EXPANDING WITHIN

FLEXIBLE HOUSING FOR GROWING FAMILIES IN URBAN NEIGHBOURHOOD

by

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Bachelor of Architectural Science, Ryerson University, 2013

A thesis
presented to Ryerson University
in partial fulfillment of the
requirement for the degree of
Master of Architecture
in the Program of
Architecture

Toronto, Ontario, Canada, 2018

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EXPANDING WITHIN
Flexible Housing for Growing Families in Urban Neighbourhood

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ABSTRACT

Two- thirds of the world's population will be living in urbanized areas by 2050. The response to this trend in housing demand has been intensification of the urban core, or sprawl. However, this solution addresses only current conditions and does not allow for future change.

People's housing needs are greatly influenced by their stages of life and by socio-economic factors that are constantly changing over time. However, most housing offers unchanging physical environments. Therefore, there is a conflict the between dynamic nature of people's lifestyle and their dwellings.

Living in a fast-paced society where change is inevitable, how can we design future housing that responds to the evolving needs and desires of diverse households throughout their life cycle? This thesis argues that homes should not be designed with a single purpose. Instead, they must be flexible and open-ended, and lend themselves conveniently to transformation.

ACKNOWLEDGEMENTS

First and foremost, I would like to thank my supervisor George Kapelos for his constant guidance, support and patience throughout the process of this thesis. I would also like to thank Jenn McArthur and Colin Ripley for generously sharing their professional expertise and insight over the past two years.

I wish to extend my gratitude to my fellow colleagues at Ryerson University for their input, advice and companionship. I will miss the moments working in the studio with them.

Finally, to my family and friends, I wish I had the words to express my appreciation for your unconditional support. I am forever grateful.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

Figure 1.1 Mies van der Rohe's steel-frame apartment at the Stuttgart Exhibition ("Stuttgart-Weißenhof", 1927)

1. Introduction

There is a conflict between the dynamic nature of people's lives and the static layout of their dwellings. As occupants age, their habit, lifestyle, and spatial needs change. Often, residents consider the physical environment of their dwelling as something fixed because home modifications are perceived to involve complicated and costly work. People often opt to change aspects of their lifestyles or even move to a different place to meet new needs. However, if housing modifications were made simple and convenient to accommodate the evolving needs of occupants, then homes could be designed as life-cycle houses that adapt to changes whenever they are needed or desired.

Dwellings that offer a great range of choices and flexible design strategies are more and more suitable to contemporary society. Families have changed dramatically over the past sixty years in North America. Socio-economic and technological forces constantly influence people's lives and how they choose to inhabit their dwellings. Now, people not only live much longer, but patterns of home occupation have changed significantly. Modern phenomena include work-from-home arrangements and non-traditional households. The notion of "family" has expanded from the traditional nuclear family to diverse family types, thereby creating different needs and expectations of home.

At the same time, housing types have been limited due to the public's preference for single-detached houses in North America after the Second World War. For consumers, a detached single-family home was a symbol of success. For builders, consumers' needs were predictable because nuclear families with two parents and children were predominant. In fact, the size of homes in North America has increased since the 1960s, whereas family household sizes have decreased (Nichols and Adams, 2013). Clearly, social and demographic trends suggest a need for greater flexibility and innovation in home design and construction in an era of rapid change.

Housing concepts for greater occupancy choices and future modifications have been studied and developed in the past by architectural scholars and practitioners. According to Friedman (2002), Mies van der Rohe's steel-frame house presented at the Stuttgart Exhibition in 1927 (Figure 1.1), in which tenants could position walls in accordance with their preference, marks the starting point of adaptable housing in modern architecture (p. x). Unfortunately, many housing ideas that were generated throughout the post-war era were largely abandoned as society entered more prosperous time. Today's fast paced society has further accelerated changes, making it necessary to re-visit designs and re-interpret them in a manner that is responsive to contemporary needs.

In a context where land is valuable and limited, how can architects create efficient use of residential space while providing an opportunity to adapt to change? How can a home be physically altered to accommodate different needs through different stages of life? Employing flexible design strategies, this thesis focuses on developing a life-cycle, prototype home that is capable of responding to various spatial needs.

1.1 Defining Flexibility: Etymology, Concept, and Clarification

The etymology of the term 'flexible' originates from the early 15th-century Middle French flexible, meaning "capable of being bent" or directly from Latin flexibilis meaning "[something] that may be bent, pliant, flexible, yielding" (Harper, 2001). The Cambridge Dictionary defines the word 'flexibility' as "the quality of being able to change or be changed easily according to the situation" (Flexibility, n.d.). In architecture, terms like 'flexibility', 'adaptability', and 'polyvalence' have such numerous and overlapping connotations that it is almost impossible for everyone to agree on their meanings (Habraken, 2008).

Architectural theorists and practitioners interpret the word 'flexible' differently (Figure 1.2). Kronenburg (2007) states that flexible architecture refers to buildings that can respond to changing conditions through their use, operation or location: "This is architecture that adapts, rather than stagnates; transforms, rather than restricts; is motive, rather than static; interacts with its users, rather than inhibits" (p. 11). His interpretation implies that 'flexible' is a comprehensive term encompassing adaptive, transformable, mobile, and interactive architecture.

Till and Schneider (2007) focus on residential flexibility and define flexible housing as "housing that can respond to the volatility of dwelling … by being adaptable or flexible or both" (p. 5). Volatility of dwelling signifies changing needs and patterns. Needs are domestic and affect people at an individual level; they arise for personal, practical or technological reasons: expanding family, old age, or outdated services. Patterns are external variables that affect society generally; they include demographic, economic, or environmental shifts: a decreased number of nuclear family types, the rise of rental markets, or home improvements according to climate change (Till and Schneider, 2007, pg. 4). Their interpretation of the term 'flexible', similar to Kronenburg's, is intentionally broad in order to cover the entire spectrum of design methods which divert from rigid functionality. However, for a clearer distinction between 'flexibility' and 'adaptability', Till and Schneider refer to Steven Groak's definition in The Idea of Building. Groak (1992) distinguishes between flexibility and adaptability where the former is defined as "capable of different physical arrangements" and the latter as "capable of different social uses" (p. 14).

In contrast, Friedman chooses the word 'adaptability' and not 'flexible'. While the term is used comprehensively with various connotations, his definition of 'adaptable' would include precedents or design strategies that Till and Schneider would not classify as adaptable. Friedman (2002) acknowledges that there can be many other interpretations of the term, and his is "[p]roviding occupants with forms and means that facilitate a fit between their space needs and the constraints of their homes either before or after occupancy" (pg. 1).

Borrowing Groak's definition, 'flexibility' represents alterations of physical elements of the building. These alterations could include joining multiple units, extending them, or reconfiguring layout of space through a tangible change. 'Adaptability,' on the other hand, is accomplished through the design of interior spaces which can be utilized in various ways (Schneider and Till, 2007, pg. 5). Lastly, 'transformation' is a subsidiary term under 'flexibility'. One aspect of a transformable building is its kinetic nature, its capacity to change quickly in response to any demand. Transformable architecture involves movements so that a building "opens, closes, expands or contracts" (Kronenburg, 2007, pg. 146). For the purposes of this thesis, 'flexible' or 'flexibility' will be used as comprehensive terms.

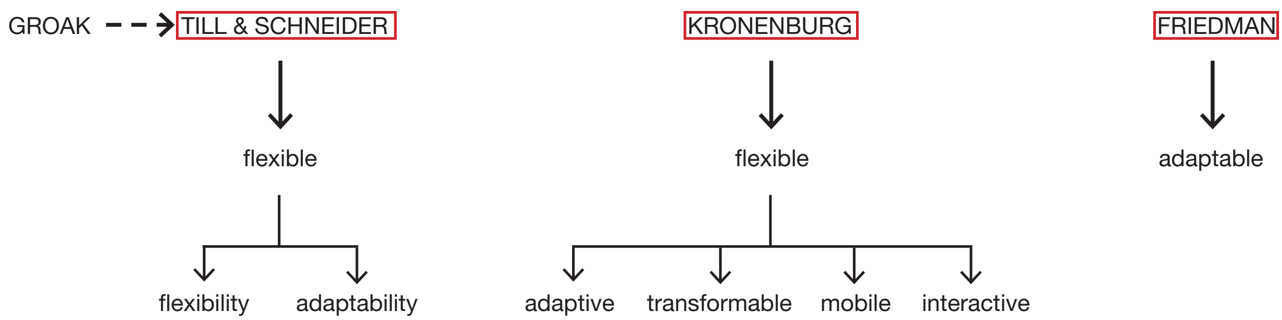


Figure 1.2 Different interpretation of flexibility (Kim, 2018)

1.2 History of Flexible Housing

It is difficult to trace the origin of flexible architecture since it has either appeared as a form of vernacular architecture or as a result of socio-economic pressures. Although the root of today's notion of flexible housing emerged in the1920s, the 1960s was a significant period for it, as it was at this time that it became clear that conventional housing methods were not sufficient to support the increasing population and to respond to the urbanization process. In Europe, new strategies and theories re-propounded by young and emerging architects who shifted from formal purity to the expression of infrastructural mechanisms that were adaptable to growth over time. For example, Archigram in 1966 criticized static architecture stating that "buildings with no capacity to change can only become slums or ancient monuments." (Sadler, 2005, p.94) Archigram conceived of architecture as an open-ended process that adapts to the changing needs of its inhabitants. Archigram embraced the uncertainty of the future by proposing unfinished buildings that are flexible, that is, able to transform, grow and be controlled instantaneously. Cedric Price, who was involved with the works of Archigram but never joined the group, also believed that adaptable and temporary buildings should be favoured when trying to anticipate uncertain future. He thought that architecture concerned with uncertainty should grant people the freedom to control and build their own environment.

While Cedric Price and Archigram attempted to develop flexible architecture through a mechanistic approach and anticipatory design, John Habraken and John F.C. Turner explored a more passive strategy where flexibility was accomplished through openness and indefiniteness. Turner and Habraken re-examined the idea of sporadic organic growth prevalent in developing countries and tested new strategies that considered housing not as an end product but as a "flexible, dynamic, incremental activity". (Hamdi, 1991, p. 41) Though incremental development is typically associated with informal settlements in developing countries, the idea is quite common even in developed nations as well; for example, informally converted garage apartments, unfinished basement in single family homes, and additional housing units in backyards are all part of incremental development. One common theme of flexible architecture in the 1960s was the participation of occupants in the design process either directly or indirectly.

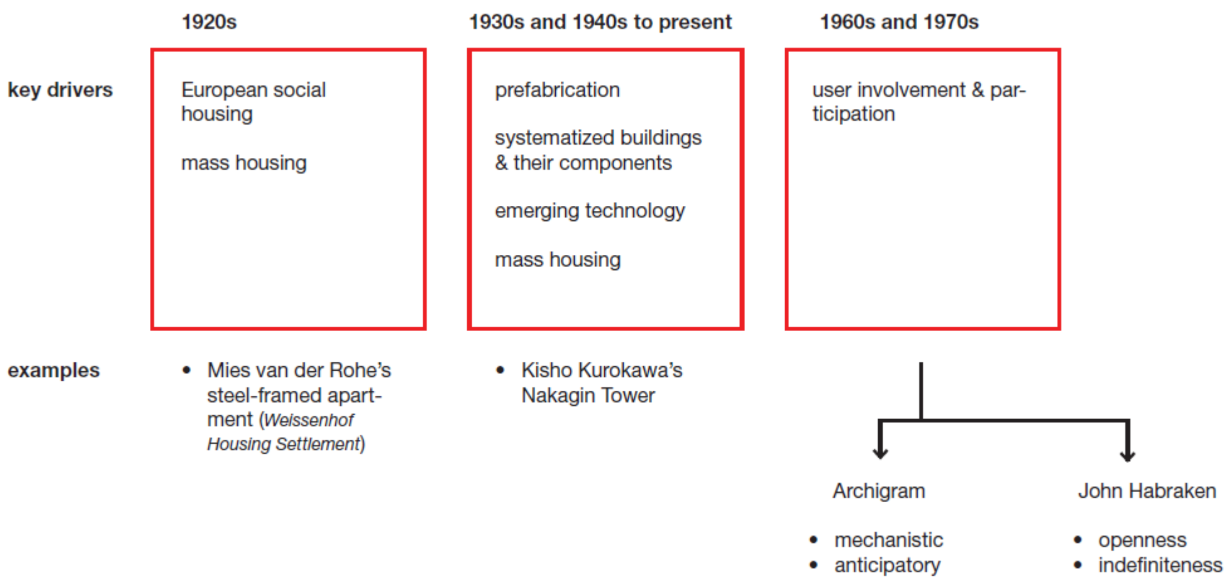


Figure 1.3 Three key drivers of flexible housing (Kim, 2018)

In general, the history and development of flexible housing has been influenced by the three key drivers. The first driver was the need for the European social housing programs to provide mass housing in the 1920s. The downward shift in space standards and the new construction methods induced architects to develop flexible housing so that users were not constrained by the new minimum standards. The second driver, which has been prevalent in the 1930s, 1940s and even today, was the belief that prefabrication and emerging technologies would provide a solution to mass housing. The third driver, which emerged in the 1960s and 1970s, was the idea that inhabitants' participation during the design process could make housing more flexible by providing user choice (Figure 1.3).

2. What is Flexible Housing?

2.1 Soft and Hard Elements

There are numerous methods for achieving flexibility in housing. However, these can be broadly classified according to the soft and hard elements that they comprise. 'Soft' refers to tactics that allow a degree of indeterminacy, while 'hard' refers to the way(s) a design may be used. Despite the fact that these two notions seem contradictory, both have historically been employed and developed along parallel historically.

The "soft view" approach keeps designers in the background and passes control over to the user. This gives occupants more freedom over their dwellings and enables them to alter the space as they see fit. Architects or designers, on the other hand, take the role of a facilitator rather than a determiner. John Habraken's Open Building theory illustrates a soft approach in which the internal layout, the 'infill', is determined by occupants (see Section 2.3). The concept of incremental housing also proposes housing as an on-going process developed by occupants (see Appendix C). The idea of soft view is not to shift the responsibility on to users as a form of glorified DIY, but to make constructional system simple and understandable for non-experts.

Conversely, hard view has designers working in the foreground, allowing them to determine how spaces can be used over time. Architects who highlight the discourse of flexibility are often associated with hard techniques. For instance, sliding doors, fold-down furniture, and moving walls are hard elements that delineate users as operators of architectural devices. Throughout history, many examples of flexible housing in history have been experimented on, with the result of a new system of technologies. The notion of hard use extends the influence of the architect but develops flexibility only on his or her own terms.

Historically, the soft view has been associated with the realm of vernacular architecture, suggesting hints for flexible housing. The hard view, on the other hand, has been related to architects providing one-off housing tailored to specific needs. Today, factors such as architects, social pressures and market demands have overridden the organic sensibility of the vernacular. Housing design is subjected to order and to the rationale of modernity in which architects are expected to provide a sensible solution that reflects predictability and control. Due to the fact that modern architecture puts emphasis on functionality and spatial efficiency, it has a close tie to hard views. Both functionalism and hard view believe that every available space, at the levels of building, unit and room, can be tuned in a program-specific way.

In order to attain flexible housing, some favour soft tactics that employ indeterminacy, whereas others prefer hard technologies with constructional system invented anew. There is no right or wrong approach for designers, but one may be more appropriate than another depending on context. This thesis, which aims to serve the neighbourhoods adjacent to downtown Toronto, seeks to utilize both soft and hard tactics to meets the demands of potential occupants.

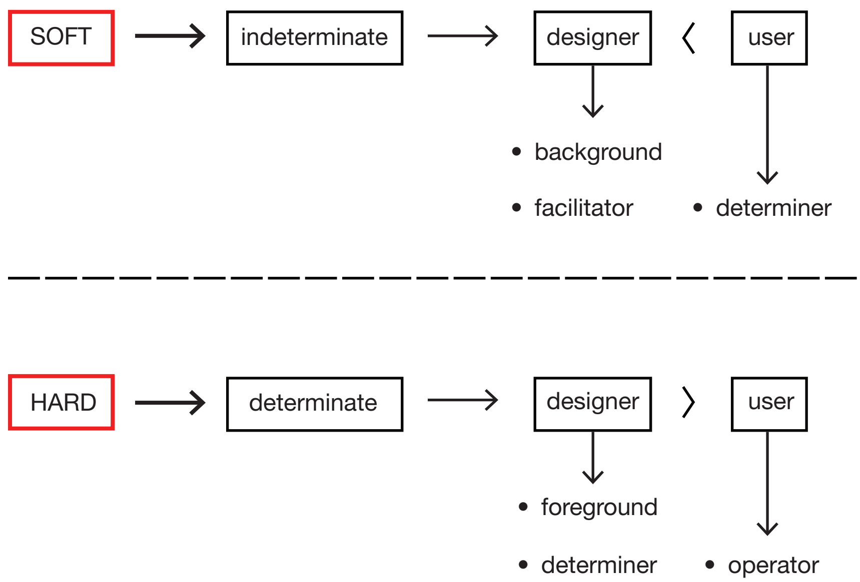


Figure 2.1 Hard versus soft elements (Kim, 2018)

2.2 Pre- and Post-Occupancy Flexibility

Design for flexibility begins with an investigation into the elements related to a home's interior, and into the relation between a single dwelling unit and group of homes. The process of encompassing flexible strategy for a specific client is different from tract housing development. For the custom design of homes, architects gather information on number and size of room needs, style, quality of finishes, layout and budget. The needs and desires of known occupants are accommodated prior to moving in. On the other hand, complying with clients' needs prior to occupancy is more difficult for tract housing when the identity of occupants is unknown.

In modern architecture, the methodological investigation of pre-occupancy flexibility in housing started due to the need to accommodate requirements of occupants whose specific characteristics were unidentified. According to Rabeneck, the origin of pre-occupancy flexibility traces back to the post World War II period when mass-produced, homogeneous mid-rises were dominant (1973). Pre-occupancy flexibility is regarded as providing choices and adapting housing according to needs or budgets prior to occupancy for either custom build homes or tract housing. It is a process that requires anticipation (Friedman, 2002, p.13). A clear example of pre-occupancy flexibility is the Next Home, designed by Avi Friedman and his collaborators. It offers a catalogue from which prospective occupants can choose interior components and layouts.

Furthermore, architects seek to foresee the future use of residential spaces where the modification happens after the building has been occupied. For example, young couples may consider expanding their family, wanting to turn a study into an extra bedroom or finish a basement that was left bare in the initial phase. It is a process that involves not only predicting how families evolve but also responding to their stages and events in life by providing probable scenarios or solutions. Architects aim to achieve post-occupancy flexibility by proposing designs that can allow inhabitants to adjust their homes according to emerging needs. Friedman defines post-occupancy flexibility as “incorporating strategies and building systems into homes to permit occupants to adapt them to their evolving space needs or budgets” (2002, p.13). Taking post-occupancy flexibility into account is more challenging for mass-produced housing than for custom-built housing because architects need to anticipate not only the profile of families but also their growing needs.

2.3 Open Building and User Participation

The open building theory was first articulated by John Habraken in his book Supports: An Alternative to Mass Housing in 1961. Similar to the notion of incremental development, its design concept aims to “deliver buildings with maximum capacity for accommodating the diverse needs of different households over time” (Tu, 2014). In order to achieve this goal, Habraken introduces two principles: ‘support’ and ‘infill’ of a building (Figure 2.2). The ‘support’ is base building elements with longer lives that remain unchanged such as structure and envelope. The ‘infill’ refers to fit-out elements that have shorter lifespans and change more often, such as floors, partitions, equipment and mechanicals (Tu, 2014). The ‘support’ structure facilitates open and flexible architecture by accommodating various infill components, which are filled by residents according to their needs (Figure 2.3). The infill industry would be responsive to these demands, whether the components were installed independently or upgraded within the skeleton of the building.

When inhabitants are neglected in the design process, housings become uniform and rigid. But when they become the main decision-maker in the process, there can be disorder and conflict. In the book, Freedom to Build, John Turner states that:

> "When dwellers control the major decisions and are free to make their own contributions in the design, construction, or management of their housing, both this process and the environment produced stimulate individual and social well-being. When people have no control over, nor responsibility for key decisions in the housing process, on the other hand, dwelling environments may instead become a barrier to personal fulfillment and a burden on the economy." (Turner & Fitcher, 1973, p. 241)

The open building theory recognizes the two domains of support and infill that create a balance between rigidity and spontaneity. The architect providing flexible housing needs to define how much control is given to the dwellers. Since occupants' needs and tastes change over time, flexible housing should not be considered as a static end product but instead as an activity in a state of constant transformation.

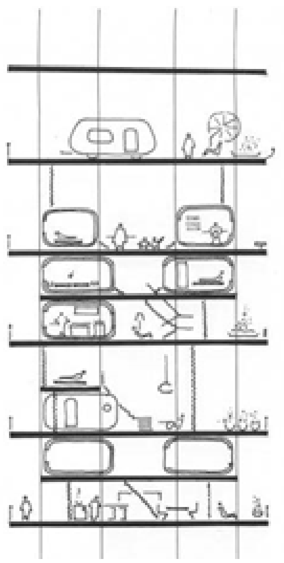


Figure 2.2 Support and infill concept (Habraken, 1972)

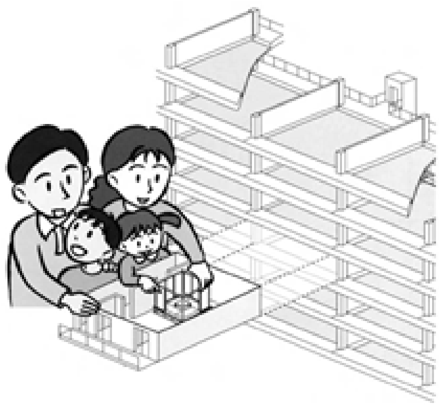


Figure 2.3 User participation (Kendall, 2015)

3. Why Flexible Housing?

3.1 Housing as Commodity

Before advocating flexible housing and arguing for its advantages, it is necessary to explore why the majority of current housing models are designed inflexibly. Housing is affected by various changes and failure to adapt to these changes makes them undesirable, or even obsolete. Today, developed countries "accept the built-in obsolescence of consumer products, largely persuaded by the manufacturers that it is desirable to continually upgrade our lifestyles through endless consumption" (Schneider and Till, 2007, pg. 35). Similarly, housing is seen as product that can be discarded and bought anew once its desirability is over. Therefore, the short-term view on housing provision is prevalent, with long-term considerations like future adaptability being neglected.

However, the consideration of housing as just another disposable commodity of everyday life poses problems, since housing is unique in terms of its social, physical and economic implications. There are a number of conditions, mainly economic, that are conducive to planned obsolescence in housing. First, housing demand vastly exceeds supply due to limited land availability, especially in urban areas. Houses are usually guaranteed to be sold, making developers uninterested in renovations or added value. For example, the current imbalance between restricted housing supply and booming demand in Ontario's Greater Golden Horseshoe region is unparalleled, and the number of months of inventory is reported to be less than one month in February 2017 (Leduc & Lemoine, 2017). For developers, the main goal is to sell houses as quickly as possible, with the future needs of inhabitants a minor concern. Secondly, the number of rooms is considered more important than the size of rooms in the housing market (Till & Schneider, 2005). As a result, room size is often reduced to bare minimum standards, with the creation of more rooms maximizing profit. Often, the furniture layout determines the function and limits of a room. Rabeneck, Sheppard and Town (1973) describe this kind of occurrence as a tight-fit functionalism: the notion that a room or space can only be used for preconceived purpose due to its size and shape. Thirdly, conventional construction methods that are inflexible by nature are the norm in the industry due to building economics. For instance, load-bearing internal walls and trussed rafters in the roof structure make future change very difficult.

In the housing sector, inflexibility is responsible for built-in obsolescence. Inflexibility gives people no other choice than to purchase new homes and move to different locations once their needs change. Thus, the housing market will always have higher demands over supply. In order to surmount the problem of imbalance between supply and demand, houses need to be designed flexibly so that occupants can adapt and live longer in them. Furthermore, flexible housing must have the capability to deal with future changes such as demographic shifts, an aging population and changing work patterns.

3.2 Shift in Family Composition

Changing demographics is one of the problems that challenge the notion that housing is a static commodity with fixed design parameters. A house that satisfies occupants' present needs may not be appropriate for the future as their needs and desires change. Another consideration is the ongoing transformation of the traditional family structure that has been greatly influenced by such turning points as the Industrial Revolution and the Second World War. During the post-war period, identifying family composition was relatively straightforward for the building industry. Typically, a nuclear family with a bread-winning father, stay-at-home mother, and their children lived in a limited number of housing prototypes such as bungalow, rancher or two-story styles which were very common (Friedman, 2002, pg. 5).

Over the past thirty years there has been a decrease in the number of nuclear families, and an emergence of other family compositions. In the 21st century, societal moral values have changed significantly, with the approval of same-sex marriage, non-family union and living alone. These non-traditional households have become potential homebuyers with new lifestyles and living habits. For example, there are childless couples who need a home with one bedroom but will require more spaces as their family grows. Also, there are unrelated people who wish to live together in order to share the expense of living while at the same time wanting a degree of privacy. Another consideration is a family with one or more members who work from home and need a work space separate from living spaces.

The 1960s was the era when composition of the family started to change. Since then, Canadian families and households have become smaller, and young people not only have fewer children, but have them later in life. This change came about partly because of lower fertility rates after the baby boom period, and also due to the rise of single-parent households. According to Statistics Canada (2012), the average number of children per family has decreased from 2.7 in 1961 to 1.0 in 2011. Factors such as the introduction of birth control pills to the public in the 1960s and the entry of women into the workforce played a significant role in this demographic shift.

Since the end of the Second World War, social expectations, formal rules, and family customs on marriage and divorce have been eroded. Before the war, although most people got married, divorce was very rare and difficult. (Figure 3.1). In fact, Canada had one of the lowest divorce rates in the Western world before 1960s due to social norms articulated by social and religious leaders that treated divorce as a threat to the family (Ward, 2008). However, the Divorce Act of 1968 and its revision in 1986 made divorce easier to obtain, influencing the composition of family. With easier access to divorce, the number of single-parent households increased significantly. Although family arrangements became more dynamic owing to the commonplaceness of change in marital status, the static character of homes remained unchanged. According to Friedman (2002), for example, "[m]arrying, having children, getting divorced, and then remarrying require spatial arrangements that permit the move from one status to another if the household wishes to remain in the same residence" (pg. 6). Adaptable homes, therefore, should be able to respond to various situations that families experience today where children grow up and leave their parents to form their own family then, after a divorce, return to the original household only to get remarried and leave again (Figure 3.2).

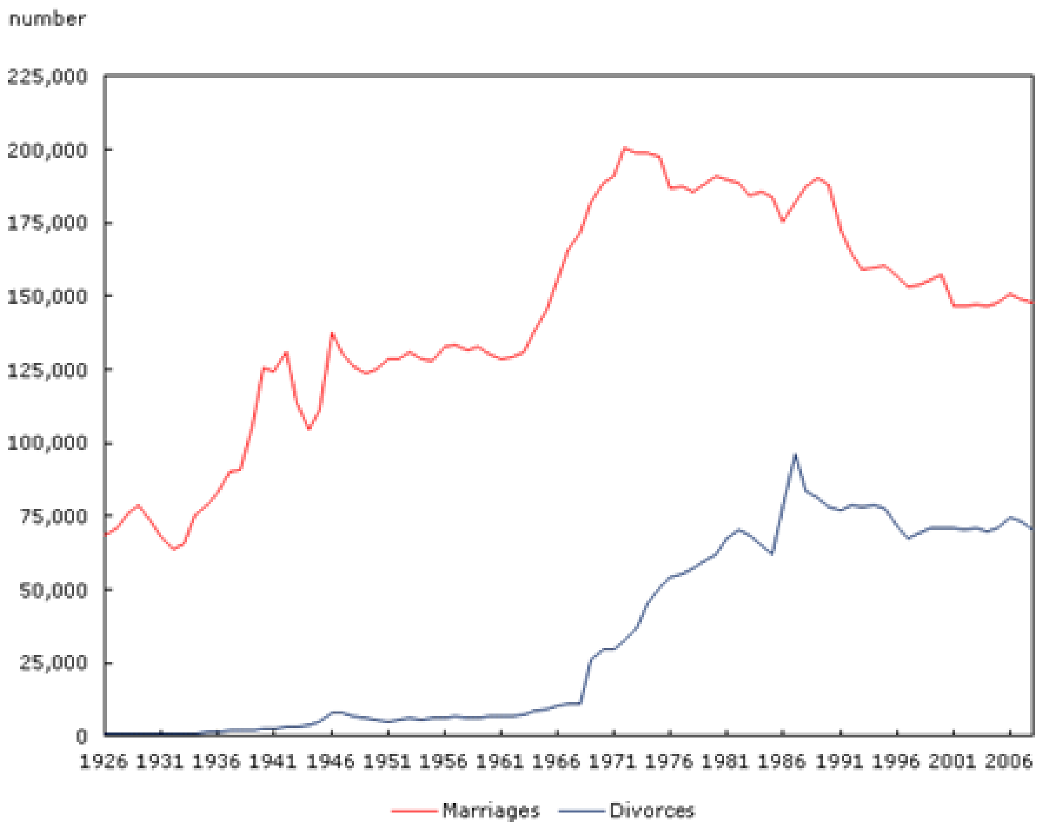


Figure 3.1 Number of marriages and divorces, Canada, 1926 to 2008 (Statistics Canada, 2015)

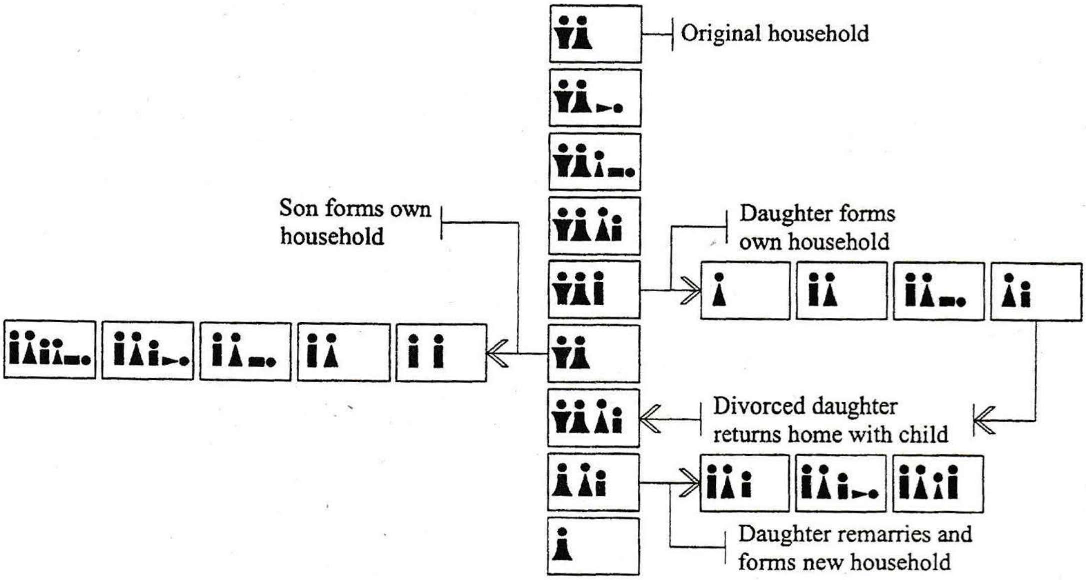


Figure 3.2 Process of family transformation (Friedman, 2002)

3.3 Growing Family and Aging Population

The demographic shift referenced above relates housing to external environments which are seen at the macro level: the ways that one occupies a dwelling starts at the scale of the building. However, flexible housing correspondingly needs to respond to internal changes during the lifespan of its occupants; it must focus on micro changes that occur at an individual level. These include growth from toddlers to young adults, and preparing for old age when people become physically less able. The growing process from children to young adults requires different spatial configurations. For instance, teenagers seek a greater degree of privacy compared to younger children. Spatial needs change according to growing up, the result been the requirement for a new conceptual model of housing.

Another reason for advocating adaptable housing is because populations are aging and many seniors wish to stay at their own home. The advancement of science in the field of medicine has helped to achieve longer life expectancy for both men and women. From 1920 to 1922, the life expectancy of for males was 59 and for females 61; between 2007 and 2009, the numbers have increased significantly where men's life expectancy reached 79 while women's extended to 83 (Statistics Canada, n.d.). By the year 2036, seniors aged 65 years or over will constitute between 23% and 25% of the entire Canadian population, compared to 14% in 2009 (Figure 3.3)(Statistics Canada, 2010). Government intervention to provide institutional care for the elderly is unlikely, and obtaining adequate housing for them is becoming one of the most important issues since the aging trend began. (Friedman, 2002, pg. 7).

As seniors get older they have different housing options. Some may choose to stay in their own places after kids have moved out to form their own family. Others may move to smaller units or retirement homes that provide social and medical care. Surveys consistently reveal that seniors prefer to continue their lives at home independently – not necessarily their current ones but in their own neighbourhood or close to friends or family – rather than living the rest of their lives in an institution (Ipsos Reid, 2013). Therefore, their residences must adapt to the aging process and the changes it necessitates.

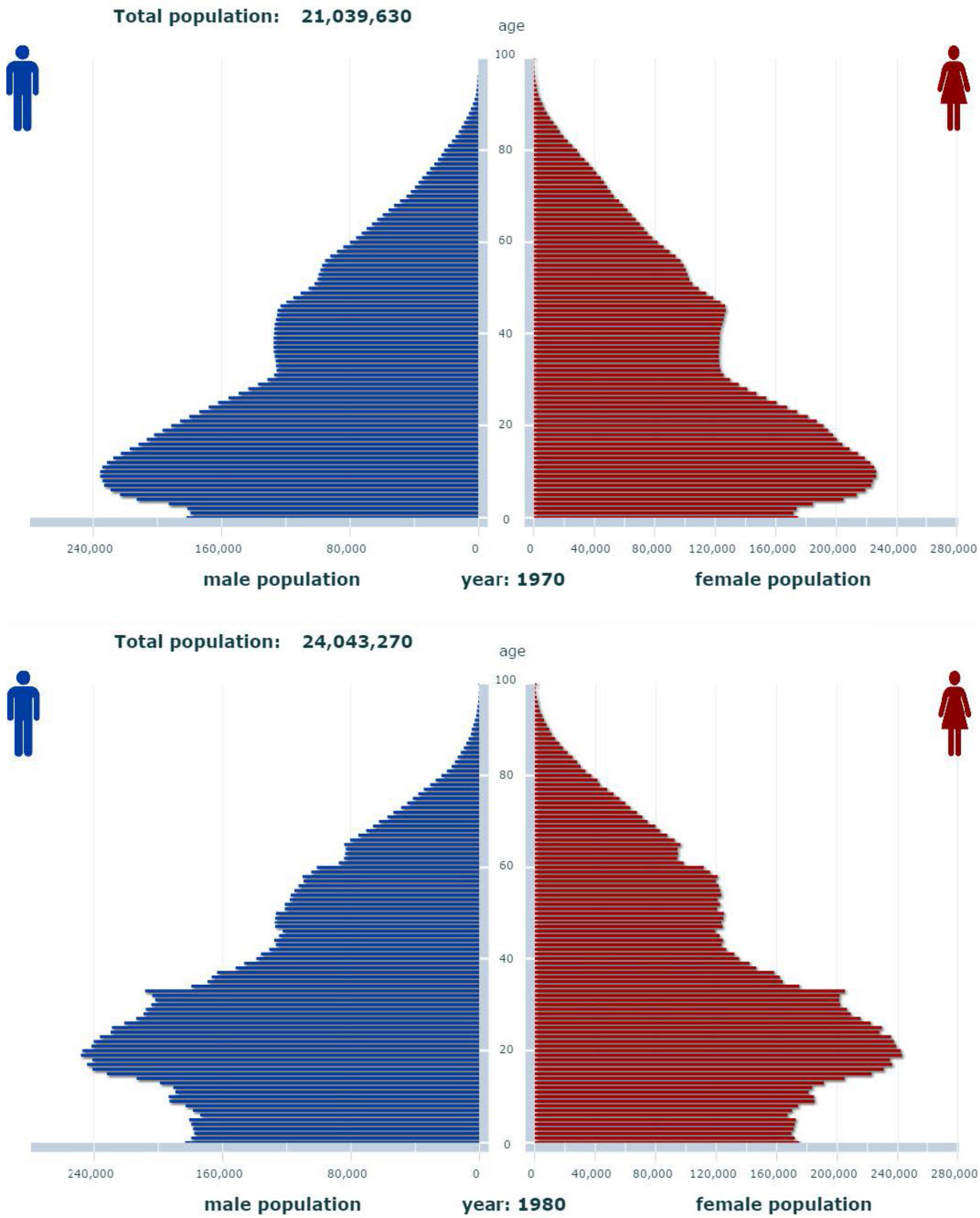
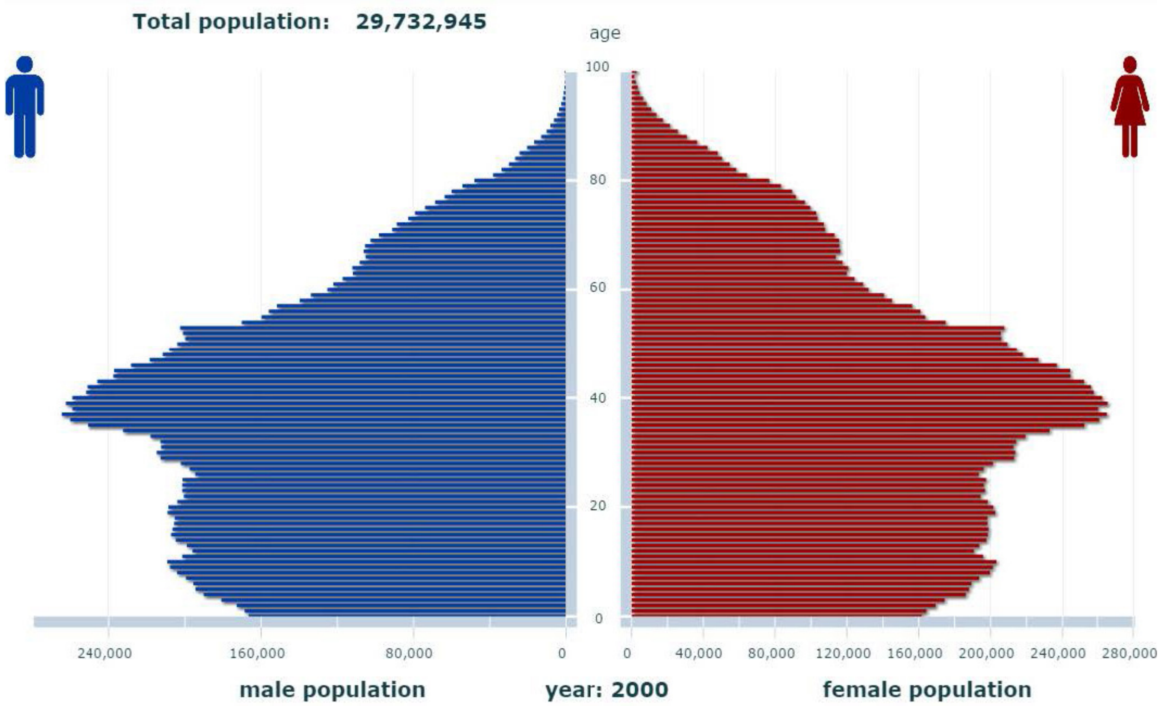
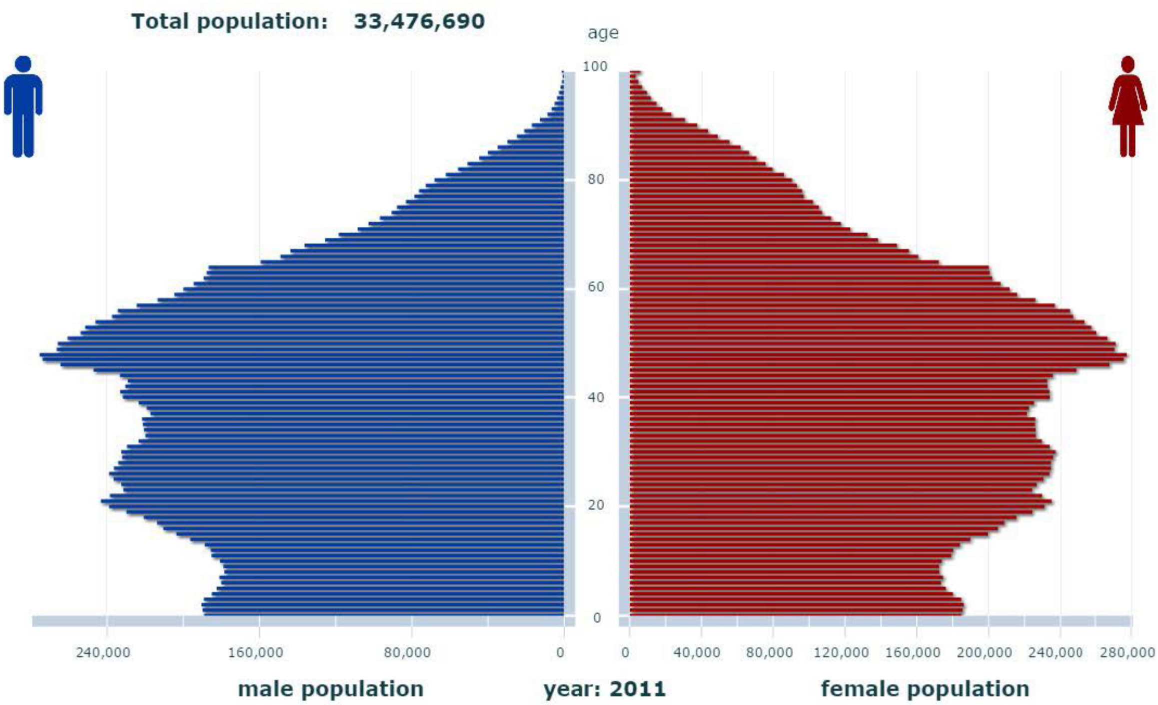


Figure 3.3 Historical age pyramid from 1970 to 2011 in Canada (Statistics Canada, 2016)


Total population: 29,732,945
age
100
80
60
40
20
0
240,000
160,000
80,000
0
0
40,000
80,000
120,000
160,000
200,000
240,000
280,000
male population
year: 2000
female population


Total population: 33,476,690
age
100
80
60
40
20
0
240,000
160,000
80,000
0
0
40,000
80,000
120,000
160,000
200,000
240,000
280,000
male population
year: 2011
female population

4. Flexible Design Strategies

> “The permanent constitutes the frame within which change can take place. While the frame is specific, the space inside the frame is general.” (Leupen, 2006, p. 43)

While the previous sections have addressed ‘what’ and ‘why’ aspects of flexible housing, the current and following sections deliberate how these aspects may be achieved. This section focuses on strategies related to plan and use of flexible housing, whereas the following section presents principles of structure and construction that can maximize flexibility in housing. A number of design strategies that have been identified by researchers (Friedman, 2002; Schneider & Till, 2007) can be classified into three categories: buildings, units and rooms. Since this thesis targets single-family detached housing, strategies that are related specifically to this topic will be investigated.

4.1 Add-On Method

One of the flexible design strategies that responds to change is the add-on method, which is centered on the idea of expansion through addition. This growth takes several different forms whether it derives from a need for additional space or from an economic strategy to start small and expand later as resources become available. In a rural setting, expansion is generally easier due to larger lots and inexpensive land costs, whereas meticulous planning is required for the urban areas in which space is much more constrained.

There are various forms of growth for the add-on method; the method of expansion depends on the basic structure and how the original building was constructed (Figure 4.1). One of the most common forms of an expansion is a rear addition, where the new structure is built and joined with the original building. Another form of expansion is addition of a new floor to an existing housing unit. This type of growth is more common with flat-roofed houses; for houses with a pitched roof, the addition can take place after trusses or rafters have been removed, floors added, and the roof rebuilt. Also, if there are two existing buildings, an addition can occur in-between, bridging the two. Other forms of growth include constructing an independent ancillary unit that connects to the main building and adding a component such as a bay window to make spaces seem larger (Friedman, 2002, p. 101).

Because the initial design decisions directly affect the opportunity for future expansion, fundamental elements of design must be planned carefully. First, ideally, access to the future addition will use the existing circulation. If this is not possible, then users may need to enter the addition through an existing room, limiting its use. In the case of a detached home, a central, double-loaded corridor is a fitting approach because the passageway can act as a spine that allows for expansion without blocking circulation (Figure 4.2). Secondly, the potential addition needs to consider whether it would lead to loss of light to existing windows. Typically, the loss of light is more likely to be a problem if the existing building has a more complex plan form (Schneider & Till, 2007, p.183). Thirdly, the connection of addition to the existing building must consider the placement of utilities. For example, wet functions such as the kitchen and bathroom should be positioned at the rear (Friedman, 2002, p.104). Once the addition is integrated, these service spaces will be centrally located (Figure 4.3).

The add-on method can either be developed over time through multiple phases or be completed almost instantaneously. Incremental housing demonstrates a gradual process of the add-on method requiring longer on-site construction process, while modular and prefabricated construction causes less disturbance and saves time. As this thesis positions itself in the urban context, modular and prefabricated expansion is considered a more appropriate selection for employing the add-on strategy. The constructional system of a prefabricated modular addition is simple enough for laypersons to understand the process of growth. Furthermore, modules and panel components can be developed into various prototypes, providing a wide range of housing options for occupants and allowing them to decide how future growth may occur (See Case Study 6.1.1, 6.1.2 & 6.1.3).

In the case of modular and prefabricated construction, the form of expansion is dependent on structure. Modules are self-supporting structures, which could be stacked on top of each other, expanded horizontally side-by-side, or attached to the structural core. In taller buildings comprised of steel-framed modular units, a concrete or steel core is required after roughly ten floors of modular components to act as structural support for lateral loads (Chown et al., 2014). Another form of modular expansion is to extend existing housing without much site work. For example, modules may be added onto rooftops to create an additional one or two floors without having to reinforce the foundations or structure of the existing building.

Although the add-on method offers the opportunity to customize and expand housing as occupants' needs change, adapting to the future addition presents several challenges. Most importantly, space must be available for the new expansion, and this incurs extra costs. Moreover, most building types are restricted regarding direction of growth and accessibility. Therefore, the add-on method is viable only on the condition that there is enough space and sufficient resources to expand and develop them.

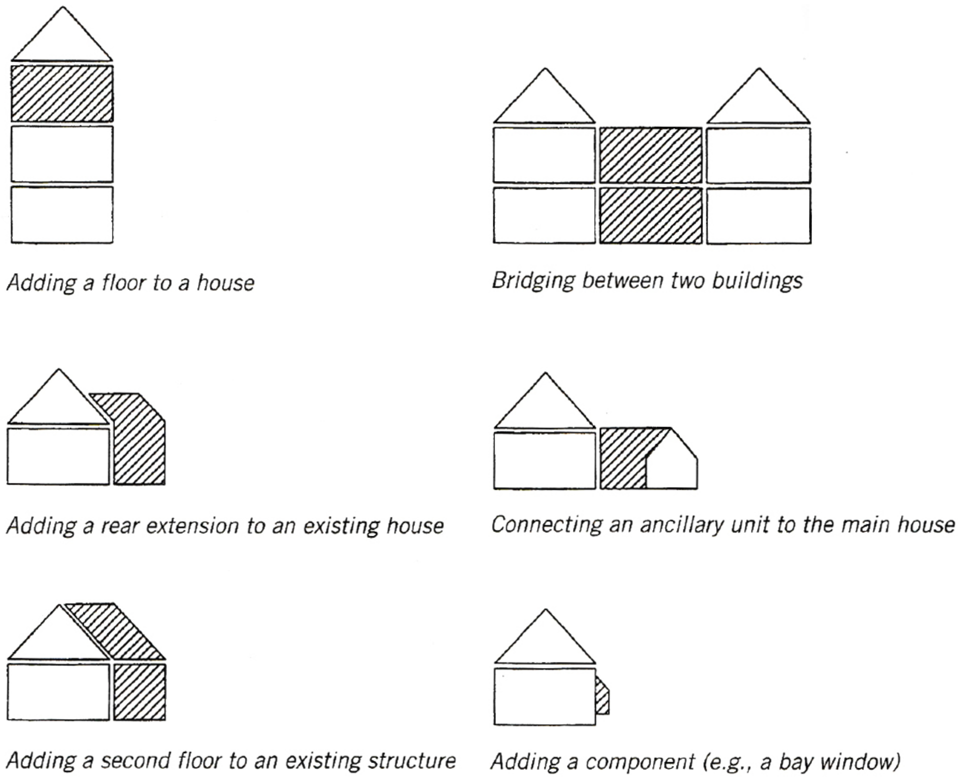


Figure 4.1 Expressions of growth of dwelling units (Friedman, 2002)

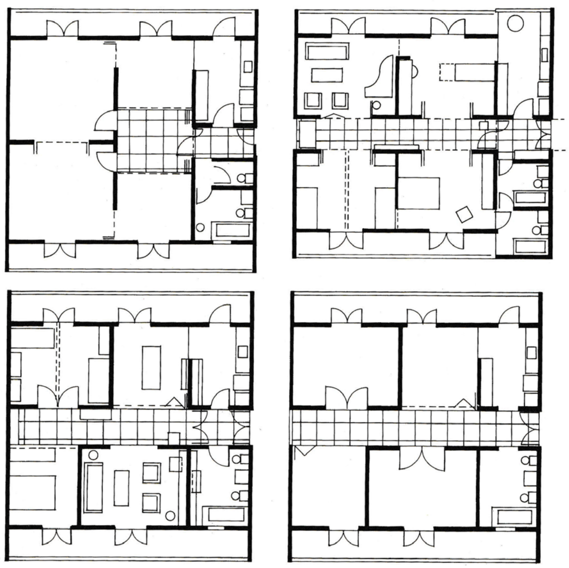


Figure 4.2 Central double-loaded corridor and expansion (Rabeneck, 1973)

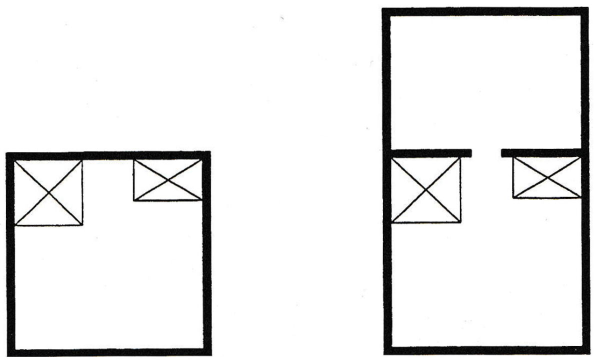


Figure 4.3 Centralization of wet function in the rear (Friedman, 2002)

4.2 Add-In Method

The second strategy for expansion, the add-in method, involves prearrangement of unfinished spaces within the building enclosure that can be filled in at a later date by occupants as the means and needs arise. Compared to the add-on method, this strategy requires higher initial investments in space and structure; however, the compensation for these drawbacks is a significantly lower cost at the time of expansion. When the add-in method is used, a large area can be divided into a few spaces each with its own entrance.

Add-in homes require initial consideration regarding the potential direction of expansion. Often, vertical expansion tends to be most appropriate option, for instance, to the basement or the attic. There are a few prototypical low-rise homes appropriate for the add-in method: the bungalow where the lower level can be left unfinished at first and expanded later; the one-and- a-half storey where the attic can be expanded; and the two-storey where the second floor allows for a variety of bedroom configurations (Figure 4.4). In the case of multi-storey attached structure, units can also be expanded horizontally.

When building a home on a small and costly plot, the rational approach is to take advantage of the entire buildable volume once setbacks have been subtracted and maximum building height has been determined (Friedman, 2002, p. 154). Once the buildable volume has been determined, how the space is used can take various configurations. For example, one floor may be constructed within a shell as the initial phase home with the remaining floors to be added later by the occupants.

Another type of add-in strategy is to exploit a high ceiling. Mezzanines are often used when industrial buildings are converted into residences, and can also be applied when constructing new homes. The designer can either provide an unfinished mezzanine space for a further expansion or make arrangements for the convenient future introduction of one. In most North American jurisdictions, the maximum size of a mezzanine can be 40% of the area below, with a minimum clearance of 4.9 metres (16 feet) in height (Friedman, 2002, p. 155). Therefore, the functionality of such a space is often only suitable for a bedroom or home office.

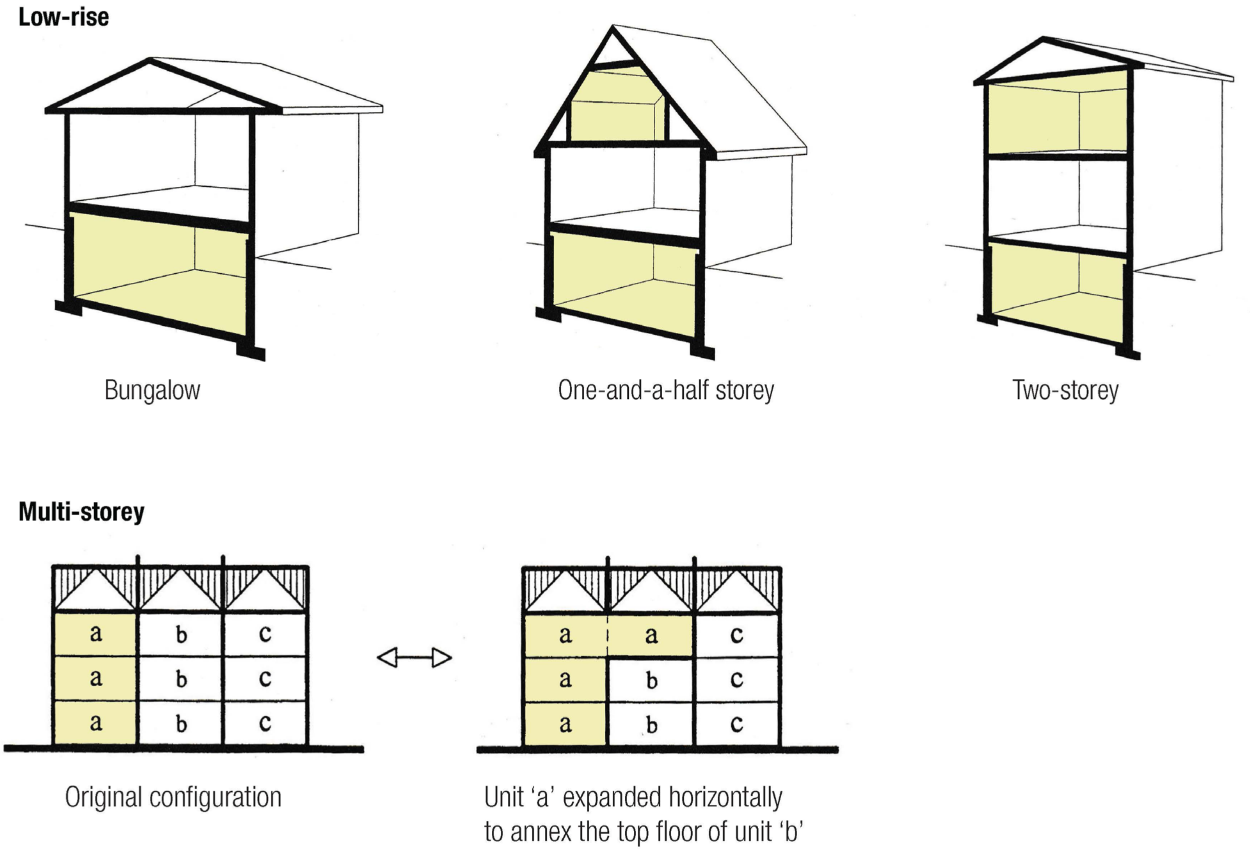


Figure 4.4 Types of add-in methods (Friedman, 2002)

4.3 Slack Space

Slack space is intentional excess space that may be adapted or infilled by occupants for various uses. It is designed to accommodate future change, but its exact use or configuration is undetermined. The add-in method and the use of slack space are similar in that they ‘fill in’ unfinished or unwanted spaces. However, while the former examines only such unfinished internal spaces as a basement or attic, the latter is more versatile and encompasses both internal and external spaces. For example, internal slack space would include an alcove that can later be enclosed or have furniture built into it, or a balcony that can be glazed to add an extra space for a room; external slack space can be found on top of a flat roof, and in courtyards that can be filled (Schneider & Till, 2007, p. 136). ELEMENTAL’s Quinta Monroy is a good example of slack space being used to achieve a flexible and cost-efficient housing (See Case Study 6.2.2).

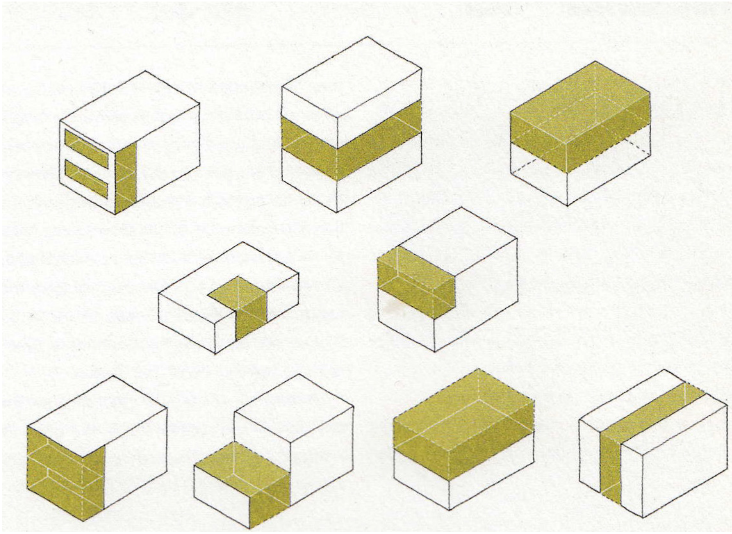


Figure 4.5 Slack space (Schneider et al., 2007)

4.4 Rooms Without Labels

Rooms in houses are labeled and programmed specifically for a certain use because of various design standards and client demands. This kind of tight-fit functionalism leads to planning that dictates where and how activities should occur. One of the most provocative strategies of achieving flexibility, which resists the notion of rooms being designed with a single purpose, is to accommodate functionally neutral rooms.

This strategy requires providing a series of similarly-sized rooms with access through a central hall or main circulation area. Rooms that require servicing such as kitchens and bathrooms can either be included in one of these rooms or located in a separate smaller space. An advantage of presenting a number of undefined, equal-sized rooms in a housing unit is that it incites different social interpretations, allowing for diverse cultural scenarios. Moreover, various user groups are viable; for example, three bedrooms for three adults can easily be converted into two bedrooms and one living room for a small family. By removing hierarchical order present in labels, rooms not only become independent entities, but also can be used more flexibly by users whose needs change over time. Functionally neutral rooms give inhabitants more control over their living environment.

In relation to spatial configuration, the size of living rooms is reduced when bedrooms and kitchens are increased.

Although there is no rule about the minimum size of functionally neutral rooms, one may infer dimensions based on different furniture layouts. According to Schneider and Till (2007), 3.6 metres wide by 4.0 metres deep is ideal to accommodate bedrooms and a living room, but they can be reduced to 3.2 metres wide by 3.8 metres deep (p.186).

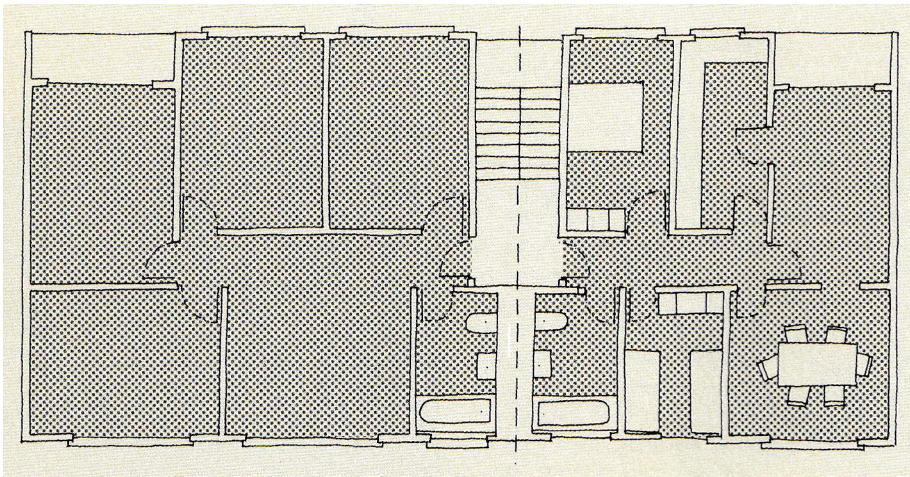


Figure 4.6 Indeterminate uses versus tight-fit functionalism (Schneider et al., 2007)

4.5 Joining Together

Housing units are generally designed as independent entities that are isolated from others, preventing the possibility of combining units conveniently and efficiently at a later date. Joining units together can happen horizontally or vertically. While multi-story residential buildings can manage both vertical and horizontal expansion by joining units (Figure 4.4), joining generally occurs vertically for single-detached houses. This strategy allows, for example, two one-bedroom units to be merged to form a one three-bedroom unit, allowing a family to stay and grow. The potential to expand into a larger unit addresses the needs of extended families that appear in some social and ethnic contexts.

There are few things to consider when joining units together to form a larger one. First, horizontal joining requires careful planning for openings such as doors and windows, in order to facilitate convenient future expansion. Poorly positioned openings hinder the flexibility of a housing unit as they dictate wall locations. Secondly, a dividing wall between two units should be able to be taken out easily. A soft panel, which is a type of wall that can be knocked through, renders the process of joining units together simpler (Figure 4.7). Thirdly, shared access points with generous space make potential joining and division easier (Schneider & Till, 2007, p.187).

As a result of joining, a combined unit will duplicate the kitchen and bathroom. An extra bathroom is not an issue but an extra kitchen may not be so easy to deal with. Occupants must decide what the space will become when a kitchen is removed. This decision will vary depending on the configuration of the kitchen, whether it is part of an open space next to a dining room, or in a separate room.

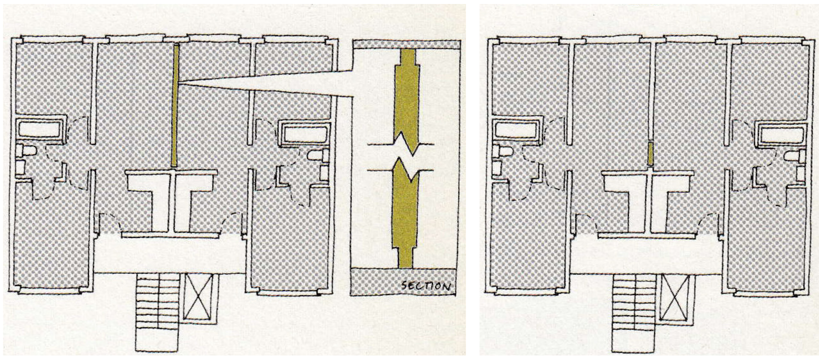


Figure 4.7 Joining together (Schneider et al., 2007)

4.6 Dividing Up

There are scenarios when a larger unit is no longer necessary and a smaller space is more appropriate. When children mature and move out, for instance, parents may not wish to move and may instead decide to divide up spaces for renting out. The original single large unit must be carefully designed so the division at a later date can occur seamlessly: it is critical to consider entry points, circulation and service when combining or dividing units. When a large unit is split to form two or more self-contained units, it is necessary to allow for separate entrances for each unit during the design phase.

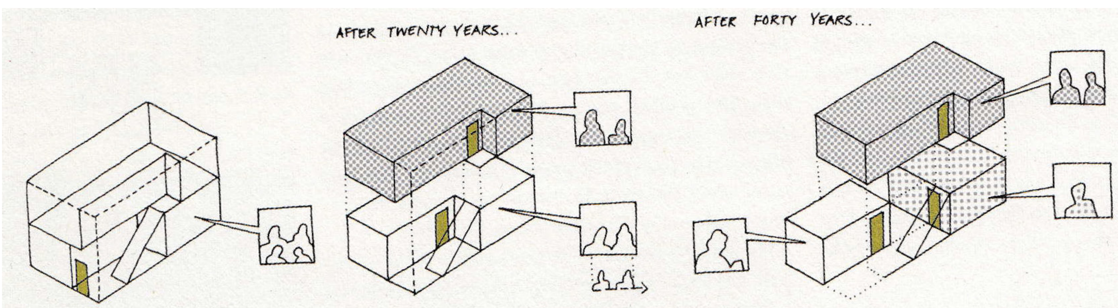


Figure 4.8 Dividing up (Schneider et al., 2007)

4.7 Shared Room

The notion of a shared room originates from the German concept of Schaltzimmer, which literally means ‘switch rooms’ (Schneider & Till, 2007, p.189). It is a term for a non-specific room between two units, or for rooms that can be owned by either unit. In a layout of a typical two one-bedroom apartment, for example, a shared room allows an extra bed or work room for one unit that can be given to the other unit once it is no longer needed. By utilizing a shared room, occupants are given the opportunity to either expand or diminish by an extra room. Furthermore, more elaborate type of shared rooms involve an added bathroom and kitchen.

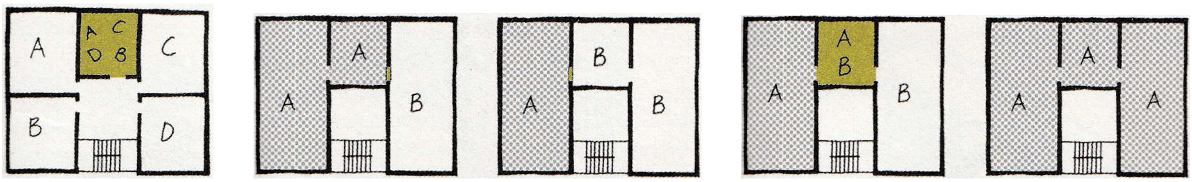


Figure 4.9 Shared room (Schneider et al., 2007)

4.8 Movable and Sliding Walls

Sliding and folding walls are one of the most common features of flexible housing in the twentieth century. These movable walls provide a wide range of flexibility such as creating an open space or dividing a living room and a kitchen. A good method of introducing movable walls is to make sure that the basic layout of the housing unit works well even without them, then to add them in. (Schneider & Till, 2007, p.191).

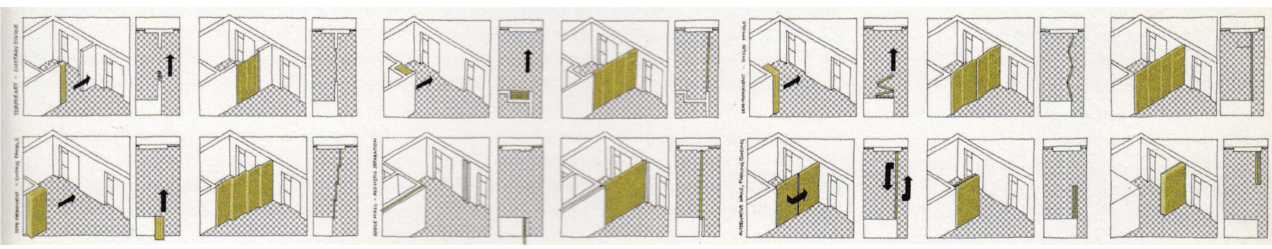


Figure 4.10 Movable walls (Schneider et al., 2007)

Figure 5.1 Modular structure of the Domino 21 allowed quick assembly (IDM et al., n.d.)

5. Flexible Construction

Whereas the last section explores how flexibility in housing may be achieved through usage and planning, this section investigates flexible construction principles and strategies. Only principles and strategies relevant to the subject of this thesis will be dealt with. Two construction principles covered in this section are *frame* and *simplicity*, and the two construction strategies are *clear spans* and *services*.

5.1 Frame

In contrast to flexible design strategies, which concentrate on specific uses and plans, flexible construction is associated with generic elements such as the development of background frames. The frame is one of the constructional principals that acts as a support system, allowing for various infills and layouts. Its key feature is the provision of long spans so as to accommodate indeterminate spaces within, allowing non-load-bearing partitions to be installed or removed as desired. Yet, the frame does not regulate what goes inside but instead provides a skeleton for infills to be attached to.

For the frame to work, it needs to be an independent system separate from internal partitions, services, and preferably, even external walls that can be upgraded at a later date. The frame is conceived as a static, permanent element while the infill elements are more dynamic and have shorter lifespans that can be adapted over time or be updated with new parts.

The principal of the frame is not limited to specific materials or construction methods. Framing materials are typically natural wood, engineered wood, structural steel or concrete in accordance with either heavy-frame or light-frame construction. However, a horizontal layer of materials used for wall-based constructional systems, such as masonry and rammed earth, can still convey the underlying concept. In general, the more the frame is open, the more opportunity exists for infills to be flexible and adaptable over time. The main idea is to provide a clear distinction of building hierarchy between support and infill, and generous free span space between walls.

5.2 Simplicity & Legibility

A simple and legible construction system is necessary to make future adaptations successful. When the difference between load-bearing and non-load-bearing elements is clear, the input of a specialist may not be required. According to

Schneider and Till (2007), there have been a number of failed examples of flexible dwellings where over-complicated technology deterred flexibility because users found it difficult to determine what could or could not be altered (p.194). A simple constructional system allows laypeople to take control of their living environment and adapt to it as they see fit.

Similarly, modularity and prefabrication work coherently in a legible manner. The two are frequently confused; the difference is that whereas modularity refers a building constructed with a series of separate and repeated components, prefabrication refers to building components that are manufactured and assembled offsite in a controlled environment. How modules are added, subtracted or replaced is clearly visualized and anticipated since they perform within the boundaries of an established system. However, caution is required when utilizing these defining principles. When technological solutions become a means of achieving flexibility, there is a risk of that technological determinism that "has shadowed the history of modern architecture" (Schneider and Till, 2007, p.175). The authorship and the role of architects are questioned when employing prefabricated systems (See Appendix D). Furthermore, a designer should consider long-term sustainability when relying on technology and beware of one-off and outdated approaches.

5.3 Clear Spans

One of the most important construction principles for achieving flexibility in housing is to allow a clear span between individual units. Internal partitions are non-load-bearing, which allows for various configurations of the interior layout. Partitions can be moved around, knocked out, or replaced in the future with the exception of the service core. Internal space is not permanently fixed, which allows clear spans to create an opportunity to adapt to future changes. With technical advancement, clear spans are easy to achieve but not the norm; they are often seen in terraced housing (Schneider and Till, 2007, p.195). Generally, the clear span in housing is approximately six metres with the materials comprising it varying according to developers' or clients' specifications. However, steel and concrete beams and column frames are considered most flexible since only the position of columns affect the interior layouts.

5.4 Services

The location and design of services affect flexibility in housing. Since services may become obsolete in the future, designers need to consider plans for upgrading and replacement. It may be cumbersome when structurally sound projects are torn apart for new services to be upgraded. However, if the services are designed flexibly at the initial stage to accommodate future upgrades, then the costs can be reduced, and the small, initial investment will pay off over the long term. The location of services and the methods of their distribution are important because the effects of servicing are as long-lasting as those of structural decisions. In terms of the key servicing strategy, there are vertical and horizontal distributions.

For vertical distribution, services are collected in risers or stacks with main service rooms being grouped around the stacks (Figure 5.2). Positioning of the stacks is very important in order to facilitate a flexible layout. Moreover, stacks need to be accessible for future upgrading should services become obsolete. Since vertical stacks determine the position of kitchens and bathrooms, they affect the future flexibility of all rooms. To be foolproof against future changes, one of the most sensible solutions is to provide extra space either within the riser or adjacent to it. In this way, the space can be taken over by the new servicing technology, or it can be used as an extra storage space inside the housing unit.

Horizontal servicing, like layering and legibility, needs to be easily accessible, manageable and exchangeable (Figure 5.3). In order to achieve a flexible plan in housing, wherever possible services such as pipes and wiring should not be embedded into internal, non-load-bearing walls. There are a few methods to make horizontal servicing more flexible. The simplest way is to surface-mount everything; however, the drawback here would be the creation of an aesthetically unpleasant interior due to exposed wires and pipes. However, development of the skirting trunking systems has made this approach more reasonable in terms of cost and appearance. Another method, although more expensive, is to utilize a raised floor or ceiling in which the services are installed. Lastly, the horizontal service runs can be collected in permanent walls and remain in one place even if the non-load-bearing walls are reworked.

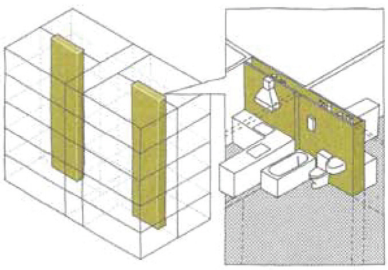


Figure 5.2 Vertical servicing (Schneider et al., 2007)

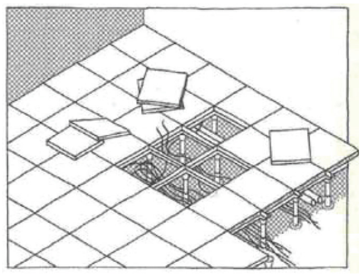


Figure 5.3 Horizontal servicing (Schneider et al., 2007)

Figure 6.1 Moduli 225 (Rista et al., 2016)

6. Case Studies

6.1 Add-On Method

6.1.1 Moduli 225

The Moduli 225, designed by Finnish architects Kristian Gullichsen and Juhani Pallasmaa, is a prefabricated housing project that was built throughout Finland between 1969 and 1971 (Figure 6.1). The intention of this project was to create prefabricated houses through industrial production and to update the tradition of prefabricated wooden housing in the Nordic countries, a tradition which had been increasingly replaced by steel construction. Built of wood, steel and glass, Moduli 225 is presented as a solution for a holiday home because it can be easily and quickly assembled and disassem-

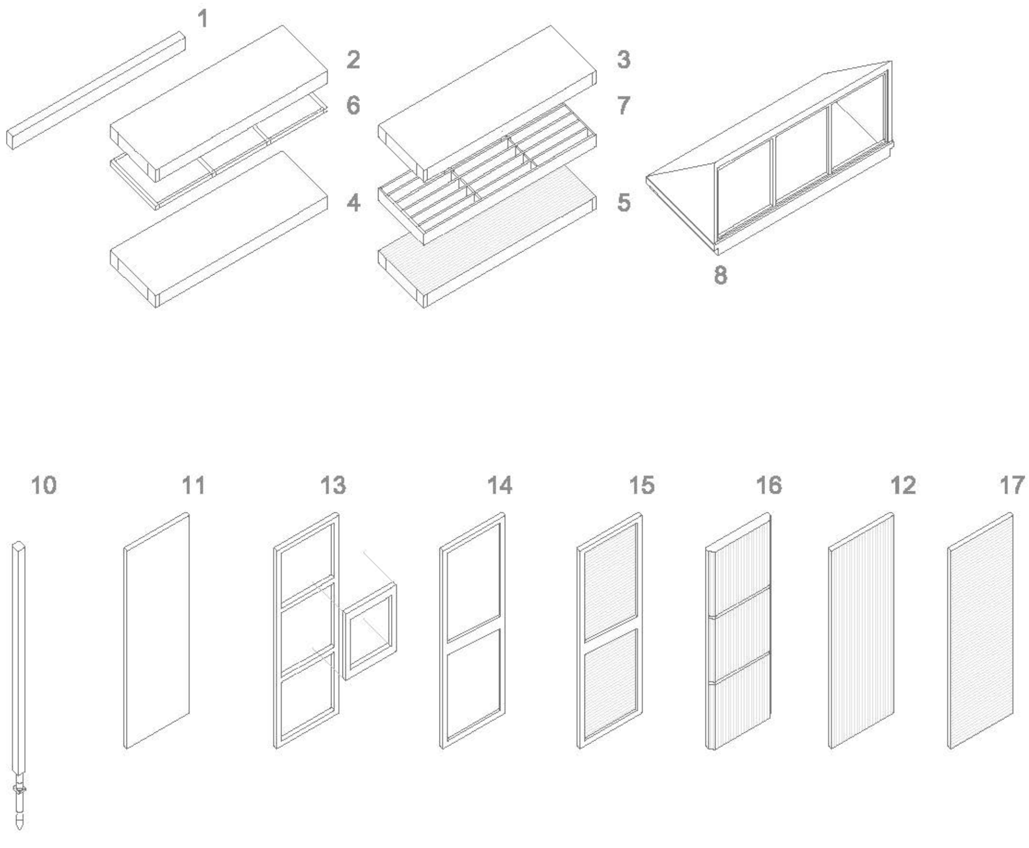


Figure 6.2 Modular system - horizontal and vertical components (Rista et al., n.d.)

bled.

A single module measures 225 centimetres in each of its cubic dimensions, and each dimension or frame can accommodate three slots of 75-centimetre prefabricated panels. Used for doors, windows and solid walls, the panels are fixed to the module by screwing (Figure 6.2). As a frame module could be added if more space was needed, the house had the opportunity to evolve in a multiple number of combined ways (Figure 6.3). For the foundation, adjustable metal supports were used, eliminating the need for an on-site, poured foundation (Figure 6.4). The adjustable support can accommodate a range of topographic variation up to 1.5 metres. The assembly time for the most basic configurations was two days and the price was shown to be more affordable than existing housing systems (Bergdoll & Christensen, 2008, pg. 152).

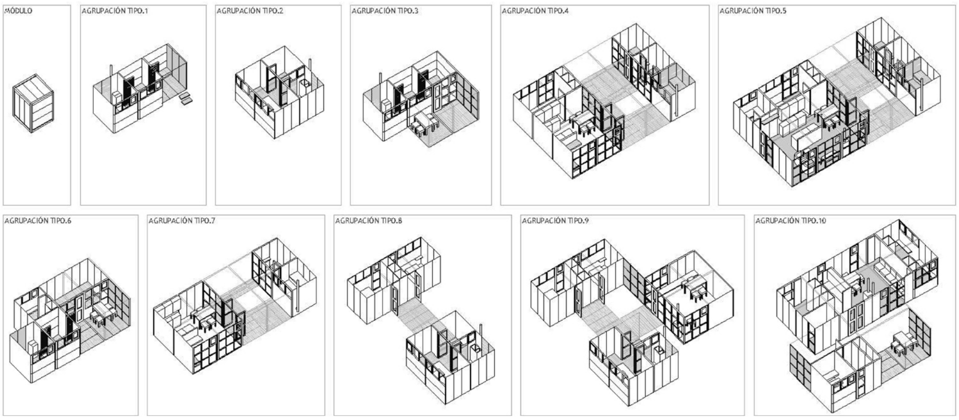


Figure 6.3 Growth variations (Rista et al., n.d.)

Although the objective was to create a summer vacation home, the house was primarily used as a residence, and sixty homes were built across Finland. Despite the advantages of innovative modular frames and systems of prefabricated components, the project was not practical due to several shortcomings. The chosen environment was not suitable for Moduli 225 and its maintenance was expensive, making the project unprofitable in the long run, and leading to its being abandoned. Bergdoll and Christensen (2008) note that “[i]n artistic terms this system was the peak of wooden prefab in Scandinavia, but its flat roofs were poorly adapted to Scandinavian winters” (pg. 29). However, Moduli 225 suggests that the cost of prefabricated systematized housing can be reasonable under the right environmental conditions. Moreover, an array of components and expandable modules not only allows inhabitants to participate in the design process but also enhances the individuality of the buildings, a characteristic that is sometimes missing in modular constructions.

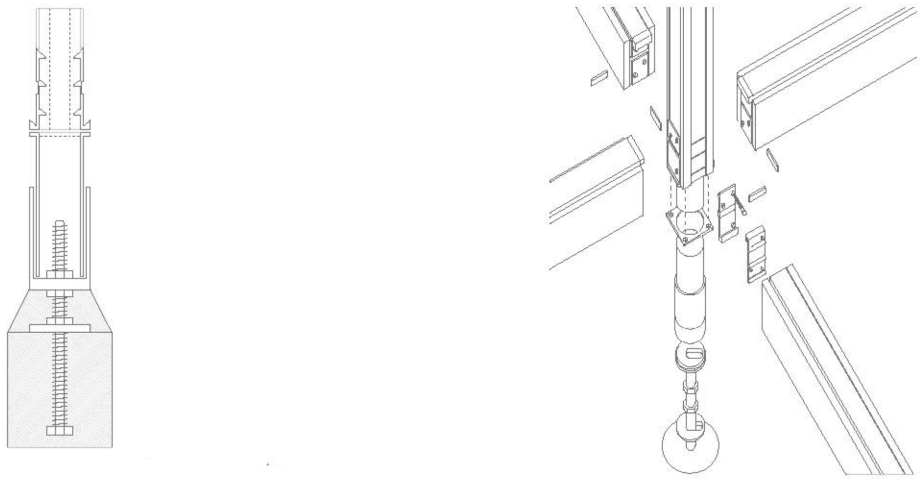


Figure 6.4 Connection to foundation (Rista et al., n.d.)

6.1.2 Zip-Up Enclosure

Zip-Up Enclosure is an unbuilt project designed by Richard and Su Rogers, based on the belief that the future of housing is tied to mass production. The project was an entry in a competition known as ‘The House of Today,’ and it was exhibited at the 1969 Ideal Home Exhibition in London. The architects’ aim was to offer various choices to customers, to realize low-cost housing with minimum maintenance, and to achieve a high degree of environmental control.

The expandable and portable project consists of floors, walls, and roof panels that are fabricated from a factory in separate pieces and then assembled together on site to create a structural module; this ‘rings’ structure is 3 feet wide and 30 feet long. The adaptability of Zip-Up Enclosure is achieved in three ways. First, each of the four pieces constituting a module is customizable in various ways, including colour, fenestration, and texture. Secondly, the ring’s capacity to “zip up” with other rings allows the house to expand when more space is needed. Owing to the 9-metre clear structural span, the flexibility of the interior layout was maximized with the use of demountable partitions on retractable casters (Figure 6.5). Thirdly, site adaptability was improved with the application of adjustable steel jack stilts that can respond to various topographic conditions (Figure 6.6). These circumvent the need for an expensive concrete foundation that is permanently fixed to one location.

One of Zip-Up Enclosure’s strengths is the fact that the occupant could simply order as many of these modules as needed for the creation of a new home or the expansion of an existing residence. Moreover, insulation is installed on the structural panels, out-performing the capacity of traditional options by seven times (Bergdoll & Christen, 2008, pg. 148). However, its advantages can also be its disadvantages. Even though the long, uninterrupted span of the ring permits greater internal spatial adaptability, the length of the ring necessitates the situation of the house in an open area. The size of modules limits potential sites, especially in urban areas where size and availability of land is restricted. Also, the addition of each ring takes place in a linear manner, placing a restraint on lateral growth.

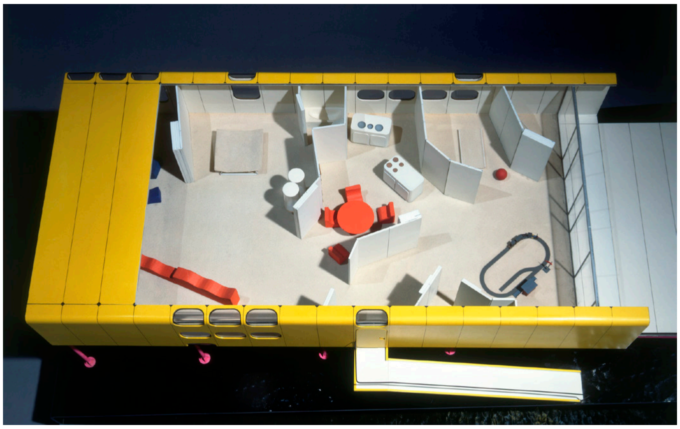


Figure 6.5 Flexible interior layout with demountable walls ("Zip-Up House physical model." 2014)

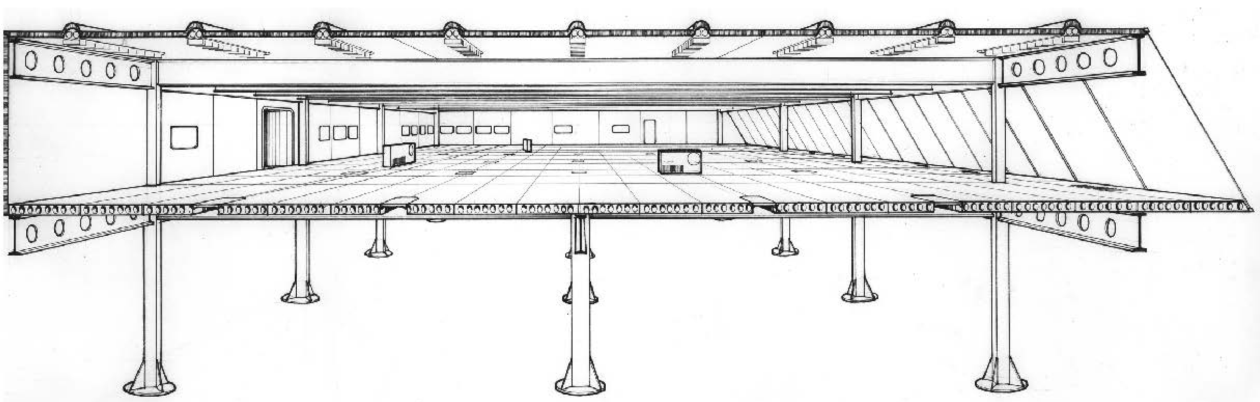


Figure 6.6 Adjustable steel jack stilts ("Zip-Up House sectional perspective." 2014)

6.1.3 Stelco Catalogue Housing

Stelco Catalogue Housing is the design outcome of a steel housing prototype competition held by the Canadian steel company Stelco in collaboration with Canadian Home magazine in the late 1960s. The objective of the competition was to re-establish the popularity of steel in the architectural industry, as it had been supplanted by plastics (Bergdoll & Christen, 2008, pg. 138). Although Barton Myers Associates' proposal was not the winning entry, the firm made a notable contribution to the discourse of prefabrication.

The firm developed a modular system comprised of external panels, interior panels, and framing members: "steel column sections, hollow tube beams, and number of different sandwich panels of prefinished steel with a urethane core for horizontal and vertical surfaces" (Figure 6.7) (Bergdoll & Christen, 2008, pg. 138). These panels could be attached to frames in various arrangements with industrial Velcro, and joints between them were sealed with neoprene tongues. The modules are self-supporting, and can be stacked up to three storeys (Figure 6.8).

The greatest asset of this proposal is the quick and straightforward assembly of ordered parts from a catalogue. Two unskilled persons could assemble these parts with an eye to their future expansion and modification. Also, since used components are unchanged by fastening, they are reusable as well. On the other hand, since there is only one type of module with consistent dimensions, designs will be of uniform appearance despite the module's capacity for various arrangements.

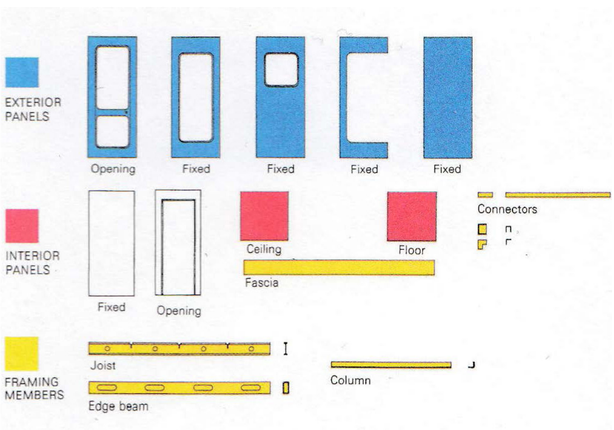


Figure 6.7 Unit components
(Bergdoll et al., 2008)

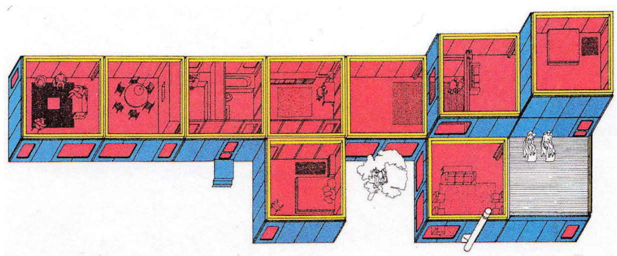


Figure 6.8 Axonometric view of cluster
(Bergdoll et al., 2008)

6.1.4 Nakagin Capsule Tower

The Nakagin Capsule Tower in Tokyo, designed by Kisho Kurokawa in 1972, consists of two towers that are interconnected at the 11th and 13th stories; they include both residential and office spaces. A total of 144 interchangeable "capsules" that resemble shipping containers in their size and shape are attached to structural cores. Each capsule is a self-contained unit that connects to the core with flexible joints, demonstrating the Metabolist concept of replaceability and adaptability (Figure 6.9) (Lin, 2011).

Metabolism is based on the idea that a city is like an organism, and the Nakagin Capsule Tower was influenced this concept at every step of its design. Metabolism distinguishes permanent and transient elements of different scales and durations. Kurokawa categorized the building as having three elements: "the permanent structure (two ferroconcrete

Figure 6.9 Nakagin Capsule Tower (Arcspace, 2011)

shafts), the movable elements (144 capsules), and the service equipment (utilities) (Lin, 2011).” The capsules, which were prefabricated offsite and built of lightweight welded steel frame, were hoisted by a crane and tied to the concrete cores using four high-tension bolts (Figure 6.10). This construction method suggests the opportunity for renewal of the system whenever necessary, since it enables each capsule’s removal for updating. The only on-site construction involved the two structural cores and space for utilities and equipment. The construction of the Nakagin Capsule Tower took only a year to complete.

However, the Nakagin Capsule Tower ultimately failed to satisfy Kurokawa’s vision of it as a mass-produced model for prefabricated housing in an urban setting. First, the cost of innovative construction was high and each capsules accommodated only the needs of a single person. Secondly, the cultural growth of Tokyo was so rapid that it outpaced the expected lifespan of the capsule tower; ironically, the building became old and outdated. Thirdly, paradoxically, the distinction between mega-structures and capsules made the building rather inflexible in terms of occupancy and structural expansion. Despite its shortcomings, however, the Nakagin Capsule Tower represents a meaningful early attempt to realize a system adaptable to a rapidly changing society.

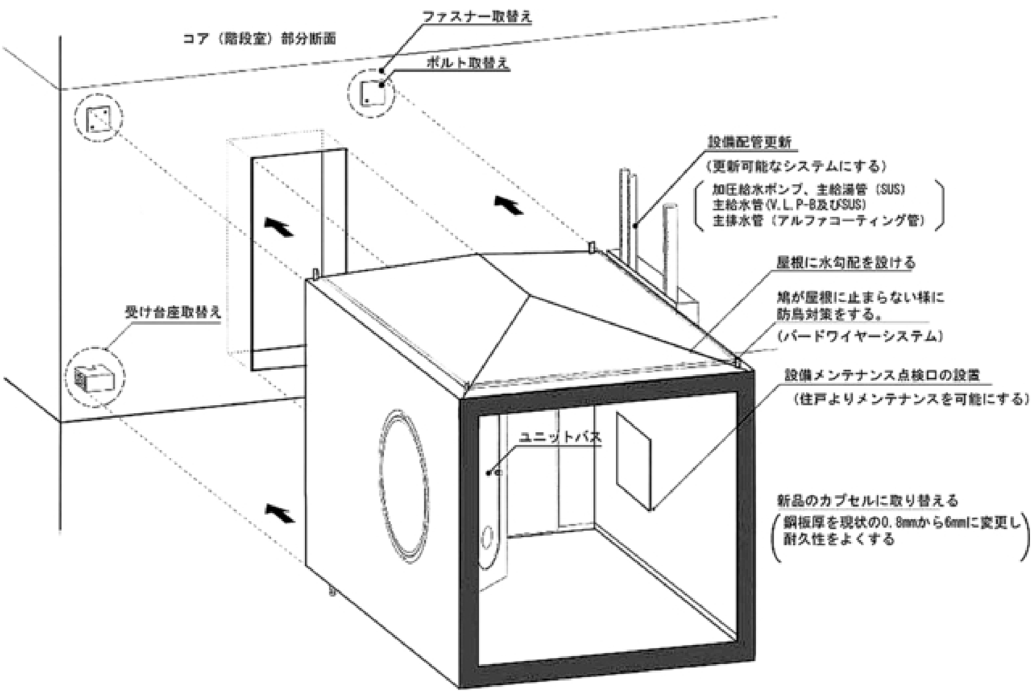


Figure 6.10 Capsule to the structural core, 1972 (Arcspace, 2011)

6.2 Add-In Method

6.2.1 TILA Housing Block

One of the most notable projects that demonstrates Habraken's idea of an 'open building' is the TILA housing block located in Helsinki, Finland, by Talli Architecture and Design. The five-storey concrete and steel frame apartment provides such fundamental cores as structure, envelope, walls and bathrooms; the rest is up to the residents who determine the number of subdivisions and personally build the interior volume of their units (Figure 6.12). A catalogue of pre-designed layouts is available to residents should they wish to simply hire a contractor. The ceiling height of each unit is 5 meters, creating an opportunity for a loft floor level above. The ground level of the apartment is comprised of a garbage room, laundry and storage while the top floor includes a sauna, communal space and a terrace. After the completion of the shell building in 2009, the ongoing construction of the owner-built interior volumes was finished in 2011, resulting in 39 units that are all unique (Figure 6.11). Habraken himself visited the project in 2010 and considered it a successful reflection of the open building philosophy. This project illustrates how pre-occupancy flexibility can be achieved when residents participate in the design process.

Figure 6.11 Variation of infill space by the residents ("Report on the TILA open building project in Helsinki." 2014)

Figure 6.12 The empty shell space ("Report on the TILA open building project in Helsinki." 2014)

6.2.2 Quinta Monroy

Completed in 2004, Quinta Monroy is a successful project that employs incremental growth as a strategy to make social housing both affordable and flexible. The Chilean architecture practice ELEMENTAL was asked to re-house 97 families who had occupied the site illegally since the 1960s. Their biggest challenge was to stay within a limited budget while keeping the site which had very high land value due to its central location. A government subsidy equal to $7,500 USD per family had to pay for land, infrastructure and building; however, 70% of the budget was spent on the land. In attempt to provide decent homes at a reduced cost, ELEMENTAL decided to design 'half-a-house'. Their aim was to maintain the quality of middle-income homes by sacrificing their size (with size being flexible for later expansion by the inhabitants) (Figure 6.13). What ELEMENTAL provided is a starter core shelter with a row-house typology, where the voids have potential for future development.

Figure 6.13 Quinta Monroy - before and after (Jalocha, n.d.)

Figure 7.1 The prototype housing (Kim, 2018)

7. Design Exploration

Following prior research and analysis, this thesis aims to develop a prototype for a single-detached home that can respond to changing demographics and growing families. The design methodology is based on analysis of both the benefits and shortcomings of flexible housing strategies and on the re-application of them in the context of Toronto neighbourhoods. The goal is to provide new perspectives on how homes can remain livable even when the needs and desires of residents change. These questions were addressed within the design proposal of this thesis, to re-state: in a society where rapid urbanization and increased population affect people's lifestyle especially in a city, how can architects develop a housing system that not only adapts to growing families but also to shifts in family composition? How can architects achieve spatial flexibility in an urban environment where space is strictly limited?

7.1 Current Housing Situation in Toronto

The current housing market in Toronto has been greatly influenced by the Millennials, also known as the "echo" generation, the children of baby boomers. There is no precise date defining the age of this group, but it is generally understood to include those born between the early 1980s and the mid-1990s. The population of the Millennials has surpassed that of baby boomers, becoming the largest age group in Canada. Between 2006 and 2011, the population growth rate in downtown Toronto nearly quadrupled from 4.3% to 16.2% over the past three census periods (Figure 7.2) (TD Economics, 2013). Downtown Toronto refers to Trinity-Spadina and Toronto Centre districts (Figure 7.4). Whereas the aging baby

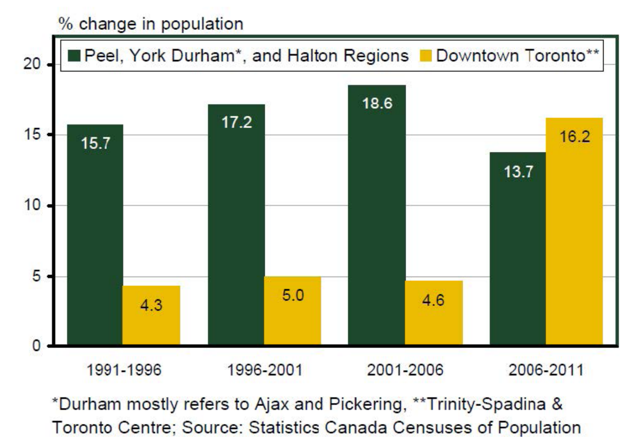


Figure 7.2 Population growth in the GTA (Statistics Canada, n.d.)

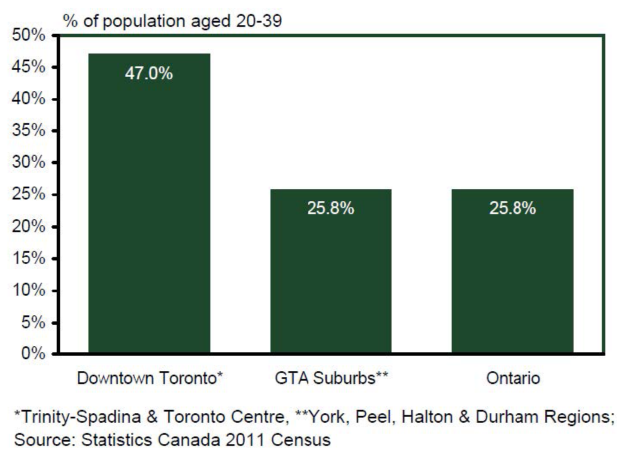


Figure 7.3 Approximate Echo Boomer share of population (Statistics Canada, n.d.)

boomers are retreating to the suburbs or their hometowns, the Millennials are attracted to the downtown because of the access to jobs, transit and amenities. In 2011, nearly 47% of the downtown population in Toronto was between 20 and 39 years old (Figure 7.3) (TD Economics, 2013). The desire to live near the urban core, paired with the gentrification of old and deteriorating commercial and industrial plots, triggered the development on an unprecedented scale of massive residential high-rises.

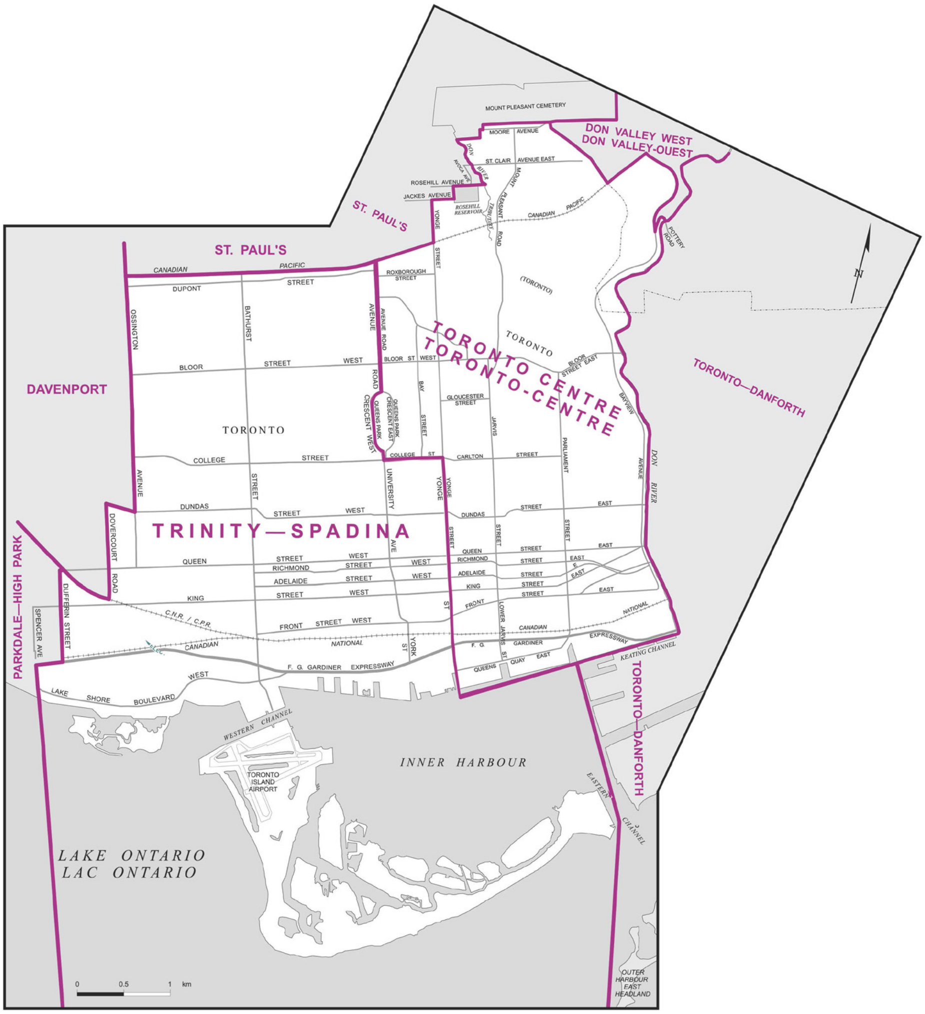


Figure 7.4 Trinity-Spadina & Toronto Centre (Ontario Electoral Districts, 2005)

With an increased population of younger people, the types of households that gained in numbers were those of singles and unmarried couples. In the past, young singles were not considered as potential homebuyers and they were often neglected by architects, planners, and home builders. Today, both young male and female singles, as well as unmarried couples, are either purchasing or renting units before their marriage, and many of them buy homes without any specific intention of getting married soon. For these types of households, a relatively more affordable housing choice is a condominium, if they wish to continue an urban lifestyle. Developers have targeted the echo generation and have been building smaller units to keep the costs attractive. In 2012, 63% of the 6,005 condos ready for occupancy in the city of Toronto consisted of bachelor units, one-bedrooms, and one-bedrooms with a den, with the average size being 822 square feet (Yelaja, 2012).

However, high-rise living has several drawbacks such as social isolation and diminished public realm amenities. The current housing trend in Toronto that focuses on residential towers can entail reduced livability and poor environmental performance. Furthermore, larger families have trouble finding multi-bedroom units due to limited availability due to the preference for smaller units.

In general, the increase in population for the Millennials, who tend to favor an urban lifestyle, contributed to the current trend of a condo-based housing market in the downtown that targets young professionals with small household sizes. One consequence of this is that housing demands for other age groups have not been addressed. Real estate development has been responding to the needs of the majority, however it is uncertain whether this trend will be sustained in the future.

A new housing typology for Toronto, which is flexible enough to accommodate various types of households and age groups, needs to be developed. This thesis selects single-detached housing as a means of investigating housing flexibility in the city of Toronto.

7.2 Site Selection

When householders move due to housing issues, wanting a new or better home is one of the significant factors. The static layout of the traditional house either prohibits modification or entails expensive renovations. Proposed flexible housing is designed to eliminate the need to move from one area to another since it would accommodate changing needs. Therefore, prototypes tend to target groups who want to stay in their neighborhood. A proposed design can be divided into up to three different units, where the original owner can rent out remaining units. Prototypes can either function as family homes that last for generations, or be converted into apartments (and back again) to accommodate various household types. The prototype can eventually but not simultaneously satisfy those groups that place importance on neighbourhood bonds and community relationships, and also individuals who are constantly moving due to demands of careers and education, and for other personal reasons.

In order to take demographic factors into account and respond to the needs of different groups, it is crucial to pick a site that allows multiple units per lot. In all R-zones, detached housing can have a maximum of three units per lot provided that the main house holds two units and the additional unit derives from a laneway suite (Figure 7.5). As for the footprint of a laneway suite, the maximum width allowed is 8.0m, which also determines the maximum lot width of the proposed design (Figure 7.6). Many Toronto neighbourhoods offer opportunities for the development of laneway housing. Some examples include Cabbagetown, Dufferin Grove, and Little Italy (Figure 7.7, 7.8 and 7.9).

The lots abutting a laneway in these neighbourhoods are narrow. Typically, they are 7.6 metres (20 feet) wide with varying lengths (between 100 to 130 feet), providing for single-detached housing. Since the purpose of this thesis is to develop a flexible housing system that responds to changing lifestyles and needs in a rapidly changing society, the actual site is less important than its parameters and conditions, which must provide opportunities for flexibility. Although the proposed design is 'site-less', it can in fact be located anywhere as long as certain conditions are met.

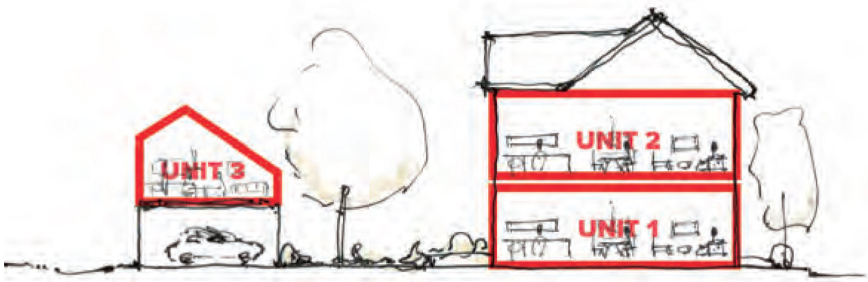


Figure 7.5 Units per lot on R-zones (Lanescape et al., 2017)

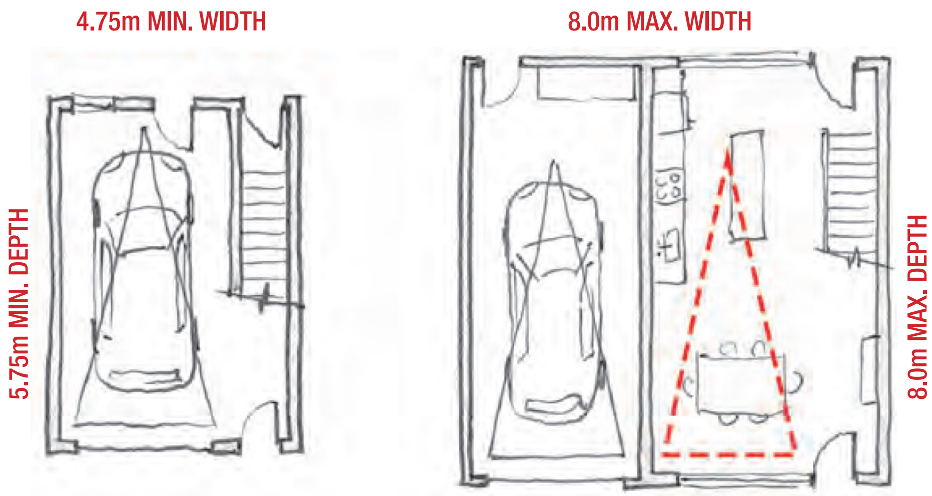


Figure 7.6 Laneway housing MIN/MAX dimensions (Lanescape et al., 2017)

CABBAGETOWN

Minimum Area for Laneway Suite		Total Laneway Lots:	276
Non-Compliant Lot		Compliant Lots:	102 (37%)
45m radius from hydrant		Non-Compliant Lots:	174 (63%)

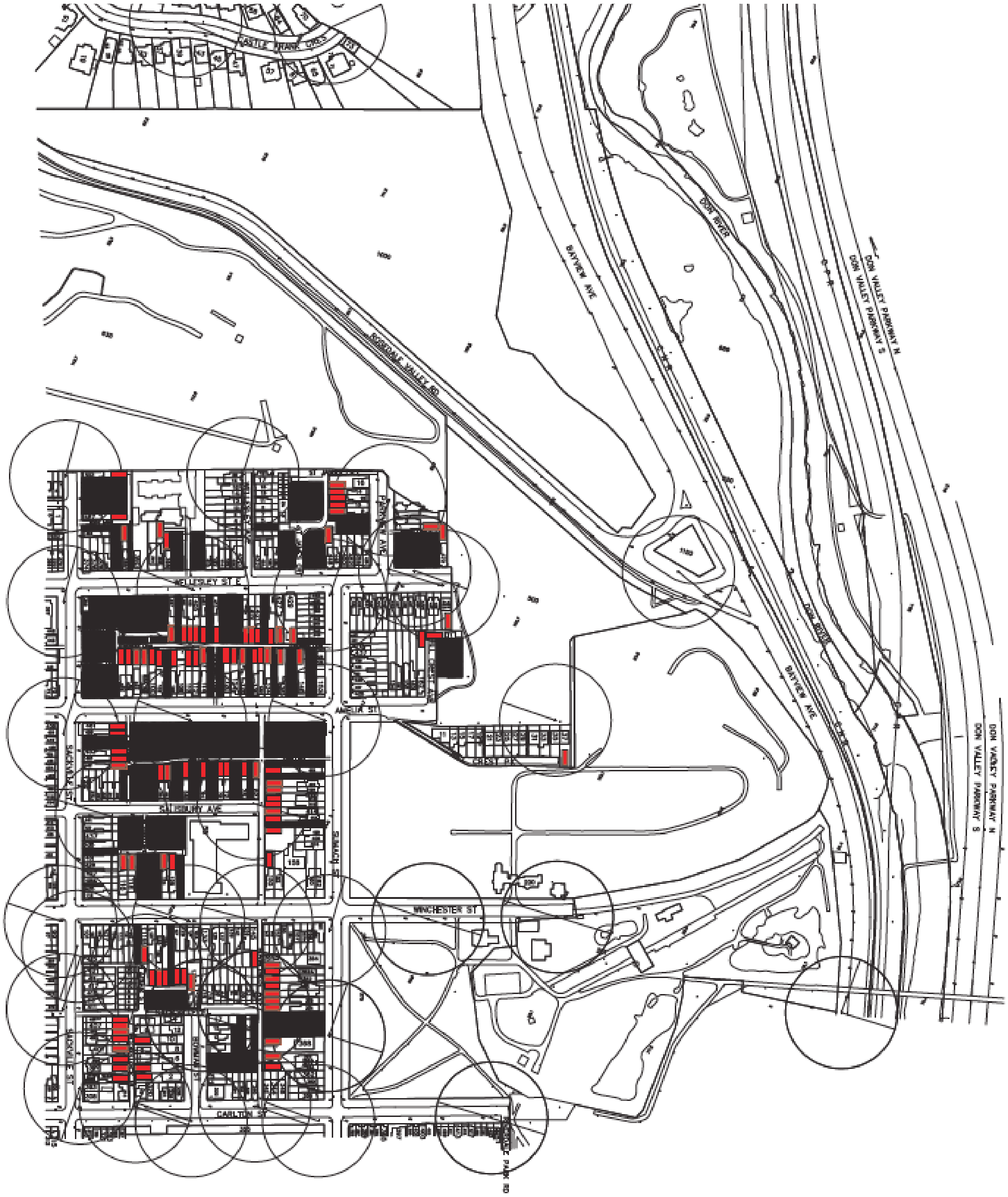


Figure 7.7 Potential sites - Cabbagetown (Lanescape et al., 2017)

DUFFERIN GROVE

Minimum Area for Laneway Suite		Total Laneway Lots:	570
Non-Compliant Lot		Compliant Lots:	484 (85%)
45m radius from hydrant		Non-Compliant Lots:	86 (15%)

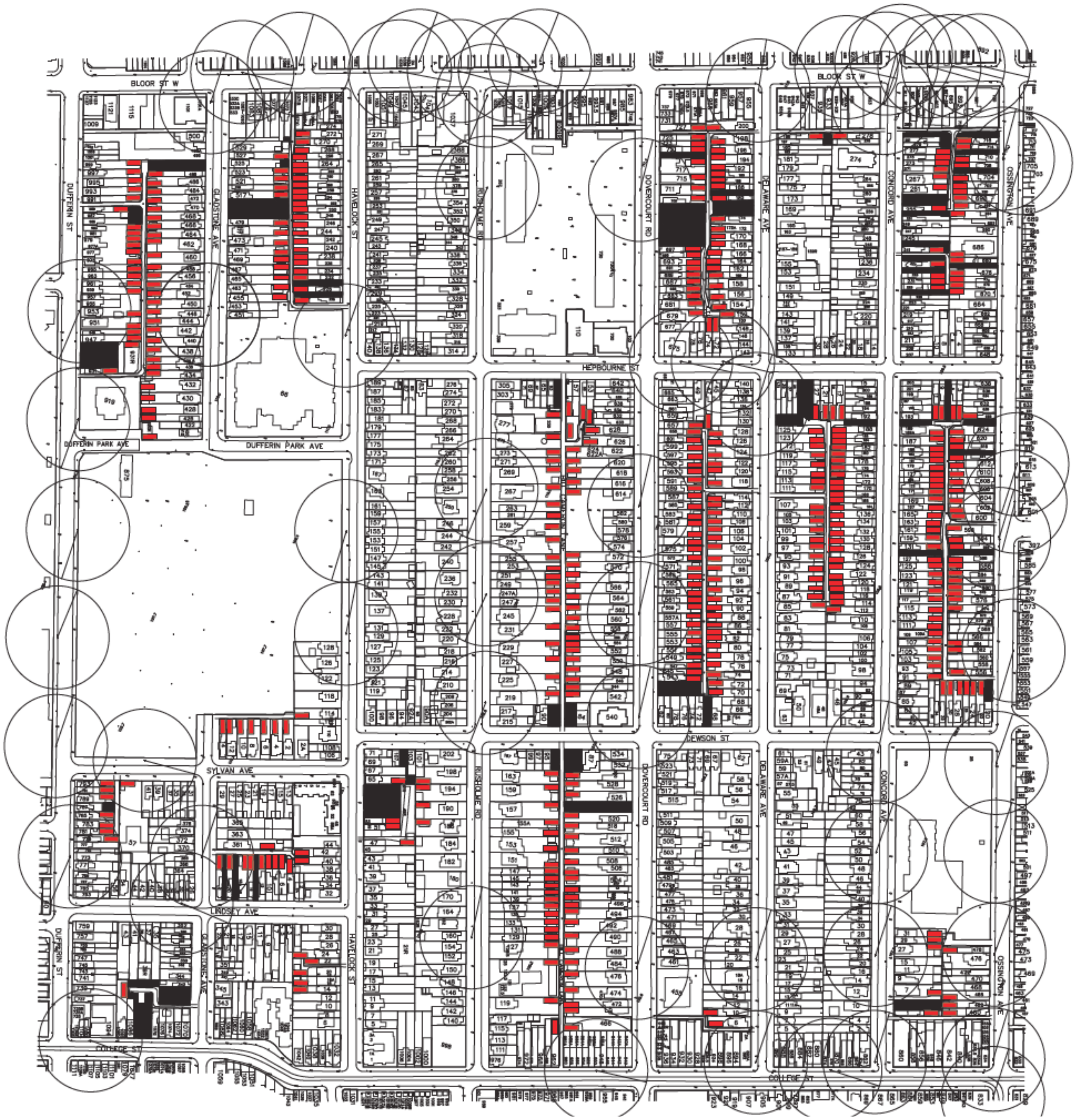


Figure 7.8 Potential sites - Dufferin Grove (Lanescape et al., 2017)

LITTLE ITALY

Minimum Area for Laneway Suite	Total Laneway Lots:	1349
Non-Compliant Lot	Compliant Lots:	775 (57%)
45m radius from hydrant	Non-Compliant Lots:	574 (43%)

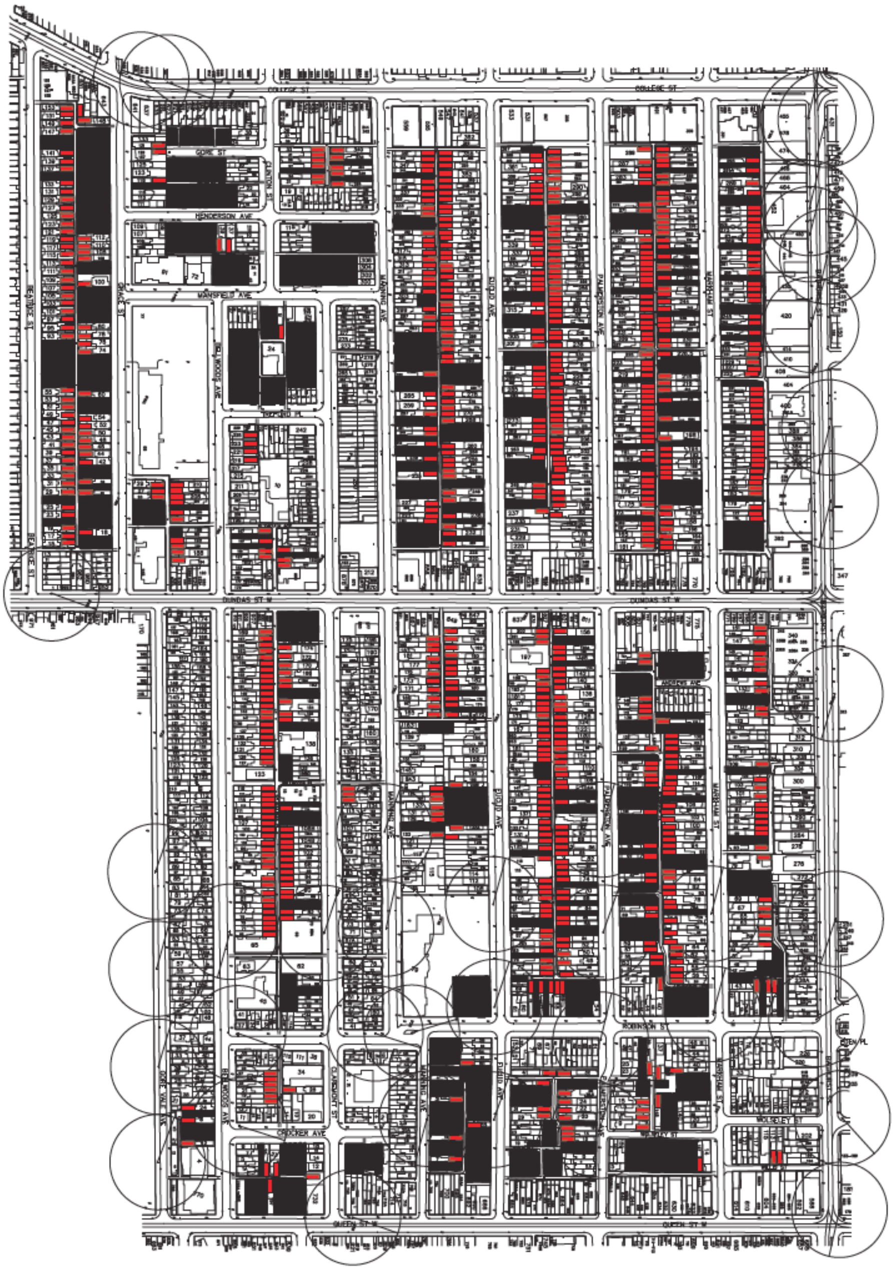


Figure 7.9 Potential sites - Little Italy (Lanescape et al., 2017)

Figure 7.10 Elevation drawing showing adjacent buildings (Kim, 2018)

7.4 Service: Vertical Distribution

In a vertically stacked, multi-unit housing where residents are able to decide on the layout of their own unit, the design strategy needs to allow for the easy distribution of utilities. One strategy is to create a vertical shaft that runs through the height of the building. The location of shafts is important because a misplaced shaft could hinder future changes. Since the prototype is a narrow and simple lot for downtown neighbourhoods, arrangement of the core affects everything from the size of rooms to the general appearance and layout of the interior space. In the proposed design, bathrooms, kitchen and stairs are clustered around the core. There are two parallel, vertical shafts with bathrooms centrally located between them on the ground and second levels; the basement core holds a mechanical room (Figure 7.11). The two shafts provide multiple potential kitchen locations. (These are highlighted in magenta), and locations for either a kitchen or bathroom on the basement level (highlighted in green) (Figure 7.12). The central double shafts contribute to the flexibility of the prototype since occupants have the option to choose the location and number of kitchens. This is beneficial especially when the prototype house is divided into two units.

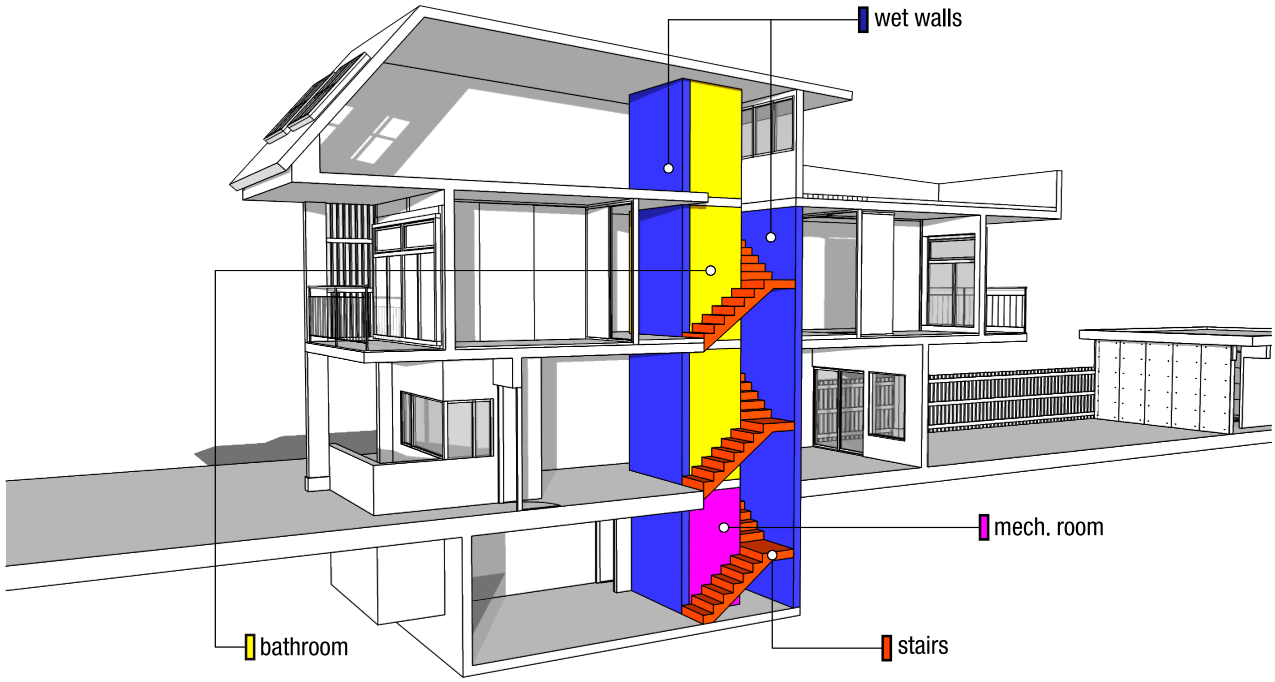


Figure 7.11 Core diagram (Kim, 2018)

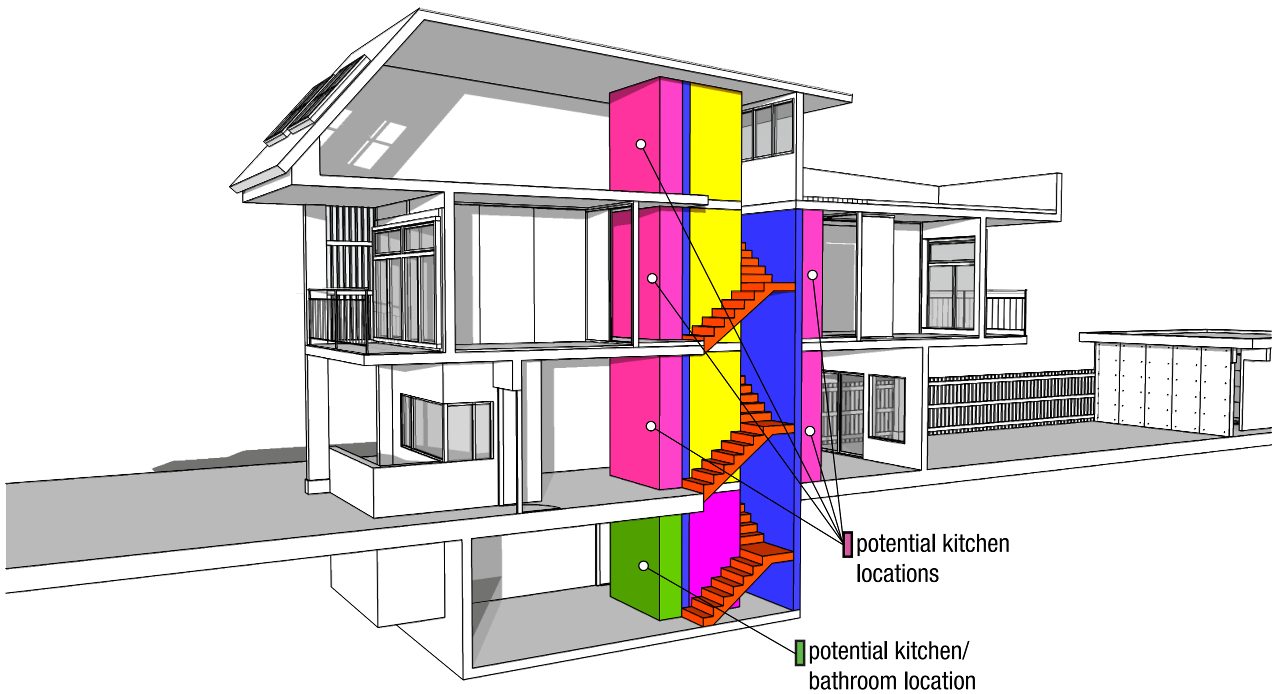


Figure 7.12 Potential kitchen/bathroom locations (Kim, 2018)

7.5 Movable and Sliding Walls

In order to facilitate a flexible interior layout that can accommodate different programs, movable and sliding wall/door system has been developed. Sliding wall is one of the most common devices for flexible space, creating an open space or dividing it. However, its shortcoming is revealed when the walls are stacked to the side to create an open space; the open-sliding wall in the Figure 7.13 shows that the walls in fact prevent a space being fully open. Therefore, in order to overcome the weakness, a traditional Korean wall/door system known as *angojigi* door has been studied. The unique feature of *angojigi* door is the fact that doors are both horizontally pivoted and sliding. The sliding walls and *angojigi* are integrated to create a new system of flexible interior partitions that can either be completely open or closed to created up to two small bedrooms; the removed wall panels can be kept in a storage and then inserted back in again if the space needs to be divided (Figure 7.14).

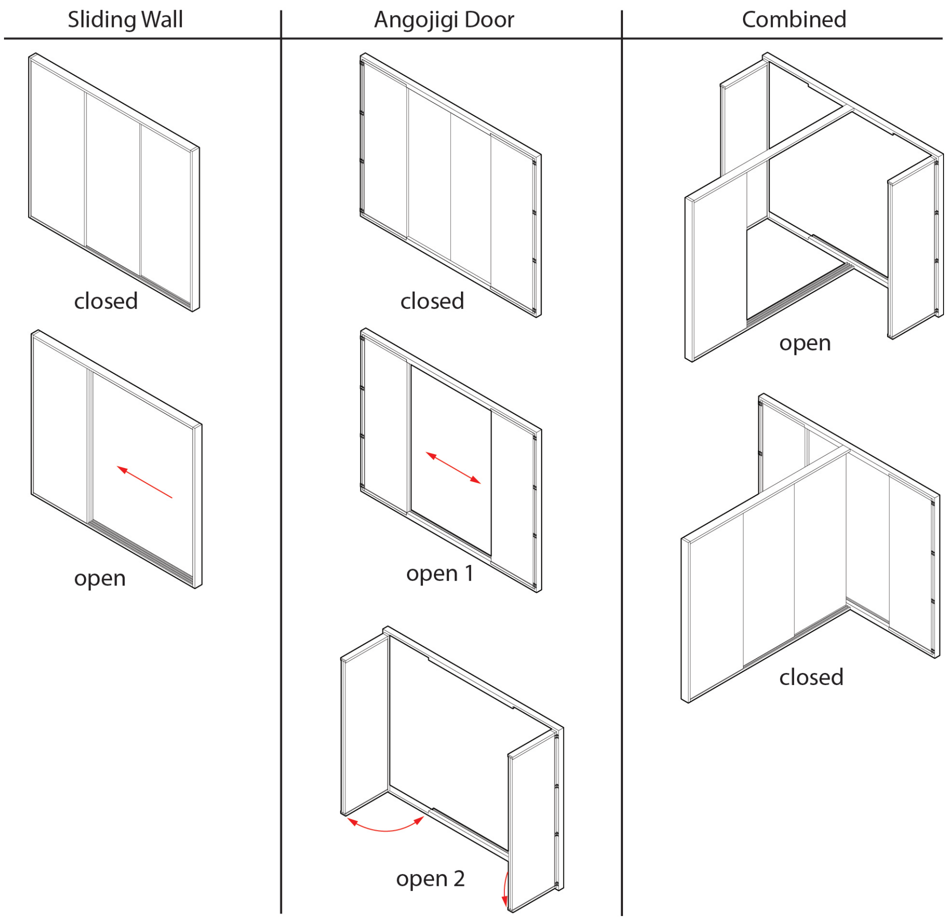


Figure 7.13 Analysis of partition systems (Kim, 2018)

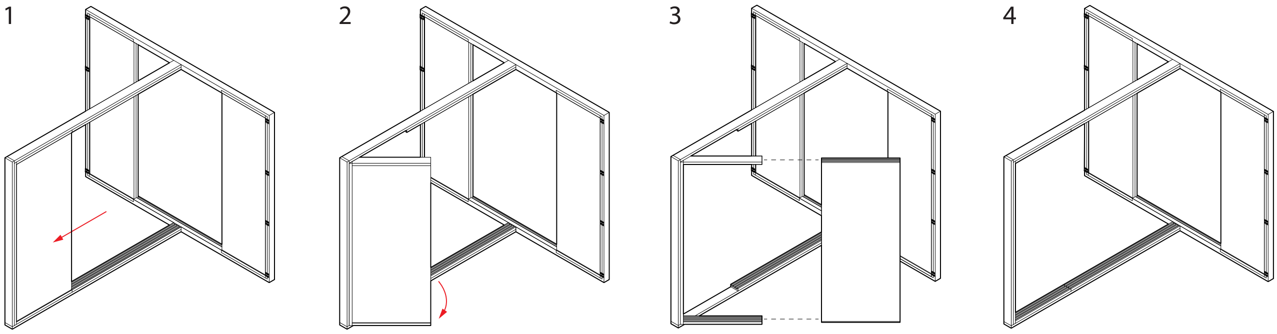


Figure 7.14 Process of opening up the interior space (Kim, 2018)


Figure 7.15 Closed sliding doors and walls form two small bedrooms (Kim, 2018)


Figure 7.16 Completely open partition system creates space for a kitchen and dining room (Kim, 2018)

7.6 Interior Layouts

The aforementioned double vertical shafts and movable partition system contributes to flexible spatial configurations. Thanks to these strategies, almost all kinds of programs for a house can be positioned anywhere other than the core itself. For instance, if an extra bedroom is required, one can simply close one of the sliding walls to convert one large space into two small rooms. Also, owners can choose where a kitchen would be installed, and how many of them would be needed. Also, numerous adaptations of floors plans can be achieved, ones that can respond to a growing family whose needs are constantly changing. The total floor area of the prototype is 149 square metres (1,600 square feet). For smaller families, the house may be somewhat be too large to occupy. Renting might be a more reasonable alternative for smaller families. The following figures demonstrate how the space could be occupied as the family grows.

Figure 7.17 Rear view (Kim, 2018)

Figure 7.18 Potential floor plans for a couple (Author)

Figure 7.19 Potential floor plans for a small family (Author)

Large Family (4 bedrooms)

Figure 7.20 Potential floor plans for a large family (Author)

7.3 Modular Expansion

There are a number of different design and construction strategies for the realization of flexible housing. In general, the two main methods are the add-on and add-in approaches. Before the advancements in modular and prefabricated construction, both techniques of expansion – using unfinished spaces within a building and growing through an addition – were laborious and expensive. Factory-produced modules, although they were not necessarily cheaper, were quickly manufactured and could be easily installed. Rapid fabrication and convenient installation are strong assets when pursuing flexible housing in an urban context. Large proportions of the urban populace are people who have come to the city in order to make a living. The add-in method, which often involves a do-it-yourself (DIY) element, together with the incremental housing approach, puts a heavy burden on city-dwellers because time is a luxury they cannot afford. Even though these strategies are successful in developing countries, they are less appropriate in the fast paced Toronto environment. However, there are instances where people invest their free time on weekends to complete unfinished basements or attics. The prototype for the proposed design offers both options: residents can choose to either purchase the module to expand their house, or can complete an unfinished basement on their own should they decide to expand the house.

The modules are prefabricated and assembled in a factory, transported to the site, and installed using a crane. The crane is necessary for the preliminary insertion of the bottom of the module (Figure 7.22). Installation is completed by fastening four high-tension bolts on the top corners of the module (Figure 7.23). These modules, which can be attached on both ends of the second level, are connected to the frame supported by shear walls on the sides (Figure 7.25). The exterior of the module is composed of operable window/door panels on the front, and of wood siding panels on the sides. The module is serviced using under-floor heating ducts which rest on a 4-inch reinforced concrete slab (Figure 7.24).

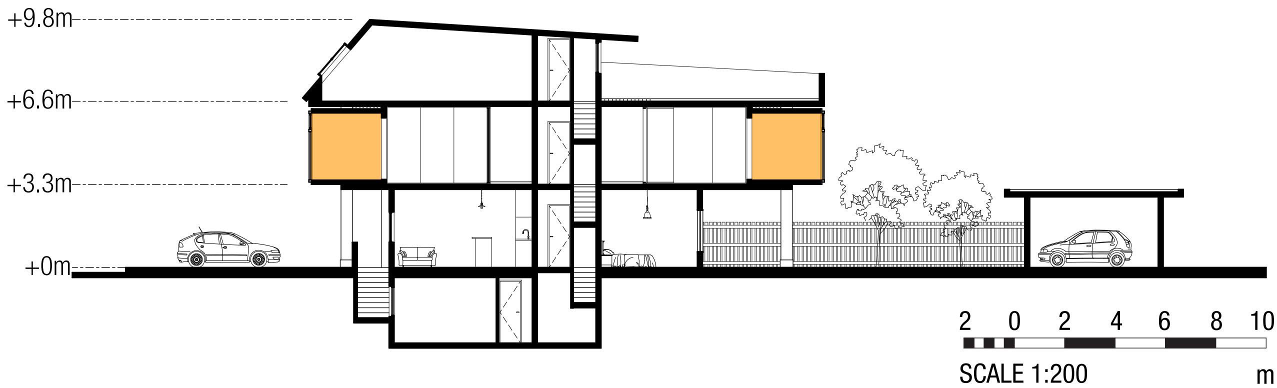


Figure 7.21 Section drawing with modules (Kim, 2018)

If an owner wishes to utilize the module to create an additional unit as laneway housing on top of the garage, the modules can simply be removed and relocated. Subsequently, prefabricated exterior sliding door, flooring and railings can be installed to create a balcony (Figure 7.24).

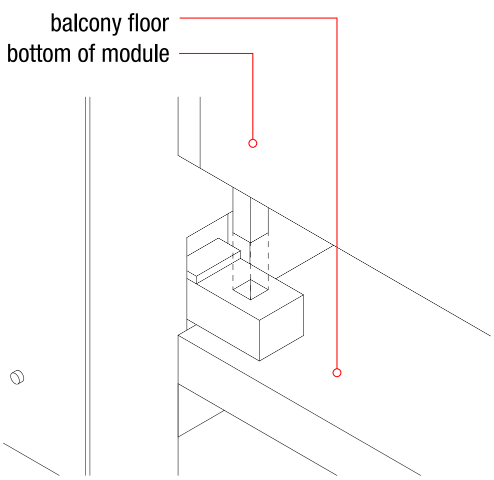


Figure 7.22 Bottom connection of module (Kim, 2018)

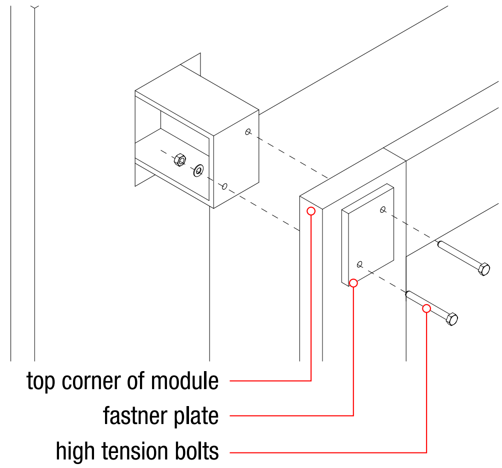


Figure 7.23 Top connection of module (Kim, 2018)

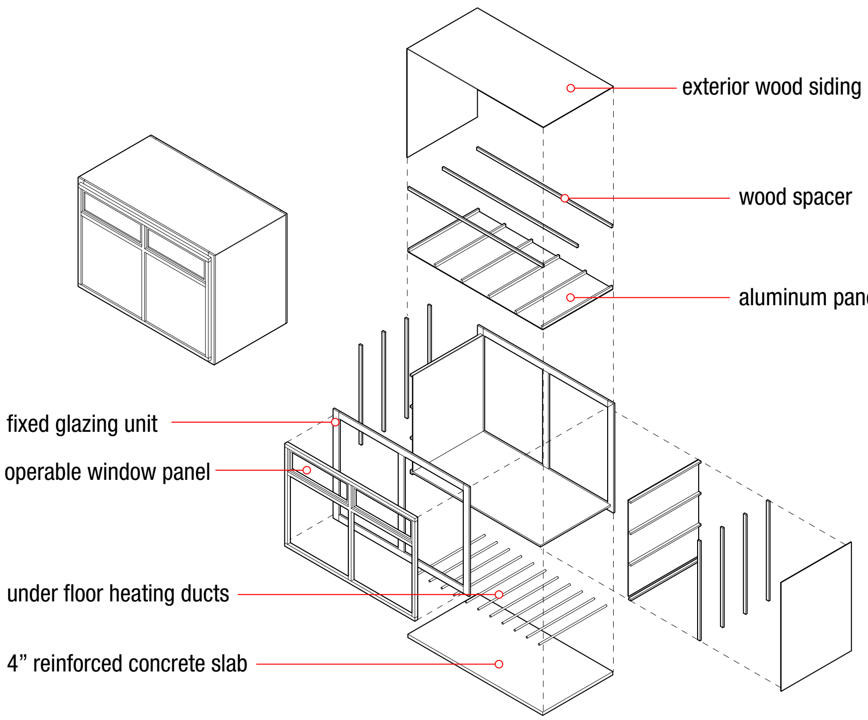


Figure 7.24 Exploded axonometric of module components (Kim, 2018)

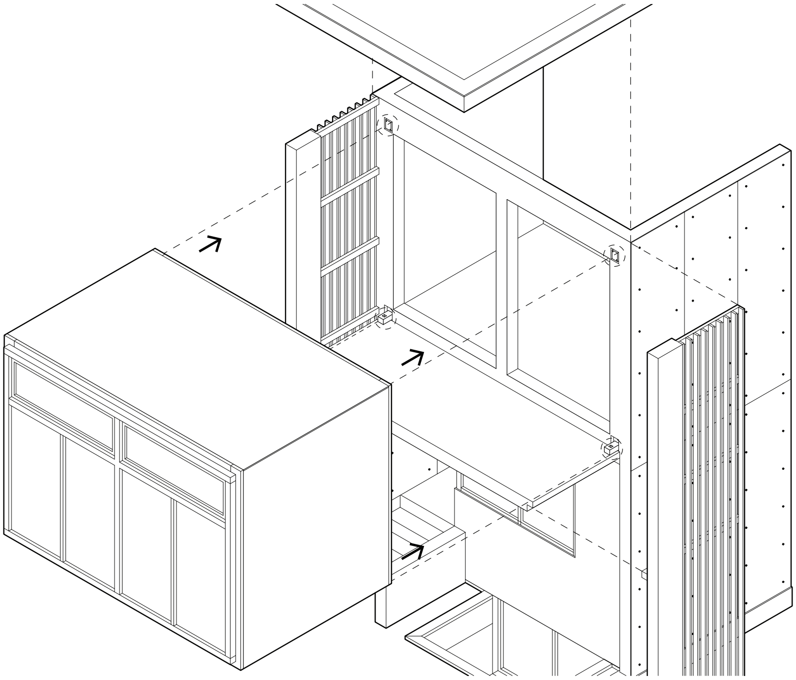


Figure 7.25 Modular option (Kim, 2018)

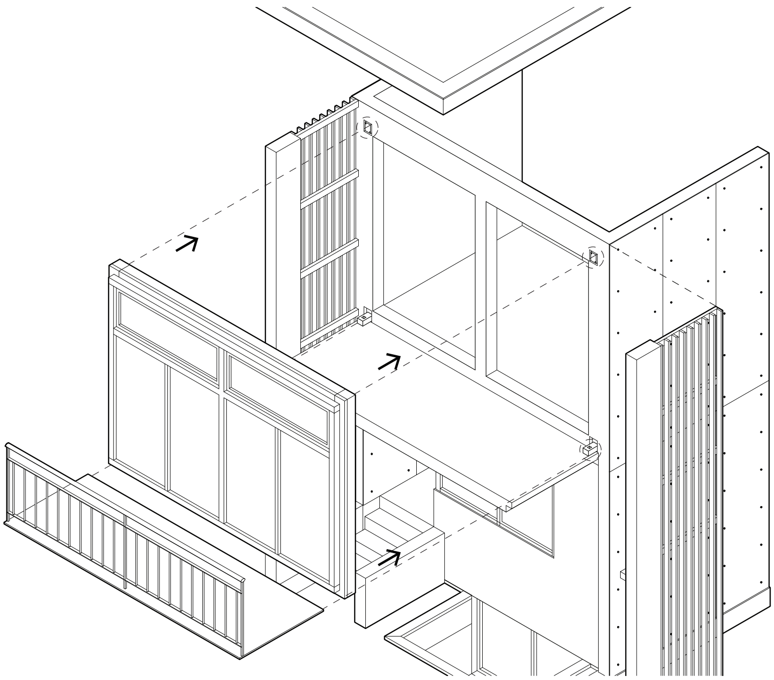


Figure 7.26 Balcony option (Kim, 2018)

7.7 Dividing Up

As nuclear families age and young adults move out, the prototype house can be divided to create two more units. On all R-zoned lots containing detached, semi-detached, row houses, and duplex, a laneway suite can serve as a third unit. In Toronto, all residential lots are permitted to have up to two units in the main house. These existing two units will still be permitted when a third unit is added as a laneway housing.

Generally, single-family detached homes great flexibility as regards location of the entrance owing to the fact that any perimeter walls can potentially accommodate a door. However, even though the prototype house is a single-detached home, providing access to multiple entrances can be challenging due to spatial limitations. The width of a typical lot in Toronto downtown neighbourhoods is very narrow. When conditions of a minimum setback of 0.45 metres on both sides, and a 0.9 metre-wide clear path of travel for a laneway suite entrance have been met, the remaining buildable width is only 4.3 metres. Thus, the placement of access for the prototype must be devised in a manner similar to that for multi-story and multi-family apartments, where residents are required to pass through common areas like lobbies (Figure 7.27). Since interior partitions are non-load bearing, these walls can be knocked out should the owner wish to convert multiple units into a single unit, or vice versa.

When the prototype is divided into three different units, it will be possible to accommodate more types of households. For example, the original unit on the ground floor is designed with a granny flat in mind. The basement can be used as a guest room or can provide accommodations for a live-in caregiver. The second floor would be more appropriate for a young couple or a family with one child since it is the largest of the three. The third unit on the laneway, which is constructed by relocating the add-on module, is ideal for one-person households (Figure 7.28). Figure 7.29 illustrates an example where one family resides in the prototype housing. Assuming that the family is small and young, bedrooms and workspace are located on the upper two levels whereas the ground level consists of living, dining and kitchen areas. The basement is yet unfinished. Figure 7.30 illustrates a situation where the house is shared by two separate units: unit one includes the finished basement and the ground level, and unit two includes second and third level, where modules on the second floor increase the size of rooms. Lastly, Figure 7.31 demonstrates an example where the prototype house is divided into three separate units. The modules used on the second floors can be relocated on top of the garage in order to create a laneway suite, allowing a small studio unit. Dividing up units is a flexible strategy that not only benefits the owner by providing income from the renting of under-used spaces, but also benefits Toronto neighbourhoods by revitalizing them with an influx of renters who seek a place close to the urban core.

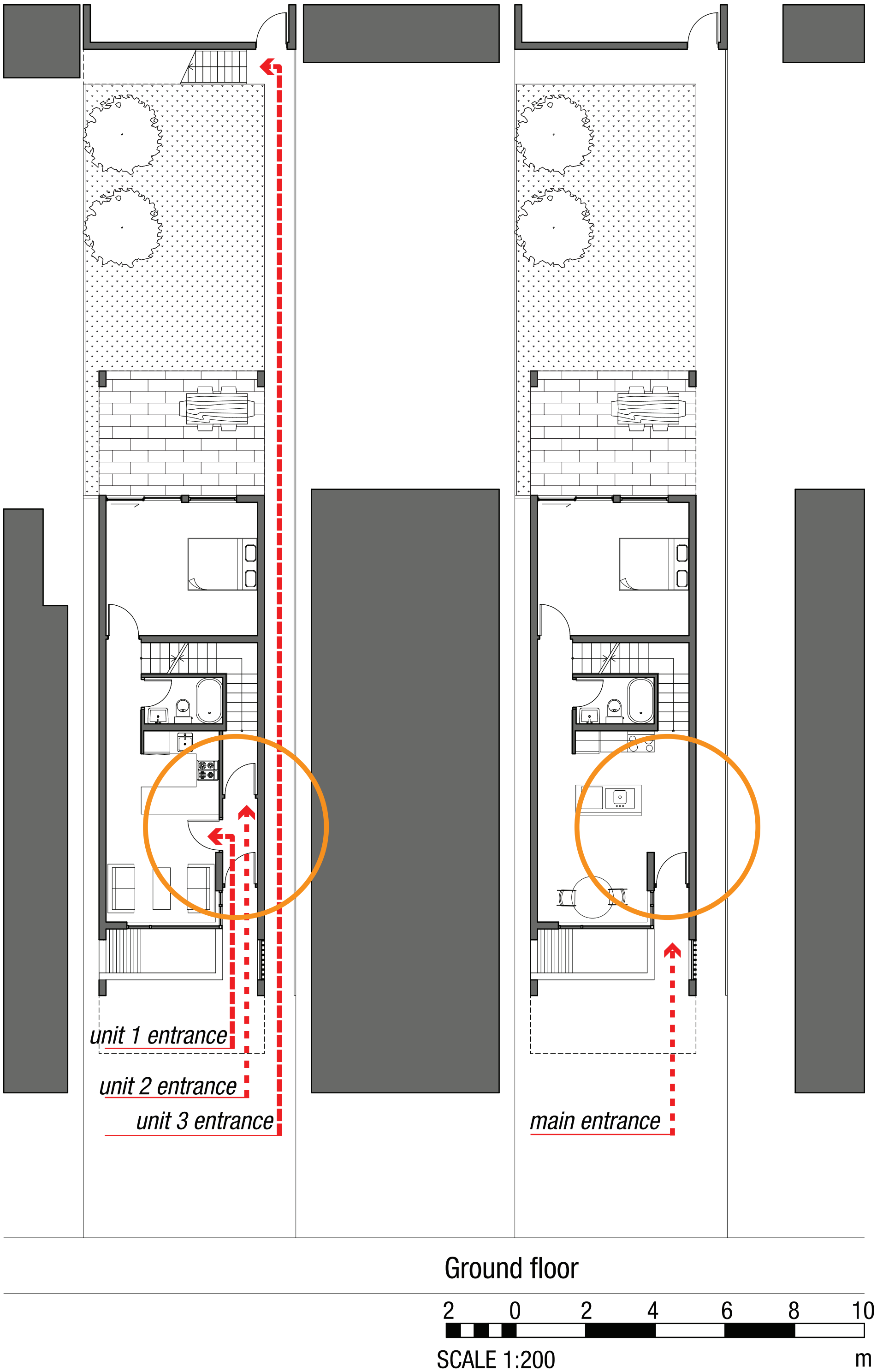


Figure 7.27 Entrances to multi-(*left*) or single-family (*right*) homes (Kim, 2018)

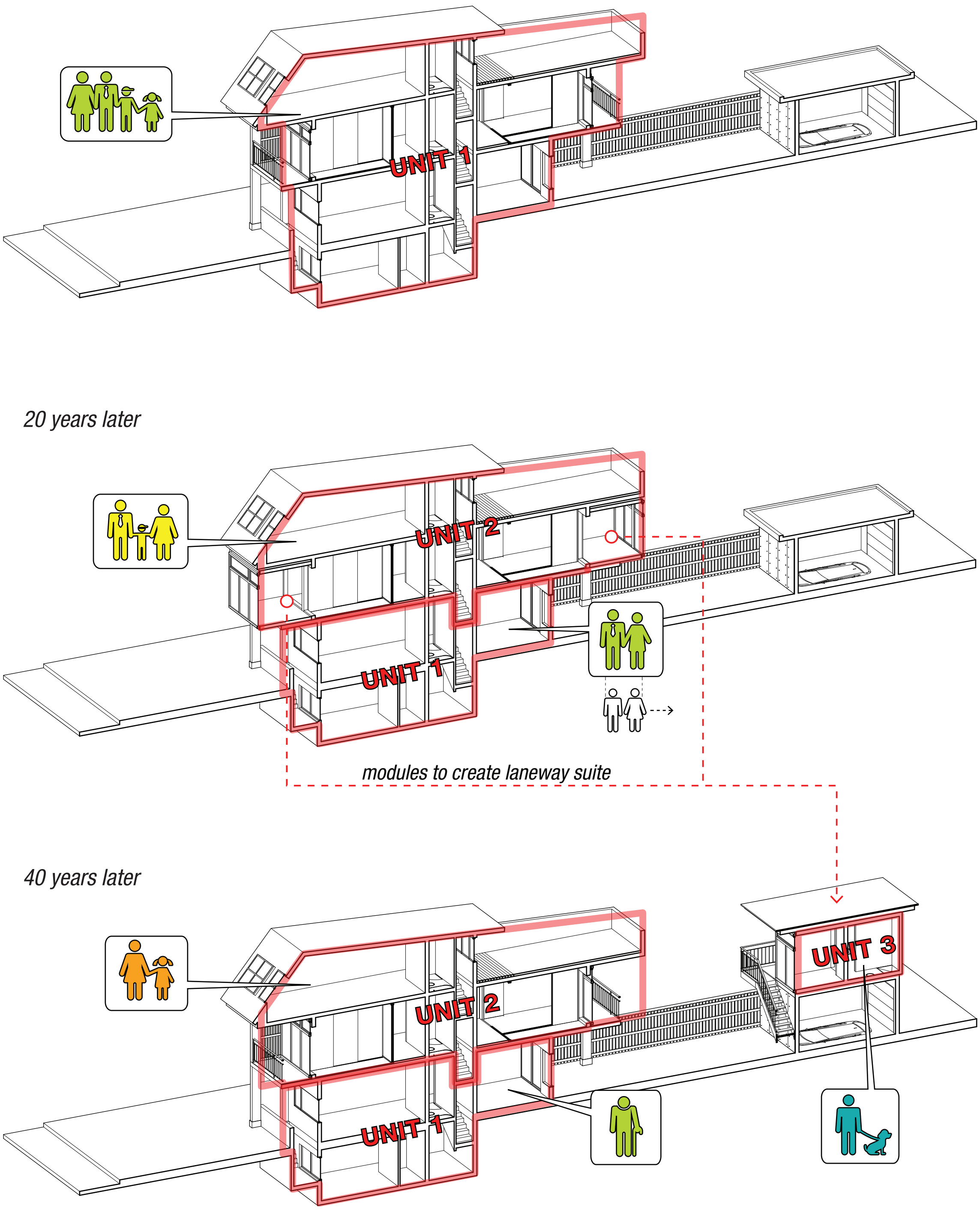


Figure 7.28 Life cycle of flexible housing (Kim, 2018)

Figure 7.29 Potential floor plans for a single unit (Kim, 2018)

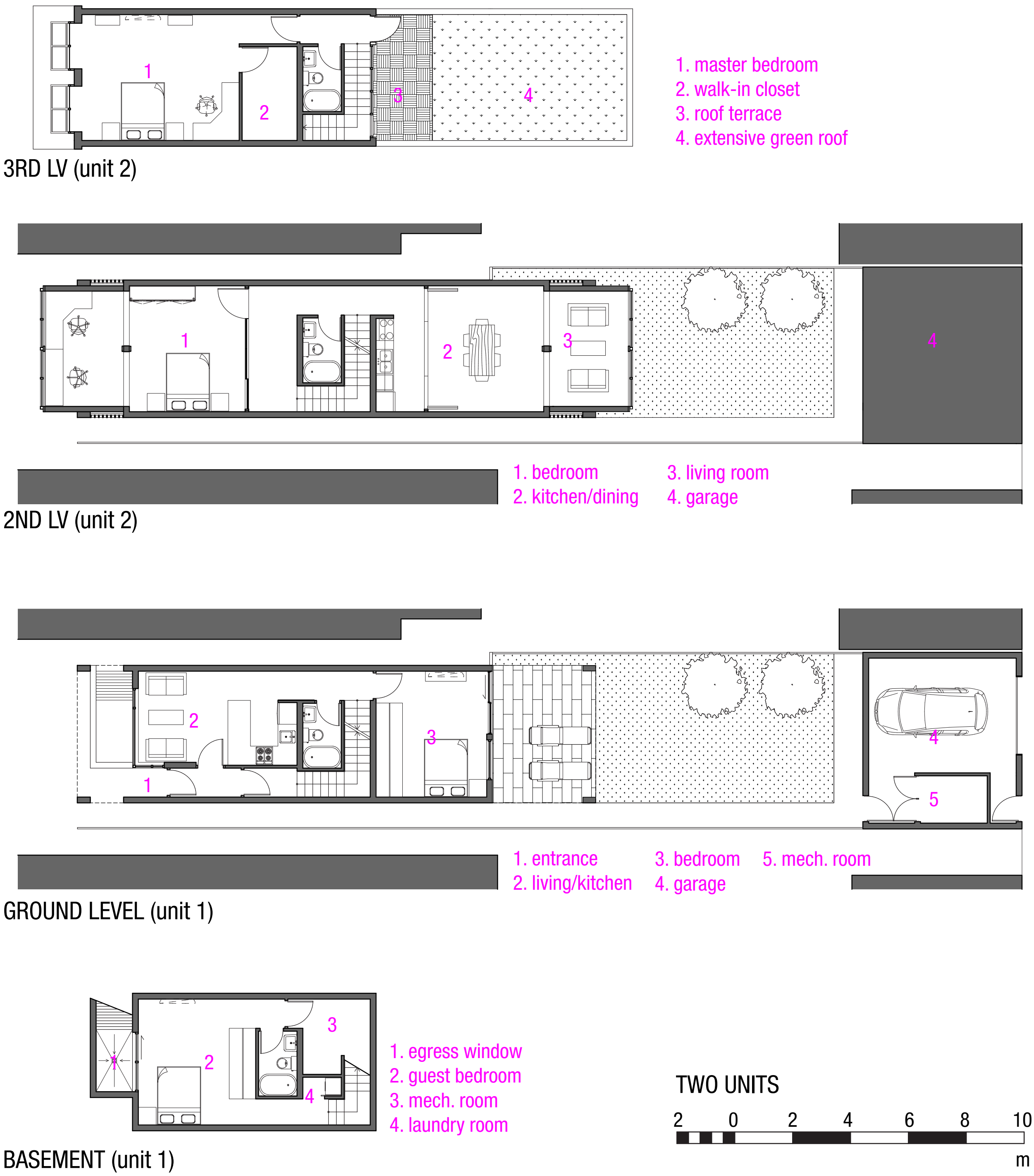


Figure 7.30 Potential floor plans for two units (Kim, 2018)

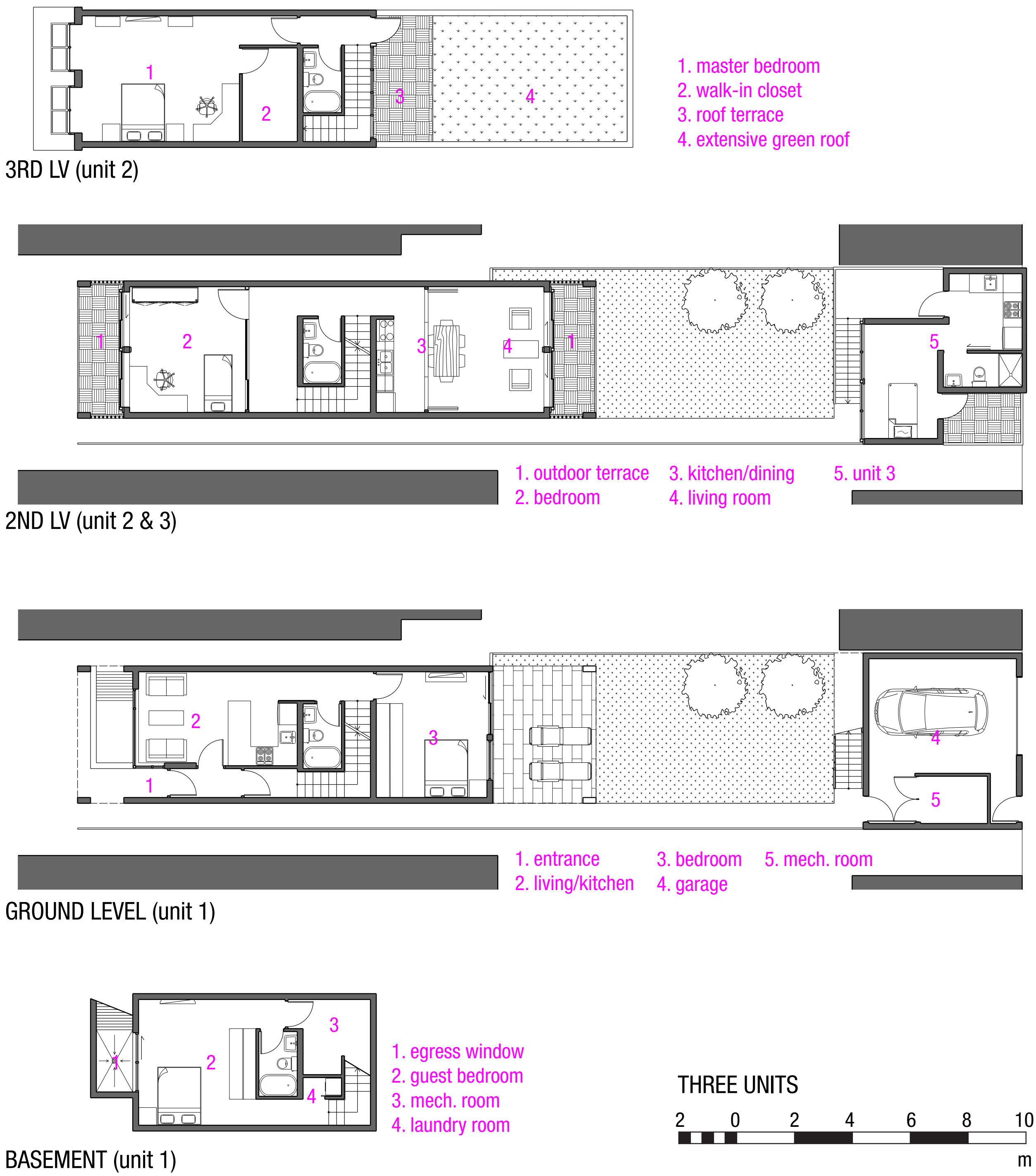


Figure 7.31 Potential floor plans for three units (Kim, 2018)

7.8 Conclusion

The purpose of this thesis is to develop a flexible housing system that will be responsive to the evolving needs and desires of diverse households throughout their life cycles. As discussed in the previous sections, the traditional single-detached home for a nuclear family is no longer a viable response to the housing needs of today. Society is constantly changing and so are the people who are looking for a new home.

This thesis elucidates the socio-economic factors that necessitate a flexible approach in housing, and proposes a prototype for housing that can expand under constraints and within limitations, one that can result in a housing system that could last generations. Numerous projects have experimented with principles and strategies of flexible housing in the past. The core components of this thesis project are not completely new, but have been tested and investigated before. However, many of the previous projects appeared in homes during the post-war period. What this thesis attempts to do is to place these concepts in a contemporary context, and re-invent them to meet the needs of today's society.

8. Appendices

Appendix A: Physical Models

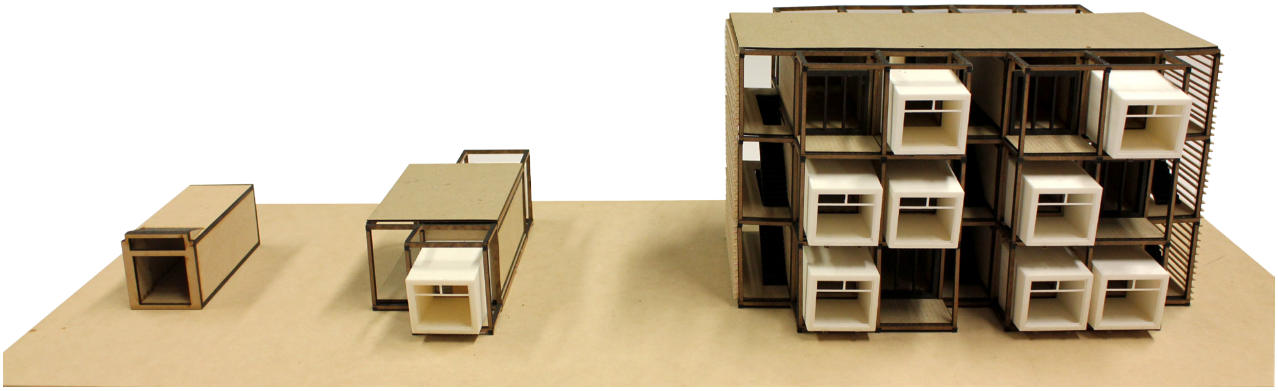


Figure 8.1 Past design iteration 1 (Kim, 2017)

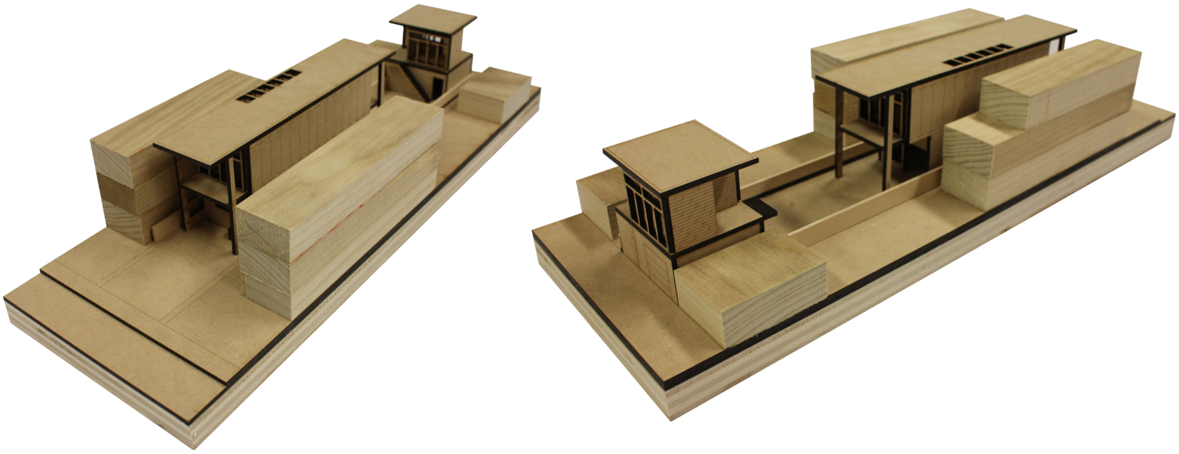


Figure 8.2 Past design iteration 2 (Kim, 2018)

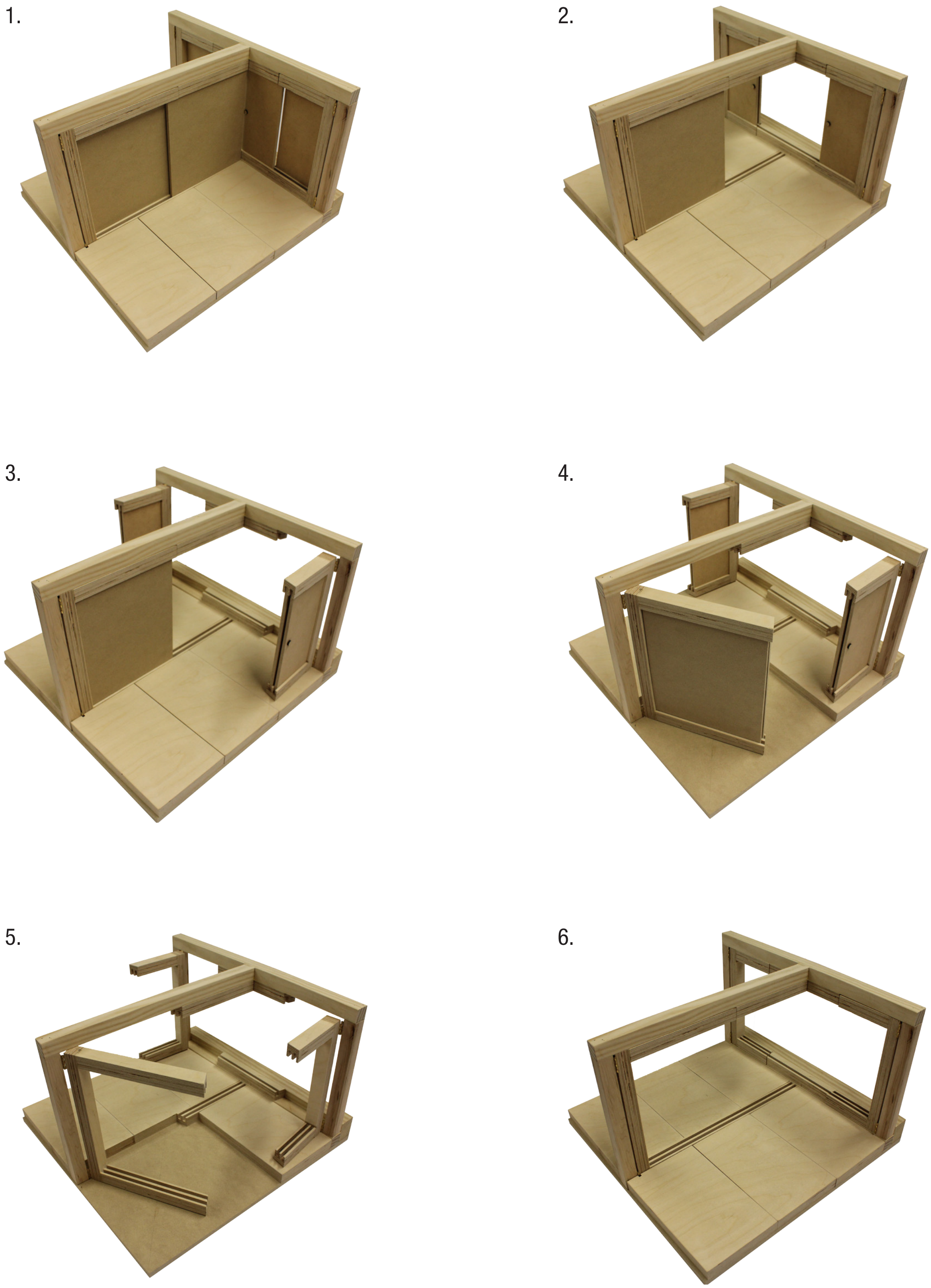


Figure 8.3 Detail model of the new wall system (Kim, 2018)

Appendix B: Past Design Iterations

Previous designs aimed to achieve two goals: to revitalize underutilized spaces and to attain flexibility in housing. The development of modular designs was the main vehicle to achieve flexibility. The initial idea was to create a modular system that allowed units to be added on next to each other or on top of another so that the design grows according to the changing needs and desires of users. However, in an urban context where land value is high and space is extremely limited, the "add-on" approach of modular design was inefficient and inappropriate. Consequently, the current design exploration has become a product of hybrid flexible strategies.

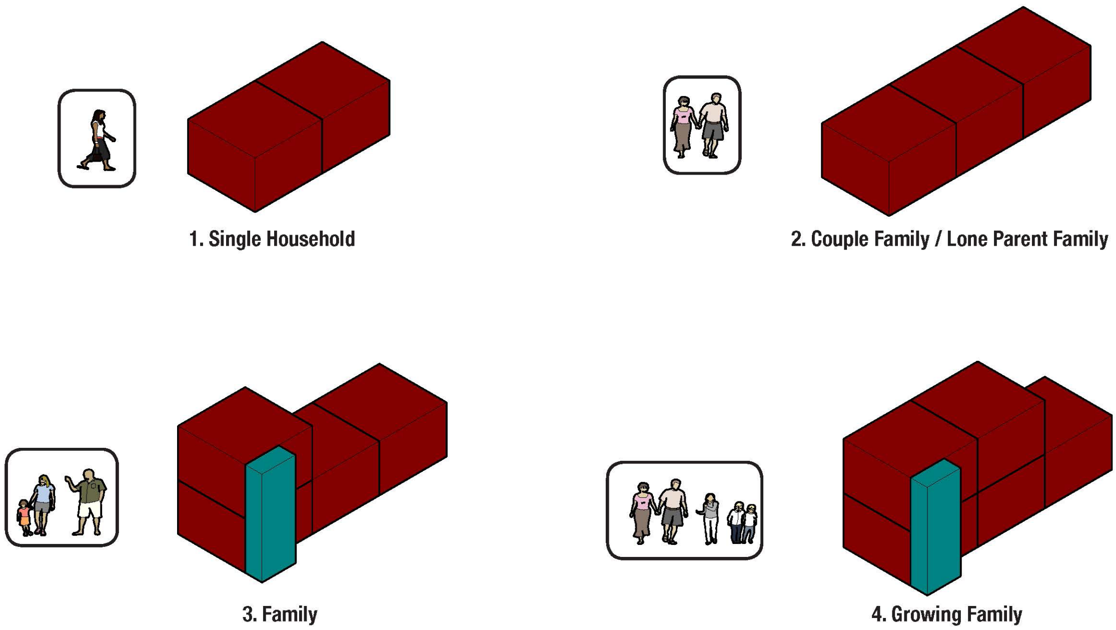


Figure 8.4 Modular development (Kim, 2017)

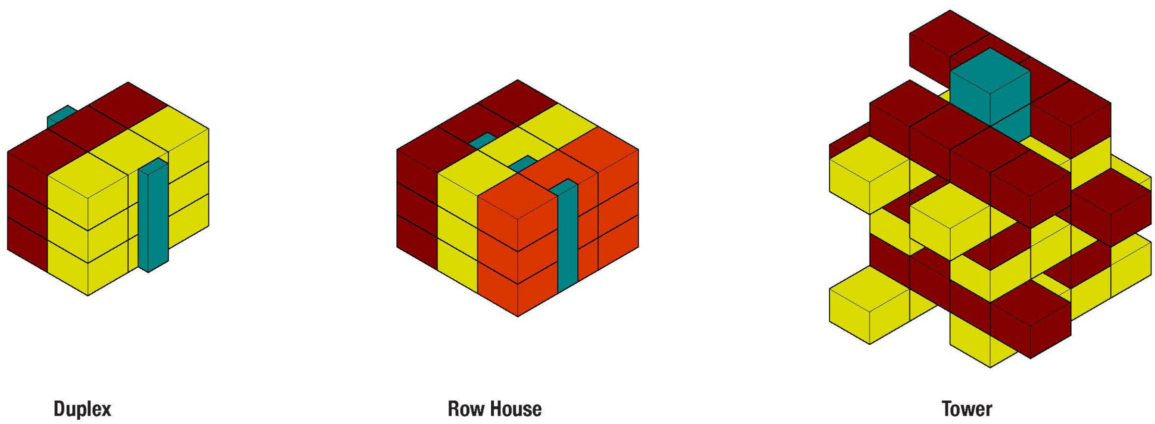


Figure 8.5 Modular building typology (Kim, 2017)

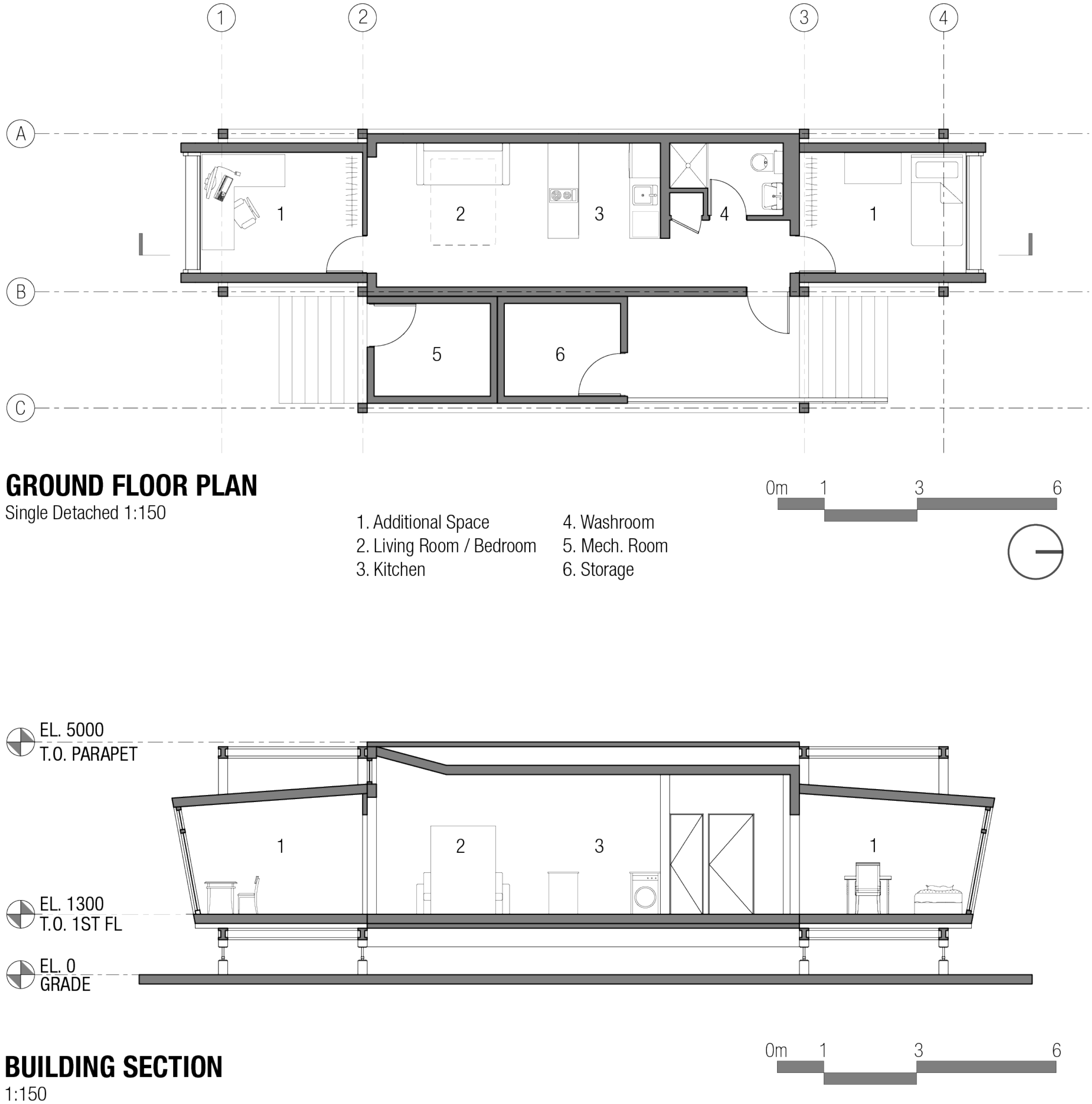
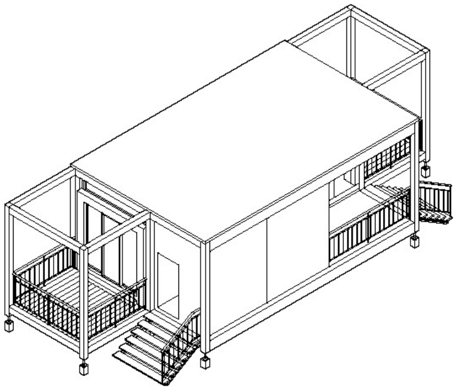
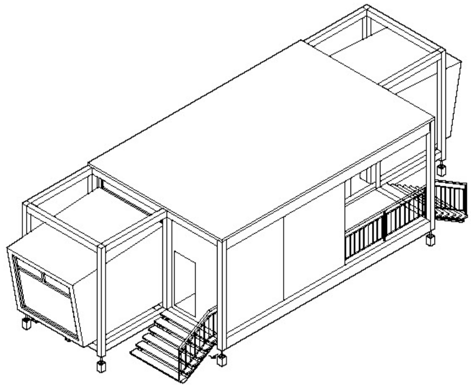


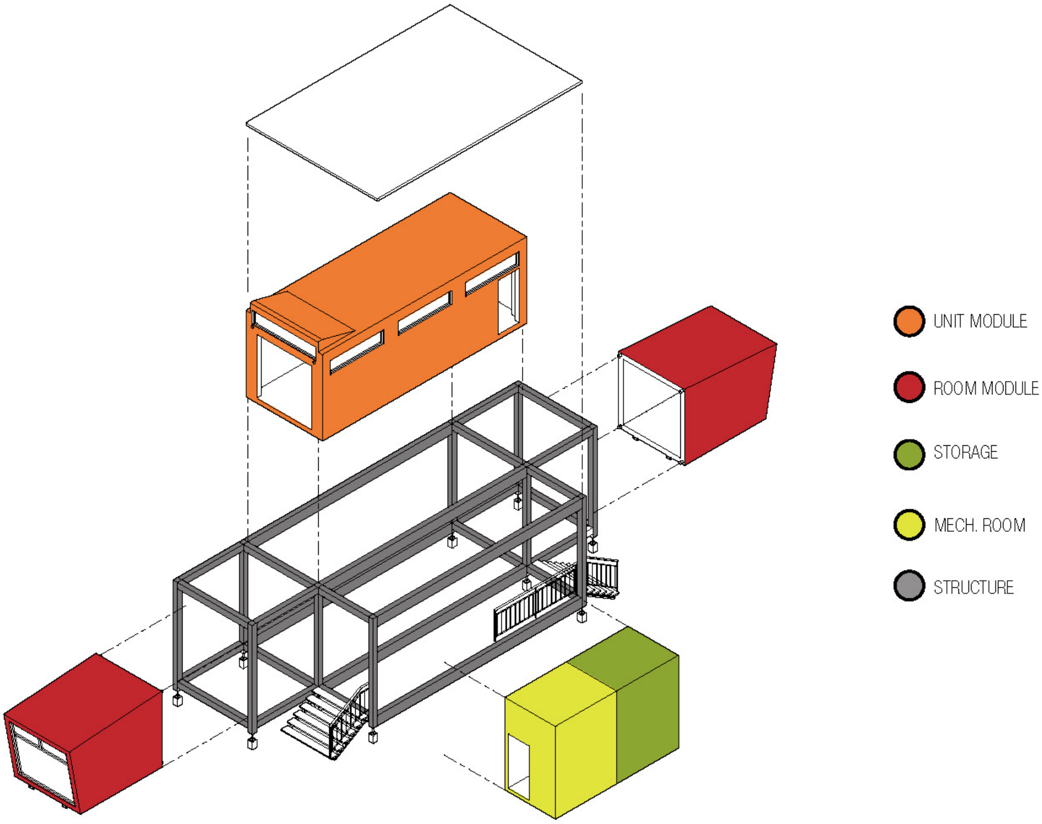
Figure 8.6 Ground floor plan and section of a single unit (Kim, 2017)



BASIC CONFIGURATION
Detached House



BASIC CONFIGURATION
Add-on Expansion



COMPONENTS
Modules and Structure

Figure 8.7 Basic program of a single unit (Kim, 2017)

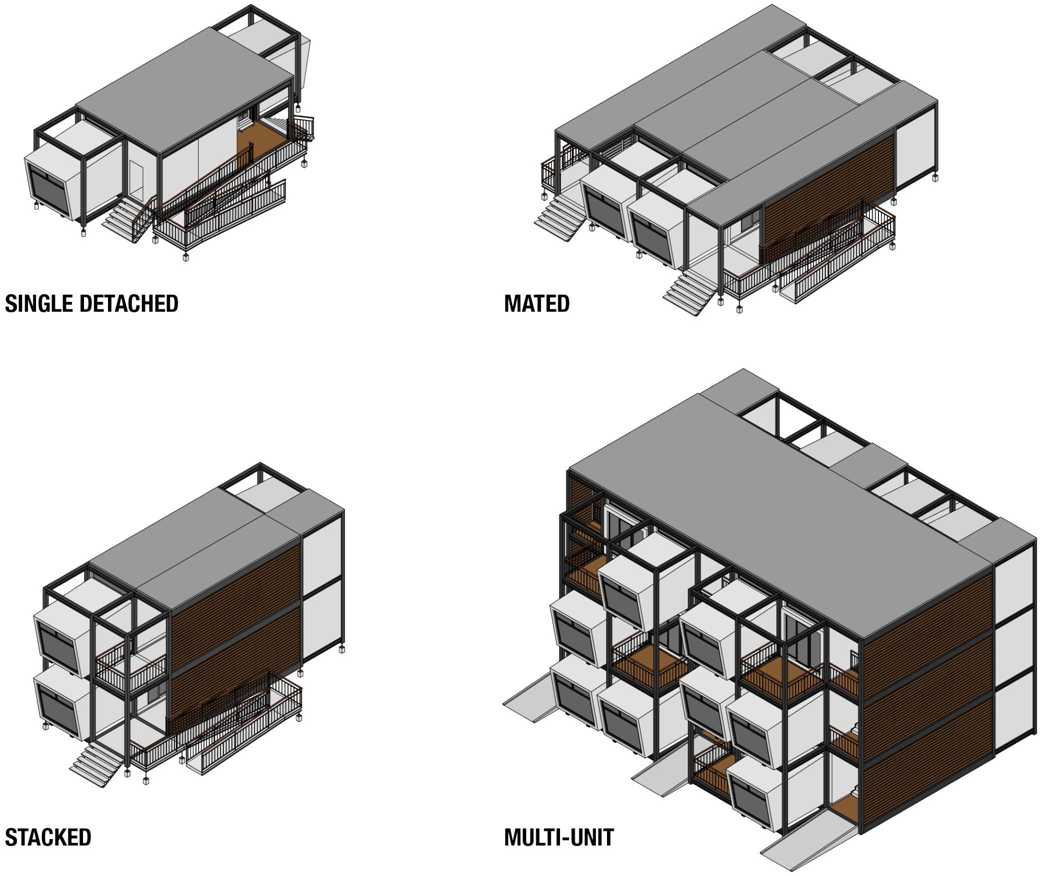


Figure 8.8 Variation of modular combination (Kim, 2017)

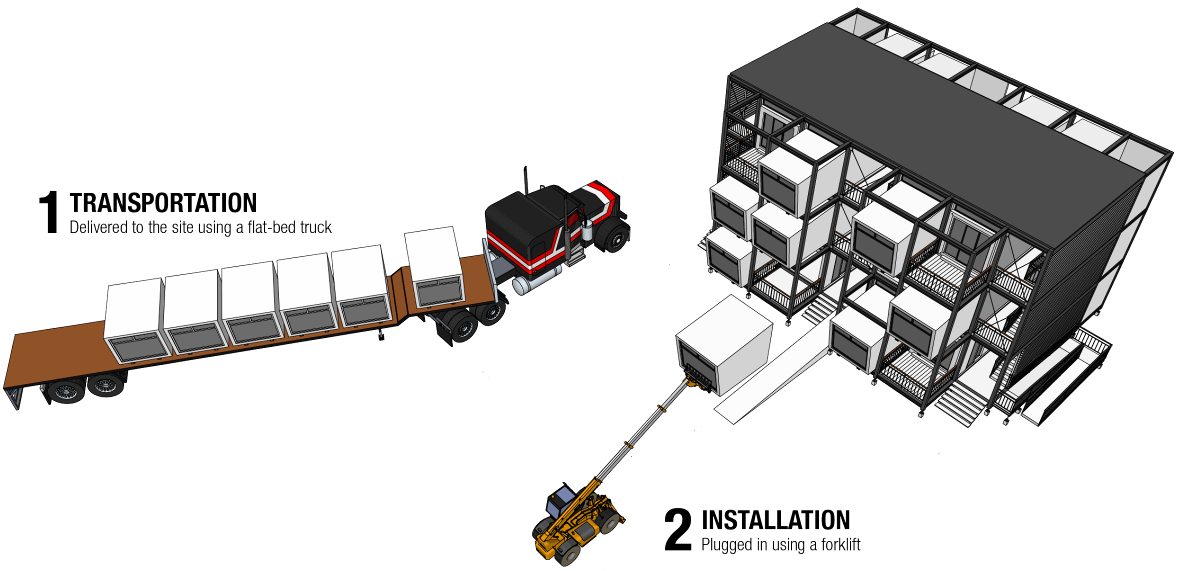
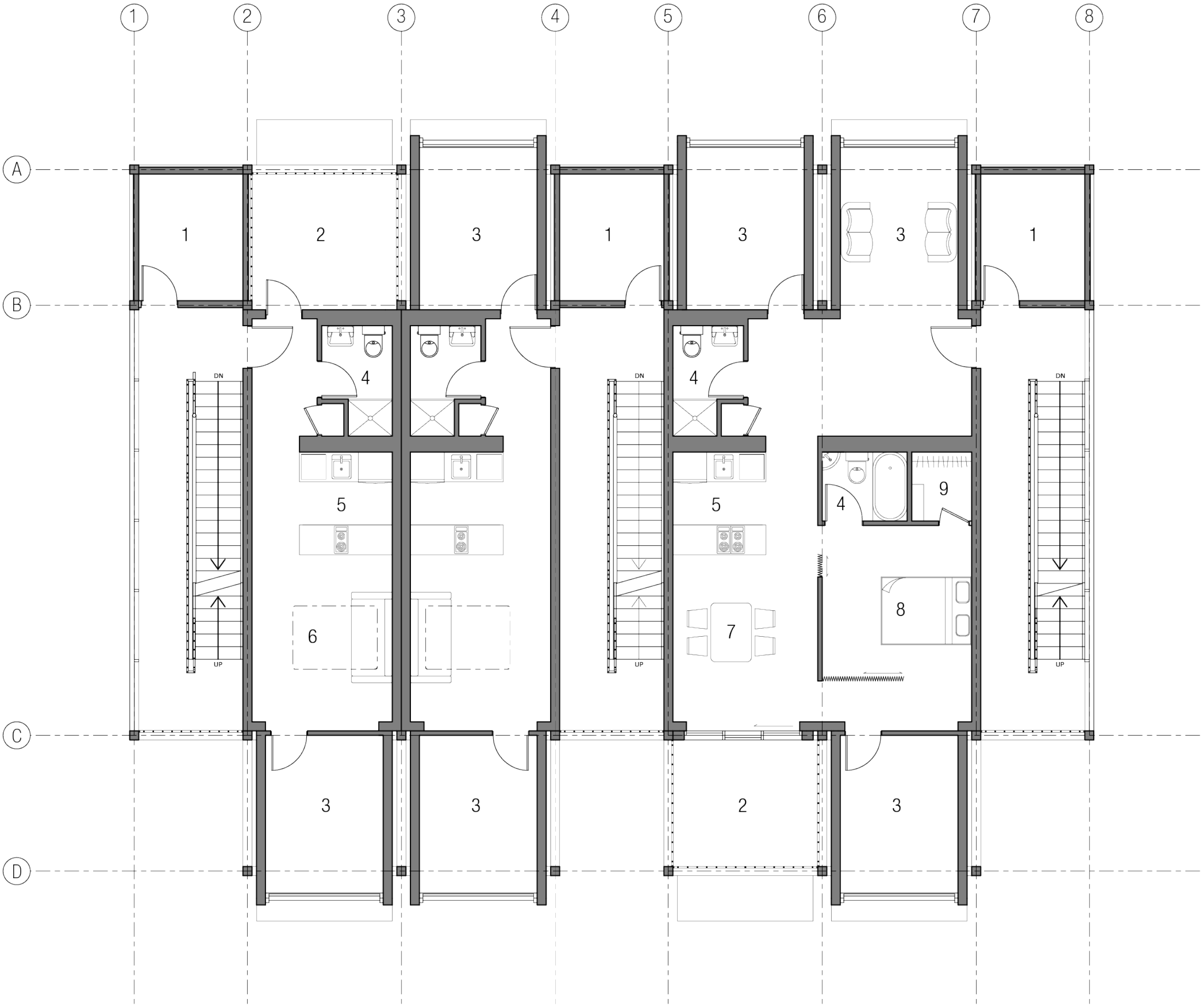


Figure 8.9 Transportation and installation (Kim, 2017)

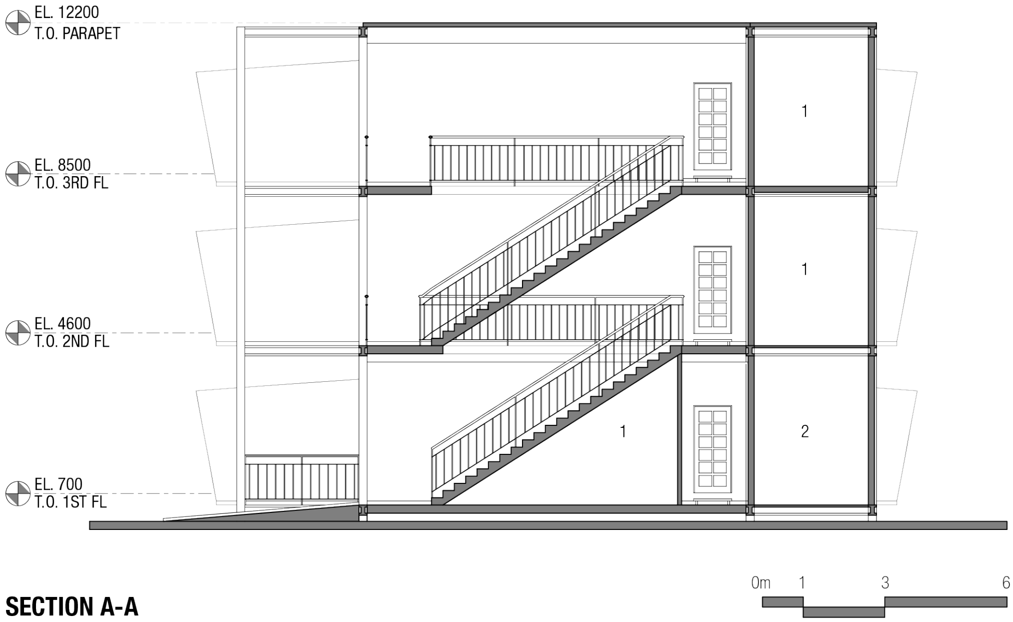


TYPICAL FLOOR PLAN
Multi-unit Residential 1:150

0m 1 3 6

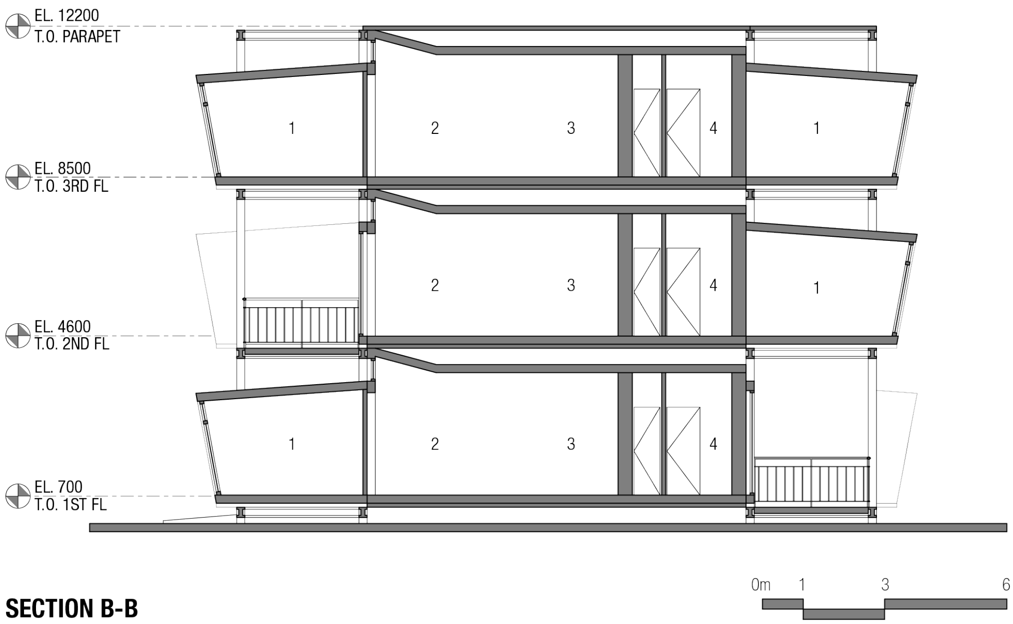
1. Storage
2. Balcony
3. Additional Space
4. Washroom
5. Kitchen
6. Living Room / Bedroom
7. Dining Room
8. Master Bedroom
9. Walk-in Closet

Figure 8.10 Typical floor plan of multi-storey housing (Kim, 2017)



SECTION A-A
Cut through Stairs 1:150

1. Storage
2. Mechanical



SECTION B-B
Cut through Units 1:150

1. Additional Space
2. Living Room / Bedroom
3. Kitchen
4. Washroom

Figure 8.11 Section A-A and B-B of a multi-storey housing (Kim, 2017)

Figure 8.12 Section C-C of a multi-storey housing (Kim, 2018)

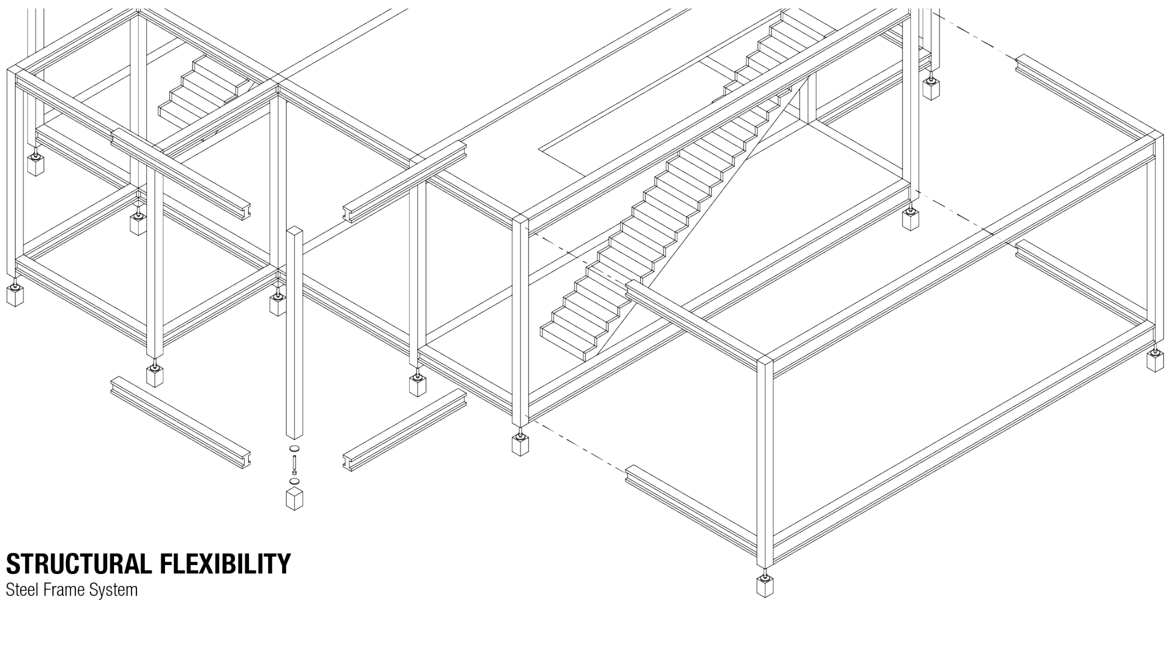


Figure 8.13 Structural flexibility (Kim, 2017)

Figure 8.14 Getaway house (Kim, 2017)

Figure 8.15 Multi-storey housing on tower-in-the-park (Kim, 2017)

Figure 8.16 Single unit modular housing on commercial rooftop (Kim, 2017)

Appendix C: Incremental Housing

Incremental housing is a branch of flexible architecture that supports the notion that housing is not a finished building delivered to the occupants. Instead, it suggests that housing is an ongoing process developed and reinforced by its users. An incremental strategy encourages user participation and increases user responsibility during the design and construction phases. The term "incremental housing" has several other names: self-housing, starter house, phased-development house, and owner-driven house. However, the overarching idea is a step-by-step process in which growth happens over time. Generally, incremental development can be classified into three types of housing provisions: "site and services" providing a lot with access to water, electricity, and sewer; "starter core shelter" including basic essentials such as kitchen, washroom, and a bedroom; and a nearly completed house that leaves some choices for the residents to configure the internal layout and finishes (Figure 8.17). From there, households gradually expand and improve their homes: wall by wall, room by room and floor by floor.

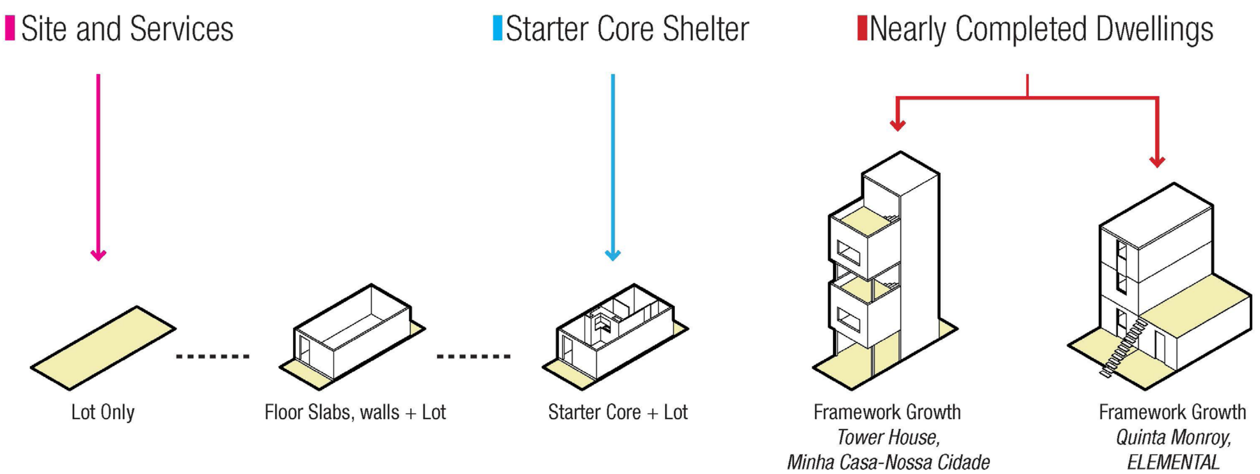


Figure 8.17 Types of incremental growth (Kim, 2017)

Contrary to traditional housing, incremental housing allows owners to control the expansion based on their needs and resources. A modest design that permits progressive expansion and improvements over time has an important role in making homeownership more affordable. A starter core that is appropriately designed offers expansion flexibility while quickly providing shelters to many families. Also, there are a range of options to choose from different types of housing provisions. Unlike the monolithic and banal mass housings that were ubiquitous during the post-war period, housing built based on incremental principles flourishes with individuality. Incremental housing is also beneficial at the scale of a city because it is an efficient method for providing families with housing within the framework of city planning, allowing the government to manage, control and support them. This makes city expansion predictable, and limited funds can be utilized more effectively. The challenge for an architect employing incremental design strategy in an urban context is twofold: first, one needs to translate the strategy according to rigorous planning regulations and codes; second, one is compelled to work within a limited lot where outward growth is difficult.

Appendix D: Perplexity of Prefabrication

Despite the rich history, the 20th century marks an important architectural discourse on prefabricated housing. The promise of prefab captivated both the architectural and commercial industries; it was a failure in the former, and a success in the latter. Pioneers such as Le Corbusier, Frank Lloyd Wright, Buckminster Fuller and Walter Gropius experimented with prefabrication to enhance mass production. With the exception of mobile homes, nearly all the attempts to bring industrialized building system to market have failed. The goal of these architects was to produce "cheap, individual houses for working people," but it was a complete failure as people preferred the traditional image of a house over the Modernistic aesthetics when they were given a choice (Davies, 2005, p. 19). Also, there was a resistance in the profession towards prefabrication because architects found it difficult to agree that their work of art could be produced in a factory. In other words, the loss of authorship and commodification of architecture led architects to lose their interest in prefab. Furthermore, the idea of John Ruskin prevailed in the 20th century, emphasizing that "a morally good building is assumed to be permanent, fixed in one place, architect-designed and unique" (Davies, 2005, pg. 110). Because the prefabricated architecture did not adhere to these parameters, it was considered undesirable. In contrast, non-architectural sectors employing prefabrication technology were successful, including balloon-frame construction, postwar British pre-cast concrete systems, and Sears & Roebuck catalogue houses. For instance, between 1908 and 1940, Sears, Roebuck, and Company sold more than 70,000 prefabricated kit-built homes that was shipped across North America, and some of these homes are still in use owing to durable materials and high craftsmanship (Sylvester, 2009). The non-architectural sector showed that architects' authorship is irrelevant in the popular housing market.

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