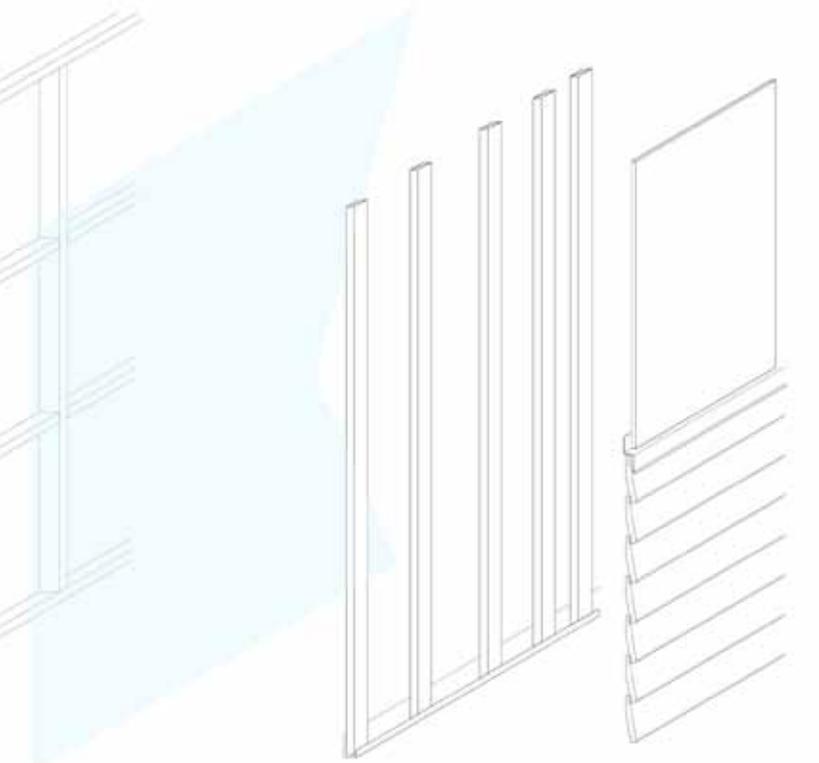


internal lining  
batters

insulation

timber framing

figure 2.4 Timber wall construction, showing the materials needed to construct a basic timber wall in New Zealand



building paper

battens

exterior cladding

Braces are attached to the frames and the floor structure at variable distances, and adjusted until a vertically straight wall is created. This process is repeated with every wall, until all wall frames are standing, ready for the next floor or the roof structure to be put in place.

Once all walls are erected and the roof is on, preparing external walls for cladding is next. In the past, building a wall was very simple. You erect a wall, you then wrap with building paper, you fix external and internal cladding and then you are complete. Now there is the adding of a cavity, insulation, bracing elements and preparation for window insertion. This has seen extra work for a builder as a cavity needs battens, cavity closers, and vermin strips, which have added time, thus increasing cost. Once this is done the external walls can have windows and doors put in and external claddings can be added. Internally, it is usually a simple task of adding required insulation and lining walls with materials like Gib or plywood.

As one can imagine, the

process of using timber is rather complex, and somewhat slow. There seems to be a want to add more layers as the solution, rather than trying to simplify the methodology to remove areas of error.

Timber is a renewable natural resource, with an attached "Green" label, but is it as green as it is made out to be? The chemical treatments that ensure that timber doesn't decay or gather mould are harsh, and not suitable for any environment. Recently an article relating to building materials in New Zealand stated that many timber products are full of harmful and hazardous chemicals, which could damage our environment.<sup>23</sup> With construction accounting for 50% of all New Zealand's waste going to landfills, removing even the smallest percentage will only benefit the land and people.<sup>24</sup>

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23 Treated Timber; Toxic Time-bomb: The Need for a Precautionary Approach to the Use of Copper Chrome Arsenate (CCA) as a Timber Preservative [http://www.justice.govt.nz/courts/environment-court/documents/attachment-02\(2005\)](http://www.justice.govt.nz/courts/environment-court/documents/attachment-02(2005))

24 Construction and Demolition Waste-

### 2.3.2 CONCRETE BLOCKS

Concrete masonry blocks are a suitable form of construction, for a wide variety of works. Concrete blocks have an aesthetic quality as well as structural strength.

The benefits of concrete blocks are; a high fire rating, sound control, and energy efficiency. The most valuable of benefits when using concrete block construction is the ability to become a thermal mass. This can benefit households through better interior comfort levels, while also reducing energy consumption, making this a more cost-effective material<sup>25</sup>.

When it comes to construction, using concrete blocks is a specialised skill. In most circumstance, a builder will employ a block layer, due to complexity and required detail.

Complex shapes and styles

Best Practice and Cost [http://www.branz.co.nz/cms\\_show\\_download.php?id=2ceae0b5459983af6e369891d170d00771d2ebd](http://www.branz.co.nz/cms_show_download.php?id=2ceae0b5459983af6e369891d170d00771d2ebd)

25 Firth, "Masonry & Architectural Masonry", <http://www.firth.co.nz/product-information/commercial/masonry-architectural-masonry.aspx> Accessed Sept 2014

can be built with concrete blocks, but even the simplest of forms have complexity. "Do-it-yourself" block work is hard, and would not be recommended, especially if the wall is to be structural.

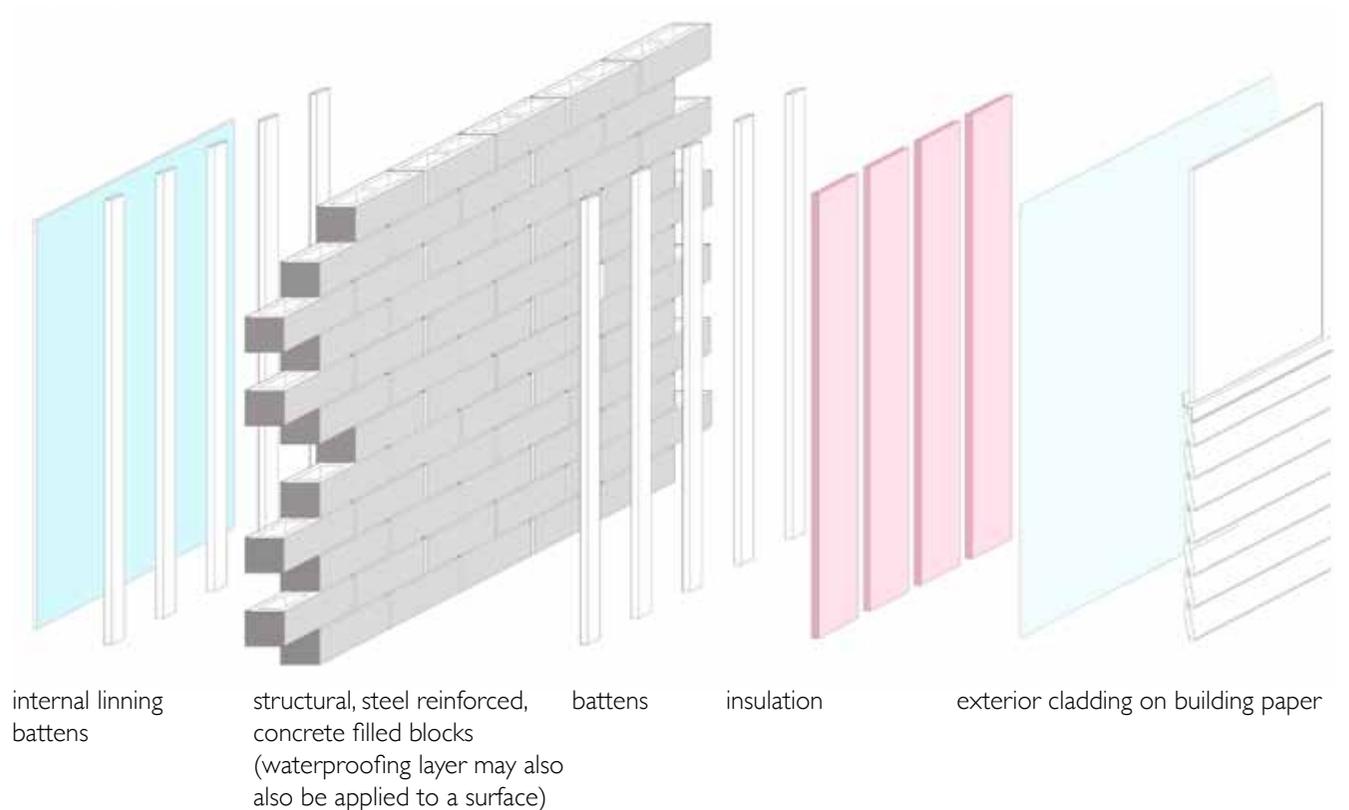


figure 2.5 Block Construction, showing the materials needed to construct a basic concrete wall in New Zealand

### 2.3.3 PRECAST PANELS

The use of pre-cast panel systems for the walls of a concrete home offer the opportunity to control the quality of the end product to a very high degree, as pre-cast panels are usually supplied from specialist precasting factories. Pre-cast panels are prefabricated, usually off site. Casting panels from the mould can also help reduce building costs by creating multiple panels from one mould. Surface finishes are possible using pre-cast panels. To create unique finishes for the exterior, a pattern can be imprinted during formation. Once revealed, the imprint can form a continuous pattern or language. This can eliminate the need for any on going coatings or other decorative finishes. Pre-cast construction is often chosen as it also offers the same thermal mass benefits as concrete. Due to limitless flexibility of shape and size, consideration of placement and treatment of joints are the designers' and builders' major issues.

Because pre-casting is usually prefabricated off site, this gives the contractors time to prepare the site, organising around delivery dates of panels, to help keep construction time down. Once the floor slab or foundations are made ready to accept the system and the panels are delivered, it is often possible to erect all of the walls within a day, and have the house closed in and secured shortly thereafter.

Pre-cast panels are large, heavy, slabs of concrete. Large machines are required to pick up and place each individual panel in place. There is no room for error, and if one is to occur, it will be a costly mistake.

Pre-cast panels are rather a time-efficient form of construction. The shell of a building can be erected very quickly. This application has limitations when it comes to site location. Due to the size and scale of most panels, on rural sites, with limited access, vehicles would struggle in delivering the panels.



figure 2.6 Precast panel transportation , being craned onto site



figure 2.7 Precast panels standing on site



figure 2.8 Precast panel finished with a timber touch detail

### 2.3.4. STRUCTURAL INSULATED PANELS

Structural insulated panels (SIP) are not new to architecture but they are still not common practice when it comes to residential construction. This three-layered wall system comprises two outer layers of structural timber materials with an polystyrene insulated core. These walls have excellent thermal capabilities, fire resistance and also have the ability to be load bearing. With their recent release from patenting, their development and availability has evolved and now many more products are available on the market.

The system works best as a modular system. One designs a building around certain dimensions, so that there is reduced cutting and wastage when it comes to panel sizes. Once a plan has been devised, the plans can be sent to the manufacturer and the panels can start being produced<sup>26</sup>. Every single panel is cut and labelled to

create easy construction. All windows and doors are already cut out, so this step can also be done in quickly.

The disadvantage of SIP panels is that they are not very flexible. If there is a mistake, or a change needed, the process, similar to pre-cast panels, is complex rather than simple.



figure 2.9 Structural Insulated panel section core, showing the make up of each panel



figure 2.10 Structural Insulated panel construction site example

26 ModPrefFab. <http://www.modprefab.co.nz/sips.html> Accessed October 2 014

### 2.3.5 EXISTING CONSTRUCTION CONCLUSION

Current practices for timber and concrete block construction are based on tradition, and are construction methodologies that people trust. There is a perceived honesty attached to traditional construction methods, as in what you see is what you get.

The issue that can be seen with many of the current construction practices is variability. When it comes to construction, the more variables there are, the more the construction is likely to cost. Whether it is transport or flexibility, changes mean increased costs.

Taking everything into consideration, creating a simple construction method will be the most complex part, while competing against that which has been around for generations and what is perceived to be standard practice. Convincing people that these practices are causing high

building costs and significant damage to our environment should raise the opportunity to facilitate pathways for new construction methods and materials.

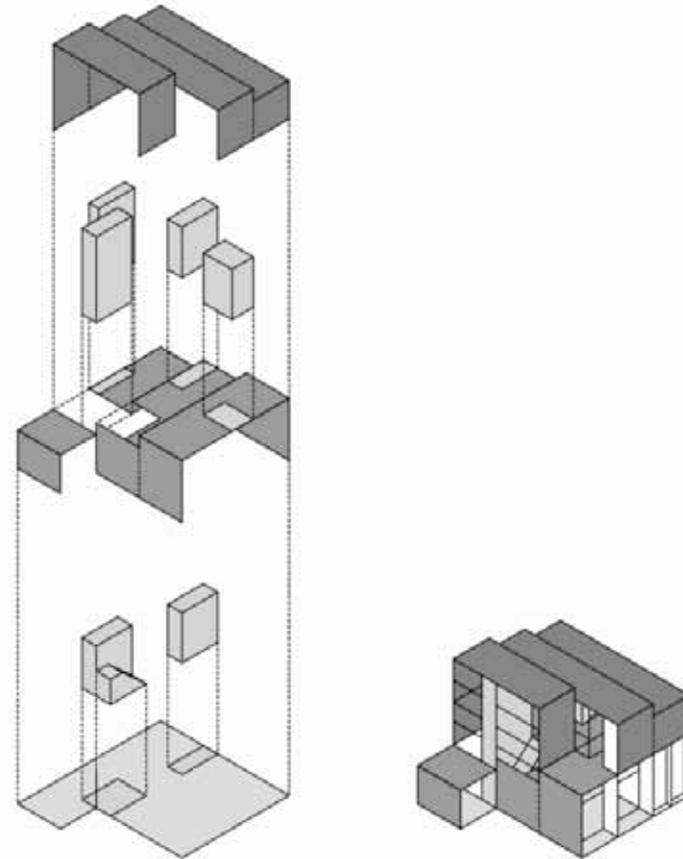


figure 2.11 Modular House Example, showing the piecing together parts to make a whole house

## 2.4 PRECEDENTS

### 2.4.1 CHRISTOPHER ALEXANDER PREVI / LIMA LOW COST HOUSING PROJECT:

In the mid 1960s, an “experimental housing project” was conceived in Lima. Peru’s architect President Fernando Belaunde Terry began formulating explorative processes, with the intent of controlling the flow of people seeking urban living, while also spreading the idea of self-built, informal *barriadas*, shantytowns, in urban Peru. The government of Peru submitted this to the United Nations Development Programme (UNDP) for an experimental Housing Project (Proyecto Experimental de Vivienda ‘PREVI’) which was approved in June 1967.<sup>27</sup>

This development was split into three pilot schemes to be implemented simultaneously in Lima.

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27 Christopher Alexander Previ / Lima low cost Housing project, <http://isites.harvard.edu/fs/docs/icb.topic892112.files/Previ/AD.pdf>

The main focus of the project was to develop methods and techniques, to then be applied afterwards on a larger and significant scale as part of Peru’s housing development policy. Architectural design can be used to design a solution, but if the solution is not financially viable, who is really being helped? This experimental housing development was to create construction systems to be used by the people.

In August 1966, the government of Peru initiated a design competition to formulate an experimental housing project which had, as its objective, the development of techniques utilising Peruvian and foreign experience<sup>28</sup>.

Christopher Alexander was one such architect who designed a system to create a simplified, flexible, modular component. The floor was a floating slab that was laid by a road-building machine. The walls were an interlocking system of mortarless

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28 ibid



figure 2.12 Lima, Peru photo taken during the experimental

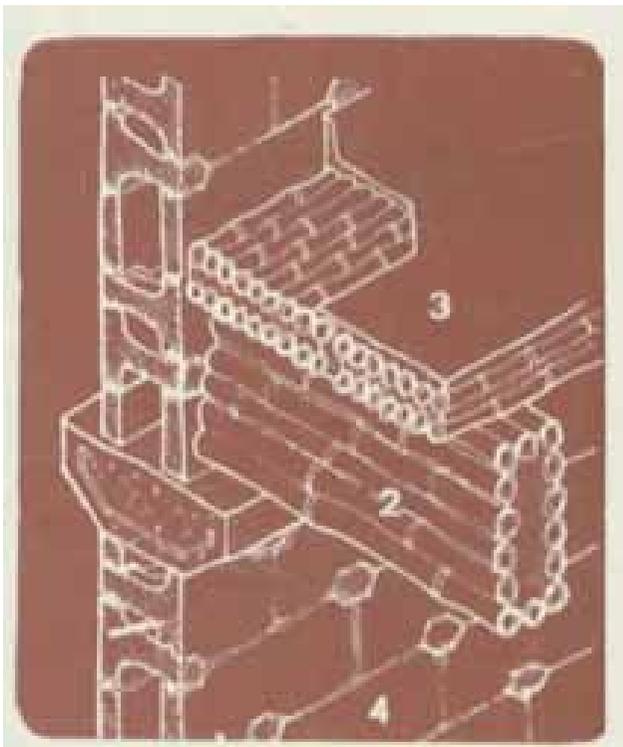


figure 2.13 Christopher Alexandra Construction system, detailing floor to wall detailing

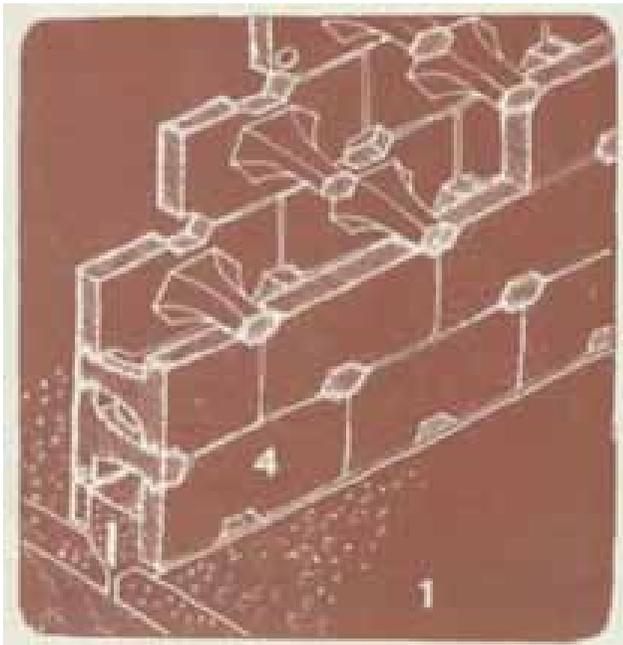


figure 2.14 Christopher Alexandra Construction system, this picture shows the unique block system that was developed

concrete blocks reinforced with sulphur. These blocks were constructed to have a cavity space to run all plumbing and conduits for power. The planks and beams were urethane foam-plastic and bamboo that was reinforced with a sulphur sand topping.

All building components could be produced with materials and skills available in Peru. The building materials were appropriate to the earthquake conditions.

To keep construction simple, all components were prefabricated on site. This created a situation where the houses were easily constructed by contractors, and then also easily changed by the families who lived in them. Christopher Alexander says, "We have chosen these components with special emphasis on the idea of future do it yourself construction."<sup>29</sup> The mortarless block gives the greatest opportunity for do-it-yourself renovation. These blocks can easily be removed or added to, and the hollow space makes it easy to access all plumbing and conduits. The moulds for the blocks was designed to be easily operated, meaning that people can easily

create their own blocks.

Currently there are still a few of these structures standing. They have been renovated and added to, giving each individual home a personalised flare. When it comes to standing up to conditions, they have lasted through all manners of environmental issues, even standing strong in earthquakes.

The design of these buildings is hinged off a pattern language of site design. Though the construction methodology is what is interesting for this project by creating a building system that is flexible and adjustable, there is a chance to redevelop a building according to the desired use of the occupants. The system is based on simplicity and flexibility, which it seems to deliver:

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29      ibid

## 2.4.2 STUDIO 19 SOCIAL HOUSING DE- SIGN

Run for two semester quarters in the third year of the Bachelor of Architecture at Unitec, 'Studio 19' is a design build assignment. Students, accompanied by Strachan Group Architects, are given the opportunity to be involved in a real world design and build scenario. The first quarter makes up the stage of the project where a house is designed around a brief set out by clients. Strachan Group Architects has had previous practice utilising prefab and modulation methodologies for design and construction.

In 2012 Vision West Church contacted Strachan Group Architects requesting a social housing strategy. Vision West's Community Housing programme is about offering and providing those in need with emergency, transitional and long-term supported housing in West Auckland.

Vision West would purchase sites with the purpose of building safe, healthy affordable quality houses. Previously they had contracted out the design and building of homes to housing companies, but they were not achieving the quality that they wanted.

The project brief in 2012 was for the development of two houses: a four-bedroom dwelling with a floor area of approximately 100 square metres and a two-bedroom minor dwelling with a floor area of approximately 65 square metres. The major concern when it comes to any social housing is budget. The goal was to design and build quality homes, not only spatially, but also structurally and based on the building materials. With this in mind, the architectural design was to be based on modules previously used in other Studio 19 projects.

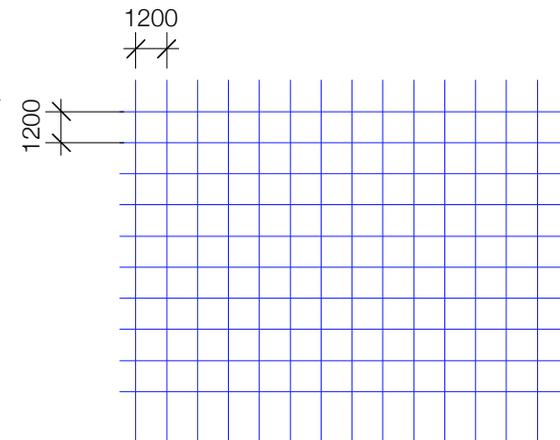
This was to be a prefabricated building project. As well as meeting the design requirements involved in modular, the buildings were to be moved to

site. These buildings would be craned onto trucks and then transported to site. This meant that all site preparation would have to be completed on time to ensure buildings were placed on the site on time.

The systems that were to be used were a module floor system called "Flexus", a modular structural insulated panel wall system, and "Kingspan", a modular roof panel system.

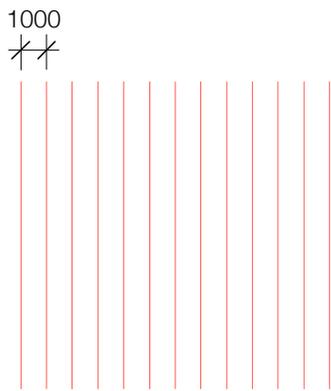
These systems were all new to every student on the project, and as a design-build project, this meant a new way of designing and then understanding the product's practical application when construction began.

The designing side was initially different. It had to do with creating lines of modular dimensions and trying to get all systems to work within each other's parameters and requirements. Once the design was completed and we were on site, there were a few issues that could be seen but were not considered during design. The floor sys-



1. SIP Panel Layout

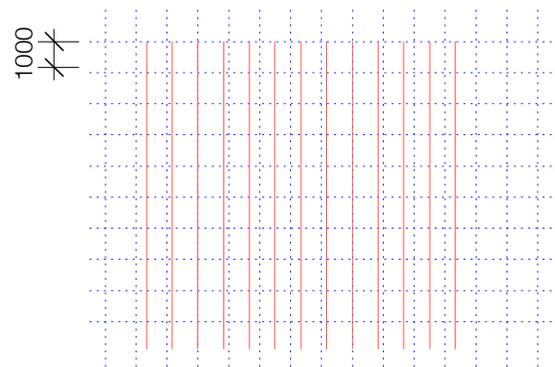
figure 2.15 Studio 19 Modular set out that was employed during the initial concept stage



2. Flexus floor layout



3. Roof Panel Layout



4. Layout combinations

tem used had unforeseen extra work attached to it, this was due to manufacturing side effects. A lot of extra time was spent levelling out the floors to create a level base to drop the walls on to. The structural insulated panels were not as fast to erect as initially believed. There was a lot of ground preparation, and the connection between panels was considerably messier in practice than expected. If the polystyrene was not perfect, the timber inserts to join panels together would not fit, meaning extra work and more time. The other issue was that the services could not be run through the walls once the panels were made. The services had to be run internally, through conjoint, which had to be installed prior.

The walls also had no flexibility once delivered to site. Additionally the walls were to be lined externally and internally. The internal surface could be left bare, with a sealant treatment. But the external needed the same considerations of timber-framed walls.



Figure 2.16 (above), 2.17 and 2.18 (below) Studio 19 site photos

Figure 2.19 (above) Studio 19 render and 2.20 (below) Studio 19 completed





and site photos



Building wrap was applied, and then cavity battens and exterior ply cladding.

In the end, it seemed that traditional timber-framed external walls still had more merit than the structural panel system used, especially when all internal walls were timber framed.

The only truly modular system that lived up to expectations was the roof system. The roof panels were easily installed and did not require much labour. The 65-metre square roof was laid in roughly two hours, from start to finish. The only downside was that again there was no ability to run services through the roof once panels were completed.

In the end the quality and design was superior to what Vision West had received and they were very pleased with result. The structural insulated panels were a welcome addition because they were solid timber, lessening the likelihood of damage.

Designing with modular in mind, as well as transport specifications,

required a different design approach. The size of modular panels created certain dimensions to design within. This meant that flexibility of shape and form was limited.

The overall construction of the building would not be suitable for a do it yourself enthusiast due to the size and scale of the objects, and the knowledge required need to bring all elements together.

The end design engaged with the site, and created two homes that were unique in design and considerate to the surrounding environment.



3.0 Design

The design process will be split into two sections.

The initial section will concentrate on developing a modular construction component. Throughout this section the process of designing, fabricating and testing the modular component will be documented. The component concept will be fast, simple; building practices that can be manageable by anyone with the want to undertake do it yourself. Within this section there will be precedents of previous examples of modular architecture, and how these processes have contributed to the block concept.

Secondly, the component will be engaged on a selected site to show its architectural intent. This will demonstrate the uses of this component in regards to construction, demonstrating variation in the component's use and also showing typical architectural details.

The function of a wall is set, to provide structure between floor

and roof, and provide protection for the occupants on the interior of the structure.

Precedents will show attempts at redesigning the wall construction techniques, and try to establish why many of these new techniques are still not utilised.



### 3.1.1 COMPONENT PRECEDENTS

#### Frank Lloyd Wright – Usonian Block

Architect Frank Lloyd Wright thought all people should have their own home on their own land. To make this dream a reality, in 1955 Lloyd Wright designed a concrete masonry system that could be built, similar to Lego™ blocks. Lloyd Wright designed this concrete masonry system with the young, middle-class homeowners in mind. It was meant to be an inexpensive form of construction, with an informal style of architecture<sup>30</sup>.

Lloyd Wright's system was designed so his concrete blocks could be laid up without mortar. The blocks are held together instead by #3 rebar's running vertically and horizontally in the joints. The 1x2-foot blocks are usually 100mm thick, solid cast or with window openings. The steel rebar are centred

in pockets formed by semi-circular grooves formed on all joining sides of the block. To make the structure solid, grout is either pumped or poured into the pockets, fixing the rebar into place. This process occurred after laying two courses. Lloyd Wright created these blocks using metal moulds, and also constructed a variety of block designs. Not only could the blocks be variable, they could also differ in colour, and could be cast with different textures and patterns applied.

The end result was a block that was decorative that could be used in many capacities of construction. Walls were not the only function, and fireplaces, balustrades, balconies, piers and gardens were seen as possible uses for this block. The function of this block was limited only by the architect's imagination<sup>31</sup>.

31 "Frank Lloyd Wright's Usonian", [http://www.masonryconstruction.com/Images/Frank%20Lloyd%20Wright's%20Usonian%20Automatic\\_tcm68-1375850.pdf](http://www.masonryconstruction.com/Images/Frank%20Lloyd%20Wright's%20Usonian%20Automatic_tcm68-1375850.pdf), 1998

30 Hurd, M.K. "Concrete in housing, Usonian Automatic: Wright's concrete masonry" PUBLICATION #C881028 The Aberdeen Group, 1988

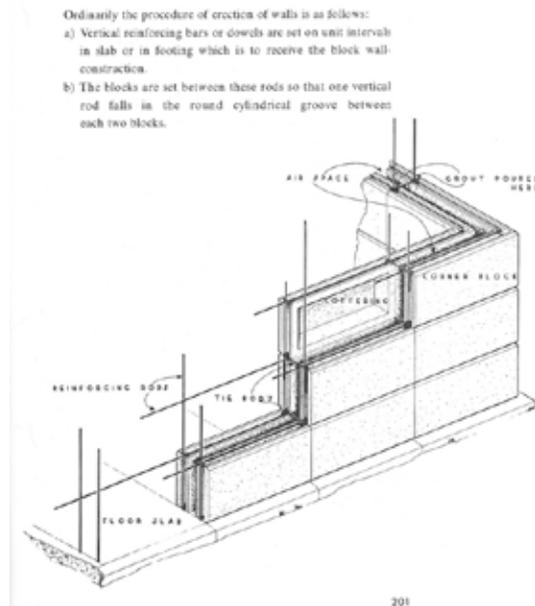


figure 3.0 Frank Lloyd Wright's Usonian Block

### 3.1.2 Architectural Applications for 3D Printing

Experimentation in building construction is now beginning in areas that are compelling, but have uncertainties attached. 3D printing is gradually becoming increasingly available, especially as a tool for architecture. Design firms and manufacturers are using this new method to enable a generation of innovative, intriguing, building blocks and assemblies<sup>32</sup>.

Two architectural practices in the USA that embody this change in process are Emerging Objects and Smith Allen Studio, both from Oakland, California. These firms represent promising pathways for the integration of 3D printing in architecture, each with its own unique set of ambitions and challenges<sup>33</sup>.

Bryan Allen and Stephanie

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32 "Architectural Applications for 3D Printing" by [http://www.architectmagazine.com/Technology/digifab-update-architectural-applications-for-3d-printing\\_o.aspx?utm\\_referrer=](http://www.architectmagazine.com/Technology/digifab-update-architectural-applications-for-3d-printing_o.aspx?utm_referrer=) (2015)

33 *ibid*

Smith of Smith Allen designed and constructed an Echoviren shelter. The shelter was made of 500 individually printed parts and was assembled on site in a redwood forest in Gualala, California.<sup>34</sup>

Emerging Objects recently researched printing with more durable materials. They printed structures out of sawdust, cement, and ceramic. There were also attempts at using rubber from recycled tires, glass from broken windshields, and salt from the San Francisco Bay. Currently, a developer in Beijing, China, to design and print a series of houses, has commissioned them. Emerging Objects wanted to 3D print a house that did not lose its architectural relevance to a 3D form. The process will be about creating parts and materials that are different, from floor to ceiling.<sup>35</sup>

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34 "Build by Number", by Shonquis Moreno, <http://www.architectmagazine.com/technology/smith-allens-3d-printed-pavilion-features-a-natural-form-with-high-tech-roots.aspx>. (2013)

35 "Material Focus" By Alex Hoyt [http://www.architectmagazine.com/architects/next-progressives-rael-san-fratello\\_o.aspx](http://www.architectmagazine.com/architects/next-progressives-rael-san-fratello_o.aspx) (2014)



figure 3.1 Echoviren shelter



figure 3.2 Echoviren shelter



figure 3.3 3d Printed block

These are two examples where 3D printing offers a unique direction in production. There is now an opportunity to start bridging the gaps between virtual and physical realms. With the continual development in software and material research, there will be more possible building methods slowly emerging, as confidence grows and knowledge increases.

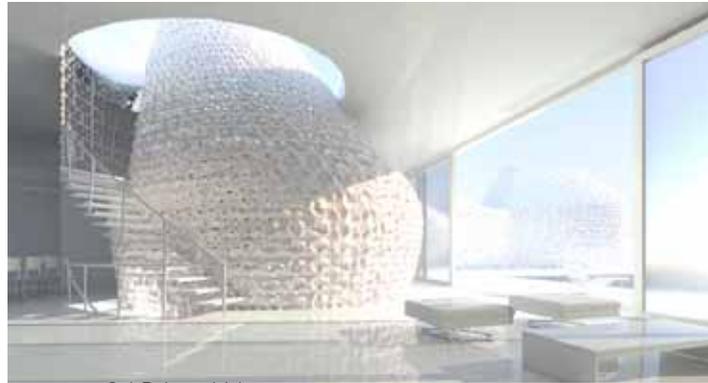


figure 3.4 3d Printed House



figure 3.5 3d Printed experiment

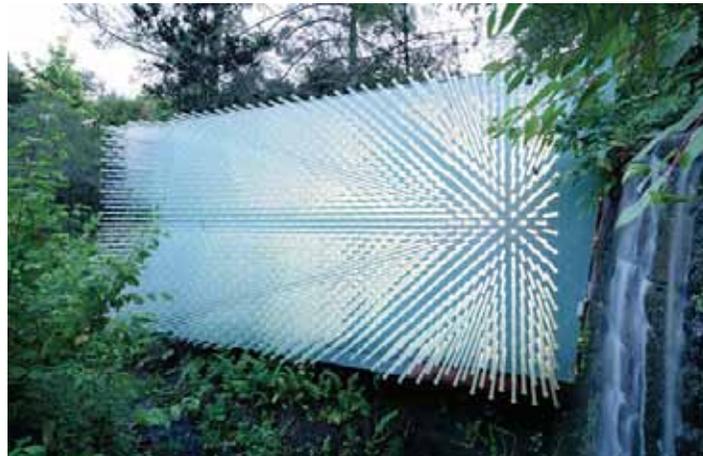


figure 3.6 3d Printed example

## 3.2.PROTOTYE INTRODUCTION

The form of the component is derived from connections and constructability; form follows function (reference), with the main function being simplicity. As Lego is to children, the components must easily be pieced together, requiring simplicity in construction, coupled with structural integrity and an aesthetic finish, though the finish can always be adjusted to suit the surrounding vernacular. Basically, this form must be easily assembled with very little instruction and supervision.

With this said, there must be an element of intuitiveness of the cognitive problem solving. This is seen when children play with Lego. As with Lego, the user will be able to purchase the components and piece the elements together to build a wall.

Recycling will be the main criteria when it comes to the materiality. With the consumption of natural materials being high, moving away from wasting natural resources will help stimulate a greener future.

### 3.2.1 PROTOTYPE MATERIALITY

The process of diverting waste from landfill, and combining it with a binding agent (similar to a Thermo set Polymer process), is the intention to be developed on, in the production of a component. The idea is to form a system that is reusable; developing a single component that is constructed can be re-introduced into the system.

Plastic waste, construction waste and tyres are all used as filler materials. When it comes to the binding material, a suitable element will be chosen that allows the consumption of waste while also assisting in strength and durability. Considering the life cycle of the block from construction will help reduce waste entering our landfills. If the end component is recyclable, not disposable, the block can be continually be reintroduced into the system to create a continuous circle of life.

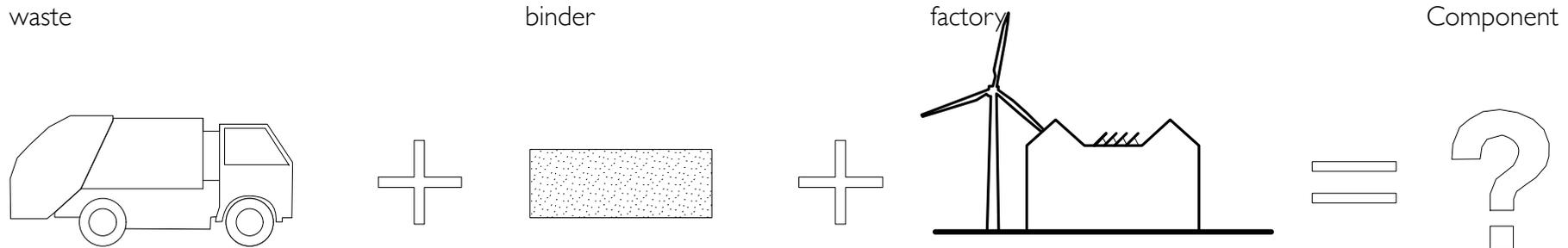


figure 3.7 Material thought process

### 3.3 PROTOTYPE DEVELOPMENT

#### 3.3.1 PROTOTYPE ONE

Initially, sketches were randomly drawn during the research stage. Concept ideas were developed through precedent studies, taking the positive and negative of the construction methods and using these to fuel thoughts. Connections between different building elements were the first concern. Having a system that had the ability to be flexible with other materials was important to incorporate into current building practices.

Also, from studying the nodules found on Lego, a service channel will be built into every block. With many modular products not having accessible services, implementing this channel will

The first prototype is a direct result of the redesigning of the standard concrete block, while beginning to bring

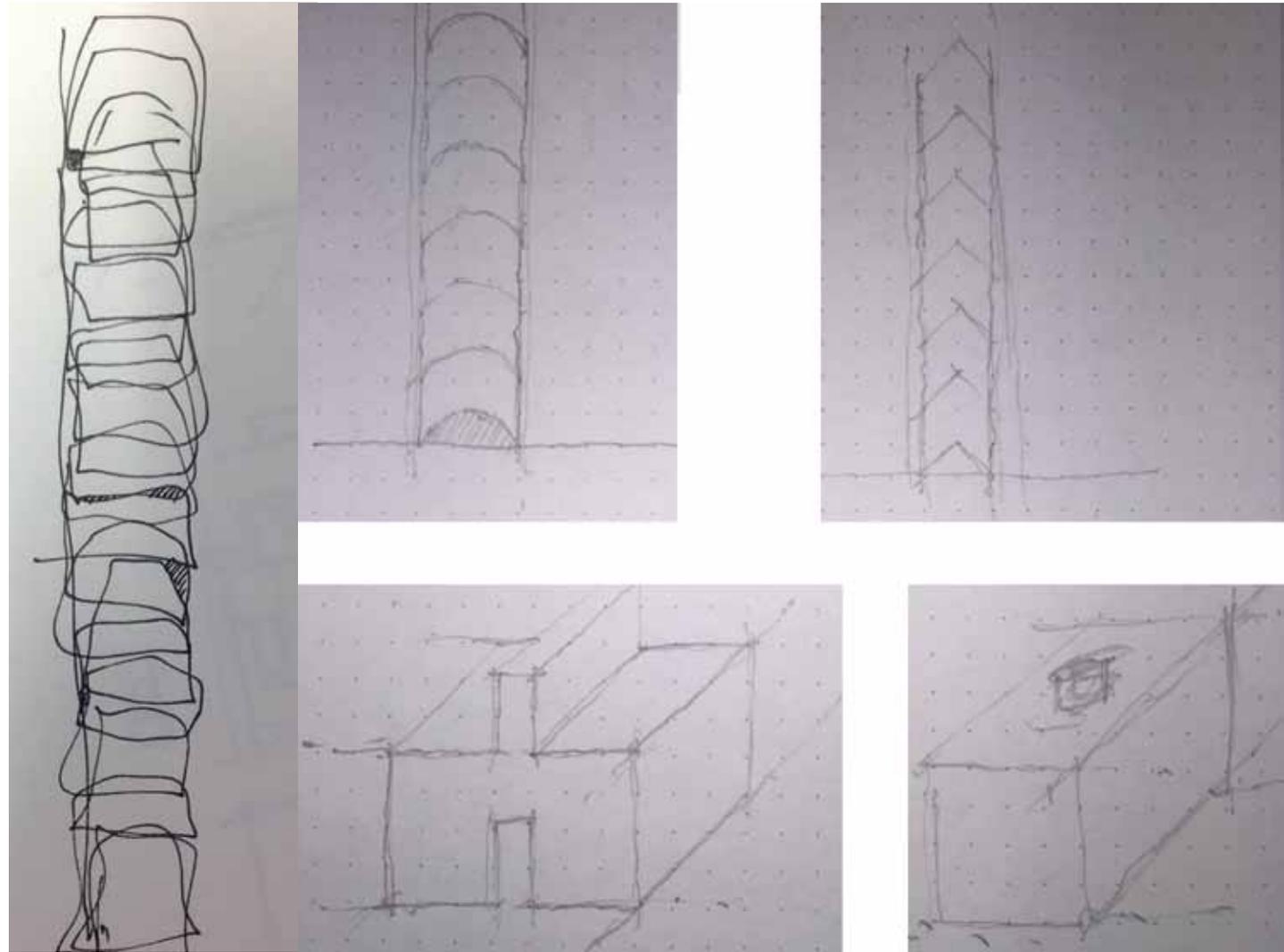


figure 3.8 Concept sketches for wall ideas

Lego block principles of stacking and joining into the design process.

This is also the first attempt to produce a block by making a mould. Similar to Frank Lloyd Wright's Usonian block, this hands on mould fabrication raises questions regarding mould construction processes.

Prototype one is based on knowledge from precedents and existing building techniques.

To form the prototype one mould, the outer dimensions of the block had to be constructed. When the form was filled, the block dimensions would match those specified in the drawings.

Using recycled MDF, sourced from a local kitchen company, the form started to take shape. It was decided that to make the mould multiple use, it should then have the ability to be pulled apart. The mould was pinned and glued on some joints, and screwed and fixed on others.

In preparation for pouring the



figure 3.9 Concrete Lego

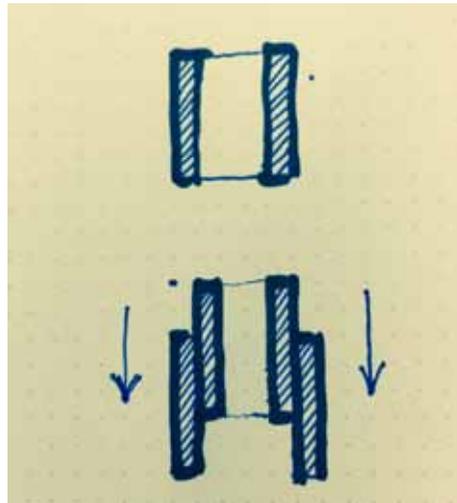


figure 3.10 Block sketches, The process of subtle change of a typical cinder block

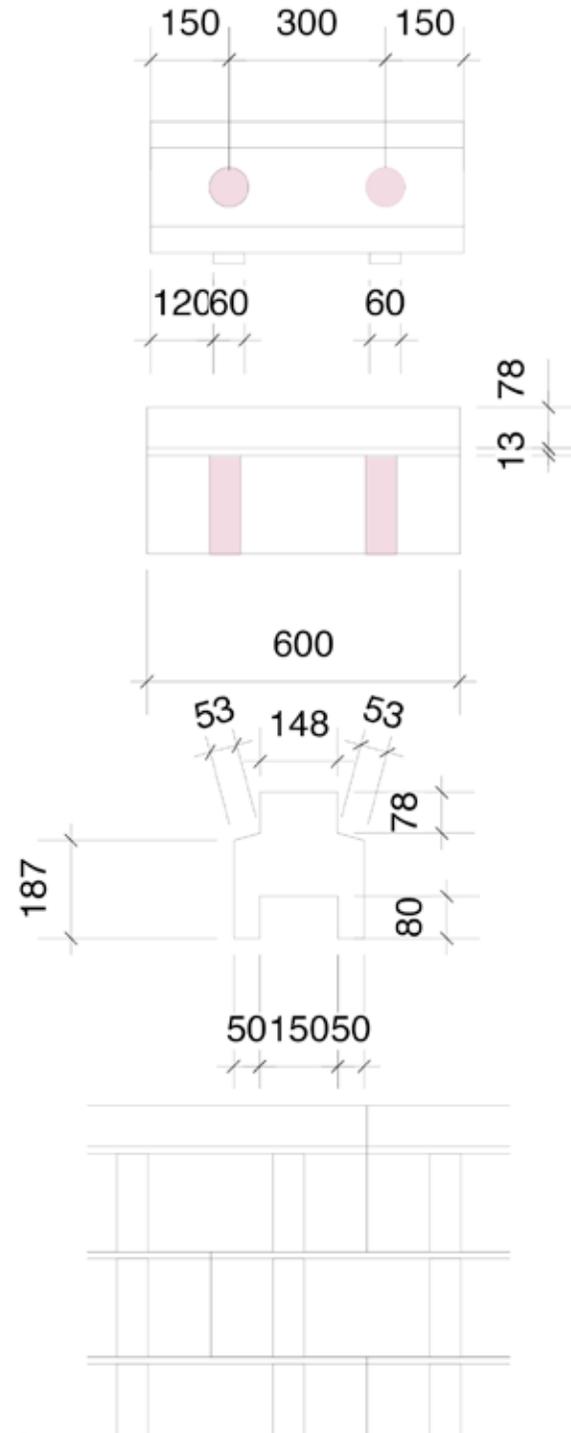


figure 3.11 Block dimensions.

plaster, every internal surface of the mould was sanded lightly to create a smooth surface to apply polyurethane. This surface protected the MDF from the moisture from the plaster mixture. Two coats were applied and before the plaster was poured into the mould, oil was also applied to each surface. This would aid in the releasing of the block from the mould. A painted piece of MDF was fixed to the bottom, as the paint also created another smooth surface, preventing plaster from sticking.

Now that the mould was prepared, plaster was mixed by hand to a desired consistency. Once this was achieved, the plaster was poured into the mould. No leaking could be seen, and the mould was hammered lightly on all sides, to try to release any air bubbles trapped.

The process is rather slow and complicated. Most drawings were done by hand and many dimensions were measured, not giving the greatest accuracy. It is important to start this

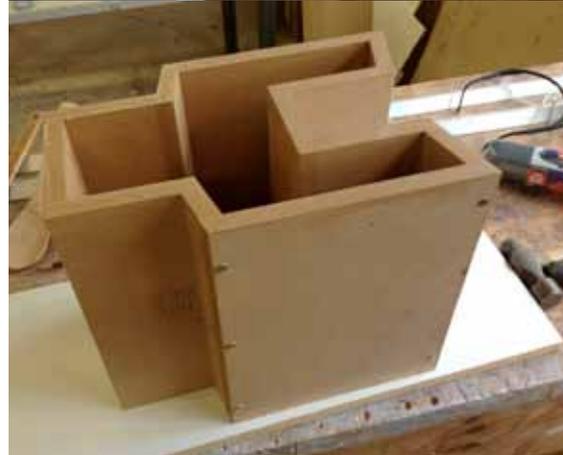


figure 3.11 mold construction , the images show the construction process of building a mould for the block

process using the traditional New Zealand do it yourself attitude, as it will give a better understanding of how everything is built, hoping that when technology is included, there is a base understanding, giving better results.

Now that the plaster has had 24 hours to set, it is time to pull the mould apart. There are many issues that could occur when creating a mould, such as leakage, trapped air bubbles, or the worst, that the mould won't come apart. As the screws are slowly pulled out, the first panel just falls off to expose the smooth plaster surface. This process was repeated until the first block was revealed.

The process was then repeated, to then give another block to test connection.

Once the second block was free from the mould, the testing could begin. Initially the blocks did not slot over each other. This was due to the degree of flexibility/give in the MDF mould, meaning that dimensions were



*figure 3.12* Block Construction, the plaster has been poured in, and then the mould is removed showing the final plaster block



*figure 3.13 Two blocks stacked, showing construction detail*

not exact. The plaster block sides were sanded down, using a surform rasp. This then created space, and the blocks fitted snugly together over each other.

As this was the first block concept, expecting to resolve all issues was not a realistic possibility. This block was always going to fail. It would begin creating questions and understanding of what was trying to be achieved. This would influence design, designing a smarter and simpler option.

The blocks came out all from the moulds easily due to preparation. Due to the movement in the MDF, and inaccuracies in construction, there was a lack of exactitude in the blocks. This resulted in the block being slightly warped, meaning the blocks did not fit together. Once they had been sanded, the blocks fitted snugly together. At this point, it was noticed that the bottom edges of the block were rather pointed. These edges would not take easily to continual movement and being placed on the ground, likely resulting

in the edges being damaged and the clean line being lost. So the first issue raised was whether or not the blocks needed a tapered edge on all sides, but rather the bottom edge becoming flat to create strength, and reworking the shape to be closer to proportionally correct.

The other major issue was incorrectly proportioned. Reworking shape and scale would improve connection and also ensure efficiency in materiality.

### 3.3.2 PROTOTYPE

#### TWO

The second version of the block uses the addressed issues from prototype one. Firstly the drip edge was reworked. Looking at water disbursement, how would it be drained from the building? Edge A still has a 15-degree fall, to stop water pooling, whereas edge B was flattened, ensuring that it would not be damaged in handling. There was also consideration regarding isolating this slope to only one side, creating interior and exterior faces. This idea was quashed to keep the idea of block as simple as possible, and reducing human error when it comes to construction.

The construction of the mould was similar to the existing methods used to build prototype one's mould.

With the previous block moulds, a plaster mixture was used. For this prototype, plaster will still be used, but there is the opportunity to experiment with materials. With Lego™

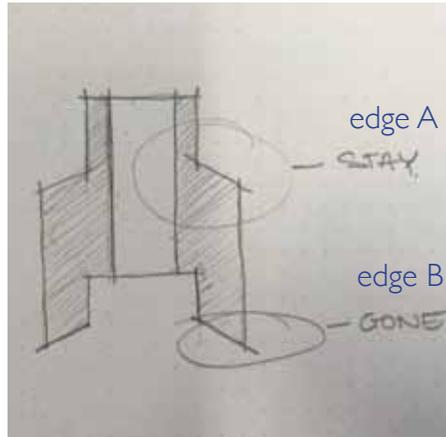


figure 3.14 Block reworked sketches, noting areas of concern with current block

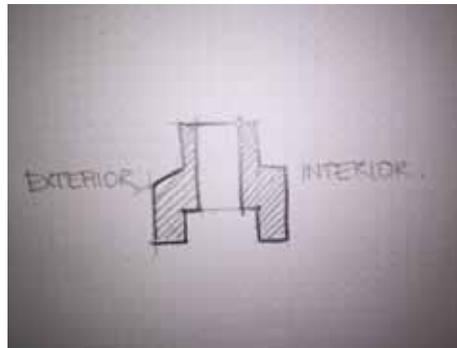


figure 3.15 15 Block reworked sketches, possible changing of design to show interior and exterior sides of block

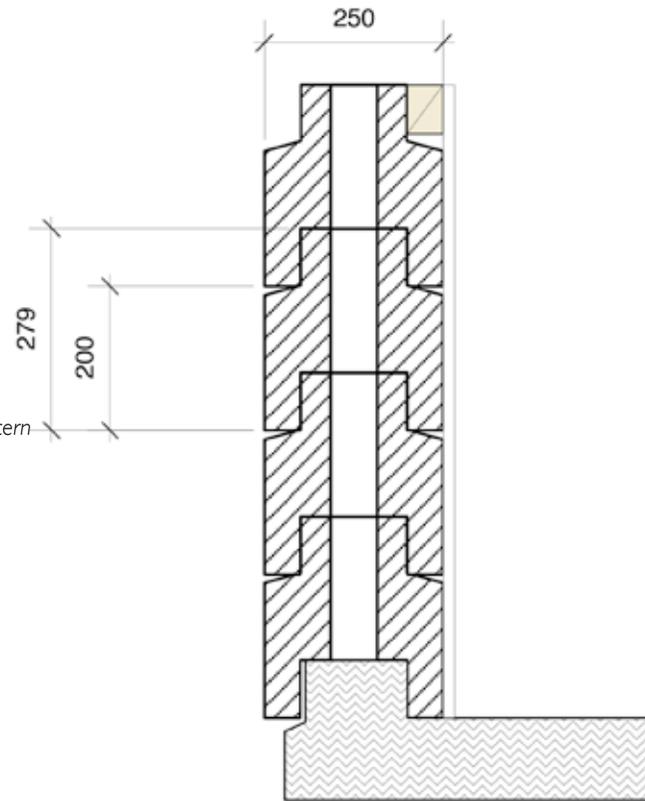


figure 3.16 New Block Dimensions as a small wall

being made out of plastic, there was an inherent want to construct the blocks out of plastic. The idea was to use waste material to create the body of the block. The first material to be used was wax. The reason wax was chosen was because once it was solid, there was the opportunity to modify (drill holes) to check connections.

Secondly, a plastic block was made. The first acquisition was waste material. A metal recycling company in Onehunga, Auckland, removes copper wire from abandoned electrical wire. Using raw plastic purchased as the binding, the next step was to see how both plastics reacted to heat.

Using gas supply and cooking pots, this process to heat up waste plastic began. The waste material took a long time to melt. It never made it to liquid form, the consistency being similar to sludge. With the heat it was thick and had the ability to create forms. Once it had cooled it, it had created a solid plastic form.



figure 3.17 Plastic Block construction, Waste material melting test



figure 3.18 Waste material test result, a solid plastic ball

With this experiment completed the melting of the waste plastic was not required; it would be used as filler, added at the final stage.

Melting the raw plastic first took 15 minutes. It became a viscous consistency. The thought was to combine roughly 25% of raw plastic, to 75% of the waste plastic. The waste plastic was to be added just before the plastic was to be poured into the mould.

The plastic mixture was poured into the mould. Once it had cooled, the mould was pulled apart, revealing a plastic block.

The issue with this block was tolerance. The block's dimensions did not create a perfect grid system. For this system to work, the block must transfer into a modular grid system, similar to that shown in the Studio 19 project.

The 250mm width did not transfer to 600mm length. This meant that the width would be increased to 300mm.



figure 3.19 Raw Plastic which was purchased from a supplier was melted



figure 3.20 (above) and 3.21 (below) Raw plastic mixed with waste material in the mould, preparing to dry



figure 3.22 Plastic Block cooled and removed from the mould



figure 3.23 block combined with plaster



### 3.3.3 PROTOTYPE

#### THREE

The final iteration of the block will express the implemented concept in architectural intent. The next step will be the fabrication of a steel mould, to begin mass production of the blocks. The one-to-one scaled blocks will have service ducts added. This will show simplicity in how services are added.

Next, the produced blocks will be structurally tested. A built section of the wall will go through a series of tests to give data regarding its structural strength. This will give the constructed block validation and also show how quickly and easily the wall is constructed.

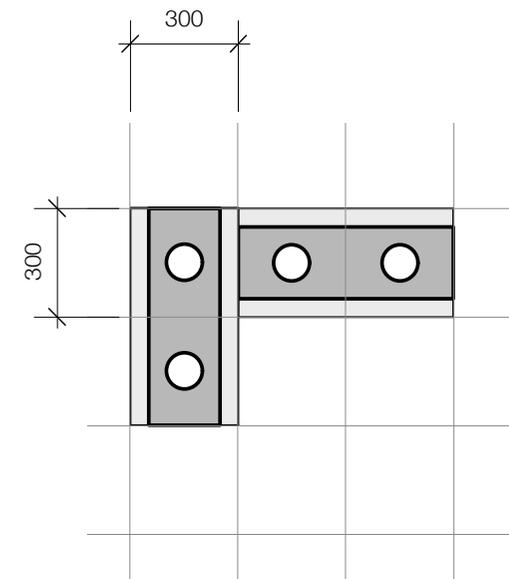


figure 3.24 Grid and block dimensions, showing the dimensional grid for designing

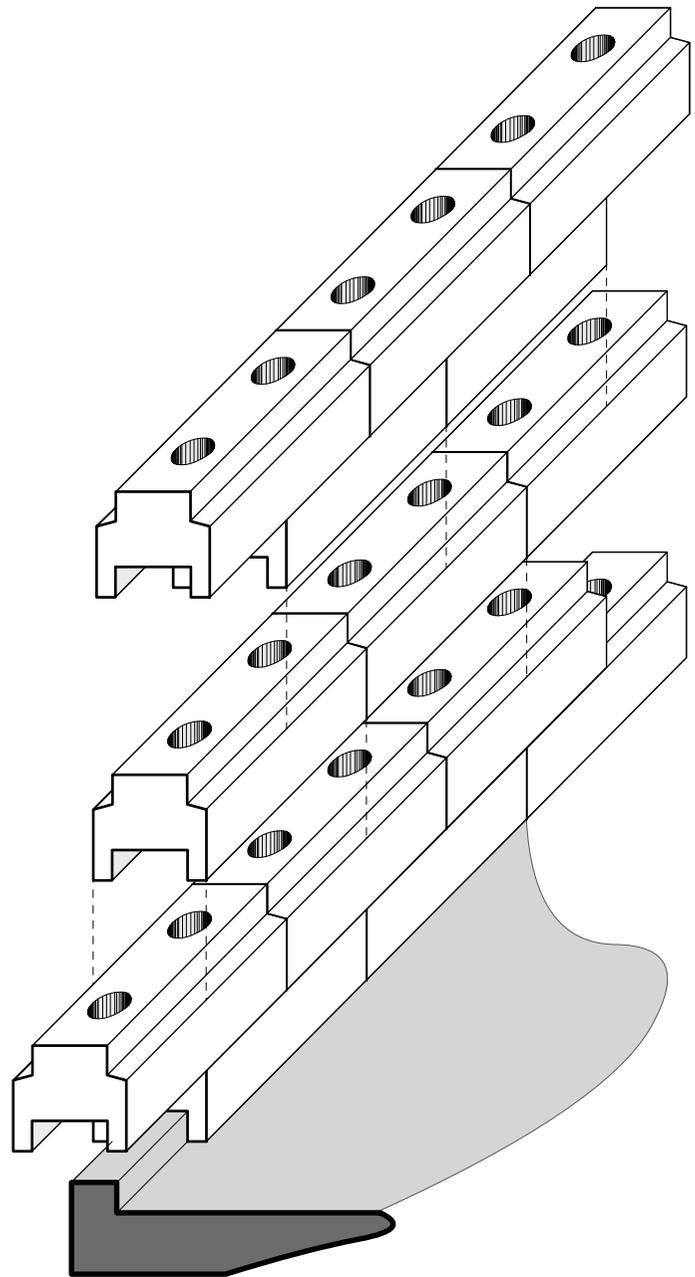


figure 3.25 Block wall proposal drawing

## 3.4.ARCHITECTURAL INTENT

### 3.4.1 SITE DESCRIPTION

This site was chosen due to its location and the existing building located on the site.

The site chosen for this project is in Muriwai, north west of Auckland.

Muriwai, also known as Muriwai Beach, is a coastal community located on the west coast of the Auckland region. Muriwai is part of the Rodney District, and is approximately 17 km from Kumeu and 42 km from Auckland's central city. Muriwai Beach has black sand as a result of the iron content of the sand. Muriwai Regional Park takes up most of the southern end of Muriwai Beach. Muriwai is a 50-km long stretch of beach, with Maukatia (Maori Bay) to the south, separated by Otakamiro Point. This point is a series of steep cliffs, and is home to a nesting gannet colony.



figure 3.26 New Zealand



figure 3.27 Site , Muriwai

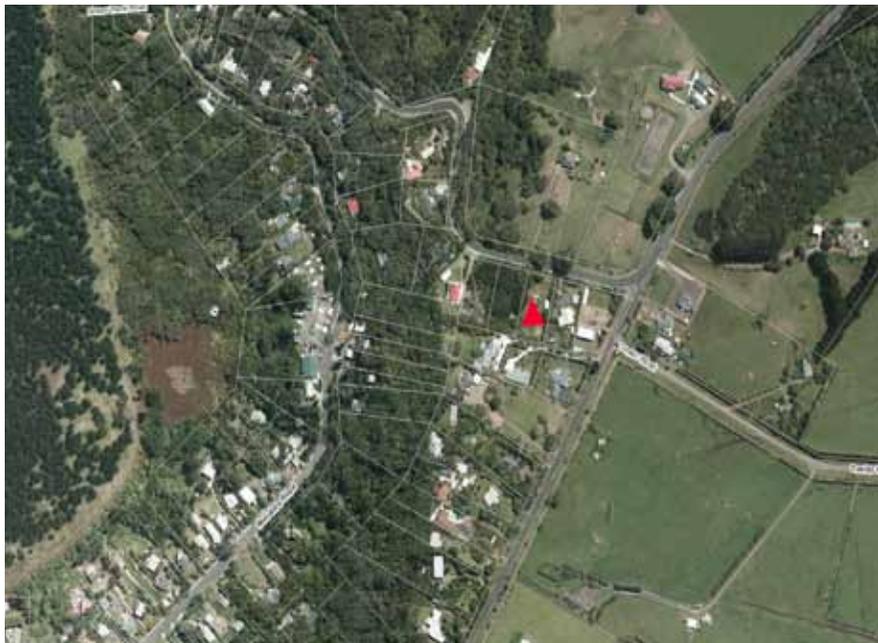
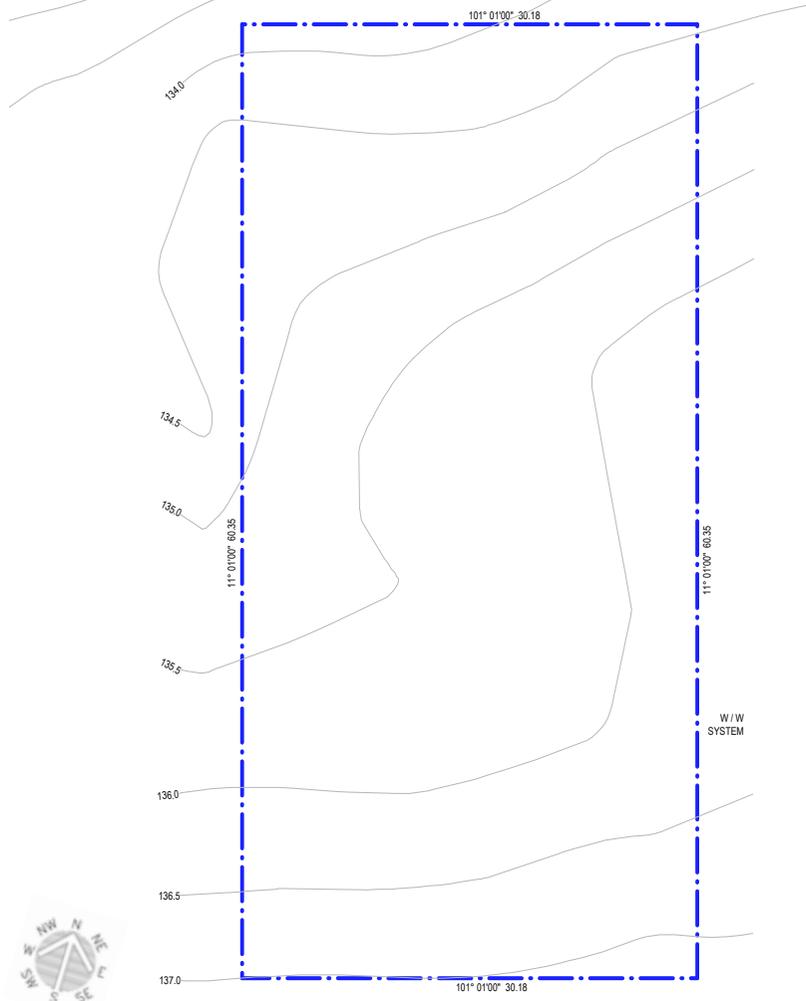
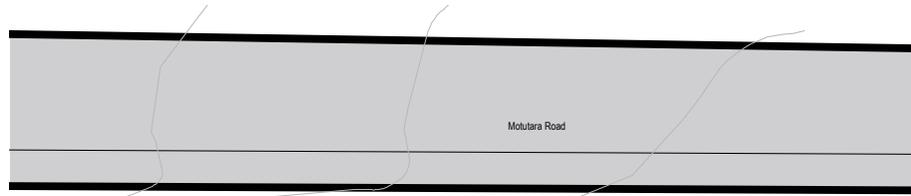


figure 3.28 (above) and 3.29 (below) Site , Muriwai



This 1827-square metre site has a timber-constructed cottage located on the rear, southern side of the site. The land has a slight down gradient from the southern boundary to the north (where the road is located). The site has a lot of natural vegetation, and has a large expanse of grass. There is no apparent view, but if you can gain height it is possible to see water to the west.

The conditions are rather harsh in Muriwai, which is ideal for testing this building block. The prevailing south westerly wind brings salt and sand spray, which can cause damage and or increase building decay/erosion.



The first site visit showed the beauty and simplicity of this site. Walking onto the site off the road, the small cottage appears. Slightly dwarfed by the size of land, the house is positioned at the south side of the site, slight raised. The site slopes gently from the southern boundary to the north boundary (road side).

Figure 3.30 Site, bare, showing basic boundary and contours

The site is surrounded by a variety of established and juvenile flora. One of the largest trees on the site is just to the west of the house. This tree has an attached sense, “heart of the site”.

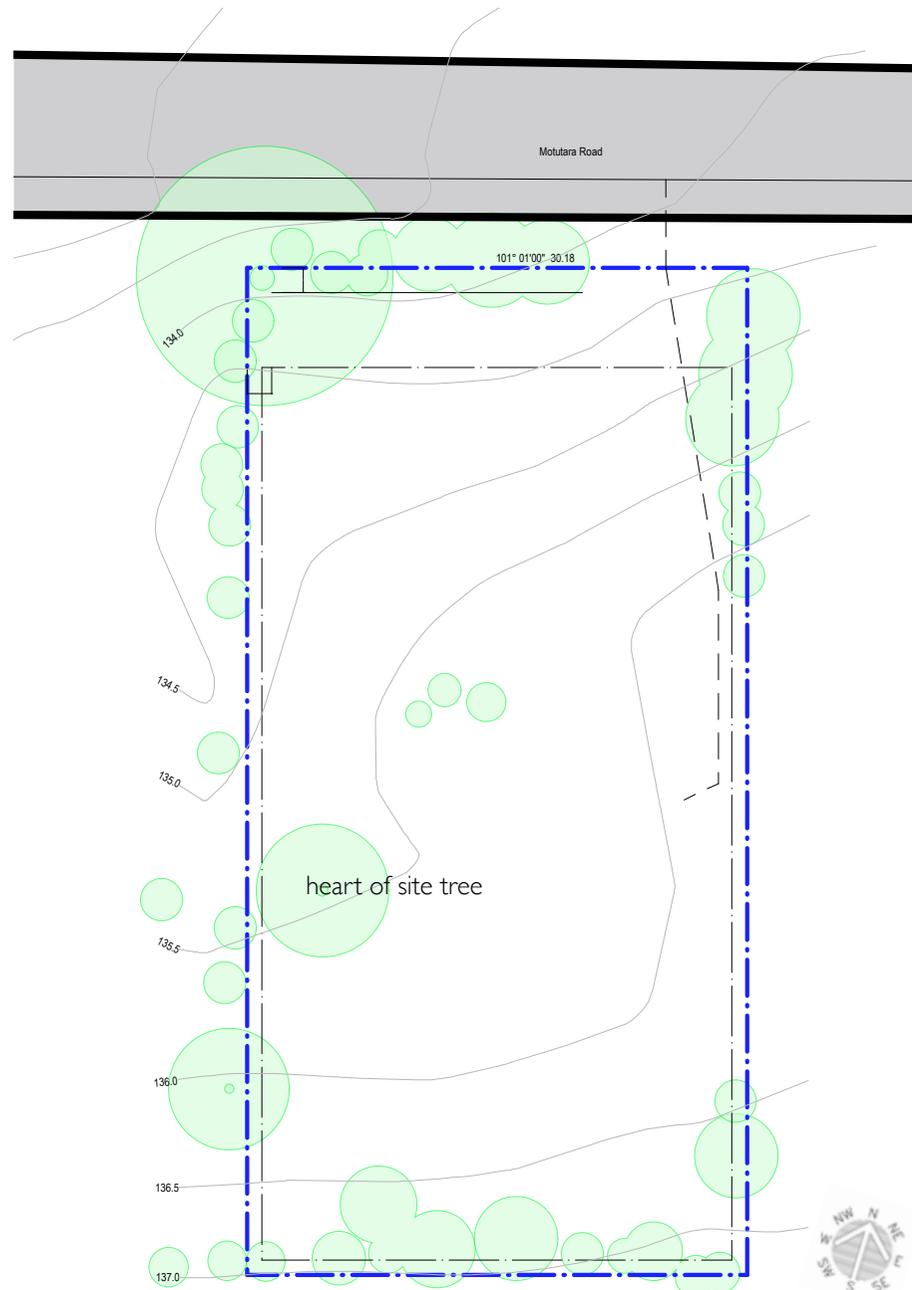


figure 3.31 Site analysis , showing the vegetation around the site

### 3.4.2 CLIMATIC CONDITIONS

Located in the Southern Hemisphere, Auckland has a climate with a moderate temperature range throughout the year. Muriwai has an average rainfall of approximately 2000 millimetres per annum, significantly more compared to that of Auckland city, with 1268 millimetres per annum<sup>36</sup>. The site is exposed to the natural warmth of the sun throughout the season. Facing north, the sun slowly passes the house, giving a good source of natural heat, light and solar gain. There is no concrete on the site, no double-glazing, or any heat sinking surfaces.

The prevailing wind is south-westerly. This can bring strong cold winds<sup>37</sup>, as well as picking up salt and sand from the nearby Muriwai Beach.

36 The Encyclopedia of New Zealand, "Story: Auckland places" page 7 - Waitakere Ranges. 'Accessed' 24th February 2015, <http://www.teara.govt.nz/en/auckland-places/page-7>

37 "The Climate and Weather of Auckland", 2nd Edition, P.R. Chappell, 'accessed' 25th February 2015, <http://www.niwa.co.nz/static/Auckland%20ClimateWEB.pdf>

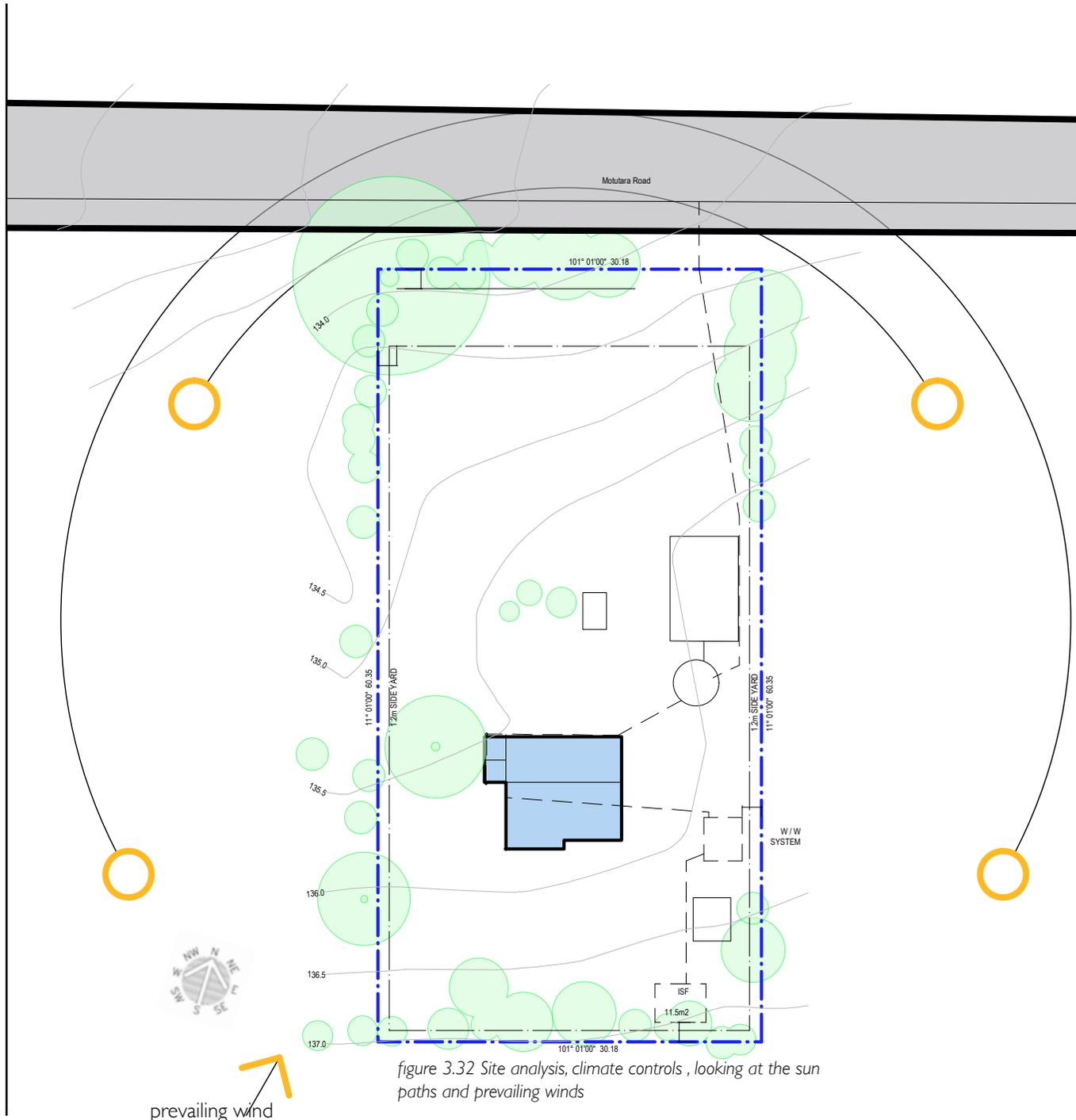


figure 3.32 Site analysis, climate controls, looking at the sun paths and prevailing winds

prevailing wind ↗

### 3.4.3 ELEVATIONS & SITE PHOTOS



figure 3.33 North Elevation of the existing site



figure 3.34 Site photos



figure 3.35 East Elevation of the existing site



*figure 3.36 South Elevation of the existing site*



*figure 3.37 & 3.38 Site photos, showing existing building in context*



*figure 3.39 West Elevation of the existing site*



*figure 3.40 & 3.41 Site photos, showing existing building in context*



*figure 3.42 Site photos, showing existing building in context*

### 3.4.4 BRIEF

The brief is to renovate and extend the existing dwelling to accommodate a growing family, with the actual building design to be formed around the new building block concept.

Currently, the cottage is made up of two bedrooms and one bathroom shared by the five occupants. The kitchen is small and opens up to a dining and living area. There is also a laundry and small storage area.

There is need for two more bedrooms, with one being a master bedroom with ensuite. A new kitchen and dining area will create more space and freedom for the family. The intent is to give as much for as little, being very conscious of budget and scale. The design must be fluent and non-intrusive to the existing dwelling and the site.

The brief must also show the architectural intent of the designed block, and how this block can be beneficial in a renovation.

The existing site will have a grid laid over the to be renovated plans. This also will help in the calculation of how many blocks are needed to construct the required walls.

The design will be executed by creating a design formed from the new block concept modular construction methodology.

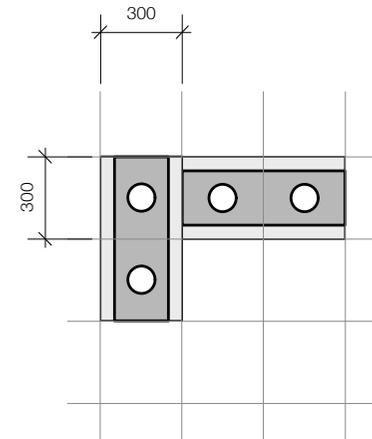


figure 3.43 Block modular set out for the brief

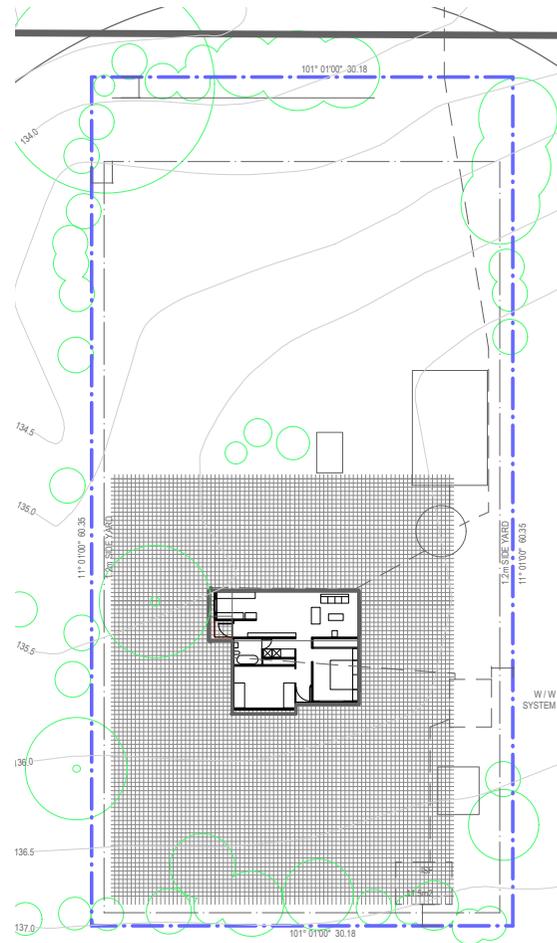
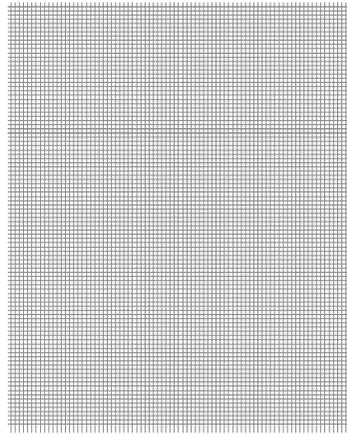
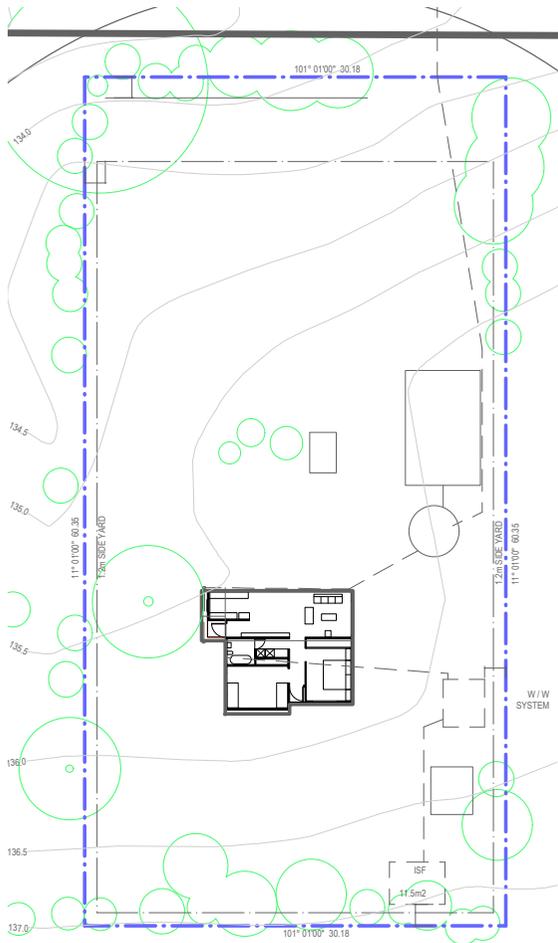


figure 3.44 Modular set out how the grid is applied to site

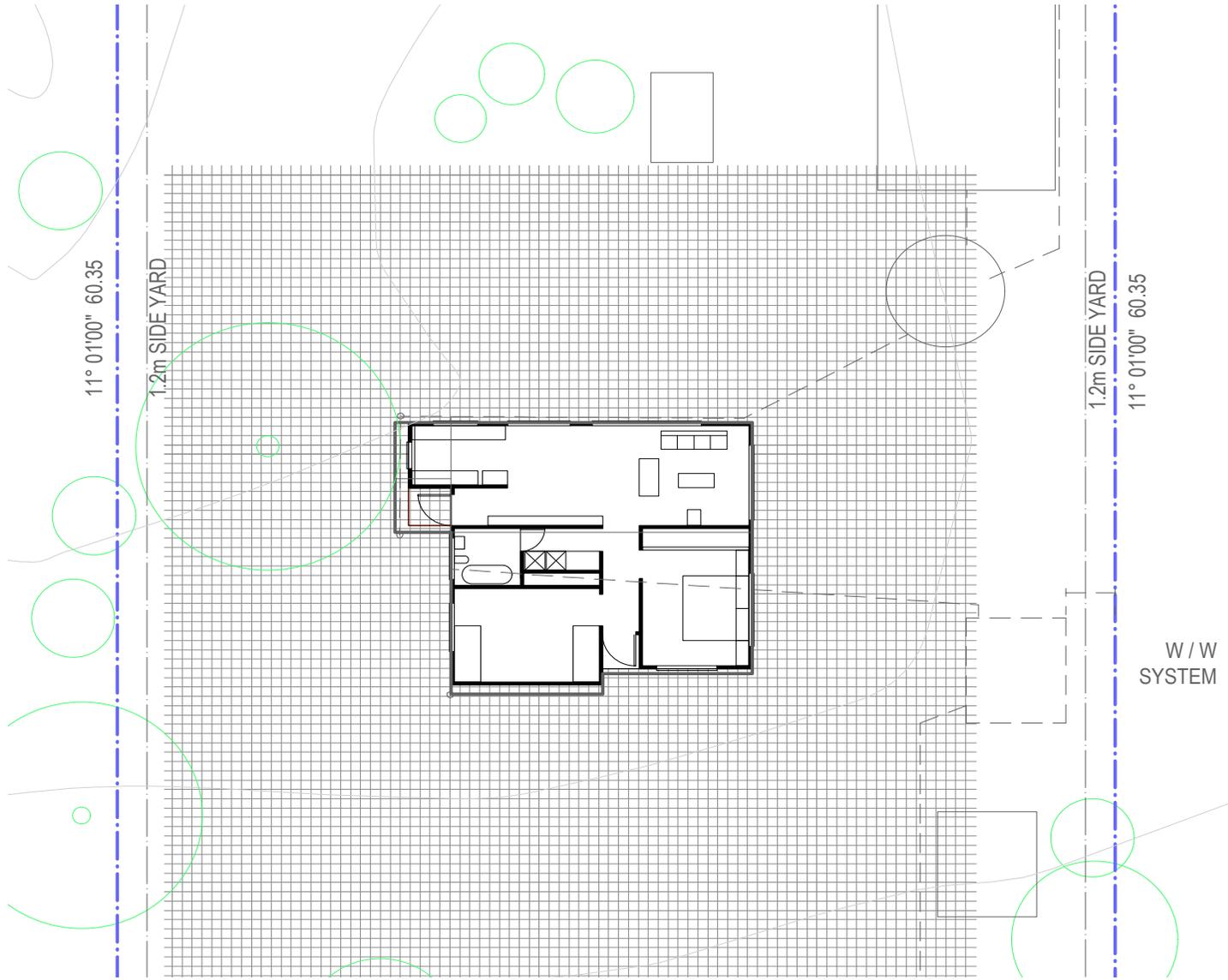


figure 3.45 Modular set out how the grid is applied to site



figure 3.46 initial thoughts of division space

### 3.4.5 DESIGN PRECEDENTS

Bearing in mind that the site is located in a rural setting, it is imperative to design with the site in mind. The precedents show forms and styles that react to the surroundings, connecting with nature while producing a proud architectural statement. The responsibility of this design is to create an extension that merges with existing building, and fits to the site's current landscape. Finishing characteristics within these precedents will help further the design in relation to the new building system.



*figure 3.47to 52 array of precedent images giving inspiration to design*



### 3.5 FINAL DESIGN

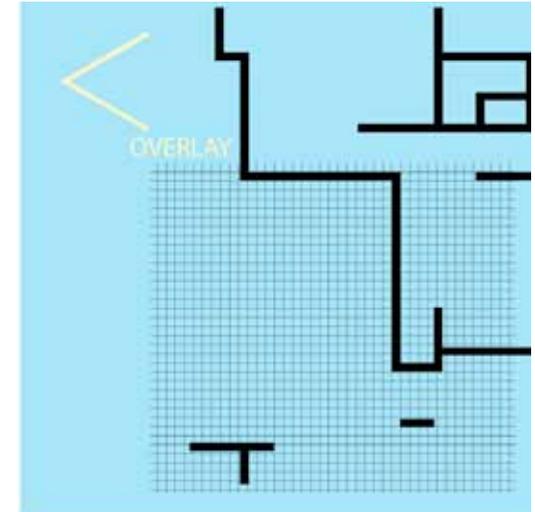
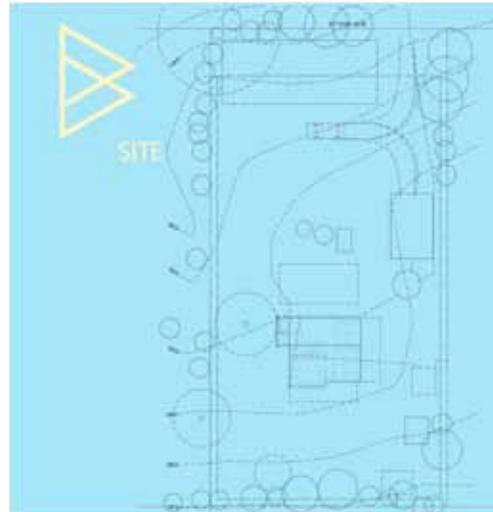
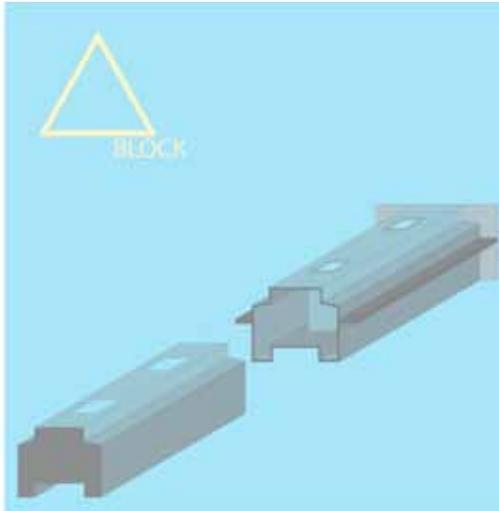
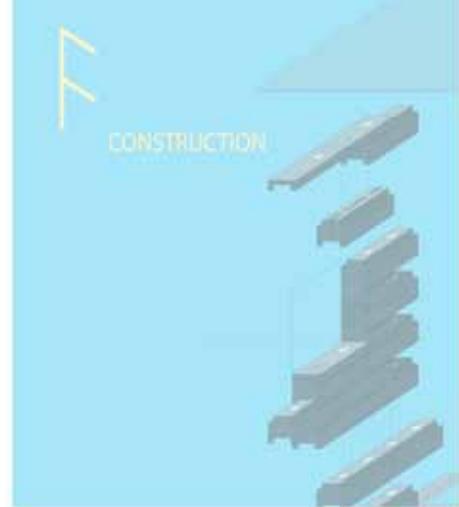
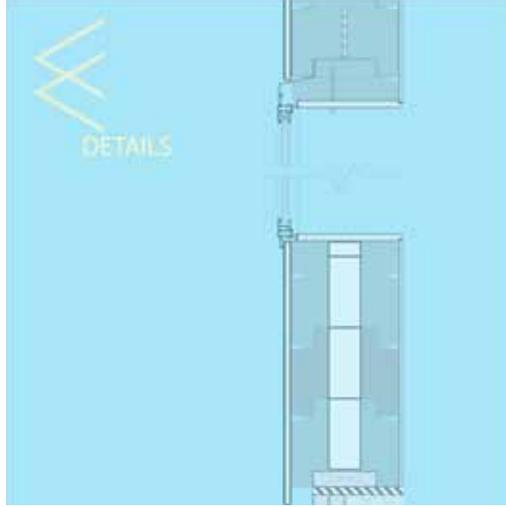
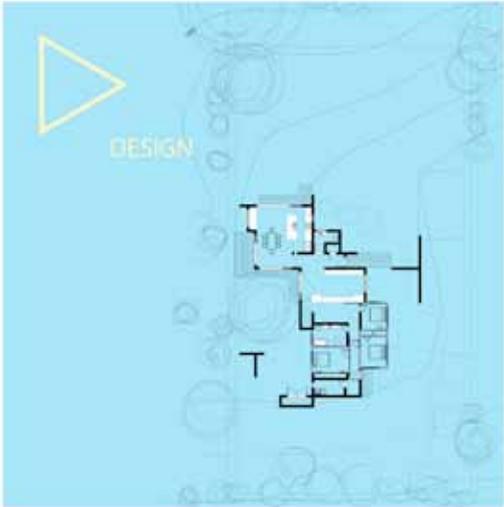
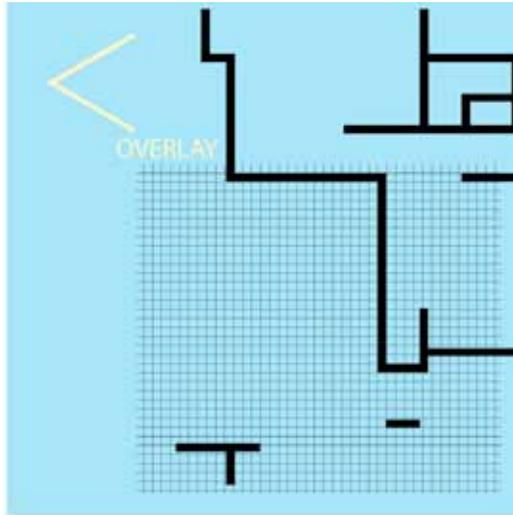


figure 3.53-59 images showing the design process of the concept block

The renovation design is relevant to show how the final block concept can be used in real building situation. Applying this construction to a renovation will give insight to how many blocks will be required, while indicating on possible time line of construction.





Laying the concept blocks grid over the existing plan, gives the designer and/or client the ability to start designing spaces. As the grid is 300mm by 300mm, the ability to create and adjust space is simple and easy to achieve. Once the plan is finalised, the blocks can be calculated and an estimated time and quantity can be found.

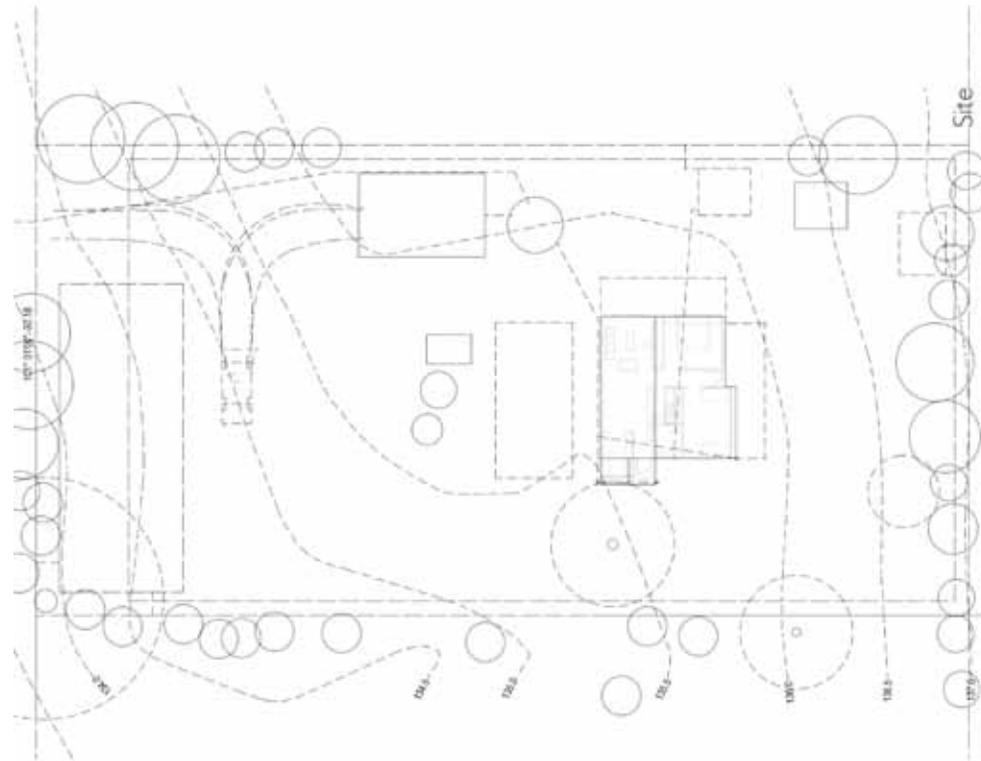
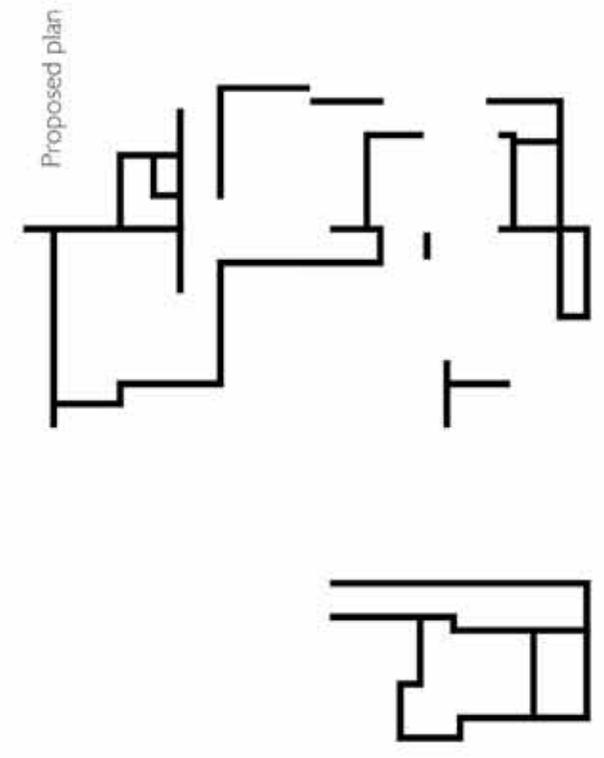


figure 3.53-59 images showing the design process of the concept block

### 3.5.1 Proposed Plans



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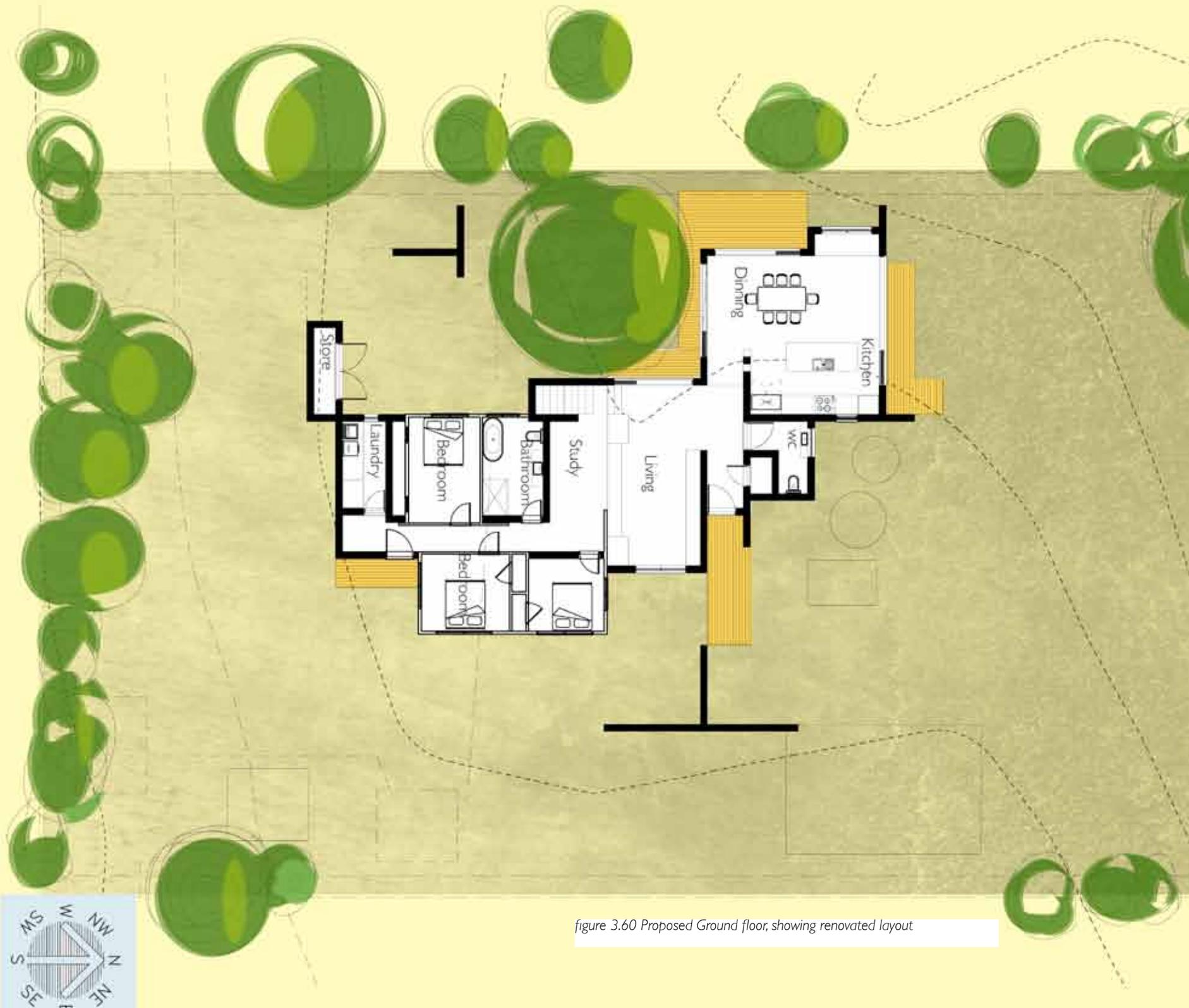
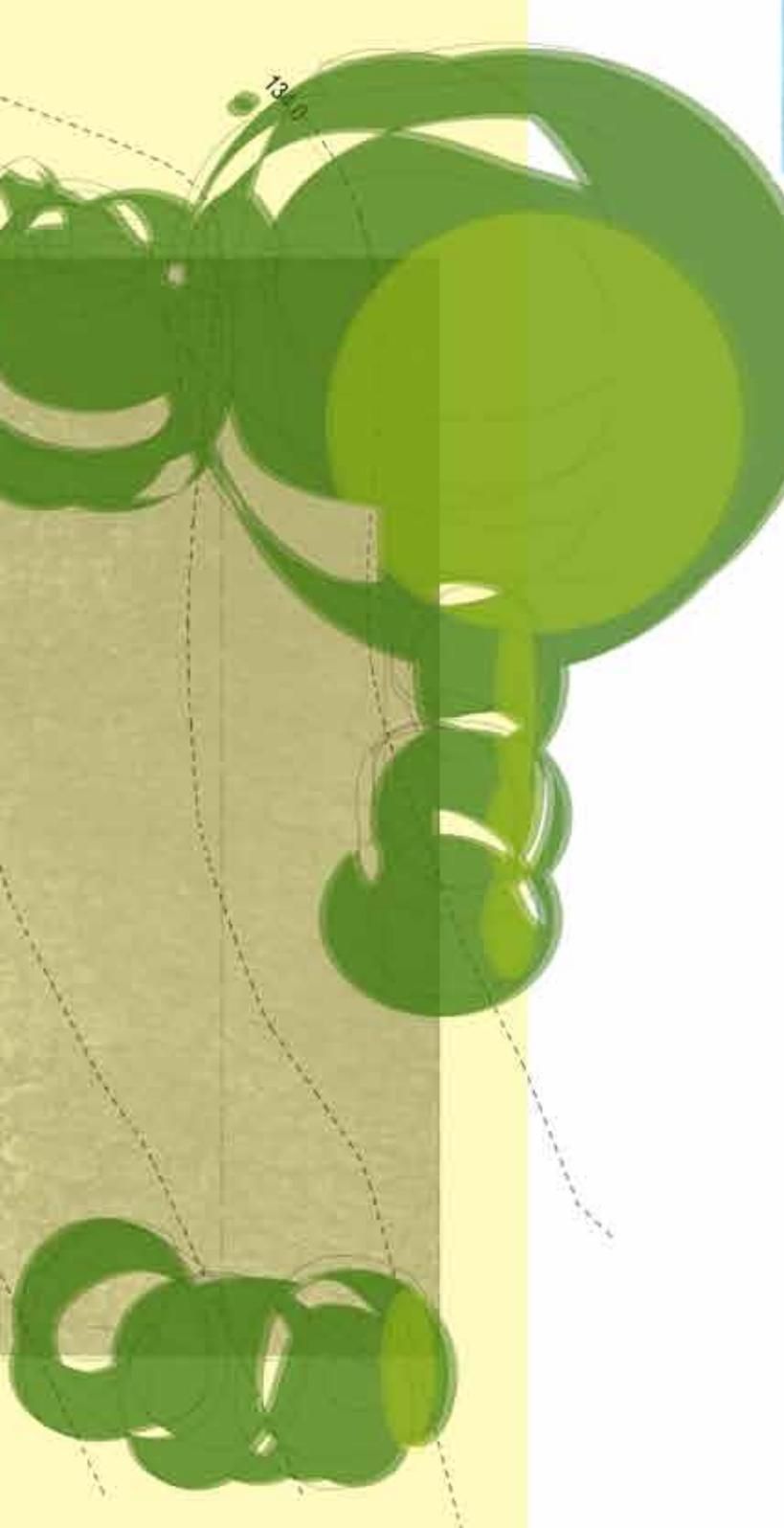


figure 3.60 Proposed Ground floor, showing renovated layout



The existing cottage located at the rear of the site, meaning the redevelopment of the property can go in any direction. The design was to focus on creating a larger home around an existing large tree on the west boundary of the site. This tree is old and large, with strong roots, which gives the feeling of a family tree. The plan began with the using and adaption of the existing floor plan spaces. The existing spaces remain relatively untouched, with a new wall coming into the existing lounge space to create a third bedroom. There is a new laundry space added at the south elevation, this will see access to existing clothesline become easier. The north elevation of the existing structure will be opened up, to make way for the new extension. With the drop from existing floor levels to ground being 600mm, there was an opportunity to have this building follow the natural slope of site. The new living room is now a two level "grandstand" living area. The new living room opens to the west,

with sliding doors opening onto the large tree. The kitchen then steps down again, lowering itself under the large tree, creating a feel of protection and family. All rooms take into consideration natural light, and trying to connect all new spaces to the landscape, while strengthening the existing buildings relationship to the site.



figure 3.61 Proposed First floor layout



The new master suite attaches itself to the existing building by creating an entry off the family area. The master suite floats above the ground, suspended, mimicking that of the beach lifeguard tower. The idea was to create separation, but have all opportunity to watch over the children at play below.

3.5.2. Proposed Elevations



*figure 3.62 . Proposed east Elevation*



*figure 3.63 . Proposed West Elevation*



figure 3.64 . Proposed North Elevation



figure 3.65 . Proposed South Elevation



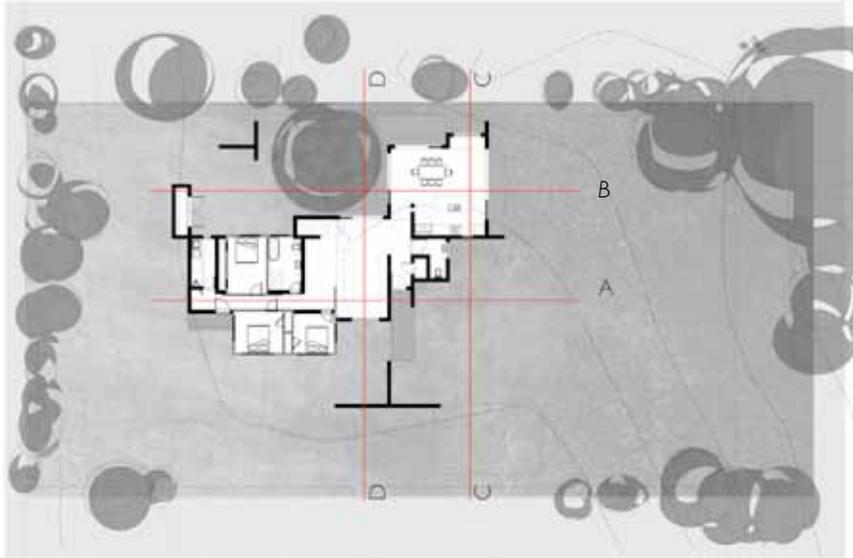


figure 3.66 . section reference plan

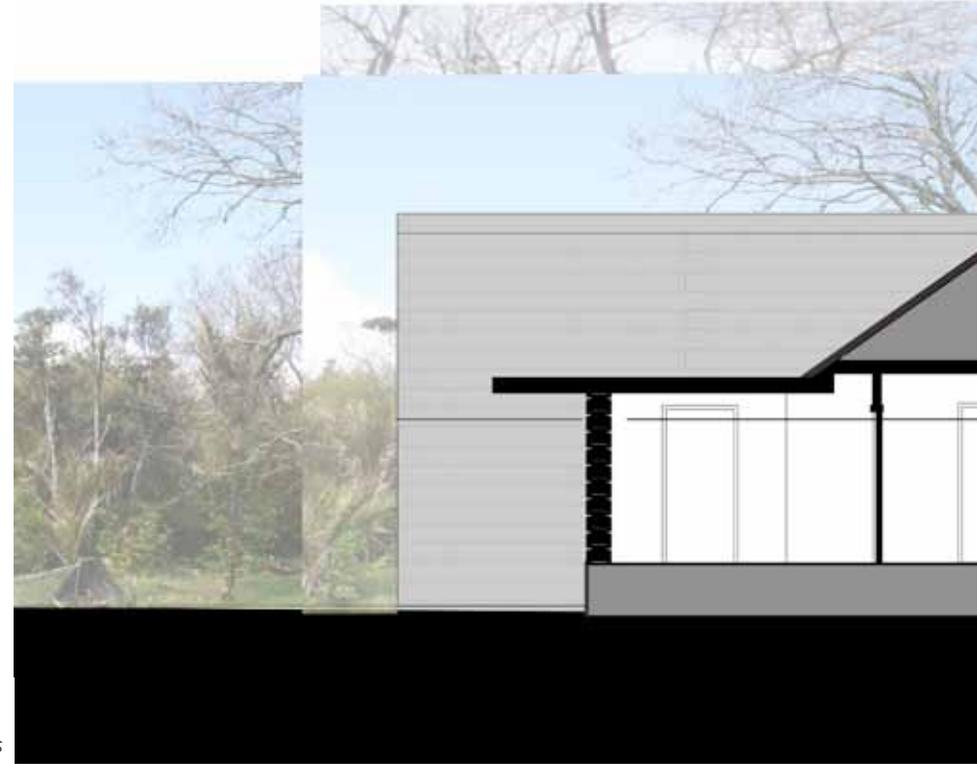


figure 3.67 . Section A-A showing proposed layout, and change in floor heights

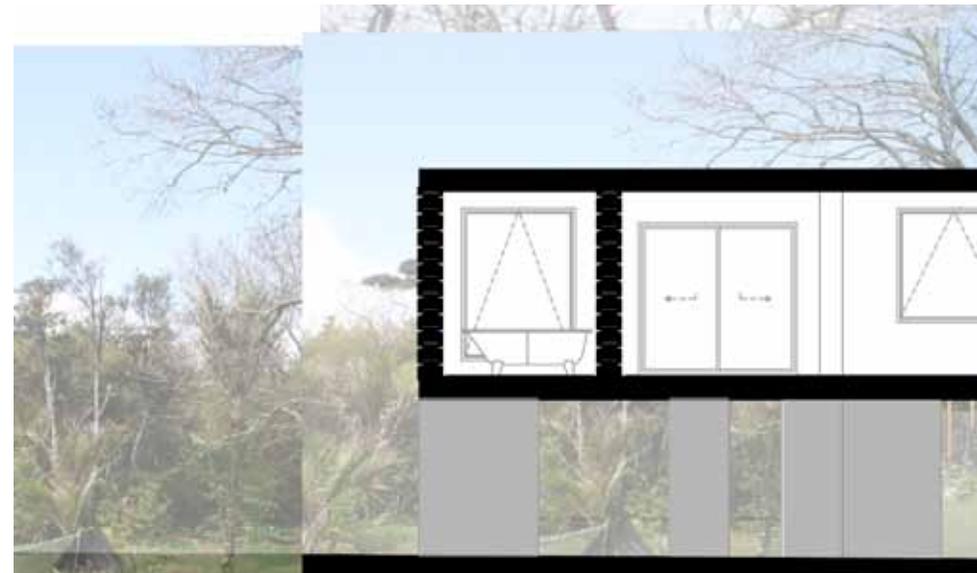
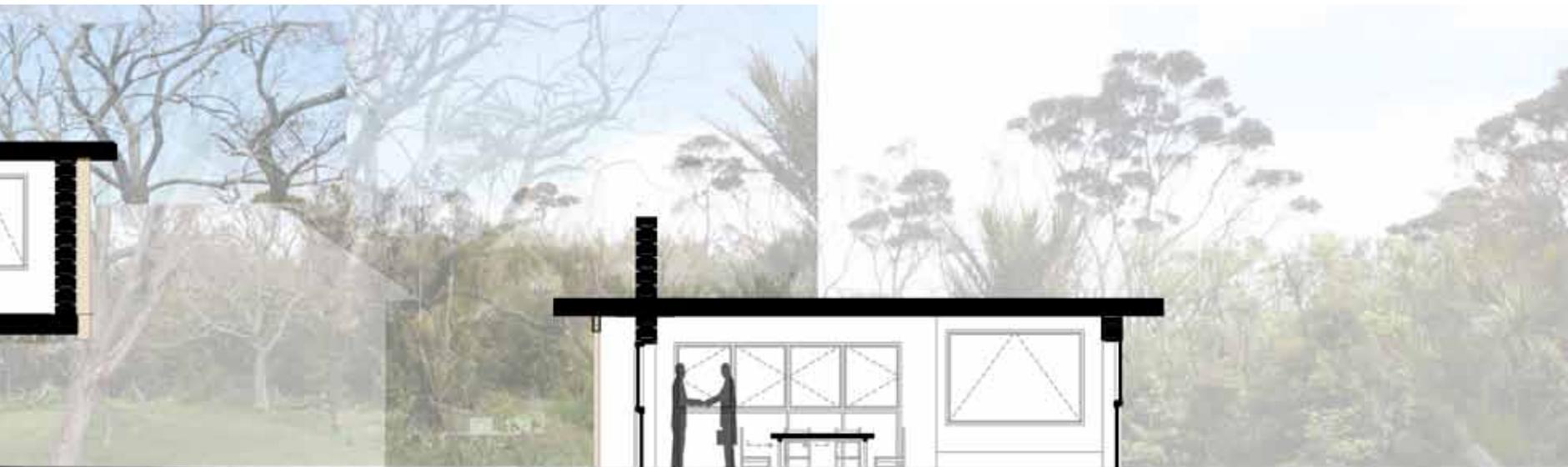


figure 3.68 . Section B-B shows master bedroom floating above landscape

### 3.5.3. Proposed Sections



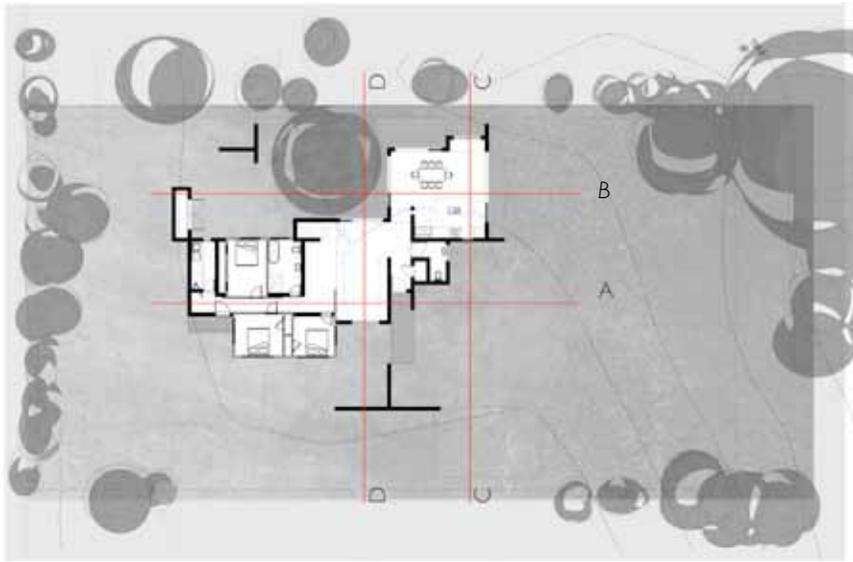


figure 3.69 . section reference plan



figure 3.70 . Section C-C,  
showing kitchen space  
stepped down with site



figure 3.71 . Section D-D  
showing the new living room,  
that steps down from existing  
floor level

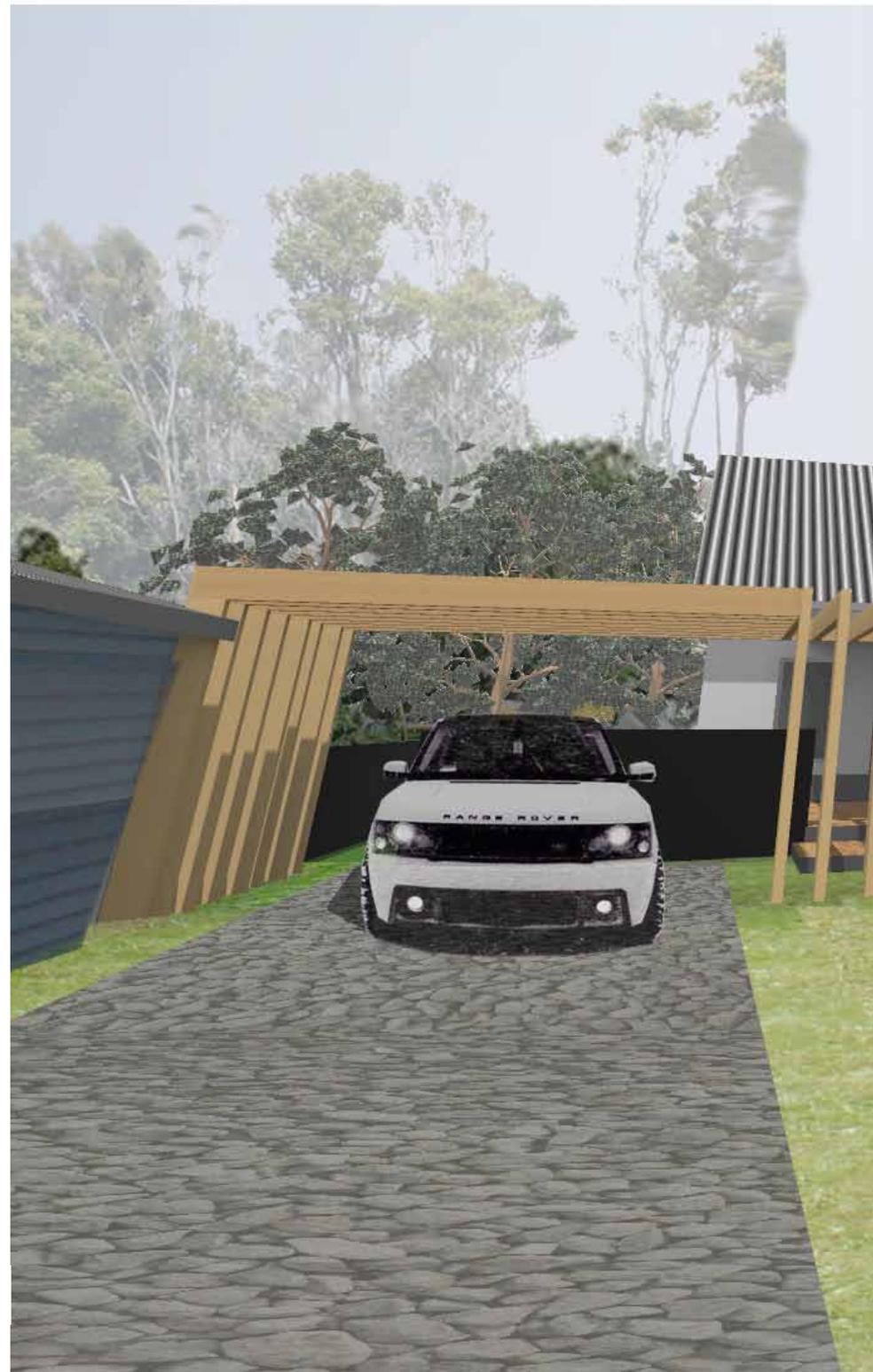


### 3.5.4. Proposed Perspectives

*figure 3.72 Perspective showing the kitchen stepped down into the landscape, the tree being the centre of the renovation, symbolising the family and growth*

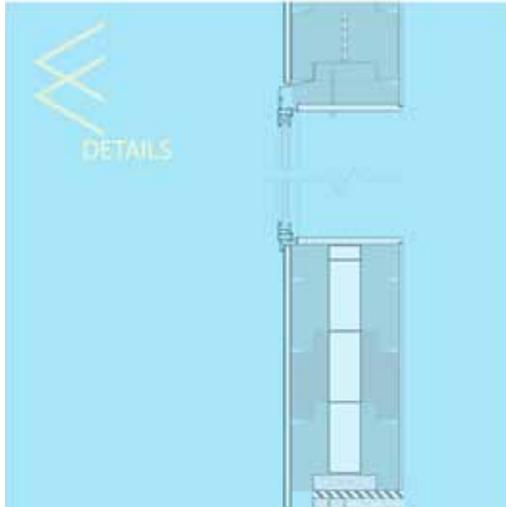






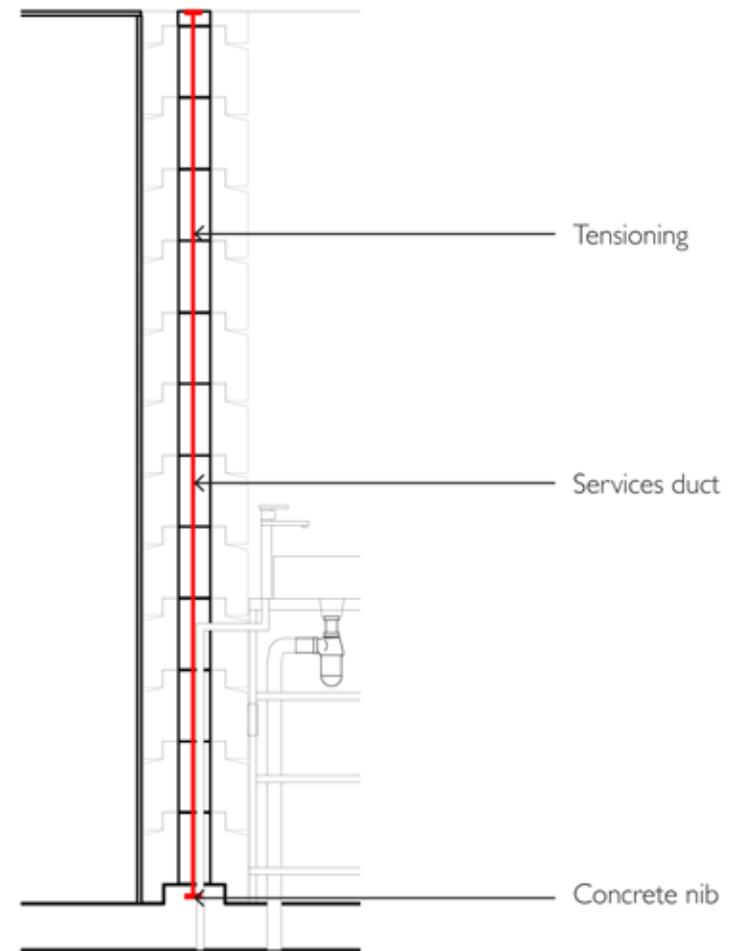
*figure 3.73 Perspective showing the entrance and new renovation*





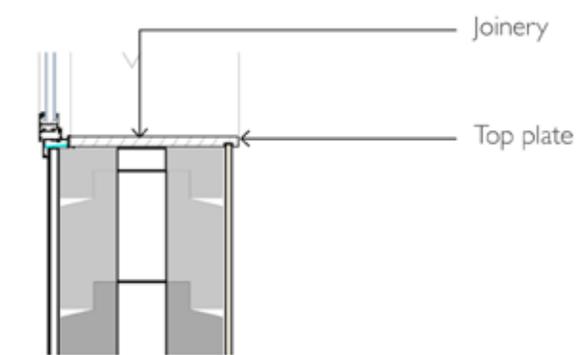
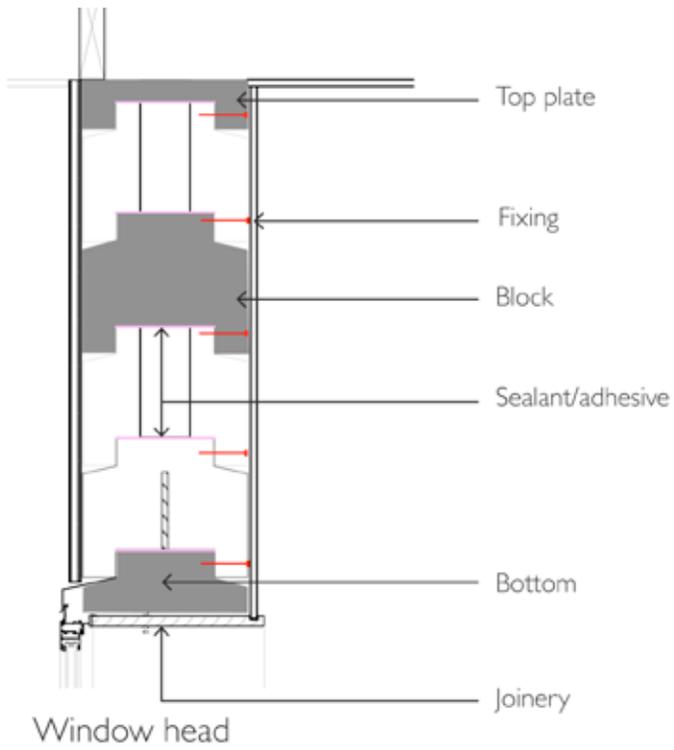
These details give a brief insight into the construction using the concept block. These details begin to show window details, the services channel that is created through the concept block, and connections between floor wall, and wall and roof, trying to create an understanding of the simplified construction method.

### 3.5.5 Details

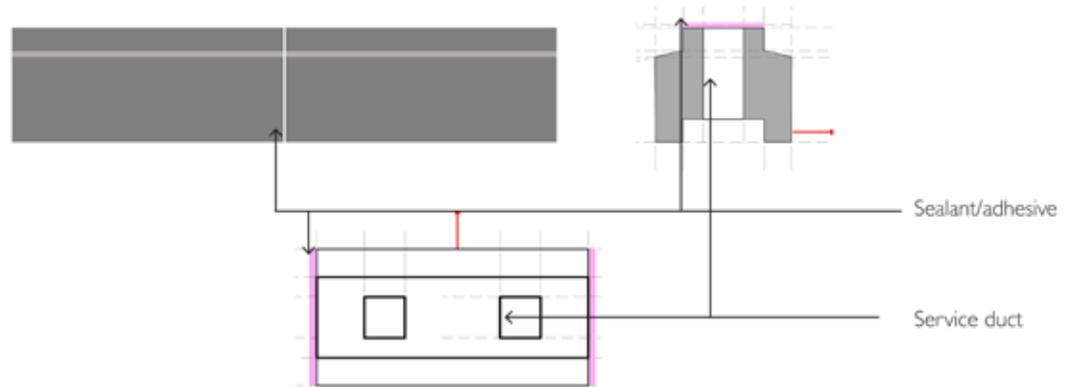


Wall section

figure 3.74 detail - typical wall section



Window sill  
 figure 3.75 detail - window details



Connections  
 figure 3.76 detail - connection details

The construction of a building can be separated in to parts. The floor structure to be built by a qualified builder. This ensures that quality is high, and that the wall nib wall track is correct. Once this is done the wall construction can be split between builder and owner. If the owner has a "do it yourself" attitude, he or she can help build their own house. This will also reduce time on site for builder and bring the cost of construction down.



figure 3.77 floor section



figure 3.78 construction of block wall

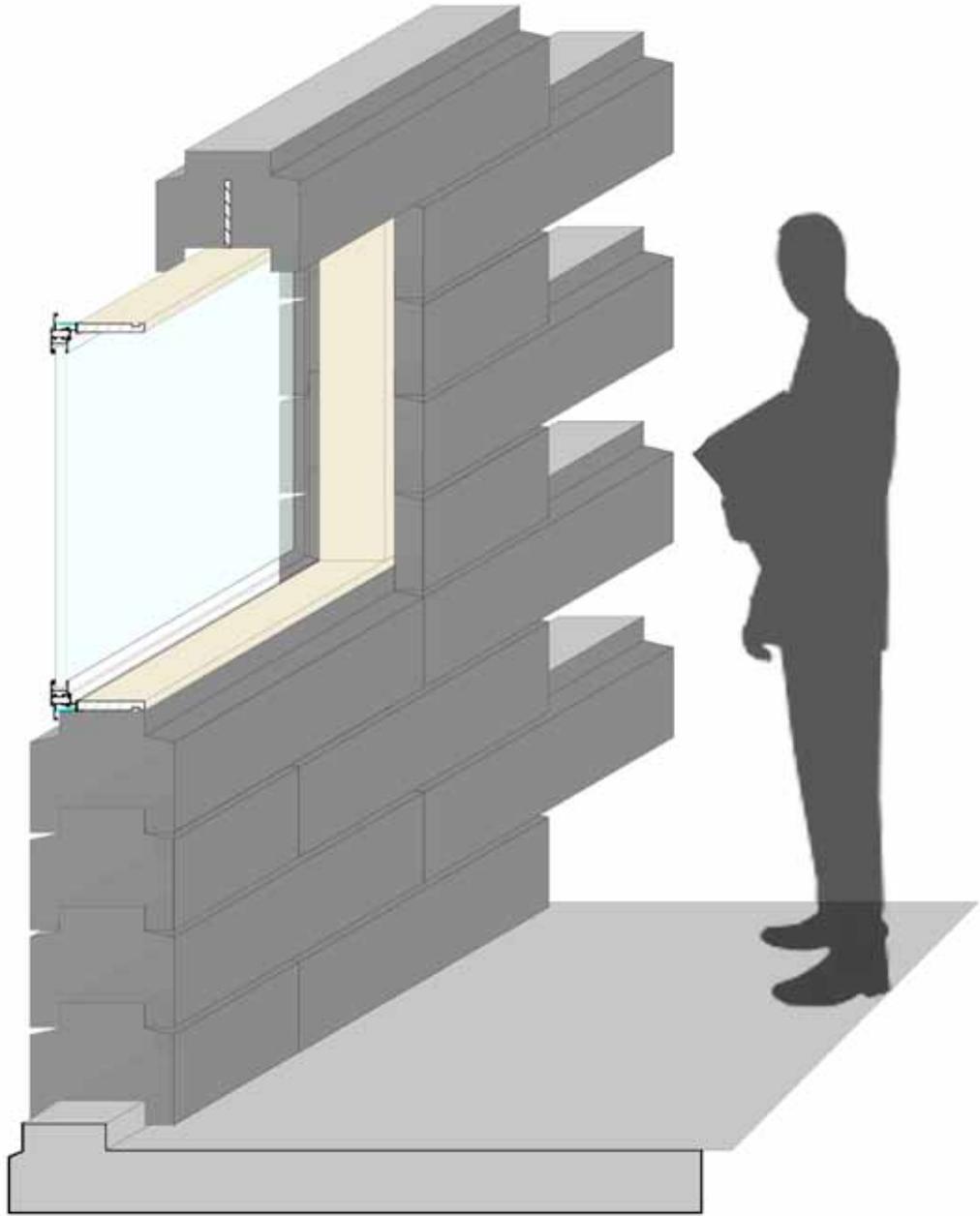
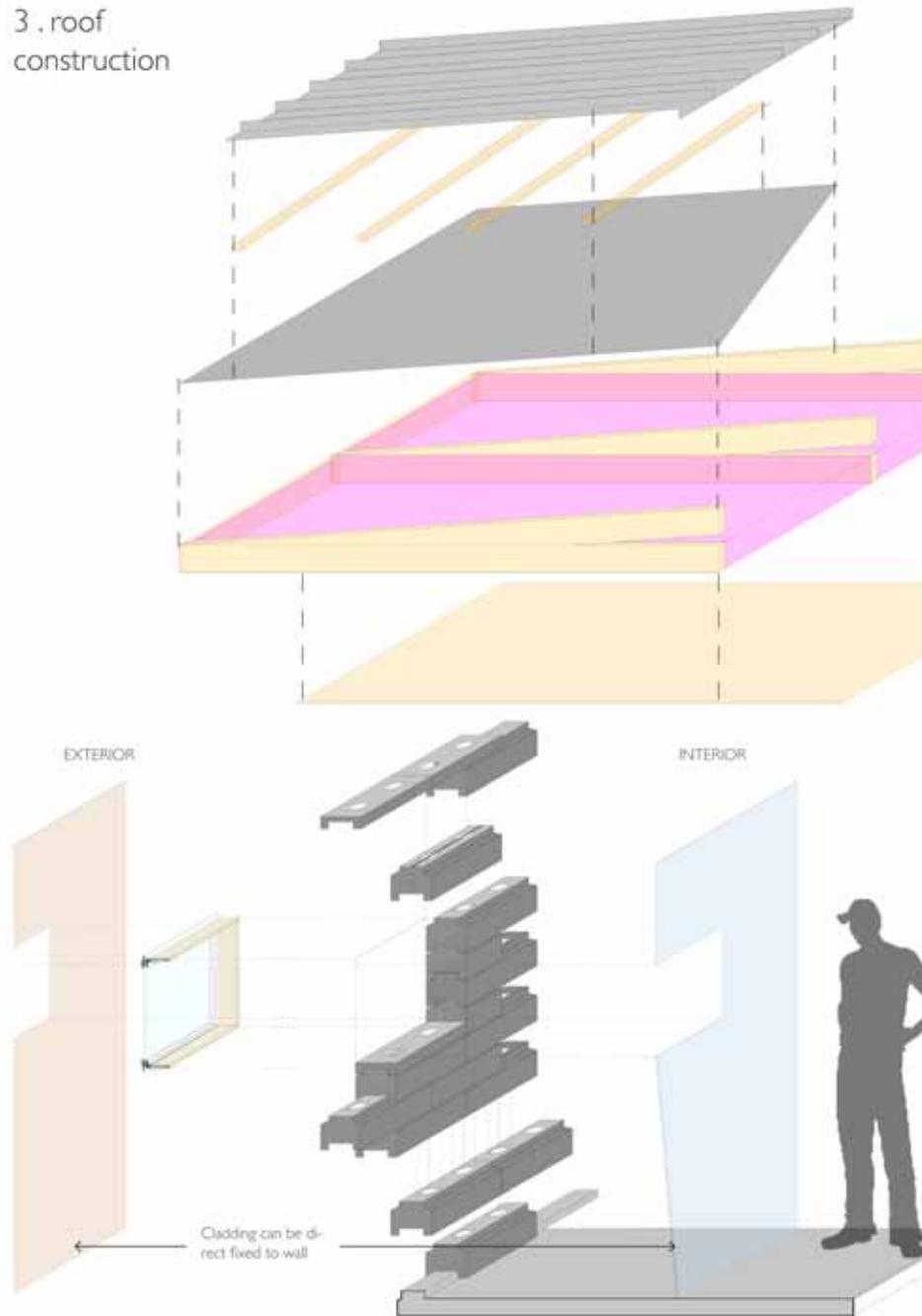


figure 3.79 finished wall section

### 3. roof construction



This image of the proposed constructed exploded shows the relationship between all necessary items needed to construct a wall section. The main reason in showing this is that the amount of parts/objects are reduced due to the concept block ability to create a whole internal structure of a wall. It also shows the wall being lined internally and externally. This is just an option, the final block in its natural form does not need to be lined. Lining means aesthetically can conform with personal or neighbouring vernacular.

figure 3.80 wall exploded to show parts.

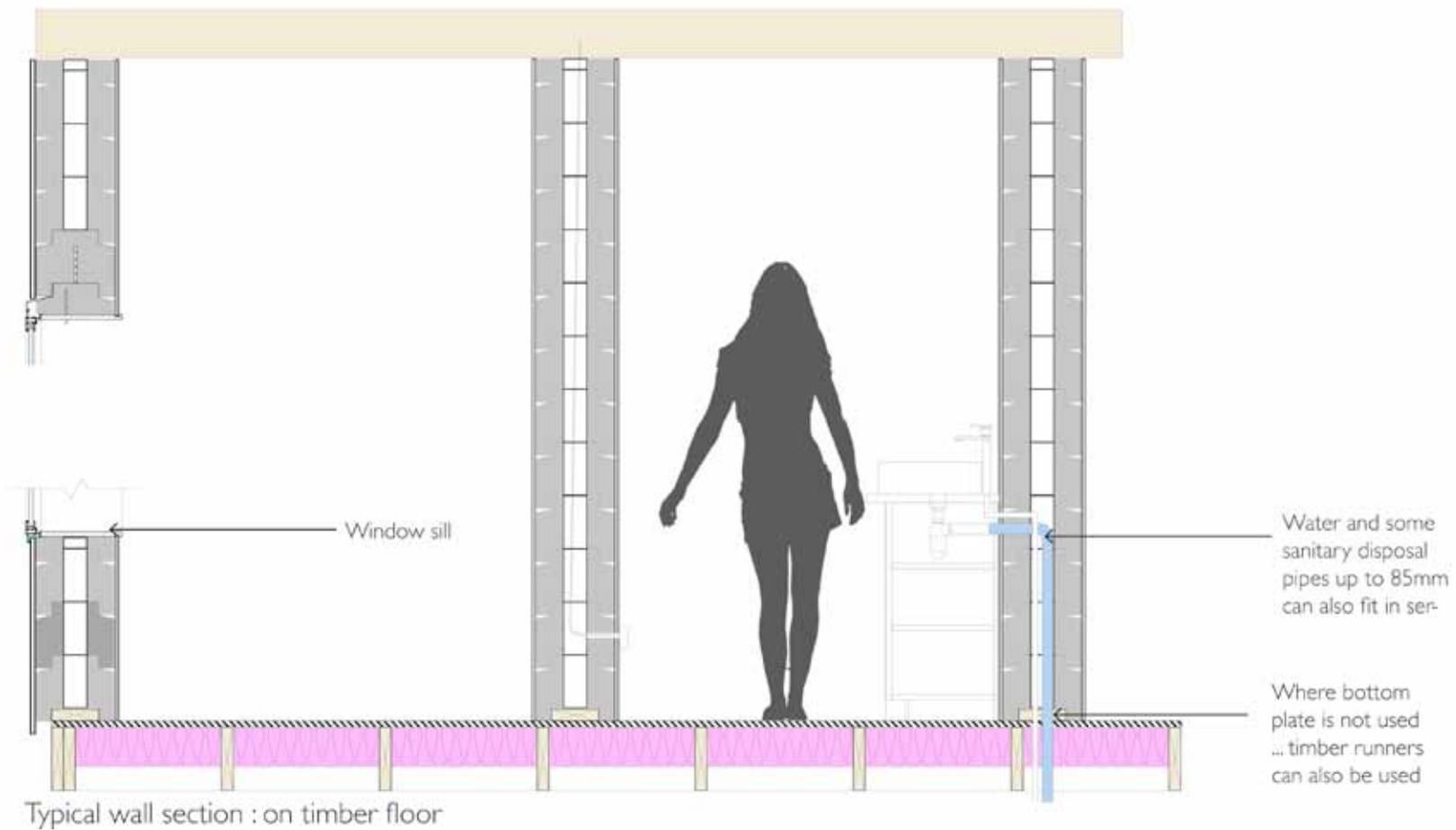
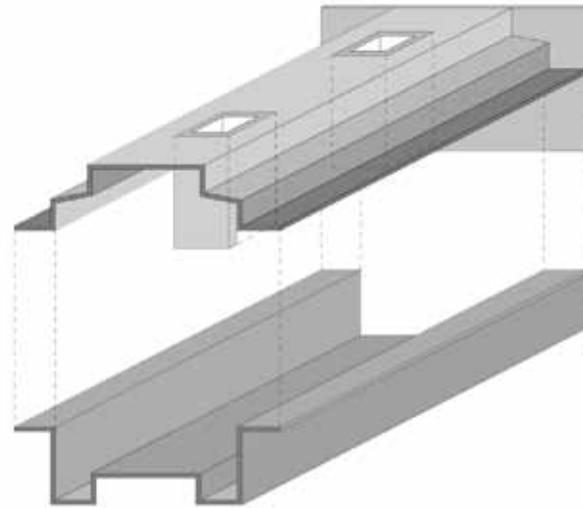
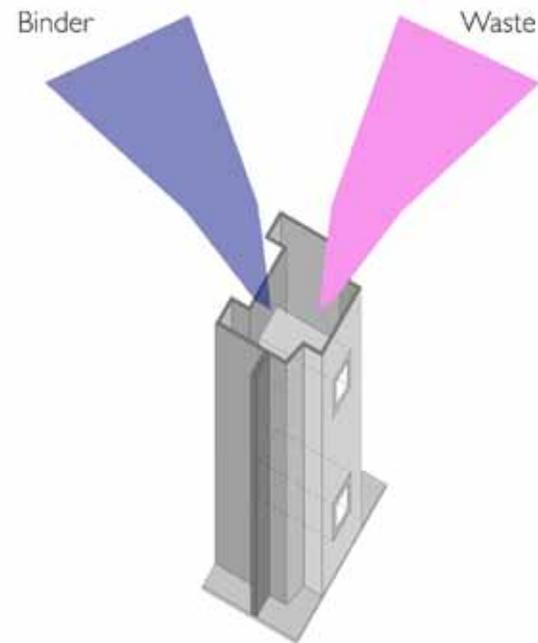


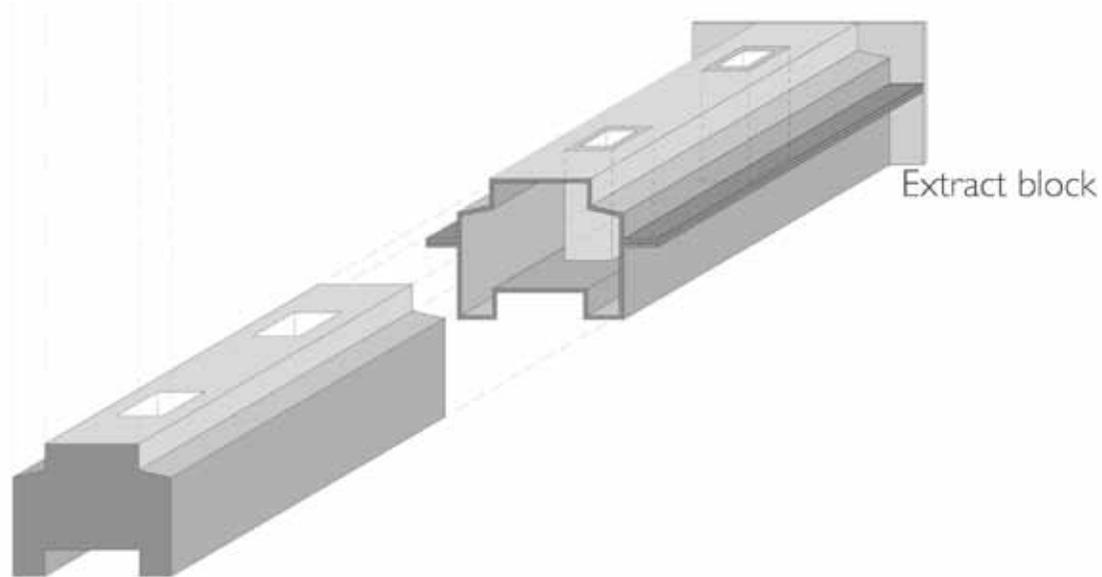
figure 3.81 typical wall section



Block mould



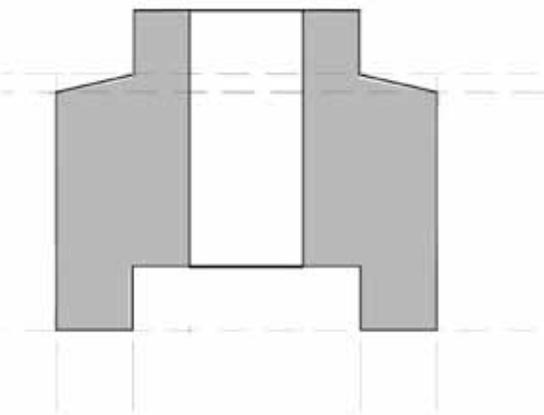
Fill mould



Extract block

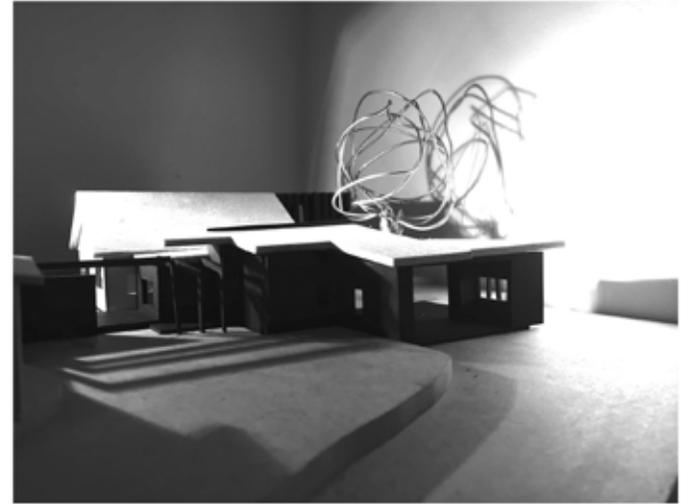
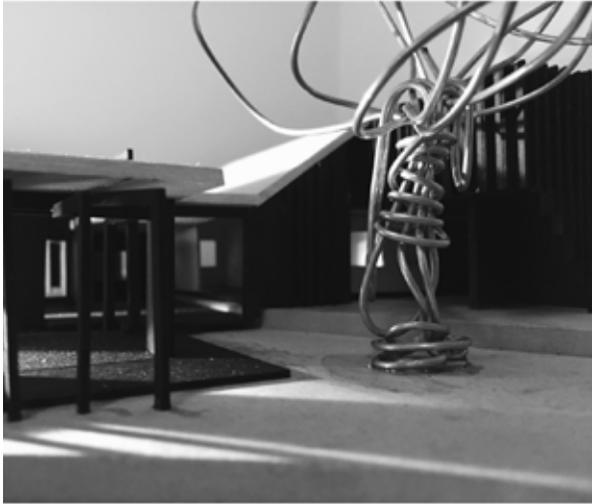
This final design requires 3100 blocks to construct all the proposed walls. If a group of builders can lay 1000 blocks in a day, that means that all the walls, built, straightened, leveled, with windows installed, could literally be construction in 5-7 working days. At its basic form, all that is needed is a roof, and you would have a watertight house within a two-week period.

The end result is a modest family home that sites well with its natural environment, and creates a arrange of different spaces.



Fire proofing spray

figure 3.83 block construction summary



*figure 3.83- 88 Model photos , Taken by Phillip Howat*

### 3.5.6 Model Photos



figure 3.89- 93 Model photos ,Taken by Phillip Howat



## 4.0 Conclusion

How might a modular building block system be created to satisfy regulatory requirements for the revival of “do it yourself” within New Zealand Architecture?”

The brief was to develop a new modular construction system to combat issues of current housing shortages, high build costs, speed of delivery of construction, and increasing housing prices. The “system” must satisfy regulatory requirements, however, also still be simple enough that any “do it yourself” individual can apply the system to their own house, within the New Zealand context.

The final block has qualities that satisfy the attributes stated in the brief: easy connection processes, services consideration, which all help with “do it yourself” revival, as well as decreasing overall construction time on site. However the materiality and weathering details still need more development,

and the block as presented in the examination, which had gone through a number of iterations to adjust to the issues stated did not perform to the highest of standards. In part due to the decision to choose a particular set of materials (recycled plastic) which in hind sight caused a set issues in the manner of the manufacturing of the block. Potentially the decision to create a new system, as well as a design outcome was a task too vast, and complex within the bounds of a Masters programme and within the time limits boundaries.

In reflection, further extensive research into other types of materiality of construction materials, in particularly in timber construction, would have been beneficial. Timber has many benefits as a construction technique, with its obvious availability flexibility and general ease of construction. However the timber construction method relies on skilled installation, and it is not hard

to find cases of timber construction when the skill set was not of a standard, necessary within industry standards.

Nonetheless, it did highlight that our simplest, most traditional construction methods needs more development, consideration, and refinement to ensure a more viable lower cost housing. Our current housing market is becoming unattainable for so many of the working population, now only dream of entering the property market, especially in our major cities like Auckland. If land is going to continue to rise in such a way, construction costs need to decrease., further research into contemporary 3D printed modules and blocks could alleviate this.

Did this modular block satisfy the revival of “do it yourself” within New Zealand Architecture?”

Partially... though the block idea is not a total failure, it is rather a conceptual block for future ideas.



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figure 2.1 Model T Ford. Factory, Assembly line construction of the model T Ford, showing efficiency of construction through small parts., Gartman, David, "From Autos to Architecture: Fordism and Architectural Aesthetics in The Twentieth Century" Princeton Architectural Press, 2009

figure 2.2. Le Corbuier's house tyoes , a series of modular concepts

Huxtable, Ada Louise "Architecture View; Le Corbusier's Housing Project, Flexible Enough to Endure". New York Times (Published: March 15, 1981)

figure 2.3 Houses of Cité Frugès, that are still standing today, and with maintenance over time, still look modern .

Le Corbusier's Cité Frugès: "Timelessly Modern and Back in Fashion" <http://en.paperblog.com/le-corbusier-s-cite-fruges-timelessly-modern-and-back-in-fashion-607149/> accessed Jan 2015

figure 2.4 Timber wall construction, showing the materials needed to construct a basic timber wall in New Zealand.. Drawn by Phillip Howat 2014

figure 2.5 Block Construction, , showing the materials needed to construct a basic concrete wall in New Zealand.. Drawn by Phillip Howat 2014

figure 2.6 Precast panel transportation , being craned onto site, <http://www.ancon.co.nz/what-s-new/enforcement-of-tough-precast-concrete-safety-requirements-gives-unicon-anchors-the-edge>

figure 2.7 Precast panels standing on site.

figure 2.8 Precast panel finished with a timber tough detail.

figure 2.9 Structural Insulated panel section core, showing the make up of each panel.

<http://musicianswantedtoronto.ca/toronto-structural-insulated-panels/>

figure 2.10 Structural Insulated panel construction site example, standing on site.

figure 2.11 Modular House Example, showing the piecing together parts to make a whole house

figure 2.12 Lima, Peru photo taken during the experimental housing project in Lima, Peru. , Christopher Alexander Previ / Lima low cost Housing project. <http://sites.harvard.edu/fs/docs/icb.topic892112.files/Previ/AD.pdf>

figure 2.13 Christopher Alexandra Construction system, detailing floor to wall detailing, Christopher Alexander Previ / Lima low cost Housing project. <http://sites.harvard.edu/fs/docs/icb.topic892112.files/Previ/AD.pdf>

figure 2.14 Christopher Alexandra Construction system, this picture shows the unique block system that was developed, Christopher Alexander Previ / Lima low cost Housing project. <http://sites.harvard.edu/fs/docs/icb.topic892112.files/Previ/AD.pdf>

figure 2.15 Studio 19 Modular set out that was employed during the initial concept stage. Drawing by Phillip Howat 2014

figure 2.16 Studio 19 site photos – shows the SIP panels on sit braced and being prepared for roof. Photo taken by Phillip Howat 2012

figure 2.17 Studio 19 site, this image was the final render of the two buildings developed for the site in Henderson. Render by the Studio 19 group

figure 2.18 Studio 19 site photos - The delivery of roofing modular product to site. Photo take by Phillip Howat 2012

figure 2.19 Studio 19 site photos - The photo shows the transportable building on site going through final stages of construction before moved to site.



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Photo take by Phillip Howat 2012

figure 2.18 Studio 19 site photos - The final buildings on site, waiting for landscaping. Photo take by Phillip Howat 201

figure 3.0 Frank Lloyd Wrights Usonian Block, "Frank Lloyd Wright's Usonian", [http://www.masonryconstruction.com/Images/Frank%20Lloyd%20Wright's%20Usonian%20Automatic\\_tcm68-1375850.pdf](http://www.masonryconstruction.com/Images/Frank%20Lloyd%20Wright's%20Usonian%20Automatic_tcm68-1375850.pdf), 1998

figure 3.1 Echoviren shelter <http://www.architectmagazine.com/technology/smith-allens-3d-printed-pavilion-features-a-natural-form-with-high-tech-roots.aspx>. Accessed January 2015

figure 3.2 Echoviren shelter <http://www.architectmagazine.com/technology/smith-allens-3d-printed-pavilion-features-a-natural-form-with-high-tech-roots.aspx>. Accessed January 2015

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figure 3.4 3d Printed House. [http://www.architectmagazine.com/architects/next-progressives-rael-san-fratello\\_o.aspx](http://www.architectmagazine.com/architects/next-progressives-rael-san-fratello_o.aspx), Accessed January 2015

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