Variations: Flexibility and Adaptability in Medium Density Housing
Research Project Explanatory Document

Meagan Grounds
388 Tauwhare Road
RD3 Hamilton
Ph: 0210777350
mmgrounds@gmail.com
Id: 1325147

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Meagan Grounds
Abstract

In Auckland, medium density housing currently provides an occupant with a standard layout in which to reside. This approach to housing appears to address the basic needs and wants of the resident yet fails to provide a necessary level of flexibility. Medium density housing is resistant to change and adaption. This is not ideal where occupants have changing needs and desires. For instance; technology, age or interests can influence the desired layout of an occupant’s house. Change is inevitable. The housing industry needs to embrace the wants and needs demanded from consumers in order to appropriately meet their demands. This thesis proposes the use of flexible housing to address with the current issues highlighted above within medium density housing in Auckland.

Flexible housing is an important concept where it allows a house to cater to the different needs and wants of occupants, adapting to change over time. Flexible housing is more than just sliding doors and folding partitions. In fact, it is the ability for a building to: “adjust to changing needs and provide both social and technological”1 benefits. Social and technological changes are currently issues that need to be addressed in medium density housing in order to make dwellings suitable both now and in the future.

This research design project challenges the current way of designing medium density housing in Auckland. In particular, it focuses on the ability to change and adapt ones home to suit changing needs and wants. This has been achieved by using flexible and adaptable strategies designed to deal with uncertainties of the future.

As supported by research, it is apparent that the current method for designing houses at medium density lacks the ability to cater for a variety of different user groups and their ever changing needs. Housing needs to be able to grow and change with the user. Occupants will benefit from greater options and control over their homes and how they use the space within.

The possibilities for flexible housing in Auckland’s urban context have been tested through the process of ‘research for design’ and ‘research by design’. Such research has clearly illustrated that flexible and adaptable housing has the potential to increase user control and variety within medium density housing while also having the ability to adapt to unknown future needs.

1 Schneider and Till, Flexible Housing, 4
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1.0 Introduction

1.1 Research Questions
How might/can architects design houses that will respond to and change with individual needs?

In what way can housing at medium density be able to achieve flexibility and adaptability?

1.2 Research Objective
The purpose of this project is to develop flexible and adaptable housing types for medium density housing that is suited to Auckland’s needs. The development of the flexible housing types will be based on knowledge of literature from books, articles and case studies on existing examples of flexible housing. The nature of information that forms the basis of this research will be in studies and records of flexible, adaptable design.

1: To create a flexible and adaptable house types that will cater to individual changing needs.
2: To test the flexible and adaptable house types on a existing developed sites in Auckland to show how the house types can work within the existing residential context.
1.3 Methodology

Three different research methods, general survey, literature review, and case study are appropriate for this study. These three methodologies will involve reviewing the literature, case studies and statistics relating to current conditions. Case studies will be an important part of this research, as this will help determine what has worked and what has not worked within the current prototypes.

All three methods will provide the knowledge needed to develop the design and will address the two main research questions proposed.

There may be other research problems that arise during the design which will be addressed through research and development of the design solutions. Research problems will be defined through the design process and will be resolved by developing the design, case studies and examination of literature, to identify possible solutions emerging from the study.

The mixture of research methodologies are:

1) General survey - history, site, climate, data collection on demographic patterns (household trends, population statistics, ethnic mix, age profiles etc which will inform the kind of people most likely to benefit from this housing typology.

2. Literature review - what is already sound knowledge in the subject area; include journals and magazines;

3. Case study analysis: This will be a criteria-based analysis of projects similar to designs developed in this thesis.
1.4 Definitions

Flexibility: Physical fabric of a building, which is capable of different physical arrangements. It includes issues of form and technique. It is achieved by altering the physical fabric of the building. 2

Adaptability: The capability of spaces to provide for different social uses. It is achieved by designing rooms that can be used in a variety of ways, by organisation, designation, and circulation patterns. 3

Support: A support is “a building containing a dwelling that can be built, altered and taken down, independently of each other”. 4

Infill: A level within the urban tissue and support. The configurations and organisation of the internal space within a support structure, in which each individual occupant determines it’s arrangement. 5

Dwelling: “A building or place of shelter to live in. A place of residence; abode; home”. 6

Individual: “A single human considered apart from a society or community”. 7

Identity: “state of having a unique identifying characteristic held by no other person or thing” 8

2 Schneider, Till. Flexible Housing, 5
3 Ibid, 5
4 Habraken, Supports: An Alternative to Mass Housing
5 Habraken, Mignucci, Supports: Housing and City,
2.0 Define Project
2.1 Literature review

The most influential texts which were relevant to this thesis were Till and Schneider’s Flexible Housing and Habraken’s Supports: An Alternative to Mass Housing. Habraken’s text has become a seminal text for flexible housing. It places an emphasis on a technical approach to flexible housing. Till and Schneider provide episodes of flexible housing, a case for flexible housing, case studies, and a manual for flexible housing. Together these two texts form the basis for the thesis and have strongly influenced the design outcome.
Flexible and Adaptable housing

Till and Schneider define flexible housing as; “housing that can adjust to changing needs and patterns, both social and technological.” That defines changes within a house, which need to be adjustable, and are personal, technological, and practical. Flexible Housing addresses the issue suggesting that these factors have many different meanings and connotations to different people.

Personal changes that affect housing can be an expanding family, while technological changes occur when old services need to be updated to meet new technologies. Practical changes refer to ageing and being less physically able. In England, the issue of practical change is addressed by the lifetime home standards, which are a set of guidelines that allow the house to cater for the occupants as they grow older. In Till and Schneider’s analysis, flexibility can be achieved through hard and soft elements.

Hard elements determine the way designs can be used; soft elements allow a degree of indeterminacy. Hard elements

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9Schneider, Till. Flexible Housing, 4
Brief episodes in flexible housing

Till and Schneider describe the history of flexible housing as episodic: the problem that arises when proposing a history of flexible housing is that this history has many outside issues that affect it, such as economic and political issues. They state that it is not possible to write a history of flexible housing, as history tends to imply the development sequence of cause and effect. In flexible housing, there is no one line of development and evolution.

Flexible housing has developed in two ways firstly as;

“a result of evolving conditions of the vernacular. The second is a result of external pressures that have prompted housing designers and providers to develop alternative design solutions, including flexible housing.”

10

Economic forces drove the first episode of flexible housing. In the 1960’s and 1970’s a new interest was driven by the idea of providing the user with choices that allow individuals to customise their environment.

Following the First World War the demand for housing in Europe was unparalleled, especially from the working classes. This demand caused space standards to be reduced, in order to produce more dwellings and at a minimal cost. As a result the standards of the Congress of International Modern Architects (CIAM) held in Frankfurt in 1929 debated solutions to the problem of space standards. One of the possible solutions was to introduce the idea of flexibility. The reasoning was that if there was less space available, the space constructed would be used as efficiently as possible.

The central concept is that housing can be designed so that a dwelling can be arranged according to the needs of the user: not to dictate the use of specific rooms but to allow the inhabitant to decide how to occupy and use the space. Mies Van Der Rohe saw flexibility as an important concept of architecture. He argued that buildings should last longer than the function for which they were initially designed. This could be achieved through designing for flexibility with the users input into the design allowing the building to change, thereby preventing the building from becoming obsolete.

The second episode of flexible housing was driven by technical influences. After the First World War and the housing crisis which followed, the development of dwellings that could be mass-produced by industrial prefabrication were appealing. Large quantities of dwellings could be produced in a short amount of time and in a cost effective manner. Walter Gropius saw this standardisation as an opportunity to provide a greater amount of variety within a floor plan. He reasoned that prefabricated components could be arranged in a large number of different ways.

10 Ibid,13
Case for flexibility

Housing design based on predetermined ideas imposed by the architect generates housing that will not grow and change with its occupants. This approach to building is unsuitable for the occupant’s changing needs and results in occupants having to move to find more suitable dwelling. Habraken describes this process as a ‘game of musical chairs’. Habraken’s 1961 text stated that there was a housing shortage (at the time, in Holland) fit for the user’s purpose. Mass housing, he argued, is not the answer to the problems discussed, as every individual has different needs and wants. Present forms of industrialised mass-produced housing (in Holland) are unable to respond to user’s domestic needs; the effect is that large numbers of houses were occupied by mis-matched families. Flexible housing can be developed as an answer to these problems, external conditions, and ideas.

Till and Schneider describe housing as a volatile subject where ever changing trends, evolving technological and environmental changes all have an impact on our life. The authors state that if a building is not able to respond to these changes they become at best unsatisfactory and at worst obsolete. Today we have come to accept short-life consumer products as manufacturers persuade us that we need to upgrade our lifestyles through the consumption of consumer products. This process has led us to continually upgrading our phones, clothes, cars, and electronics to suit our changing lifestyles. However, why is that also the case with our houses? Why are we unable to change our houses to suit our changing needs? Housing is increasingly a commodity item in our lives. Currently the way housing is marketed implies that housing is a disposable product.

This way of thinking of housing as a long-term investment which changes over time has been ignored by developers. Inflexibility is accepted in housing and inflexible construction techniques are the norm. Currently roof spaces are filled with trussed rafters and internal partitions are load bearing. Both these types of construction techniques make future change impossible or at best expensive. By building flexible and adaptable housing, the housing market would be depressed, because with the ability for occupants to adapt their house, demand for new houses would be reduced. Till and Schneider describe housing developers promoting flexibility as being as likely as “turkeys voting for Christmas” by this reasoning we will not see property developers designing flexible and adaptable housing as this would redefine the commodity status of their products. In what circumstances do people see housing as an asset rather than a commodity? In this study flexible housing will be seen as a worthwhile investment and a desirable product only when traditional notions of “house” as a permanent asset are restored; or at the point where the market punishes, rather than rewards, the short-termism of a commodity-oriented industry.

11 Ibid, 37
External demographics

One of the issues of treating housing as a commodity with fixed design parameters is that it is built in a world of constant changing demographics. While at the time of construction they meet the intermediate demand, they most likely will be inappropriate in thirty years’ time. There is nothing certain about what future housing needs will be: the only certainty is that at the end of this century, the occupant’s needs will be different from what they are today. We need to accept the uncertainty of what the future demographic trends may be, and take up the challenge to design housing that responds to immediate pressures, which are drawn from an understanding of changing needs.

Stewart Brand states, “All buildings are predictions. All predictions are wrong”\textsuperscript{12}. This recognises that when designing buildings architects predict how the building will be used now and in the future in an inevitably flawed process. The only way around the issues of our predictions being wrong is to accept that at best, all we can do is anticipate the inevitability of change, rather than try to predict what will happen. Till and Schneider propose approaches to providing a dwelling that will deal with the volatility and diversity of positional occupancy. One way is “to provide the frame, and within the empty generic space this can be in filled and adapted over time”\textsuperscript{13}, the second is to provide rooms that are intermittent of their function and allow connection to other units of space to allow a variety of configurations. An example from history that demonstrates these principals is the terrace house, which was designed for one specific purpose, but over time it has been able to accommodate change.

The demands of changing demographics and the ability to contribute to the viability and diversity of urban life can be achieved by flexible housing. Importance needs to be placed on having a social mix in new developments to create sustainable communities: this is something that is now being recognised. However, achieving a social mix to create social sustainability is difficult when dwellings are inflexible. Flexibility allows for a social mix of people to coexist in one area as dwellings cater and change to individual needs.

Internal dynamics

Housing needs to adapt and respond to changes that occur during the life of the occupant. If the house cannot adapt, the occupant has no choice but to move. This process is socially, economically and sustainably disruptive. This issue highlights the needs for housing to respond to change. It also needs to grow and contract with the changing condition of the family and cater to individuals as they grow old and are less physically able.

In England, the uses of lifetime home standards ensure that houses have the ability to cater to an ageing population.

The aim of flexible housing design is to develop houses that cater for different types of people regardless of their circumstances. Historically, typical houses provided a living environment that was able to accommodate change, but since the nineteenth and twentieth century the issue of houses accommodating change have become an architectural task. An approach to this issue is to provide a frame that can be added to or divided as needed, leaving free spanned space inside.

\textsuperscript{12} Ibid, 39
\textsuperscript{13} Ibid, 39
Financial arguments
Building and designing flexibility into housing is more expensive than traditional methods. However, in the long term flexibility is more economically viable as it limits obsolescence in housing. Housing designed in this way has a longer life span than the traditional approach. Since the house has the ability to incorporate new technological systems, spatial principles, and services strategies, the building lasts longer and is cheaper to maintain through its life span.

As the present model of housing finances are based on either direct rent or direct sales, the present model does not encourage long-term thinking as Till and Schneider note “Whether flexibility really is more expensive is difficult to measure” 14

Habracken proposed support structures to solve the issue of space and flexibility in housing. The cost of these structures are more than traditional dwellings, however we should consider whether society and the environment can afford to do without houses that can grow and change with the occupant.

Customising
The notion of housing being treated as a commodity is prevalent in today’s society. A basic level of customisation is considered; floor finishes, kitchen cabinets, window type, size, positions of internal walls and locations within the building. A more detailed level of customization is the control of size, layout, and aesthetic of the unit. A drawback of pre-occupation customisation is that it often compromises the future adaptability of the house.

Sustainability
In this context, current approaches to building are not sustainable, due to the limited design life caused by materials, changing needs and technologies. By incorporating flexibility house’s life spans will increase. John Broome argues convincingly that “involving people in the housing process is a necessary pre condition for a sustainable housing process” 15 This statement promotes flexibility as a necessary part of the sustainability. Flexibility allows housing to change and responding to users changing needs and aspirations.

Sustainability in design tends to concentrate on environmental issues, as they are easily quantifiable and are easier to address technically. The best approach to sustainability is not one of problem solving, as this just addresses the issues we have now. It does not address the uncertainty of the future and the issues that may arise. It acknowledges change as an underlying condition, but it also accepts the level and extent of change as being an unknown.

14 Ibid, 45
15 Ibid, 49
Supports: An Alternative to Mass Housing

Mass Housing

In 1961 Habraken said that “Although everyone agrees that there is such a thing as a housing problem, it is not easy to put it into a few words what the problem is.” It is now 51 years since it was written and we are no closer to solving the housing problem let alone being able to put the problem into a few words. The mass housing process in New Zealand is not properly understood and recognised the individual in the housing process. Auckland’s population is rapidly increasing, as well as its culture diversity. Auckland already has a housing shortage and with a growing population, shortage will increase in the future.

Mass housing in Auckland needs to fulfil more than the current individuals needs and wants. Habraken states “The total shape of the housing process deserves our attention; indeed, as a creative event of the first order, it has gone too long without properly being understood. The housing process is the common action of a society to fulfil certain conditions without which its existence would not be possible.”

Dwellings always exist in two spheres; the sphere of the community and the sphere of the individual. Living cannot exclusively exist in one sphere, so a home must be built in both spheres.

However, currently mass housing process is decided in the public sphere and this causes the individual to have no opinion or control in this process which results in uniformity.

Figure 2.1 spheres of control
Figure 2.2 Community control
Figure 2.3 individual control

Uniformity in mass housing is not caused by industrialization. Uniformity is based on the elimination of the individual. Where individual action exists, the existence of uniformity is impossible. We need to establish what the role of the individual is in the housing process and decide where the community’s responsibilities stop and where the individual’s responsibilities start.

Mass housing fails to recognise that everyone has different needs and that there needs change over time. When developing a large number of dwellings the project is seen

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16 Habraken, Supports; An Alternative to Mass Housing, 4
17 Ibid, 5
18 Habraken, Three R’s for Housing
as one project. The approach to the project
deals with dwellings as a single design problem,
the consequences of dealing with housing
in this manner has far-reaching effects. To
treat everyone the same fails to recognise
individuality. Habraken states, “Mass housing
pretends that the involvement of the individual
and all that it implies simply ought not to exist.
The provision of housing therefore cannot be
called a process of man housing himself. Man
no longer houses himself: he is housed”\textsuperscript{19} This
statement highlights the importance of the
individual being involved in the process, current
thinking of the individuals role in the housing
process needs to be reconsidered if we want to
start solving our housing problem.

When considering a brief
for mass housing it is argued that, human
requirements cannot be approached in this
way. “Mass housing reduces the dwelling to a
consumer article and the dweller to consumer.”\textsuperscript{20}
Consumer products are made in the knowledge
that they will be updated when they become
obsolete so they cater for individual needs now.

\begin{footnotesize}
\begin{itemize}
\item \textsuperscript{19} Habraken, Supports; An Alternative to Mass Housing,9
\item \textsuperscript{20} Ibid, 11
\end{itemize}
\end{footnotesize}

This is not the case with housing; it caters for
the needs of the individual now but unlike
consumables most housing cannot be as easily
updated.

Mass housing has been
developed in the community sphere. As soon
as the individual is introduced into the scheme,
unwanted variations are inevitable. Uniformity
is a result of the public sphere deciding what
housing should look like. If we assumed that
the dwellings represented the life it contains it
would imply that uniformity is a characteristic
of society, which is not the case. Mass housing
may be an efficient way of sheltering large
numbers of people and has a place in today’s
society but the way we approach mass housing
needs to be developed, in order to provide
housing that accepts the inevitability of change
and the uniqueness of the individual.

An architect who deals with a
living person as a client will be able to design
a house that will suit the client and meet
there needs and wants. However, in mass
housing the architect designs houses without
knowledge of who will inhabit them. He is then
developing through generic assumptions of
how people live. These assumptions will not take
into consideration different cultures or different
needs of individuals. Habraken states, “Mass
housing demands a design which is represented
for people as yet unknown who will inhabit it,
but mass housing also demands, and this avoid
all, uniformity which can never be representative
of the life to be established”\textsuperscript{21} This emphasises
the needs for individual sphere to be involved
in the design process, while this is not possible
in mass housing the way we design the interior
should allow for individual choice.

The process in which mass
housing is produced causes it to be incapable of
coping with the unforeseen. This rigidity of mass
housing causes obsolesce because we cannot
predict what future needs may be but we can
make provision in order for the building to adapt
and change to meet them.

Habraken describes the
contemporary town dweller as a “nomad who
moves from place to place without taking part in
the growth of his environment”\textsuperscript{22} This is relevant
in Auckland, as soon as an occupants needs
change they have to move, this issue has a large
\begin{footnotesize}
\begin{itemize}
\item \textsuperscript{21} Ibid, 26
\item \textsuperscript{22} Ibid 39
\end{itemize}
\end{footnotesize}
impact on the community within mass housing. You cannot force communities to exist with developments but you are able to encourage it. While communities can be encroached, “people require more time to grow into a community than it takes for mass housing to wear out”23. To make mass housing last long enough in order for occupants to grow into the community we need to develop and make houses that grow older without becoming obsolete. We need to design housing that the population can live in for generations and incorporates the ability for change. Unfortunately, this is the opposite of what mass housing currently offers us.

When considering housing we should not try to forecast what will happen in the future, but try to make provisions for what we cannot foresee. Embracing the unknown and making provisions for it will combat obsolescence. It is still necessary to plan for the future but that is not enough, we must make housing that is flexible and adaptable so that it can cater for the unforeseen. Whatever the future brings it is bound to be different from what you and I imagine it will be.

23 Ibid
The support structures
Habraken proposes a solution to the problems mentioned above. He proposes the idea of building support structures to solve the problem of inflexibility in housing. He defines a support structure as “a construction which allows provision of dwellings which can be built, altered, and taken down independently of others.” The idea of providing a support structure is a different way of approaching mass housing.

This approach acknowledges that we cannot predict what is going to happen in the future but we can provide structures that have the ability to change and provide variety. Support structures give occupants the power to choose the internal layout, finishes, size, and appearance of their dwelling. No longer is the power of design decisions lying in the community sphere, instead it is balance between the two spheres. This approach acknowledges that living takes place in both spheres, a support structure provides the framework in which this process can happen.

The problem with the mass housing process is “not with the architecture, but the circumstances that lead to architecture.” If we want to start finding solutions to the current mass housing problems we need to address who decides what and when, within the housing process. Habraken states that “housing is not about form but about the process that leads to the act of dwelling and to the distribution of power within that process.” Habraken proposes a different way of approaching the housing process, he proposes a process where the responsibility of choosing, layout and sizes is determined by the individual rather than architects and designers. He proposes the idea of infill which is developed and made within the individual sphere. Infill is independent of the support structure. The support structure allows the individual freedom and the ability to make a dwelling suites their current needs and but also the ability to easily change their dwellings as their needs change.

The industrial possibilities of support structure include the ability to have prefabricated components. Support structures allow the individual to personalise their space. This ability is not currently possible within mass housing in New Zealand, as the currently tend to have set house types. “Support dwelling is essential if the evolution of living itself is to take place without hindrance. As housing from this caters for unexpected, rapid change in current options, experimenting with life style can take place.”
The architect
In mass housing the architect designs prototypes. He designs standardized dwellings and approaches housing as an aesthetic problem. This approach results in uniformity and lack of control for the individual. The approach to design of support structures involves the architect in three main ways; “design such structures (architecture), advising manufacturers in design of components to accompany such housing (industrial design) and advising occupants on the layout and infill of their support dwellings (interior architecture). In addition he must supervise the overall building process and direct the action of the various parties involved, he is intermediary between occupants and technology.” 28 This leaves the control of the infill to the occupant and allows them to make their dwelling their own.

The occupant
Currently in mass housing to make an impression on a dwelling an occupant has three options “use it, damage it, or wear it out.” 29 Typically in the end the occupant leaves the home in search for a better one. This way of building is not environmentally, or socially sustainable. The ability for an occupant to make an impression on his home is important. Habracken states that “history tells us that the act of building as a means of self-expression- a sheltered environment which the occupant can identify- has gradually become more important than the physical result.” 30 It is important for an occupant to take possession of his home, as if he feels responsible for it he will maintain it and take care of it.

Habraken also states that; “Dwelling is an everyday solution that defines the home. Any structure, chosen at random, change from a shelter into a home not when it has a certain form, not when it fulfils certain conditions which have been written down after long study, not when certain dimensions and provisions have made to comply with multiple by laws, but only and exclusively with people come to live in it.” 31 A support structure allows for a dwelling to be created no matter how different a occupants needs and wants may be. The support allows for a space in which the occupant can personalise.
2.2 Precedent Survey

This precedent survey contains examples of flexible housing from Germany, The Netherlands (Holland), and Austria. These particular locations have been selected due to their use of:

- Structural systems that allow for clear spans
- Slack space
- Functionally neutral rooms
- Use of a service core.

I have chosen examples over a period of time from 1927 – 1972 this is to see what influence Habraken’s Theory of Support and Infill had on flexible housing after its publication in 1961.

The examples are from The Netherlands (Holland), Germany and Austria due to the quality and size of space. A lot of the theory for flexibility and adaptability were developed and tested in these countries. They had to develop a better way of using space in order to improve the quality of living. Habraken and the SAR based in The Netherlands influenced flexible housing and open buildings this impacted the flexible housing in The Netherlands.

All of the examples recognise the importance of the user involvement in the development of a dwelling. They all recognised that needs change over time and that it is impossible to predict what will happen, the only thing that can be done is to make the dwelling capable of change. All six precedents have dealt with this issue by creating a structure that allows the occupant to determine the interior layout.

The principals for flexible housing demonstrated in the six precedents parallel those that Till and Schneider describe and also illustrates how structure can be used to achieve freedom and variation within the plan. By including these within this study, the Author has been able to clearly provide six different approaches to flexibility which greatly influenced the design process.
Wohnzeile, Weibenhofsiedlung

Date: 1927  
Country: Germany  
Architect: Ludwig Mies Van Der Rohne  
Project type: Multi story Apartment Block

Mies Van Der Rohe designed Wohnzeile for the Weibenhofseidlung exhibition in 1927. The plan is completely open apart from two internal structural columns. The plan consists of one 75m² apartment to one side and to the other side there is a 45m² apartment. In both apartments, bathrooms and kitchens are place against the structural wall by the stair well. The apartments are accessed by an internal stairwell that services two apartments per floor. The apartments are left empty apart from the services and calls on the occupants to finish the raw space with internal partition walls and furnishing.
Structure
The structure of Wohnzeile consists of 2 structural walls either side of the unit with two or four internal columns depending on the units size. The approach to flexibility was to create a structure that was a minimal as possible. This was done in order to create free space that could be dived and changed in a variety of different ways. The internal columns do limit the placement of the internal walls but was the best that could be achieved at the time.

Flexible strategies and tactics used
Clear span
Communal circulation
Divisible rooms
Functionally natural rooms
Vertical distribution
Housing Block Erasmulaan

Date: 1931  
Country: The Netherlands  
Architect: Gerrit Rietveld  
Project type: Terrace

Gerrit Rietveld designed Erasmulaan housing block in 1931. He simplifies the principles that Rietveld used in the Schroder Huis. The plan is based on 1m module and the structural system allows for division of open space without load bearing walls. On the ground floor, folding walls that are guided by ceiling tracks subdivide the space. The upper floors are divided by conventional partition wall. In the plan the staircase, bathroom and kitchen are grouped together and are the only permanent fixed elements and space is then divided up around this space. The cross walls are double skin load bearing brick which support “I” beams that span the width of each house. The windows are undisturbed by structure but to allow for partition walls every 2 meters the window profiles are slightly wider.
Structure

The main idea of this housing block was to eliminate internal load bearing walls and instead use folding walls and partitions to divide the internal spaces. The structure consists of concrete floors and external walls which allowed for internal clear spans. The location of the stairs in the centre limits the ground floor flexibility.

Flexible strategies and tactics used

- Clear span
- Functionally natural rooms
- Movable and sliding walls
- Service core
Extendible Houses T’ Hool

Date: 1963  
Country: The Netherlands  
Architect: Johannes Van Der Broek, Jacob Bakema  
Project type: Terrace

The Extendible Houses T’ Hool were designed to allow for future expansion. The dwellings are placed on a long narrow site. This allows for room for future expansion and for each dwelling to have private outdoor space. The dwelling is designed to expand from 85m² up to 130m² in total.
Structure
The structure consists of two vertical concrete walls and a concrete roof plate. The concrete walls allow for future horizontal and vertical expansion. The space between these two walls allow for individual to determine room uses and for the house to grow with the occupants changing needs. The house type is meant for terrace housing and is duel aspect but also has the ability to have internal courtyards.

Flexible strategies and tactics used
Addition- horizontal
Addition- vertical
Clear span
Functionally natural rooms
Slack space
Diagoon Houses

Date: 1971  
Country: The Netherlands  
Architect: Herman Hertzberger  
Project type: Terrace

The concept for the terrace houses was based on the idea of the ‘incomplete building’. This approach gave the occupants a basic shell in which they could personalise and make their own. This approach gives the power of internal design layout over to the occupants so that they decide how they want to live in the space.

The dwelling consists of two fixed cores, the staircase and the bathroom and kitchen. Hertzberger indicates possible ways of dividing up the space using diagrams. However he does not dictate or impose how the space should be used. The buildings have a raw appearance due to the brickwork, which is used to infill the skeleton structure. Slack space has been provided in order to allow the building to grow over time.
Structure
The Diagoon House’s structure consists of a concrete floor, and fixed service core. Unlike the flowing two case studies the interior spaces within the floor plate are not free of structural elements. This limits the arrangement of internal partitions and variations of spatial layouts. Slack space is provided with the building and hints at future occupation. The internal stair case, half level floors, and services limit the future adaptability of the space and variations of layouts.

Flexible strategies and tactics used
Divisible room
Functional natural rooms
Slack space
Service core
Support structure and infill
Wohnanlage Genter Strasse

Date: 1972  
Country: Germany  
Architect: Otto Steidle and Partners  
Project type: Terrace

Wohnanlage Genter Strasse demonstrates the development and technical refinement of flexibility principals based around the idea of Habraken’s support and infill. The dwellings consist of a prefabricated concrete skeleton with corbels on every half level. The corbels anticipate future change, as they allow for cross beams to be placed and moved easily. By providing structural connections at half levels, it increased the possibility for adaptation and change in the future. The facade consists of a frame and solid panels and glazed panels. They have the ability to be taken in and out which gives the occupants the opportunity to individualize their dwelling by colour and pattern arrangement. The building illustrates principles of flexibility that are found in the Diagoon house, through the provision of slack space, structural skeleton, and user participation.
**Structure**

The structure is based around Habraken’s Theory of Support and Infill, Otto Steidle and Partners have developed dwellings which posses the ability for great change and not only in internal spaces but also the ability of the floor level to be moved. This has been achieved through a concrete skeleton with corbels at every half level which provide the ability for floor levels to be changed. This approach to Habraken’s theory has been successful in providing flexibility, user choice and individuality. Unlike the other five examples Wohnanlage Genter Strasse has given the occupants the ability to determine and change the exterior facade, by giving them coloured and glazed panels that they can arrange as they want.

**Flexible strategies and tactics used**

- Clear span
- Functionally neutral rooms
- Raw space
- Service core
- Slack space
- Support structure and infill

![Figure 2.28 Wohnanlage Genter Strasse structure](image1)

![Figure 2.29 Wohnanlage Genter Strasse floor plan](image2)
Hollabrunn

Date: 1976
Country: Austria
Architect: Ottokar Uhl and Josef Weber
Project type: Terrace

Hollabrunn is based on an entry to the 1971 “Wohnen Marger” competition that was run by the Austrian government department for building technologies. The main idea for the scheme attempted to deal with the problem of building for the unknown future user. The scheme uses Habraken’s theory of support and infill to address the issue of the unknown user. The support system consists of prefabricated concrete columns, beams, and institute concrete ceilings. The stair case is the only fixed internal element. The occupants are able to choose the arrangement of walls, positions of windows, door, finish of the dwelling, and the size of the unit. The dwelling uses clear spans to allow the occupants to re-arrange and change the internal layouts by themselves.
Structure
The use of Habraken’s support and infill theory was the driving idea of this development. The structure consists of concrete beams, columns and concrete floor panels. The structure can accommodate a variety of sized dwellings and different internal layouts due to its support structure. The use of Habraken’s theory has enabled the dwellings to change and adapt with the users.

Flexible strategies and tactics used
Clear span
Circulation core
Divisible rooms
Functional neutral rooms
Raw space
Support structure and infill
2.3: Historical analysis
To assist with the development of this research project, the history of New Zealand’s culture and society has been analysed, and the history of Auckland’s urban form has been considered. Having this basis knowledge provides a clearer understanding of Auckland’s history which helps to illustrate the affect on urban form and density. (Appendix 1) This analysis has helped define the design approach within this research paper and assisted in making the support and infill theory suitable for Auckland.
3.0: Develop Project: Design/ Research
3.1: Flexibility strategies
This exploration identifies strategies and tactics that propose ways that flexibility can be incorporated into the design. Till and Schneider’s *Flexible Housing* includes a chapter on a manual for flexible housing which offer a range of tactics and strategies that can be incorporated into design to achieve flexibility. They describe the plan as a “particular ways that housing may be physically planned in order to promote flexibility so that it can adapt to changing social uses.”

Through the precedent studies and concept support design, relevant strategies and tactics were described and analysed for their feasibility for the program.

The chosen tactics were:
- Slack space
- Raw spaces
- Functionally natural rooms
- Service core
- Clear span
- Partitions
- Dividing up

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32 Schneider, Till. *Flexible Housing*, 181
Flexibility strategies 3.1.1: Slack space

Slack space is space that is typically outside the housing unit that can be taken over by the residents for occupational use. Herman Hertzberg uses the idea of slack space in his design of the “Diagoon house”. He provided external spaces and internal spaces that could be inhabited by the occupants according to their individual needs.

Advantages
- Provides occupants with space that can be filled over time
- It is not defined but suggestive of potential occupation and allows occupants control over the space

Disadvantage
- Paying for extra space that it not occupied immediately

Figure 3.1 Slack space
Flexibility strategies 3.1.2: Raw space

Raw space is space that is anticipatory space, and it is suggestive of future occupation rather than determining it. This approach is to provide open unfinished space this allows the user to decide how they want to use the area. The provision of open neutral space is not enough to be called raw space. Raw space is greatly affected by structure. If the structure is too large it becomes insufficient, if the structure is too small it determines how the space can be used.

Advantages
- Building can be fit out as the user chooses
- No internal walls are fixed and occupants are provided with an empty space in which to personalise

Disadvantages
- Higher than average up front cost
- Placement of services and entrances need to be carefully considered as they are a fixed element.
Flexibility strategies 3.1.3: Functionally neutral rooms

A functional neutral room has no specific use. By incorporating functionally neutral rooms, room labels are gone and instead a number of equally sized rooms are provided. By removing the hierarchical order of the labels, it allows each space to become an independent entity. By having a number of equally sized rooms it means that the living room is slightly smaller than normal and the bedrooms are slightly larger than normal. An advantage of functionally neutral rooms is that they can be occupied by a variety of different user groups.

Advantages
- Rooms are not determined by name and can take on various uses
- Unit can be occupied in a variety of different ways
- High cost benefit

Disadvantages
- Living room is slightly small while bedrooms are slightly larger
- Slightly higher initial cost than typical house construction

Figure 3.2 Functionally Neutral room
Flexibility strategies 3.1.4: Service core

The position of the service core is critical in determining the flexibility of a unit. It often determines the most permanent elements in plans. The bathroom and kitchen are the rooms that are the least likely to move over time. The kitchen and bathroom should be the first consideration when planning the design of the house. Once they have been considered and placed in the plan then the space around the service core can be divided up to determine what layouts are possible.

Advantages
- Thought out placement of the service core enables flexibility and change to be achievable
- A necessity in a house

Disadvantage
- Most permanent part of the plan and has to be considered carefully as it is critical to determining the flexibility of the unit.
Flexibility strategies 3.1.5: Clear span

Providing clear spans across individual units is the most important construction principals in order to achieve flexibility. Clear spans allow internal partitioned walls to be non-load bearing and therefore make future change more easily achievable. Clear spans are easily achieved but are not commonly used in low-rise terrace housing.

Advantages
- Allows for non load bearing internal walls
- No internal columns
- Free space within plan
- High cost benefit
- Wall can be easily moved and changes without specialist help

Disadvantages
- Structure has to be stronger than typical
- House construction to allow for no internal load bearing walls
- Higher initial cost than typical construction
Flexibility strategies 3.1.6: Partitions

Rather than building fixed partitions which limit flexibility, movable partitions that have the ability to move allows for greater flexibility. For partitions to be flexible they have to be non load bearing. This enables the user to move the partitions in order to change the size of a room or the internal layout as they please. Movable partitions cannot have fixed services running through them as these services would prevent occupants being able to move wall around themselves.

Advantages
- Can be easily erected, moved and changed
- Temporary way of dividing space efficiently
- Allows raw space to be used in a variety of different ways
- High cost benefit

Disadvantages
- Cannot have services running through them

Figure 3.5 partition user choice
Flexibility strategies 3.1.7: Dividing up

Dividing up allows a larger unit to be divided up into separate units. It is the reverse of joining. It allows the owner of the unit to stay in their unit once they have downsized. The unit can be divided in two ways:

1. A large unit can be split into two separate self-contained units, this will need to have two separate entrances and will have to be considered at the design stage.
2. A larger unit can be split up into a granny flat, office or a room for rent in this case it is not necessary to have a separate entrance.

Advantages:
- Allows unit to grow and shrink
- Allows occupant to earn an income from their home if it was divided up into two units.
- Allows occupant to stay in their home when it gets to big
- Allows unit to suit and cater for a variety of different sized families

Disadvantages:
- Requires separate access for each unit this needs to be considered at the design process

Figure 3.6 Dividing up
3.2 Program
Currently Auckland is facing a housing crisis because of: a present under supply of housing to meet demands, lack of housing choice and poor quality. The Auckland council stated that “Auckland’s households, families and communities are increasingly diverse. Housing must cater for different life stages, cultures and families/whānau of different sizes and types. Ideally, the mix of housing in a neighbourhood should allow people the choice of a suitable dwelling within the same community as they move through different life stages.”

The program proposes the use of flexible housing to deal with the issue of diverse needs and suitability of dwellings to cater to different people. The program is to design Support and Infill housing that is flexible and adaptable for Housing New Zealand. Housing New Zealand’s mission is to “provide access to decent housing solutions for New Zealanders with priority needs.”

The flexible house types developed will be tested on a site to test their suitability to fit into current housing schemes. The housing will be a combination of rentals and Housing New Zealand’s ‘home ownership’ scheme. The tenants home ownership scheme works through Housing New Zealand offering state housing tenants the opportunity to buy their home.

Housing New Zealand has to cater for different needs and situations. Houses need to change to meet the current demands. The Support and Infill dwellings would allow the housing to adapt and change to the different needs with minimum cost and effort. The Flexible housing will be built through Housing New Zealand’s ‘build, buy, develop, redevelopment, and lease’ program.

The focus of the design process is first to establish the levels of control in order to determine what will be determined by the architect and what will be determined by the unknown user. The main focus of this thesis is to design flexible and adaptable house types using Till’s Schneider’s and Habraken’s theories. The theories and existing knowledge will be referred to and used to analyse the design process in order to provide housing types that are flexible and adaptable and meet a variety of different needs.

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3.3 Test Site
The test site is being used to test the feasibility of the support and infill theory to establish whether it could work in Auckland. The test site will allow the support and infill design to demonstrate its possibilities for Auckland and medium density housing. Hobsonville point is being developed by Hobsonville Land Company Limited which is a wholly owned subsidiary of Housing New Zealand Corporation.

The site
The site that has been chosen for the test is Hobsonville Point which is a current development being built in west Auckland. The scheme consists of over 3000 homes. It is a mixture of apartments, terrace housing and stand alone housing. The aim is to create a development that has a variety of different house types. The consideration for social sustainability and environmental sustainability is a big factor in the development and is key for getting it working at such a large scale.

This site has been developed with Auckland housing needs in mind and has considered the long term implication of housing. It is a new way of looking at development within Auckland. The site has been chosen for the test because of Hobsonville Point’s vision and their new approach to housing development. By applying the designed housing types it will establish the feasibility of how they could fit into Auckland’s housing

Climate
Auckland weather is varied and unpredictable due to its near-subtropical climate. Auckland is hot and humid in summer and mild and damp in winter. Auckland has a high rainfall throughout the year, its weather can be changeable and experiences extreme weather conditions e.g. thunderstorms, tropical cyclone and hail storms.

The following are average climate statistics for the Auckland area;
Average annual rainfall (mm): 1,240
Average annual sunshine (hours): 2,060
Average summer temperature (°C): 20
Average winter temperature (°C): 11

Context
Hobsonville Point is located roughly halfway between Albany and Westgate and is located just off State Highway 18. The location is just a 20 minute drive in off-peak traffic from the Auckland CBD. The inclusion of a ferry terminal in the scheme allows for public transport from Hobsonville to the inner city. The development is being built on the old RNZAF base which has gradually been unused from 2001.

Site analysis
The test will be undertaken on the south east corner of the development in Buckley B section which is in yellow in figure 3.8. This location has been chosen as it is on the boundary of the site. It is zoned for terrace housing and it has the ability to test different configurations of the supports on the site.
Hobsonville point
Hobsonville Points vision is to “build a strong vibrant community that sets benchmarks for quality and accessible urban development with an environmentally responsible focus.” The development aims to provide a variety of different housing types in order to create a diverse community of people. Suitability is a big focus and has been integrated into the design guides by including water collection, solar panels, ordination of houses, insulation, thermal mass, and careful material choice. The development has been chosen for the test site as it is forward thinking in its approach to housing design. A variety of different housing companies will provide designs for people to buy off the plan and build.

The development’s amenities and transport are important considerations. They will allow the development to work and function effectively as the location is more isolated from existing amenities so they have been designed into the plan.

Transportation options include:
- Buses
- Ferries
- Vehicles

Amenities include:
- Cafe and community spaces
- Tennis courts
- Parks
- Community hall
- Costal walk and cycle ways
- Early childhood education
- Local shops at Hobsonville
- Primary school
- Secondary school

The test site will provide the ability to show how the flexible housing types can work within the context of Auckland. Zones allocated for terrace housing will have the flexible housing types applied to it and will demonstrate the possibilities these types have for the future of Auckland’s housing.

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36 Hobsonville land company, Corporate responsibly report 2010/2011,
3.4 Design Process

The development of a flexible and adaptable housing type was approached through a series of explorations. Through the design process, different approaches to support design, infill, and flexibility were investigated through the use of C.A.D programs, physical and 3D computer modelling.

The initial design process was focused on Habraken’s theory of Support and Infill. The secondary focus was on Till and Schneider’s approach to flexible housing which provided current knowledge of flexibility which Habraken’s text from 1961 doesn’t address. The overall idea was to develop a support structure that would allow for internal change and variations of the infill plan, while not compromising the structural integrity of the buildings.

The developments were analysed taking into consideration their flexibility, variations and their execution of Habraken’s theory. The analyses were used to reach a resolved design by incorporating the positive aspects of the developments and addressing the issues that arose during the developments.
Exploration 1.0: Levels of control

Before starting the design, process-specific spheres of control and responsibilities needed to be established. This established the parameters for how the design would be approached. Habraken’s approach to spheres of control was centred around ‘levels’. Levels are defined as “a layered hierarchical structure in which higher levels serve as a context in which lower levels operate. The levels describe the interrelated configurations of physical elements and their decision making sphere occurring at different scales within the built environment”

This approach deals with the support in the community sphere and the infill in the individual sphere. This approach was taken due to the fact that a dwelling was always existing in two spheres. Living cannot exclusively exist in one sphere

The program and research determined that the level of control that the design would focus on and develop was the Support and Infill levels proposed in Habraken’s “Supports: An Alternative for Mass Housing.”

The approach of flexible housing type is to design and develop a support, and variations of possible infill for the support while not dictating the use, layout of the infill. Designing variation allows the design to be tested for its flexibility, and ensures that the design does not limit the flexibility and adaptability.
Exploration 2.0: Support

A support is a structure which contains a dwelling. The support allows the dwelling to be built, altered and taken down, independently of each other without affecting the structural integrity of the support\(^{38}\). A support structure normally includes; the building's primary structure, the building's envelope (roof and facade), circulation (stairs, lobby, corridors) and services (electrical, heating, air conditioning, telephone, water supply, drainage and gas). (Appendix 2)

Determining what a support is and what a support consist of forms the parameters for the exploration and design that is required to develop a resolved support structure. The following aspects of a support structure were investigated through plan, section, and 3d modelling:

2.1 Support size
2.2 Support structure
2.3 Support circulation
2.4 Support services
2.5 Support facade

\(^{38}\) Habraken, Supports: An Alternative to Mass Housing

Figure 3.13 Support and infill
Support 2.1: Support size

Exploration through research and concept designs determined the frontage width of the support to be 6.2m. The frontage width of 6.2m was reached by analysing the space needed for stairs (1.8m), circulation (1.2m), and usable room dimensions (3.2m). The frontage width was tested by developing variations of different layouts of the space to ensure the frontage provided flexibility and variety.

The depth of the support was developed through design of internal spaces and Till and Schneider’s idea of functionally of neutral rooms. The designs were analysed against their flexibility, adaptability and variations that the size of the support could achieve.

Two dimensions were chosen through this process 15m and 12m. Both dimensions offer different opportunities in plan, variations and design. The 15m support has the possibilities to be divisible, and internal courtyards providing slack. While the 12m support provides a unit that is smaller and has the ability to be divided in different ways. The two different support sizes were developed in order to provide choice not only in plan but also in unit size.

The finalised size of the support was important to be reach early in the design process as it affects the structure, circulation, services, facade and flexibility of the internal space.
Support 2.2: Support Structure

The support structure is the most important and critical part of achieving flexible and adaptable housing. Habraken never shows or dictates what a support structure looks like, he only states what a support structure must achieve. The vague explanation of what a support structure consists of offers little direction or parameters for how it is designed. He left the individual to decided how a support is made, and looks. Because of this there is a variety of different ways of approaching the design and development of a support structure. Each approach is different in every case, but none of them are identified as the wrong way to design a support structure.

During the preliminary conceptual design stage, different ways of support structure configurations were considered. Habraken’s theory, open building literature, and precedent studies were used to explore different design approaches to designing a support structure.

The following are different design approaches that were explored in order to reach a resolved conclusion for a support structure design. Each design concept was analysed in order to identify the positive aspect and negatives in order to develop a suitable support structure for the programme.
2.2.1: SAR’s support theory concept

This concept has been designed using the SAR’s application of support structure theory and Habraken’s support design depicted in variations. The structure consists of shear walls and concrete floor plates. There are breaks in the shear walls to allow for joining and windows to be placed. Courtyards and stairwell locations have to be determined in the early design stage so they can be incorporated into the floor plate configuration.

Figure 3.18 SAR’s Application of support and infill theory

Outcomes

Issues

1. Structure doesn’t allow for changing floor levels.
2. The concrete floor construction makes it harder to divide units as a hole for the stairs would have to be cut at a later date to accommodate separate entrances.
3. Limited placement of windows on the side of the building.
4. Variations of external spaces throughout the structure are limited by the concrete floor slabs and would have to be considered at the design stage.

This exploration has brought up issues of having solid floors and the limitations that the concrete floors have of the variations that can be achieved within the design. This approach would work within apartment’s typologies but has too many limitations in housing.

Figure 3.19 Support design concept 2.21

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39 Bosma, Van Hoogstraten, Voss, Housing for the Millions
2.2.2: Structural Skeleton concept

This approach uses a structural skeleton which could be infilled and changed to suit occupants needs. Using the outcomes reached in concept 2.2.1. The structure consists of a steel frame which addresses the issue of having permanent concrete floor plates. It also addresses the issue of limited window placements through having a structure that has no external fixed walls.

Outcomes

Issues
1. Sceptical of how the structures will work linked together in terrace or row house formation.
2. Noise transfer a potential issue
3. No flexibility and variety in floor levels.

Positive aspects
1. Variety in window placement possible depending on how they are placed on site.
2. Variety in different cladding. (Compared to previous concept)
3. Allows variation of external spaces throughout structure.

This exploration has attempted to deal with the issues of the concept 2.2.1. It has gone to the other extreme and created a minimal structure, while it possess the aspirations of a support it doesn’t depict what Habraken’s vision of what a support should be.
2.2.3 Hollabrunn concept

This concept applied the knowledge learnt from the precedent study of Hollabrunn. Hollabrunn used Habraken’s theory of support and infill and created a prefabricated concrete structure. Using this knowledge the concept design for this support uses columns, breams and, floor components to connect them together. Like Hollabrunn the staircase is a fixed element and along with the structure is the only fixed element within the support. Unlike SAR’s support concept design the floor is not fixed but made up of panels enabling the occupant to move and choose the size of the unit.

Outcomes

Issues
1. Floor levels are fixed.
2. Fixed staircase limits the potential for future change and limits the internal variations that can be achieved.

Positive aspects
1. Floor panels can be moved to allow for outdoor space and double height spaces.
2. Size of the unit can be chosen by the occupant.
3. Windows can be placed on all sides which allows for greater opportunities in site planning.

This exploration has achieved and addressed a lot of previous issues that have arisen in prior concepts. More flexibility could be achieved through moving floor levels which would create greater user control and empowerment.
2.2.4: Wohnanlage Genter Strasse concept

Using the approach investigated in the precedent studies this concept applies the same principles and technical refinement that Wohnanlage Genter Strasse used to achieve greater flexibility and user choice. This exploration was chosen due to its application of Habrakens theory and the ability to change floor levels which provides a greater degree of flexibility which the pervious explorations have struggled to achieve. The structure is concrete and consists of columns that have cobs on every half level to allow for different floor levels. Concrete beams connect the columns together and allow for floors to be placed on them.

Outcomes

Issues

1. Materiality of beams have to be considered carefully. The ability to easily move them is important otherwise it restricts the occupant’s ability to change the configuration of the structure as they need.

Positive aspects

1. Floor levels can be moved and chosen by the occupants which creates a greater user-choice.
2. It has a greater flexibility as the beams can be moved and changed.
3. Like SAR’s supports structure is shares between adjoining supports.
4. Greater ability to create different aesthetic styles while still having a distinct look of a support structure.
5. Less concrete than supports and columns and beams can be pre cast. Since they are smaller than shear walls they can be more easily made off site and transported.
6. Floor plan size can be chosen by the occupants.

This concept has addresses issues of the previous concepts and has incorporated knowledge gained through the precedent studies. It was concluded that Wohnanlage Genter Strasse was the most successful flexible housing precedent from the six studied (Appendix 3). By providing more flexibility in floor level it creates greater flexibility not only within the infill but also the support which the other three concepts do not.

Figure 3.22 Support design concept 2.2.4
In summary, two, three concepts have qualities that can be combined and developed further. Through the concepts, the importance of flexibility within the structure not only the infill has been highlighted. This project is focusing on flexibility and adaptability, while Habraken’s theory of support enables infill within the support to be flexible, the support itself is not flexible. This issue has been identified and investigated through the conceptual design.

The issue of flexibility within the structure using the three conceptual designs will be developed and resolved further to result in a conclusive support structure design that embodies not only Habrakens theory but also incorporates flexibility into the structure.
Support 2.3: Services
Consideration of services and establishing the ability to change and renew them is an important aspect of flexibility. Providing the ability to access it for future upgrades and change that may occur is an important design issue. A support includes connections for services allowing the occupant to plug in their infill unit. From the precedent study and Till and Schneider’s flexible housing manual the concept of vertical services distribution was developed into the design of the support.

Till and Schneider state that services should be collected together in vertical stacks or risers; this vertical distribution allows access for future upgrades and services⁴⁰. Bathrooms and kitchens have a large impact on determining the location of the vertical distribution, this affects the flexibility and layout of the rooms. We are not able to predict the type of technological needs that may arise in the future but we can make provision when planning in the design stage.

Through the development of variations of plans and layouts within the support, the most suitable location for the vertical service riser was identified. The service stack is integrated into the support structure and also allows for easy access.

⁴⁰ Schneider and Till, Flexible Housing
Support 2.4: Circulation
The development of circulation through the building was not an issue as it is a fixed element. The consideration of the staircase placement was important as this affected the internal flexibility and variations that could be achieved within the support. Through the present study and research it was established that the best approach to circulation was to create access directly from the front door via a small lobby or entrance space. This design development would enable the support to be divided into separate units more easily as access did not rely on going through the building.

It was an important design consideration to have the stairs entering the centre of the support to allow for rooms to have natural light and ventilation. Investigation into how the stairs would be configured was undertaken through plan and section.

Figure 3.27 Staircase
Stair concept 1
Positive aspects
1. Compact.
2. Enters into centre of the 1st floor
Issues
1. Too many stairs without a landing (potential safety hazard)

Stair concept 2
Positive aspects
1. Landing breaks up flight of stairs.
2. Enters into the centre of the building on the 1st floor.
Issues
1. Landing takes up too much space between levels.
2. Stairs could be place against wall to provide more space.
3. Restricts entrance on ground floor to front of the building which limits variations that can be achieved within the space.
Stair concept 3
Positive aspects
1. Allows ground level to be entered into the middle of the building through the lobby.
2. Enters into the middle of the building on the first floor.
3. Landing breaks up straight flight of stairs.

Stair concept 4
Positive aspects
Compact
1. Creates an interesting double height space.
2. Has potential to be used as a light well.
   Entry into the ground and first floor is in a position that allows for flexibility and variety in the infill.
Issues
1. Entry to stairs is difficult on ground floor and is more suited to the second floor situation.
Conceptual Circulation Design evaluation

In summary, concept 3 and 4 are the best solution for the circulation up the building as they are compact and enable the occupant to enter in the centre of the building at the same location on the first and second floors.
Support 2.5: Facade system

After developing a support structure, the preliminary conceptual design for the facade was designed and its effects on flexibility and adaptability were explored. The concept of using a fixed facade like typical housing was considered but ruled out due to its permanence and its restriction on the expansion to the dwelling and lack of customisation it provided.

The facade is one of the least permanent components of the support structure. It has an expected life of between 30-60 years. This was a driving force behind the design decision of having a panelised envelope system that would allow panels to be detachable. This would allow for panels to be changed and replaced when they needed to be. However it also allowed for occupants to have a say in the configuration and arrangement of the panels on their dwellings facade. This would allow them control over how the building looked and enabled them to show their individuality and eliminate the uniformity within the facades appearance.

The purpose of the program was to create flexibility and adaptability which will allow individual choice. In this design process the facades will be developed and analysed against their suitability for the programme and their flexibility and adaptability. The facade designs were developed by considering their ability for customization and change. Moveable screens or louvres could be used for privacy which would also provide movement within the facade (Appendix 4).

The following are developed concept designs that were produced using the aforementioned design considerations.
2.5.1 Facade concept design
This concept design for a facade was an exploration of how to design a facade without knowing the location of the internal walls. The concept design tried to express the supports quality of variety by varying the panel sizes. The varying panel sizes were incorporated to create interest and change.

Outcomes

Issues
1. Panel sizes are all different which could create cost issues
2. Does not resolve the issue of how to design a facade without knowing where the walls are.
3. Does not allow users to individualise their external facade.
4. Privacy would be an issue depending on its placement in relation to dwellings around it.
5. Uniformity of facade in development could be an issue

This exploration has attempted to deal with issues of unknown placements of internal walls and variety in the window configuration. While the concept design creates variety there is still the issue of internal wall placement and the issue of uniformity needs to be addressed.
2.5.2 Facade concept design
The concept design tried to simplify the facade into clean clear panels. It tries to deal with the issues of wall placement by having breaks in the facade at 0.8m. This distance was determined by testing variations within the support to determine where the wall placements are most likely to be placed due to room size and location. Through the variations it enabled the concept design to be more suited to variety of different layouts than concept design 2.5.1.

Outcomes
Issues
1. Uniformity could be an issues as all the panels are the same size.
2. Users do to have the ability to personalise their facade.
3. Privacy would be an issue.
4. No variety of flexibility to change facade configuration to combat uniformity.

Positive aspects
1. Wall placement has been investigated through investigation of possible variations to determine the best panel size

This exploration has investigated panel sizes and potential internal layouts to anticipate where walls will be placed and creates a facade that will allow them to be place there. The issue of uniformity and personalization that arose in concept 2.5.1 are still present and need to be addressed in further concept designs.
2.5.3 Facade concept design
This exploration of the facade design kept the 0.8m facade panels but introduced breaks within the 0.8m panels to provide greater variety and reduce uniformity. The breaks within the 0.8 panels provide a greater variety of wall placement within the support. The design attempts to resolve the problems that arose in 2.5.1 and 2.5.2 concept design by creating a varying pattern.

Outcomes
Issues
1. Personalization is not being addressed.
2. Privacy is still an issue.
Positive aspects
1. Panels can be varied to create variety and flexibility.
2. Uniformity is addressed by varying panel breaks.
3. Has more variety in possible placements of internal walls.

This exploration has identified and addressed issues of uniformity and unknown wall placements. Issues of personalization and privacy are still an issue that needs to be addressed. This could be addressed through solid panels in the facade and/or through louvres or shutters.
2.5.4 Facade concept design
This concept design explores the possibilities of personalization and variety within the facade. This has been explored through solid panels that can be moved and rearranged by the occupants which enables them greater control over the facade and allows them to set themselves apart from their neighbours through facade configuration. Exploration 2.5.2 and 2.5.3 have been used for their panel sizes.

Outcomes
Positive aspects
1. Uniformity is addressed by involving users and allowing them control over the façade.
2. Personalization is achieved by solid panels that can be moved and changed by occupants.
3. Privacy can be addressed by using solid panels where needed.
4. Wall placement is not an issue as the use of solid panels and panel breaks gives a greater variety of opportunities within.

This exploration has addressed the issue of uniformity and personalization in a way that involves the user and allows them control over their building appearance. The coloured panels create variety and bring in colour and material into the concrete support structure.

Figure 3.36 Façade concept design 2.5.4
Conceptual Facade Design Evaluation

In summary, through conceptual design investigations the facade conceptual design that will be developed further is concept 2.5.4. This is due to its ability for occupants to have control over the facade configuration and personalise their home. This is an important issue raised in *Supports: An Alternative to Mass Housing* to allow users control over design and allow them to choose how they want to use the support. The ability to change the face configuration is important in terms of flexibility as it provides change and enables walls to be placed anywhere. The layout of the façade panel sizes and potential pattern configuration needs further development to provide a facade that also allows for flexibility.

Figure 3.37 Concept design 2.5.4
Exploration 3.0: Infill

Infill refers to fit out or detachable units which are defined as being “the set and configuration of physical elements determined for each individual occupancy within a support structure.” The approach to the design of infill has been to develop ways and variations of how a support can be used.

The approach to infill was not to determine or dictate how the space had to be used but rather provide variations of ways the space can be split up and used. The components that make up the infill are partitions, kitchen, bathrooms and doors. The development explores the possibilities for variations and components within the developed support structure. The developments are driven by Habraken’s infill theory and Till and Schneider’s flexible housing tactics. Infill developments include:

4.1: Detachable Units
4.2: Variations

41 Habraken, Mignucci, Supports: Housing and City, 93
Infill 3.1: Detachable Units
The conceptual designs for the detachable units for the infill of the support consisted of bathroom, kitchen, walls and door units. The conceptual developments of the bathroom and kitchen had to fit into the width of 1.8m wide as the services located along the wall of the stairs determined the location of the kitchen and bathroom. The 1.8m wide space was determined in the support size design and created a parameter in which the stairs, kitchen and bathroom have to fit.

Partition wall and door components are explored through design. All the detachable units have been driven by precedent studies, literature and open building case studies. This has enabled the designs to consider other ways of achieving Habraken’s infill theory while still focusing on flexibility and adaptability. All the units are just explorations and variations of what could be done within the support. The variations allow the thesis to test the support and infill theory, and flexibility that can be achieved. As mentioned in the start of the design process where levels of control were established this is a test of the some of the variations that can be achieved within the design. There is no singular solutions to the infill and detachable units, only possible solutions.
3.1.1 Bathroom Units
The bathroom units developed are tests that the variations that can be achieved within a width of 1.8m. They explore the possibilities for small compact bathrooms and bathrooms that include baths, separate toilets and showers. These variations show the layouts that can be achieved within the width and show bathrooms that cater to different family situations.

Outcomes
Positive aspects
1. 1.8m allows for a compact bathroom.
2. Length of bathroom can be determined by occupants needs.
3. Control over the bathroom fit out can determined by the occupant

Issues
1. Unknown needs of occupants limit the ability to come to a resolved conclusion. All that can be shown is the variety of different configurations that can be achieved within the space.

Figure 3.39 Bathroom units
3.1.2 Kitchen units

The kitchen conceptual design focuses on what can be achieved within a width of 1.8m. Like the approach taken towards the bathroom these are only variations of how the space could be used. The occupant’s needs and wants determine what the kitchen and bathroom are like. While variations for a 1.8m wide kitchen have been shown there are no limits of what size the kitchen can be. The location of the kitchen can affect flexibility depending on where it is placed. Through this design process kitchens that have limited impact on flexibility have been developed.

Outcomes

Positive aspects
1. A compact kitchen can be expanded and changed as the occupants needs and wants also change.
2. User has control over what kitchen they want.
3. User has the ability to change the kitchen to suit their needs rather than them conforming to the kitchen.

Issues
1. Users needs are all different.
2. Different kitchen configurations wider than variations shown have an impact of flexibility of spaces.

Figure 3.40 Kitchen units
3.1.3 Partition components

Partitions and doors components are made of lightweight panels that can be fitted to the space. Their development through research has concluded that a variety of three different sized panels is the most efficient way to provide variety of options to divide space. The sizes of the panels were a conclusion achieved through internal variation tests and support size.

The panel width selected were; 1m, 0.8 and 0.2m. All of these panels have a height of 2.6m. The panels will be hung from ceiling rails which can be moved and changed through attaching them to the ceiling panels. This provides the ability to choose where the walls go so they are not limited by beams or fixed rails at pre deterring the spaces. The rails will allow for fixed panels and also sliding and folding panels.

Outcomes

Positive aspects
1. Partitions components variety of sizes allows for change and flexibility.
2. The ability to choose where partitions are place is important aspect to making the space flexible.
3. Provides user choice of layout of infill.

Issues
1. Rail system will have to be simple and legible to allow for its flexibility to be used to its full potential.
2. System of how rails can be put up and taken down need to be considered.

Figure 3.41 Partition components
Infill 3.2: Variations

The term variation refers to the variations of infill layouts and configurations. Variations have been used to test flexibility of support structures; size, facade and service core location. The variations have also been used to test infill unit components. Variations have been investigated and explored through plan section and physical modelling. The variations are tests for flexibility and the supports capacity to change and adapt to different situations. Variations are a way of showing how the support can be filled/used and provide the occupant with an idea of the possibilities of the support.

The following examples of infill variations show through plan and physical models the potential of the supports to provide change and the incorporation to Till and Schneider’s flexible housing tactics. They have not been analysed due to the fact that they are tests and not refined developments of a fixed internal layout.
Figure 3.43 Variation Models
5.0 Preliminary application of supports and infill on test sites

This exploration examines the potential of the developed support and infill designs to be applied to a test site in order to test how the support and infill designs work within a development and the context of Auckland. The test site will demonstrate the potential of; the supports, the variety and different configurations. This has been undertaken to ensure that the support and infill are not only flexible by themselves but are also flexible in a physical application to a site.

The preliminary application has explored the different arrangements and configurations that the supports can provide. The test site has provided the opportunity to show and test the potential of the supports and establish any limitations they may have. Considerations that need to be addressed in site planning are:
- Configuration of the supports
- Density
- Physical environment
- Social environment

See Appendix for more detail
Row/terrace houses
The supports typologies work best in row or terrace housing. This is due to the structures; height, scale and construction. As stated in Lynch and Hack’s book ‘Site Planning’, row houses “Provide the most space at the lowest cost are the cheapest to maintain heat”\(^42\). They are lower cost than average houses as they share walls with the adjoining dwelling which reduces on construction cost. The row house typology also “Provides as much outdoor privacy as the semi detached house and more privacy then the duplex.”\(^43\). Privacy is an important issue to be considered in medium density housing. Row houses make more efficient use of the land than detached houses in a medium density context as it eliminates the narrow side yard of the detached house, which is unusable due to lack of light.

The key driving forces behind the chosen typology was the fact of Habraken’s support structure is typical uses in apartments, or terrace/row housing.

Lynch and Hack state that: “Another concern, equally bound up in cultural attitudes, is the fear that personal identity may be lost in a row house complex. But it is quite possible to design row houses so that each unit has a different physiognomy or so that each can be personalised by the occupant.”\(^44\)

The issue of identity and individuality in mass housing was also addressed in Habraken’s ‘Supports: An Alternative to Mass Housing’ which described the desire to personalise a dwelling to meet one’s own needs\(^45\). The support structure and flexibility will allow the row houses to be individualized on site and eliminate the risk of identity loss within a development.

\(^{42}\) Lynch and Hack, site planning 3rd edition, 277
\(^{43}\) Ibid, 277
\(^{44}\) Ibid, 278
\(^{45}\) Habraken, Supports: An Alternative to Mass Housing

Figure 3.46 Concept configurations
4.0 Design Outcome
4.1 Support
Through the design process and exploration of the support the following resolved design has been chosen. This has been achieved through determining what a support is and what a support consists of. This formed the parameters for the explorations and designs that are required to develop a resolved support structure.
Developed design outcomes for:
- Support structure
- Materiality
- Support circulation
- Support services
- Support facade

Figure 4.1 Exploded view of support
4.1.1 Structure
The support structure was developed in detail using the findings from the support explorations. The design outcome was a structure that possesses Habraken’s theory of support but also provided flexibility. The flexibility is achieved through beams and corbels. The corbels of the support allow for beams to be moved in order to change floor levels. This allows the user choice and control, not only over the infill but also over the support. The structure is made up of concrete beams and columns that interlock to create a support structure.

This design outcome incorporates Till and Schneider’s approach to flexible housing. It provides greater flexibility in which a user can take control of configuration of internal levels as well as the infill.

Outcomes
Positive aspects:
1. Users have choice over where the floor levels are
2. Less concrete use than shear walls and more easily transportable
3. Concrete lasts longer than wood
4. Structure and materials can be used in different situations
5. Structure can be easily changed when needs and wants change
6. Can be divided more simply as there are no fixed solid floors to cut through to add more stairs
7. Windows can be placed anywhere around the structure as there are no limitations
8. Outdoor balconies and courtyards are more achievable as floor levels can be chosen rather than predetermined during design.
4.1.2 Materiality

The structure of the support is made of reinforced concrete beams and columns that will be produced off-site. Concrete was chosen due to its durability and life span. The internal beams which support the floor are made of concrete or laminated veneered lumber timber beams, this will provide the users choice and control over the structural materials. Habraken promotes user involvement and choice as it allows individuality and self expression which allows the support to truly become a dwelling. External weathering surfaces have been made of concrete to withstand the weather and last longer than timber construction.

The most suitable materials for the construction of the shared walls are concrete blocks or precast concrete panels. As they reduce noise transfer between dwellings and provide a fire wall between the attached dwellings. The facade and infill materials are dictated by the situation and individual, this provides the occupant with choice and a way to express themselves through their home.
4.1.3 Circulation
Stair placement and location within the support structure is important to the flexibility and adaptability of the internal space. The stair location was decided early on and took into consideration access, future division of the unit and its effect on the flexibility of the overall unit. Stairs are a fixed part of the support and allow the space to be inhabited. The location and configuration of the stairs were analysed through plan and section. Using variations of possible layouts that could be achieved to test the stairs viability and limitations that its location imposes.

Outcomes
Positive aspect
1. Access centre of the building
2. Compact against support wall which have a limited effect on flexibility.
3. Creates an interesting double height space.
4. Has potential to be used as a light well.
4.1.4 Services
The service core location is important and its placement within the support was considered carefully as it would affect flexibility. Access to the services was important because this enables the dwelling owner to update and change services as technology develops. The location was investigated through infill variations this established reoccurring patterns of placement where the kitchen and bathroom were placed on the plan. This enabled the service core to be placed in the most suitable position to allow the greatest flexibility.

The vertical service core can be accessed from the stairs as this doesn’t compromise flexibility. This approach was influenced by the precedent studies where vertical service cores were grouped together and accessed from the stairs. The service core constrains connection for water, electricity, drainage, telephone and gas. This enables the infill unit to plug into the support.

Outcomes
1. Located in the centre of the support where kitchen and bathroom will most likely be placed
2. Service core can be accessed for maintenance and future upgrades
3. When unit is divided services for second unit can be placed in the vertical service core
4. Service core allows infill to be plugged into amenities
5. Has limited affect on flexibility of the space
4.1.5 Facade
For the purpose of this thesis, a possible approach to a facade design has been chosen to depict one of the potential approaches to the facade. This facade design is one of the possible solutions and is not a conclusive final design for the support. By not having just one solution but many it enables the support to be suitable for different situations. It provides user choice and combats uniformity within housing developments.

The facade construction system consists of a stick system curtain wall. This enables the facade to be temporary and have the ability for change as the materials wear out or as the user needs. This concept has been developed further from the concept design, to ensure that the facade system allows for change over time and is not permanently fixed to the support structure.

The roof construction can be adapted to suit the situation and wants of the clients or developers. For the purpose of the application to the test site, and taking into consideration Auckland’s climate, a pitched roof was chosen. This conclusion was reached through the application to the test site, by exploring its affect on scale, elevation and context of surrounding buildings.

Figure 4.11 Facade and roof on support structure
Outcomes
Positive aspects
1. It embraces change
2. It allows user control and choice over facade
3. The system allows for the facade to be change as the facade wears out
4. Can be adapted and changed to create variety
5. Different patterns and configurations can be achieved
6. Deals with uniformity through user choice and control

Figure 4.12 Facade system

Figure 4.13 Stick system curtain wall diagram
4.2 Infill

Potential infill options for the support have been designed and developed to show the possibilities that the support provides. They are not conclusive designs as the infill of the unit is determined by the unknown user upon inhabiting the unit. User choice, flexibility and individuality were key design considerations when developing the infill designs. Using ‘Variations: The Systematic Design of Supports’ the infill design was developed and resolved.
4.2.1 Components

Variations of infill components have been designed and developed in order to show the potential for the space and how bathroom and kitchen units can fit into the support. The components consist of kitchen, bathroom and partitions. They are all only variations of what could be achieved within the space and are not conclusive designs. This approach allows user control over the space. The variations of infill components provide the ability to test the flexibility and adaptability of the support and also show the user the possibilities of what can be achieved within the space. The flowing design outcome of the infill components has been developed within the idea of minimal space taken up and consideration of how they affect flexibility within the space.
4.2.2 Variations

Variations of spatial layouts and external form within a support have been developed to provide and test the different options that can be achieved within the support. They have provided potential ways of how the support could be used to achieve flexibility. The variations have also been used to test infill components, stair location and service core location. The variations have been a key driving force behind critical decisions made throughout the design process, they have provided a way of testing flexibility. As the infill is not a conclusive resolved design the variations provide a way of show the possibilities of the support. The following are some possible variations of how the support can be used to create variety in plan and physical form of the building.

Figure 4.18 Variations of plans and sections
Figure 4.18 Variations of plans and sections
4.3.3 Flexibility tactics used
Till and Schneider’s flexible housing tactics played a large part in the design development of the support and also the infill. The tactics provided strategies to achieving flexibility through, structure and plan.

Support
The consideration of horizontal addition and expansion to the building was investigated through the test site by placing a support on the site and testing the potential for future expansion through diagrammatic sketches. The support provided a clear span that allowed for a free plan without load bearing internal wall or columns. This provides for greater flexibility and variations within the infill unit. The support also provided raw space and slack space that allows for user choice and doesn’t determine how the support should be used. By using both raw space and slack space it provides greater flexibility and variety, which was the main aim of using Habraken’s support and infill theory.

Plan
Through the variations of different layouts of the support, different tactics have been incorporated to provide greater flexibility. These tactics vary through the variations and tactics can be chosen by the occupant to determine what would benefit those most and enhance the space for them. The control of the plan and how the space is occupied is determined by the unknown user and variations have been provided to show the possibilities that can be achieved.
4.3 Divisibility

Till and Schneider mention the potential for a dwelling to be divisible in order for an occupant to continue to live in their home as they get older and their family grows and shrinks. The idea of divisibility is an important issue as currently the types of households are changing and will continue to change. By provide a dwelling that can be divisible it enables a building to adapt to changes. The divisible unit has to be considered in the design stage as access and how divisibility can be achieved is an important aspect of the design. Making sure that the support is divisible is important, this has been achieved through variations of different divisit

Divisibility has a large impact on density as the density will increase as each support is divided up. Divisibility is important as it deals to the key issues addressed in this thesis; flexibility, adaptability and density. Flexibility and adaptability are achieved through the support which provides the unit to be divisible and density is achieved through the way that one unit can become two then become three or more over time.
4.5 Test Site application

The test site development explores the potential of the supports to be used in an existing development. The explorations addressed the issues of density, scale and outdoor spaces. The supports application to the test site has shown that the supports can be used on a site and what their potential is. The test site allowed the supports to be used in a medium density context where there is a mixture of different housing types.

The outcome of the application of the test site was that the supports worked well in the context but careful considerations of density, scale and mass have to be made to suit the situation they are in. The test site demonstrates approaches to mass, scale and density though a series of explorations of different approaches, this shows the variations that can be provided with the supports.

The density, physical environment and social environment have all been considered during the application of the support and infill to the test site.

Density

The density of Hobsonville is at the low end of medium density and the approach to site planning took into consideration the current density and developed a plan that wasn’t too much of a higher density than the existing. Density was calculated per support structure and not the potential number of units that can be achieved within them when dividing the one unit up. The density aim for the test site was between 30-40dph this was explored through the design process.

Figure 4.22 Development of test site applications
5.0 Conclusion
5.1 Summary and Appraisal

The main aim of this thesis was to create flexible and adaptable house types at a medium density that would cater for individual’s changing needs. Through the literature review, precedent studies and research the conclusion reached was that you can’t design and develop types of house plans that will cater for different people’s needs. This is highlighted by Stewart Brand who stated;

“All buildings are predictions. All predictions are wrong” 46

This idea of not being able to predict what people’s needs and wants will be in the future is addressed through flexible housing, but it doesn’t go far enough in enabling the user the ability to make their home to suit them rather than the other way around. This issue of mass housing and user choice was addressed in Habrakens Supports; An alternative to Mass Housing which has strongly influenced the design process and outcome. He proposed the idea of a support which is designed by the architect and infill which is designed by the user.

The research by design stage used both Till and Schneider’s Flexible Housing book and Habrakens literature on supports. They were both used to develop a support and infill system to meet the aims and objectives of the thesis. The design process used variations of infill layouts to test the flexibility and adaptability of the supports. To test the ability of the support and infill to work within the Auckland context the developed designs were tested on a section of Hobsonville Point to ensure that the supports worked in the Auckland context at a medium density.

The design outcome was a developed support design and possible approaches to their infill. Both elements are flexible and adaptable. The supports and infill have been applied to the test site and show the potential of such a system in a medium density context in Auckland.

The final outcome from this thesis has been a new approach to flexible housing within Auckland. While flexible housing has been built overseas to deal with the issues of housing the unknown user, the idea of user control at medium density has not been approached in this way. The supports and infill provide an approach to housing that embraces the uncertainty of the future and provide greater flexibility than the average medium density house.

The conclusion of the thesis has posed some new questions; what is the architect’s role in the design of infill? and how would the support and infill concept fit into the culture of New Zealand housing? This approach to housing is different from the traditional of housing in New Zealand, but, as this study has demonstrated, it has the potential to be part of the solution to Auckland’s current housing crisis: adaptable structures that can be modified to meet change including sub-dividing to form practical space for two separate households. It would delay the need for further independent housing units, and also distribute existing investment in material, energy, and site space efficiently and sustainable. These are aims that have been identified within The Auckland Plan.
5.2 Future Directions
Auckland’s changing needs and growing population will have a large impact on Auckland’s approach to housing design. The Auckland Plan has identified some of the key issues that need to be addressed. The conversion of solutions to these issues - into resolved functional housing - will need to be carefully developed in order to make sure that they are able to adapt and change over time. Through this thesis the importance of a dwelling’s ability to change has been identified as a key issue of making homes suitable for the future.

This approach would work in New Zealand as it has in other countries around the world, where Habraken’s approach to housing has inspired the Open Building movement, and from which, in countries such as Holland, Denmark and Germany, numerous more adaptable models of housing have started to appear. These respond to principles of environmental and economic sustainability as well as the social ideas that have underpinned this study.

While the support and infill approach to housing would meet the key issues highlighted in The Auckland Plan it is unlikely that it would be used in the near future due to our building culture and New Zealand approach to housing. This does not mean that this approach would not work within New Zealand as it has in other countries around the world, where Habraken’s approach to housing has inspired the Open Building movement.
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8.0 Appendix
Appendix 1

Brief history of communities, society and housing in New Zealand

History of communities and society between 1850-1900 in New Zealand

For the early European settlers who came to New Zealand, this place was the land of opportunity. Most settlers came from England, Scotland, Wales and Ireland, where opportunities to buy their own land were extremely limited. New Zealand was advertised as the land of opportunity where the opportunity to own land was a possible ambition for all settlers. In the countries that most early settlers originated from society had its own social classes and rules: settlers arriving in New Zealand were able to establish new communities and a radically different society.

Society in New Zealand between 1850-1900 was developing and trends from that era still exist today. In rural areas of New Zealand individual’s kin, age, sex, and religion formed community bonds. As many rural communities were isolated throughout the region due to terrain, interaction was not strong but was varied between backgrounds of each family and the common ground they shared formed friendships and bonds. Society within New Zealand did not have the same social class systems as it did where many of the European settler’s came from. This lack of social class system did not create the social anxiety in the same way as it did from the settler’s homes. Miles Fairburn in The Ideal Society and its Enemies talks about New Zealand society and the fact that even though the social class system from the old country did not apply to New Zealand, there was still a standard that the local community model. He states; “Even through individual and strata ways vary in the economic power, everyone must appear to be the same as everyone else. The expression of differences of any sort was suppressed”

This view had a dominant impact on individual dwelling within the community. The uniformity of the classic villa expresses the views of society at the time of their construction. Each dwelling was around the same size and layout. Today the sense of everyone appearing to be the same no longer exists. Because New Zealand has developed over time, the class levels of “the old country” have never had much of an impact but individuality has thrived. This can be seen in housing today as a sense of poor, middle class, and rich has developed. State housing is seen as an example of poor housing as it was established to provide low cost housing for families on low incomes.

Many of the European immigrants moved here for a better life and opportunities. The immigrants who came from communities where status and the class system was strong, arrived to a country where there was no need to conform. Miles Fairburn states that; “The insiders view, its claims that New Zealand lacked the social mechanism to ensure conformity and status anxiety”

This statement shows that status and class structure were not present in New Zealand society. Status and class systems were social mechanisms, which ensured conformity that was upheld by community pressure. New Zealand lacked this pressure, as households in the county were isolated, and little social interaction was had with people outside the

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47 Fairburn, The Ideal of Society and its Enemies
48 Ibid 187
small communities. Many of the households were in the same line of work. Fairburn states that:

“The means of association at the local level were so thin, and such a large proportion of individuals had little or nothing to do with them, that social pressure to keep up with the Joneses must have been extremely weak”

This statement highlights the different social pressures that were experienced in the urban areas compared to the country regions where dwellings were far apart from each other.

Transient society
Weak connections within communities were partly due to the transience of individuals in society, as European settlers searched for wealth and New Zealand was seen to be a land of opportunity.

What propelled some settlers to this lifestyle was the ‘pursuit of real or illusionary better prospects’. Whether real or just perceived, the prospect of there being ‘something better out there’ is a concept that has carried through to our current culture. This is especially prevalent in housing, as many occupants move houses to find a house that is ‘better’ than the house they currently own. Whether this better prospect exists is dependent on individual perception and circumstances. This way of thinking and mentality can filter through to constantly changing job, house, and car etc.

The ideals of societies and its enemies describes the ideals of the early settlers who “desired to find a cheap and pleasant home has made me wonder for some time’ Specific themes in the mythology, furthermore actually taught colonists that itinerary was essential to getting on. The Erewhan syndrome the conviction that better, as- yet- undiscovered recourses and opportunities lay waiting over the range was wide spread”. The Erewhan syndrome is still prevalent today, currently in Auckland some individual either adapt or change homes when their needs change when they believe there is something better out there for them.

History of Auckland’s urban form
Williams Hobson the Governor of New Zealand founded Auckland on the 18th of September 1840. Between 1842-1865 Auckland was the capital of New Zealand. In 1842, the built area of Auckland was 33.2 hectares and contained a population of 2,895 people. During this time Auckland had the highest overall density of people per hectare in its history, it had 87 people per hectare compared with the density figure of 2006 calculated by the Auckland City Council to be 23 people per hectare. Auckland was therefore considered to be a ‘high density’ city at that time in New Zealand. Auckland’s urban development has been influenced by the presence of the volcanic field located across the litmus region. The resulting lakes, islands, cones, and depressions had a large impact on the look and development of Auckland urban form. The volcanic field has created a distinct visual identity and has provided the population of Auckland with large open parks and public open spaces.

Between 1860 and 1879, the population grew to 12,423 this was mostly due to the European settlers who were encouraged to immigrate to Auckland by an active recruitment drive, which included free or assigned passage to New Zealand. Some of
the settlers settled in the township, while many of them worked on clearing sections of land and helping to establish new farming areas and outlying townships. In 1871, the built-up area of Auckland was 565ha this being directly due to the increase in new settlers.

In 1896 the population of Auckland had grown to 57,616 and growth in commercial services and large scale manufacturing broadened the region’s economy, and created jobs which attracted people to work in the region. Around the commercial activities residential developments were formed. On the town fringe working class settlements formed with many of these settlements housing people that worked for the new industries, such as the brickworks and potteries in New Lynn and railway workshops in Newmarket. In new residential areas; Grey Lynn, Mt Albert, and Remuera the land was subdivided into sections by the 1890’s. However many of the sections were not built upon until the early 1920’s. Both Mt Albert and Grey Lynn have kept much of the characteristics of the 1920’s development, this is evident in the architecture and uniformity of the streets.

During the first two decades of the 20th century, dramatic changes occurred in Auckland, one of these being the dramatic change in urban form. In 1915, Auckland’s built area was 5039 ha and the population grew to 133,712, which had an impact on housing demand and land. Another dramatic change was the fact that Auckland became New Zealand’s largest industrial centre, which also affected the population and housing demand. Societies within Auckland could be defined by suburbs. The wealthy and middle class families moved out of the crowded and run down city centre to neighbourhoods that were more spacious on the edges of town.

The more wealthy residents headed to the eastern suburbs of Remuera and Epson, while the middle class built new suburbs to the south west of the city centre and the poor remained in the city centre. In the outer suburbs the housing was predominately stand alone houses on different sized plots of land these varied on the family’s wealth or there style of home. During this period, the common style of dwelling was the villa.

In the mid 1930’s, the great depression affected the growth of private individual dwellings due to the lack of loans and finances due to the great depression. Auckland experienced a new type of suburban growth, which was the introduction of state housing. The government was required to improve living conditions, which were detracting in the inner city. The Labour government’s state housing program developed single unit suburban homes, which they considered more suitable for families. The houses were built at low densities and with a large backyard and outdoor space. The state housing program was implemented all over New Zealand and provided low-income New Zealand families with a safe and healthy home that they could live in.

In 1966, the built area of Auckland was 26793 ha this with the ever increasing population made for the heavy reliance on personal vehicles to travel around Auckland. The government’s lenient lending policies allowed people to have their dream of having a detached house on a large lot, generally a quarter-acre (1100m2+) of land. This attitude and desire to have an individual house with a large plot of land lead to rapid expansion of
suburban area and suburban sprawl. State housing had a strong influence on the growth of urban form in Auckland, especially in south Auckland. By the early 1970’s over 40% of Otara’s housing was state housing. During the 1980’s New Zealand, experience broad economic deregulation, significant changes were made to the welfare system, there was a recession after the stock market crash in 1987, local government reform occurred and a growing population. All these issues affected the development and shape of urban development in the Auckland region.

Looking back at the development of Auckland’s urban form it has been characterised by the growth of suburbs, low-density development, urban sprawl, and the overwhelming growth of dependency on the motor vehicle to move around. Growth in housing developed from infill as well as development of available land was prominent in the eastern suburbs and usually took the form of units and flats.

During the 1990’s Auckland experienced a large population increase, this was a result from the change of the national immigration policy, which allowed immigrants to enter New Zealand based on their skills. By the 1996 census Auckland’s population had grown to 1 million. Between 2000-2009 Auckland had reached a population of 1.2 million with majority of the population living in urban areas that are low density areas, dominated by the presence of detached housed with an estimated 25% of housing in Auckland that are apartments and flats.
## Appendix 2

### Figure 8.1 Support sub system

<table>
<thead>
<tr>
<th>SUB-SYSTEMS</th>
<th>SUPPORT</th>
<th>INFILL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete structure (walls, floors, etc)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>facade system (windows, panels, etc)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>roof system</td>
<td></td>
<td></td>
</tr>
<tr>
<td>stairs + elevators</td>
<td></td>
<td></td>
</tr>
<tr>
<td>interior partitioning (doorframes, panels, etc)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>kitchen equipment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>bathroom equipment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>heating</td>
<td></td>
<td></td>
</tr>
<tr>
<td>gas supply</td>
<td></td>
<td></td>
</tr>
<tr>
<td>electric supply</td>
<td></td>
<td></td>
</tr>
<tr>
<td>electronics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>water supply</td>
<td></td>
<td></td>
</tr>
<tr>
<td>sewage lines</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*FIG.6*
Figure 8.2 Analysis of precedents using Till and Schneider’s flexibility questions

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Can the building accommodate multiple users?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Can the building/unit be adapted by its users?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Utility (User)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Can the unit accommodate a variety of living patterns?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Can the unit afford a variety of people?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Unit (Room)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Can the room be used for more than one function?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Can the room be furnished in a variety of ways?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Can the room be moved around in more than one way?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Can you add to the building horizontally and vertically?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Can the building contain a different number of units?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Plan (Room)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Can the room be used for more than one function?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Can the room be converted to serve in more than one way?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Can the room be furnished in a variety of ways?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Can the location of the services allow for different pipe forms?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Can the location of the unit allow for addition in terms of extensions?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Can the units be joined together or detached?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Can the units be used for anything other than purely residential?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Can the units be adapted by the user?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Can the unit accommodate a variety of living patterns?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Can the location of the services allow for different pipe forms?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Notes: 21/30, 15/30, 12/30, 18/30, 24/30, 30/30, 16/30, 20/30
2.5.3 Facade privacy considerations
This is an exploration of the different approaches that could be included onto the facade depending on the situation and location of the support. In all four of the previous concept facade designs, privacy has been an issue. Shutters, sliding, folding panels have the potential to provide variety, movement and privacy within the support. They are directly controlled by the occupant and allow them to customize their exterior. The four designs have explored the different opportunities for privacy. One is not going to be chosen as they are all cater for different situation. They are used to show a variety of different ways it can be achieved.

Appendix 4

Figure 8.3 Hinged
Figure 8.4 Folding
Figure 8.5 Hinged
Figure 8.6 Sliding
Appendix 5

Density
As part of the research, density is an important consideration, in respect to determining a housing type that works in medium density, and applying it to the test site to find ideal density for the site.

AMCORD states that site density represents “the ratio of dwelling and the area of the site they occupy. This excludes local streets, open spaces and any other land not directly related to the dwelling.”

This helps establish the way that density will be approached on the test site.

The main aim of density is to house the increasing population, in order to achieve this more houses need to be built, to sustainably achieve this density, consideration of land use needs to be considered. Another objective is to maximise the use of the physical and social infrastructure and encourage opportunities for diversity in dwelling type, location and price. This provides a more sustainable approach to housing as it maximise the use of infrastructure and land.

Density has been included in this thesis as The Auckland Plan, aims to increase density and quality of housing. Making the support structures work in an Auckland context will require the supports to be used at a higher density than Auckland’s current housing density, which was calculated to be 23 people per hectare in 2009.

On the test site, an important consideration that has been made is to ensure that the quality of the site planning completes, if not improves the existing residential amenities.

51 AMCORD, PNP 6, 2
52 AMCORD, Urban edition 1992 1, 6
53 Auckland Regional Council, A Brief History of Auckland’s Urban Form, 25
Physical environment

Car access

Car access on the test site has been considered and developed from the Buckley Design Guide for Hobsonville Point\textsuperscript{54}. It provides options and tactics to use to ensure a safe environment and that aesthetic quality of the development is still maintained. The Hobsonville master plan has incorporated a combination of different approaches to cars. These approaches are rear access lanes and access from the street. Alternative points of access have been included for visual aesthetic and to provide a variety of different options for occupants to choose from. This has been incorporated into the approach to the application of the supports to the test site.

The following options were been considered and explored:

- On-street parking
- Parking courts
- External garage
- Internal garage
- Carport

Summary

Mixtures of external garages, internal garages and carports have been integrated into the test site to provide diversity and options of how cars can be integrated onto the site. This will allow greater user choice and ensure vehicle security.

\textsuperscript{54} Hobsonville point, Buckley design guide
Orientation
Orientation is an important consideration when planning the placement of a support on a site. With row houses that only two sides exposed are “usually orientated to face east and west so that all rooms have some sun.” Sun is an important consideration as having rooms that are warm and well lit is important. As the infill is not pre determined, orientation is important so that where both side of the dwelling are equally inhabitable.
Lynch and Hack propose that “good solar orientation and attention to wind direction and microclimate can measurable decrease the energy requirements of a dwelling.”
Sustainability and habitability of the support is an important consideration during the design stage.

Orientation considerations made included:
- Sun angles (winter and summer)
- Wind direction for cross flow ventilation
- Orientation to support to ensure rooms are to be occupied in all seasons

Summary
Through sketches, 3D models and climate, weather and seasonal data, orientation of the supports placement on the test site have been careful considered. This has provided parameters of how supports can be arrange and place on the test site. It has ensured that the placement on the test site won’t limit the flexibility of the dwelling.

Sun angles
Sun angels were a key aspect when considering the placement of the supports on the test site. Sun and light needed to be considered as “the spacing between buildings not only affects the ground left over for outdoor use but the live ability of the interior rooms.” Making sure rooms are inhabitable is important. If there is not enough light or too much sun during summer it restricts the use of the space and also its flexibility.
The scale of surrounding buildings, their height and proportion, are important in identifying the usability of internal spaces and creating a sense of enclosure. The consideration of sun angles and light was important as the ability of the spaces to trap light were essential to making the space usable.

55 Lynch and Hack, site planning 3rd edition, 267
56 Ibid, 266
57 Ibid, 267
Social environment

Identity

Identity is important, not only to achieve identity through the dwellings infill, but also through the dwelling external appearance and its placement on a site. Key design considerations that have been considered during the application to the test site have included the external spaces and the outwards appearance of the building. Lynch and Hack state that “Others choose different ways to assert their identity, and may wish their unit to be outwardly similar to their neighbours, personalising only the most discreet details and their interior spaces.”

This defines the ways that people can choose to identify themselves and just reaffirms the right approach has been taken in respect to the support and infill on the test site.

Privacy

Designing privacy into the test site has been achieved through the inclusion of screens, hedges and fences. These tactics have been used throughout Hobsonville Point. The Hobsonville Point Design Guide justifies the use of the tactics in providing privacy within the overall development as well as the test site. Having outdoor spaces that are private is important and has been considered from the start of the application of the supports to the site. Consideration of orientation and location of the supports are crucial in providing privacy. Privacy has been developed through the use of the Hobsonville design guidelines and through the development of external spaces around the supports placements.

Security

As well as privacy, security is also an important aspect and has been incorporated through ensuring all spaces are useful and overlooked. This is also enhanced by a sense of community and responsibilities within the site layout.

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58 Ibid, 278

59 Hobsonville point, Buckley design guide
Community

Within Hobsonville Point, community is important. They believe that “A strong community is a diverse one”\(^60\), they are building a variety of different homes that suit a range of ages and means.\(^61\) This concept is similar to the issue that supports and infill’s deal with. Hobsonville Point places importance on the fact that; “All members of our community feel safe, supported, have a sense of belonging, a voice that counts and that they enjoy living at Hobsonville Point.”\(^62\)

This can be enhanced by the use of supports as they allow user control and a sense of belonging.

Levitt described that “A sense of place exists when resident have a permanent sense of belonging to somewhere of value. This value can be identified with a neighbourhood or even with a component of a neighbourhood that works and, most importantly is esteemed by residents.”\(^63\) The test site embodies the sense of community and the involvement in making not only their dwelling but also their community.

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\(^{60}\) Hobsonville Point, Community, http://www.hobsonvillepoint.co.nz/ (accessed August 20th 2012)

\(^{61}\) Ibid

\(^{62}\) Ibid

\(^{63}\) Levitt, The Housing Design Handbook, 4
Appendix 6

Design outcome: Environmental Sustainability
The ability to provide passive and mechanical systems to save on power, water and heating is an important issue in today’s world. Sustainability is approached in this thesis by providing solutions that occupant can incorporate into their supports. The following are examples of environmentally sustainable principles that can be used within the support.

Sunlight
Sunlight is an important issue within housing as houses need to be cool in the summer and warm in the winter. This is achieved through sun angle consideration. Considering overhangs that allow sun in during winter and exclude sun in the summer. One of the variations in Hobsonville Point has been the inclusion of an internal courtyard which provides light to habitable room. Sun angles have been carefully considered in order to provide light to the courtyards. Overhangs and louvres on building eaves can be attached to the support to make it habitable and adapt to the sun angles and orientation of the site placement.

Thermal mass
Thermal mass can use the potential of the concrete walls and floor slab to heat and cool the building. The concrete floor slab can be used as thermal mass as long is not covered with carpet or rugs. For heating during winter the floor slab and walls have to be exposed to direct sunlight. While in summer, to assist with cooling, the slab and or walls have to be shaded. This provides the occupant with passive free heating and cooling. The orientation and shading have to be carefully analysed on each site situation to achieve this.

Solar panels
Solar panels can be incorporate onto the roof to provide energy or also solar hot water heating. By including solar hot water heating it enables the occupants to save on heating hot water and provide the opportunity to generate electricity to reduce the home operating costs.
9.0 Final Presentation
Variations
Flexibility and adaptability in medium density housing

Aerial view of test site application
1:200 long section (C-D) of application on test site
1:200 short section (A-B) of application on test site

Density test 1:200
Exterior circulation space

Circulation throughout the test site

Northern outdoor shared space

Southern outdoor space

Vehicle access onto site

Application of flexible and adaptable housing types on test site 1:1000 site plan

Variation:
Variation One

Variation:
Variation Two

Variation:
Variation Three

Variation:
Variation Four

Variation:
Variation Five

Section
Ground 1st floor 2nd floor
Variation one: 1:200 floor plans

Section
Variation two: 1:200 floor plans

Section
Variation three: 1:200 floor plans

Section
Variation four: 1:200 floor plans

Section
Variation five: 1:200 floor plans

133
Flexibility and adaptability in medium density housing

27DPH

32DPH

31DPH

29DPH

24DPH

25DPH

28DPH

Density test 1:2000

Exterior circulation space

Interier view of variation Four

Courtyard view form variation Five

Southern outdoor space

Circulation throughout the test site

View from balcony of type one

Northern outdoor shared space

Vehicle access onto site

Application of flexible and adaptable housing types on test site 1:1000 site plan

Variation:

One

Variation:

Two

Variation:

Three

Variation:

Four

Variation:

Five

Section

Ground                                    1st floor                            2nd floor

Variation one: 1:200 floor plans

Section

Ground                                    1st floor

Variation two: 1:200 floor plans

Ground                                    1st floor                            2nd floor

Variation three: 1:200 floor plans

Ground                                    1st floor                            2nd floor

Variation four: 1:200 floor plans

Ground                                    1st floor                            2nd floor

Variation five: 1:200 floor plans
Flexibility and adaptability in medium density housing

Variations

Variation: One

Variation: Two

Variation: Three

Variation: Four

Variation: Five

Aerial view of test site application 1:200 long section (C-D) of application on test site 1:200 short section (A-B) of application on test site

Density test 1:2000 Exterior circulation space

Interior view of variation Four

Courtyard view from variation Five

Southern outdoor space

Circulation throughout the test site

View from balcony of type one Northern outdoor shared space

Vehicle access onto site

Application of flexible and adaptable housing types on test site 1:1000 site plan

Variation:

Ground                                    1st floor                            2nd floor

Variation one: 1:200 floor plans

Variation two: 1:200 floor plans

Variation three: 1:200 floor plans

Variation four: 1:200 floor plans

Variation five: 1:200 floor plans

135