Title of the Master Thesis:
The Flexible Housing System in China and Home Working During the Covid-19 Pandemic and Beyond

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Abstract
Nowadays, in the midst of growing population and urbanisation, the housing problem is severe in the Chinese market. This thesis investigates flexible housing combined with the homeworking model appropriate for today's Chinese housing market by studying the concept of flexible housing and the homeworking model, tracing their history, and considering the current situation. Furthermore, this thesis is based on a consideration of the development of the flexible housing system and homeworking in the residential space of the pandemic era and beyond. Keeping up with the times, this thesis employs the case study approach to investigate more flexible, healthy and liveable residences through a graphical and textual analysis of buildings constructed in the last two decades that contain homeworking and the flexible housing system, to contribute to China's real estate industry's sustainable future.

Keywords
Flexible housing, adaptability, flexibility, Chinese market, home working

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Chapter 1 Introduction

Cristiana and Michele Di (2015) discovered in their research that some of the major issues affecting social housing in the last few decades had been the disposal and renovation of these inherited buildings, as well as the risk of technical or functional obsolescence in the short term. The inability to manage the uncertainty of the socioeconomic environment and the various demands arising from the use of various types of social housing makes the housing system imperfect and shortens its lifespan. This implies that the concepts of obsolescence, longevity, and flexibility should be reconsidered during the general design phase. Flexibility is a system feature that ensures the system's life cycle is extended over time.

Schneider and Till (2007) define flexible housing as housing that is adaptable to changing needs and patterns, including social and technological needs. These changing needs may be personal (i.e. expanding households), practical (i.e. beginning to age) or technical (i.e. updating old services). The changing patterns could be demographic (for example, an increase in single-person households), economic (for example, an increase in the rental market) or environmental (i.e. need to update housing to cope with climate change). Although few studies have referred to China in the history of flexible housing development, according to Li (2014), flexible housing is not new in China. On the contrary, its fundamental principles have been practised in traditional architecture since antiquity. Due to a multi-purpose approach, most old buildings have similar forms and indeterminate spaces that can be used flexibly in various ways. During the pandemic era, home working has re-emerged as a popular way of working, with most companies choosing to work from home for the safety of their employees, not only to slow the spread of the pandemic but also to ensure that their business is carried out properly.

This thesis contends that the flexible housing system is a crucial consideration in housing design if housing is to meet the spatial quality requirements needed to work from home during the pandemic or other particular scenarios (such as the nature of work, caring for family, and flexible employment), particularly in China, a country with a large population and a flexible housing market that is currently immature and has many development opportunities. According to Schneider and Till (2007), adaptability and flexibility are characteristics of flexible housing. It is worth noting that, despite many attempts in terms of policy and users to embrace flexible housing, flexibility in housing design has never been fully adopted, and even fewer designs consider home working space within flexible housing. The tendency to design buildings that only correspond to a particular type of household at a specific time or buildings that only meet the requirements of the current market reflects a mindset based on short-term economics.

According to Chung et al. (2020), flexible jobs at home increased dramatically during the Covid-19 embargo period. Data show that many people will continue to work at home even after the Covid-19 embargo ends. Mason, Carter, and Tagg (2011) discovered that the house could be an awkward and inflexible workplace because there

is not enough space to accommodate the competing work and family life demands. The expected flexibility and control over time are frequently not realized. However, the number of people working from home has continued to grow. House design and layout may become essential criteria for many people in the near future when selecting appropriate housing. This thesis argues that, given the uncertainty of future occupational and housing needs, people should learn to think in the long term. While it is argued that flexibility and excellent home-based working space come at a financial cost, the long-term economic calculations, such as higher user ratings of the homes, reduced occupant volatility, and the ability to respond quickly to changes in the needs or desires of existing or potential residents and the market, can offset the additional investment upfront. This capability is especially crucial for users, developers, and the social housing sector because excellent home working space combined with flexible housing provides residents with more options than standard housing and can efficiently deal with various situations (e.g. pandemics, changes in nature of work, etc.).

This thesis uses two primary research methods: literature review and case study. First, the literature review of the flexible housing and home working model is conducted in order to screen out relevant literature for context, characteristics and related debate. This procedure is firstly universal (global) and then targeted (China). Second, the case study chapter contains a collection of ten architectural cases involving the combination of the flexible housing and home working model, with simple plan redrawing and axonometric analysis drawings. The graphic and textual analysis are used to summarise and derive a design approach for flexible housing with a home working model applicable to today's Chinese housing market.

Chapter 2 Literature Review of Flexible Housing System

This chapter summarises the evolution of the flexible housing system by examining the literature on flexible housing over a nearly two-decade period. It begins with an introduction to the history of flexible housing, then describes its core and properties, and concludes with a summary of the debate before moving on to the development of flexible housing in China.

2.1 Background

The evolution of flexible housing can be divided into three main stages.

2.1.1 Origin Stage

Throughout the twentieth century, flexible housing has been the centre of attention: it has been at the forefront of housing discussions. At others, it has been a pool of stagnant water for ardent enthusiasts. The difficulty in presenting a 'history' of flexible housing is indicative of the history of housing in general.

Schneider and Till (2007) claim that the first stage occurred in the 1920s. Following WWI, European countries faced unprecedented demand for urban housing. The old urban housing could no longer meet the needs for economy and density. Most European

countries' legislation has focused on lowering space standards and implementing social housing schemes to provide sufficient dwellings at the lowest possible cost.

Because of the drop in space standards and new construction methods, architects have created designs that allow for flexible use so that the new minimum standards do not restrict users. This was the origin stage when flexible housing became active.

2.1.2 Industrialisation Stage

If social and economic forces drove the first stage of flexible housing, technological influences, particularly the adoption of industrial housing supply solutions, drove the second stage.

The belief that prefabricated components and emerging technologies can and should provide solutions for mass housing is the second factor driving the development of flexible housing, which began in the 1930s and 1940s and continues to this day. It was assumed that industrial prefabrication and systematisation of buildings and their components would include flexibility. (Schneider and Till 2007)

Since the 1920s, there have been many precedents for house customisation, such as Baukasten and Gropius' Copper house. These precedents, however, provide too slight variation for the user or do not involve the user in the design process; in other words, the homes are not customised by the user.

2.1.3 User involvement Stage

According to Schneider and Till (2007), the third stage of flexible housing development occurred in the 1960s and 1970s. During this stage, a significant shift toward user participation sparked renewed interest in flexible housing to provide user choice. At the time, it was clear that flexible housing was most effective at meeting natural and pressing needs.

Improvements in building materials enabled an increasing number of residents to purchase unfinished spaces with partitions and participate in the configuration of their own houses by the end of the twentieth century, at a time of rapid change in residential culture and practice. (Friedman and Krawitz 1998)

2.2 Core

The core concept of flexible housing is housing that can withstand the volatility of a home. This is accomplished through adaptability, flexibility, or both. The two terms are sometimes used interchangeably or to describe the same thing. The most apparent distinction is that adaptability is 'the ability to have different social uses' and flexibility is 'the ability to have different physical arrangements'. (Schneider and Till 2007)

One Sustainable Development Goals (SDG) is about sustainable cities and communities. According to Estaji (2017), developing system flexibility and adaptability is one of the

most important ways to achieve sustainability. Flexible housing meets this expectation.

2.2.1 Adaptability

As Schneider and Till (2007) stated, adaptability is achieved by designing rooms or units so that they can be used in multiple ways, primarily through room organisation, circulation patterns and room design. Adaptability encompasses 'multi-use', a term frequently used by Dutch architects and theorists to describe spaces that can be used in various ways, often without requiring physical change.

Adaptability expresses the change in the occupants' living conditions over time, but the response to this situation is rigid.

2.2.2 Flexibility

Adaptability in flexible housing is based on use issues, whereas flexibility concerns form and technology. (Figure 1)

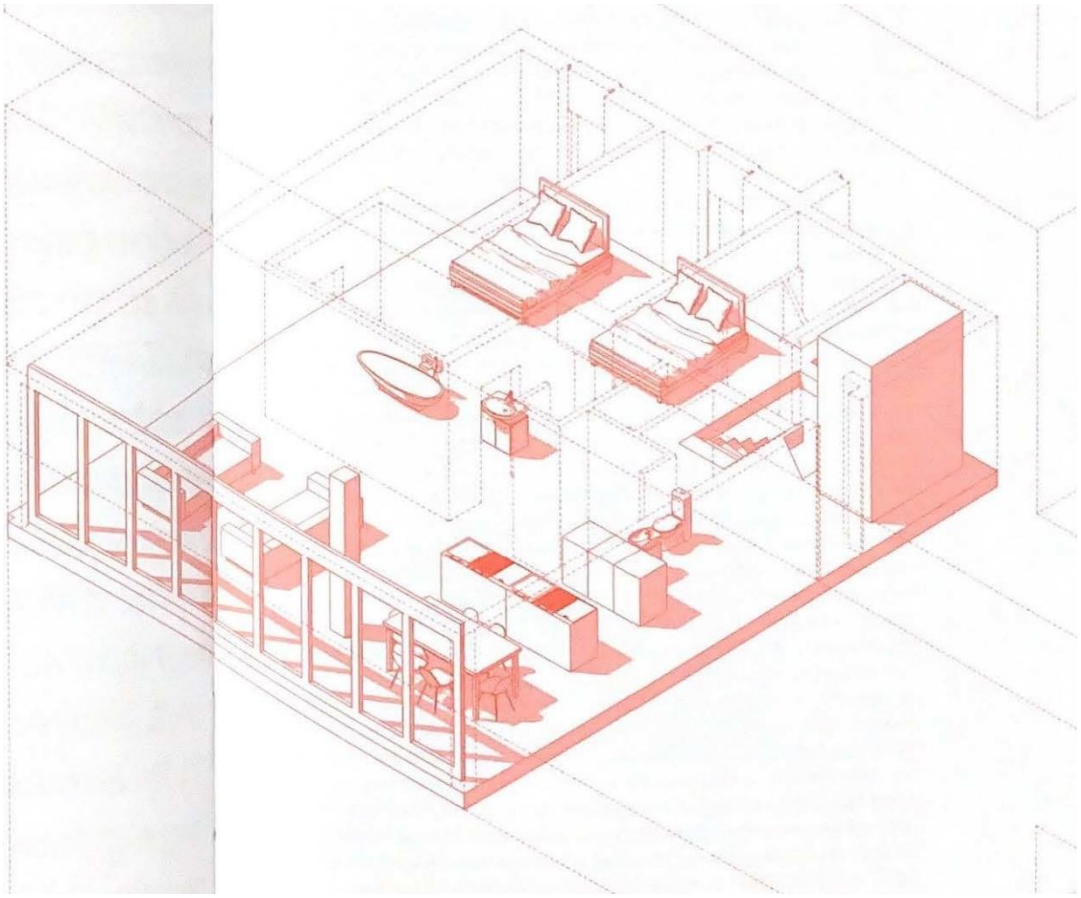


Figure 1. The wall makes flexibility, from Caviar (2015).

Emphasizing the diversity of human activities and the wide range of time spent in the house, Estaji (2017) stresses the need for flexibility in housing design. Any changes in the occupants of a house will affect spatial requirements, but the problem is that these changes cannot be predicted and controlled; for example, household size and family structure will change over time without any fixed pattern. Only a flexible system (the

house) can cope with predictable and unpredictable changes. Residential design flexibility is not new, but it has yet to reach its full potential in the residential market. The builder's or developer's limited options and customization demonstrate flexibility. (Yu 2011)

According to De Paris and Lopes (2018), the economic, technological and cultural transformations in human society today affect all aspects of everyday life. In the case of housing, these transformations include changes in the family nucleus and activities in the living space. Housing flexibility aims to meet the multiple needs of users by changing their living areas and functions. Although housing flexibility has been discussed in the past, it is still under constant study. Recently, many architects worldwide have started to use the concept of flexible housing for their clients. Through the concept of flexible housing, designers offer flexibility to the home while the client customises the functional use of the rooms they want.

Schneider and Till (2007) define flexibility as changing the building structure, such as joining rooms or units, extending them, or sliding or folding walls and furniture. Thus, flexibility applies to internal and external changes, to temporary changes (through the ability to slide walls or doors) and permanent changes (by moving interior partitions or exterior walls).

As populations congregate in cities and available land is depleted, housing flexibility becomes an essential component of the transformation of our daily lives. The flexibility of housing, associated with various typologies, offers the possibility of spatial or structural transformation of buildings to meet users' needs and adapt to technological, cultural and economic changes that occur over time. The two most important factors influencing spatial flexibility are awareness and funding. The connection between these two factors is notable, as a lack of understanding of the benefits of flexibility can lead to their use of financial resources. Surprisingly, the client, user, architect and owner are equally weighted in the decision. (De Paris and Lopes 2018)

Schneider and Till (2007) point out that flexibility can be developed in two ways. The first is a result of the development conditions for vernacular architecture. The second is the result of external pressures on housing designers and suppliers to develop alternative design solutions, such as flexibility, as discussed later. According to Cristiana and Michele Di (2015), flexibility is achieved by selecting morphological structures and techniques that allow building components to be reversed and interchanged.

Flexibility is essential to incorporate into contemporary housing prototypes to accommodate the wide range of family types. This flexibility must be reflected in all aspects of the housing typology, and such flexible housing must take into account (1) the composition of different households in a single structure, (2) the components available, and (3) the ability to make future changes with minimal inconvenience.

Furthermore, potential users' financial insecurity must not be overlooked; affordability should be improved through a multifaceted approach that allows potential homeowners to implement flexible concepts that serve their current financial situation while allowing for future expansion and modification when possible. (Friedman and Krawitz 1998)

According to Cristiana and Michele Di (2015), to incorporate the concept of flexibility in housing design, the four domains that comprise the design process must be considered: (1) the user domain, as determined by an examination of functional and psychological needs and their evolution over time; (2) the functional domain, which translates needs into design requirements (flexibility, maintainability, reversibility, and so on); (3) the physical domain, which is linked to the spatial and technical design options that satisfy the functional domain; and (4) the programmatic domain, which adapts housing requirements through design(for different users, for the needs of customised housing), linking it to the rediscovery of low-cost building systems and local materials, as well as local professionals collaboration.

Estaji (2017) suggests that one aspect of sustainable development is flexibility. Building construction and operation use a lot of energy and materials. Sustainable buildings are intended to reduce material and energy consumption. Significant energy and material savings can be realised if a building not only serves its current purpose but also meets some future requirements. As a result, the most difficult challenge for buildings is rapidly changing needs and requirements. Buildings must have a flexible structure and spatial configuration in order to respond to rapidly changing conditions. The house's flexibility can be adapted to the user's current needs as well as future conditions, saving the user money and correspondingly reducing material losses when compared to an inflexible house. The building components' flexibility is achieved through prefabricated technology, which also has a positive impact on sustainable development.

2.3 Property

At the turn of the twentieth century, increased technological capacity and rising housing demand fuelled interest in standardising housing production. In response to the post-World War I housing crisis, architects began to design homes that could be mass-produced using industrial prefabrication. Modularity and customisation entered the picture during this time period. These two factors are also the primary charateristics of flexible housing.

2.3.1 Modularity

Modularity and modular systems have been utilised as appropriate solutions for designing and implementing flexible spaces. Meanwhile, employing modular design principles effectively achieves flexibility in product diversity to meet various services and prevent complexity while creating multiple combinations of spaces. (Garip, Sağlar Onay, and Garip 2021)

Modularity, according to Silva and Campos (2019), is an exciting concept because of

its effectiveness. This working method has numerous advantages, beginning with the design stage and continuing through construction. It is becoming a more popular topic for research, development and application. Modular systems have proven to be very effective when used correctly. Careful planning is essential, and it ultimately translates into optimising the time spent on the project and its execution, lowering costs through problem prevention and waste of raw materials. The modular architecture concept is both efficient and appealing. (Ferdous et al. 2019)

Modular construction, compared to traditional construction, provides faster and safer fabrication, more accurate and predictable completion times, superior quality, fewer workers on site, less waste of resources and a more environmentally friendly process. It is also becoming more prevalent in multi-story buildings. Despite the benefits of modular construction, the private sector continues to rely heavily on traditional on-site construction methods. Modular construction is more advantageous than traditional building methods. However, modular construction is not widely used today, and this may necessitate a concerted effort from all sectors of society, including government, businesses and design firms. (Figure 2)

(a) (b)

Figure 2. Modular buildings with: (a) self-supporting load-bearing modules; and (b) frame-supported modules. From Ferdous et al. (2019).

Because of their low cost, environmental friendliness and safety, modern modular building systems are becoming increasingly popular around the world. Furthermore, they have a bright future in providing comfortable, environmentally friendly housing and responding to the United Nations' call for sustainable development. They are a powerful force in human society's healthy and harmonious development. Moreover, according to Wang and Tsavdaridis (2022), modular building construction is thriving as it continues to assist many cities around the world in dealing with the current housing crisis and the critical need for medical facilities during the pandemic.

Despite the advantages of modular construction, its adoption in the construction industry has been slower than anticipated (Ferdous et al. 2019). The development and production of a flexible housing system can be investigated in terms of the relationship

between contractors and suppliers, which is governed by both demand and supply; additionally, the diversity of customer needs, the extent of supplier investment and the intentions of suppliers and buyers can all have an impact on the development and production of flexible housing systems. The market's impetus is critical to the development of flexible housing.

In general, modular architecture is a product of its time, responding to global development. Modularity will become a widely used methodology in the future, so it must be to studies and justified.

2.3.2 Customization

Wang (2018) defines mass customization as 'the efficiency of mass production of personalized products on a large scale without losing money'. Furthermore, mass customization is viewed as a path to housing sustainability, addressing environmental concerns while improving user satisfaction and well-being (Jimenez-Moreno 2021). Mass customization has emerged as a business model in the last 20 years, but it is still a new area for the housing industry. (Wang 2018)

Mass customization refers to the ability to provide individuals with customized products or services at a scale, cost or efficiency comparable to mass production. (Jimenez-Moreno 2021)

The third industrial revolution will arrive on time by 2050, bringing dramatic changes in architecture practice and itself. Just as the first industrial revolution of the nineteenth century mechanised our manual labour and the second industrial revolution of the twentieth century saw assembly lines replace fixed buildings, the third industrial revolution will usher in a shift in mass production and consumption over the next 100 years. The economy is currently shifting toward mass customisation. 3D printing, laser cutting, and CNC manufacturing of consumer goods, buildings parts, and even entire facilities have been made possible by digital-based technologies have enabled. (Fisher 2015)

In general, mass customization is a solution that provides products and services that are tailored to the specific needs of each customer in terms of product characteristics, with the operation taking place within a fixed solution space characterized by a stable but still flexible and responsive customisation process, and does not imply a shift in the high-end market segment. In practice, however, mass customisation is complex because it requires the customer's(the end-user) involvement in the production process, implying production and manufacturing delays based on customer orders. Mass customisation increases profits for developers, provides high-quality living spaces for customers and provides dynamism for the market.

2.3.3 Advantage and Disadvantage

Housing construction costs are continuing to rise, according to Hakim and Endangsih

(2021), and efforts to reduce the cost of building special housing are a hot topic today. Using fabricated modular construction systems is one technique for rapidly constructing one-of-a-kind houses.

Flexible space is used as a solution for social housing, a space shortage problem that architects frequently face, depending on the scale of the inhabitants and the aspects of human life. The inhabitants' needs are being met by flexible housing. In other words, it adapts to the changing needs of its residents and promises adaptability to their living conditions. This spatial adaptability replaces spatial hierarchy and improves life quality. The primary goal of spatial organisation is to plan an interior space in order to create functional efficiency in the layout of the home. Furthermore, flexible housing allows residents to participate in the design of their homes and organise their living spaces according to their lifestyles and needs, resulting in the creation of new and temporary spaces throughout the day and night. (Hosseini Raviz et al. 2015)

Friedman and Krawitz (1998) discuss and contextualise a wide range of architectural configurations for flexible housing: the increased density created by aligned buildings contributes to a more vibrant public realm and a more organised streetscape, expanding the viability of commercial and office uses for ground floor units and lively semi-public and public open spaces. However, one of the common drawbacks of this situation is the homogeneity and repetition of development, and avoiding this drawback necessitates the provision of a diverse appearance. The concept of flexibility is extended to the character by introducing mixed-activity neighbourhoods. According to Friedman and Krawitz (1998), the principles of flexible, affordable and sustainable design are an enthusiastic response to the urgent need to adapt to a wide range of contemporary user and household types while extending affordability to a larger population.

Housing flexibility is based on extending the life of the building (avoiding obsolescence) and practising sustainable consumption in accordance with recycling and waste management. As a result of their flexibility, buildings can be used for a long time using adaptations that ensure continued use. (De Paris and Lopes 2018)

Overall, flexible housing allows residents to participate in the design process, resulting in an appropriate spatial environment for the duration of their lives. Flexible housing emphasises that advanced architecture is expressed not only through form but also by carefully combining function and usability into the home's layout to accommodate its residents' changing needs over time.

2.4 Debate

2.4.1 Mass Customization

Kieran and Timberlake (2003) investigate mass customisation by first reflecting on how Henry Ford built automobiles in the early twentieth century and why this concept was not pursued in architecture and construction. The concept of mass customisation offers the opportunity to reduce construction costs, have more choice, more customisation and

higher quality in design. Mass customisation, while not a panacea, represents a fundamental shift in architecture and construction. Unlike Henry Ford, who did not believe that 'one size fits all' would work for all designs, projects, locations and clients, Kieran and Timberlake (2003)'s explorations demonstrate the driving force behind the development of flexible housing at the time.

Furthermore, Kieran and Timberlake (2003) present case studies of off-site construction, which, while requiring staff training in assembly techniques, saves money and time compared to traditional construction and is no longer limited by space (if some construction sites such as toilets are too narrow to accommodate much stuff at once). Kieran and Timberlake (2003) attempt to make the production of buildings similar to the production of automobiles, aeroplanes and so on. Despite their compelling arguments for how this should be done, construction is always tricky. This is because architecture is distinguished by its details, unlike cars and planes. Architecture components or systems can be prefabricated and mass-produced. Still, different methods of designing materials and facades for architecture can lead to more aesthetic appeal. It is excessively complex and diverse. The transition from mass-produced, prefabricated components to mass customisation is also the foundation for the growth of flexibility in flexible housing.

2.4.2 Residential Open Building

Residential Open Building, according to Kendall and Teicher (2000), is a new multidisciplinary approach to the design, financing, construction, renovation and long-term management of residential buildings, including mixed-use structures. Its goals include the creation of diverse, fine-grained and sustainable environments that increase individual choice and responsibility. Vernacular architecture has influenced the development of residential open buildings, which has also played an essential role in the development of flexible housing. Thus, residential open building and flexible housing are related in some way.

The evolution of the open building can be traced back to a reinterpretation of vernacular architecture tradition. The rationalisation process and strategy of delineating controlled boundaries in open building extend a practice that may be as old as the built environment. Similarly, element-based structure construction and closure, as well as separation of the infill structure from the foundation structure before the interior renovation, have practical implications, especially in harsh climatic conditions. Builders learned long ago to make infill layers unique, versatile and less durable, wherever this was done without compromising structural performance or the underlying social understanding embodied in the building type because most vernacular architecture types have seen extensive use over their lifetimes. (Kendall et al., 2000)

The term ‘open building’ refers to a variety of distinct but related ideas about the creation of the environment (Table 1).

Environment Making Idea	Example
Distinct levels of intervention in the built environment	'Support' and 'Infill', or urban design and architecture
Users/ inhabitants may make design decisions as well	The house buyers/ renters infill the house according to their needs or rearrange them to respond to changes
Designing is a process with multiple participants also, including different kinds of professionals	
The interface between technical systems allows the replacement of one system with another performing the same function	Different fit-out systems applied in a given base building
The built environment is in constant transformation, and change must be recognized and understood	
The built environment is the product of an ongoing, never-ending design process, in which the environment transforms part by part	

Table 1. From Estaji (2017): Open Building ideas about the making of the environment (Based on Habraken)

Urban design, architecture, interior design, product design and production, contracting and construction management, finance and development, public housing institutions, facilities management, supporters of sustainable development, construction management, finance and development, public housing institutions, facilities management, and supporters of sustainable development are among the categories that can benefit from the open building.

The ability to provide for changing needs, including eventual tenant turnover and future sales, increases the long-term value of the open building, which has some links to the adaptability and flexibility of flexible housing. Furthermore, open buildings responded to the post-WWII demand for large-scale housing, similar to the origins of the initial phase of flexible housing (which responded to the need for housing after WWI).

2.5 Housing Development in China

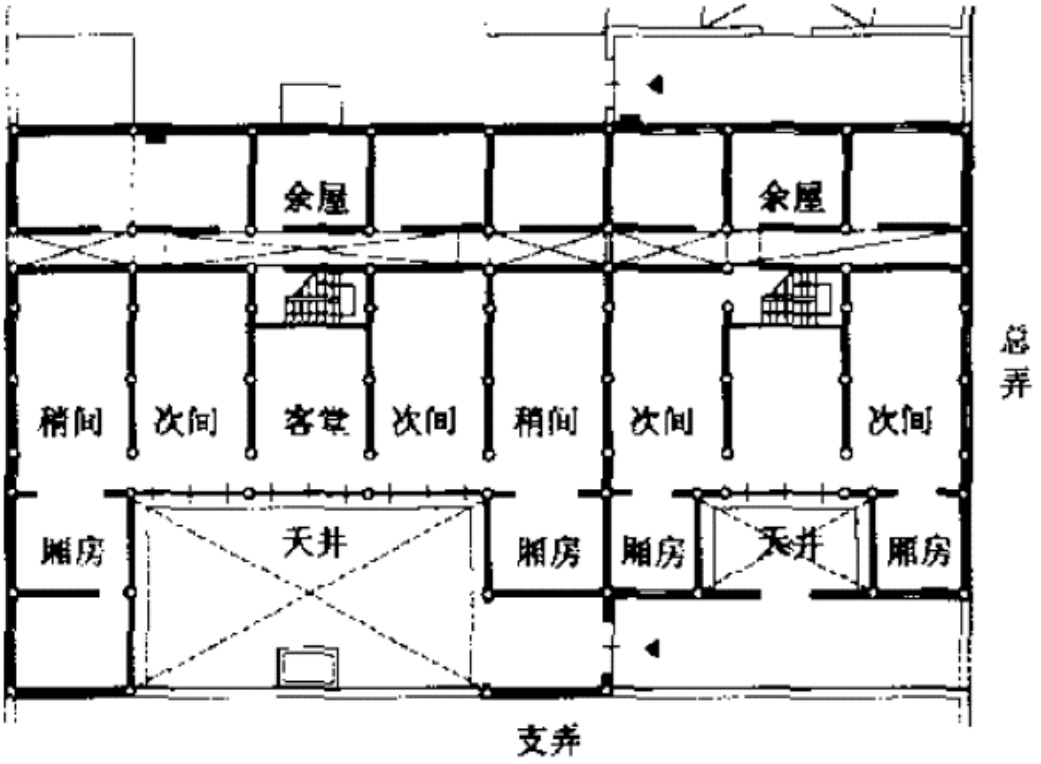
From two perspectives, Lü, Rowe, and Zhang (2001) summarise the development of China's residential history over the last 160 years. The two perspectives are the significant historical stages of residential building development in China and the shifts that have influenced the type of dwelling. According to their summary, there are three primary stages in the development of Chinese residential history as follows.

2.5.1 Housing Development in Early Modern Cities (1840-1948)

This was a critical period in the transition from a feudal to modern democratic society. During this period of political, economic, and social change, a slew of new urban activities was launched, and contemporary urban housing emerged in cities as a result. In terms of investment and construction methods, layout and architectural forms, building structure, and technology, these urban dwellings differed from traditional Chinese dwellings.

In terms of housing types, on the one hand, the housing built during this period is represented by the Shikumen lane houses of Shanghai (Figure 3 and Figure 4) and the northern courtyard lanes (Figure 5), while on the other hand, various Western housing types were introduced to Chinese cities during this period. Western housing was introduced to Chinese cities via two main channels: first, the Western-style townhouses, flats and garden houses, which first appeared in the concessions of the opening cities and spread to other cities; and second, the Russian and Japanese style townhouses, flats and verandahs, which were built in pieces with the construction of railway annexes in north-eastern China (Figure 6). The rapid advancement of construction technology is reflected in the improvement of houses' interiors, the use of new materials and construction techniques, and in particular, the increase in storeys and the emergence of high-rise houses.

In terms of a housing construction organisation, in addition to real estate developers investing in various types of housing of varying quality and size for rent and sale, there are factories and enterprises building housing for their employees and workers, as well as city governments intervening in various ways in housing construction in response to various urban housing problems.



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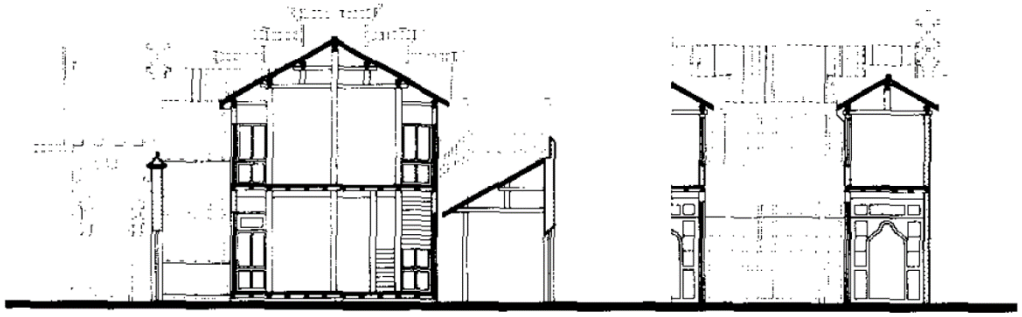


(b)

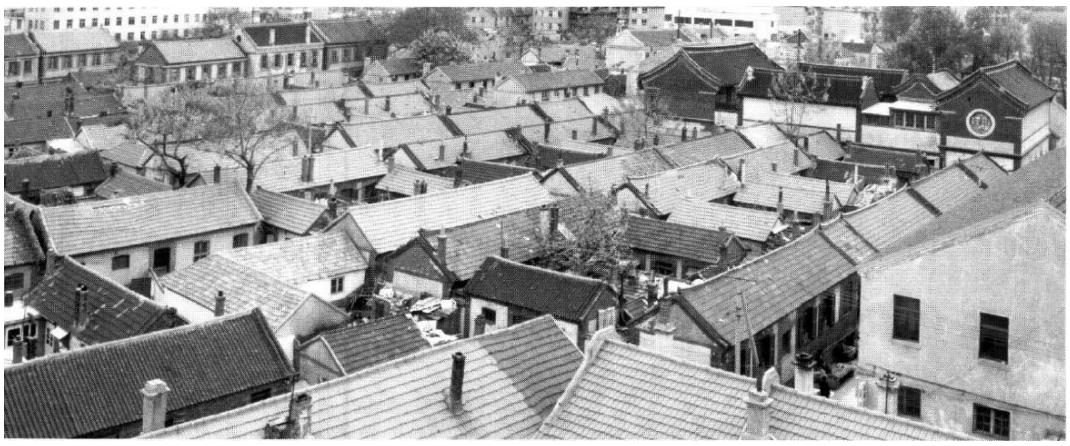
Figure 3. Plan (a) and section (b) of a typical old Shikumen lane. From Lü, Rowe, and Zhang (2001).

Ground Floor First Floor Second Floor

(a)

(b)

Figure 4. Plan (a) and section (b) of A typical new style Shikumen lane: Meilanfang, Shanghai. From Lü, Rowe, and Zhang (2001).



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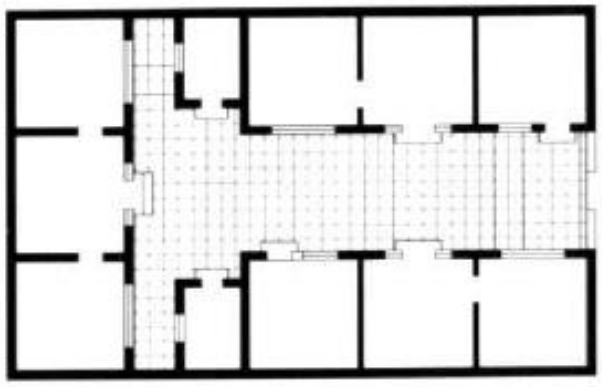


(b)

Figure 5. Aerial view (a) and ground floor plan (b) of a northern courtyard lane house (brick and timber construction). From Lü, Rowe, and Zhang (2001).1

(a)

(b)

(c)

(d)

Figure 6.
Exterior of townhouses in different styles:
(a) Verdun Gardens, Shanghai;
(b) Shanghai Siming Village;
(c) Tianjin Racecourse Villa;
(d) Dalian Gorgie Road Townhouse.
From Lü, Rowe, and Zhang (2001).

2.5.2 Housing Development During the Socialist Planned Economy (1949-1978)

During this period, China prioritised the development of heavy industry and adopted a policy of high accumulation and low consumption via a planned economy in order to ensure the ongoing, substantial investment and resources required for the development of heavy industry, and on this basis, a dualistic socio-economic structure of urban and rural China, as well as a series of systems of urban wages, welfare and household registration. Because the level of urban housing in this period was kept at a low standard for policy reasons, the primary goal of residential planning and design was to control the cost and standard of housing. The government widely promoted standard housing design to control costs and develop urban housing quickly. Even though residential industrialisation has been a development goal for cities during this period, the overall level of residential industrialisation has been low due to the constraints of the overall economic and industrial development, as well as a lack of policy guidance and financial promotion. The majority of industrialised housing built during these three decades was low-tech brick and mortar structures.

The goal of this period in terms of housing type was primarily to address the extreme housing shortage by constructing semi-temporary clusters of low-rise row houses or dormitory-style buildings in emerging cities and industrial areas on the outskirts of cities. During this time, in addition to row-type settlements, neighbourhood units were also used in residential planning (Figure 7). Residential buildings from this era are mostly made of brick and brick concrete, with wooden roof frames and prefabricated floor slabs.

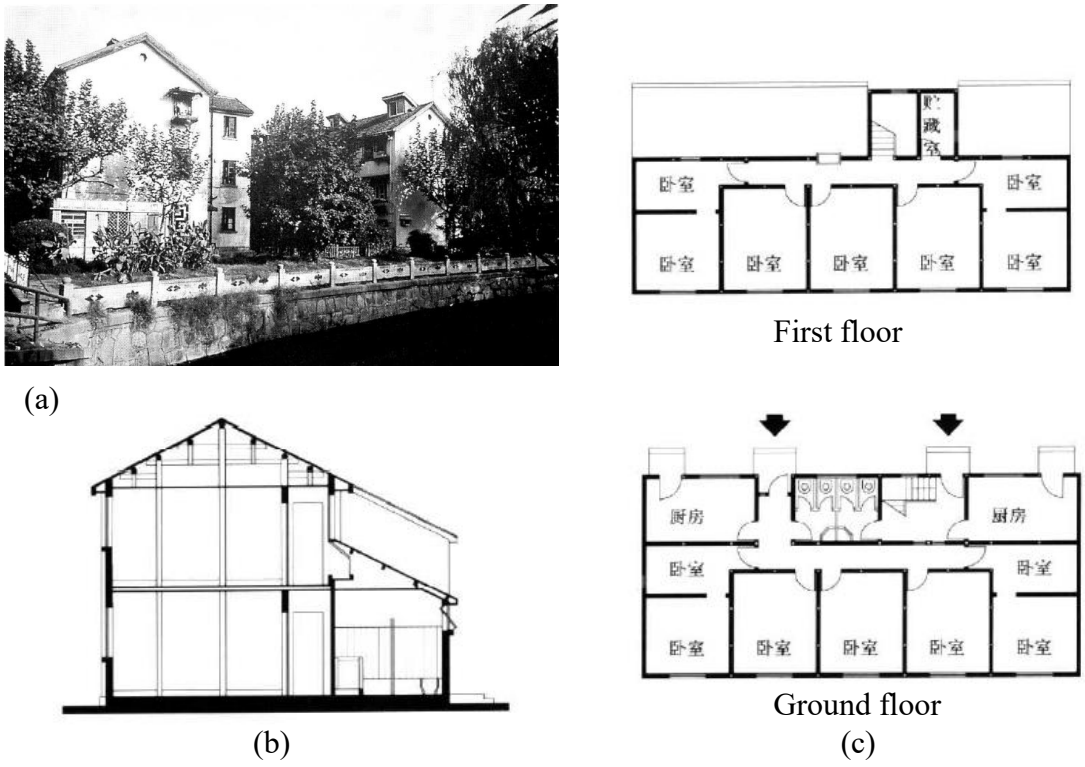


Figure 7. Perspective view (a), Section (b) and plans (c) of Shanghai Cao Yang Xin Cun Residence. From Lü, Rowe, and Zhang (2001).

In terms of the organisation of residential construction, the simplest and most cost-effective designs, primarily one-storey, were used for new dwellings, as the construction goal was to build quickly and accommodate as many families as possible with limited funds. Furthermore, many cities upgraded slums with urban infrastructure and environmental improvements. Standard housing design methods were also introduced from the Soviet Union, but because their standards differed so significantly from the actual standard of living in China, the Chinese government modified them as needed to account for the realities. As housing standards fell and reflections on the phenomenon of shared housing began to emerge, the idea of single-family houses started to be implemented. Thus the outer corridor house was born (Figure 8). The Chinese government proposed a policy of protecting arable land and developing urban construction into the air in the early 1970s, as the growing conflict between the urban population and land made the issue of land conservation increasingly important. Some major cities, such as Beijing and Shanghai, began constructing high-rise residential buildings (Figure 9).

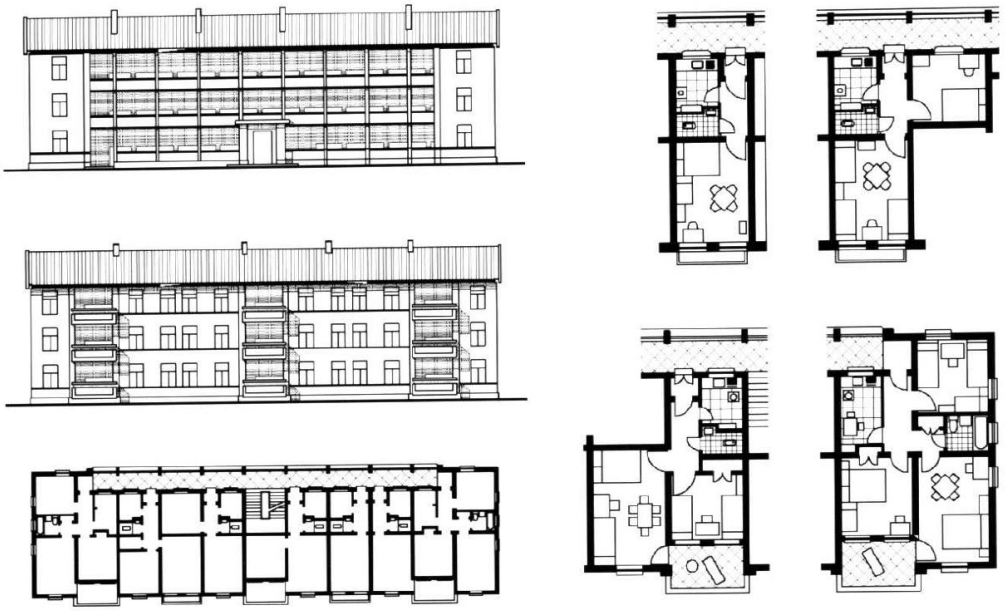
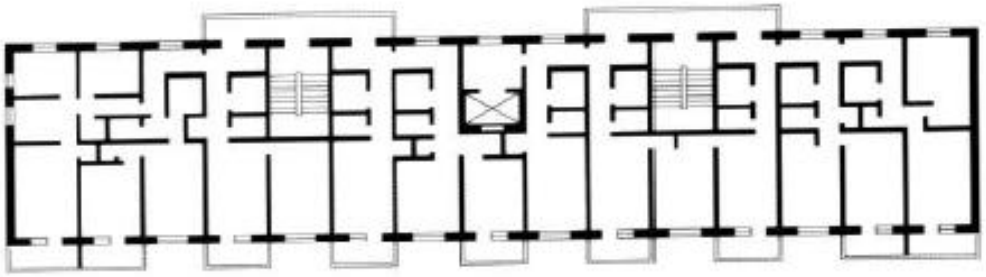


Figure 8. Beijing Happiness Village Small Area Exterior Porch House. From Lü, Rowe, and Zhang (2001).

(a)



(b)

Figure 9. Perspective view (a) and standard floor plan (b) Beijing Qian San Men High Rise Residence. From Lü, Rowe, and Zhang (2001).

2.5.3 Housing Development Since the 22 Years of Reform and Opening Up (1979-2000)

At the start of this period, residential construction was geared toward quantity and alleviating the extreme housing shortage. Large-scale residential construction also encouraged research into improving the living environment and diversifying housing forms. Some architectural schools, in particular, were very active in theory and practice, contributing to the overall level of residential design at the time.

In terms of the housing construction organisation, high-rise housing was rapidly developing due to its advantages in terms of land saving, which suited the realities of China at the time. At the same time, architects were considering increasing the depth of the dwelling to save the land and increase the number of storeys. Residential design became more focused on changes in family structure during this period, as people's demands for quality of life increased. Furthermore, the outdoor living environment, home amenities, and design diversity were highlighted. Based on the previous period's further development of the standardisation and diversity of dwellings, the field of residential design in China began to investigate adaptability and flexibility (Figure 10).

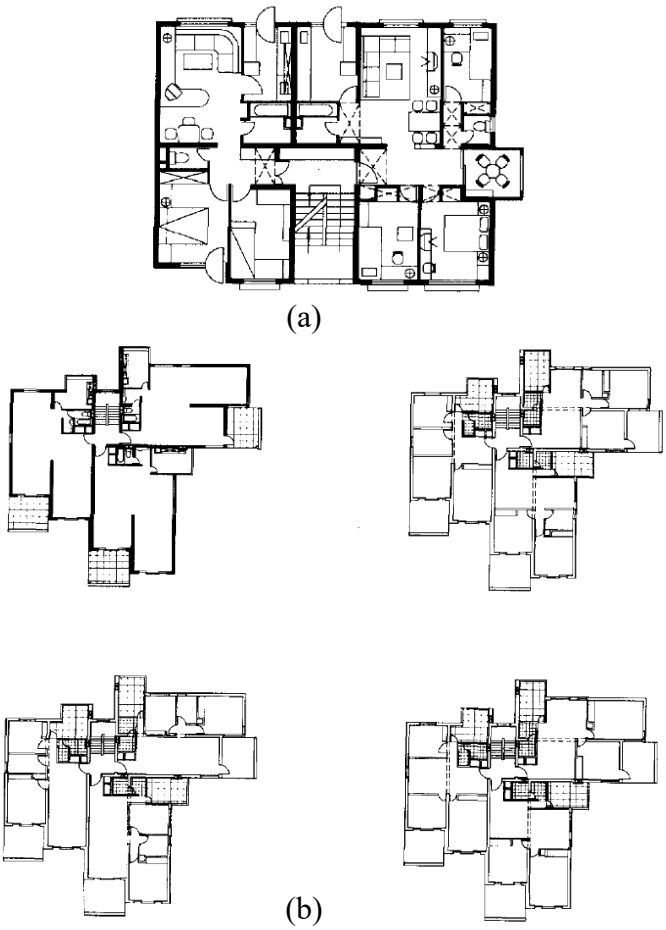


Figure 10. Shijiazhuang Xiaokang House Plan (a) and Yantai Terrace Garden House Plan (b). From Lü, Rowe, and Zhang (2001).

2.6 Conclusion

The third stage of housing development in China demonstrates that it was only after Reform and Opening Up that China began to focus on adaptability and flexibility of housing, and that research and application of flexible housing in China began later than in other countries around the world. This phenomenon, as well as the subsequent development trends, are worth investigating and researching.

On the one hand, the planet has reached a geographical tipping point where, for the first time in human history, the majority of people live in cities. Faced with this reality, the demand for urban housing will rise, placing greater emphasis on science, technology, and modern residential architecture.

On the other hand, housing construction costs continue to rise as a result of design flaws, increased project cost inputs, and socioeconomic influences. The social problems that result cannot be ignored. Controlling the rise in housing costs and promoting the sustainable development of housing construction are critical tasks.

As a result, the emergence of flexible housing has responded to housing demand and the growing popularity of modular construction, which has clear advantages over traditional construction methods. However, modular construction is not widely used today, which may necessitate a concerted effort from all sectors of society, including governments, businesses, and design firms. The development of flexible housing is in line with the needs of today's times, but its popularity is not yet high enough, especially in the Chinese market. The public is expected to gradually accept flexible housing in the near future. Furthermore, in today's technologically advanced age, the design, construction, and use of flexible housing will become more sophisticated and in line with human society's sustainable development.

Chapter 3 Literature Review of Home Working

This chapter examines and summarises relevant legal policy and literature from the last 20 years, provides a scientific understanding of the facts, and summarises the evolution of home working.

3.1 Background

3.1.1 The Period Before the Industrial Revolution

Home working can be traced back to mediaeval England, according to Holliss (2007). Most people in the Middle Ages were members of subsistence and self-reproducing communities, with their lives consisting of an undifferentiated and indistinguishable combination of productive and domestic work. At the time, walking was the most common mode of transportation, with only a few people using horses. Travel was a slow, laborious, and dangerous business in any case, so it was only done when it was unavoidable, except for the lord and his family, who did it partly to demonstrate his wealth and power. In such a social context, working from home makes perfect sense.

According to Holliss (2017), the pattern of home-based work during this time period was primarily concentrated in England. Among them were blacksmiths, weavers, barbers, innkeepers, and so on. They usually lived in 'workhomes,' which had four to eight rooms, at least one of which was a dedicated workspace or a dual-use living space for productive work. The space for working from home has been combined with the residence during this time period. Holliss (2012) points out that, prior to the Industrial Revolution, home-based work was almost universal, so most pre-industrial buildings combined the home and the workplace in some way. For instance, the majority of manufacturing was done at home, often in purpose-built structures (Figure 11). For many people, the invention of the factory and the development of the city as a financial institution resulted in a separation of home and work. The globalised economy, as well as advancements in telecommunications and information technology, have made it increasingly unnecessary for a large proportion of the workforce to congregate in collaborative workplaces to carry out their work. As a result, the number of workers working from home will continue to rise.

According to Lake and Dwelly (2008), the live/work unit is not a new concept, but dates back to the industrial revolution, when workplaces and homes began to be divided into separate zones. At the moment, they argued that the benefits of live/work should be more widely applied as a mainstream approach to building design and land use, that homeworking should be encouraged, and that buildings should be designed to allow for more flexible economic uses. Despite policymakers' encouragement of the home-work model, no policies or measures on the practicalities have been implemented.

Figure 11. Interior of early nineteenth-century Bethnal Green weaver’s house, From Holliss (2012).

3.1.2 Industrial Revolution Period

Home-based work continued throughout the nineteenth century, according to Holliss (2012), though the work-from-home model was no longer dominant. Moreover, Holliss (2017) argues that with industrialisation, there was a social and spatial separation between the home and the workplace. This was fueled partly by the invention of factories and the growth of urban centres where labourers could find work. It was, however, also related to the social attitudes of the time, when the widely held conservative view was that the male role was to earn the family wage and the female role was to care for the home. For various reasons, trade unions, employees, and social reformers opposed working from home.

According to Holliss (2007), the industrial revolution was a gradual process rather than an event. Although many manufacturing processes were industrialised throughout the nineteenth century, many occupations retained pre-industrial, home-based practices. People continued to work in traditional pre-industrial ways in some areas, such as weaving, into the twentieth century, even though trade had industrialised by then. Many of the buildings built during the nineteenth-century building boom were workplaces. These phenomena persisted into the twentieth century. (Holliss 2012)

3.1.3 The Period After the Industrial Revolution

According to Holliss (2017), by the early twentieth century, the separation of living space and work sorting was widely accepted and increasingly ingrained in the governance structures of the time. The 'live/work' movement of the 1980s and 1990s recognised that, as a result of changing social and economic conditions and technological innovations, work practices were changing radically and rapidly, with significant implications for buildings and cities. To varying degrees, the home-working paradigm has been impacted. Home working mode is growing rapidly in the twenty-first century, with more women employed than ever before, as well as the enabling of new technologies, a globalized economy, increasingly devolved corporate risks, and structural unemployment. Factors contributing to the increase in the number of people working from home are the increase in information-based and service-related jobs, more contract and part-time work, improvements in computers and telecommunications, and the impact of company restructuring. (Friedman and Krawitz 1998)

Paid work and family separation became normal in the twentieth century, according to Holliss (2007). Despite the fact that the factors that led to this outcome were complex, such as the effects of two world wars and the development of mass production processes. Work from home was initially discouraged, even not prohibited, in the United Kingdom at the time. Gender division of labor became regular, with men frequently 'working outside the home.' People from all socioeconomic classes, however, continued to work at home, in the home, or live in the workplace. When spatial separations between home and work were accepted as 'normal,' they became less visible. The visibility of the twentieth century studio-house, the live/work unit and the modern movement workhome means that they can help us to trace the existence of this building type over

time.

3.2 Feature

3.2.1 Advantages

Mason, Carter, and Tagg (2011) conclude that when employees work from home rather than in the office, businesses save on overhead and increase productivity; home-based businesses play an important role in the sustainable development of rural communities and small towns by reducing travel, revitalizing daytime economies, and increasing local purchasing power; and can meet family needs while avoiding the need for commuting. Some people who are unable to participate in the labor market due to medical or nursing care may be able to run a home business or work from home. They also discovered that the primary requirement for many knowledge-based professional services businesses (such as accountants, web developers, online traders, consultants and so on) is IT equipment and internet access, which means they can work from home and require very little space to do so, but it also means they may have high residential separation requirements between work and living areas in their homes.

Employees who work from home have control over their own space and time, according to Lake and Dwelly (2008). Home working mode offers a less stressful work experience and a better work-life balance as commutes become longer and more unpleasant. Individuals can work more flexibly, and the elimination of the need for regular commuting allows for more leisure time. Lake and Dwelly (2008) also demonstrate real savings for businesses by reducing the need for valuable office space, increasing employee satisfaction, improving staff retention, and lowering absenteeism.

According to Chung et al. (2020), employees identified positive aspects of working from home during the COVID-19 embargo, such as being able to care for children, do housework, and spend more time with their partner. During the embargo, the employees were able to complete more work at home in less time. A sizable proportion also stated that they would most likely continue to work from home after the COVID-19 embargo was lifted. Other employees stated that they would like to work from home more in the future for the following reasons: less commuting time, more time with their families, increased productivity, and better health.

Holliss (2012) argues that home-based working is a popular way of working and can offer many potential social benefits. It has benefits for cities in addition to allowing people to combine paid work with home-based work because it increases the number of people living in the local community during a 24 hour period, which tends to help increase local social networks and busyness, making communities more active and safe. It also helps to reduce carbon emissions by reducing commuting and increasing the overall efficiency of the building stock. Home working mode is also beneficial to the economy because both large corporations and start-ups use it to reduce overhead and improve profitability.

Through the work-at-home phenomenon, more and more people are turning part of their home space into a working environment. For many telecommuters, the availability, affordability and accessibility of personal computers, fax machines, modems and photocopiers have outweighed the cost of renting office space. By working from home, a person can save on office costs, which can then be directed to business-related resources. (Friedman and Krawitz 1998)

3.2.2 Disadvantages

Mason, Carter, and Tagg (2011) discovered that working from home for extended periods of time can cause social isolation, partner stress, and problems related to the lack of physical boundaries between work and home. Furthermore, many industries and sectors will never allow workers to participate in the work-from-home model. Home working remains uncommon among salespeople and may never become a reality in the UK's large service sector, particularly retail. Many people are distracted at home, even if their jobs appear to lend themselves to working from home and on the go. Perhaps it is not reasonable to control when, where, and how people work. The current approach emphasizes very specific people and very specific architectural and planning responses.

According to Holliss (2012), working from home can also have a number of potential problems and disadvantages, such as social isolation and professional identity issues. According to Chung et al. (2020), one of the major disadvantages of working from home is the blurring of work and home boundaries. Many people complain about a lack of equipment and space when working from home. Lack of interaction with coworkers was also mentioned as a major disadvantage of working from home, particularly among women without children. Parents, especially mothers, identified increased housework and childcare as a major negative experience of working from home. Furthermore, Holliss (2017) gives a specific example of a binary property tax system in the UK, including council tax for residential properties and business rates for non-residential properties, where the tax system can lead to the disadvantages of working from home.

3.3 Debate

3.3.1 Home Working: A Win-win Option

Home working mode benefits not only employees, but also employers and those starting their own businesses. Mason, Carter, and Tagg (2011) discovered that the generation born between 1918 and 2001 were heavy users of technology, and that they grew up with computers and the internet, and that these uses made the choice of workplace less important, because anywhere there is a internet connection can be a workplace. This is a significant advantage for starting or working from home at a low cost. As few large companies now offer permanent job security, they are more likely to work for themselves than previous generations, which means they are more likely to start a business or find work that maintains their independence, and the work-from-home model is one of their options.

According to Lake and Dwelly (2008), separate areas for the home (quiet, safe, and

clean) and the workplace (noisy, stinky, and polluted) may have been necessary during the industrial age. However, we now live in the age of broadband, the knowledge economy, the iPhone, video conferencing, and online commerce. People can now literally run a global business from their homes. Even businesses and employers involved in manufacturing and services that cannot be performed from home can benefit from some of the functions available at home. Cars, kitchens, and buildings, for example, can be designed from home using computers; electricians and plumbers can do their accounts and take orders from home; financial advisors can work from home; and so on.

Mason, Carter, and Tagg (2011) highlight that the family appears destined to become an even more important focal point for business activity in the future. Demographic trends will be a major motivator. Because of the ageing population, longer life expectancy, and improved health, an increasing number of people of retirement age will want to or need to remain economically active. As a result, more older people will be running businesses from home in semi-retirement.

For employees, the rising cost of commuting, increased traffic congestion and the introduction of a carbon tax have made them more inclined to work from home. For enterprises or self-employed people, inexpensive and powerful new technologies, web-based tools and search engines have created new opportunities, as well as increased flexibility of location, allowing many types of work to be carried out 'anywhere', which also makes them more inclined to work from home.

3.3.2 Home Working: The Low Carbon Option

The trend is towards more home-based working and greater flexibility, with new technologies enabling individuals to connect their homes to global markets. These changes are transforming society and presenting new challenges to the way humans live and work.

Home working, according to Lake and Dwelly (2008), not only reduces the environmental costs of commuting, but also the energy consumed to build and fuel office space. This approach has the potential to make a significant contribution to reducing carbon emissions, and it has arguably been overlooked for a long time. They argue that a fundamental shift in policy is required to reap the full benefits of a low-carbon economy. People who own and fuel two separate buildings and commute between them are more likely to pollute than those who combine their workplace and home into one. A number of studies have shown that working from home and other forms of teleworking can create considerable environmental benefits, including a reduction in carbon emissions. The case for working at home goes beyond the proven environmental benefits. Lake and Dwelly (2008) conclude that there are lasting individual and collective benefits to be gained by moving to a more environmentally friendly work-from-home economy.

Over the years, researchers have been striving to find a more compact and efficient house to tackle the housing problems that many people face (Nurdiani, Katarina, and Putra 2021). Meanwhile, homeworking has proven to be advantageous in terms of energy savings and, for many people, quality of life, which has become a norm during the 2020/2021 pandemic. Many large corporations promote this new habit due to the associated cost savings. (Roggeri, Olivari, and Tagliabue 2021)

3.4 Conclusion

According to Mason, Carter, and Tagg (2011), the complexity of home as a theoretical concept grows as it increasingly becomes a place of work - particularly business - rather than a place where people occasionally come back to eat and sleep before going out. Making the home into a place where home and business coexist inevitably generates new sensations, attachments, experiences, and meanings, increasing its porosity and generating new relational geographies. This necessitates research into how the home working model can be integrated into the home.

Lake and Dwelly (2008) argue that in an era of high fuel costs, global financial uncertainty, and climate change, it is appropriate to transition to a mix of single buildings (workspace and home), which will reduce costs and business risk. They conclude with a thought-provoking question: with high-quality video conferencing poised to become the "killer app" for workplace meetings within a few years, why are we still driving people to places they don't necessarily need to be in order to contribute to the economy? Given the growing popularity of working from home, it is critical to assist people who work from home in avoiding isolation and increasing their networking capabilities, as well as sharing knowledge, skills, and opportunities. Lake and Dwelly (2008) believe that working from home necessitates flexibility, which is consistent with the thesis's goal of creating exceptional home working spaces in flexible homes. The role as planners and designers is to build a framework that provides people with the opportunity and potential to choose a better way of working for themselves. Despite the rapid growth of home working mode, housing is still widely perceived as a collection of pre-planned, purposeful spaces.

A need to work within existing constraints emerges, therefore, to design workhomes that facilitate extended fungibility in the use of space as both a domestic and an income-generating resource.

In the pandemic era, working patterns have changed dramatically, and 'homeworking' is gradually becoming the primary way. In this context, residential space is becoming increasingly crucial. In China, the design of sustainable and affordable mass customisation housing, combined with the increasingly popular flexible housing system, seems to meet the era’s requirements. This thesis will focus on designing quality teleworking spaces in plug-in housing. Efforts to combine work and family to improve the living environment and the general desire to balance family life and the work sphere should be areas for architects and developers to consider in the post-pandemic era.

Chapter 4 Cases Studies

This chapter presents a collection of ten examples of flexible housing and home working design. The examples are primarily based on flexible housing with a home working model, and are analysed in relation to the design concept of home working combined with flexible housing. The selection of cases is not limited to a specific location or country, but is drawn from all over the world, making the process of analysis in this chapter universal and the results objective. Furthermore, in order to ensure the breadth of the case studies, the ten residential cases collected are of various types and natures: some are single-family houses, some are apartment buildings; some are renovated and refurbished, some are original designs; some are coping strategies in response to the Covid-19 design, and some are simply for the client's requirements.

The global economic that followed the Covid-19 period had a significant impact on the real estate market. In China, the pandemic shock and market reaction, as well as policy hedging may cause not only increased monthly and quarterly fluctuations in the real estate market, but also an increase in the annual cooling of the real estate market, while remaining stable overall. The purpose of the analysis in this chapter is mainly to be able to provide some theoretical support for the current state of the real estate market in China. During Covid-19, the Chinese government's prevention and control measures were premised on the safety of people's lives and promoted the work-from-home model. After more than two years under the influence of both the policy and the pandemic, the work-from-home model, which was prevalent in medieval England, entered people's lives.

According to Hern (2020), many employees who were forced to work from home due to Covid-19 did not want to return to work and preferred the home working model. This demonstrates that Covid-19 has a significant impact on work patterns, which may result in the birth of workplace flexibility.

The design of working space in a residence is crucial and has an impact on people's lives, not only in the past but also in the future. The home’s flexibility provides a good space for the home working while maintaining the quality and functionality. Whether it is a trend or a market demand, flexible housing with excellent home working space will be popular for some time to come. The findings in this chapter are intended to have a positive impact on the Chinese real estate market with this in mind.

The ten cases collected in this chapter are divided into three families based on the designer's thinking about the design problem, the specific design approach and the response to residential flexibility and home working: flexible furniture and working space, flexible furniture and fixed working space, flexible facility and fixed working space. The information about the cases is then further classified statistically using tables, based on year of construction, country, attributes of flexible housing (adaptability, flexibility, modularity and customisation), and home working mode (live-with or live-nearby) (as in Table 2). In the analysis of the case studies, the focus of this chapter is

on how the architects use architectural techniques or architectural means to define the working and living spaces in the residences. The floor plans of each case are briefly redrawn, followed by the relevant analytical drawings and a textual analysis of the combination of flexibility and home working patterns, from which conclusions are drawn.

N°	Family	Case	Architects	Year	Country	Adaptability	Flexibility	Modularity	Customization	Home Working	
										Live-nearby	Live-with
1	Flexible furniture and working space	Van B Housing	UNStudio	2018	Germany	+	+	+	+	-	+
2	Flexible furniture and fixed working space	Suburban Studio	Ashton Porter Architects	2010	UK	+	+	-	-	+	-
		Pyhätunturintie 2 Public Housing Block	Lahdelma & Mahlamäki Architects	2021	Finland	+	+	+	+	-	+
		Zushi House	ROOVICE	2021	Japan	+	+	-	-	-	+
		GRACE	APOLLO	2021	Japan	+	+	-	-	-	+
		Enigma	MEM Arquitectos	2022	Mexico	+	+	-	-	-	+
		Raw Housing	Ilase Arquitectos	2022	Argentina	+	+	-	-	-	+
3	Flexible facility and fixed working space	Naked House	Shigeru Ban	1999	Japan	+	+	-	-	-	+
		CHINA House Vision No. 8 Pavilion	Crossboundaries	2018	China	+	+	+	+	-	+
		KAPPA House	Archipelago Architects Studio	2021	Japan	+	+	-	-	-	+
Note: '+' shows the aspects that the case includes, '-'shows the aspects that the case does not include.											

Table 2. Basic information about the collected cases.

4.1 Flexible Furniture and Working Space

4.1.1 Van B Housing

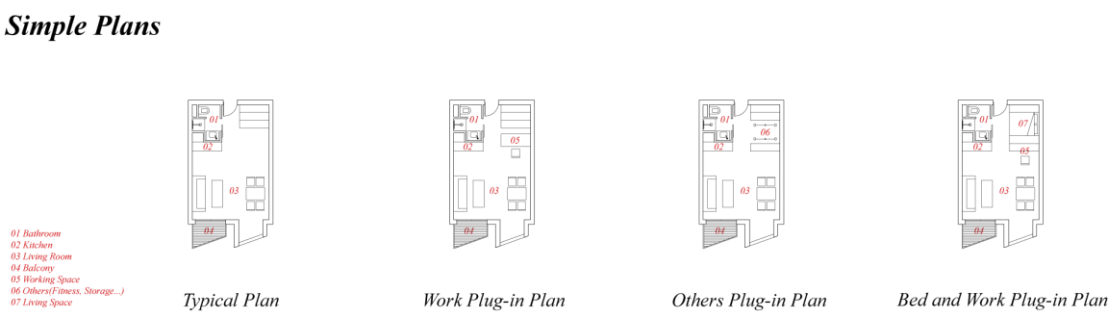
The Van B Housing, designed by UNStudio, is a new residential project located in Munich. This residential project's primary goal is flexibility, reimagining the possibilities of future urban living and allowing residents to reconfigure their homes as needed.

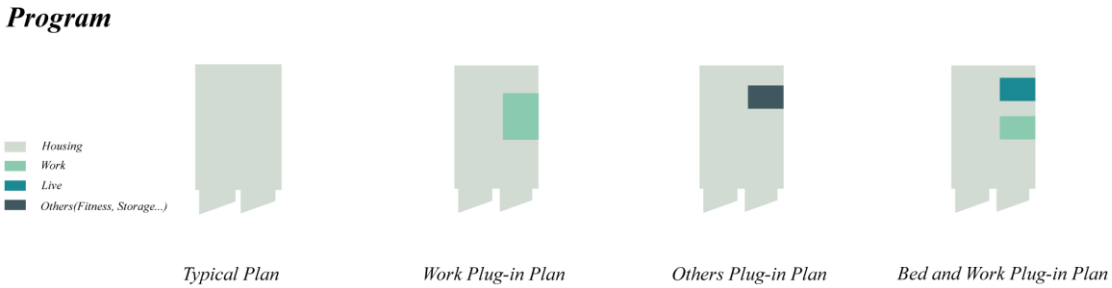
When this residential project is put up for sale, users will be able to choose which features they want based on their specific requirements. A multifunctional plug-in system at the heart of this residence allows the user to easily change the use of the same space in a short period of time (see figure 12), allowing the room to be transformed from a spacious working space into a comfortable living room or bedroom or a gym or storage space.

With the help of this plug-in system, a large functional space can be used in a small residential area. A typical room plan can be varied in a variety of ways thanks to the plug-in system, such as having a large working space, a fitness space and a storage space, or combining living space and working space at the same time (see figure 13). The plug-in system makes it possible to have 66 square metres of usable space in a 48 square metre house.

This case is extremely valuable in the Chinese real estate market. First, the use of the plug-in system allows for the use of a large space for a small area of housing, which is consistent with the current situation of intensive land use in China; second, there is a scarcity of such flexible, user-configurable housing in the Chinese real estate market, which has a promising future; and finally, this type of housing meets the needs of the post-pandemic era, with the benefits of flexible housing and the mode of home working.

Figure 12. Multi-Functional Plugin System.
Note: UNStudio (2018), *Van B*, from
https://www.unstudio.com/en/page/14624/van-b.





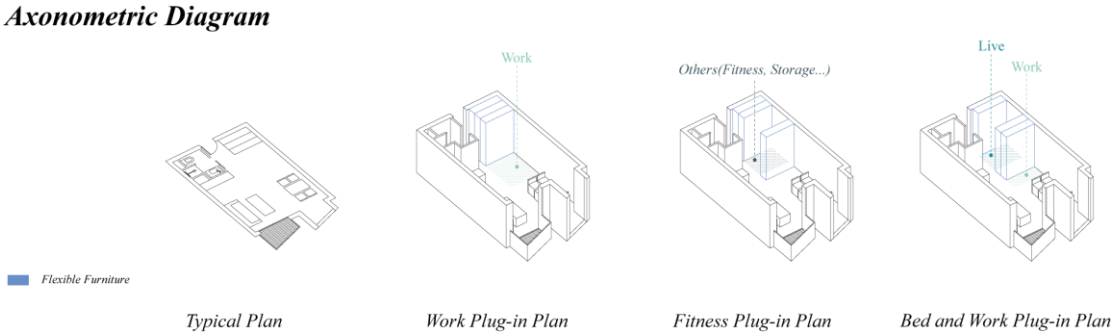


Figure 13. Simple plans and diagrams.
Note: UNStudio (2018), *Van B*, revised from
https://www.unstudio.com/en/page/14624/van-b.

4.2 Flexible Furniture and Fixed Working Space

4.2.1 Suburban Studio

This is a renovation project designed by Ashton Porter Architects in the London Borough of Enfield with the goal of creating a separation between work and home life for the users. The conversion separates the house from the studio and the middle garden (which was converted into a courtyard at the back) is also a point of conversion. Inside the house only the dining room is fixed, the other room can be used as a living space, library or meeting room; the studio is open for work; the courtyard in the middle serves as a transition between work and family life, not only as a landscape but also changing depending on the state of use, for example it can be used as a family space on weekends evenings (Figure 14).

Figure 14. The Courtyard of the Suburban Studio. (Copyright by Andy Stag)
Note: Ashton Porter Architects (2011), *SUBURBANSTUDIO*, from http://ashtonporter.com/portfolio_page/suburbanstudio/.

In the same house, the living and working spaces are "roughly" separated by a courtyard, which reduces work interference with the living environment; on the other hand, the courtyard serves as a transition between the two spaces, where domestic activities can also serve as a link between home and work (Figure 15). This design may be more appropriate for homes with courtyards in the Chinese real estate market, such as those in smaller cities or rural areas. Most city dwellers live in small apartments and are unable to completely separate their home working space from their living space.

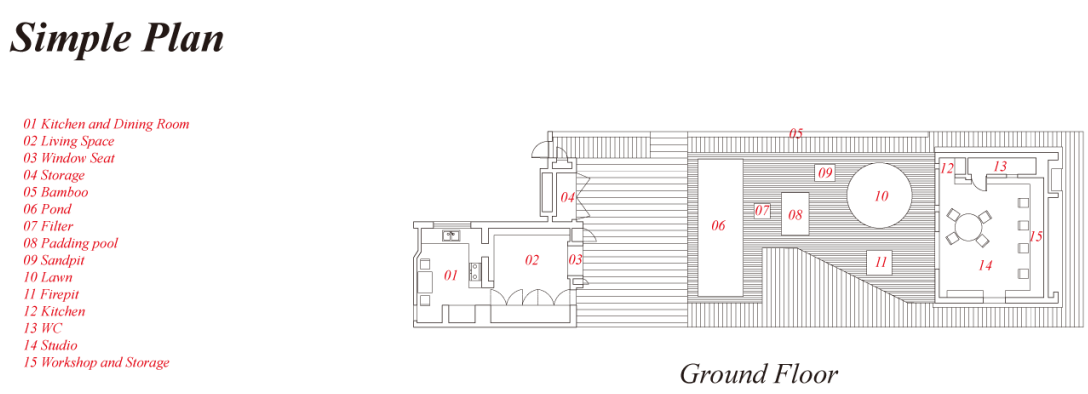


Figure 15. Simple plan and diagrams.
Note: Ashton Porter Architects (2011), *SUBURBANSTUDIO*, revised from http://ashtonporter.com/portfolio_page/suburbanstudio/.

4.2.2 Pyhätunturintie 2 Public Housing Block

Pyhätunturintie 2 is a public housing complex in Helsinki designed by Lahdelma & Mahlamäki Architects with the aim of meeting the needs of families in various situations and utilising the flexibility of the dwelling to create more possibilities for the occupants. In this case, there are several house types, and only one has been selected for discussion in this chapter in relation to home working and flexible housing (see Figure 16). Alcoves, which were originally designed as a sleeping space but were used as a home working space during the Covid-19 outbreak, are a example of flexibility in this flat. Furthermore, the alcoves can be used as a home extension space during normal times.

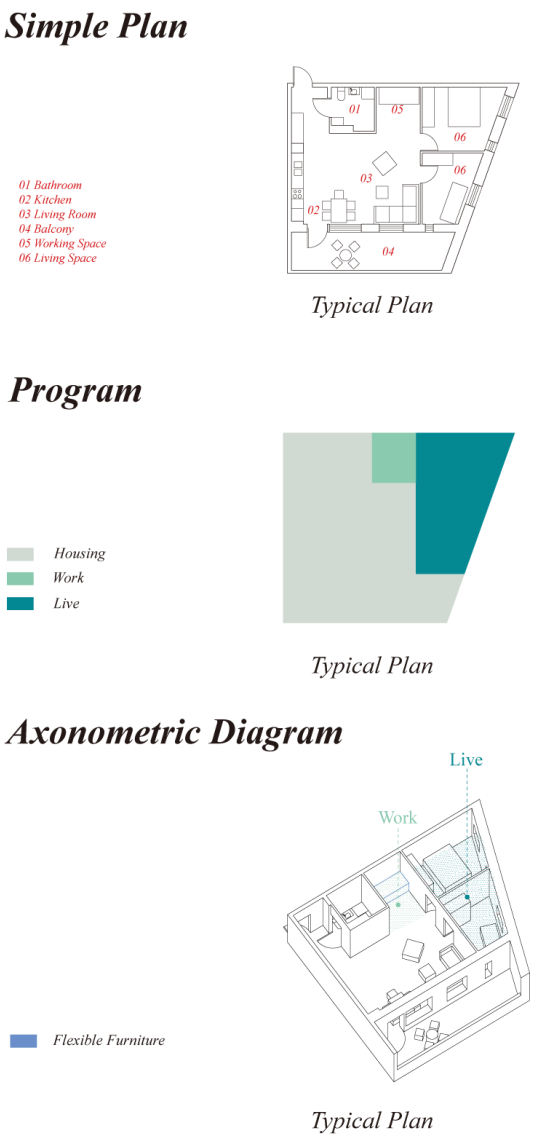


Figure 16. Simple plan and diagrams.
Note: Lahdelma & Mahlamäki Architects (2021), *Pyhätunturintie 2 Public Housing Block*, revised from https://www.gooood.cn/pyhatunturintie-2-public-housing-block-helsinki-by-lahdelma-mahlamaki-architects.htm

The current real estate market in China is dominated by mid to high-rise residential products, which are similar to this case. However, the design of this case focuses more on the flexibility of the residential development, attempting to provide the user with a variety of different home experiences. Whereas most traditional Chinese urban residential floor plans have a fixed layout and lack flexibility and variation, this design of a flexible housing in a mid-rise building is worth considering.

4.2.3 Zushi House

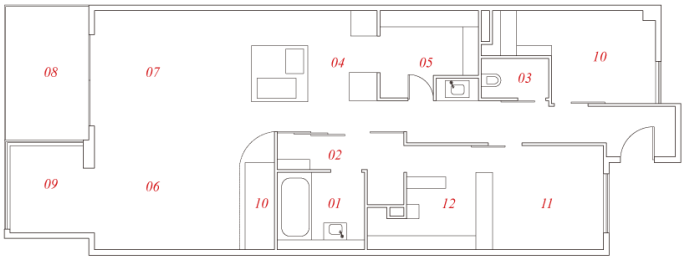
ROOVICE has renovated a flat in a multi-storey house for a couple called Zushi House, the main focus of the renovation being the living room (which has a large window with a view of the bay), around which ROOVICE created a number of designs, the most interesting of which is the use of curtains to divide the living room into a work area that can be flexibly divided. This workspace provides a degree of privacy for the home working occupants and, although not very effective in terms of acoustic insulation, creates a 'space' by blocking the view (Figure 17).

Figure 17. Studio in the living room. (Copyright by Akira Nakamura)
Note: ROOVICE (2021), *Zushi House*, from https://www.roovice.com/works/14356.

There was already a studio room to the north of the flat, but in order to be able to enjoy the stunning view of the bay while working, the designers used additional curtains as partitions in the living room to create a new temporary studio (Figure 18). For the Chinese real estate market, due to the low cost and effectiveness of this case's approach to housing flexibility, these approaches can be adapted and used in volume for real estate products to improve product quality and as a new selling point to attract customers.

Simple Plan

01 Bathroom
02 Bathroom Storage
03 Toilet
04 Kitchen
05 Kitchen Storage
06 Living Room
07 Dining Room
08 Balcony
09 Niche
10 Working Space(Studio)
11 Bedroom
12 Closet



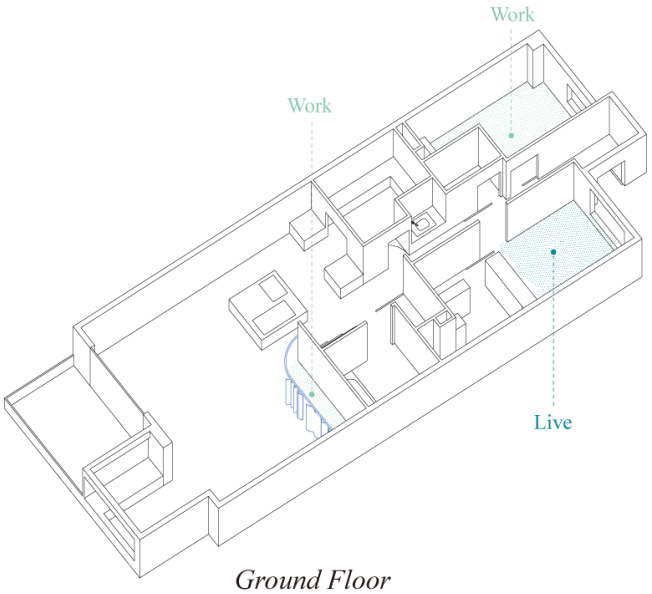
Ground Floor

Program

Housing
Work
Live
Others(Fitness, Storage...)

Ground Floor

Axonometric Diagram



Flexible Furniture

Ground Floor

Figure 18. Simple plans and diagrams.
Note: ROOVICE (2021), *Zushi House*, revised from https://www.roovice.com/works/14356.

4.2.4 GRACE

This project is a timber-frame house designed by APOLLO for a family of three in Tokyo, Japan. The design began with the goal of creating a home that combines daily life and work for the owners, catering to a home working lifestyle.

The work area is set on the first floor, adjacent to the communal spaces of the residence, and flexible storage spaces have been used to create a good working environment. All functional elements are embedded in wall storage units and the flexible storage space allows for a more visually pure room (Figure 19), providing a more focused environment for the home working.

Figure 19. Wall storage units.
(Copyright by Masao Nishikawa)
Note: APOLLO (2021), *GRACE*, from https://apollo-aa.jp/works/grace/.

The challenge in the design was how to deal with the various contradictory relationships, encompassing the treatment of the work space and the living space. The first floor is set

up as a separate open public living area, in contrast to the private area (living space) on the ground floor (Figure 20).

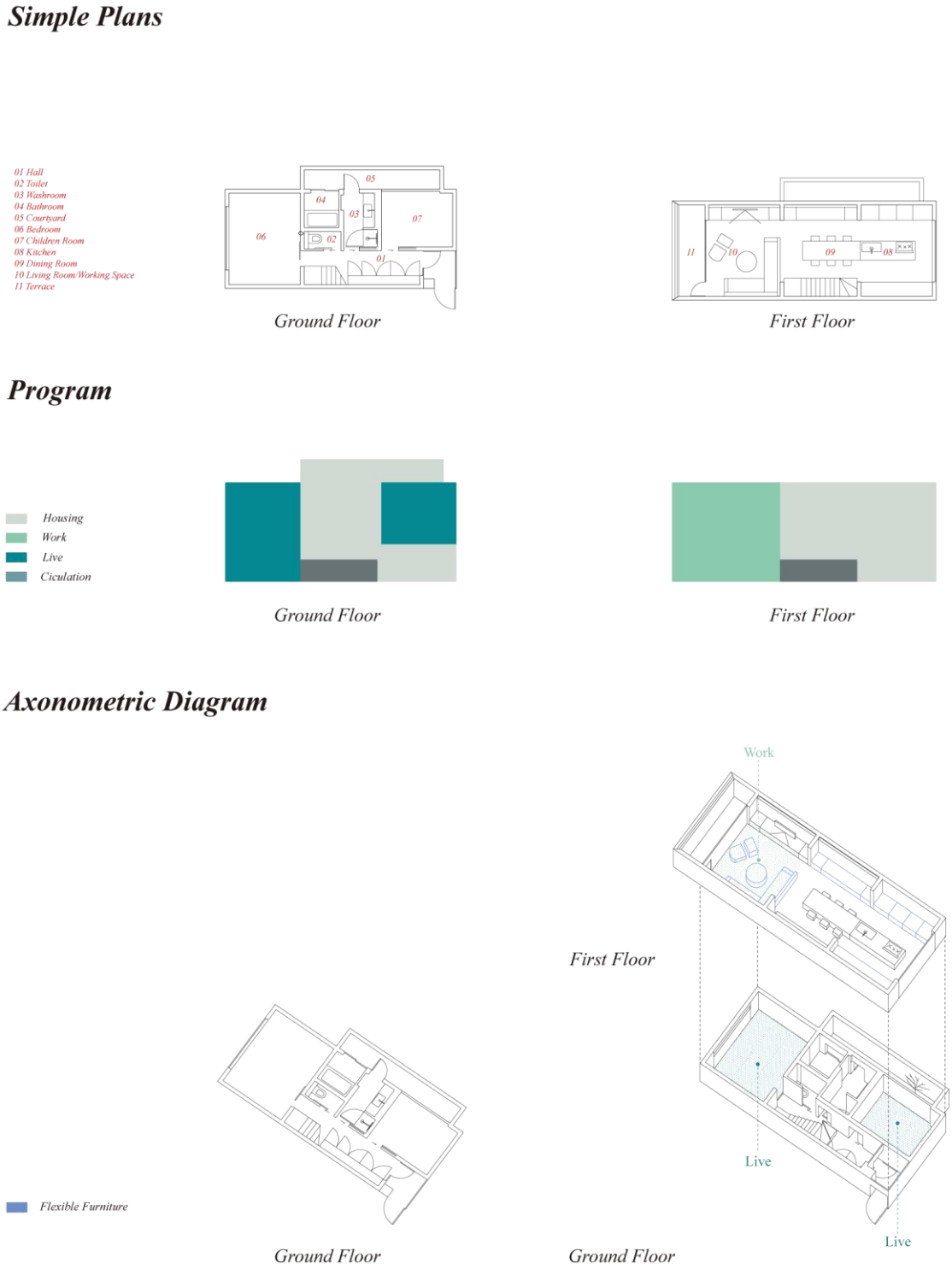


Figure 20. Simple plans and diagrams.
Note: APOLLO (2021), *GRACE*, revised from https://apollo-aa.jp/works/grace/.

This case focuses on the development of a home working residence, and these lessons learned can be applied to the future of the Chinese real estate market. After the Covid-19 pandemic era, it is believed that the home working model will continue to be used by an increasing number of businesses and individuals in the post-pandemic era and in the near future. Residential products designed for home working will be of interest as well.

4.2.5 Enigma

This residence in Mexico was designed by MEM Arquitectos. It is a detached residence with an internal central garden that serves as the visual focal point of the entire building and also separates the social areas from the private areas, providing ventilation and light for the residence (see Figure 21).

Figure 21. View of the central garden. (Copyright by Ariadna Polo Fotografia)
Note: MEM Arquitectos (2022), *Enigma*, from https://www.archdaily.com/981148/enigma-house-mem-arquitectos.

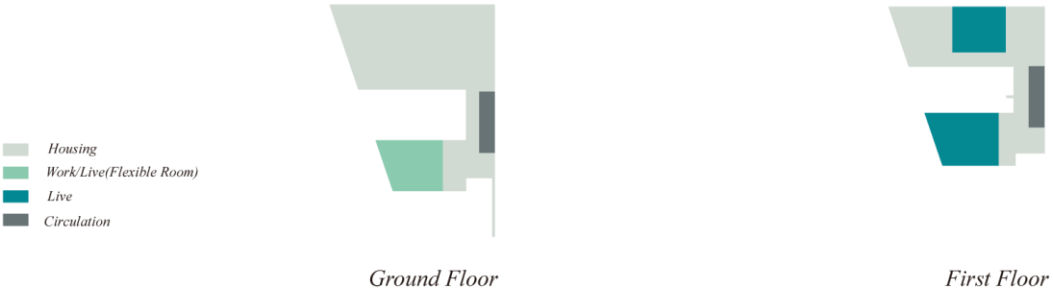
The ground floor of the residence is set up with a room that has no clear function, but can be converted into different functional rooms such as workplace, bedroom or playroom through different flexible variations (Figure 22).

In this case, the design approach for the combination of flexible housing and home working model is to have a dedicated fixed room as an expression of the overall flexibility of the house, which is a little pricey but effective enough. It appears a little 'redundant' for a Chinese real estate product to have such a separate room for the functions that the client chooses to use. It is reasonable to assume that after once a home

has been sold, the occupants can change the function of the room to meet their needs, but at a different cost.

Simple Plans

Program



Axonometric Diagram

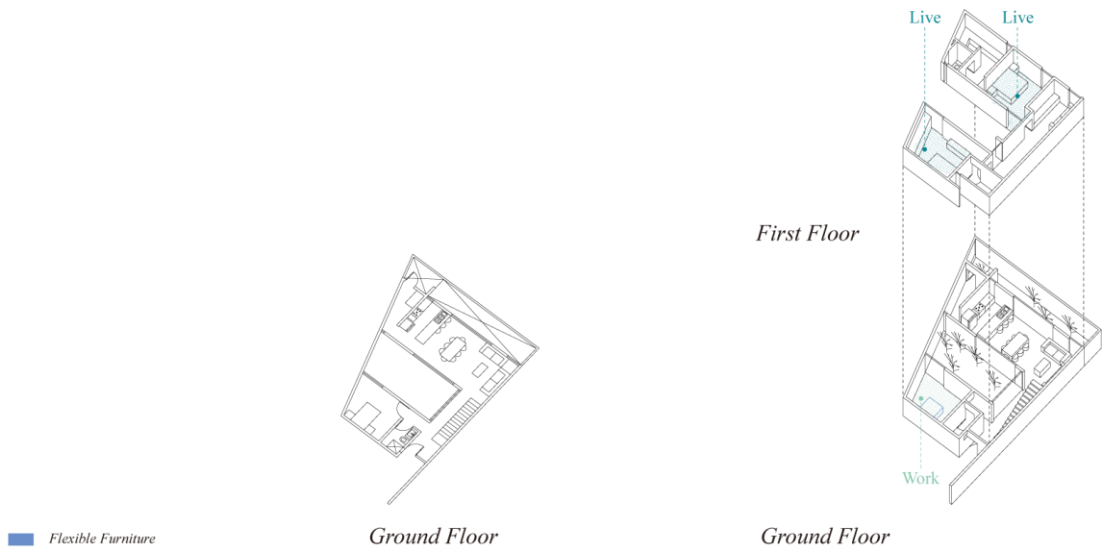


Figure 22. Simple plans and diagrams.
Note: MEM Arquitectos (2022), *Enigma*, revised from https://www.archdaily.com/981148/enigma-house-mem-arquitectos.

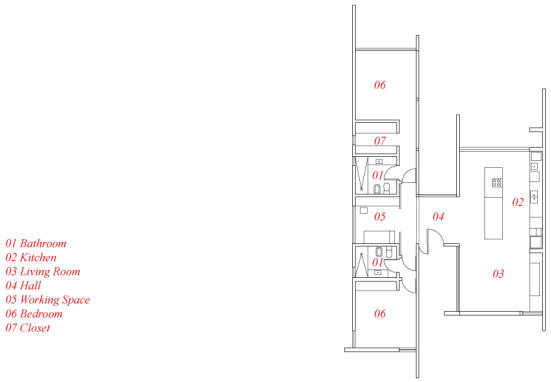
4.2.6 Raw Housing

Raw Housing, designed by Iase Arquitectos in Argentina, is a project whose two points are connected by a long pool that conceptually spans all spaces, separating the social activity spaces from the private spaces in two wings of the building (Figure 23).

Figure 23. Swimming pool crosses both spaces. (Copyright by Gonzalo Viramonte)
Note: Iase Arquitectos (2022), *Raw Housing*, from https://www.gooood.cn/raw-housing-iase-arquitectos.htm.

The space between the bedrooms embodies the project's flexibility and the combination of the home working model. This space responds to the work-from-home model of the post-pandemic era and can be adjusted to the desired level of privacy by moving partitions (See Figure 24). This method of adapting the flexibility of space through mobile partitions can be applied to residential products in the Chinese real estate market, giving users more options for space within the home.

Simple Plan

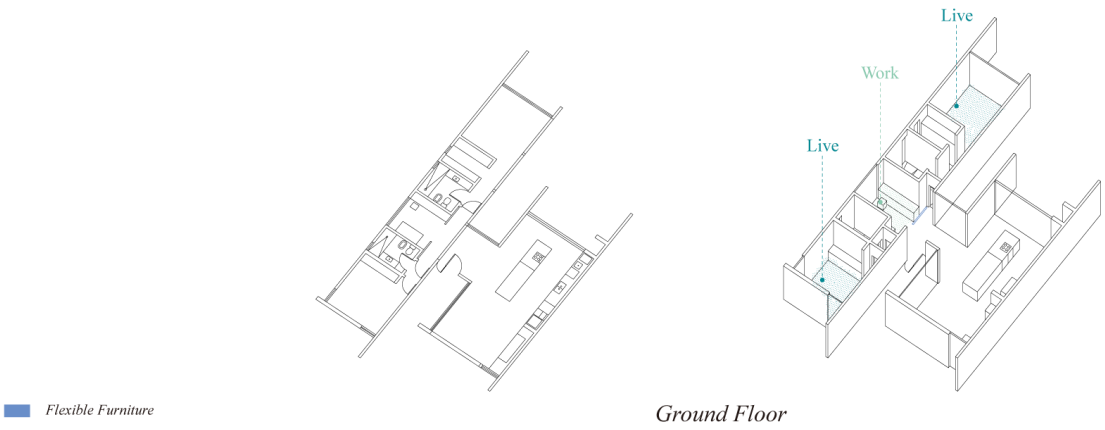


Ground Floor

Program

Ground Floor

Axonometric Diagram



Ground Floor

Figure 24. Simple plan and diagrams.
Note: Iase Arquitectos (2022), *Raw Housing*, revised from https://www.gooood.cn/raw-housing-iase-arquitectos.htm.

4.3 Flexible Facility and Fixed Working Space

4.3.1 Naked House

For Naked House, designed by Shigeru Ban, the owners expressed a desire to create a united family atmosphere where the whole family could carry out individual activities inside a common space. To meet the client's requirements, the house was designed so that only the kitchen and bathroom have fixed positions, while the other four rooms are rooms with wheels (see Figure 24), which can be adjusted at any time according to the owner's needs. This flexible arrangement allows for a wide range of permutations of the house (see Figure 25), and the fact that these flexible rooms with wheels can be replicated and added to or subtracted from at any time makes this house more adaptable. For example, when the owner wants a quiet and independent home office, one of the rooms can be pushed out of the glass door on the west side to isolate the noise of the children inside; or when the owner wants an enclosed and sufficiently large home cinema, several rooms can be combined for use together; depending on the owner's needs, the use of the residence is no longer limited thanks to this flexible design.

Figure 24. Mobile Furniture of the Naked House. (Copyright by Hiroyuki Hirai)
Note: Shigeru Ban (2000), *Naked House*, from http://www.shigerubanarchitects.com/works/2000_naked-house/.

Although the design meets the owner's desire for the entire family to move around together, one of the drawbacks of this house is that there is not much privacy and not enough private space is provided. Furthermore, the architects did not design space that could be used for storage in each of the moveable rooms in order to reduce the self-weight.

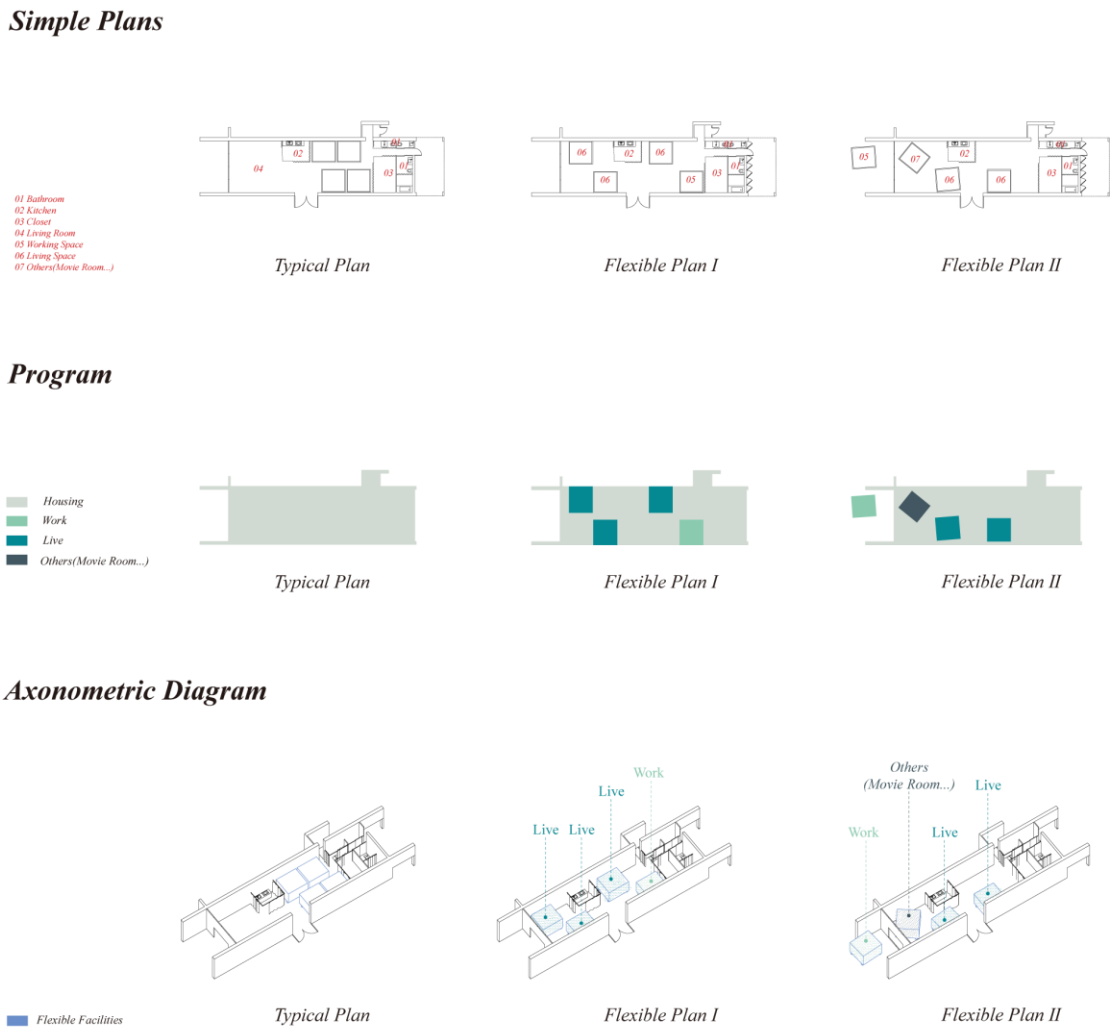


Figure 25. Simple plans and diagrams.
Note: Shigeru Ban (2000), *Naked House*, revised from http://www.shigerubanarchitects.com/works/2000_naked-house/.

The design approach used in this project in response to flexibility could be useful for the Chinese real estate market for those clients with such specialised specific needs, but in the long run is not suitable for the majority of Chinese citizens, especially those living in large cities. However, this use of the wheel and box to visualise space could be considered for inclusion in the current real estate offerings, but given the limitations of size, it may only appear as a small flexible room.

4.3.2 China House Vision No. 8 Pavilion

This project, located in Beijing, China, was designed by Crossboundaries with the aim of designing a more responsive and flexible housing that would combine traditional Chinese urban housing with individual needs to design a housing module that could be personalised.

The design is a 1:1 model of a residence, an experimental variable living environment, combined with futuristic technology that allows the occupant to enjoy endless variations in living space, a variation achieved mainly through the use of changeable furniture and movable partition walls (Figure 26). In addition to being able to use the flexibility of the home to adapt the space they want at any time, the occupants will also be able to customise the features they want in their home through a smart panel, as well as store their living preferences and apply them via the cloud when they visit a home in another city that also has this smart system. It's like the 'copy' and 'paste' function in a computer. This is an exhibit, not an actual case, but the novel design concept attracted many visitors to the project, which promotes a different way of life than the traditional Chinese concept of living. It also reflects the current shortage of flexible housing in the Chinese real estate market because it is an experimental piece.

Figure 26. Movable partitions.
(Copyright by Hao Dong)
Note: Crossboundaries (2018), *CHINA House Vision No. 8 Pavilion*, from http://www.crossboundaries.com/zh/portfolio-item/china-house-vision/.

As the functional spaces in this building consist mainly of partitions and furniture, although flexible enough, the limited number of moveable walls also creates a situation where multiple functional spaces cannot be used at the same time (Figure 27). This problem can perhaps be solved by increasing the number of movable walls appropriately, while care should be taken that the movable walls do not take up too much of the residential space.

This is a case of a local flexible housing located in China, which is a great inspiration for flexible housing real estate development in China. Its intelligent system-based management approach both allows residents to participate in the customisation of the home and to easily modify the layout of the rooms by using the system in the cloud. In the near future, Chinese real estate developers can also learn from this design approach

and management tools to improve the quality of their products and attract more customers.

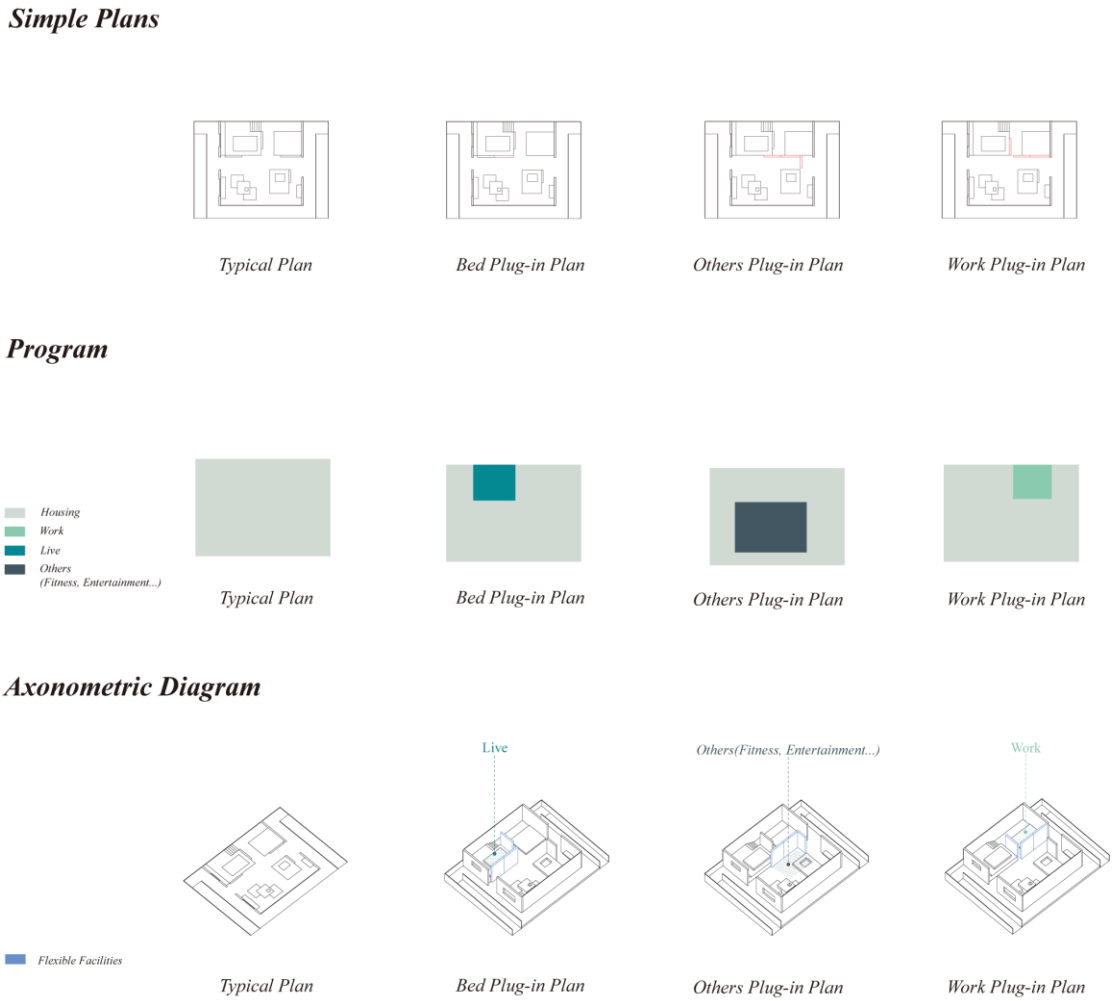


Figure 27. Simple plans and diagrams.
Note: Crossboundaries (2018), *CHINA House Vision No. 8 Pavilion*, revised from http://www.crossboundaries.com/zh/portfolio-item/china-house-vision/.

4.3.3 KAPPA House

Archipelago Architects Studio designed KAPPA House, a single family house in Japan, where the height of the house is restricted due to local laws and regulations, so the architects achieved flexibility through the staircase. The staircase, the flexibility of the building, is the central part of the building, linking the vertical spaces of the house. The staggered arrangement of floors on both sides of the staircase, in terms of width and height, allows this staircase to sometimes act as a ceiling for a particular floor, or as a partition wall for a particular floor, creating a three-dimensional connecting space (see Figure 28).

Figure 28. Space next to the stairs. (Copyright by Kenya Chiba)
Note: Archipelago Architects Studio (2021), *KAPPA House*, from https://www.gooood.cn/kappa-house-by-archipelago-architects-studio.htm.

On the top floor, the staircase does not stop there, but is used flexibly as an extension of the floor, on the one hand as a shelf to connect with the kitchen and other storage furniture, and on the other hand as a terrace to enjoy the view outside (see Figure 29).

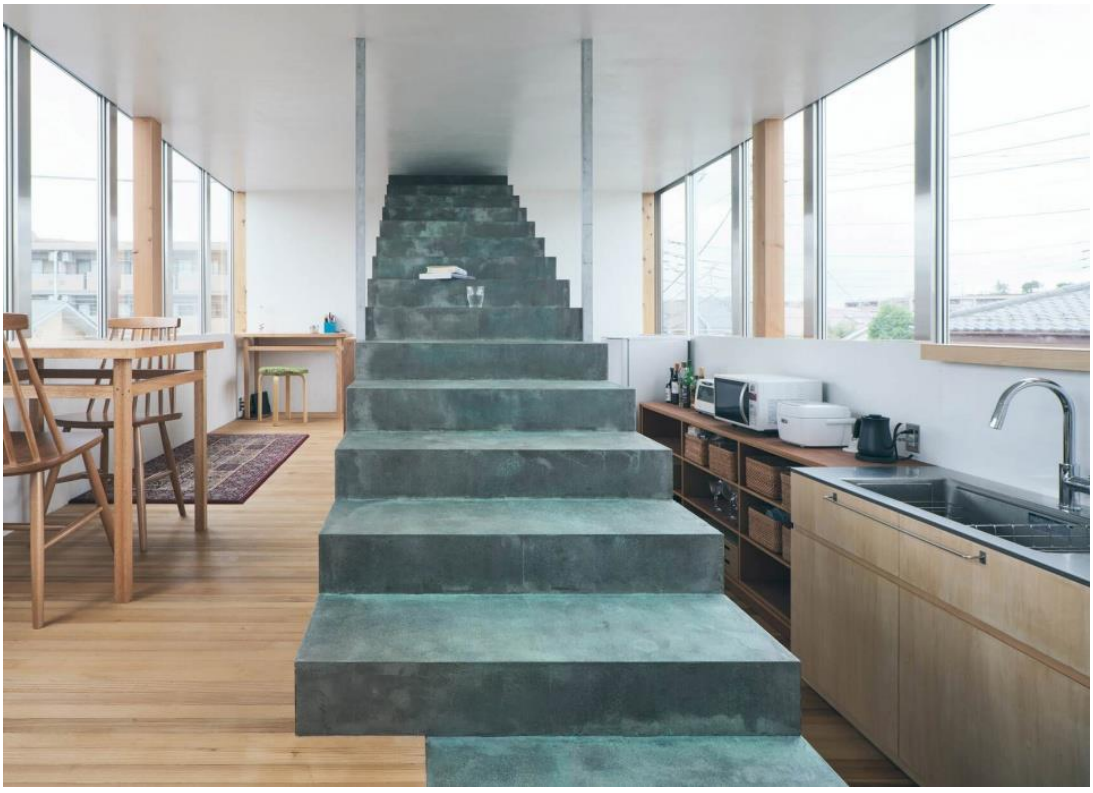


Figure 29. View of the top floor. (Copyright by Kenya Chiba)
Note: Archipelago Architects Studio (2021), *KAPPA House*, from https://www.gooood.cn/kappa-house-by-archipelago-architects-studio.htm.

The staircase is no longer a fixed installation in this building, but a flexible one that can be used for other purposes.

In this building, the staircase is always present not only as a 'fixed' facility on each floor level, but also as a 'flexible' facility with different functions on each floor level. It also separates a number of different functional rooms (Figure 30). For the Chinese real estate market, the inspiration for flexibility in this case may be that, in addition to focusing on those units that can be moved, perhaps fixed units can also show some flexibility in the appropriate design of flexible housing.

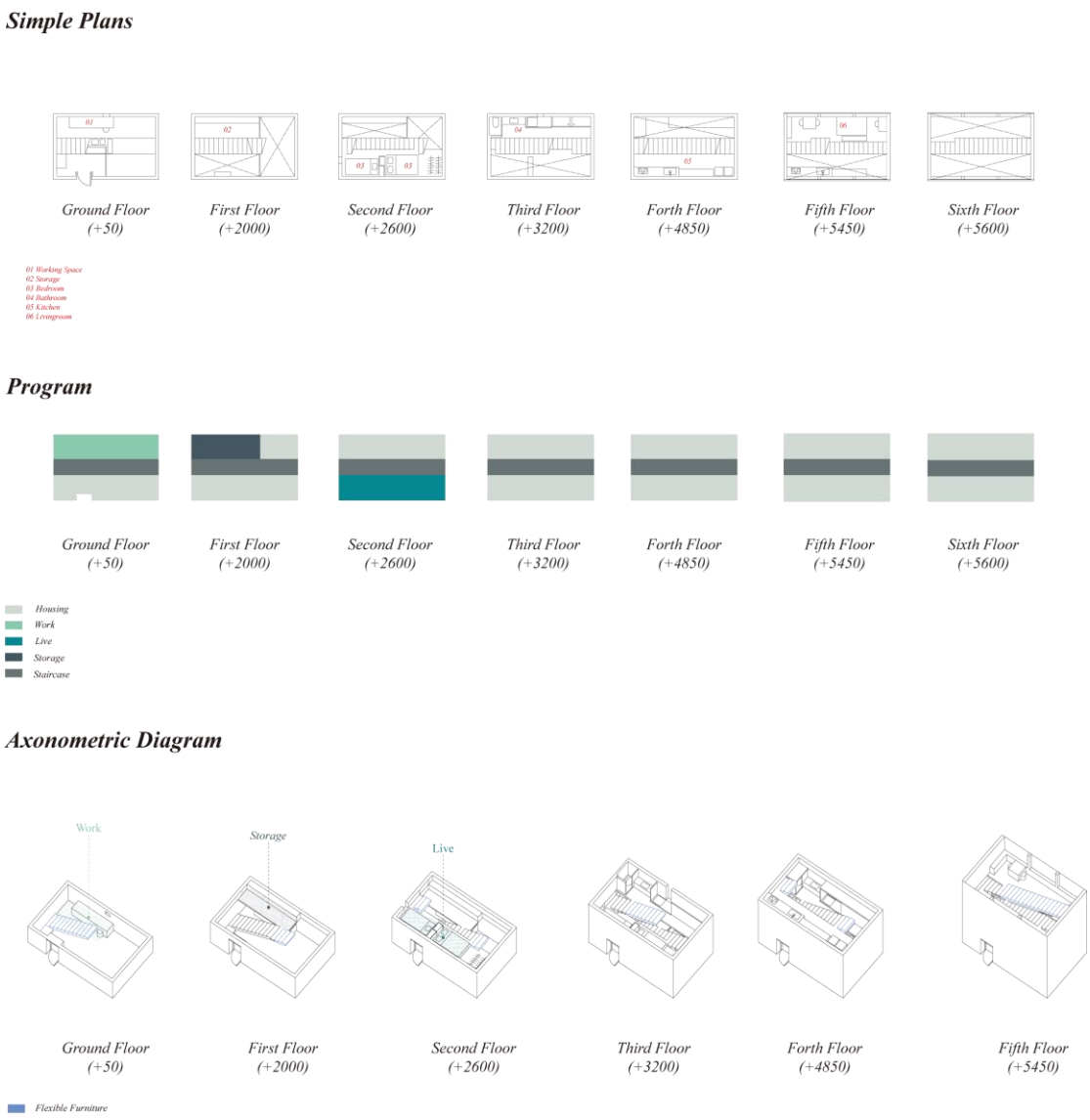


Figure 30. Simple plans and diagrams.
Note: Archipelago Architects Studio (2021), *KAPPA House*, revised from https://www.gooood.cn/kappa-house-by-archipelago-architects-studio.htm.

Chapter 5 Conclusion

As shown above, the combination of flexible housing and home working model is desirable and beneficial to the lives of the inhabitants, particularly during the Covid-19 period. As previously stated, today, in the context of population growth and urbanisation, the housing problem is extremely serious not only in China, but also in many other parts of the world. People were forced to work from home during the Covid-19 period. Although the home working model was popular in England a long time ago, it was not taken seriously, and little research on its use in dwellings was conducted. The flexible housing will become increasingly popular in the market as a result of the technological advances made by the industrial revolution. Taking into account the home working model, as well as the flexibility of flexible housing design, will not only provide the client with more living options, but will also create a good home working environment.

The development of adaptability and flexibility in housing in China started late, yet China is also the world's most populous country and still has a lot of way to go in exploring housing issues. During the Covid-19 blockade, most people chose to work from home for the sake of their own and their families' safety. Many people's attitudes towards the working environment have gradually changed as a result of a long period of working from home, and they have gradually adapted to the trend of working from home. Home working is expected to take up a significant portion of people's lives in the future. In this context, there are greater demands on the residential working environment. According to the preceding case studies, there are numerous ways to combine home working model and flexible housing, but only a few of them can be implemented and generate benefits into the Chinese real estate market, such as UNStuidio's Van B Housing, which is largely in line with the Chinese real estate market, both in terms of design approach and from a market perspective.

In terms of the design approach, the plug-in system designed by UNStudio in the Van B project is a physical manifestation of flexibility in flexible housing. Van B housing can offer a variety of different uses in the same space by using easily adjustable furniture, ensuring both the adaptability of the residential space and the comfort of the home working model in the residential space. From a marketing standpoint, Van B housing can provide the use of a variety of functional spaces, allowing users to experience the feeling of using a large residential area in a small one. This increases user comfort and satisfaction with the product, thereby improving the market economy. And, in terms of sustainability, flexible housing meets the requirements of a sustainable city by meeting not only the user's current needs but also future needs through flexibility and sustainability; additionally, prefabricated components are an important part of flexible housing, with prefabrication technology reflecting sustainable industrialisation and constantly promoting innovation.

While each of the cases listed in this thesis is unique, it is crucial to note that the flexible housing approach can be combined with the home working model to address a broader

range of household use cases (e.g. households that themselves require home working space, home working during the Covid-19 period or households that want home working space after the Covid-19 period). Furthermore, by taking into account usage and technology, flexible housing can be realised without incurring significant additional costs.

Although the majority of the cases were not intended to combine flexible housing with a home working model, there is a need for a home working space at the later stage of use. On a building-wide scale, flexible housing will allow the user to adapt the functional space required to their specific needs. At the city scale, the combination of flexible housing and home working model residential clusters will contribute to the area's sustainable development, both in terms of building construction and user living experience. The combination of flexible housing systems and home working models is novel and promising for the Chinese residential market, both in terms of timing and market needs.

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