The Motivations, Possibilities and Constrains of Flexible Housing Practices in The UK and Turkey

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ABSTRACT

Housing has, in different contexts, become a volatile issue under the pressure of different forces of change such as social, economic and cultural pressures that influence households' needs in their dwellings, and if it is not able to respond to these changes this would actually reduce the useful life of the buildings. This research seeks to highlight the concept of "flexible housing" to reveal its importance in producing creative options that can accommodate households' changing needs in their dwellings over time. This is a particularly important consideration with regard to developing countries such as Syria, that are witnessing a widespread transformation of their housing stock, given the rapid process of change, economic, social, cultural, etc., which has marked the last decade.

The research is concerned with flexible housing practices in two different countries: the UK as a developed country that has different flexible housing practices and a policy and regulatory environment that is more relevant to flexible housing provision, and Turkey as a developing country in the Middle East region with some flexible housing experience, but with a policy context relating less to flexible housing. This research aims to discover the motivations, possibilities and constraints of different flexible housing design approaches and how the policy and regulatory environment may affect practice, which could provide lessons on policy and practice for further application of flexible housing indifferent contexts, including Syria. The research first examined the national planning policy in both UK contexts, England and Scotland, to discover how the policy context at strategic level could potentially underpin the provision of flexible housing; second, it examined the national housing standards to   assess the extent to which the regulatory environment promotes flexible design solutions for housing in this context. Little evidence was found to indicate that planning policy promotes flexibility in housing design at strategic level in either context. Moreover, in terms of guidance or regulation, there was little relating to what the research identifies as flexible design criteria.

As a focus for the exploration of the motivations, possibilities and constraints of flexible design approaches, the research identified four flexible housing projects, two in each of the selected countries, all of which represent a particular cultural and design context, and policy and regulatory environment. The research evaluated the flexible design of these projects through assessing physical aspects including the plan, construction and services, and social aspects relating to use and the user, and also investigated the cost implications of incorporating and delivering flexibility. The empirical work indicated that the demand of households for housing that can accept change and the developer's desire to build in best practice are the key motivations for implementing flexibility initiatives in housing design. Policy can play a role in driving flexible housing practices, but this is insufficient if the requirements are not mandatory. The potential to increase the size of the plan can lead to best practice for flexibility in the plan and in use. The construction methods need to support flexibility by providing separation between the main structure and the infill elements, allowing clear space between structural elements and using light materials and non- specialist forms of construction for infill parts. It is concluded that the incorporation of flexibility is likely to increase building costs, which may impact on the providers' willingness to build with flexibility. Finally, raising market awareness in regard to building performance is important in making flexible housing deliverable on the market.

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Abbreviation:

LTH Lifetime Home

HVN Housing for Varying Needs

WLH Whole Life House

FEH Flexible Extendable Home

SFH Super Flexible Housing

MKC Milton Keynes Council

MKP Milton Keynes partnership

EP English Partnership

TOKI Toplu Konut İdaresi (Housing Development Administration of Turkey)

HHA Highland Housing Alliance

HCA Home and Community Agency

ODPM Office of the Deputy Prime Minister

PPS1 Planning Policy Statement 1

PPS3 Planning Policy Statement 1

SPP1 Scottish Planning Policy 1

SPP3 Scottish Planning Policy 3

DWH David Wilson Home

Chapter 1 Introduction

1.1 Background to the research

This research seeks to highlight the concept of "flexible housing" to reveal its importance in producing creative options that can accommodate households' changing needs in their dwellings over time. This is a particularly important consideration with regards to the housing stock of developing countries and Middle East countries, which have witnessed a widespread transformation in housing stock, given the rapid process of change that has marked the last decade and affected economic, social, cultural life, etc.

The key principle of this study stems from the fact that housing is liable to change rapidly and unpredictably in contexts that come under pressure from social, economic and cultural forces, and if housing is not able to respond to these changes this will actually reduce the useful life of the building. This situation can be seen in contexts such as Syria, a country which originally inspired the researcher to bring this subject to the fore. Due to the uprising and ongoing crisis since 2011, it has not been possible to carryout fieldwork in this context, so the research has focused on flexible housing in two other countries: the UK and Turkey. However, it is useful to set out here why the researcher was motivated initially to study flexible housing in Syria as an example that would allow understanding of housing transformation in developing countries in the Middle East region.

Until 2011, Syria had been undergoing rapid economic growth and social development for several years. Housing in both the private and public sector was designed for standard users and designs gave no consideration to differences in occupants' characteristics and the changing needs of users over time. Moreover, as people prefer to own their dwelling if possible, households have tended to remain in the same dwelling for a long period of time. Meanwhile, housing policy was focused on solving the quantitative shortage of dwellings caused by population growth, which in 2009 exceeded the world average rate of 1.17% (Central Bureau of Statistics Syria, 2010). Meanwhile, the rapid urbanisation that had been taking place since the 1980s meant that more than 50% of the population living in urban areas by 2008 (Lavinal, 2008). The latter process, which caused increased internal migration of people from the countryside to urban areas and the major cities in pursuit of employment, increased the population growth in these cities to such an extent that the housing sector was unable to respond to the housing demand. Due to the shortage of housing supply created by this increase in housing demand, and families lacking the economic resources to move to a dwelling that better fits their changing needs, occupants have resorted to making adaptations to their current homes.

To focus on a particular example, Latakia [1]city, which was the area of focus in the author's prior research, has seen a rise in recent years of this sort of adaptation of housing. The reasons behind such practices, which occur even in new housing developments, are varied. Often this happens as a response to change in the make-up of the household, such as change in the number and ages of family members. In other cases, it is due to changes in the social, cultural and economic circumstances of households that occur as a result of modernisation, globalisation and urbanisation and directly affect physical housing resources (Abo Kanon, 2008 and 2010). The limited options in the housing market make it difficult for families to relocate, particularly as they often lack the economic resources to buy a more expensive house. The scarcity of regulated land exacerbates their dilemma. Households are often left with one choice, namely, where possible, to adapt their dwellings.

These adaptations made by households to their dwelling have implications for the existing construction, its services and the building's external appearance. For instance, sporadic closures that can be seen in the facades of residential blocks, are as a result of balconies being enclosed, to be used, for example, as an extra sitting room, to add a new function to the plan such as a single bedroom, new bathroom, or expand the adjacent space. Creating these enclosures requires using materials such as glass or masonry bricks. Both the creation of these areas and the resulting change in use puts excess load on this zone. This causes cracks in the construction, leading to deterioration of the loaded elements, and the potential for this part of the building to collapse. Another factor is that these closures not only affect the structure of the building, but can also have a negative impact on its external appearance (Abo Kanon 2010).

[1] Latakia is a major Syrian Province located on the Mediterranean and contains the country's main seaport. Latakia governorate covers an area of 887 sq. miles (2,297 sq. km) and its population was estimated at around 959000 in 2009 (CBS, 2009).

Figure 1.1: Some samples of balcony adaptations in Lattakia-Syria. Source: Abo Kanon (2010).

Internal adaptations of dwellings vary between altering the partitions of rooms and changing their functions. Load-bearing walls are commonly used in the construction of residential buildings and therefore form an essential part of internal partitions. This construction system is recommended by the local authority design regulations for residential buildings, particularly in multi-storey buildings (Building Design Regulations of Latakia, 1979). The wide use of these elements in building designs limits the possibility of change, and drives occupants to remove part of a wall or create an opening. This threatens the construction of the building and constitutes a serious risk to safety. Furthermore, rearranging the configuration of units and functions often requires relocation of "wet spaces" such as kitchens and bathrooms, which are not necessarily placed in the same zone. This commonly causes disruption to services in the building, such as the water pipes and wiring system, and leads to sewage leaks damaging cladding layers inside and outside buildings. Despite the fact that all of these factors may result in premature obsolescence of the building over time, little attention has been paid to the implications for the state of the housing stock, in research or practice.

Despite these severe consequences, housing adaptations are still considered the only way for users to have their say in the design of their homes, albeit within a narrow range of choices. Users do not have any participatory role at any stage in the design process. Therefore, consumers are bound by the range of options delivered by private sector developers. In the public sector, the situation is much worse, due to the stereotypical design of units in terms of size and configuration, as well as the low quality of the housing.

Taking a closer look at the delivery of the design, one can notice that part of the problem lies in the method of construction of the buildings, as both the private and public sector rely on load-bearing walls and short spans between structural elements, as well as a fixed internal partition system. This form of construction restricts both the potential for change after occupancy and the ability to provide a variety of housing types prior to occupation. The other part of the problem emerges from the conventional approaches applied to housing design, which treat housing spaces as fixed entities, both spatially and functionally. In the private residential development field, local authority design regulations are responsible in a large part for restricting innovation in design, as they prescribe minimum standards and fixed proportions for the spaces, leaving few choices to designers. These factors, along with the reluctance of developers to accept adding value to housing in ways that could adversely affect their profit, mean that applying innovation in the design of housing is very difficult.

Amendments to legislation, whether at administrative level or in design codes, exacerbate this situation. For instance, Syrian government law 1/2003, aimed at taking control of the phenomenon of housing transformation, states that adaptations that were carried out by occupants before the date of the law needed to be registered with local authorities, and that any change after this date would not allowed and must be removed by the authority. Moreover, amendments to Latakia local authority's design regulations, issued in 1970 and 1972, made the standards more restrictive in terms of design. A clear example of this is the addition of specifications in terms of dimensions and proportions for open-air extensions such as balconies, which effectively limit the formation of open air spaces in residential buildings.

Legislation on housing policy and related amendments did not go beyond responding to the quantitative demand for housing and the current needs of users, as noted above. Support for provision of housing for young families in the fifth government plan provides an example in this respect. Actions identified included providing housing of small size for young families. Because growth in the size of the family over time was not taken into account, this drove households to increase the internal spaces of their dwellings by adding parts of balconies or even joining two units together where possible. As the plans were not developed to accept such changes, these adaptations caused a series of problems that are likely to negatively affect the buildings in the future. Despite these problems, the mindset in the provision of housing remains short term in this context.

This policy environment does not encourage delivery of flexible housing and practice, but instead promotes inflexibility. This can be seen in many developing and Middle East countries, such as Egypt, Algeria, Turkey, Saudi Arabia, Ghana, Bangladesh, Zimbabwe, Nigeria and so on, where housing transformations are widespread among the housing stock in different cities (Tipple, 2000, Tipple 1999, Salama, 1995, Dasgupta, 1990, Ibem and Opoka, 2013 and Altas and Ozsoy, 1997). For example, Turkey has been undergoing rapid population growth and urbanisation since the 1950s. Major cities in Turkey such as Istanbul and Ankara have experienced continuous population growth due to rural-urban migration (Kellekci and Berkoz, 2006, and Caliskan and Hamarat, 2011). The government, in attempting to solve the housing shortage, has been forced to promote rapid mass housing production in different ways. For instance, the Housing Estate Bank was encouraged to provide housing credit for the middle-higher income groups. The government also encouraged mass housing development through provision of cooperative housing for middle-low income groups using credit from the Social Security Association (Altas and Ozsoy, 1998).

TOKI, which is one of the biggest house suppliers, was established by the government in 1984 and has since then constructed more than 500,000 houses for different income groups. According to Torus and Sener (2013), most of the housing production was built in systematic housing blocks and designed by repetition of certain house types and for average (standard) users rather than catering for differences in users' characteristics, variety of lifestyles and households' changing needs over time. As a result, in order to address their emerging special needs over time, families have resorted to adapting their houses, as they prefer to stay in their own communities and dwellings rather than move (Altas and Ozsoy, 1998). However, Torus and Sener, (2013) reported that the plans of these dwellings reflect little ability for change or re-organisation in response to households' evolving needs, as potential is limited by the construction methods and the difficulty and expense of adapting services systems such as cabling, plumbing, etc.

This situation renders it necessary to study different examples and experiences of flexible housing provision in particular contexts to discover the latent aspects of the equation of policy and practice and learn lessons in order to develop and apply such approaches to different contexts, including Syria.

1.2 Experience of flexible housing in different contexts

The potential for provision of flexible housing is a neglected option in the policy and practice of most developing countries affected by housing transformations, which instead of dealing with this as a “solution”, see it as a “problem”. However, Turkey, as a developing Middle East country, has some, if limited, examples of buildings that demonstrate an awareness of this type of housing design, although there is an absence of a policy and regulatory environment to support such practices. For instance, residential projects in Istanbul developed around the principle of loft design that promotes flexibility in housing through adaptive reuse strategy, such as the Levent Loft 1, Goksu Rope Factory Loft and Misir Loft developments, can be considered as examples of flexible housing design in this context. Meanwhile, another example, Eyraman third stage project, demonstrates how flexible housing practice can emerge in response to households’ need for adaptable housing. In addition, studies and research on Turkey have recently started to pay attention to the importance of the concepts of flexibility and adaptability in housing design as a response to the current state of the housing stock in Turkey, particularly as mass housing built in the last decade to resolve the rapidly increasing housing shortage has proven unable to accommodate demographic change and new emerging lifestyle patterns (Altas and Ozsoy, 1997, Eren, 2010, Torus and Sener, 2013 and Hizli and Mizrak, 2015). The possibilities both in practice and research make this a significant context for selecting flexible housing experiences as case studies through which to explore the motivations that lie behind provision of this housing type, to understand how a design environment with a lack of policy and regulation can support such housing provision, and to determine how successful these practices are in addressing the issue of flexibility in housing design in relation to meeting households’ changing needs. In addition, the geographical proximity of Turkey and Syria, and the similarities between the two societies in terms of the social, cultural and housing context, provide an opportunity to understand and learn lessons about flexible housing design in a context similar to Syria.

In developed countries, the practice of flexible housing has proliferated in the last decade. In the UK, for instance, recent flexible housing design developments such as the Whole Life House project in Inverness, Scotland have been identified as reflecting best practice, and flexibility has been incorporated as a key value in housing design in large scale housing developments such as the “super-flexible” housing project in Milton Keynes, England. In addition, in the UK, retrofitting homes for people who become disabled already costs £350 million per year. With an ageing population, this figure is set to rise dramatically if houses are not developed to be adaptable from the start (Schneider and Till, 2007, p.41). This has resulted in programmes that promote approaches which respond to particular household's changing needs, such as "Lifetime Homes" and "Housing for Varying Needs", developed to create housing adaptable to the needs of occupants as they grow old or become physically impaired. These programmes have been supported by the government to encourage local authorities and developers to deliver housing that can respond to these particular needs, and have currently started to be considered as mandatory requirements in domestic building regulations. Such housing programmes and their implications for policy and practice make this a fruitful context for selection of case studies to enable the current research to explore how the issue of flexibility is being addressed in housing design and how an environment with more policy and regulation could play a role in the emergence of practices for flexible housing.

1.3 Research focus

Housing that can respond to the changing needs of occupants is not a new interest for the author of this study. Rather, this interest in adaptable housing grew through working as an architect for 10 years in the field of housing design in the city of Latakia, in Syria, after the completion of undergraduate studies. The common practice of developing two scenarios of the same plan in the design stage, one for authorisation and the other to be used as the actual plan, was the first step in thinking about how designs can be changed at a later date. The possibility of overriding the restrictive legislations after gaining permission for the building granted the opportunity to create alternative scenarios which were more compatible with the consumers' desires. Furthermore, this evolved towards designing housing with multiple layout solutions according to the desire of the developers and landowners in order to offer different choices for the buyers at the point of purchase, and so the scheme sold quicker than normal. This developed the experience to an advanced stage by attempting to link the current and future needs of different family types with proposed solutions. During this practical experience, which showed different challenges and limitations, either as a result of restrictive legislation to create different floor plans or due to the conventional systems of both the construction and services, the researcher was led to investigate what design approaches can produce flexible designs and how such design strategies are implemented in particular housing projects.

The researcher's Master's studies into the on-going adaptations of existing and newly planned housing in Latakia, Syria provided a clear image of how housing adaptations can respond to the evolving needs of occupants in this context, although the plans were not developed around the principle of adaptable housing. In addition, the highlighting in previous research of housing transformations in some developing countries, in particular Middle Eastern countries such as Turkey, Egypt and so on, has brought more understanding about the equation of adaptations and changing needs, as well as aiding discovery of what further steps can be taken to deal with the issue of adaptations in design practices and legislation. This was followed by further personal investigation into the practice of flexible housing in some developed countries, in particular the UK, where there are recent examples of flexible housing practice, housing programmes and potentially a policy context conducive to flexible housing, and developing countries such as Turkey that have some experience of flexible housing practice but a less conducive policy and regulatory environment. Consequently, concerns later emerged regarding, first, the importance of an environment with more policy and regulation in supporting flexible housing provision in the particular context, second, how flexible housing can respond to households' changing needs over time, and third, the physical approaches required for delivering flexible housing and the possibilities and limitations in terms of their implementation in housing design. These concerns form the focus of this research.

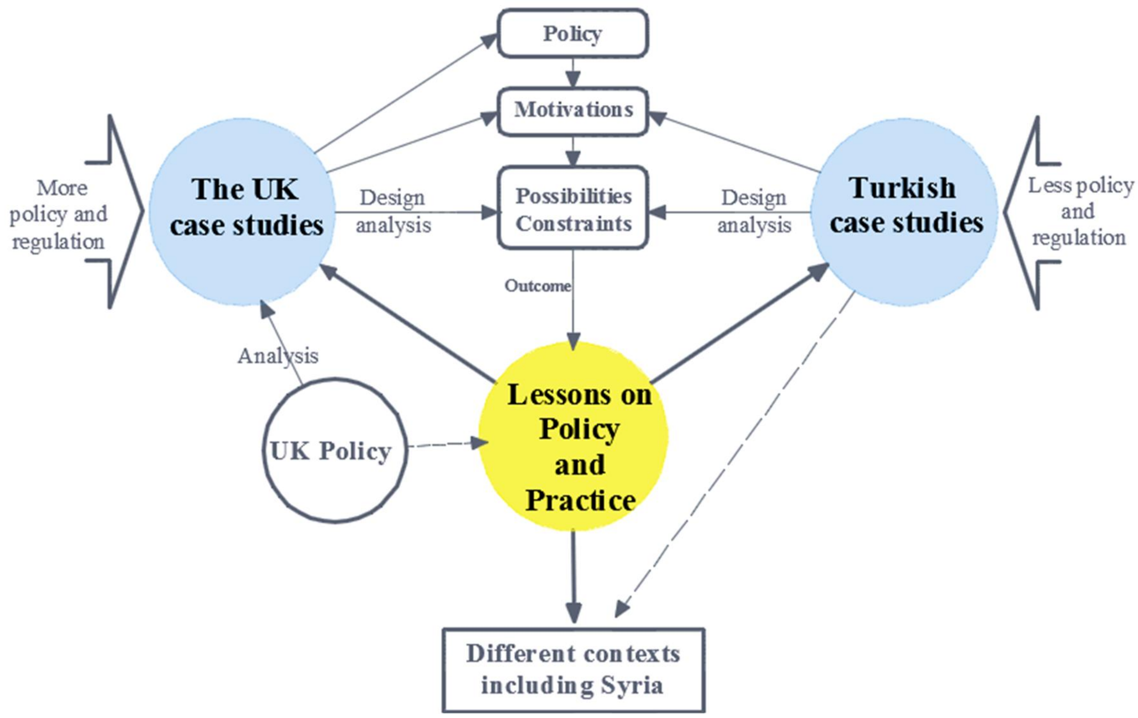


Figure 1.2 Integration of key concepts for this research

1.4 Research aim, objectives and questions

In light of the above discussion, the main aim of this study is to produce and test an analytical framework which permits analysis of different flexible housing practices in different contexts. This framework will facilitate exploration of the motivations, possibilities and constraints of different flexible housing design approaches applied in selected case studies in the UK and Turkey, and consideration of how the policy and regulatory environment in each of these contexts may affect practice, thus providing lessons on practice and policy for further applications of flexible housing in different contexts, including Syria.

Key objective 1:

To investigate the motivations for flexible housing in terms of households' changing needs and develop an analytical framework for the research that allows analysis of flexible housing practices in different contexts.

Key question 1:

What are the changes in household needs that require delivery of flexible housing design and how can an analytical framework be developed to analyse the different aspects of flexible housing design?

Sub-questions:

1.1 - What are the different definitions and forms of flexible housing?

1.2 - What are the changing needs driving households to adapt their dwellings over time in different contexts?

1.3 - What key concepts can be identified as important for flexible housing? How can these be used as a basis to develop a framework for analysis of different aspects of flexible housing design?

Key objective 2:

To investigate and analyse national planning policy and housing programmes relevant to flexible housing provision in the contexts of the UK case studies.

Key question 2:

How do national planning policy and housing programmes promote the provision of flexible housing in the contexts of the UK case studies?

Sub-questions:

2.1 - What planning policies at national level have relevance to flexible housing? How do these policies potentially promote the provision of flexible housing?

2.2 - What are the key housing programmes that promote flexible design in housing in the contexts of the UK case studies? How do their standards promote achievement of flexibility in housing design?

Key objective 3:

To analyse the UK case studies of flexible housing in order to discover the relevant motivations, possibilities and constraints for flexible design, and the relation between policy and practice.

Key question 3:

What are the motivations, possibilities and constraints for flexible housing design in the UK, and how does policy affect practice?

Sub-questions:

3.1 - What existing policies have supported flexible housing provision in the selected projects? What role does policy potentially play in delivering flexible design in the selected projects?

3.2 - What motivations have contributed to incorporation of flexibility into the designs in the case studies? What are the changing needs that drove the adoption of flexible housing strategies in these projects?

3.3 - What are the resulting possibilities and limitations for these flexible housing practices?

Key objective 4:

To analyse Turkish case studies of flexible housing in order to explore motivations, possibilities and constraints for flexible design in these practices in a context with less policy and regulation.

Key question 4:

What are the motivations, opportunities and limitations for flexible housing design in the Turkish case studies, as a context with less legislation and regulation?

Sub-questions:

4.1 - What are the key reasons for flexible design in these practices in the absence of such legislation and regulation? What are the drivers for flexible housing provision?

4.2 - What are the resulting possibilities and limitations for flexible housing practices?

Key objective 5:

To identify lessons and relevant best practice from these experiences in relation to policy and procurement of flexible housing that will potentially benefit future applications of flexible housing in different contexts, including Syria.

1.5 Research Methodology

The research as a whole uses a qualitative approach, focusing on policy and practice. In terms of final results, the housing policy context and housing programmes relevant to flexible housing in the contexts of the UK case studies are examined at different levels theoretically and by using particular case studies to discover how policy affects practice in this context. Moreover, the motivations for flexibility in different case studies are investigated and their flexibility practices are analysed in terms of physical, social and economic aspects. The different methods used for data collection include literature review, interviews with key stakeholders, case study and fieldwork, and analyses such as thematic analysis, document review and analysis of plans.

The following provides a summary of the methods used to achieve the research objectives as set out in section 1.4.

Objective 1 was achieved mainly through conducting an academic literature review, which allowed, first, the investigation of drivers of flexible housing on the basis of households' changing needs that require adaptations to their dwellings. Second, it helped to identify the key concepts in relation to flexible housing, in order to develop an analytical framework for analysis of different flexible housing practices. This framework was tested and refined in the process of meeting Objectives 3 and 4, i.e. through analysis of several case studies in different contexts which differ in terms of the local regulatory and housing environment.

In order to achieve Objective 2, national planning policies and housing programmes relevant to flexible housing in the contexts of the UK case studies, that were in existence during the design stage of these case studies, were investigated and analysed to discover how the policy and regulatory environment of this context could have promoted flexible housing delivery at that time. The main method of inquiry into the policy content was examination of official documents of national planning statements relevant to housing

and sustainable development and published online by central government, which were analysed based on the key definition of flexible housing as stated in Chapter 2, section 2.2. Housing programmes relevant to flexible housing were investigated through a combination of official documents, publications, reports and academic articles, and analysed using assessment tools described in Chapter 3.

Objectives 3 and 4 were addressed through the analysis of information obtained from the selected UK and Turkish case studies by using mixed methods including available documents, reports and publications, drawings and plans relevant to each project, and in-depth/semi-structured interviews with stakeholders of each case study. An assessment of the design approaches of the selected flexible housing project was carried out through the application of the evaluation criteria developed in Chapter 3, whereas motivations and the effects of policy on practice in the UK case studies were investigated through document analysis and stakeholders' experiences.

Finally, to address Objective 5, understandings gained from analysis of the national policy context, housing programmes in the contexts of the UK case studies and the selected case studies of flexible housing in different contexts were integrated to discuss lessons learned on policy and practice that could potentially benefit future applications of flexible housing in different contexts, including Syria.

1.6 Contribution of the research

This study aims to contribute to the existing knowledge in the field of flexible housing design in the following ways:

First, the research seeks to contribute to theory by investigating the motivations for flexible housing in different contexts in terms of households' changing needs that require them to make adaptations to their home over time. This enables linkage between the physical approaches of flexible housing and the different nature of households' changing needs in terms of their dwellings.

Second, the research aims to contribute to theory through developing an analytical framework which allows analysis of important aspects of flexible housing design in different contexts and regulatory and housing environments.

Third, the research seeks to contribute to empirical knowledge of flexible housing through analysing different flexible housing practices that address different aspects of flexibility in housing design in different contexts based on the analytical framework developed by this thesis. This will enable discussion of the best practice and possibilities and constraints regarding creation and implementation of flexible housing in these contexts and other different contexts, including Syria.

Finally, the research intends to contribute to development of a policy framework for flexible housing by investigating how flexible housing practices differ in environments with more or less policy and regulation. This informs how the policy and regulatory context could affect flexible housing practices, and thus increases understanding of the level of importance of the legislative and regulatory environment for delivery of such practices, in different contexts, including Syria.

1.7 Thesis structure

The thesis contains eight chapters structured as follows:

Chapter one, the introductory chapter, explains the motivations and concerns that drew the researcher to this subject. It provides a brief introduction to the research topic and puts forward the key aims of the research, with objectives and research questions. In addition, it clarifies the methodology applied to achieve the objectives and the contributions of the research to the knowledge.

Chapter two initiates a review of the concepts of “flexibility” and “adaptability” in housing design, the key definitions of flexible/adaptable housing, the terminology used and the binary of “soft” and “hard” forms of flexible housing. The second section traces historically the development of flexible housing. The third section investigates the different drivers of flexible housing in terms of households’ changing needs through undertaking a wide ranging and in-depth review of literature dealing with housing design.

Chapter Three reviews the main concepts of flexible housing and their relevant indicators and evaluation criteria, and then draws these together in a framework for analysis of a series of case studies in different contexts.

Chapter Four explains the research approach and methodology, which includes discussion of the case studies of the research and the methods used for collection and analysis of data.

Chapter five explores and analyses national planning policy in England and Scotland (the national contexts of the UK selected case studies), including approaches and objectives in relation to housing, particularly those in existence at the time of the design stage of the selected projects. It discusses how the policy context potentially supports flexible housing provision in these contexts. Moreover, it discusses housing programmes that promote adaptability in housing design from the outset to enable response to households' changing needs in the contexts of case studies such as Lifetime Homes in England and Housing for Varying Needs in Scotland, and examines the scope for flexibility in their standards through document analysis and assessment tools developed in the analytical framework.

Chapter six first considers those local authority policies relevant to the contexts of the selected case studies in Scotland and England that were in existence at the time of the design phase of the selected projects, and discusses how they potentially encouraged flexible housing provision in these contexts. It also provides analysis of policy and practice in relation to two selected flexible housing projects in different contexts, in order to advance understanding of how policies at different levels (national, regional and local) could affect practice, identify the motivations behind these practices, and explore the possibilities and limitations of the flexible design approaches in each case.

Chapter seven presents an introduction to housing provision in Turkey, followed by a brief discussion of the planning system and Turkish housing policy. It then provides analysis of two selected flexible housing examples in two different contexts -Istanbul and Ankara- in order to explore the motivations for implementing flexible housing and the opportunities and constraints for designing and delivering flexible housing in this context.

Chapter eight summarises the main findings and draws conclusions regarding the key research questions and objectives by identifying actions that could promote delivery of flexible housing in different contexts, including Syria, especially in regard to policy and practice. Finally, the chapter outlines opportunities for further study.

Chapter 2: The key definitions and drivers of flexible housing

2.1 Introduction

The key ambitions of this chapter are to review and discuss the main concepts surrounding flexible housing, to identify why flexible housing is important and the different and changing household needs that require provision of flexible housing. This contributes to addressing objective 1 of this research which seeks to develop an analytical framework for the research and identify drivers of flexible housing based on evolving needs.

In order to discuss flexible housing, the chapter reviews the concepts of flexibility and adaptability in the housing context and discusses definitions of adaptable and flexible housing in recent studies by Friedman (2002) and Schneider and Till (2007). The different social and economic benefits that may accrue through the delivery of flexible housing are also highlighted. The main focus of this chapter, however, is to review households' changing needs that may create the need for changes to their home over time.

2.2 Historical background

According to Schneider and Till (2007), historically, the notion of flexible housing has developed into two ways: first, through the development of the vernacular house, and second, due to external pressures that drove architects to create flexible design solutions for housing.

In the former case, the roots of flexibility can be traced to the innate capacity of the vernacular house to evolve according to the changing needs of its occupants. Oliver (2003) acknowledges the legacy of the vernacular in the emergence and development of flexible housing. Here, the roots of soft architecture can be seen in the way that vernacular architecture can accommodate changes, additions and extensions. Vernacular housing's readiness for adaptation is set in sharp contrast to the rigidity of the modern housing system.

In the latter case, the notion of flexibility was begotten through the marriage of two social and ideological forces during the post WWI era: mass housing crisis and modernist ideologies. In this respect, flexibility can be traced through the ways in which European nations were driven to respond to the post WWI increasing demand for housing. Deemed no longer useful, old models of housing were replaced by new ones that focused on cost minimisation and reduction of space to address the crisis in mass housing provision.

Designers by that time had begun to realise the necessity of providing apartments to fit the various needs of their occupants through looking at the processes of use, changeability of use and the use of spaces in as efficient and flexible a manner as possible. By crossbreeding these concepts with the modernist ideologies of Bruno Taut, new models of housing with variability in plan forms marked the beginning of flexibility as a trend that allowed architects to revolutionise housing and living patterns. Taut's famous sentence: "versatile is the house: just like men, flexible yet solid" (Schneider and Till, 2007, p17), is not only a reflection of the new models of housing but rather an ideologically laden utterance that reflects the new liberating trends and dynamism of modernity. Put architecturally, every house, however finalised it may be, is still in the making process. Lissitzky said in this context: "every form it might take at a certain time is a frozen momentary image of a process....it is a moment of becoming and not a solidified end" (Schneider and Till, 2007, p17).

These new models of housing which focused on cost minimisation and space reduction techniques were known as minimal dwellings (Teige, 2002). The emergence of flexibility in minimal dwellings in this era was twofold: social/non-architectural and physical/architectural (Schneider and Till, 2007). In the former, flexibility can be achieved through the provision of rooms with indeterminate use, whereas the latter has to do with how to render the parts of a house alterable, such as by using foldable furniture, and thus to deliver more internal variability.

It has been argued that flexibility in housing design was enhanced during the housing crisis of the late 1920s through the adoption of industrialised means of housing provision based on new technological advancements. Seeking a solution for the unprecedented demand for houses, designers started to develop methods of building houses using industrial prefabrication (Schneider and Till, 2007). Advocators of prefabrication such as Gropius (1910) and the like suggested that through using modularity and standardisation of building components users could be offered more choice and variability (cited in Davies, 2005). In this sense, houses were seen as constituted of a set of components rather than as finalised products, and through the various choices of components users could have more potential for variability.

Here one can see the strong link between industrialised methods of housing and the notion of prefabrication, though arguing for flexible prefabricated housing is a much trickier task. The basic principle behind prefabricated houses in terms of flexibility is the capacity for moving and altering their separate components in a fairly customisable manner. To this can be added the efficiency argument propounded by Gropius (1910) which drew attention to the minimisation of site time and the better quality achieved through industrialized mass production (cited in Davies, 2005).

It is not hard to perceive the modernist cues of liberation and freedom of choice implied in the variability and efficiency arguments. Influenced by technological advances as well as the new trend towards customisation though prefabrication, the 1940s-era marked the introduction of the one permanent partition including all the plumbing, with all the other parts kept movable and subject to family transformation needs (Wurster, 1942). However, Davies (2005) problematised the history of prefabrication through dividing it into two main parts. The first is architect driven and embodied in the single projects of Le Corbusier and the like. The second is non-architectural and was apparent in the United States in the 1940s through the industrialised methods of housing production. The latter type was said to offer more choices to the user and to provide economies of scale (Davies, 2005). Yet it is not very difficult to see how long term flexibility was sacrificed on the altar of short-term freedom of choice when large parts and even entire houses were prefabricated. In this sense, Gropius' idea of the long-term flexibility of prefabrication based on the simple idea of movable parts crumbled under the extreme efficiency argument for economic production of housing. At this stage of industrialisation in the development of flexibility a war erupted between long-term flexibility on one hand and immediate provision and short-term customer satisfaction on the other.

2.3 The concepts of flexibility/adaptability and adaptable/flexible housing

Flexibility and adaptability in the context of housing have been variously conceptualised. Researchers such as Rabeneck et al. (1973, 1974) and Groak (1992) have viewed flexibility and adaptability as two separate yet complementary concepts. Others, like Maccreanor (1998), have seen flexibility as inclusive of adaptability. This has sparked off considerable debate among researchers in the domain of flexibility in housing. However, two main arguments that follow the above perspective have succeeded in adopting different views by utilising the two terms as interchangeable adaptable/flexible housing (Friedman 2002; Schneider and Till 2007).

Historically, flexibility as a concept emerged in response to what came to be known as "tight-fit functionalism", which characterised the unhealthy condition of mass housing in twentieth century Europe, and which is depicted by Rabeneck, et al. (1973, p.698) as "miniaturized living areas with cell type rooms which do not allow any changes". According to Rabeneck et al. (1973, p.698), flexible housing should be capable of accommodating "choice" and "personalization". This is set in sharp contrast to the "tight-fit functionalism" which allowed none of these whatsoever. However, early unsuccessful attempts at flexibility led them to criticise what they term "the fallacy of freedom through control" (ibid: p.701), where flexibility can lead to housing projects being too complex and technical. They eventually determine the scope of flexibility in housing design so as "to provide a private domain that will fulfil each occupant's expectations" (ibid: p.709). They conclude that flexibility ultimately deals with "constructional technique and services distribution" (Rabeneck, et al., 1974, p.86).

Adaptability in the context of housing is defined by Rabeneck et al. (1973, p.699) as producing housing units that "can be easily altered as circumstances change". In this sense, adaptability, unlike flexibility, deals with planning and layout aspects of buildings such as "slightly generous openings between spaces and little overt expression of room function" (Rabeneck, et al. 1974, p.86), whether regarding the sizes of rooms or the relationship between them. Seen in this light, according to Rabeneck et al. (1973), flexibility and adaptability are two separate yet complementary concepts. Flexibility deals with the configuration of the infill parts of a building or physical change, whereas adaptability is concerned with issues related to the actual architectural layout of the remaining spaces of the building, i.e. with how the rooms are organised, their dimensions and the relationship between them, and thus non-physical change.

Following Rabeneck et al., Groak (1992, p15-17) defines flexibility as the "capability of different physical arrangements" in relation to both the interior and the exterior of a unit of building. However, he conceptualises adaptability as the "capability for different social uses". In this sense, he stresses the physical/non-physical opposition between flexibility and adaptability respectively. Flexibility in the context of housing is meant to refer to different physical arrangements, whether internal or external, to suit different needs, whereas adaptability in the same context is mainly concerned with how internal spaces are manipulated to suit different needs non-physically. Thus, Groak concurs with Rabeneck et al. in the distinction of the two concepts of flexibility and adaptability as separate yet complementary, but not in the same way.

Against this distinction between flexibility and adaptability in the context of housing (physical/non-physical), Maccreanor (1998) views flexibility in the context of housing from a problem oriented perspective. He goes a step further in this debate of terms by uncovering the contradiction that arises when using these terms in the context of housing. In this sense, flexibility no longer implies “endless change and breakdown of accepted formula…as the most adaptable buildings were those not originally planned for flexibility” (ibid, p.40). Therefore, Maccreanor (1998) suggests that flexibility is inclusive of adaptability and that “adaptability is a different way of viewing flexibility” (ibid, p.40). In this sense, flexibility is meant to refer to both physical and non-physical changes in the plan. Hence, the concept of flexibility can be used as an inclusive term to refer to the binary of physical and non-physical change in design.

As has been discussed above, the concepts of flexibility and adaptability have provoked many contradictory views which have led to many misinterpretations. However, Friedman (2002) and Schneider and Till (2007) introduced the concept of the adaptable/flexible house which avoids the contradictions that surrounded the two notions of flexibility and adaptability. The notion of the adaptable house was introduced by Friedman (2002, p:12) to mean “the refitting of a physical environment as the result of a new circumstance”. On the other hand, Schneider and Till (2007) adopted the term of flexible housing to refer to “housing that can adjust to changing needs and patterns both social and technological.” (ibid: p4). In this sense, adaptable and flexible housing emerges as the broadest term by including physical and non-physical change. Therefore, the two terms can be used interchangeably to refer to housing that can be adapted, whether via altering the physical or the non-physical fabric.

Moreover, the two definitions of the terms infer that flexible housing is a process within which the physical and non-physical elements of architecture should be at the disposal of social needs and goals. Similarly, Maccreanor (1998) infers that flexibility should be seen as a means to a social end rather than in physical terms, and the fact that this end represents the users’ needs and desires prevents any attempt to see it as separate from its social dimension. Therefore, adaptable/flexible housing cannot be achieved in an absolute sense and any attempt to separate it from its social context strips it of its significance and usability as a concept that exists to achieve the main end of responding to users’ needs and desires.

Consequently, this study adopts a rather pragmatic stance by using the two terms interchangeably to refer to physical or non-physical change. The review of adaptable housing and flexible housing definitions differently revealed the possibility to use both terms interchangeably to refer to the same notion. It should be borne in mind that the ultimate objective of flexible housing is to produce design that is flexible enough for different social uses. Therefore, the point of departure of this study is to investigate the social elements that brought about the need for flexibility in housing design.

2.4 Soft and hard concepts of flexible housing

Schneider and Till (2007, p: 6) devised a simple categorisation of flexible housing as “soft” or “hard”, which can reveal the different nature of flexibility in much flexible housing in terms of use and form. “Soft refers to tactics which allow a certain indeterminacy, whereas hard refers to elements that more specifically determine the way that the design may be used” (Ibid, p: 7). Therefore, the binary of soft and hard in terms of use reveals whether flexibility is achieved through indeterminate or determinate form in the plan. According to Schneider and Till (2007), soft use generally requires more space and a relaxed attitude towards space planning and technology, to allow the user to adapt the plan based on their own terms. Meanwhile, hard use relies primarily on the architects’ determination of how space can be used and adapted over time, and where space is ideal for use. Seen in this light, user and architect control over design are also key considerations in distinguishing between the binary of soft and hard flexibility in design in terms of use. In this sense, as Schneider and Till (2007, p: 7) suggest, hard use came to the fore “as a set of mechanisms that frame the user as an operator of architectural equipment”, where the architects work in the foreground. On the other hand, soft use passes control over to the users, allowing them to play “the role of facilitator rather than determiner” (Ibid, p. 7).

Schneider and Till (2007) also use the soft and hard analogy to distinguish between forms and methods of construction in flexible housing. Hard forms “are those that have been developed specifically to achieve flexibility” (Ibid, p: 7). Therefore, in this form of flexible housing, the construction system is the main consideration in flexible housing design, and is designed only to fulfil this ultimate goal. Soft form, on the other hand, is “the stuff that enables flexible housing to unfold in a manner not completely controlled by the foreground of construction techniques” (Ibid, p: 7). According to Schneider and Till (2007), this form can be recognised in a number of flexible housing schemes, many of which rely primarily on a grid structure with no loadbearing internal partitions, or the use of a beam and column structural system that allows the user to adapt and fill the frame according to their needs and wants. This can be seen in the Brandhofchen scheme designed by Kramm and Strigl in 1995 in Germany, as four storey rows of housing. The plan was designed with a regular grid structure of columns and beams, so none of the internal partitions are load-bearing, and with the services core (kitchen, bathrooms and entrance) located on one side (at the north façade), allowing different layout arrangements and combinations between the units to be developed over time (www.afewthoughts.co.uk) (see figure 2.1).

Figure 2.1: Brandhofchen scheme, Kramm +Strigl, Germany, 1995.Soft form flexibility. Source: (www.afewthoughts.co.uk)

In summary, the binary of soft and hard flexibility in terms of use and form revealed that indeterminacy or determinacy in the approach of the design practice and use of a specialised or non-specialised system of construction identify the different characters of flexible housing and reflect the designer's attitude towards control. The research adopts these themes as generic concepts for flexible housing to determine the different types of flexibility through the selected case studies and explore their impact on the possibilities and limitations of flexibility in design.

2.5 Post-occupancy evaluation (POE)

According to Prieser (1995, p. 19), "post-occupancy evaluation is a diagnostic tool and system which allows to identify and evaluate aspects of building performance systematically". This aids in identifying problems in existing buildings and developing design guidance and criteria for future buildings.

Historically, POE was first used to explore problems in terms of building performance of institutional care facilities, such as mental hospitals, nursing homes, and correctional facilities, through taking into account the perspective of the buildings' users. This contributed to identification of commonly shared problems affecting these buildings' performance, such as health and safety problems; security problems; leakage; lack of privacy; handicapped accessibility problems; lack of storage; poor air circulation and temperature control. Since then POE has been used in a number of countries for different building types such as residential and office buildings, police facilities, and military services. (Prieser, 1995).

Prieser (1995) explains that the term "post-occupancy evaluation" has been criticised by some experts as it appears to refer to building evaluation only after occupancy, whereas the evaluation process should be undertaken throughout the different stages of the building delivery cycle. Therefore, alternative names such as "building diagnostics", "building pathology" and more recently, "building evaluation" were introduced that attempt to bring together both the technical aspects of building performance (structural, mechanical, etc.) and those building performance aspects which affect the building's occupant/end-user, thus offering a truly comprehensive perspective on evaluation.

Gifford (2002) outlined four dimensions for distinguishing different forms of POE. First, POEs can be based on buildings' "size and scope" according to the amount of resources invested. Second, the dimension of "generality" can distinguish between POE designed specifically for one building, meaning that the results are not applicable to any other building, and POE developed with the explicit expectation that the results gained from the study will apply to other buildings with similar functions. The third dimension, "breadth of focus", relates to the range of building characteristics considered for evaluation; in some cases, the focus may be on only one or two building aspects, while in others a much larger range may be evaluated. Finally, "application timing" is concerned with when the result may be needed; therefore, in some cases the POE may provide information after, for example, one month, while in other cases the POE may not be tied to a particular date.

It can be concluded from the discussion above that POE can be applied in different ways and for different purposes to assess and improve various aspects of building performance, and thus can be used as a tool in systematic evaluation of building performance in relation to flexibility, throughout the entire building delivery cycle. This can help in identifying problems affecting flexible housing design and in developing appropriate solutions in response to households' different needs, enabling the positive and negative lessons learned to be fed forward into the design of future buildings.

2.6 The importance of flexible housing

Housing is volatile, subject to unpredictable changes over its life cycle, and it has always been required to adapt and change dwellings according to the household's varying needs. According to Habraken (1972, p. 35), it is imperative to see housing in relationship to the living phenomenon, which is in a constant state of change. Therefore, he considers that "the test of ability of a building to cope with time lies in its ability to adapt and accept the new and to alter part by part". On the other hand, Friedman (2002) argues that in a society marked by constant change, it is difficult if not impossible to foretell future tendencies with precision. However, he stresses that homes will continue to reflect the trends and lifestyles of their occupants, and thus the dwelling is certainly changeable over time and needs to be framed intellectually and physically as a dynamic. Similar beliefs were advocated by Schneider and Till (2007, p: 35) when they wrote: "housing is inevitably dynamic, subject to a whole range of cyclic, non-cyclic and tendency changes". Such changes would include demographic tendencies, national economic performance and technological developments. Therefore, at a basic level, the previous academics collectively viewed that the importance of flexible design lies in its ability to respond to these inevitable changing conditions in the living environment.

Furthermore, the literature suggests that the flexible design of housing can enhance user empowerment over their dwellings and contribute to stabilising communities, and thus it brings social benefits to the context. The idea of user involvement can be traced to Habraken (1972, p: 13) who, in his book *Supports: an Alternative to Mass Housing,* makes it clear that the ultimate consideration in creating housing that can cope with change is neither technical nor architectural; rather it is more about user participation and involvement. Schneider and Till (2007) similarly claimed that flexible housing means that users are no longer standardised stereotyped receivers; rather, they now have their say in how their homes should be designed and built. They argue that the new trend towards flexibility and user involvement is not only the result of architectural forces, as sociologists also believed that dwellers should be able to take part in the design process and to personalise the layout of their dwelling according to their needs and wishes. They go so far as to suggest that flexible housing can promote user empowerment in three different ways. The first is through the customisation of housing, which gives potential buyers different options over their future dwellings pre-occupancy. The second is through user participation which permits the customers to modify designs in all development stages. The third way is through enabling users to make adaptations themselves after occupancy based on their future needs. This is explained in more detail in Chapter 3, section 3.5, in the discussion of user empowerment among the key concepts of flexible housing design.

Social benefits of flexible housing are not confined to the idea of user involvement, but also can be observed through its influence in stabilising communities. According to Schneider and Till (2007), flexible housing contributes to creating stable communities through its ability to respond to demographic change. They argue that flexible housing can be adapted to accommodate unseen and uncertain demographic developments such as an increasing number of older aged occupants and emerging trends in family structure (single households) and lifestyle (home working), which are persistently changing over time. Moreover, they claim that flexibility in design allows housing to respond to changing needs throughout the individual's lifecycle, deriving from such as ageing and decline in physical or mental ability, and changing needs in terms of family structure over time, which are, according to both Schneider and Till (2007) and Friedman (2002), the key reasons that drive occupants to relocate. Hence, by reducing users' need to move and encouraging them to stay in their homes longer, flexible housing improves the coherence of communities. On the same lines, Habraken (1972), in his critique of mass housing, argues that the rigidity of mass housing creates the need for occupants to move at each new stage in their lives and at each change in the family structure. This means that inhabitants are continuously on the move, "in a manner which reminds one of primitive tribes who, after exhausting their pasture, move to fresh fields", therefore, "we have to make possible the creation of districts ……….in which the population can live for generations, and which incorporate potential for change" (Ibid, p: 38 and 39). Consequently, Schneider and Till (2007) contend that through its ability to stabilise communities by involving users and responding to changing demographics, flexible housing embeds itself at the heart of social sustainability.

In addition to the social benefits, academics such as Habraken, Friedman and Schneider and Till go on to suggest that flexible housing has significant advantages from an economic perspective. In this respect, Schneider and Till (2007) argued that flexibility is a beneficial economic strategy in the long term since it reduces obsolescence of the housing stock. Habraken (1972, p. 89) similarly claims that because flexible support structures have such a long lifespan, "in the long run, they might well prove to be the cheapest way of building dwellings above the ground". Hence, these academics agree that the key economic benefit of flexible housing is based on the long-term vision of its ability to be upgraded over time, which gives it longevity. Flexibility can thus be seen as meeting both economic and social criteria of sustainability in housing. If it also provides a response to climate change, flexible housing can offer a comprehensive range of sustainability solutions.

Schneider and Till (2007) also suggest that due to its capacity for adjustment, whether regarding technological systems, servicing strategies or spatial principles, flexible housing can be cheaper in the long term because there will be lower maintenance costs and less need for wholesale refurbishment, thus avoiding long-term capital expenses. However, the long term benefits of flexible housing are still unproven and cannot be exhibited in a transparent manner. Although difficult to quantify, financial benefits can also be manifested through latent elements of flexible housing such as user satisfaction. In this regard, flexibly designed housing is more desirable to customers at the point of purchase, thus such houses sell faster and at an increased price.

Friedman (2002) identifies additional economic aspects of adaptable housing that directly affect households. In his view, adaptability in housing can have promising cost reduction benefits through, for instance, "progressive occupancy" strategy which entails leaving a certain space in a home unfinished or unbuilt to reduce the upfront cost, with the intention that users complete it in accordance with their desires at a later date when finances permit (Ibid, p.11). Friedman and Krawitz (1998) go further and suggest that affordability can be enhanced by integrating flexibility into the design to enable it to meet the needs of the household's current financial situation. They identified working from home as an instance that can require transformation of part of the dwelling. In flexible housing, such adaptation can be an easy task and less costly than renting an office space. Furthermore, Friedman (2002) considers that adaptation of housing can be cheaper than relocation, as relocation fees may be costlier than the process of adaptation. This concurs with Schneider and Till's (2007) finding that flexible housing has the financial benefit of decreasing the need for inhabitants to relocate.

The previous paragraphs have discussed the potential social and economic benefits of flexible housing, but according to Schneider and Till (2007), user involvement also has political benefits. As it has been argued previously, flexible housing treats the user as a participant in the design process along with architects and planners, and empowers the potential occupant to make changes during any stage of the work. Thus, by ensuring that users have their say in their future dwellings, flexibility promotes democratisation of housing.

From the review above, it is concluded that there is general agreement among academics on the potential economic, social and political benefits of flexible and adaptable housing. However, by differently accentuating the various benefits of flexible housing, these authors have enriched discussion of this topic. Having highlighted the benefits of flexible housing, he following sections build on the above discussion in reviewing the changing household needs that drive incorporation of flexibility in housing design.

2.7 Drivers for flexible housing

It has been argued in section 2.2 of this chapter that the essence of the notion of flexible housing is its ability to respond to the household's different and changing needs over time; therefore, this section discusses the changes in household needs that drive incorporation of flexibility in housing design. This discussion includes a wide ranging and in-depth review of flexible housing literature, residential adaptations and mobility studies.

Drivers for flexible housing have been variously classified by academics. Authors such as Friedman (2002) adopted a direct down-to-earth reason-generated approach to depict the reasons that create the need for flexible housing. In this regard, he identifies the four following key conditions: "Family transformation, preparing for old age, fitting new technology, and affording in stages". Although the foregoing factors clearly reflect a non-systematic approach to assessing drivers, they serve to highlight different sources of change. Family transformation and preparing for old age can be related to changes in demographic characteristics of the household. Affording in stages discusses the usefulness of adaptable design in responding to economic changes in the household, whereas fitting new technology directly relates to the technical aspects of housing.

Schneider and Till (2007) offer a systematic framework by which to understand the reasons that shape flexible housing. In their classification, Schneider and Till (2007) highlight an external/macro internal/micro division of factors, using a more sources-oriented approach. External/macro factors or "external demographics", to use their term (Ibid, p: 37), include issues emerging from changing demographics such as new family types and "cultural heterogeneity" (Ibid, p: 38), whereas internal/micro factors or "internal dynamics" involve changes in household circumstances such as changing needs of individuals as they grow older or less physically able, and the changing constitution of the family as it grows and then contracts (Ibid, p: 41). Whilst this approach tends towards a source-generated method which views the forces for change as arising from either the external or internal housing environment, this research seeks to identify these different forces and classify them as sources with direct relevance to the household, regardless of whether they are external or internal.

To further understand the sources of change in household needs that drive flexible housing provision, the research undertakes a review of studies on residential adaptation and mobility. Such studies focus generally on the role of the household lifecycle in the decision to move (Rossi, 1955; Coupe and Morgan, 1981; Clark and Onaka, 1983; Parrott and Lodi, 1991 and Morris and Winter 1991). The relevant literature suggests that changes in the household lifecycle relate to changing characteristics of the household as it progresses from initial formation to dissolution, thereby generating mobility or remodelling. The types of characteristics that undergo change may be demographic, economic or cultural. Demographic variables may include changes in household structure, such as in household size, which is the most frequently cited reason for both housing adaptation and relocation (Clark and Onaka, 1983 and Parrott and Lodi, 1991). Economic aspects include changes in household income and employment status, which can primarily lead to household relocation (Rossi, 1955). Furthermore, Morris and Winter (1991) argued that households assess their dwellings in terms of cultural norms and if their housing cannot meet these norms, a normative deficit occurs and the occupants become dissatisfied with the dwelling; thus they have to either adapt their home or relocate to satisfy their housing aspirations.

Consequently, this research classifies drivers for flexible housing based on different sources of changes in household needs that might be demographic, cultural, economic or technical in nature. The following sections investigate these different sources of household changes in relation to their implications for housing.

2.7.1 Changes in the household's demographic characteristics

Change in demographic characteristics that occurs in a single individual household is referred to as internal change, and includes such as changes in size, age and physical ability within the household, while change at the level of several individual households is referred to as external change. The literature on flexible housing has extensively highlighted these changes as key drivers for incorporation of flexibility and as changes that inevitably occur during the household's lifecycle, which often require adaptation of the home or relocation. Therefore, this section discusses these changes in households' human assets and their potential impact on the household's housing needs, and highlights the importance of flexibility in housing design in responding to such needs.

1- Change in household size

The size of the household is liable to change over time, as the household grows in number when, for instance, a child is born, or as the household contracts in size when, for example, a grown-up child decides to move out. Schneider and Till (2007) argued that housing needs to be flexible enough to respond to "the changing constitution of a family as it grows and then contracts". Friedman (2002, p. 4) also referred to growth in family size in his discussion about "family transformations" as a motivation for adapting the home, stating that "young couples who purchase a home may need one bedroom at first, but later, as their families expand will need additional space". Friedman (2002) explains that as the family grows in size the need for additional space becomes paramount and creates a need for a change in housing

The housing adjustment literature makes clear that increase in the demand for space caused by an increase in household size is a major generator of decisions to increase housing consumption, which lead to housing adjustment (Michelson, 1977; McLeod and Ellis, 1982; Seek 1983). Tipple (2000, p.23) described this succinctly: "as a household increases in size through the addition of children or other dependants, or reduces when the children leave to marry and form their own household, needs and demands for space will change". Through his study of housing transformation in developing countries such as Bangladesh, Egypt, Ghana and Zimbabwe he suggested a transformation model of how housing consumption changes over time. The model showed the different types of demand for space through the household lifecycle, and similarly indicated an increased need for space as more children or dependants join the household and a reduction in the need for space below supply level as parents are left alone when grown up children decide to move out (see figure 2.2).

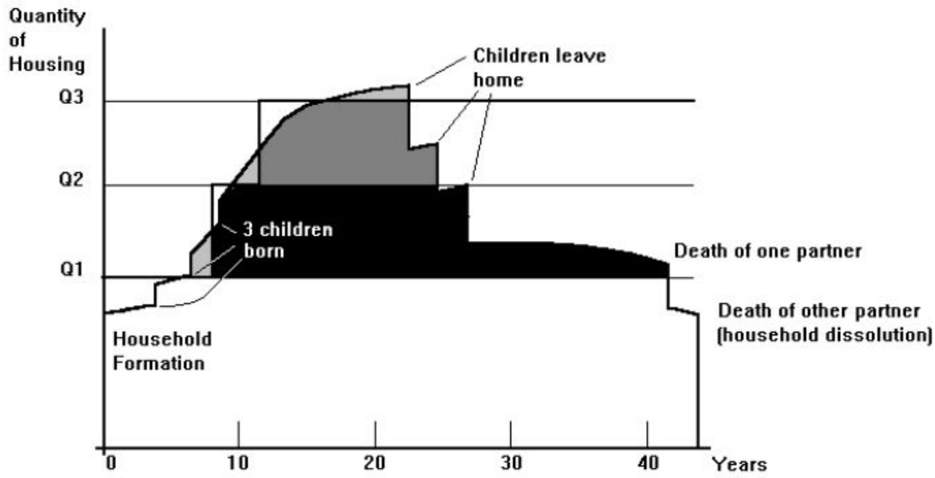


Figure 2.2: Changing patterns of housing consumption. Source: Tipple (2000)

The former trend, conceptualised by Seek (1983) as a growing mismatch over time between current level of consumption of housing and the demands and preferences of the occupiers for space, is termed "housing stress". However, households vary in their stress threshold, which is "the point at which some action is taken to relieve rather than continue to tolerate it" (Tipple, 2001, p.24). Seek (1983) and Tipple (2000) consider that the arrival in the household of additional members such as a new baby or elderly parents is a discrete event which markedly increases housing stress.

Empirical studies about housing transformation in developing countries such as Egypt, Ghana, Bangladesh, Saudi Aribia, Zimbabwe and Nigeria (Tipple 2000, Tipple 1999, Salama, 1995, Ibem and Opoka, 2013 and Al-Naim and Mohmud, 2010) have all identified change in the size of a household as an event that changes the demand for space and drives the household to change their dwelling. For instance, a study that investigated the physical transformation of dwelling units on low-income housing estates in Lagos, Nigeria indicated that a large percentage of people who had transformed their houses by increasing the number of bedrooms did so to accommodate children (Ibem and Opoka, 2013). Similarly, a study that investigated the addition of self-help extensions to government-built housing in developing countries such as Bangladesh, Egypt and Ghana found that the main motive for extending these dwellings was to accommodate growth of the household caused by the arrival of a new child or other dependants (Tipple, 1999).

In summary, household size is subject to change over time and this has a great influence on housing, particularly when the household grows, as it leads to housing stress and eventually to housing adjustment either through housing adaptations or relocation. Studies have extensively indicated that change in household size results in change in housing consumption and in the demand for space, which however differs among contexts. Therefore, housing needs to be flexible to respond to such change in household demographic characteristics over time.

2- Changing needs of growing children

Friedman and Krawits (2002, p: 97) state that “the family is the dynamic entity which generates the need for change, and the home is the arena in which the changes are played out”. They reported that interaction between parents and children gradually increases as the infant enters the toddler stage. The home life of children might involve use of the whole house and its different spaces to accommodate their newly emerging activities. For instance, the kitchen can be used as a space for play, the dinner table might be suitable for doing homework and the living space can be utilised for play and games. Furthermore, the functions of rooms might be switched from nursery to bedroom to study space, and very likely back to a bedroom again. Therefore, they suggest that housing design concepts need to welcome and accommodate the participation of the child in everyday household goings-on.

Throughout the home life of children, two stages can be considered: pre-school and the school years. In the first stage children spend most of their time playing and participating in different household activities with their parents, and all spaces in a house are possibly used for their activities. Therefore, housing design needs to be adapted to facilitate access to different spaces and accommodate such activities. During the school years, Friedman and Krawits (2002) point out that in addition to playing, watching television and other daily activities that usually happened before this stage, children have to spend time on their homework and have less time to play indoors, which requires allocating a space in the home for schoolwork. In terms of the transformation of children from toddlers to young adults, Friedman (2002) identifies privacy as the key emerging need among teenagers. Deilmann et al. (1973) described this period as a low point of family interaction, because although the child is still under the protection of the family, he/she exhibits constantly increasingly independent behaviour. It is therefore essential to accommodate teenagers’ various activities such as sleeping, doing homework, entertaining and meeting their friends, by giving them an independent space to call their own, possibly in their bedrooms or an unused space in a basement.

Consequently, the main impacts on the dwelling of children growing up at home are the increasing demand for shared activity spaces such as the kitchen and living space to accommodate different activities at the same time, and the need for children to have additional space as they become teenagers and want more privacy.

3- Requirements relating to children's gender

The literature review indicates that when children reach a certain age, requirements relating to their gender create the need to make changes to the home. Morris and Winter (1976) claim that there is a relationship between the number of bedrooms in the dwelling and resident children's gender, stating that when children reach a certain age, different genders may require separate bedrooms. Also, Brich (1973) points out that in looking for new housing, a main consideration of families with children of different gender is for each gender to have separate bedrooms. Winter and Stone (1997) view that children's gender is a crucial issue in considering age limits for sharing bedrooms. Moreover, Tipple (2000) cited that in most cultures, a married couple with a grown up (over 16) son and daughter would require three rooms. Further evidence can be traced through empirical studies of housing transformation in developing countries such as Egypt, Algeria, Bangladesh, Ghana and Zimbabwe that frequently mentioned the need to separate children of different gender once they reach their teenage years as a reason for housing adaptations (Salma, 1995, Tipple, 2001 and Sibley, 2002). For instance, a study that explored types and patterns of transformation and their explanatory factors in public housing projects in two Egyptian cities - El Zawya el Hamra and Helwan - indicated that most of the transformers expressed the importance of providing separate rooms for children of different gender as they become teenagers.

To sum up, children's gender is a factor that creates a need for change in the family home due to the need to provide separate rooms for children of different gender, and thus housing needs to be designed flexibly to respond to this need.

4- Ageing and disability

Studies on ageing overwhelmingly report that elderly people prefer to spend their later years at home rather than in an institution, for reasons of dignity, autonomy and independence (Turcotte and Schellenberg, 2007, Fange and Ivanoff, 2009 and Ekstam, 2016).

Older people are susceptible to long-term illnesses, functional challenges, and disabilities which can affect their sensory, cognitive, and mobility functions. The impact of age on mobility is also evident to the casual observer. The range of body motion becomes restricted, muscle strength declines, and the body becomes less flexible. In addition, reflexes become slower, trunk height and arm reach decrease, making it harder to reach objects in the home (Kroemer, 1997 Farage et al., 2012).

Therefore, researchers such as Gitlin (2001, 2003) and Johansson et al. (2007) assert the need for home adaptations to compensate for older people's physical decline. Gitlin et al. (2001) and Friedman and Krawits (2002) consider that the bathroom and the kitchen are the most important spaces to adapt in supporting independent living of the elderly, due to the difficulties that older people often encounter in bathing, grooming and preparing meals for themselves. Older residents need to be able to access and use the bathroom easily and safely. This involves considering such factors as size of the space, non-slip finishes, incorporating helpful features, and the way of opening the door. Moreover, declining motor ability may make it difficult for the elderly to go out alone or use internal or external stairs. Therefore, it is necessary to provide vertical and horizontal accessibility within the home, and there should be potential to provide means of vertical access such as a lift in houses with more than one storey. Exterior stairs may not be suitable for the elderly; in addition, stairs should be made safe for use by aged people through adaptations such as providing handrails on both sides and carpets to absorb falls. For wheelchair users, lifts are a particularly important requirement at building level.

To meet the needs of visually impaired aged people, the appropriate use of lighting and maximum use of natural light, logical building layouts, level thresholds, colour contrast between adjacent surfaces, and matte finishes are all important design features that need to be considered in relation to the home (Goodman, 2008 and Barker et al., 1995).

Friedman (2002) highlighted particular social needs of people as they get older. In terms of personal/social needs, studies on post-retirement living indicate that the loneliness of old age and greater number of leisure hours mean that older people devote more time to their hobbies, which might require converting a space in a home to accommodate newly emerging activities or equip an office. Another social need could arise due to an increase in social interaction in support of elderly parents, which requires a space to be available for hosting visiting children and grandchildren when they come to stay.

Hence, ageing and increasing disability create different needs in the home in terms of access, ease of use and social needs. Therefore, housing should have the ability to respond to emerging needs that often accompany the ageing process.

2.7.2 Cultural changes in the household

Cultural diversity and cultural change

Diversity of culture is a major issue in many societies (Lee and Parrott, 2004). Ratcliffe (1999) stated that no society is mono-ethnic, as most societies contain numerous sub-populations incorporating a myriad of diverse cultures, and thus communities are inherently differentiated in cultural terms. Lawrence (1987) suggested that the design and use of a house reflect a certain culture, while Aragones et al. (2002) stated that the dwelling is more than a structure full of things; its form and organisation are influenced by the culture in which it develops and may be viewed as reflecting the relationship between culture and environment. This means that housing has to meet a multiplicity of needs, desires and aspirations arising from differences in users' cultural backgrounds.

Schneider and Till (2007) consider that immigration plays a major role in creating cultural diversity of societies, as each migrant group brings with it a certain set of cultural expectations and thus different perceptions of housing spaces. A prominent example is the UK, where increased immigration has resulted in growing diversity in the nature of housing demand. These facts are supported by a report from the Commission of the Built Environment and The Royal Institution of British Architects which states that cultural diversity and changing modes of living are the most prominent factors in shaping the future of housing. Empirical studies on immigrants' residential settlements have found that the failure of the house to satisfy the needs of immigrants and minority ethnic groups often leads to behavioural adaptation and housing adjustment to compensate for constraints of the living environment (Buzzelli, 2001; Kumar, 2005). For example, Kumar's (2005) study documents how Asian Indian immigrants in Toronto changed the interiors of their homes in accordance to their particular socio-cultural values (large social gatherings, extended family). The study suggested flexible house design would allow simple modifications in relation to cultural needs in daily domestic life.

It has, moreover, been argued that the phenomenon of urbanisation can transform the cultural landscape and structure of major cities. In developing countries, such as Turkey, massive migration from rural areas to large metropolitan areas has resulted in clustering of subcultural groups who represent different villages. Aktas (2013) explains that the newly urbanised population are often unable to adapt to their new city life, socially or culturally, and remain anchored to their traditions, customs and habits. In terms of housing, this means that each migrant group has its own space expectations and adapts its dwellings in accordance to its own local culture.

On the other hand, culture is subject to change in most societies over time. Ochieng (2004) considers that when new forces emerge in a society, cultural dimensions undergo change. In Rapoport's (2001) view, change can occur in an individual and within the community and this change may take place within any of the attributes of culture. In this regard, issues of modernisation and westernisation have been considered the main forces and movements that have impacted on culture.

Modernisation refers to the transition from a pre-modern or *traditional* to a modern society, which often means a more complex society in political, economic and social terms. Westernisation, on the other hand, "refers to the influence of Western ideas, values, and practices on the non-Western world". Westernisation, according to Özay Mehmet, 'is reconstructing or shaping the rest of the world on western norms and institutions'. In this respect, Tran Hoai Anh (1999) argues that the crucial impact of these movements in the third world relates to their impact on local cultures. She observes that modernisation and westernisation bring about changes in the relationship between the individual and society that result in various new culture forms. For example, social transition from solidarity based on kinship to a form in which the nuclear family becomes more central and significant is one such impact of these forces on local culture. In terms of housing, Larsson (1990) argues that housing adaptations may be interpreted as an evolution from traditional to modern dwellings. She concludes that modernisation of housing consists mainly of change from traditional to modern building materials and change in use of space. She points out that, for instance, in a modern society houses are considered as means for income generation through renting out houses or rooms, while in a traditional society a dwelling has only use value.

Significant cultural aspects in relation to housing

Rapoport (1998) views culture as being too abstract and too global to be useful. The abstract nature means that the link between culture and the living environment is hardly conceivable unless culture can be dismantled in order to study its components and the ways in which these components interrelate with other variables. He perceives the possibility of capturing and researching this linkage by conceptualising three main aspects of the relationship between culture and environment in a bottom-up manner: the relation between activity systems and housing, lifestyles and housing, socio-cultural variables or norms and housing. Furthermore, Rapoport (1977 and 2001) and other scholars such as Altman (1975), Even et al. (2000), Stokols (1977), Desor (1972), and Altman and Chemers, (1980) highlighted concepts such as privacy, crowding, identity and comfort as cultural aspects that can also have an impact on the built environment. These concepts have been extensively used to examine cross-cultural differences among groups and their effect on housing choice and preferences (Kaya and Weber, 2003; Even et al., 2000; Ozaki, 2002).

1- Activities

Rapoport (2001) defines activities as things people do in their dwellings, such as sleeping, eating, sitting etc., which can greatly differ across cultures and are subject to change over time. He considers activities as "the most specific expression of culture". Each activity has four component aspects: first, the instrumental aspect of the activity, then how it is carried out, how it is associated with others into a system, and finally, the relationship between the activity and its meaning (latent aspects). These four aspects help to explain the extraordinary variety of dwelling forms among different cultures, as dwellings are intended to accommodate and support activities of the particular culture. Rapoport (1998) uses cooking as an example to clarify the component aspects of activity. How food is cooked is extraordinarily varied. How cooking is associated with other activities, the meaning of cooking to a specific culture, and its social and ritual significance are even more variable. These social and ritual aspects influence the specific cooking arrangements including the design of what is known as the "kitchen".

According to Rapoport (1998, p: 12), a single activity cannot be considered in a built environment; rather, there is a system of activities, and thus variability rises. Activities systems vary among different groups according to the "sequence of these activities, their linkage in space and time, or who is included or excluded". The linkages between systems are variable in terms of images and schemata, and in the norm and rules, which in turn make certain activities or uses inappropriate in certain environments.

Rapoport (2001) cites different examples of outside forces that influence activities and their system in a home. In this regard, the increasing demand for working/living spaces has a major effect on the household's system of activities in terms of space, time use, organisation and furnishings of the dwelling. Changes in roles and family structure change lifestyles, and thus activities. For instance, cooking may become less important (except as a hobby) and be replaced by eating prepared foods or eating out. This change will influence the use of such as the kitchen and dining spaces. A fear of crime (or rising crime) often changes activities by deterring people from going out at night, or doing certain things at a home. Hence, given the variety in activities and activity systems among cultures, housing arrangements need to respond to the specific needs of cross-cultural societies. Possible change in such activities over time also indicates the need for a variable approach to housing, particularly in rapidly developing countries.

2- Lifestyle

Lifestyle refers to repetitive functions in people's lives, and how the way of life of a group in their dwellings reflects that group's values, image and norms. Understanding culture entails perception of the various lifestyles that distinguish different groups and determine the systems of activities these groups perform as an expression of their culture or as a "way of life" (Williams, 1973, p93). Rapoport (1998) affirms the usefulness of using lifestyles as a tool to identify links between culture and the environment and consequently housing design. Since lifestyles can be "operationalised" and perceived, they can be utilised to draw a profile of the various expressions of activities and ways of life.

According to Rapoport (1998, p: 12), "Lifestyle is also useful because it is defined operationally in terms of choice". People tend to choose environments which suit their particular lifestyle. Thus, this linkage of lifestyle and environment is a matter of choice. He argues that "design can also be visualised as a choice process". Choices are made among available alternatives, and are about what to include or exclude. This process is related to images and schemata, thus lifestyles, and is expressed through norms and rules which lead each group to make different systematic choices. In this light, the variables are the schemata and ideas, thus lifestyles of groups can be used in the process of making choices of housing design. For Rapoport (1998), choice is a common theme in both lifestyle and design, and, moreover, that relates lifestyles with housing in a number of different ways.

Rapoport (2001) used examples relating to gentrification in a small area in Chicago (Lincoln Park) to illustrate how lifestyle affects housing. Three different lifestyle groups were identified, each with very different views on housing, use of housing, and hence furnishings and decorations. The first group saw the dwelling as a stage for social performance; for the second it needed to function as a setting for expressing one's unique individuality; for the third it needed to sustain an atmosphere of private family life and domesticity. Thus, one can conclude that the diversity of lifestyles in a society requires a variable approach to housing to accommodate emerging needs of each lifestyle type. On the other hand, people's lifestyles may change over time, consequently affecting housing. To illustrate this case, Rapoport (2001) uses an example of how living rooms are being transformed in US houses in line with change in lifestyle. Living rooms, once central to the dwelling, are shrinking or even disappearing, to be replaced by "family rooms" linked to the kitchen. In this light, new norms and standards are incorporated into housing design to respond to lifestyle shifts.

3- Socio-cultural aspects

Socio-cultural variables refer to the social expression of culture. Rapoport (1998) suggests that social norms are the highest level of cultural elements and can involve different social factors such as kinship relations, social links, roles, etc. The research discusses these factors in relation to how they can bring about the need for change in homes.

Kinship relations

The review of the literature shows that the power of relations with relatives or kinship ties differs among different cultures and has different implications in terms of housing. In traditional societies, kinship links are extremely strong and kinship groups need places to hold large social gatherings. For example, in Kiripur, Nepal, where kinship ties are very important, most of the ancestral dwellings have created large extensions in the rear gardens for holding such gatherings (Rapoport, 2001). In modernised communities, where kinship plays a less central role, life is much more private and activities centre on the nuclear family, and thus there is no particular need to have space for such large social gatherings.

Studies of housing transformation in developing countries such as Egypt, Ghana and Bangladesh have also revealed that kinship relations can create a need to accommodate members of the extended family, which often causes a demand for additional space. According to Tipple (2000), transformers in these contexts tend to create space through extensions to accommodate, for instance, married adult children, as their parents want them close by for support and company, or a relative who moves in as a tenant or to live rent-free. Similarly, in the case of industrialised countries such as Australia and Japan, Rapoport (2001) highlights the consequent use of ‘granny flats’ as clear evidence of the role of kinship links in new arrangements created by housing design.

Therefore, differences in the power of kinship relations across cultures lead to differences in households’ need to hold social gatherings or to accommodate a relative in the home, which may impose different demands in terms of housing arrangements and space.

Social links

Rapoport (2001) draws attention to different factors that influence the form and power of households’ social networks. One such factor is the spatial extent of social networks, which may be intensive in that they are based mainly on neighbours and friends within the immediate community, or extensive, where the focus is on shared interests, lifestyles, activities, etc. It has been argued that the former is being replaced by the latter in modernised communities, but this shift is far from proven, and thus its impact on housing layouts is still unclear. In traditional societies, where the intensive type of social ties takes precedence, receiving neighbours as guests is an important activity in households’ social life, and thus provision of adequate space for a living room and a separate guest reception room are important considerations within homes in such a context. According to Rapoport (2001), in the modern context or in traditional societies that have undergone rapid change, replacement of such social networks by nuclear family-centred and private relations is influencing dwelling forms. Meanwhile, in some groups there is typically an absence of social relations, whilst for other groups social networks are still very important (Rapoport, 2001). This can create lifestyle variations which may impact on the level of demand for such as living space in the home. Hence, these variations in social networks among different groups, either in the same context or different cultures, clearly indicate the need for flexible housing that can respond to the differences and changes in these social factors, through approaches that allow extension and internal re-configuration.

Social roles

According to Rapoport (2001), social roles of the household have a major effect on the organisation and use of the dwelling, and historical or cross-cultural examination of these roles reveals different patterns and relevant housing designs. Historically, changes in roles have influenced the housing system at the level of the dwelling or part of the dwelling, e.g. the kitchen. For instance, in North America, the change in women's roles because of their increasing employment in the workplace has influenced how space is used inside and outside the dwelling. Women now tend to spend a long time working outside the home and the hectic lifestyle of the working family has increased their use of restaurants and prepared food, and thus spaces such as the dining room, kitchen and outdoor areas may become less used (Friedman, 2001). This has reduced the demand for spaces to accommodate these functions and decreased their size over time. Continuing change in the household's social role, particularly in societies that have undergone rapid social change, and the different patterns exhibited across cultures, both indicate the importance of housing design having the flexibility to allow for personalisation of unit space in terms of uses and organisation in accordance with the household's social roles.

4- The perception of identity

Expression of identity has been considered as one of the important functions of the home (Desprès, 1991; Moore, 2000). People's thoughts and feelings are often reflected in their residences as expressions of identity, as they use their physical environment and possessions as media by which to perceive each other and express themselves (Goffman, 1959). Humans occupy and appropriate a space and convert it into their own place through allocating symbols. People usually symbolise their house through the building itself, as well as through the landscape in which it is set and the furniture it contains, as a means of expressing their identity and distinctiveness. Through these elements, messages are communicated about the inhabitants' status, taste and values. In other words, the materials people use in the house, the furnishings they install, the pictures they hang, etc., are all messages about themselves that they want to convey back to themselves or to others, and can hence be considered as an expression of personal and social identity.

On the other hand, physical settings serve to distinguish between cultures, as well as different groups within a culture, such as racial, ethnic, age, sex, social class, religious, etc. This means that place-identities of different ethnic, social, national and religious groups in a given culture or different culture should reveal not only different uses and experiences with space and place, but corresponding variations in the social values, meanings, and ideas which underlie the use of those spaces. Along the same lines, Rapoport (2001) has pointed out that "identity" depends on culture and housing, which are factors that help people know who they are (Duncan, 1982). He emphasises that every individual group seeks to establish and maintain its particular identity, as an expression of that group's culture, and dwellings and other built environments often help to communicate identity.

According to Proshansky et al. (1983), maintaining a sense of identity in home environments and among residents is significant because social and physical identities are formed over time and might be connected to other environments. Individuals' sense of identity can be significantly influenced by changes in the home environment and the self may be threatened by undesirable emotional disruptions (Twigger-Ross and Uzzell, 1996). Since individuals' place identity can be represented through their spatial past, the role of individuals can be defined by the meanings and implications found in the physical setting and its ability to support different physical systems. Hence, flexibility in the environment can perform an important role in enabling residents to act according to their identities. Residents should also be able to modify their environment in order to personalise their spaces according to their taste and preferences. In this way, groups with different cultures can express their particular identities through their homes.

5- The perception of privacy

According to Altman (1975), privacy serves the function of enabling people to supervise their relationships through creating boundaries. In Altman's opinion, privacy is a dialectic process which is built on the basis of two different powers: "being with others" and "avoidance of being with others". Altman (1975, p: 18) also defined privacy as "a selective control of access to self or to one's group". Similarly, Sanders (1990) argues that privacy is the control of unwanted interpersonal interaction and communication. Thus, the flow of information and communication at individual, group or social level is influenced by the rules of privacy. She goes on to suggest that privacy can be related also to "ideas of free will and freedom to control or not to control the flow of information"

(Sanders, 1990:50). Based on these definitions, one can conclude that the common element of privacy is the ability to control interactions, which may be considered as a preference, expectation, value, need, or behaviour.

In the housing arena, the issue of privacy has important implications for the home (Tognoli, 1987). Privacy within a home can be seen through the establishment of rules to control access to certain spaces and define the limits of spaces and space use. Privacy in a built environment can be linked with space defining elements such as barriers, hedges, partitioning, etc. (Rapoport, 1977). Smith (1994) states that the control of space can be construed as control of social interactions within that space, or control of access to the self, and this implies a state of privacy in a space. Hayward (1977), meanwhile, the feeling of being in control is salient for most people within a home, and is linked to the satisfaction of basic needs. Thus, when individuals can control their space and have their privacy needs met, they experience feelings of comfort, and freedom in terms of being able to relax and do as they wish.

Differences in privacy behaviour originate from differences in personal characteristics, social situations, physical settings, and culture. Some people, because of their culture, require more privacy or express privacy needs differently from others (Altman 1975; Hall, 1966). Cultural differences in communities' privacy needs can be seen through the proxemics theory proposed by Hall (1966). In this respect, he divides cultures into two different classes: contact and noncontact cultures. In contact cultures (e.g. Mediterranean, Middle Eastern, Arabic, Hispanic) people face one another more directly, interact more closely with one another, touch one another more, look one another in the eye more, and speak in a louder voice than is the case in noncontact cultures (e.g. Northern European, North American) (Ibid). Thus, people who prefer close interactive proximity have less need for privacy than people who prefer greater interactive distance (Ibid). Similar findings have been produced by Altman's privacy regulation model (1975), which conclude that the degree of desired privacy may vary across individuals and cultures according to the preferred distance for social interaction.

According to Ozaki (2002), differences in the concepts of "self" and "family" among cultures have had a considerable effect on privatisation of living. In this respect, he distinguishes between collectivist cultures and individualistic cultures and their attitudes toward privacy in the living environment. Collectivist cultures adhere to stronger group-oriented values, like interdependence, group harmony, and shared responsibility, rather than individualism. Thus, the notion of self, which is closely linked with the state of privacy, tends to be identified with the family or secondary group in collectivist cultures, whereas individual self-fulfilment for each family member is much more important in individualist cultures. Therefore, people in individualist cultures have greater need for privacy in their homes than people in collectivist cultures. For instance, in the English context, privacy within the family has become increasingly important, and 'individual self-fulfilment' for each family member, as distinct from collective happy family life, has become vital (Chapman, 1999). Due to this desire for privacy, which gradually became a status symbol or a criterion of respectability, corridors were added and homes were divided into more and smaller enclosed rooms (Ozaki, 2001). The notion of privacy in Japan is different from the English concept, since a person's 'self' tends to be identified with the family or secondary groups. Privacy in Japan has traditionally been closely related to a spirit of happy intimacy within the family and comforting security. Parents and children sleeping close together in the same room rather than being isolated in separate rooms was considered to be more pleasant, intimate and safe. Rapoport (1977), in his book *House form and culture*, emphasises that the pursuit of privacy may be affected by attitudes towards sex, feelings of personal worth, territoriality, and the place of the individual in each community. These factors may decide whether a house is left open and unsub-divided, is divided, or even has separate smaller enclosures within it.

6- The perception of crowding

In general, crowding is defined as a psychological state caused by one's demand for physical space exceeding the available supply (Horn, 1994). Desor, 1972 explains the experience of crowding through the theoretical approach of stimulus overload, which has been described as resulting from inappropriate or unwanted social contact. In this sense, a physical environment is evaluated as crowded if a person is overwhelmed by the presence of others or when physical conditions in an environment increase the salience of social density.

According to Gifford (2002), crowding can be defined according to social and spatial characteristics. Social crowding is the consequence of the number of people exceeding the available amount of personal space. Social crowding occurs in the case where the amount of space remains constant, whilst changing the amount of space leads to spatial crowding in the case where the number of people remains constant.

According to some studies, attitudes towards crowding differ across cultures. Cultural differences in the perception of crowding can be seen, first, among different communities, for instance, through people of Latin or Asian descent perceiving a given level of population density in the living environment, on average, as less crowded compared to how it is perceived by Anglo-American individuals (Evans, Lepore, and Allen, 2000). Second, some cultures may have higher tolerance of crowding, which "means enhanced ability to withstand the adverse effects of high-density living conditions" (Ibid, p: 204). Taking into consideration Hall's model of contact and noncontact cultures, people in a contact culture may prefer closer social interaction based on less interpersonal distance, and therefore have more tolerance of crowded living situations than people in non-contact cultures differences relating to the perception and tolerance of crowding create different space demands among communities, which require a correspondingly variable approach to housing in terms of size.

7- The perception of comfort

Contributions from anthropological studies regarding the concept of comfort in the built environment are abundant and mainly related to "thermal comfort". Field studies of the thermal performance of buildings have offered further insights into occupants' perceptions of comfort that have influenced definitions of comfort in the real world. In this respect, Rapoport (1977) offered anthropological evidence that embodies different understandings of what constitutes comfort. This evidence suggests that comfort is a cultural phenomenon and highlights how specific approaches to building design reflect accepted ideas about what creates a 'comfort' environment in different contexts. The findings emphasise that the design features of comfortable buildings embody ideas about what is culturally acceptable and that a 'comfortable' building in one setting might be totally unsatisfactory to members of other cultures or communities (Crowley, 2001 and Rybczynski, 1987).

An investigation by Kempton et al. (1992) of room air-conditioner use in multi-family apartments in New Jersey, United States illustrated how such use was influenced by cultural factors. For example, households may choose to open windows in air-conditioned homes in ways that make no thermodynamic sense but are consistent with what they have always done. Researchers' examinations of meanings and perceptions of thermal comfort in different cultures and climatic conditions have also revealed a wide range of differences in the temperatures that people from different cultures find comfortable s. Nicol et al.

(1999) and Nicol and Roaf (1996) found that Pakistani office workers reported being comfortable at temperatures of up to 31°C and that preferred indoor temperatures varied according to the climate and season. People have also reported being comfortable indoors at around 6 °C during an Antarctic winter (Goldsmith 1960). Meanwhile, a study by Busch (1992) found that office workers in Thailand were comfortable at higher indoor temperatures than those working in more temperate regions. Focusing on the relation between thermal expectations and changing weather conditions, Stoops (2002) indicates that Portuguese office workers are content with a range of seasonal variation of up to 5 °C, while Swedes do not expect indoor temperatures to waver by more than half a degree. The results of these field studies hence imply that design standards based on universal methods for measuring and calculating comfort are inadequate because of their failure to account for cultural or climatic variation in peoples' interpretations of comfort.

Another set of field studies examined differences in thermal perceptions and practices between occupants of artificially and naturally ventilated buildings, again recording variations in relation to cultural expectations and climatic conditions (de Dear and Auliciems 1988). In their investigation of the attitudes and perceptions of Australian office workers in three climatically disparate cities (Darwin, Brisbane and Melbourne), de Dear and Auliciems (1988) noted significant differences in comfort between those in air-conditioned and passively ventilated buildings. Specifically, those with no experience of air-conditioned offices stated a preference for passively ventilated environments, even when these recorded the hottest temperatures. Day-to-day management of the indoor environment has also revealed variations in household practices across different cultures. Comfort in such situations is tied to issues of cultural status and is governed by what is considered socially appropriate in a particular community. Many aspects of routine consumption, including practices of heating and cooling, carry social meaning. The intention is not only to meet thermal needs, but also to fulfil symbolic and aesthetic dimensions. Wilhite et al.'s (1996) study of energy using practices in Japanese and Norwegian households highlights important cross-cultural differences in heating and cooling habits. In Norway, the researchers found it was common to heat all rooms, thereby creating a thermally consistent environment in which to move around. In Japanese households, it was more common to use technologies such as the "kotatsu" – a small heating unit placed under a table – designed to heat individual bodies rather than surrounding spaces. In both cases, strategies of heating were related to culturally relative ideas about comfort. A wealth of evidence generated by cross-cultural studies confirms the importance of understanding "thermal comfort" as a dynamic achievement rather than a definable condition or attribute in the living environment. These variations in households' perceptions and practices regarding thermal comfort indicate a need for an adaptive design response, particularly in multi-cultural societies.

2.7.3 Changes in the household's economic circumstances

In general, this part of the research discusses economic variables of the household and their impact on housing. The main concern of this discussion is to explore how changes in household economic circumstances can create a need for changes to the home and whether flexibility can offer a solution in response to such evolving needs.

The literature on residential adaptations and mobility has frequently mentioned changes in household financial circumstances as reasons for housing adjustment (Rossi, 1955 and Clark and Onaka, 1983, Tipple, 1996, 2000 and Seek, 1983). In addition, flexible housing literature has clearly highlighted such changes among motivations for providing housing with flexibility. As Schneider and Till (2007, p: 41) stated: "if economic or family circumstances change, an adaptable housing should provide the possibility of re-designating existing room or use patterns". Therefore, it is important to understand the economic motivation for flexible housing provision by exploring the relevant economic variables and their impact on housing. This research focuses primarily on variables relating to income and employment, as changes in household circumstances in relation to these factors have a direct and clear impact on housing.

1- Household income

In this section, the key concern is to highlight the impact of changes in household income on housing and how the arising needs can be accommodated by incorporating flexibility in housing. Most studies of residential mobility and adaptations refer to change in income as a key reason motivating households to relocate or make adaptations to the home (Rossi, 1955; Clark and Onaka, 1983; Tipple, 1996, 2000 and Seek, 1983).

Previous studies of residential mobility in developed countries such as the United States have generally shown that changes in household income have a significant effect on the decision to move, although results of different studies appear contradictory. Crull (1979) refers to the positive effect of household income on the desire to relocate. This means the higher the household income, the greater the desire of the household to move. However, Varady (1983) found that the lower the household's income, the higher the mobility intention; thus the relationship between these two factors is negative. Meanwhile, Roistacher (1974) differently concluded that the relationship between household income and housing mobility is curvilinear in nature. Irrespective of the precise nature of the link between these two factors, it is obvious that when there is a change in household income, an intention towards mobility also exists. From reviewing empirical studies, Morris and Winter (1978) found that an increase in income causes households to move to higher quality and more expensive housing. Therefore, in such cases the desire for better quality housing is the factor linking household income and the decision to move.

In the case of residential adaptation, quality can similarly be seen as the link between household income and housing adaptation. The difference is that as household income increases these occupants seek to improve the quality of their homes by carrying out adaptations rather than moving. In developing countries, housing transformation studies − particularly those conducted by Tipple (2000) in Bangladesh, Ghana, Zimbabwe and Egypt − refer to adaptations in housing as the most affordable way to improve housing quality, specifically among middle and low income households.

In relation to the important scenario where household income decreases, researchers have viewed flexibility as offering various possibilities to respond to such change. The key principle is the provision of means that allow income to be earned from the home itself. Schneider and Till (2007) suggest the possibility of dividing the unit and providing a section for letting out. Friedman (2002), on the other hand, proposes incorporating the flexibility to create a working space that can be used for business purposes. Adaptation of homes for economic activities can be illustrated through research examples from developed and developing countries. In developing countries, studies of housing transformation have highlighted particular means for generating income from housing adaptation. For instance, in Harare, Zimbabwe, transformers are motivated mainly by the possibility of earning rental income (Tipple, 2000). On the other hand, in Bangladesh and Ghana, adaptations were mostly carried out to enable the house to accommodate commercial uses such as shops, clinics and so on (Tipple, 2000, p:80). In developed countries, adapting the home for economic activities is also a common practice. For example, in UK houses, rooms have commonly been converted into corner shops by Indian Sikh families, or garages have been turned into workshops for garment manufacture (Al-Naim and Mahmud, 1997).

Consequently, it is possible to consider changes in household income as among drivers toward flexible/adaptable housing as they are likely to bring about a need for change to the home.

2- Employment

This subsection discusses the impact of changes in employment status on housing in order to clarify whether flexible housing can play a role in responding to such changes. Authors similarly refer to employment status as a socioeconomic indicator for change in housing. As the focus here is on the economic dimension, the research considers employment from this point of view. There is no doubt that the economic importance of this indicator stems from its strong relationship with household income. Therefore, it is logical to say that changes in employment status lead to changes in the home, since they inevitably cause variations in household income.

Changes in household income in accordance with employment status may follow a regular trajectory throughout the household's lifecycle and thus, according to McCarthy (1976), particular stages can be recognised. The first is the beginning of regular full-time employment, when earnings are usually low. As occupational skills develop and workers acquire seniority, a gradual increase in household income occurs. Finally, when household earners retire, there is usually a sudden and sharp drop in income. Because of these variations in employment status and thus household income, housing preferences and aspirations are likely to differ accordingly. Flexible housing can adapt to these different scenarios of employment status as has been explained in the previous section. However, this research does not assume that there is a universal trajectory for changes in household employment status; instead, expected scenarios of changes can be recognised in a given context (a country, a region, etc.) and these have implications for designing housing flexibly.

Existing studies of residential mobility in developed countries such as the United States clearly identify changes in employment status among the reasons that encourage households to move. From an economic perspective, the studies similarly find that changes in employment status have an influence on household income; thus the decision to relocate.

Residential adaptations research in developing countries has highlighted different impacts of change in employment status on the home. These studies have identified several practices whereby households provide a space for working at home, for self-employment, as has been discussed under the household income section. Therefore, if nobody in the household has a job, converting a space within the home for work is an available solution. These housing adaptations can be seen widely in different contexts such as Bangladesh, Ghana, Zimbabwe, Egypt, Saudi Arabia and so on. In Bangladesh, although the occupants were tenants, they invested in extending their houses to create workspaces that provided at least 3,600 jobs across the neighbourhood (Tipple 1991). Whereas in Dhaka and Hofuf, Saudi Arabia, Al-Naim and Mahmud (1997) report that most adaptations in the home are related to economic production of the space, such as conversion of rooms into shops, grocery stores, clinics or barber shops.

In developed countries, transforming part of the home into a working environment is part of the working from home phenomenon. Friedman and Krawitz (1998) argue that different factors, all related to the issue of employment, such as the rise of information-based and service-related jobs, more contract work and part-time employment, have contributed to an increase in the number of home workers. Added to this is the possibility of saving on office costs, which can be channelled directly into business-related resources. Friedman and Krawitz (1998) suggest integrating flexibility into housing design, so that as households' employment status changes, their homes can be adapted easily according to the new emerging needs.

2.7.4 Changes in technical and physical requirements for housing

This section discusses issues relating to technical aspects of housing that are liable to change over time, and thus require constant adaptation of the home. These physical changes can be related to key themes such as responding to building obsolescence, the introduction of new technological developments, and updating of safety and security requirements over time.

1- Responding to building obsolescence

According to Douglas (2002, p. 28), "obsolescence is the process of an asset going out of use". It refers to an object's usefulness over time and its transition towards the state of being obsolete or useless, and its operations becoming out of date, outmoded, or old-fashioned due, for instance, to it breaking, wearing out, or becoming otherwise dysfunctional. However, although these conditions do not necessarily mean that an object is obsolete, they may point to the obsolescence of a building.

Douglas (2002) highlighted different factors that may lead to building obsolescence. One such factor is technological change that means the existing building cannot fulfil the requirements of modern production processes. For example, many multi-storey telephone exchanges built in the 1960s and 1970s have become obsolete because of the rapid advances in information and communication technologies. Another key factor is deterioration of the building's structure and fabric over time that may affect the appearance and usability of the building, and thus reduce its efficiency in meeting both users' needs and performance requirements. Moreover, inflexibility can be a factor in building obsolescence when there is restricted scope to adapt the building or change its use as a result of its tight-fit design in terms of layout and size and structural system. In order to accentuate the importance of responding to building obsolescence, he identified three main categories of consequences of obsolescence, namely, economic, technical and functional. The primary economic consequence is reduction of the value of the property; the key technical consequence is reduction of the efficiency of the building's performance; while the functional consequence of obsolescence is that the building usually becomes underused.

Douglas (2002, p29) argued that building obsolescence should be viewed as "a function of human decision rather than a consequence of natural forces". Therefore, actions can be taken to reduce a building's obsolescence, and thus increase its usefulness and life span. He suggested enabling building adaptations such as alterations, extensions and refurbishment as primary actions that can delay, if not postpone, building obsolescence. Similarly, but with more focus on housing building, Schneider and Till (2007) indicated that flexibility in building design can limit obsolescence in housing stock. They argued that if the structural system, services strategies and special design features of buildings enable their flexible use, these buildings will last longer, and thus the need for pulling them down will be significantly reduced. Friedman (2002), meanwhile, focused primarily on the importance of incorporating flexibility into services systems when designing homes so that any required renovation and upgrading can be carried out easily, thus extending the home's useful life.

2- Technological developments

Researchers have made much reference to the importance of housing's ability to accommodate new technological developments over time. Friedman (2002, p: 9) suggests that the issue of "fitting new technologies" inevitably arises in any home. He argues that when homes are designed and built, the technologies installed are of their and such technologies become outdated and obsolete over time. Thus, if designs of new homes do not take these potential changes into account, carrying out these adaptations will entail major work and high expenditure. The renovation process may involve such work as installing new wiring systems or replacing plumbing, heating or ventilation systems with new, more advanced ones. Therefore, Friedman states that housing design needs to accommodate the fact that all servicing systems in buildings are liable to change over time.

Friedman and Krawits (2002) reported that the introduction of new technologies also promotes the emergence of new uses and activities in the home. Advances in the field of communications, such as the introduction of the fax machine, electronic email and so on, for instance, encouraged the emergence of the home office. In addition, advances in electronic devices for use by children, such as computers and video games, have also contributed to the appearance of new activities and the decline of others.

Consequently, new technological developments emerge constantly and inevitably over time, which has implications for housing, although at the same time these are hard to predict. However, the evidence all indicates that flexibility in the design and installation of services can help in responding to such unforeseen events.

3- Safety

Safety is an issue that has a wide range of implications for the home. What is of concern here is how conditions relating to safety requirements necessitate making changes in the home. Safety requirements can change over time due to such as children growing up or people growing old at home. According to Friedman and Krawits (2002), safety requirements are important from the early stages of children's lives at a home and change as they progress through the different developmental stages. "Child-proofing" is a term used principally to describe steps taken to address hazards relating to such as access control, and these may require initial consideration in the design stage.

Adaptations to meet safety requirements are also important in homes that house old people. It is well known that with advancing age, people are very likely to encounter deterioration in their physical abilities, and thus are at increased risk of falling or having other mishaps deriving from loss of balance and coordination (Friedman and Krawits, 2002). They may be particularly at risk when using such as the bathroom and stairs.

Friedman (2002), as has been explained in section 2.4.2, suggested that special consideration should therefore be given to providing safety features such as non-slip floors, etc.

The above cases illustrate the importance to household safety of adopting construction practices that will allow appropriate safety equipment and fixtures to be installed easily in the future.

4- Security

The need for more security can be considered as another reason behind change in the home. The literature review revealed different situations that can create the need for more security in the home, such as fear of burglary or opportunistic crime (Napier et al., 1998 and Vanderschueren, 1998). In developing countries, studies on housing transformations have identified security as a reason for making adaptations to the home, particularly in poorer urban contexts. These adaptations are mainly associated with access control or reducing access to certain areas, for instance by constructing fences around the houses or around the doors and windows (Nguluma, 2003). Therefore, access control can be a key need in terms of demand for improved security in the home.

Designing homes that provide good security has been intensively discussed in studies on preventing crime through environmental design, which focuses on the spatial dimensions of crime and prevention of criminal behaviour by means of appropriate design techniques (Cozens, Saville, & Hillier, 2005). "Surveillance" strategy is one such technique and involves incorporating different mechanisms to maximise visibility within and around the building. These mechanisms may involve the use of physical features or mechanical and electronic devices (Marzbali et al', 2012, p.80). The concept of access control, on the other hand, is another strategy that focuses on the reduction of opportunities for crime by denying access to potential targets and creating high perceptions of risk among potential offenders. This can be done by utilising different forms of real barrier to deter criminal acts. Primitive forms of these mechanisms have already been seen through housing adaptations in cases involving the urban poor in developing countries, which gives an indication of the importance of addressing this issue (Marzbali et al., 2012). It is obvious that providing security in the home, particularly at access points, requires installation of resilient services distribution systems and construction practices that facilitate compliance with changing security requirements.

2.8 Conclusion

The above discussion of concepts of flexible housing reveals that contradictory views surround the terminology of flexibility and adaptability in the housing context, in terms of the character of the change that each concept seeks to address. Therefore, the research adopted the same pragmatic stance as recent researchers such as Friedman (2002) and Schneider and Till (2007) by using these two terms interchangeably to refer to the same notion. The research also adopts the soft and hard analogy to distinguish between different types of flexibility in use and form and their influence on the scope of flexibility. The key definitions of adaptable/flexible housing revealed that responding to the household's changing needs is of paramount importance and the ultimate target for flexibility in housing. These changing needs can be regarded as deriving mainly from demographic, cultural, economic and technical factors, which this research therefore uses to form a framework for analysis of flexible housing drivers across the different selected case studies.

Chapter 3: Analytical concepts and evaluation criteria of flexible housing

3.1 The key themes of flexible housing

This chapter seeks to explore the main concepts that flexible housing centres on and to develop their evaluation criteria. In order to achieve this, a review of the key approaches to flexible housing proposed by different researchers is undertaken to discover the main building elements into which flexibility needs to be incorporated. The review emphasises the more holistic approaches to addressing different building features in terms of flexibility.

Habraken (1972) asserted that in order to achieve housing that can accommodate future change, flexibility should be considered in the construction. In this regard, he proposed his approach of "Support structure" that introduced two key concepts - "support" and "infill"- as key characteristics of flexible construction. The support is concerned with the basic structural frame of the building that needs to be considered as a long life permanent base. Meanwhile, the infill provides parts of the dwelling which are adaptable and therefore have shorter lifespans. In this approach, he also focuses on the importance of the users being able to claim housing units as their home through their assuming more control over the infill parts.

Duffy (1990), Brand (1994) and Leupen (2006) proposed different approaches that share the same principle of conceptualising the building as layers of change to achieve a building that can cope with change, where each layer identified can be changed at a different pace. Brand (1994, p.13) argued that "because of the different rate of change of its components, a building is always tearing itself apart". Duffy (1990), using the principles found in the commercial office, developed the first categorisation of layers by dividing the building into four layers as shell (structure and skin), services, scenery (partitions) and set (furniture). Brand (1994) took these four layers and added two of his own to create his approach of "shearing layers of change": Site, Structure, Skin, Service, Space plan and Stuff (see figure 3.1). Leupen (2006) removed two of these six (site and stuff) as not relating directly to the building and added an additional layer: access. Therefore, these approaches view flexibility as achievable by creating the building as a hierarchy of layers that can be adapted at a different rate and pace.

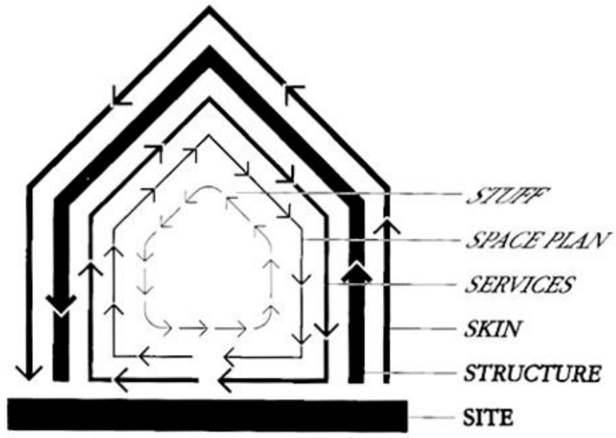


Figure 3.1: Shearing layers for change. Source: Brand (1994).

Friedman (2002), in his book *The Adaptable House,* promoted flexibility in four key entities of the building: volume, spatial arrangement, size and subcomponents. The concepts of volume, spatial arrangement and size are themes related to the plan of the building in which flexibility can be achieved. Flexibility in volume refers to the ability to manipulate the entire volume of the building, such as by combining several floors to make a large unit, then dividing it at a later date. Flexibility in spatial arrangement considers the way in which the layout spaces can be adapted. Flexibility in size refers to the processes of growth and division that allow the expansion and reduction of volumes or spaces of the building. Finally, subcomponents relate to the need to be able to manipulate the construction and services of the building in order to achieve flexibility in the building. However, he noted that the form of flexibility relies on many factors such as the type of home, the method of construction and the procedure used to make the change.

Schneider and Till (2007), in their book *Flexible Housing,* discussed two key processes, namely the design and making of flexible housing, and their study of a range of flexible housing projects led them to conclude that flexibility has to be addressed via four key themes of the building: use, plan, construction and services. In their manual on how to design for flexibility, they presented a range of design strategies under these key themes and developed a series of questions testing flexibility in housing. Flexibility in use addresses the possibility of the building being adaptable enough to accommodate the different users' needs and desires. The plan is concerned with the principles in terms of designing the plan flexibly. Construction considers the structural system and principles that enable change in the building. Services refers to the ways in which different servicing systems can be upgraded over time. Moreover, Schneider and Till (2007) highlight issues relating to the user and financial considerations of flexible housing that need to be investigated. In terms of the user, they suggest that flexible housing empowers the users in their dwellings and discuss the different opportunities offered by flexible design for user empowerment. Financial aspects are concerned with the different cost implications of incorporating flexibility into the design.

Consequently, the research adopted the four key themes − plan, construction, services and use − as key concepts for the analysis of flexible housing as they simply present and distinguish the different aspects of building that need to be sufficiently flexible to accommodate change, and considers the implications of user and financial aspects in relation to previous concepts on these issues. The following sections discuss the considerations associated with each aspect in order to explore the key indicators and evaluation criteria that are relevant for achieving flexibility in these aspects (see figure 3.2).

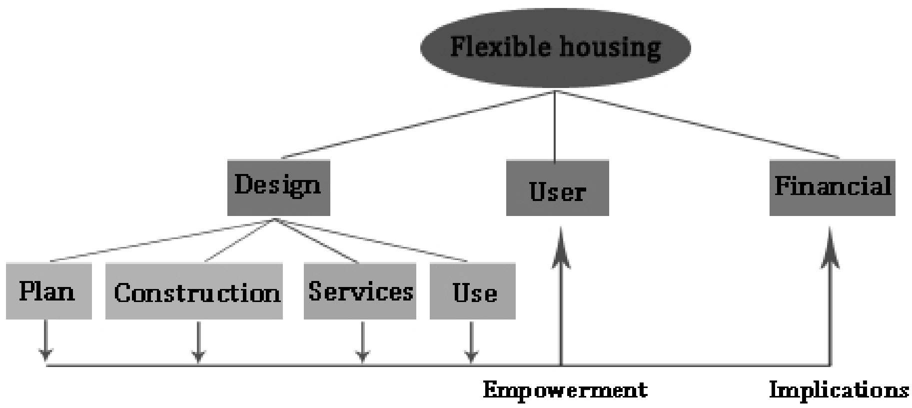


Figure 3.2: The key themes of flexible housing adopted by this research

3.2 Key concepts of flexibility in the plan and their evaluation criteria

In this section, the main concern is to explore the key elements of the plan that require flexibility in order to achieve a flexible plan for housing design. Researchers differ in how they address flexibility in the plan. Venturi (1966) and Rabeneck et al. (1974) focused exclusively on achieving flexibility in the interior of the plan and on the scale of a single unit, through carefully considering the design of the layout of spaces. In contrast, Dittert (1982), Hertzberger (1991) and Davis (1997) highlighted the importance to achieving a flexible plan of considering flexibility in the interior and size of spaces in individual dwellings through the potential for internal change and growth of the unit. In addition to the size of spaces and the internal organisation, Chow (2002) highlighted access as a concept that needs to be considered in terms of flexibility. On the same line, MacCreanor (1998) focused on the importance of achieving flexibility in the external circulation through designing its spaces for more than access purposes. Friedman (2002) defined the plan through three main concepts: volume, spatial arrangement and size, as mentioned in the previous section, to achieve flexibility in different dimensions of the plan: height, internal layout and the amount of space in the building. Boerman et al. (1992) state that a flexible plan is achieved through conceiving changeability of the building objects at different scale levels: "furnishing of rooms, walls of room, interior lay-out and lay-out of the building" (cited in Lans and Hofland, 2005), or in other words room, dwelling and residential building. Schneider and Till (2007) similarly suggest a systematic and hierarchical approach to define the plan by dividing it into three key levels: building, unit and room, with flexibility requiring to be integrated into each level to achieve a flexible plan. Building is concerned with achieving flexibility at the level of the whole building, such as through having the ability to change the number of units in the building. Unit level considers the incorporation of flexibility at the level of the individual unit, for instance the potential to change the size of the unit. Room level flexibility requires integration of the ability to use individual rooms in a variety of ways. This division has been adopted by the research to define the plan as it allows the different concepts of flexibility in the plan to be determined at different levels (see figure 3.3).

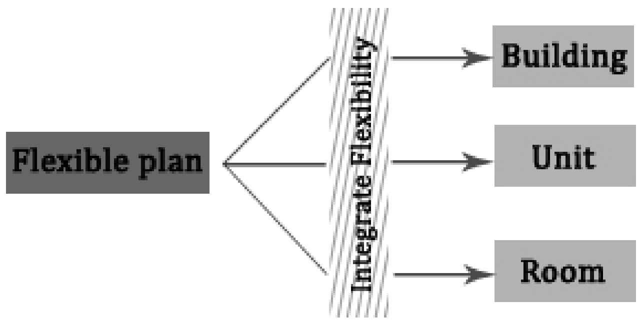


Figure 3.3: The main concepts for the flexible plan as adopted by the researcher

3.2.1 Flexibility in the plan at building level

Researchers suggest a range of design strategies that lead eventually to flexibility in the plan at building level. Generally, the strategies promote the importance of the building being flexible in terms of unit mix, use and communal circulation. Unit mix is concerned with the ability of the building to accept change in its number of units. Use addresses the possibility of the building accommodating different uses such as commercial, office and so on. Communal circulation suggests the ability of the communal spaces of the building to accommodate different uses.

1- Unit mix

The concept of unit mix refers to the ability of the building with multiple units to accept change in structure between the units. Schneider and Till (2007) view the importance of flexibility in unit mix within the building as stemming from the need to respond to the users' cyclic changing requirements and changes in the market situation in the long term. Therefore, they included this possibility for change among their key questions testing for flexibility in the plan at building level. Friedman (2002) referred also to the importance of the plan of the building being flexible in the unit mix, because this allows changes to be made in the building structure according to the users' preferences during the construction and marketing phase. In this regard, he noted that as far as flexibility is concerned, a structure that was designed to accommodate three households may need to accommodate two or even a single household and vice versa. Here two key considerations in the design of the building are important: 1) the strategic placement of the communal access in the building to allow response to changes in the structure of the units, 2) a construction method that will allow such changes between units.

2- Building use

According to MacCreanor (1998, p.42), the flexible building is "both transfunctional and multifunctional and must allow the possibility of changing use; living into working, working into leisure or as a container of several uses simultaneously". This allows the building to accommodate future needs and changing circumstances. MacCreanor (1998) defined a range of characteristics that enable the building to accept changes in use, such as over-dimensioning of building space, ceiling height, circulation space and mechanical services, neutral façades that do not reflect any particular use, timelessness that makes the building independent of fashion and material quality that reflects a sense of timelessness and robust identity. MacCreanor and Lavington noted that different building types must be able to accept changes in use over time. Industrial buildings − mills and warehouses, are considered flexible in use through "a combination of neutrality in layout and expression, and through the use of ordinary and adaptable building technologies" (Grafe, 1999, p. 33).

Schneider and Till (2007) stress the importance of the building having sufficient indeterminacy to accept exchangeability of functions, thereby preventing the obsolescence which is a major problem in building. Having the ability to respond to a wider range of social and economic demands potentially increases the useful life of the building. Therefore, in their questions list examining flexibility at this level, Schneider and Till (2007) included the ability of the building to accept multiple modes of occupancy as an indicator for flexibility in the plan at building level. Similarly, they noted that some building types designed for other uses, such as offices and warehouses, and then converted to housing at a later date, are more flexible. Therefore, it is useful to incorporate the design standards of these building types in the design of new housing for more flexibility. To achieve this, they suggested design considerations such as incorporating an indeterminate large open space between the permanent structural parts of the building. The location and separation of the structure of the services core in the building are also important to facilitate multiple uses of the building. Moreover, Schmidt and Austin (2016) noted that one of the important considerations for maximising the ability of the building to accept different uses is the provision of multiple access points, which can facilitate the building's capability to serve different uses and users.

495 West Street in New York, USA, designed by Tamarkin Architecture in 2000, is an example of a building that can be adapted easily to other uses. The project consists of an 11 storey loft development with 9 apartments designed around the principle of raw space units. The structural gird with just a few construction elements within allows creation of an indeterminate space that can be used for multiple purposes. The layout of the building's spaces is not pre-described but left open to be interpreted by the users themselves. The service core consists of four shafts for services systems which open directly into the indeterminate spaces. The design of the façade does not reflect the particular character of any building function (Schneider and Till, 2007) (see figure 3.4).

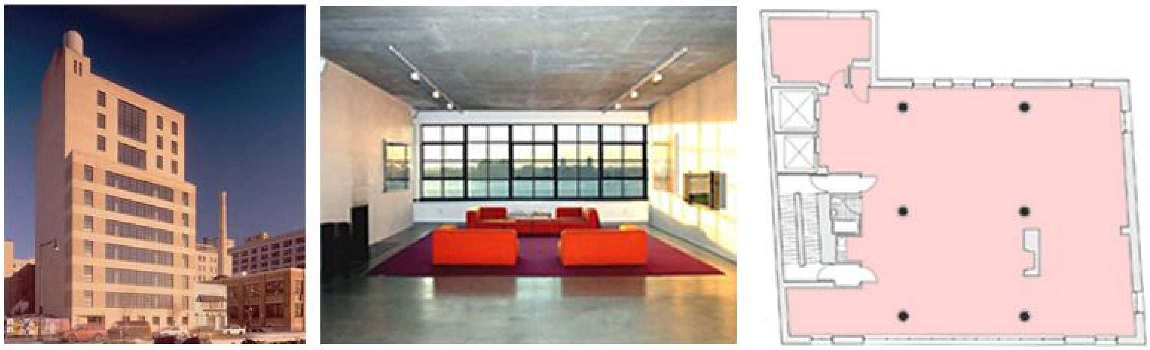


Figure 3.4: 495 West Street, Tamarkin Architecture, New York City, USA, 2000, flexibility in building use. Source: www.afewthoughts.co.uk.

According to Schneider and Till (2007), a number of housing types, particularly terraced housing, have proved robust in accepting different uses over time. Therefore, the issue of flexibility in building use has a relation to housing types. It can be argued here that flexibility in use is more applicable in the large apartment block than a single house, and thus this possibility for different use can be used as a concept for analysis mainly in such a type of building. In this regard, different design principles are important for flexibility in building use: 1) indeterminate large open space, 2) over-dimensioning of ceiling height, 3) neutral façades in terms of opening and fashion, 4) strategic location of the services core in the building, 5) oversize of circulation space, 6) and multiple access points to the building.

3- Communal circulation

Different researchers have referred to the importance of considering flexibility in the communal circulation in multi-unit housing. MacCreanor (1998), Leupen (2006) and Schneider and Till (2007) have all addressed the issue of flexibility in communal circulation through the potential for using the communal spaces for additional purposes. MacCreanor (1998, p.42) argued that the external circulation can be addressed as an extension of the street, “inviting communal activities to take place”, so it opens up flexibility in terms of use. To achieve this, some generosity in the size of communal space is needed, so the circulation can be used for more than means of access. Schneider and Till (2007) similarly view that flexibility in communal circulation can be embedded through a small increase in its size, enabling its use for different activities such as sitting, eating, social activities and so on. On the same lines, Leupen (2006) referred also to the importance of the access taking on additional uses when stating that “the access can only gain significance as a frame if it assumes an additional duty”. He suggested that some forms have greater potential to achieve this, such as streets, a balcony and a front garden. The Hellmutstrasse project in Zurich, Switzerland, designed by ADP-Architekten in 1991, is an example that achieves flexibility in communal circulation, where all units are accessed from the external staircase and balconies designed wide enough to share activities with others (Leupen et al., 2005) (see figure 3.5).

Figure 3.5: Hellmutstrasse. ADP-Architekten, Zurich, Switzerland, 1991, flexibility in communal circulation. Source: Leupen et al. (2005).

3.2.2 Flexibility in the plan at unit level

At the scale of the single unit, the literature review discusses three main aspects for achieving a flexible unit. The first relates to flexibility in the size of the unit across its three dimensions through the ability to accept growth and division. The second is concerned with flexibility in layout arrangement either through physical or non-physical adaptations or both. The last considers flexibility in internal circulation in terms of use.

1- Unit size

Researchers have addressed the issue of flexibility in unit size in different ways. Researchers such as Priemus (1969), Zuk and Clark (1970), Dittert, (1982), Fulwood (1987), Herztberger (1991), Brand (1994), Hofland, 2005, Al-Dakeel (2006) and Leupen (2006) addressed flexibility in size of the unit through its ability to grow and enlarge. Others like Schroeder (1979), Friedman (2001 and 2002) and Schneider and Till (2007) focused on two key processes: growth and division that lead eventually to flexibility in the size of the unit. Growth refers to the ability of the unit to expand its interior usable space through, for instance, the potential for extension beyond or within the unit outline or joining two units together; whereas division is concerned with the ability to divide the unit into two smaller units or to split off an independent section. The research hence adopts these two processes as indicators for flexibility in size and discusses their different possibilities and strategies.

Growth

Zuk and Clark (1970) argued that the ability of the building to expand provides an opportunity to envision a range of possibilities for the building to “accept new, outside elements which may not have existed at the time of the original inception”. Fulwood (1987) viewed the concept of growth or extendibility as a viable alternative for many families, in times of high housing costs, to increase housing satisfaction and improve housing quality. Friedman (2002) reported that the urban appearance of old towns and villages is largely a result of constant growth beyond the original envelope of the house, because of the demand for more space throughout the household’s lifecycle or as an economic strategy, starting small and expanding later on as financial circumstances improve. Schneider and Till (2007) consider that a plan with capability for expansion is the best suited to respond to demographic change in households. Rosenberg (2009) noted that it is important to envision buildings able to grow, in order to respond to uncertainty during the life of a building.

Researchers have suggested theoretical approaches incorporating a range of design strategies for implementation by architects in housing projects with flexibility for the units to grow in size. Generally, these strategies can be listed under two key categories: add on and add in. Add on refers to the design strategies that allow the unit to expand beyond the building shell, whereas add in considers the design approaches that enable the units to grow with the building frame (Fulwood, 1986, Brand, 1994, Friedman, 2002). Differently yet similarly, Leupen (2006, p.25) distinguished between two processes for growth through extendibility on the basis of the building’s impact on the surrounding area. The first is “independent extendibility” that considers the increase in the space of a dwelling without consequences for surrounding homes, such as add in approaches. The second is “dependent extendibility” that considers the extension with consequences for surrounding homes, such as add on strategies. Therefore, both terms, add in and add on, can refer to processes of independent and dependent extendibility. Joining two units together is another design strategy addressed by different researchers such as Friedman (2001 and 2002) and Schneider and Till (2007) and used in different flexible housing designs such as the Verwandelbare Wohnung project to enable substantial expansion of the unit. The research undertakes a review of the different design methods of additions (add on and add in), as well as joining two units together approach to discover their different characteristics and how they are important to achieving flexibility in the size of the unit.

In terms of add on approaches, Friedman (2002) presents different design methods by which external additions can be added to the unit. Rear addition is the most common strategy of add on, where an additional structure can be built onto and incorporated into an existing building. Another strategy is to add a new floor over an existing house, which is common in houses with a flat roof. Expansion could also take place as a bridge between two existing buildings. It is important here to ensure construction of a segment that suits the space between the two. Constructing an independent annexe and connecting it to the main structure in the future is another strategy of add on. Expansion can also occur by adding to the building's marginal space in the form of a component, such as replacing a window with a bay that adds a small amount of space to the unit (see figure 3.6). In all forms of add on strategies, four key design considerations are important: 1) an independent access to the addition, 2) strategic placement of the wet functions, 3) considering the plot size and zoning regulations in terms of setback and land coverage, 4) considering layout configuration in a manner that will ensure a sufficient source of light once the expansion is complete.

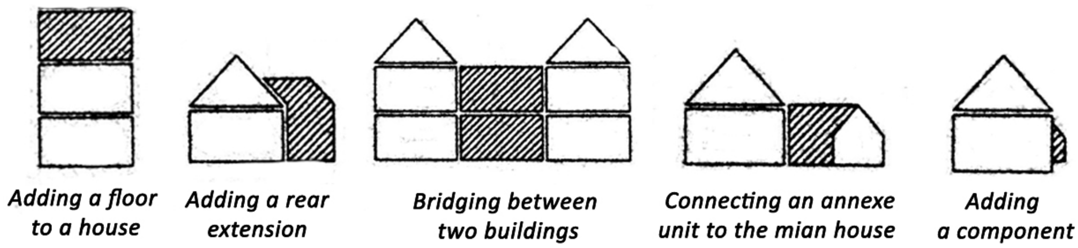


Figure 3.6: The different forms of add on approach. Source: Friedman (2002, p.100)

According to Al-Dakheel (2006), the add on approach can be carried out either on the site, unit structure, or unit skin (cladding), and may take the form of expansion or addition. Two key popular strategies are relevant: vertical expandability that enables vertical addition of space on an extra floor and horizontal expandability that allows attachment of an addition to the building envelope on-site. He indicated that application of this approach should take account of flexible zoning requirements in terms of design.

In their classification, Schneider and Till (2007) similarly identified strategies of vertical and horizontal addition, but also slack space (see figure 3. 7). The vertical addition strategy considers the possibility to enlarge the unit vertically over the building roof in the case of a flat roof. This strategy can increase the size of a single dwelling by adding another storey that could be used for additional bedrooms or other required functions. In this instance, the strategic location and form of the stair case for easy extending in the future to facilitate the additional space are important considerations. On the other hand, the horizontal addition method enables addition to the unit's space in a horizontal direction. This strategy involves two key design considerations: 1) enabling access to the extension in the case of adding an additional room, 2) a simple plan form that ensures good light in the case of horizontal addition.

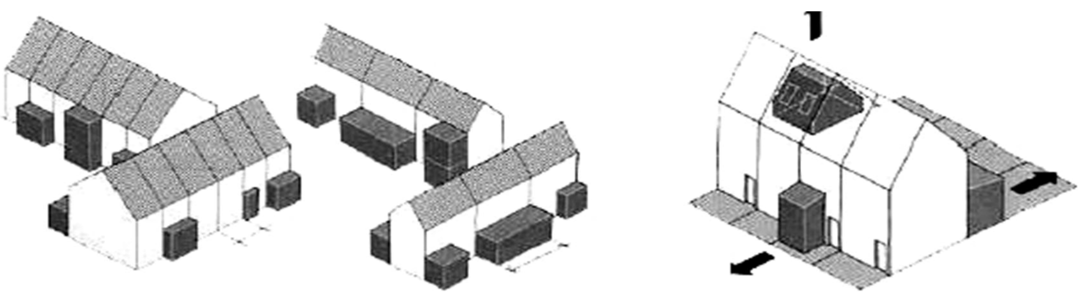


Figure 3.7: Horizontal and vertical extensions to buildings. Source: Schneider and Till (2007).

Moreover, both Friedman (2002) and Schneider and Till (2007) drew attention to the relation between building types and add on strategies, particularly regarding horizontal extensions. Friedman (2002) viewed the detached home as offering more freedom for expansion horizontally than semidetached and row housing, which have more constraints on growth beyond the building envelope. Whereas Schneider and Till (2007) asserted that add on strategies are less useful in multi-storey housing than in detached or terraced houses, as it is difficult structurally and problematic legally to apply them individually at the upper levels. Therefore, such methods of expansion are not usually possible unless applied across all the building units (see figure 3.8).

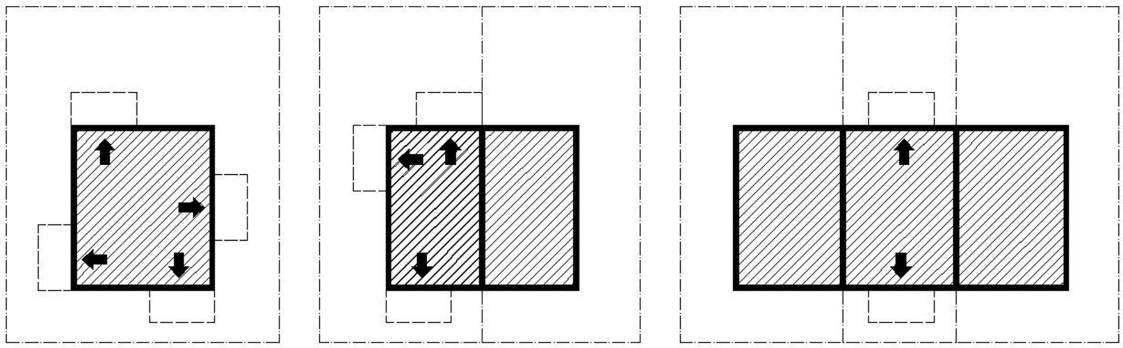


Figure 3.8: The different building types and possible ways of horizontial expansion, (a) detached house, (b) semidetached housing, (c) row or terraced housing. Source: Friedman (2002, p.87) re-drawn and edited by the researcher.

A flexible housing project in Almere, Netherlands, designed by UN Studio in 2001, provides an example of horizontal extension strategy. The types of flexible houses in the project range from detached and semi-detached to houses grouped as terraces, with three storeys. The original plan consists of two modules of 10 by 6 meters. The basic volume of the house can be extended horizontally in two ways. The first way is by adding a further half-length module to the first floor, to allow enlargement of the size of the rooms. The second way is by adding a prefabricated box, 2.5 by 6 meters, to the second floor, which enables addition of a new room to the plan, with independent access. Therefore, these extensions were included as pre- designed and fixed-dimensions to increase the size of the plan (Schittich, 2006), (see figure 3.9).

Slack space was first introduced by Peter Barber, based on Cedric Price's idea of unprogrammed space. According to Schneider and Till (2007), it is a space provided by the designer externally, the occupation of which is not fully determined. External slack space can be used to apply add on strategies and takes forms such as a roof space that can be built upon, courtyards that can be filled in or a communal stairwell big enough for occupation by its users. A clear example is Donnybrook Quarter in London, designed by Peter Barber in 2006, where flat roofs or terraces on the first floor were provided for the units as slack space to be taken over or enclosed in the future by their users based on their wishes (Spring, 2006) (see figure 3.10).

Figure 3.9: Flexible housing in Almere, UN Studio, Netherlands, 2001, flexibility through horizontal extension. Source: Schittich, (2006, p.88), edited by the researcher.

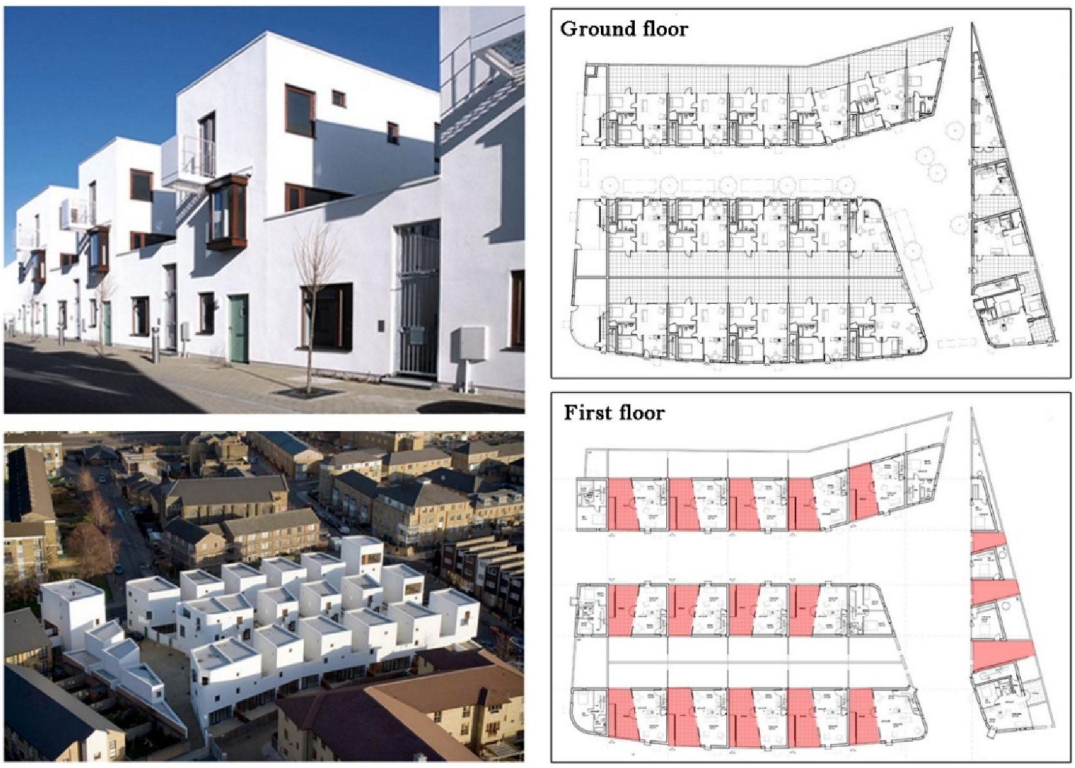


Figure 3.10: Donnybrook Quarter housing, Peter Barber, London, 2006, flexibility through slack space. Source: openbuildings.com, edited by the researcher.

According to the discussion above, it can be concluded that the add on approach can take two different forms: additions and slack space. Additions are strategies that allow programmed growth of the plan and include: vertical expandability and horizontal expandability. Vertical addition can be carried out on the flat roofed building type and one key design principle is the strategic location and form of the staircase to allow easy extension in the future to provide additional space. Horizontal addition strategy can be applied to different building types including detached, semidetached and terraced housing, but it is less useful in the case of multi-storey buildings. The important design considerations here are: 1) an independent access to the extension in the case of addition, 2) strategic placement of the wet functions in order to avoid restricting creation of the addition, 3) designing the layout configuration in a manner that will ensure a sufficient source of light once the expansion is undertaken, 4) considering the impact of the plot size and zoning regulations in terms of setback and land coverage on future expansion. On the other hand, external slack space is a strategy that allows addition or expansion through unprogrammed growth by the architect, which considers providing space outside the unit that can be filled by the users based on their own terms. Using this strategy, the architect works on the background and appropriates the external space for unpredicted scenarios of occupation over time.

In terms of add in approaches, researchers have presented a range of design strategies that allow the unit to grow within the building envelope. Friedman (2002) suggests "adding within an open shell" as an add in strategy, which enables the unit to expand vertically within the parameters of the building envelope, such as by providing a double height volume, thereby allowing an additional floor to be added to the unit in the future. Since zoning regulations mandate a certain building height, the suggestion is that the buildable volume can be created and one floor or more may be constructed, with the remaining floors to be added in the future. The Projekt Wohnhaus, designed by Anton Schwelghofer in 1984, is a design for multi-storey apartments in Berlin that employs this strategy for future expansion within the building envelope. The design offers double height volume and one level floor in use, with the second floor to be built and added in later, enabling 49m2 of space to potentially grow to 98 m2. Beams at regular intervals at the level of the first future floor were added to the building, so the floor could be laid out easily at a later date. (Schneider and Till, 2007) (see figure 3.11).

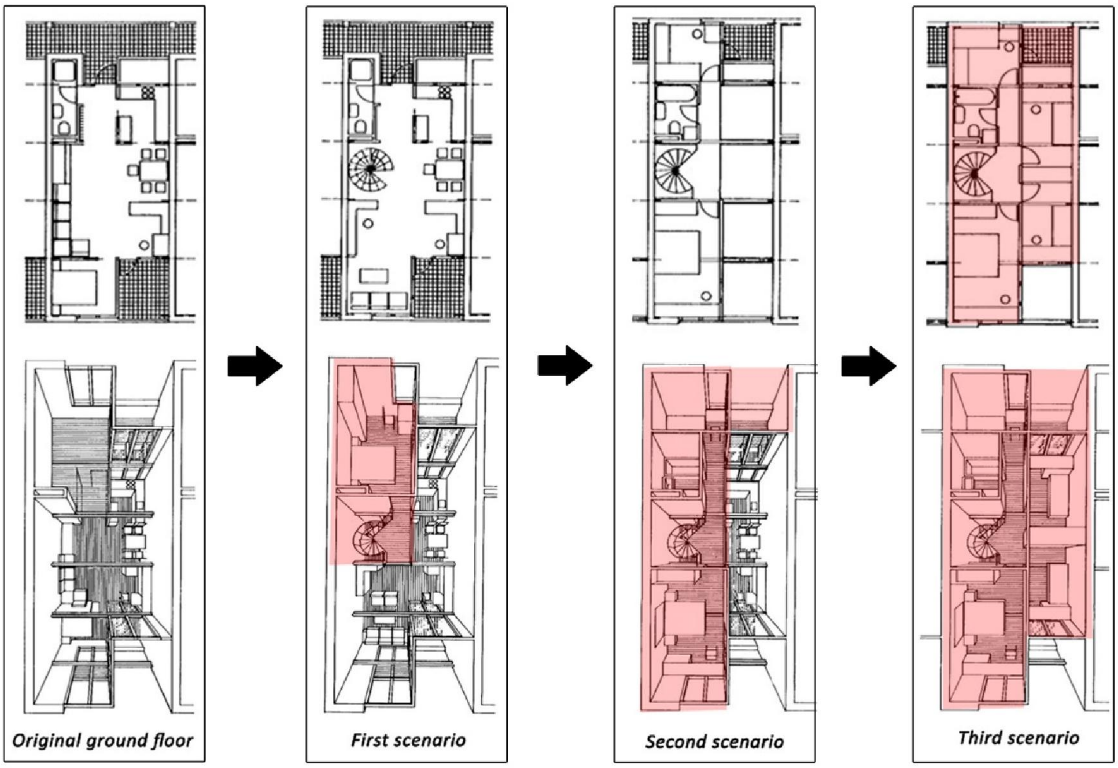


Figure 3.11: Projekt Wohnhaus. Anton Schwelghofer, Berlin, 1984, Flexibility through adding in an open shell. Source: www.afewthoughts.co.uk, edited by the researcher.

Therefore, the method of application for this strategy requires primarily constructional principles to be taken into account, such as preparing the main structure to accept an additional floor, and the ability to extend the staircase and services to the new floor. In terms of design, determining the height of the unit envelope is the key consideration. The location and form of the vertical circulation and wet spaces need to be conceived also in the unit layout from the outset to facilitate provision of future floors. It is also important to note that the strategy can be applied on different building types, including multi-storey buildings, and can therefore facilitate the ability of the dwelling to grow in size.

"Extending within", presented by Schneider and Till (2007, p. 140), is a design strategy relevant to the add in approach which enables the unit to enlarge in size within the building envelope. It depends on the idea of providing excess space within building parameters, enabling individual apartments in a multi-storey building to expand, often horizontally, when needed. A number of flexible housing projects have employed this method to allow future increases in space in the individual units.

Febtgasse Housing in Austria, designed by Ottokar Uhl in 1980, is a project that considers "Extending within" approach through integrating front and rear facades as non-fixed elements, providing the potential to size the units differently. By locating the façade at the most inward possible point, an apartment can be as small as 11.4 by 5.8 m or by placing the façade as far out as possible it can be as big as 15 by 5.8 m. It is notable also that the services core was placed in the central zone of the units, which freed up both the front and rear façade for change in future expansion (see figure 3.12).

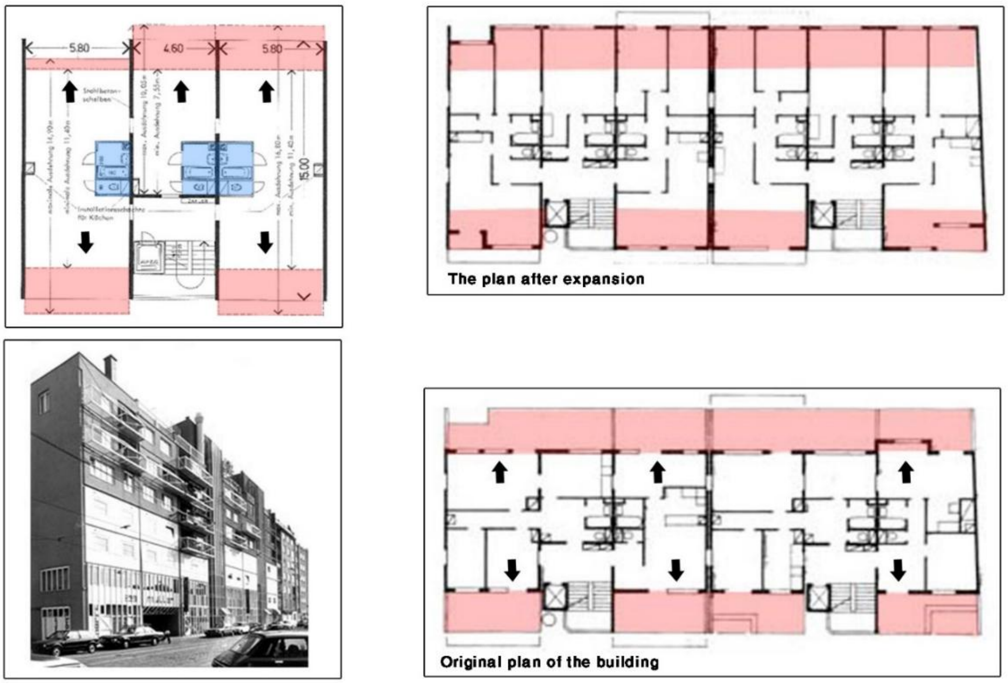


Figure 3.12: Febtgasse Housing, Ottokar Uhl, Austria, 1980, flexibility through extending within. Source: www.afewthoughts.co.uk, edited by the researcher.

Therefore, the key design principles of this strategy are, first, to provide excess space that can be added to the unit with a logic relation to the interior, and second, strategic location of the wet space within the plan that avoids restricting the ability of the unit to expand. In terms of construction, the structure of walls between the excess and interior space needs to be considered as non-load bearing, with no services located within and with the ability to be moved around.

Extending into unfinished space is another common strategy of add in presented by different authors. Brand (1994) suggests that when the family needs space to expand, the easiest and cheapest option is to expand into existing space such as the attic or raw space. Therefore, houses require more or less determinate space for future expansion, as it's easier to add in than add on. According to Friedman (2002), designing the unit for expansion into unfinished space can take the form of an uncompleted second floor of a two-storey dwelling, an attic for future conversion, or raised basement. In the case of expansion into an unfinished attic space, both Friedman (2002) and Schneider and Till

(2007) indicate some design considerations that need to be taken into account: 1) the strategic location and form of the staircase for easy extending to serve the additional future space, 2) considering sufficient height at both the ridge and the edges of the pitched roof, so it can be occupied in the future. Some construction considerations are also important in this strategy, which are discussed in the next section of this chapter. In terms of services, extending the services systems to the upper level needs to be considered to avoid major construction works. In the case of expansion into an uncompleted basement, the main design principles are, first, to consider a raised basement that will allow provision of a large opening for natural light, so the space can be used for a range of functions, and second, considering the location of the stairs in order to facilitate different layout arrangements.

Another strategy of add in is the shared room. This is a German concept called "Schaltzimmer", which entails the provision of a non-specific room between two adjacent units so it can be switched from one unit to another. For example, if this room is located between two one bedroom apartments, this means that at any one time either could become a two-bed apartment. If this space is large enough and provided with its own utilities (bathroom, toilet, etc.), more possibilities for use can be created, such as an independent apartment or small office (Schneider and Till, 2007). This can be seen in the Am Steinberg Scheme in Germany, designed by Metron – Architekten AG in 1990. The project is a series of two-storey rows of terraced houses, with 90 units in total, 36 of which were designed with a switch room. The units are organised in 9 strips, each strip containing 10 units, of which 4 units are switch room apartments (see figure 3.13). The switch rooms were located between every two units on both floors, and thus the switch rooms on the ground floor can be given over to one of the units, whilst the shared room on the first floor can be given to the other unit. It is possible also for both shared rooms to go to one unit. Another possibility is to convert the shared rooms on the ground floor to independent small studio units (Schneider and Till, 2007).

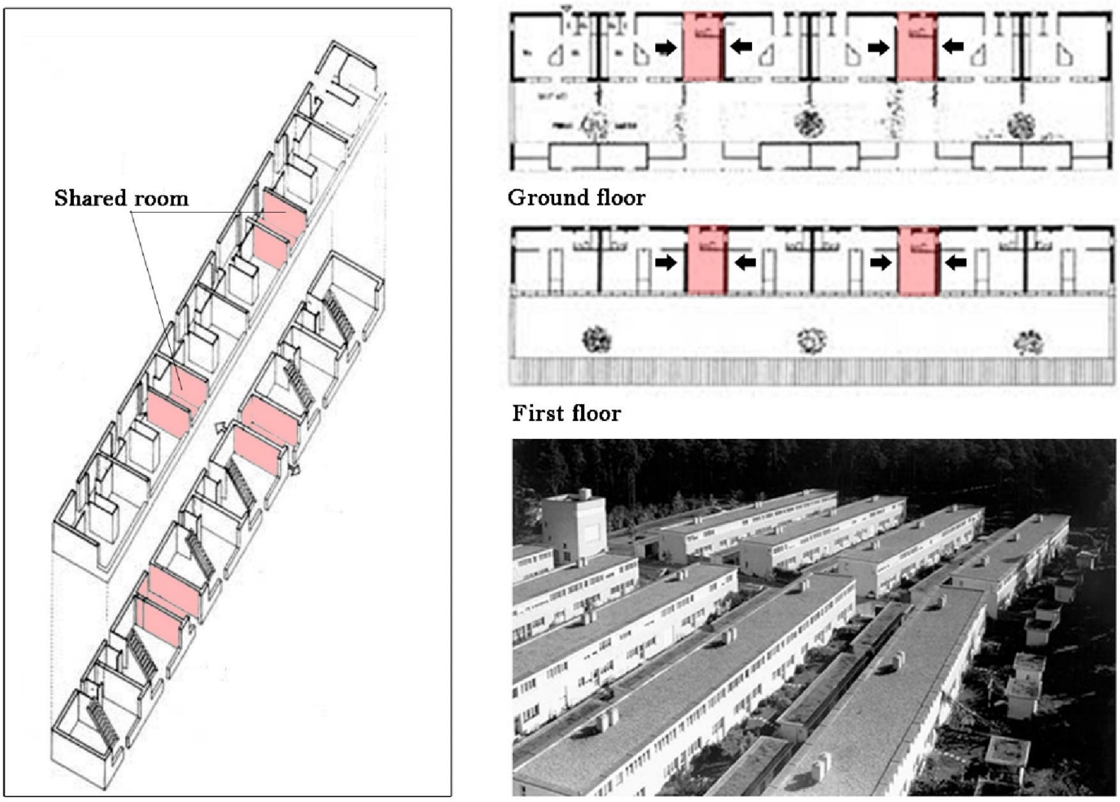


Figure 3.13: Am Steinberg Scheme. Metron - Architekten AG, Germany, 1990, Flexibility through shared rooms, Source: www.db-bauzeitung.de, edited by the researcher.

It can be argued that the key limitation of this strategy may arise when the two tenants both require or neither needs this extra space. However, the advantage is that this design strategy offers the landlord the ability to respond to the social and market demand. In this strategy, different design principles are important: 1) to provide a space that can be accessed from two units, 2) considering the logical relationship between the shared room and adjacent space, 3) when designing a room with a large space an independent access and wet space are important, so it can be converted into an independent unit. In addition to the design principles, some construction and services considerations need to be taken into account: 1) the ability to create openings in the adjacent wall between the shared room and the units through, for instance, designing the shared walls around a panel system, 2) the ability for easy connection and disconnection of the switch room services from one unit to another, 3) taking into account the sound, fire and thermal requirements (CPD, 2014, p. 29).

The literature review of add in strategies revealed three key forms for growth within the building envelope: vertical expansion, horizontal expansion and shared room. Vertical expansion comprises two key forms: adding an additional floor within an open unit envelope, which can be implemented on different building types, and extending into an existing unfinished space such as a basement or attic. Horizontal expansion concerns the ability of the unit to be enlarged horizontally into excess space located within the building envelope, such as balconies, which is more useful for expansion in a multi-storey building. Shared room strategy can be considered in multi-unit buildings to facilitate the ability of the units for expansion over time. In all forms of add in, different design principles and construction and services considerations need to be taken into account, to enable the layout of the unit to be enlarged easily within the building parameters.

Joining together can be seen as another way of growth that can enable the size of the unit to be considerably increased. According to Schneider and Till (2007), it is an economic approach to expansion within multi-unit housing and can provide a range of options such as joining two one bedroom to form a three bedroom apartment or combining a family house with a small apartment to create a large house that can accommodate an extended family. However, the disadvantage of this strategy is that it relies on an adjacent property being free at the appropriate time. Verwandelbare Wohnung project in Germany, designed by Karl Schneider in 1927, is a flexible project that exploits the strategy of joining together to enable the unit to grow in the future. The plan consists of four apartments which can be combined into two units. To facilitate this, the circulation space of the building was designed to allow access to two units, so they can be entered separately or as one. This was achieved by creating an access to the two flats adjacent to the staircase directly from the staircase zone and another access to the outer apartments from the deck. When the units on the right and left of the staircase are combined, the new apartment is accessed straight from the staircase enclosure and the deck becomes a private space. The wet spaces in the enlarged unit remain in the same location and one of the kitchen spaces becomes a bathroom. In terms of construction, incorporating a regular grid of columns into the layer of the external walls freed up the internal layout to facilitate any future change through joining (see figure 3.14).

Figure 3.14: Verwandelbare Wohnung, Karl Schneider, Germany, 1972, flexibility through joining together. Source: Schneider and Till (2007, p. 59), edited by the researcher.

Consequently, this strategy requires different design considerations in terms of plan and construction. In terms of design, as the key principle is to provide generous shared access to facilitate future joining, the design of the unit needs to be conceived in relation to the adjacent units in a way that facilitates logical combination of the units, and location of services space should not restrict the ability of the units to be joined to each other. In terms of construction, the main considerations are: 1) creating an opening between the units by means of such as partitions that can be knocked out easily, 2) designing the wet spaces, particularly the kitchen, to allow removal of the duplication with minimal modification work, 3) considering fire regulations and sound insulation between rooms (Schneider and Till, 2007 and CPD, 2014).

Division

Division involves design strategies that facilitate dividing of a large space into smaller units, as the need arises. According to Schneider and Till (2007), this process could respond to the household’s changing and different needs, such as children growing up and wanting to leave home, whilst the parents may not want to move home, or where a divorcing couple have a jointly owned home, so the house requires to be divided up along with the relationship. Therefore, the strategy is to design a single large unit with the potential to be divided up in the future. This has particular importance in the private sector as it allows the landlord to stay in his/her dwelling even though it has exceeded their needs. Friedman (2002) similarly views this process as having the benefit of offering different choices such as single or multifamily dwellings at delivery point or upon a decrease in household size, as the occupant can partition the space and create more than one unit. The division of the unit can be carried out horizontally or vertically according to the unit type and as a single or two storey extension. Two key strategies for dividing up can be recognised: 1) a large unit designed to be divided into two small units, 2) a large unit that can provide a small portion as an independent unit. The latter can respond to an arising need to accommodate an elderly family member, home-office, space for rent, etc.

Prominent examples of this approach include the London Flexhouse project, designed by Nouvelle Development Corporation in 1996, and the Next Home, designed by Avi Friedman in 1996. The projects were designed to be built as single detached, semi-detached or row houses with three or four storeys. In both projects, dividing single dwellings vertically into three independent units is made possible by positioning vertical circulation and entrances in order to facilitate independent access to each level (see figure 3.15).

Figure 3.15: Next Home, Avi Friedman, Canada, 1996 flexibility through dividing up. Source: Schneider and Till (2007, p. 112), edited by the researcher.

Friedman (2002) and Schneider and Till (2007) identified two key design considerations for this strategy: 1) the design of access in a manner that allows for the provision of an independent entrance for both sections, 2) and the potential for independent services spaces in each division. Another consideration that seems important for this strategy is the ability of the divisible plan to accept new arrangements of functions either through physical or non-physical adaptations. In a similar way to the shared room, it can be claimed that the services need to have the ability to serve the separated section independently, particularly in the case of creating an independent unit. It is important also to note that joining and dividing up processes can work as two complementary strategies to enable the unit to grow and shrink in size over time.

Consequently, flexibility in the size of the unit can take two key forms, growth and division, which can be achieved by different methods (see figure 3.16). However, this is largely conditioned by the type of building. Generally, it can be argued that two key approaches to flexibility in size are important in enabling the building to cope with change: joining/dividing processes which can be applied on different building types to allow considerable change in unit size, whether in terms of growth or shrinkage, and additions, either through add on or add in, that offer a range of strategies according to building type. Therefore, the researcher investigates these two key possibilities for changing the size of the unit in the selected case studies, in order to evaluate the design of the unit on the basis of flexibility in size.

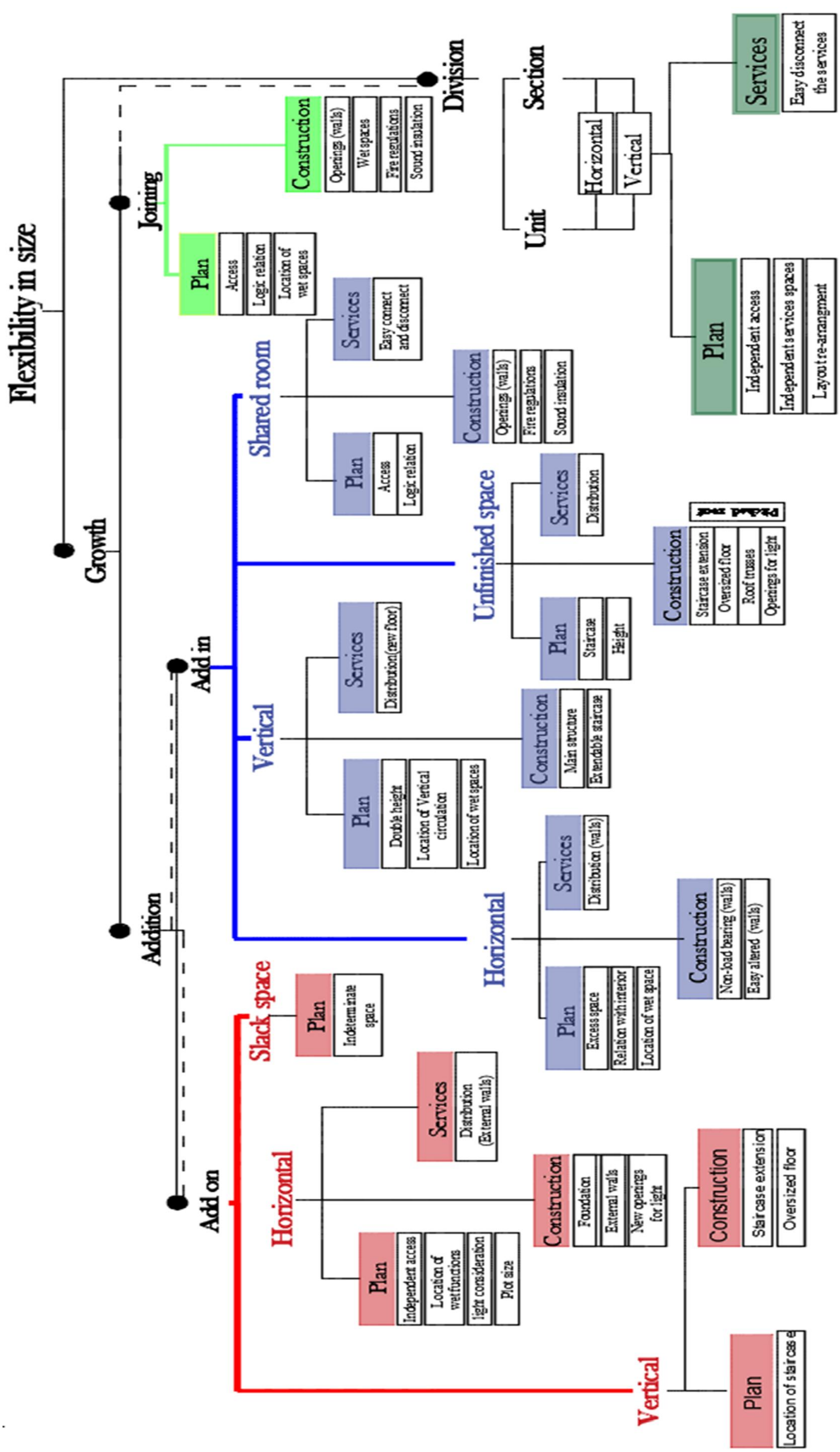


Figure 3.16: The main concepts for flexibility in size adopted by the researcher.

2- Layout arrangement

Historically, flexibility came as a response to what was termed by Rabeneck et al. (1974) as "tight fit functionalism" of modern houses, where the dwelling spaces are usually designed to the minimum limits of their designed functions. According to Schneider and Till (2007, p.36), it is an attitude that arose from a modernist fixation with spatial standards of housing space based on "typical furniture layout and circulation clearness". Flexibility was seen as the best solution for the trend of reduced space standards and the internal variability of dwellings was identified as the key to achieving this.

The ability of the layout arrangement to accommodate change has been addressed differently among researchers. Venturi (1966) and Rabeneck et al. (1974) argued that the layout arrangement can cope with change through the ability of the planned spaces to accept variation in function within a fixed structure. Differently, Rietveld (1924) and Habraken (1972) viewed that flexibility in architecture needs to be delivered through actual physical change. Moudon (1986) and Hartizberger (1991) focused on the ability of the plan to be adapted without the need to create significant physical adaptations. However, they realised the need of occupants to create modifications to their spaces. Therefore, they indicated the need for allowing users a degree of freedom to make physical changes to their dwellings and the diversity that such changes enhance. Schroeder (1979) viewed the ability of the layout arrangement to accommodate change as lying in its capacity to adapt without changing the building's structure and/or with structural interventions. Groak (1992, p. 15) similarly indicated that the capacity of the building to cope with change will depend on the extent to which it is flexible for "different social uses" and/or "different physical arrangements". Chow (2002), who viewed the dwelling as a fabric, advocated that in order to accommodate change, housing needs to support both physical and non-physical adaptations. The latter is achieved through designing the space in a manner that can be interpreted in different ways and the former is considered through the ability to change construction elements. He argued that the spaces in which people live are settings depending on how everyday activities occur; therefore, they have to be interpreted and change in different ways. In this respect, he stated that "every setting has structure, a form, that is inhabited, interpreted, and read. Our use of setting is always changing, and the form is continually being reread and reinterpreted. To accommodate this dialogue, our settings need to support multiple associations and uses”. To accommodate the temporality of dwelling, “a structure must easily give up a particular reading and take on a new one” (Ibid, p. 108).

Consequently, the research adopts the latter position along with researchers such as Groak and Chow who view flexibility in layout arrangement as needing to be manifested through the ability of the internal layout to be adapted physically and non-physically. Therefore, analysing flexibility in spatial arrangement requires looking at two possibilities in the design of the plan: 1) whether the layout’s spaces can be occupied in different ways without physical alterations, 2) the potential to develop different layout configurations through physical adaptation

Functional flexibility

Venturi (1966, p.16) promoted design features that can be “accommodating rather than excluding” and elements that have a “richness of meaning rather than clarity of meaning”. Therefore, he suggested the strategy of “multifunction room” to achieve flexibility in internal layout that promotes “the room with a generic rather than a specific purpose, and with movable furniture rather than movable partitions". On the same lines, Rabeneck et al. (1974, p.79) recommended housing design based on “occupant choice through ambiguity”, that emphasises “planning and layout rather than constructional technique and services distribution”. It basically relies on “carefully considered variations in room size, relationship between rooms, slightly generous usable floor area, generous openings between spaces and little overt expression of room function”. Different design requirements are important for this strategy: 1) to avoid extremes in the size of the room, 2) considering simplicity in form, 3) to avoid the determination of a room’s function through windows and built in furniture, 4) plan form, circulation space and the location of doors need to be considered in a manner that allows a variety of room uses.

In her analysis of housing in San Francisco, Moudon (1986) focused on studying the ability of the Victorian row houses to accommodate a large range of changes, primarily through non-physical adaptations. She drew a radical conclusion: “a return to the room as module for residential design is a necessary step toward creating resilient space, we must abandon the use of dwellings as modules of spatial arrangement” (Ibid, p 65). She also drew similar conclusions to those of Rabeneck et al. in terms of providing spaces with generous dimensions, simple shape and the potential to be connected in different ways to achieve houses that can accommodate change over time.

Friedman (2002) and Schneider and Till (2007), classifiers of the different approaches to adaptable/flexible housing, focused clearly on design strategies that achieve flexibility in interior design through non-physical adaptations. Like Venturi (1966), Friedman (2002, p.129) promoted "multipurpose spaces" as a strategy to achieve internal flexibility through non-physical adaptations. The objective of this strategy is to design the rooms with dimensions and proportions that permit different uses to take place within their spaces. In order to achieve this, he focused on these two criteria and suggested "the larger the space is the wider the options of adaptability will be" (Ibid, p.130). In terms of proportion, the suggestion is that a square form for a room's space is more desirable as it allows different furniture layouts. In a similar way to Rabeneck et al., he drew attention to the importance of designing the rooms without permanent interior features, and providing ample light that facilitates a range of uses. Schneider and Till (2007, p. 186) use the term "functionally neutral rooms" to refer to this strategy and propose the design of a number of equal size rooms with no labels, so the hierarchical order is removed in the unit and thus each space can become an independent entity. The Grieshofrasse project, designed by Helmut Wimmer in Austria in 1996, is a prominent example of the application of this approach to achieve functional flexibility. The project consists of nine apartments on five storeys, each floor containing two equal size apartments. Each apartment was designed in the plan as nearly square clear rooms of equal size, which can be accessed from a central hall space. No particular use defined the spaces of these rooms, which gives the layout's spaces a certain neutrality in function, so the units can be interpreted in different ways by their users (see figure 3. 17).

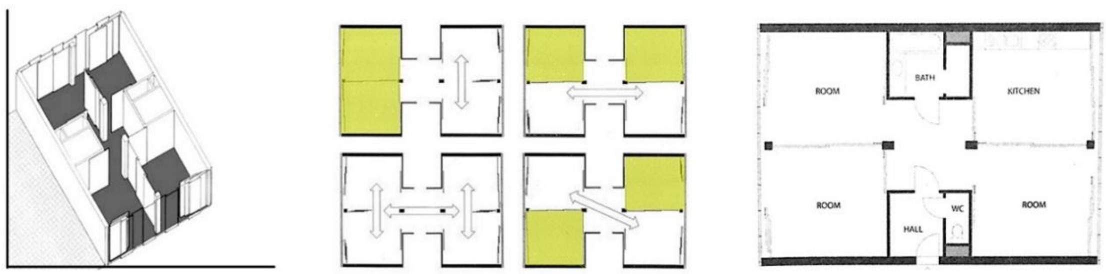


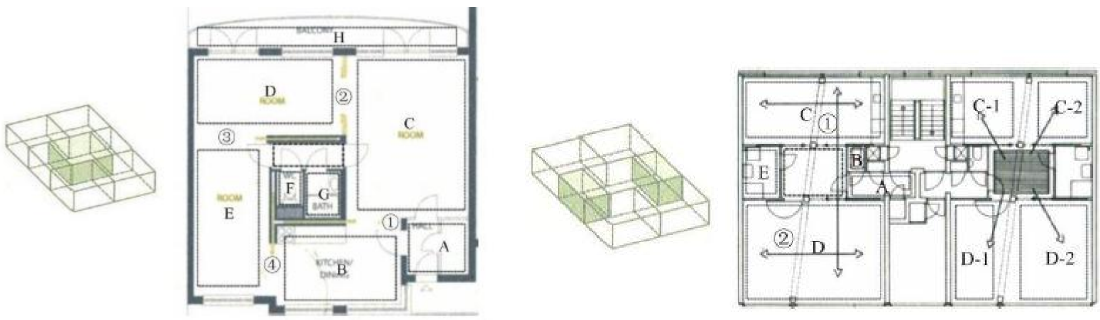
Figure 3.17: Grieshofrasse, Helmut Wimmer, Austria, 1996, functional flexibility, Source: www.afewthoughts.co.uk.

"Polyvalency", proposed by Hertzberger in 1962, is another strategy that promotes flexibility through non-physical adaptations, asserting that "the building can be used in different ways without structural interventions" (Leupen, 2006, p. 24). A more clear definition of the concept of polyvalence is provided by Australian architect Stefan Picusa, as “built into the initial design, giving the occupant choice through intentional ambiguity, within fixed physical constraints of a given plan” (cited in Seo and Kim, 2013, p. 76). In contrast to Rabeneck et al., Hertzberger (1991) argues that the layout of spaces should have a degree of specification, and not be absolutely general, so the plan can offer a variety of uses and at the same time suggests a range of occupations based on how the space is interpreted by users. In this respect, he stated “we should go about designing in such a way that the result does not refer too outspokenly to an unequivocal goal, but that it still permits interpretation, so that it will take on its identity through usage” (Ibid, p. 152). In order to achieve this, Hertzberger (1991, p. 164) called for emphasis on the dimensions within the rooms to determine the “accommodating capacity” of these spaces, but he did not offer a clear method to describe these adaptable spaces.

The Diagoon Houses project, designed by Hertzberger in The Netherlands in 1971, is the key example in terms of representing this concept in its design. The typical design consists of three plans with two fixed cores (staircase and, kitchen and bathroom on different levels). The ground floor contains the main entrance, workspace, small storage area and open space of no specific size that can be used for different purposes such as garages. The first floor has a fixed kitchen and spaces around it with different forms and proportions that can be interpreted in different ways by the user. On the last floor, the bathroom is the fixed space, while the space around it is also designed in a form that allows variety in use (see figure 3.18).

Figure 3.18: Diagoon House, Hertzberger, Netherlands, 1971, functional flexibility. Source: Schneider and Till (2007), edited by the researcher

“Enfilade” or “permeable circulation” is another strategy that can lead eventually to flexibility in spatial functions. This strategy refers back to Robin Evan who showed how rooms with multiple doors and plans without corridors enhance the sense of sociality. According to Schneider and Till (2007, p. 151), the importance of this strategy is that it “dissolves the strict hierarchy and categorisation of rooms”, and thus allows the user to interpret their spaces in a different ways. Seo and Kim (2013) distinguished between two ways for incorporating the enfilade strategy in housing. The first way is to create a ring form of enfilade through placing the services core of the plan in the middle. The second way is to create a central hall that can be connected to different rooms in an enfilade way by placing the services cores on each side of the plan. They argued that when enfilade is created with a ring shape, more adaptability can be obtained. This strategy can be achieved at two different levels: unit and room. In the latter, two access points in one partitioned space need to be considered. At unit level, a global ring that connects the rooms needs to be created in the outline plan (see figure 3.19).



(a) (b)

Figure 3.19: Two basic ways of making enfilades: central core type (a), central hall type (b). Source: Seo and Kim (2013, p.80)

Schneider and Till (2007) view that the modest scope of this strategy is represented in the connection of two or more rooms. Therefore, it is more applicable at room level than the level of individual unit. An example of application of this strategy with a ring shape design is the Housing Graz-Strassgang project, designed by Riegler Riewe Architeckten, in Austria in 1994. The building consists of three levels with a staircase serving two apartments per floor. The design of the unit features a central zone that connects to services spaces and rooms placed on either side of this central core. The rooms are connected to each other through openings with sliding walls, which create permeable circulation in the plan, thus allowing the user to occupy the room in a variety of ways (see figure 3.20).

.Figure 3.20: Housing Graz-Strassgang, Riegler Riewe Architeckten, Austria, 1994. Source: spiluttini.azw.at.

Consequently, while the previous approaches share the same aim of achieving housing spaces that can be used in different ways within a fixed structure, they generally differ in their solution to achieve this. However, three key principles of functional flexibility can be concluded from these different approaches: 1) appropriate size and simple form of the layout spaces to allow the spaces to be occupied in different ways by the user, 2) ample lighting of the layout spaces to facilitate different functions, 3) different space layouts all having independent access. Another principle is the connection between the layout spaces, which increases the scope of functional flexibility and thus improves the functionality of the space.

Spatial flexibility

There is a direct belief that flexibility in spatial arrangement of the plan is best delivered through physical change. Habraken (1975, p18.) stressed that "dwelling is indissolubly connected with building", and inhabitants have a need for "a personal environment" as this "concerns one of the strongest urges of mankind: the desire for possession". Therefore, housing units need to have the ability to be modified by their users. He critiqued the legacy of mass housing due to the inability to change and proposed the use of modern technology such as prefabricated elements to develop buildings that can be adapted to accommodate personal choice and change over time, through separating the internal configurations from the main structure. The separation of the two building components, support and infill, allows radical internal changes to units.

Brand (1994, p.20) argued that the space plan is what occupants deal with all day, and they rapidly grow bored, frustrated, or embarrassed by what they see. "Between constant tinkering and whole renovation, few interiors stay the same for even ten years". Therefore, he considers the layout of the rooms as the least fixed element in the building and thus the flexible deployment of internal partitions that define the final spatial layout is important. Historically, architects developed different partition systems that enable the internal layout to be changed. Sliding and folding walls were one of the earliest systems and trace back to Rietveld who first used this method in the design of the Schroder house in 1924. The integrating of sliding elements allows the house to offer a series of layout configurations from completely open plan to a range of scenarios that allow rooms to be separated on a temporary basis. For example, the first floor, which includes living and sleeping spaces, can be opened up during the day into a single open space and re-divided at night for privacy purposes into separated individual spaces (see figure 3.21). Leupen (2006) argues that as some parts of the partitions are movable, the space itself is movable, and thus can be changed over time. However, as these elements cannot be taken out or placed anywhere within the plan, they combine permanence with the ability to move only within a fixed pattern, and thus they become among the determinations of the space. The use of sliding panels allows the different functions to be bounded temporarily, which offers "visual enlargement of the space rather than any increase in its ability to function" (Ibid, 187).

(a) (b)

Figure 3.21: Schroder house, Gerrit Rietveld, The Netherlands, 1924. Source: Schneider and Till (2007, p. 57) (a) and Leupen (2006, p. 187) (b).

According to Schneider and Till (2007), these movable elements are a more deterministic system, as they are usually conceived of as foreground mechanisms. Another reason that makes this strategy deterministic is that the sliding walls usually do not disappear into the wall pocket, and thus the layout spaces will never be entirely open. Theoretically, the use of this system would be able to provide open space, but in terms of practicability this is conditioned by different factors such as the need for privacy, level of tidiness of the occupants and the way of furnishing the space. This puts the occupants in constant charge, and thus the users' lives are controlled by the walls rather than vice-versa.

A less determinate approach is to figure out the layout without moveable elements and then integrate them to create other plan forms in terms of configurations and functions (Schneider and Till, 2007). One of the key examples of this approach is the Greenwich Millennium Village (II) in the UK, designed by Proctor and Matthews Architects in 2001. The plans were designed with integrating sliding walls that disappear completely into the thickness of the walls in order to create different floor plans. Since the sliding walls are acoustically isolated, they allow dividing up of the spaces on both a temporary and permanent basis (see figure, 3.22).

Figure 3.22: Greenwich Millennium Village (II), Proctor and Matthews Architects, the UK, 2001. Source: www.afewthoughts.co.uk

Similarly, but with more possibilities for internal change, in their project "Movable Space Dividers" Fred Mackie and Karl Kamrath (1942) introduced the idea of movable partitions as a piece of furniture to divide a modular grid of large open space into different combinations of smaller spaces and rooms according to the users' wishes and needs, which could otherwise be used as closets (see figure 3.23).

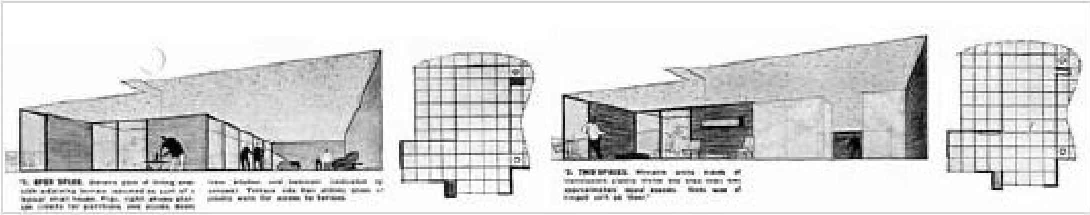


Figure 3.23: Movable Space Dividers, Fred Mackie and Karl Kamrath, 1942. Source: www.afewthoughts.co.uk.

A more indeterminate approach to achieve flexibility in internal layouts, proposed by researchers such as Brand (1994) and Leupen (2006), is to develop the building on the basis of a layering approach. Leupen (2006) suggests moving through the hierarchy of fixed elements in terms of their permanency, ranging from structure, skin, access and services to scenery. This means starting with identifying the permanent elements in the design process in order to enable flexibility in the more temporary components of the building. Louis Kahn similarly depended on the idea of permanence of elements to distinguish between two types of spaces in housing: services spaces (bathroom and kitchen) as fixed elements that are difficult to change, and served spaces (living space) as less fixed elements that can be adapted easily (Griffin, 2005). Schneider and Till (2007, p.189) similarly conceive the services core as "the least likely rooms to be moved over the lifetime of the home". They asserted the importance of locating the wet spaces in a strategic place that will allow internal alterations to take place in different ways, without the need for change or moving these spaces. A good example is the Siedlung Hegianwandweg in Zurich, where the external walls, communal circulation, bathrooms and entrance hall are provided as load bearing walls and the services core is located in a strategic place in the centre of the building. This enables the free organisation of the internal walls of the units in different ways and the ability to change the configuration of the layout in the future.

In contrast, in the 1960s, architects started to consider the services spaces as mobile objects, thus freeing them from their cores to create completely open and flexible plan. An apartment with transformable cores was designed by Abalos and Herreros in 1990, providing an example of such mobile services in a housing project, where the interior, including the kitchen and bathroom, was designed as a series of mobile elements, which enabled a range of possible arrangements for the unit layout, depending on its user's wishes (see figure 3.24).

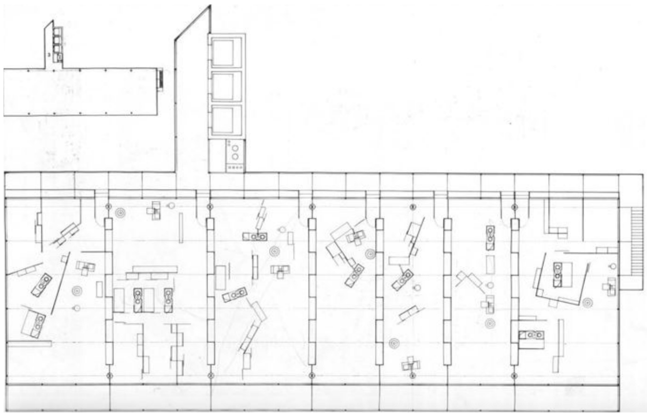


Figure 3.24: Apartment with transformable cores, Abalos and Herreros (1990). Source: Schneider and Till (2007, p. 157).

Therefore, there are two opposite ways to design the services elements to facilitate spatial flexibility of the plan. The first is to conceive the services (kitchen, bathroom and toilet) as fixed elements, meaning that the location of the services space within the plan needs to be considered in a manner that allows different layout forms to be developed over time. The second is to free the services from their core and design the services as moving appliances, so a completely open and flexible plan can be obtained over time.

Moreover, Friedman (2002) highlights the importance of considering the location of the entry door as it influences the ability of the layout to accept different spatial configurations. He provides some examples of possible locations of the door and explains the impact on the scope of spatial re-arrangement of the plan. For instance, placing the entry door in the middle of the façade divides the front space into two, which limits spatial flexibility of the layout, whereas locating the main entrance adjacent to the side wall or as a side entrance provides greater exposure to natural light, and thus increases the spatial flexibility of the plan (see figure 3.25). However, the location of the door to facilitate the re-configuration strategy is conditioned by the type of unit, as whilst it can allow different choices in the case of single detached house, it becomes more limited in other types such as semi-detached, row houses and flats.

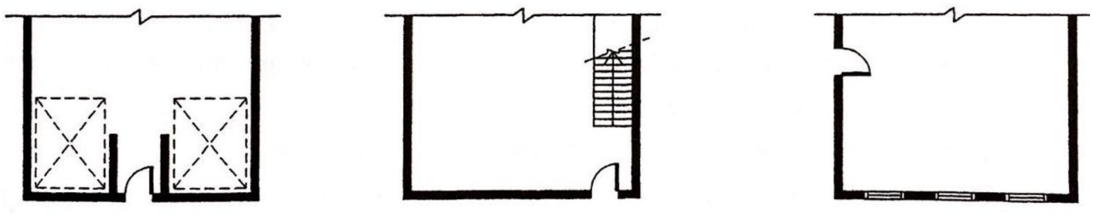


Figure 2.25: Example of the possible location of the main entry door: Source: Friedman (2002, p. 93).

In summary, there are different ways to achieve flexibility in spatial configurations that range from determinate to indeterminate methods. However, the main characteristics of spatial flexibility are: 1) the strategic placement of the services core including kitchen, bathroom, toilet, or the ability of appliances to be moved easily within the plan, 2) consideration of the location of the vertical circulation in the case of multi-storey units, 3) the possibility of using internal partitions that can be moved around easily, 4) and careful location of the entry door to the unit.

Flexibility through furniture

Schneider and Till (2007, p.155) consider that the most extreme approach to achieving interior flexibility is “to treat the house as a piece of complex equipment and then to design it in the most efficient manner possible”. It is an approach that is appropriate when the layout spaces are limited and tight. Historically, architects started to develop types of furniture that can be used for different needs. In order to achieve this, the furniture was designed to be compressed in function, minimised or composed in parts to suit combination with other functions. Gilbert Rohde was among the earliest furniture designers to develop this idea and designed over the 1930s and 1940s “many lines of modular furniture, promoted for its flexibility, functionality, and suitability for apartments and small homes” (cited in Gjakun, 2015, p. 40). In the mid-1940s, the architect George Nelson introduced the idea of “storagewall” which combined the traditional function of the wall as a divider of the space with storage to create a multi-functional wall. The development of this type of furniture has improved the spatial efficiency of space through making its uses convertible over time.

Le Corbusier, in his project Maisons Loucheur (1928/9), used the idea of moveable and fold down furniture to improve functionality of the space. In this regard, the design for the living space incorporated folding and movable beds that allow the space to be used for two different functions: as a sleeping space at night, while during the day the beds disappear beneath built-in wardrobe elements, making the space usable for daytime activities (see figure 3.26).

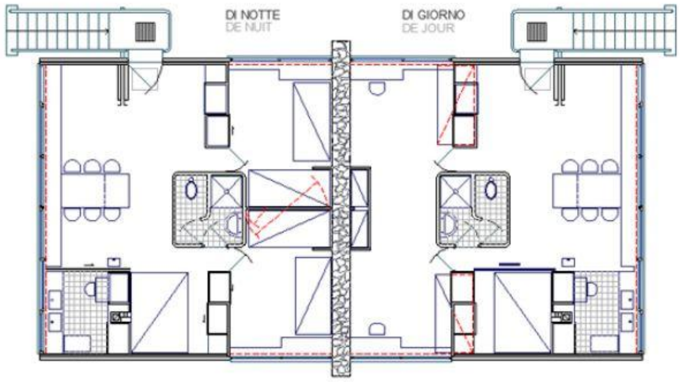


Figure 3.26: Maisons Loucheur, Le Corbusier, 1928/9. Source: [www.afewthoughts.co.uk.](www.afewthoughts.co.uk)

Internal circulation

Typically, architects seek to keep corridors and hallways in housing to an absolute minimum in their designs, so they can only be used for access purposes. Schneider and Till (2007) argued that at standard 0.9 m width a passage is no more than a space for access. Therefore, to see these spaces as flexible, as something more than a means of access, a marginal increase in the dimensions of circulation spaces needs to be considered. This allows the circulation space to accommodate other functions and increases the ways in which overall the units can be used. For example, a corridor of 1.2m width can be exploited for incorporating storage space, and at 1.60 m it can be used for a variety of functions such as a play space for children, space for a desk and so on. Thus the consideration of a slight increase in the dimension of circulation space is the most important criterion for flexibility in this space. Similarly, Friedman (2002, p.137) argued that due to the fact that the access elements can form 30% of a house area, these spaces have to permit more than single use. They should be able to accommodate different needs of the household throughout their lifecycle, such as the need for more storage space, which can be achieved by allocating 1.2m to the hallway and corridor space. Another important use of these spaces is to accommodate new functions when a home has the capacity for vertical extension. For example, the space can be initially used as storage space and later it can be replaced by a staircase.

To summarise, flexibility in design can be achieved through using internal circulation space for more than access purposes. This can be manifested through providing such spaces with adequate dimensions to allow them to accommodate additional functions.

3.2.3 Flexibility in the plan at room level

In their questioning to test flexibility in rooms, Schneider and Till (2007) assumed that the flexible room is achieved by considering three key design principles: 1) the capacity of the room to accept more than one function, 2) the potential of the room to be connected to the adjacent rooms in more than one way, 3) the ability of the room to be furnished in different ways. The research adopts these key principles as concepts to analyse flexibility in rooms and discusses the possible ways to achieve this goal.

Rooms that provide flexibility in function can be designed via various methods. The most common approach is the strategy of multifunction room presented by researchers such as Venturi (1966), Rabenek et al. (1974) and Friedman (2002), which considers the design of the room space in terms of accepting different functions. To achieve this, the emphasis, as explained in the previous section, is on the appropriate dimensions and proportions of the room, simple form, ample light and avoiding the determination of a room's function through windows and fixed furniture elements. Another strategy that leads eventually to flexibility in function, but is particularly appropriate when dealing with tight spaces, is the use of built-in foldable furniture that allows the space to function in more than one way, such as the use of foldable beds, so the space can be used in one way during the day and then as a bedroom at night. In order to achieve this, Schneider and Till (2007) explain that the foldable furniture needs to be considered in the design of the room from the outset as this requires incorporation of the item into the fabric of the room and consideration of the layout of the room when the furniture is either up or down. The divisible room is a concept that could give the room the flexibility in function through division of the space to serve two different functions; for example, a large double bedroom might be divided into two small single bedrooms. This would require a large double room size with proportions of 2:1 and consideration of the number and location of the windows, and the potential for independent access in the case of permanent division of the space (Schneider and Till, 2007).

In terms of flexibility in room connection, two design strategies can be recognised. The first is to consider a new opening to connect two rooms to one another, such as a door that allows intermittent connection through being opened when required or closed when more privacy is needed. This allows the user, for instance, to connect between kitchen and dining or living room, which increases the ways in which the room can be occupied by its user. The consideration of the location of the door is important in this strategy as its position may reduce the actual space for activities within. The second is to use a sliding wall that enables a big opening to be formed. This greatly increases the options as to how a room might be used and the perceptual size of a space (Schneider and Till, 2007).

Rooms with flexibility in furniture can be achieved in two different ways. The first is by designing the layout of the room in terms of dimensions and proportions to accept different ways of furnishing it. Brand (1994) and Friedman (2002, p. 130) suggest a minimum dimension of 3.7m for a room in a small house, in a nearly square form that will present fewer limitations on furniture arrangement. In addition, Friedman (2002) asserted that fixed interior furniture, such as a closet in a bedroom, will affect the ability to use different ways of furnishing the room. The location of the entry door of the room can also influence furniture arrangement within the room space. For example, placing the door close to the side wall leaves large expanses of wall area against which furniture can be placed, while shallow storage furniture can be placed in a small space left behind the door. Schneider and Till (2007) highlight that use of fixed heating elements such as radiators limits in various ways how a room can be furnished. Therefore, all of these principles need to be taken into account when flexibility in furniture is important in the design of the room. Another approach that can provide a room with flexibility in furniture, but in a determinate manner, is by using foldable multifunction furniture that can furnish the same space in two different ways. This approach is particularly appropriate when dealing with tight room space as in the case of the Maisons Loucheur project, where the foldable design of the furniture enabled the whole space to be furnished as a bedroom at night and study/work space during the day (see figure 3.26).

It can be concluded from the discussion above that the principles of the flexible room can be followed in different ways. However, the methods used are conditioned by the size of the space in the room. For instance, if space is tight, then foldable furniture is the most appropriate way to achieve a flexible room, but this flexibility has a determinant form. With more available space a more indeterminate form of flexibility can be obtained. This is maximised by having the potential to connect the room with other rooms in more than one way. Therefore, the extent to which the room is flexible relies on the extent to which the appropriate design principles are followed.

Table 3.1 summarises the main categories and concepts along with their evaluation criteria for flexible housing as drawn from the literature. These evaluation criteria have been discussed in detail in this section, and in particular Schneider and Till's (2007) systematic approach that clearly defines the different possibilities for flexibility in the design of housing. However, this table includes more specific points relating to each of the concepts derived from the reviewed approaches.

Category	Concept	Criteria for evaluation
Building	**Units mix**	This is the ability of the building to accept change in the number of units. This can be seen through one of various possibilities according to the building type, such as: 1- The ability of the building to accept the joining together of some units in the case of multi-unit buildings. 2- The ability of the building to accept division of some units into two small independent units in the case of large dwellings. 3- The ability of the building to be extended vertically to provide additional units. 4- Convertible basement that can be functioned as an independent unit or units.
	Use	Generally, this is the ability of the building to be used for more than residential purposes, particularly in the large building block. Six key principles in the design of the building are important: 1- Space: indeterminate open space. 2- Height: ceiling height suitable for non- residential purpose. 3- Circulation: appropriate size of circulation space facilitates non-residential use or mix of use of the building. 4- Services: possibility to provide independent services. 5- Façade: neutral façade in terms of fashion. 6- Opening: considerable opening for non-residential use. 7- Access point: multiple access points or independent access.
	Communal circulation	This is the ability of the horizontal circulation (corridors) in multi-dwellings building to accommodate more than access purposes. The following principle is important in the design: 1- Oversize of the communal circulation space.
Unit	**Size**	This looks at the ability of the unit to accept change in its size in two different ways: **1-** The first is the ability of the unit to be divided up, and the following principles are important:

In terms of design

- Independent access for the divided units.
- Independent services spaces in each unit.
- The ability of the plan to accept new arrangements of functions when needed.

In terms of services.

- Independent services systems for the divided units.

2- The second is the ability of the unit to accept growth in size through applying one of the following approaches:

A- Joining two units together: the following considerations are essential:

In terms of design

- Generous shared access.
- Logical combination of the units.
- Careful location of services space.

In terms of construction

- Partitions that can be knocked out easily.
- Easy dismantling of the services units and items.
- Considering fire regulations and sound insulation between rooms.

B- Accepts addition either externally (add on), which is more often applied to single family houses (detached, semi-detached and row houses) or internally (add in), which can be applied essentially to multi-unit buildings but also to other building types.

- **Add on approach:** one of the following strategies needs to be investigated:

1- **Horizontal addition** is the ability of the house to accept addition in a horizontal direction, and the following considerations need to be investigated:

In terms of design

- Access: possible access to the addition.
- Services: careful location of the services.
- Light: sufficient light for space after extension.
- Plot size: appropriate size of the plot to accept extension.

In terms of construction and services

- Pre-installed foundations
- The possibility for creating openings within external walls that could potentially be changed. (non-loadbearing and no services located within)
- The ability to serve the addition easily.

2- **Vertical addition**: the following considerations are important:

In terms of design

- Strategic location and form of the staircase for ease of extension in the future.

In terms of construction

- Pre-cut joints for future extension of the staircase.
- Oversized floor to accept additional dead and live loading.

3- **Slack space:** the following principle is important**:**

- Unprogrammed space in growth.

- **Add in approach**: one of the following strategies needs to be investigated:

1- **Horizontal extension** is the ability of the unit to be extended into a considerable excess space within the building envelope, and the following considerations are important:

In terms of design

- Logical relation with the interior layout.
- Strategic location of the wet space within the unit layout.

In terms of construction and services

- Non-load bearing external wall.
- No services located within.
- The ability of the external wall to be moved around.

2- **Vertical extension** is the ability to create future floor within the building envelope for expansion, and the following principles are important:

In terms of design

- Double height of the unit space.

		• The location and form of the staircase to facilitate easy extension in the future. • Location of wet space. *In terms of construction and services* • Preparing the main structure to accept additional floor. • The ability to extend the services to facilitate the new floor. **3- Unfinished space** is provision of uncompleted space within the building envelope that will allow the unit to be extended internally in the future, such as an attic or basement: In the case of a basement, the following principles are essential: *In terms of design* • The location of staircase should facilitate future arrangement of the basement. • Raised basement with large opening for windows. *In terms of services* • The ability to extend the services to serve the basement space. In the case of an attic: *In terms of design* • Staircase: The location and form of the staircase should facilitate easy extension in the future. • Height: sufficient height for habitable use. • Light: the potential for suitable source of light. *In terms of construction and services* • Pre-cut joists for future staircase extension. • Pre-cut joists for potential roof light. • Open roof trusses. • Oversized floor to accept additional dead and live loading. • The ability to extend the services to serve the attic. **4- Shared room is** the design of a room between two units so that it can be switched over time from one unit to the other; the following principles are essential:

		In terms of design • The ability to access the space from two units • Logical relation between the room and interior layout of the unit. • Independent access and wet spaces in the case of a room covering a large space. *In terms of construction and services.* • The ability to create an opening in the adjacent wall between the shared room and the units. • The ability to connect and disconnect the switch room services from one unit to another easily. • Taking into account the sound, fire and thermal requirements.
	Layout arrangement	**Functional flexibility** This is the ability of the layout to accept different arrangements through non-physical adaptations. The following principles need to be followed in the design of the layout spaces: 1- **Size**: layout spaces of adequate size. 2- **Proportion**: adequate proportions for the layout spaces. 3- **Access**: independent access to the layout spaces. Another possibility for increasing the scope of functional flexibility is connection between the layout spaces.
		Spatial flexibility This is the ability of the layout to accept different arrangements through physical adaptations. The following possibilities need to be considered in the plan: 1- **Services**: the strategic placement of the services core (kitchen, bathroom and toilet, and vertical access in the case of a multi-storey unit), 2- **Internal partition**: the ability of internal partitions to be moved around in different and easy ways. 3- **Main entry**: the location of the main entrance should facilitate different layout configurations.
		Internal circulation This is the ability of internal circulation (corridors and hallways) to be used for more than access purposes and by a variety of people.

<table>
<tr><td></td><td></td><td>The following possibilities need to be achieved in the design of circulation space:

1- An appropriate size of access space to permit additional uses of the space, such as storage space, a deck, etc.

2- Suitable dimensions of the circulation space to enable its use by different groups of people, for example wheelchair users.

In terms of vertical circulation, and the ability of a variety of people to use the space, the following is essential:

1- The possibility of adding a lift as an additional vertical access means in the case of multi-storey dwellings.</td></tr>
<tr><td rowspan="3">Room</td><td>Function</td><td>This is the ability of the room to accept change in function, and two key possibilities in the design of the room need to be investigated:

1- Size and proportion: suitable size and proportions for the room

2- Form: simple form for the room.

3- Light: ample light that fits different functions.</td></tr>
<tr><td>Connection</td><td>This is the ability of the room to be connected to others, and the following key design element needs to be investigated:

1- The connection means (door, sliding walls or so on) or the potential for providing one in the future through, for instance, knocking out wall panels, dismantling walls, etc.</td></tr>
<tr><td>Furniture</td><td>This is the ability of the room to be furnished in a variety of ways, and four key design possibilities should be considered:

1- Size and proportion: Adequate dimensions and proportions for the room.

2- Clear internal space: No fixed, built in furniture or heating elements.

3- Access: Consider location of the door.

4- Opening: Size and number of windows for the room.

Another strategy is the use of foldable furniture that allows the room's space to be furnished in more than one way in the case of small sized room.</td></tr>
</table>

Table 3.1: Categories and concepts of flexibility for the plan and their corresponding evaluation criteria, drawn from the different flexible housing approaches.

3.3 Flexibility in construction

3.3.1 Concepts and evaluating criteria relating to flexibility in the construction

In addition to the plan, different flexible housing approaches have particular implications for construction. Therefore, this section focuses on aspects of construction that have been considered as important for flexible housing and can potentially accommodate change, in order to explore the main indicators for analysing the construction of flexible housing.

1- Structure

According to Leupen (2006, p. 32), the main structure of a building is "the structure [that] transmits the load to the ground". This can include columns, beams, load-bearing walls and structural floors. In the beginning of modern architecture, the Maison Domino (1914), designed by the architect Le Corbusier, presented the idea of Dom-Ino structure, which is a form of structure based on the idea of distinction between the structure and infill to enable change. The structure consists of concrete slabs and columns, where the columns are positioned at the very edge of the concrete slabs in a longitudinal direction, creating clear spans within the structure, and thus the potential for variations in the floor plans. In addition, the columns are moved back from the edges in the other direction, which separates the structure from the façade to enable change (see figure 3.27).

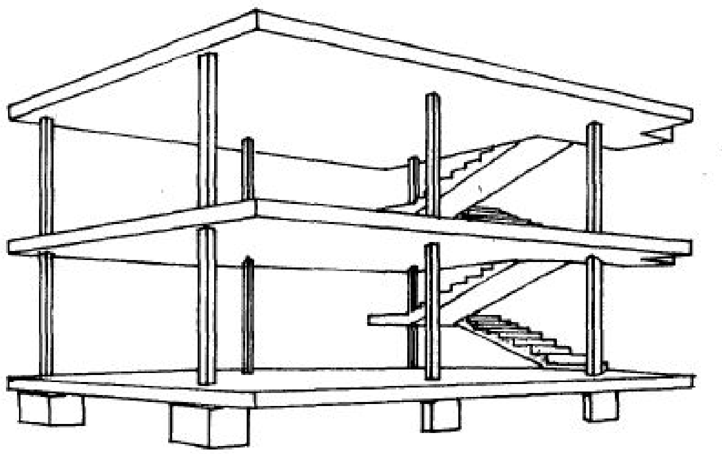


Figure 3.27: The structure of the Domino project. Source: Leupen (2006).

According to Schneider and Till (2007), this type of structure distinguishes between different lifespans of construction elements: the columns and slab have long lifespans, whereas the infill parts (internal and external walls) have much shorter lifespans.

Habraken insistently rejected the Domino as a model for flexible structures, stating that "seen as a building, the support would not be a neutral skeleton like Domino: it would be architecture" (Leupen, 2006, p.162). In his "support structure" approach, Habraken (1972, p. 59) defined the flexible structure as "a construction which allows the provision of dwellings which can be built, altered and taken down independently of others". Similarly, Kendall and Teicher (2000, p. 42, 33) who focused on open building practice define the support as "the building's shared infrastructure of spaces and built form", which "is intended to accommodate and outlast infill change". Therefore, the first consideration is to separate the main structure from the dwellings elements to enable change. In addition, Habraken (1972) focused on the importance of conceiving the structure as the permanent support components that have long lifespans, such as the columns, beams, slabs, etc., in contrast to the structural infill parts of the building such as internal and external partitions, fixtures and so on, that have a short life and are subject to change by users during time. The form of the structure is also among issues that have been raised in this approach. Developing the structure around a generic form is a guiding principle, so different plan configurations can be accommodated within the building shell. The generic form of the structure means that it is not tied to a single project and what is going to happen to it cannot be predicted, thus allowing for the unexpected. According to Leupen et al. (2005, p. 17) and Leupen (2006), the association between the support concept and high rise led to a new idea of a "carcass", which generally is currently known as "based building". These concepts have been related to the idea of a "cocoon" in which "a living organism changes from one state to another". The essence of these concepts is a support structure unrelated to a particular building form that can contain separate dwellings.

Brand (1994, p 194), in his shearing layers for change, identifies the structure as a building layer whose long lifespan "invites the long term tampering it takes for a building to reach an adaptive state". This layer includes the foundations and load bearing elements that are expensive to change and which have a lifespan ranging from 30 to 300 years. On the same lines, in order to create a structure that enables change, Leupen (2006) suggests that the structure layer needs to become a frame. This can be achieved by disconnecting the structure from the other framed layers such as skin and scenery. This disconnection can only take place if the structure can be separated physically from other layers. However, Leupen (2006) argues that complete disconnection is not a realistic option in structural terms; therefore, in order to achieve disconnection between the structure and other related layers, there is a need for an excision, that can be razor-sharp, material or comprise a space. A good example of a structure designed as a frame is the Amsterdam Warehouse design. The structure combines timber beams and cast-iron columns in a grid pattern with load bearing perimeter walls, which allows generation of a large open floor. The internal elements such as access, services and part of the scenery are unconnected to the structure, so they can be removed without affecting the structure. Therefore, this structure can be considered as a frame (see figure 3.28).

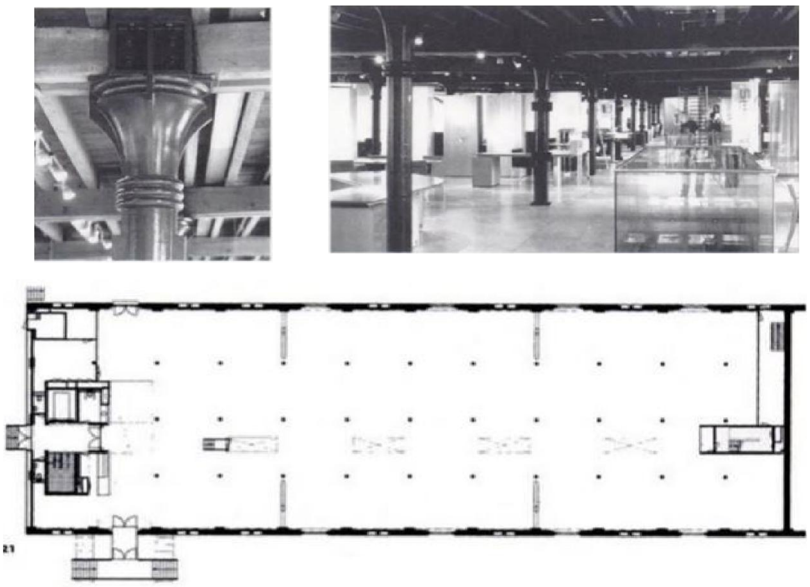
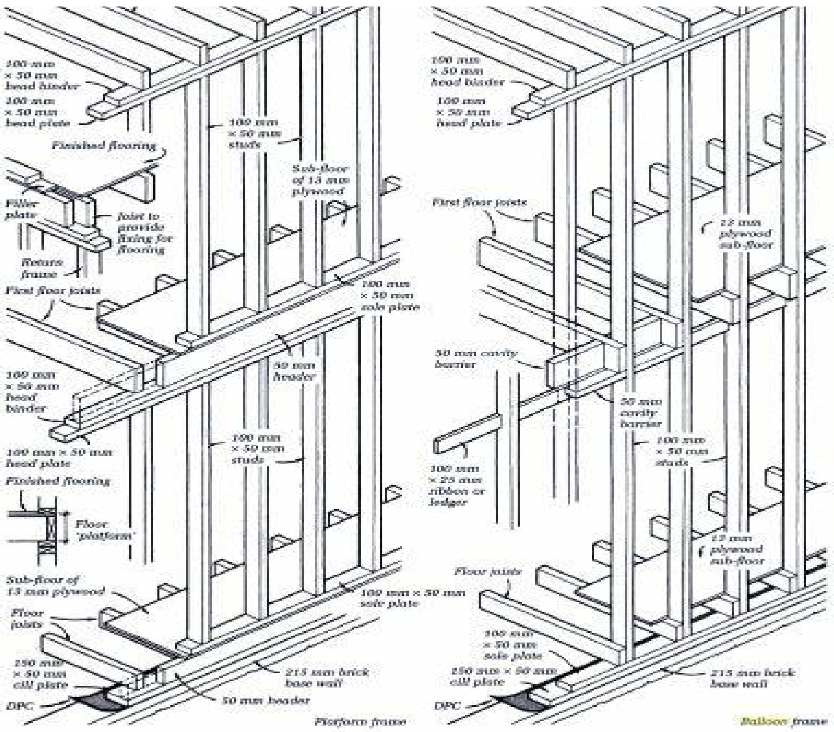


Figure 3.28: The Amsterdam Warehouse project. Source: Leupen (2006)

Schneider and Till (2007, p. 165) view the speculative office as a good example of a structure that enables change and thus its principle can be transferred to flexible housing. They defined the structure of the speculative office as a “dump, generic, frame” that provides long spans with indeterminate space within, which allows different floor plans to be created through the possibility to distribute non-loadbearing partitions freely. Therefore, in terms of housing, the flexible structure needs to be generic and separated from the infill parts of the building such as internal partitions, services and fittings, and preferably from external walls, so different layout forms can be created. Like Habraken, they also conceive the structure as permanent with as long lifespan as possible, while the infill would have a shorter lifespan and could be adapted over time. Another feature of flexible structures is that “the more open the frame, the more scope there is for the infill to be flexible and adaptable over time” (Ibid, p: 192). Therefore, as long as the structure can provide a generous free span between the walls, greater flexibility can be achieved. For example, the timber structure with standard stud walls tends to restrict flexibility due to the need for incorporating the structural elements close to the centre of the plan, while the balloon frame is generally oversized so that more open space can be created, allowing variations in the floor plan. Schneider and Till (2007) argued that despite the flexible structure being conceived more often as column and beams construction, wall-based structures can be designed with built-in flexibility through the creation of generous free spans between the walls, to allow maintenance of separation between the permanent and infill structures.

In discussing potential forms of flexible structure in housing, Zivkovic and Jovanvic (2012, p. 29) comparatively analyse two different structural systems which are commonly used in domestic practice: 1) the "massive" structural system, 2) and "skeletal" structural system. The massive system depends on construction with transverse or longitudinal loadbearing walls or both. Leupen & Mooij (2012) also refers to this system as "monolithic" structure. A common building method with this structure type is the tunnel-form structure that employs load-bearing walls that tend to be tied to a horizontal solid floor. Zivkovic and Jovanvic (2012) argue that plans that incorporate the massive system generally limit flexibility and restrict the ability to change the layout. However, this can be overcome through the application of larger spans between walls. The degree of flexibility in the massive system relies on the direction of loadbearing walls according to the plan. When the structural walls are placed in both transverse and longitudinal directions, the level of flexibility is minimised because the structural walls restrict the ability to change the space on all sides. On the other hand, if the structural walls are distributed in one direction, the level of space flexibility is larger. In contrast to the massive system, the skeletal structural system uses columns to transmit the load, which generally allows the greatest scope in terms of flexibility due to the ability to change the space in two orthogonal directions. In this system, limitations may arise from the dimensions and positions of structural elements. However, Zivkovic and Jovanvic (2012) go on to conclude that as both structural systems have advantages and disadvantages, the choice of the most appropriate structure to achieve flexibility needs to be left to the designers.

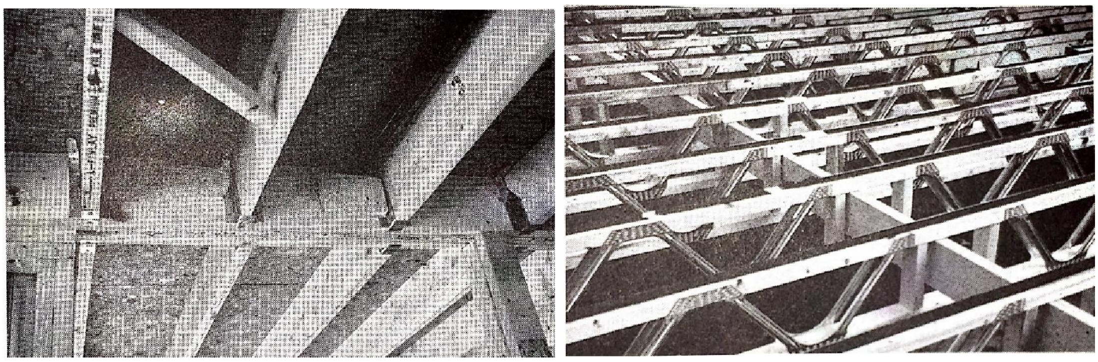
Friedman (2002) focuses more on flexibility in wood-frame structures. He argues that the choice of structural system is important, since it can increase or lessen the ability of the building to change. For example, the use of a “post-and-beam system”, where the walls (either exterior or interior) can act as infill elements and thus non-loadbearing walls, can give the designer more possibilities for flexibility. However, this system is considered impractical in terms of cost. Another wood structure is the balloon frame, with continuous studs from the foundation to the roof that can therefore be erected independently of the floor structure. This has an advantage for flexibility through the ability to modify the floor structure independently from the stud walls. In contrast, in the platform structure the floor is constructed first and then the remaining structural elements are erected on top of it. This leads to an integrated structure of external walls and floor, which is more difficult to change (see figure 3.29).



(a) *(b)*

Figure 3.29: The platform (a) and balloon (b) structural systems. Source: Foster and Greeno (2007)

In addition, the type of floor joints used in the floor system is important, since this determines the range of spans between the support elements in a wood-frame structure. In a conventional floor system, Friedman (2002) explains that the average joints, made of dimensional lumber, are not more than 4.6 metres apart, so when the house dimensions exceed this length, a bearing partition needs to be located in the space and this restricts any interior changes. On the other hand, the engineered floor system is an alternative web-designed floor-joint system that allows an increase in span between structural elements (up to 12.2 m using metal web joints). This frees the interior space from the use of loadbearing walls, and thus permits variation of the internal layouts (see figure 3.30).



(a) (b)

Figure 3.30: The conventional floor (a) and engineered floor (b) systems of wood construction. Source: Friedman (2002).

The literature review of different researchers' approaches and relevant projects regarding flexibility in structures, revealed some common principles that enable structures to accommodate change. The first is the ability of the structure to be separated from the infill parts (mainly the internal walls and services) of the building. A flexible structure may be conceived that also has separation from the external walls, but this relies mainly on the type of construction, such as using a skeletal structure instead of wall-based construction where the external walls are the support structure. The second principle is the ability of the structure to generate open clear space between the structural elements, so different layout forms can be created. By using large clear spans between structural elements, a more flexible structure can be achieved as different types of occupation can be accommodated. Researchers such as Schneider and Till (2007) also assume that the ability of the construction to accept additions is one of the principles of creating flexible structures. For Spangenberg, this ability to accept additions requires the structure to have "a greater capacity and the possibility of taking up greater loads locally or across larger surface areas" (cited in Leupen et al 2005, p. 76). The research argues that such ability should be considered only in the case of add on approaches, to enable the plan to grow in size.

2- External walls

Brand (1994) noted that as the external surface of a building now tends to change every 20 years to keep up with fashion, technology or for wholesale refurbishment, it needs to be conceived as one of the building shearing layers for change. Schneider and Till (2007) assert that the importance of considering flexibility in external walls is that it enables the users to personalise their dwellings through the possibility for adapting the façade based on their desires. Another opportunity is the potential to upgrade and replace the façade in the future. Finally, this flexibility has a particular importance in the case of horizontal extension of dwellings. In this respect, they present the cavity wall type as an example of an inflexible external wall, which cannot be changed due to the difficulty of creating future openings or altering it without major construction work.

Leupen (2006) considers that flexibility in external walls (skin) is achieved when these building elements become a frame, which means they need to be disconnected from the frame layer (structure). He presents the Bauhaus in Dessau, designed by Walter Gropius in 1926, as an example of external walls being designed as curtain walls. The architectural novelty in this project was not the use of a glass façade but the possibility to disconnect the external walls from the concrete structure behind them, which enables the external walls layer to work as a frame (see figure 3.31).

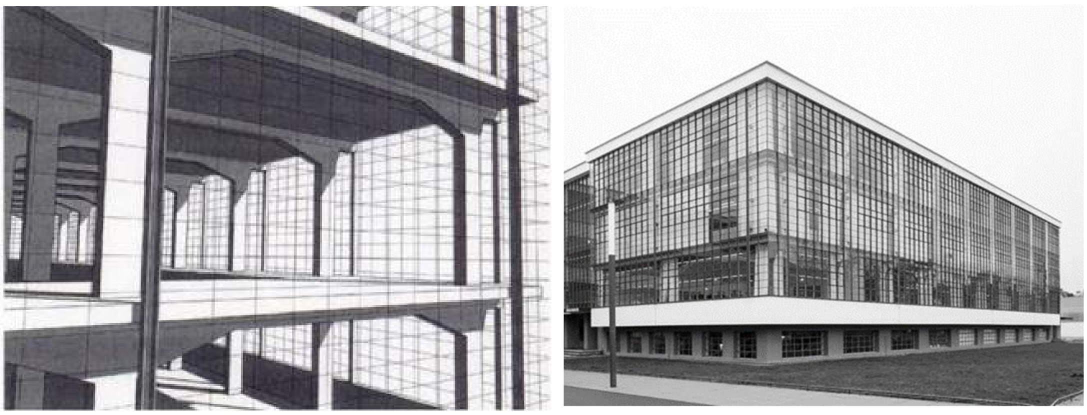
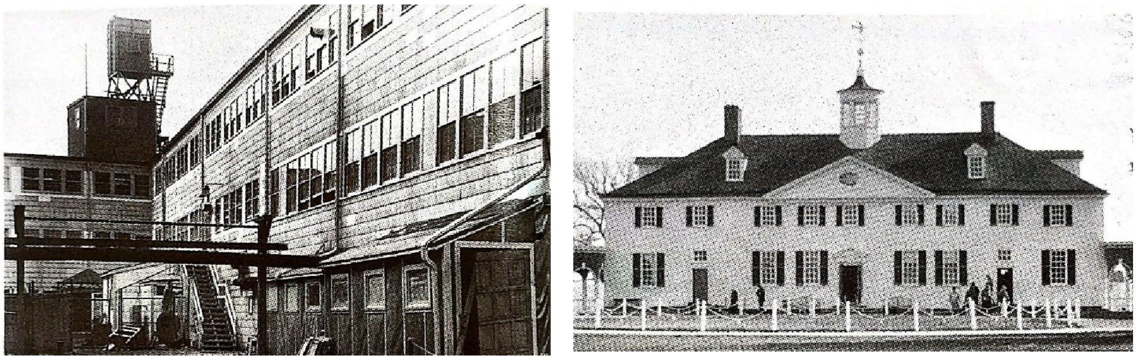


Figure 3.31: The Dessau Bauhaus project, Source: Leupen (2006)

In his discussion about how to build for change, Brand (1994) similarly suggests that the external walls need to be separated from structure and services so they can be changed easily. Other important aspects include the vertical, flat and simple shape of the walls to facilitate potential expansion of the dwelling in any direction. In addition, they need to have the ability to accommodate new openings such as doors and windows. In this regard, he views such opportunities as achievable by using stud walls. He reported that the external walls can be based on one of two approaches: high road or low road, or a combination of the two. Low road refers to walls that can be adapted for change, and which may be placed at the back of the building. They are simple and cheap to build and alter, so they are not expensive to replace. High road walls are more permanent and may consist of masonry positioned at the front to give an impressive façade. Therefore, they are hard to change, although they need little maintenance (see figure 3.32).



(a) *(b)*

Figure 3.32: The low (a) and high (b) road external walls types. Source: Brand (1994)

Friedman (2002) similarly advocated the importance of preparing external walls for the possibility of future change, to offer users the opportunity to personalise their facades. He focuses on the ability of the façade to accept variation in the size and placement of the windows and doors. In order to achieve this, two key principles need to be considered in the design of the external walls from the outset: "opening zones and infill component" (Ibid, p.110). Opening zones are areas in the external partitions that are structurally prepared to accept future openings and change in the infill elements such as windows and doors, to enable change to be carried out without major structural work. Schneider and Till (2007, p. 196) suggest the use of "a panelised external wall system" that can offer easy dismantling of the walls either prior to occupancy or in the long term. This method, however, requires an easily dismantled system and depends also on the availability of replacement parts in the market.

To sum up, the integration of flexibility in the external walls is an important consideration for flexible construction as it enables the building façade to cope with change over time. The key principle to achieve this is the ability to disconnect the external walls from the main structure and services of the building. The second principle is to enable the external walls to accept future openings and change in the infill elements (windows and doors). The final consideration is the ability of external walls to be easily dismantled.

3- Internal partitions

Brand (1994, p. 13) and Schneider and Till (2007, p. 193) classify the internal partitions of the building within the space plan layer, and as needing to be moved over a 5-30 year cycle. Leupen (2006) similarly asserts that the internal partitions among the building layers should be disconnected from the other building layers to become a frame. He claims that when the structure takes the entire load, the internal partitions can be separated and changed at will. A prominent example is the Villa Savoye project, designed by Le Corbusier in 1929. In this design, the internal partitions were separated from the column grid structurally by using a skeleton structure that entirely freed the walls from load-transferring duties, which allows the scenery steadily to gain independence (see figure 3.33).

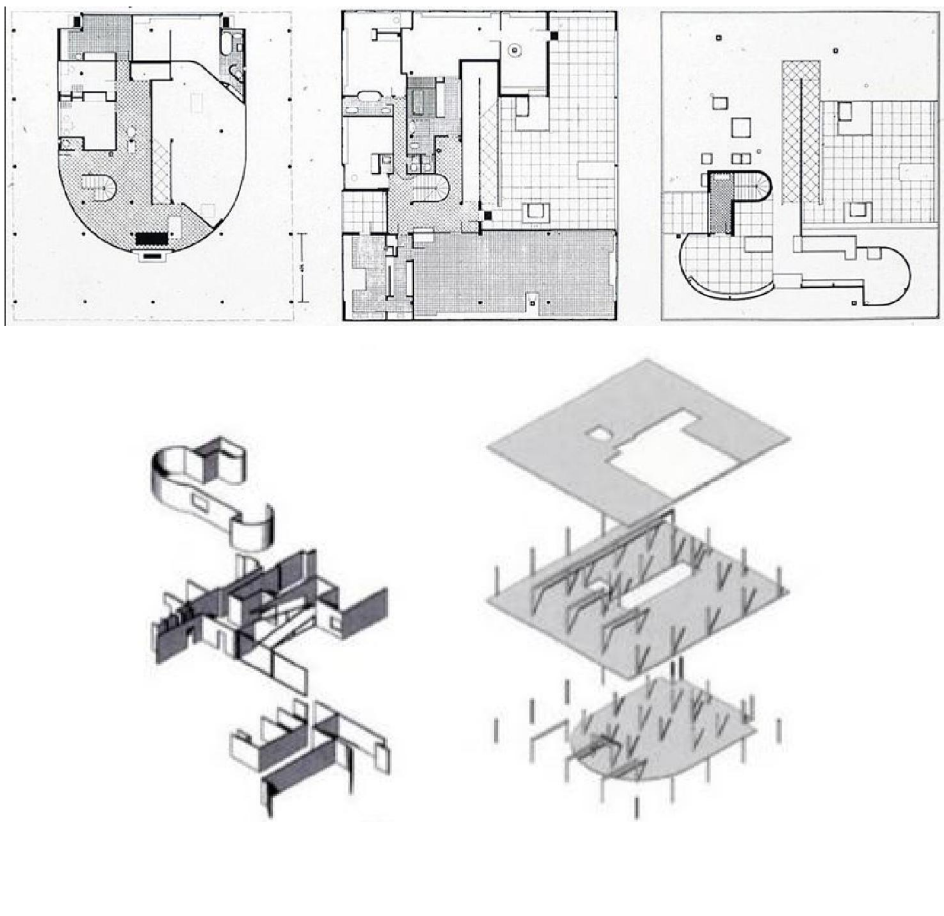
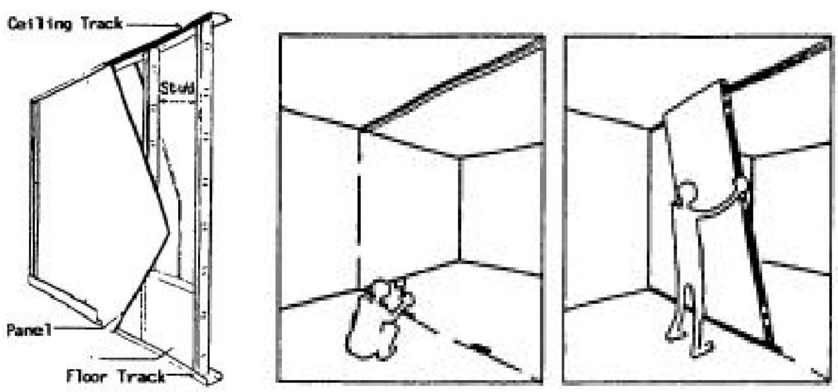


Figure 3.33: Villa Savoye project, Source: Leupen (2006)

In their discussion on achieving flexible internal partition structures, Schneider and Till (2007) criticise the internal partition system used in the standard UK house on the grounds that some loadbearing partitions need to be incorporated in order to support the joint floors and the internal dividers in the floor above. Even when the plan has no loadbearing walls, the developer may often consider using some blockwork walls to give a more robust impression to the building. This makes it difficult to alter these internal partitions, as this requires undertaking major structural works, particularly in terms of loadbearing walls. Therefore, the internal walls need to be integrated as non-loadbearing walls so they can be disconnected from the main structure, and thus variations in the layout configurations can be achieved either pre or post-occupancy. This needs to be considered along with continuation of the finishes around the removable partitions to facilitate the disconnection process. Both Brand (1994) and Schneider and Till (2007) caution that in order to equip the internal partitions for future change, services should not be placed within the changeable walls.

In addition, in order to create a flexible structure for internal partitions, researchers have suggested different methods for easy dismantling of the walls. Yamin (1989) and Friedman (2002) present two methods for building wall structures that enable easy disassembly. The first method is similar to a dry walls system, where the walls are constructed with metal studs that are placed at specific intervals, after which prefinished wallboards can be attached with special clips to the metal stud. The second method is a "portable partition system" that comprises prefabricated panels which can be fixed in place through channels in the ceiling and floor (see figure 3.34).



(a) *(b)*

Figure3.34: Demountable (a) and portable (b) partition systems. Source: (Yamin, 1989)

Schneider and Till (2007) similarly promote a modular prefabricated panel system that consists of doors, wall panels and framed openings that create internal partitions that can be disassembled easily, without damaging any other part of the interior. This method is based on the use of readily available materials rather than an expensive high maintenance system which may become obsolete over time. An additional principle for design of flexible internal partition structures is the ability to create openings such as doors in these walls, which can be achieved, for example, through basing the wall design on the principles of knock-out panels. This can facilitate incorporation into the plan of different design strategies such as joining two rooms and units, without requiring major structural work.

According to the discussion above, four key principles are important for designing flexible internal wall structures: 1), non-loadbearing internal partitions, 2) avoiding location of services within, 3) the ability for easy disassembly, 4) and the ability to create openings.

4- Roof

Schneider and Till (2007) discussed different principles for flexible roof structures. In this respect, they distinguish between two forms of roof construction. If the roof is flat, flexibility can be achieved by oversizing the slab to allow for additional dead and life loads on the floor in the case of vertical extension. When the roof is pitched, different structural considerations are important: 1) using an open roof structure to allow the roof to be occupied in the future, 2) oversizing the slab to enable the roof to accept additional load, 3) pre-cut joints to allow future provision of roof lights, 4) and pre-framing of the floor for future extension of the staircase.

5- Foundations

Two key principles can be considered for flexible construction of foundations. The first is to oversize the foundations, so additional storeys can be added to the building in the future. This is essential from a long-term viewpoint, as the foundations cannot be adapted in the future, unlike other building parts. The second is that the foundation system requires careful consideration to allow change in the future. For example, the use of a strip foundation system that follows the line of internal partitions can prevent future change by restricting the ability of the ground floor to accept variation in layout configurations. In this case, the internal walls can only be placed in a position where the foundations underneath are available to transmit the load (Schneider and Till, 2007).

6- Construction principles

Simplicity and legibility are important principles guiding the construction of flexible housing. According to Schneider and Till (2007), simplicity means adopting a relaxed attitude towards technologies and structural techniques and thereby staying away from over complication. Meanwhile, legibility entails making the construction techniques clear enough for the users to distinguish between what could or what could not be changed. They argue that these principles are very much related to the forms of construction (soft and hard) of flexible housing. The use of soft technologies in the construction of flexible housing enables “flexible housing to unfold in a manner not completely controlled by the foreground of construction techniques” (Ibid, p: 172), and thus the user or non-expert can make changes by themselves. In contrast, the hard form achieves flexibility in the dwelling through the use of technologies, with specialists often required to make future adaptations, and thus the method of construction is more complicated and users would find it more difficult to make changes by themselves.

Another design principle behind flexible construction is building in ease of disassembly to allow construction of the building with a view to potentially dismantling it at a later date. For Schneider and Till (2007), the idea of disassembly already exists as the layering approach, with simplicity and legibility considered in the construction. The principle behind disassembly of a layering system is that each layer can be easily separated when replacements or changes are needed. This in particular requires simple technical fixings that will allow the various elements to be separated without damaging their host. Brand (1994) confirms that construction for change needs to accept disassembly, and thus there should be potential for reshaping the building even at structural level. In this regard, he suggests using timber for the frame and as a building material, as for him wood represents the ideal material for disassembly.

The discussion about construction for flexible housing also focuses on the impact of construction methods on achieving flexibility. Schneider and Till (2007, p: 174) discuss two approaches to construction for flexible housing: “modularity” and “prefabrication”. Modular refers to “buildings that are assembled from a set of separated and repeated components” (Ibid, p: 175). Therefore, it inherently promotes the idea of exchangeability that is important for flexible design. Schneider and Till (2007) argue that although modular construction methods are consistent with flexible design in housing, they are not in themselves sufficient. Therefore, when flexible housing is constructed by modular system, two key considerations need to be taken into account. The first is to avoid "technological determinism" by considering the social use together with technological solutions. The second is to avoid the use of "one-off technologies" (Ibid, p: 175) that can lead to a technological system for which replacement parts may cease to be available on the market over time.

Prefabrication refers to "buildings that are to a greater or lesser extent manufactured and assembled off site" (Schneider and Till, 2007, p:175). Therefore, prefabrication involves the manufacture of house parts such as panels and modules (ready-made rooms) away from the construction site in a specially designed factory. The house parts are then assembled quickly in the building site, with services such as wiring and plumbing already incorporated inside them. Schneider and Till (2007) through their discussion about the construction methods indicted that although the prefabrication construction approach can often increase choice for the purchasers, it does not necessarily lead to flexibility in construction. This is generally for two key reasons: 1) the panelised approach currently used in most prefabricated systems tends to combine the different construction layers together, 2) and "the bespoke nature" of prefabricated construction leads to very specific spatial configurations that are locked in place from the outset. Therefore, to achieve flexibility using prefabricated methods, it is important to incorporate the principles of simplicity and disassembly. In addition, prefabrication in relation to flexible housing is not a system that is designed specifically for a particular project, but one that is created from popular prefabricated parts in a flexible way (Schneider and Till, 2007).

On the other hand, Lovell and Smith (2010), in their discussion on the assemblage of the UK markets for masonry and prefabrication methods of housing construction, highlighted more disadvantages of using prefabrications that have led to the market for prefabrication remaining small and this method never being more than an innovation. In terms of the construction process, the authors drew attention to similar yet different limitations such as design freeze at an early stage in the planning process which restrict flexibility. As this process involves constructing ready-made rooms away from the construction site in a specially designed factory, the exact layout and dimensions of the houses are fixed from the outset. Another disadvantage of prefabrication is the potential risk of systematic failure of dwellings. In this respect, Lovell and Smith (2010) explained that if a defect is found with prefabrication, this will appear in all dwellings built via that particular technology. The occurrence of this issue in the past has created negative consumer and industry attitudes towards prefabricated housing. Prefabricated buildings also tend to have a fixed (short) life-time (c.60 years design life), which puts this building method at odds with the flexibility principle of creating a structure with a long lifespan.

Moreover, researchers have highlighted social and cost barriers to the use of prefabrication in the UK context. Social factors relating to negative public attitudes towards prefabricated homes such as their strong association with social (low-income) housing and the unproven durability of prefabricated houses have limited consumer demand. In terms of cost, most evidence points to building costs being approximately 10% higher for prefabricated housing developing compared to housing of masonry construction (Lovell and Smith, 2010, p.459). Indeed, the high costs of prefabrication (capital and construction costs) are seen as the most significant barrier to its further adoption for housing construction. Consequently, the viability of flexible housing should not only be seen in terms of achieving flexibility in the design but also the cost implications and user and industry perceptions of the construction method should be taken into account.

Table 3.2 summarises the main concepts of flexible construction as represented by the different constructional elements along with the corresponding principles for flexibility, drawn from the literature review

Constructional elements	Principles for flexibility
Structure	This refers to the load bearing elements of the construction and comprises four key principles in the design of the main structure of the building: 1- The ability of the structure to be separated from the infill parts (mainly the internal walls and services) of the building, and probably the external walls. 2- The ability of the structure to generate open clear space between the structural elements, so different layout forms can be created. 3- Simplicity and legibility. 4- The potential of the structure to accept addition in the case of add on approaches.
External walls	This comprises four main principles in the construction of the external walls: 1- The ability to disconnect the external walls from the main structure and services of the building. 2- The possibility of the external walls accepting future openings and change in the infill elements (windows and doors). 3- The ability to dismantle the external walls. 4- Simplicity and legibility
Internal partitions	This comprises five principles in the construction of the internal wall: 1- Non-load bearing construction of the wall. 2- No services located within the partitions. 3- The ability for disassembly. 4- The potential to create openings. 5- Simplicity and legibility.
Foundations	This comprises two possibilities in constructing the foundations: 1- Over capacity of foundations to accept additional floors. 2- In terms of placement, a foundation system that allows variations in the layout configuration on the ground floor.

Roof	This comprises different principles in the construction of the roof. • In the case of flat roofs one key principle is important: 1- The structure of the roof to be appropriately sized to bear potential dead and live loads, snow loads and wind loads. • In the case of pitched roofs other aspects are important: 2- Using an open roof structure that allows the roof to be occupied in the future. 3- Pre-cut joints for future provision of roof lights. 4- Pre-framing of the floor for future extension of the staircase. 5- Simplicity and legibility.

Table 3.2: The constructional elements along with their corresponding principles for flexibility, drawn from the literature review.

3.4 Flexibility in services

3.4.1 Concepts and evaluation criteria relating to flexibility in services

Achieving flexible housing also requires the consideration of services in the building since they are liable to change over time. Services refer to different utility systems that are typically incorporated into the building, such as plumbing, electrical wiring, ventilation and so on. Therefore, this part of the research discusses the key issues associated with designing the services for change in order to discover the main aspects for analysing flexibility in services.

In his model of shearing layers of change, Brand (1994) suggested that services among the layers of the building "wear out or obsolesce every 7 to 15 years" (Ibid, p.13). Therefore, if the services are not placed with a view to how they can be changed, the building will have to be demolished early. This layer includes services elements such as wiring systems, either for communication or electricity, plumbing, HVAC (heating, ventilation, and air conditioning), and moving elements such as lifts. Leupen (2006) similarly included the services as a layer in his building frame model and proposed that it be made into a framed layer by disconnecting it from the other layers of the building. Leupen (2006) divided the services layer into three assemblies: 1) pipes and cables for supplying energy, information, air and water that need to be organised in a building so as to have a liberating effect, 2) appliances that regulate the elements requiring energy should be expressed as independent elements, 3) and servant spaces where the services are assembled, such as kitchen, bathroom and toilet, which have to be well organised to accept the services function in frame form.

Kendall and Teicher (2002), in discussing the mechanical systems of residential open buildings, reported that the services are organised at two levels: support and infill. At each level, the main concern is how to lay the services in a manner that will allow for change over time. Services at infill level consist of the horizontal runs of water, drainage, gas, electricity, data, heating and cooling and their methods of distribution at each building level. The services at support level comprise vertical runs such as cabling, ducts and pipes and the distribution methods that allow laying the services inside the building to serve the dwellings at different levels.

Friedman (2002) states that technological development in recent decades has caused rapid change in building services. Therefore, there is a need to conceive the services in such a way that they can be adapted when they become obsolete. In order to achieve this, he suggested a range of design strategies to deal with the laying of conduits at building (macro) and unit (micro) level in a manner that will allow services to be easily accessed and changed in the future.

Guy and Ciarimboli (2005) reported that in traditional construction, ducts, wiring and pipes are often installed in ways that are destructive to other building elements: through holes in members, welds, clips, clamps, etc. The placement of these services within construction elements such as walls, floors and ceilings also makes it difficult to access them for repairs without also damaging overlying elements. Therefore, they suggest designing the layer for easy disassembly to facilitate future change and eventual dismantlement through developing appropriate assembly methods, materials, and construction techniques.

Schneider and Till (2007, p: 164) state that the inflexibility in the services system is due to a design process that is generally considered in "a back to front manner", as it starts with providing the services outlets to the plan and then connects them back to the junction box. This leads to the services (pipes and wires) being run in places where they do not really belong, and thus the difficulty in accessing and changing them in the future. In order to cope with this, Schneider and Till (2007, p. 198) view the services as a layer, in a similar way to Brand (1994) and Leupen (2006), and stress that "the key principle in any servicing strategy for flexible housing is how the services are distributed". This requires that both the vertical and horizontal distributions of the services systems are installed in such a way that they can be reached and adapted easily.

From the discussion above, it can be concluded that the researchers collectively agree that in order to design the services for change, the services need to be considered as one of the building layers and the distribution methods of servicing systems require careful consideration, so that they can be adapted without disturbing other building components. As has been explained before, Leupen (2006) divided the services into three groups: pipes and wires, appliances, and servant spaces. The current research adopts this same categorisation, with a focus on the first two categories, to discuss how services systems for housing can be designed appropriately to cope with change over time.

1- Pipes and wires

According to Leupen (2006), the pipes and wires category refers to the services elements that supply and discharge energy, information, air and water. He views these services as "liberators". Therefore, they need to be organised in a building so as to have a liberating effect by accommodating change. In considering how these services can be designed in housing to cope with change, researchers have organised these components differently. While Friedman (2002) dealt with these elements at building and unit level, Kendall and Teicher (2002) organised them at support and infill levels. Meanwhile, Schneider and Till (2007) categorised these services components as vertical and horizontal runs. The research adopts the latter categorisation of pipes and wires elements to explore how to achieve a services system that can accept change over time.

Horizontal runs

In discussing how to design horizontal runs of the services to accommodate change over time, researchers have focused on different design strategies for horizontal services distribution. Friedman (2002) suggested creating an accessible chase and positioning the different services systems in a single known area in the plan, such as floor, wall or ceiling, so that the different services can be run out to different spaces in the house from this known point. This allows easy access to the services for maintenance or change and enables location of the wet spaces anywhere in the plan. For instance, in a wood-frame construction, the chase can be located in the floor, along a wall or main corridor and covered with removable floor panels that can be removed easily later on (see figure 3.35). Schneider and Till (2007) suggested a similar approach, but proposed positioning the services in a permanent structural element that cannot be changed, which would allow the services to remain in place and enable non-loadbearing partitions to be modified without any restriction, in addition to providing easy access to the services for maintenance. Therefore, this approach has the advantages of enabling the different horizontal services to be run in a manner that allows easy access and change over time, offering flexibility in planning location of the wet functions, and freeing the internal non-loadbearing walls for future change.

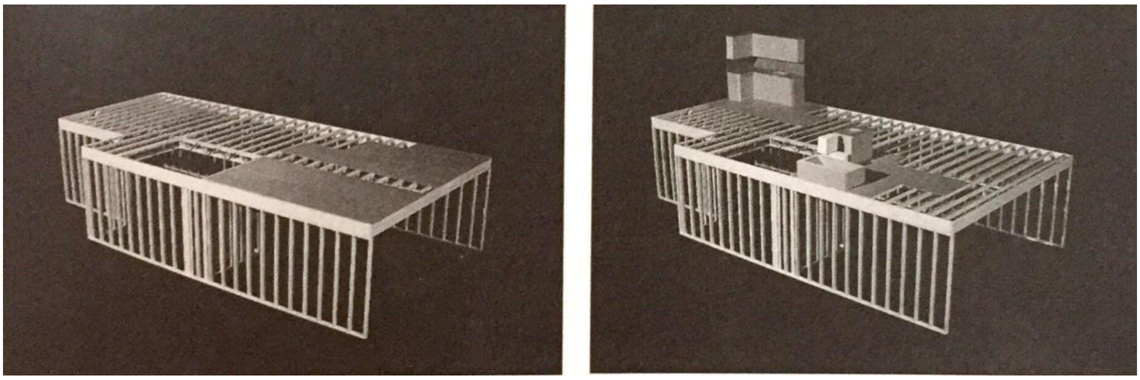


Figure 3.35: A floor chase for horizontal services distribution. Source: Friedman (2002).

Friedman (2002), Guy and Ciarimboli (2005) and Schneider and Till (2007) presented an alternative approach for dealing with electrical horizontal runs within the internal walls. Friedman (2002) simply proposed creating channels in the partition systems that would enable easy fixing of cables and wires. This method also allows easy dismantling of the partitions and access to the services for maintenance and updates in the future (see figure 3.36). Guy and Ciarimboli (2005) referred to their approach as "electrical raceways", relying similarly on the creation of a small cavity along the baseboard of a wall, with a clip-on baseboard cover. This allows the electrical distribution wiring to be hidden while remaining readily accessible. Schneider and Till (2007) referred to such an approach as a skirting access system, which differently considers the use of a slimline dado that allows surface-mounting of the services without the need to create a cavity in the wall. Friedman (2002) described this approach as a baseboard raceway, and similarly noted that it allows installation of wires in a special device outside the wall. This system was developed in response to the need to introduce and upgrade computers and telecommunications wires in the home. It consists of a three-piece design: base with channel for wiring, snap-on cover with built in flanges, and snap-on trim provided with tabs for locking it. Therefore, this strategy, applicable in two forms, can offer ease of access for maintenance and upgrading the electrical services and make internal partitions easier to dismantle. However, it seems that it is more applicable to stud wall systems than block work structural walls.

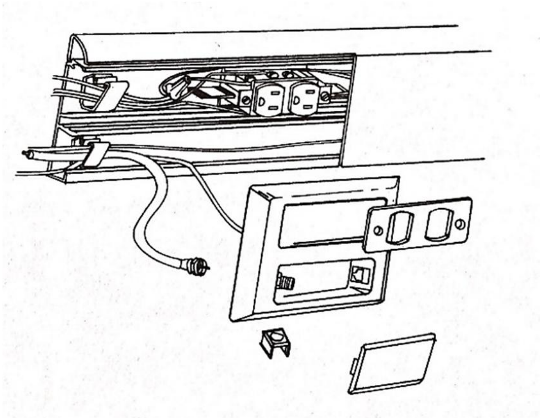


Figure 3.36: Baseboard raceway system for electrical horizontial runs. Source: Friedman (2002)

Raised access floor and suspended ceiling systems are other strategies presented by researchers such as Friedman (2002), Kendall and Teicher (2002), Guy and Ciarimboli (2005), Leupen (2006) and Schneider and Till (2007) as methods to achieve flexibility in horizontal services runs. For Friedman (2002), this enables quick rerouting of ventilation and pipes or the installing of new computer cables. Guy and Ciarimboli (2005) are more concerned with raised flooring systems due to their ability to reduce duct work and make such as electrical and telecommunications services more accessible. In order to achieve this, the floor system needs to be created from a modular kit comprising parts that can be simply changed, partly or comprehensively. The Nieuw Australie building in central Amsterdam is presented by Leupen (2006) as an example of the floor used as a frame, employing the idea of a raised floor to enable the users to fit out the space in compete freedom. The floor is created from concrete elements of 60*60 cm supported at the corners by steel feet. The use of a raised floor system frees the internal partitions from the services run and creates the possibility to place the wet space anywhere (see figure 3.37).

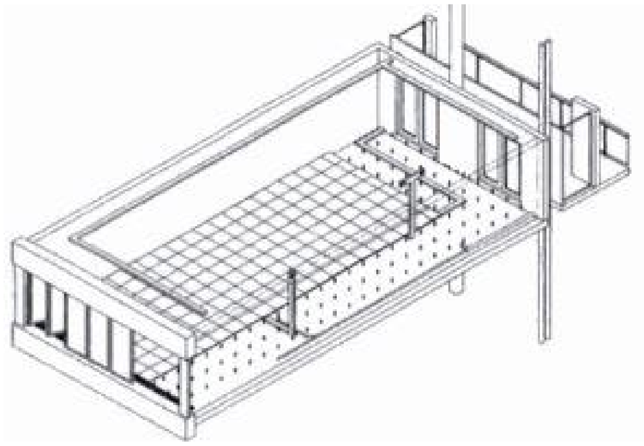


Figure 3.37: Raised floor system in Nieuw Australie project in Amsterdam. Source: Leupen (2006)

Schneider and Till (2007) view this method of distribution as expensive, but allowing the walls and furniture to be freely located and easy accommodation of future developments in services.

The Matura floor system is another strategy developed as an outcome of OBOM research to deal with the problems of services horizontal runs, appliances and their points of connection. The key principle of the Matura system is the use of a “matrix tile” which is an “insulating tile with grooves on two sides” (Leupen, 2006, p. 176). This method allows the services run to be accessed inside the floor without the need for them to intersect (see figure 3.38). The main benefit of this method is the quick fit during building construction. However, a disadvantage is the need to break open the protective finish in order to make changes in the services runs. Kendall and Teicher (2002) applied this method as the Matura zero-slope system, which relies on the use of zero-slope grey water drain lines. It has particular importance for plumbing services and has been certified for residential infill application in both Germany and the Netherlands.

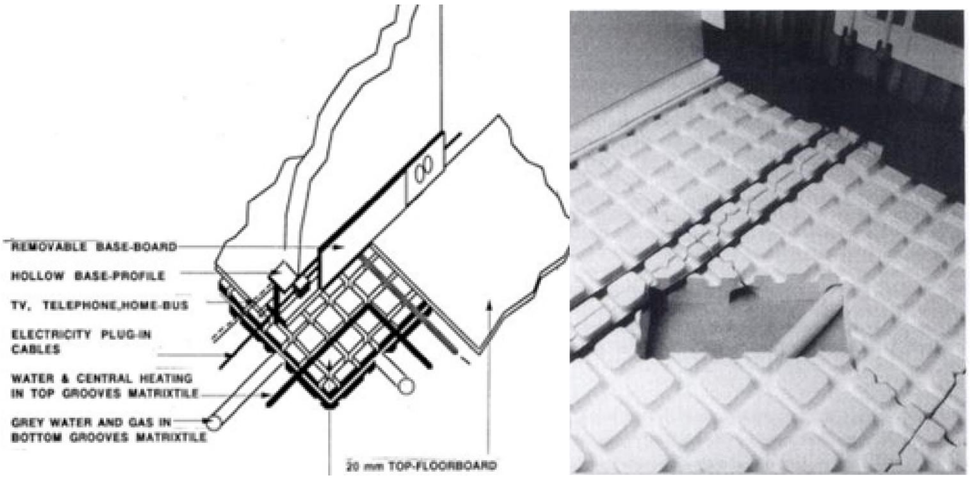
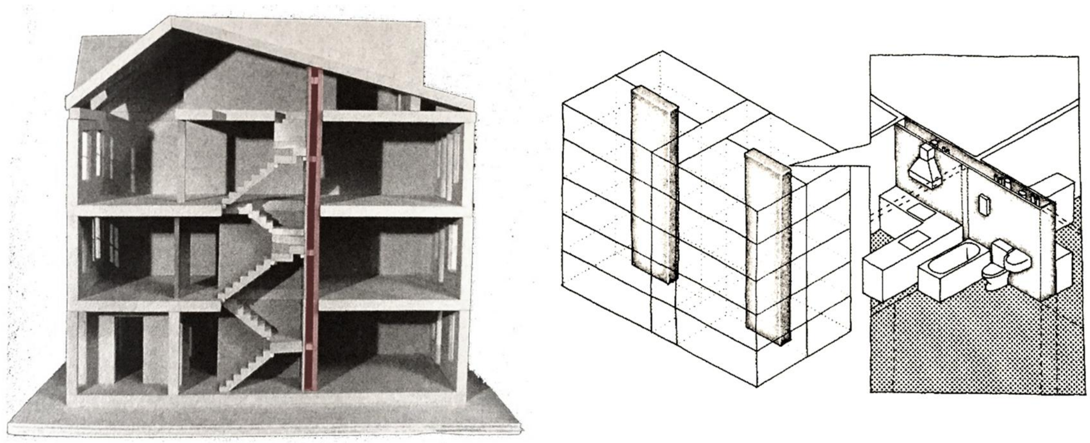


Figure 3.38: Matura infill system: Source: Leupen (2006).

Schneider and Till (2007) proposed another strategy that works on the principle of incorporating a layer into the wall construction that is separate from other wall elements such as structural components and insulation. In order to achieve this, the suggestion is to install small battens horizontally on the surface of the structural wall, which can be covered with plasterboard or drywall. Services are run in the space between the wall and plasterboard and then collected in ducts that run horizontally behind the skirting board.

Vertical runs

Similarly, the discussion in this section centres on design approaches to vertical distribution that allow vertical services to accommodate change. Both Friedman (2002) and Schneider and Till (2007) proposed incorporating accessible vertical stacks or rises into the multi-storey building, in which the different servicing systems can be gathered independently and branched out to different floor levels. Friedman (2002) highlights the importance of designing a vertical shaft with suitable location and dimensions to allow easy access in the event of a system upgrade. In the case of semidetached and row houses, the suggestion is to locate the shaft next to the common walls. Schneider and Till (2007) suggest grouping the serviced rooms around these stacks. However, this determines the position of the wet spaces in the plan, therefore, careful consideration is needed of the stacks' location in the layout, in order to build future flexibility into the plan. A further contribution by Schneider and Till (2007) to this approach is the provision of an extra room within or adjacent to the vertical rises that can be used to accommodate future technological developments as necessary (see figure 3.39) .



(a) (b)

Figure 3.39: The vertical shaft for vertical services distribution (a): Source: Friedman (2002), and possible arrangement for services rooms around these stacks (b): Source: Schneider and Till (2007).

Leupen (2006) noted that one of the key differences between multi-storey buildings and low-rise housing lies in the freedom in accommodating services. He argued that in order to provide services with the ability to change, the frame should free up the services runs. For vertical runs, two key approaches and examples were presented: a combined frame of ducting and columns and integrated frame of skin and services. The former deals with the vertical runs through integrating the services in the columns. One prominent example is the project designed by Fausto and Passarelli, where the columns were designed as assemblages of four smaller elements with a space in the centre that contained the cable, pipes and ventilation ducts. Although this principle would seem to offer an integrated frame, Leupen (2006) claimed that such integration of the services runs in columns cannot be considered as a long-term solution, as this method involves incorporation of two layers with different lifespans. In addition, the space between the small parts of the columns is insufficient to cope with unforeseen future developments. He argued for an increase in cavity and column size, which would equip them better for unpredicted change; however, the column itself would then look less attractive from an architectural perspective (see figure 3.40).

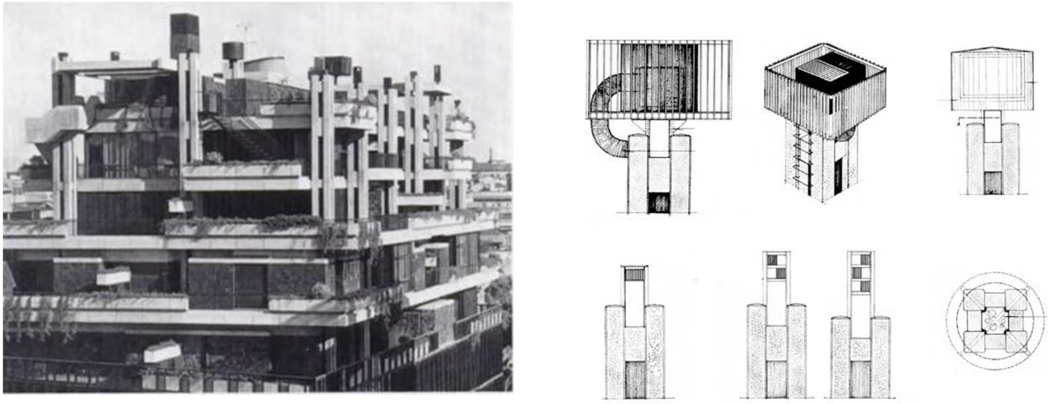


Figure 3.40: The vertical distribution of services in the Fausto and Passarelli project. Source: Leupen (2006).

The second method relies on taking the services up through the façade zone. In the case of the Domus Demain project, designed by the architects Lion and Leclercq, the wet spaces and services shafts were brought out to the façade zone. The architects describe the approach as an “active layer” which is the light and services supplier as the façade provides not only insulation, ventilation and sources of daylight but also the supply and discharge of clean and dirty water, information and energy (see figure 3.41). Therefore, this approach seeks to address the vertical distribution of the services by using integrated frames of services including the vertical shafts, servant spaces and façade. Leupen (2006) considers again that the difference in lifespan between the two building parts that define the frame is a problem, and thus this cannot be viewed as a long-term solution. In addition, the differences in managing the two elements – services and façade –make this integration incompatible to that extent.

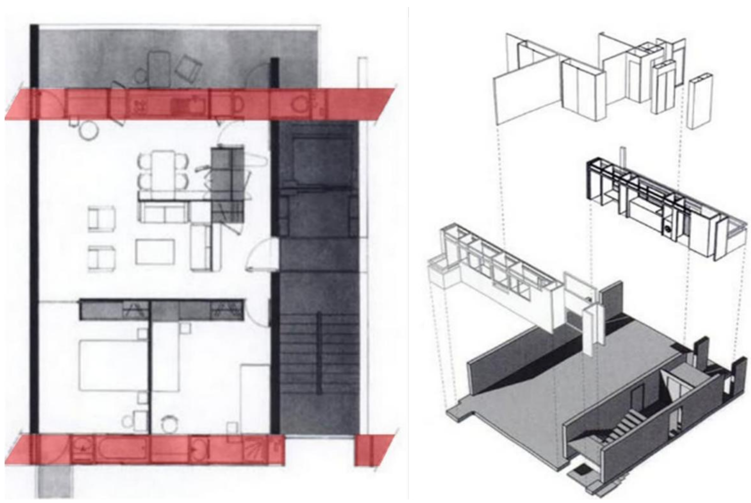


Figure 3.41: The vertical distribution of services in the Domus Demain project. Source: Leupen (2006).

From the review above, it can be concluded that in order to design services systems to cope with change, the distribution methods for pipes and wires have to achieve four key principles: 1) the disconnection of services from the other construction elements so they can be changed without disturbing such elements that may be framing them, 2) the ability to access the services runs easily, for instance, by being able to uncover them in a simple way and locating them in a known space, 3) designing for overcapacity in order to accommodate unforeseen change, 4) careful location of services to facilitate future adaptations. This largely concurs with the Schneider and Till (2007) questioning test for flexibility in services systems, which similarly examines whether the location of services facilitates future change, the possibility for incorporating future technologies and accessibility of the services for maintenance and upgrading.

2- Appliances

The pipes and cables passing into a dwelling are fed into different kinds of appliances that facilitate the indoor environment. These appliances can be categorised into four main groups: 1) appliances that take care of the indoor climate, 2) appliances needed for hygiene, 3) appliances needed for food preparation, 4) and appliances for lighting. According to Leupen (2006), the positioning of these machines is largely responsible for their liberating effect of making the space adaptable. The appliances used in a house for hygiene and preparing the food are rarely positioned individually; instead, they are usually placed together in certain spaces, so-called servant spaces such as the kitchen and bathroom. Therefore, the liberating effect of these appliances relies entirely on the positioning of servant spaces in the layout, which was discussed in section 3.2.2.

Appliances that take care of the indoor climate incorporate the elements of heating and cooling, which provide thermal comfort and acceptable indoor air quality. In this respect, Leupen (2006) presented different examples of building designs such as the Faculty building for Cambridge University and the Centre Pompidou that dealt with the issue of appliances through strategic placement of the units in a frame to create freedom in the interior space for future change. In both examples, the HVAC system was used, where appliances of air conditioning were placed outside the space, on the roof.

While Leupen (2006) focused his discussion on applications of the HVCA system, both Friedman (2002) and Schneider and Till (2007) examined the viability of the wet system of heating for flexible housing. Friedman (2002) discusses the best location of wet system appliances such as the boiler and hot water tank in a single-family dwelling. In this respect, he assumes that these appliances are usually gathered in a mechanical room and suggests their location in the lower level, with independent access from the outside. This frees the upper floor for changes and facilitates the dividing up process through the ability to access the room independently, without the need to enter the house itself. Schneider and Till (2007) see a problem in using this system because radiators are fixed elements that cannot be moved easily, which restricts adaptation inside the unit and the way in which the room may be furnished. Therefore, they suggest using alternatives in order to achieve flexibility in the design

The capacity of heating and cooling appliances is another issue that needs to be addressed in order to ensure services can accommodate change. For example, potential future growth in demand for hot water and heating should be taken into account in the design of the services through considering additional capacity of appliances such as boilers, cylinders and storage tanks from the outset (CPD, 2014).

Similarly, lighting appliances such as switches and pendant light fittings have to be considered in the design to accommodate change. This can be achieved first by careful consideration of their location in terms of facilitating potential change in the layout. For example, if a room may be split in half in the future, appropriate consideration of the location of pendant lights from the outset could allow this process to be achieved without major change (CPD, 2014). At a more advanced level, the light fittings can accommodate change through mechanical and electrical flexibility. This allows rapid reconfiguration of lighting to facilitate changing the floor plan or space usage with maximum energy efficiency. In order to achieve this, the principles of "modular wiring" and "re-mountable lighting systems" need to be considered, for instance, by using a "plug and play" lighting system that facilitates ease of reconfiguration (Benya et al., 2001).

The positioning of other appliance outlets such as power sockets, TV and phone is another consideration that needs to be taken into account during the design phase. This requires avoidance of incorporating appliance outlets on walls that may potentially be changed in the future.

The consideration of appliance capacity is also an important issue regarding lighting. Brand (1994) indicates clearly the importance of oversizing components of electrical services such as electrical feeders and breakers. This also can be achieved in terms of switches and light fittings, through building in potential to provide additional elements of these appliances, for instance, in the case of dividing up a room, which will necessitate provision of additional switches and pendant lights.

In summary, heating and cooling appliances and lighting systems also have to be considered in order to provide services that can cope with change. Here, two key principles are important: 1) the location of the appliances in a manner that facilitates future change in the building or the use of re-mountable lighting systems, 2) providing overcapacity for the appliances to respond to unpredicted future demand.

Figure 3.42 illustrates the main categories of services identified by the research along with indicators that will be used for analysis. The pipes and wires category refers to the vertical and horizontal runs of the different services systems such as energy, information, air and water. The appliances category covers heating and cooling components and lighting elements such as switches, sockets and light fittings.

Table 3.3 presents the main indicators along with the corresponding evaluation criteria as identified from the literature review.

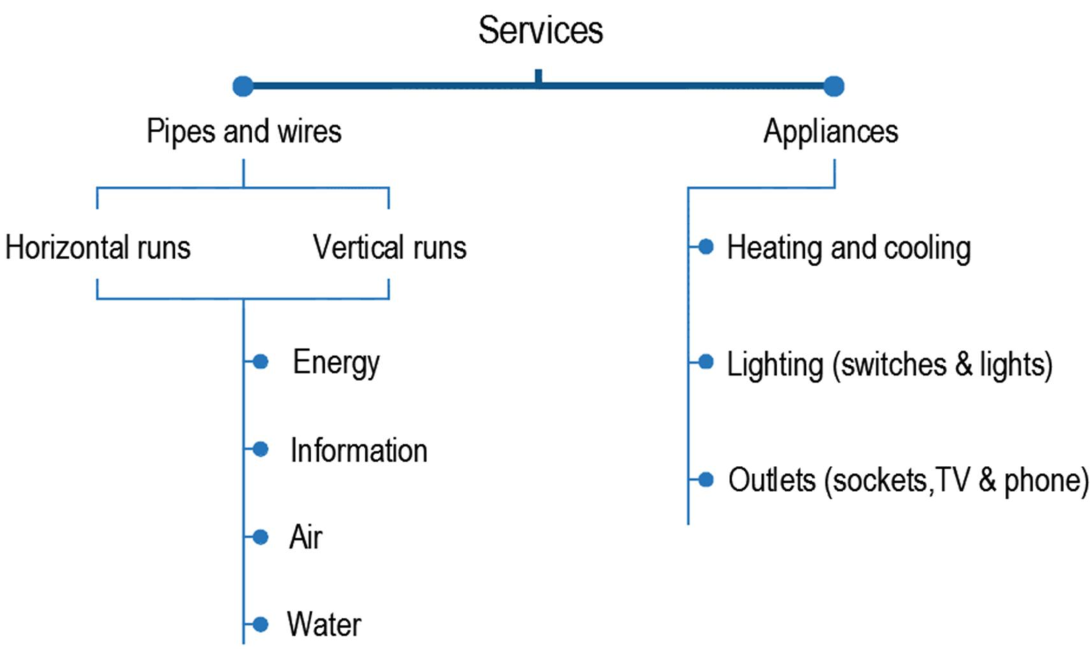


Figure 3.42: The main categories of services for flexible housing along with their corresponding concepts for analysis.

<table>
<tr><th>Categories</th><th>Concepts</th><th>Criteria for evaluation</th></tr>
<tr><td rowspan="2">Pipes and wires</td><td>Vertical runs</td><td rowspan="2">Analysis of four key criteria in the design of distribution systems of services:
1- Disconnection of the different services systems from the other construction elements.
2- Ability to access the services runs in an easy way.
3- Overcapacity of the distribution systems to accept future technologies.
4- Careful location of services to facilitate future adaptations.</td></tr>
<tr><td>Horizontal runs</td></tr>
<tr><td rowspan="3">Appliances</td><td>Heating and cooling</td><td rowspan="3">Analysis of one key criterion in the design of the services appliances:
1- Location of the appliances and their controls in a manner that allows future change.</td></tr>
<tr><td>Lighting
(switches and lights)</td></tr>
<tr><td>Outlets
(sockets, TV and phone)</td></tr>
</table>

Table 3.3: The concepts of flexibility in services along with their evaluation criteria, drawn from the literature review.

3.5 Flexibility in use

According to Lans and Hofland (2005), the concept of flexibility can be considered as a response to households' changing circumstances. Similarly, Schneider and Till (2007) reported that the main aim of flexibility in housing lies in how to make the design flexible enough to accommodate the users' different and changing needs. Therefore, the scope of flexibility is very much associated with the ability of the design to respond to the household's changing needs over time. Imrie (2006, p. 371) suggests that "flexibility is achieved through the building, to one whereby it is conceived of in relation to diverse human action and activities, that is, the purposive ways in which people use buildings".

Schneider and Till (2007, p. 4) consider that flexible housing is housing that can respond to changing needs and patterns. These changing needs may be personal (i.e. change in housing size), practical (i.e. ageing process) or technological (i.e. services upgrade).

Changing patterns, meanwhile, refers to changes in demographic, economic and environmental situations. At unit level, they focus on the ability of the unit's layout to "accommodate a variety of living patterns" and "accept variety of people", through considerations of plan and construction, such as the arrangement and designation of the room, the use of open span structure, etc. Differently, Priemus (1969) asserts that the building can be designed to be adaptable to internal and external changes. Internal changes are concerned with one specific household, including such as change in size, physical ability and so on. External changes are related to groupings of individual households and include such as societal changes (demographic, cultural, economic, natural, technological and political factors) (cited in Lans and Hofland, 2005).

On the other hand, the review conducted in Chapter 2 of reasons that brought about the need for change in the home revealed four key categories of households' changing needs as drivers for integrating flexibility into housing design. These categories consist of basic changes and differences in the needs of households in terms of demographic, cultural, economic and technological characteristics, which are frequently mentioned as drivers for moving or improving housing in different contexts. The review revealed the importance of housing being adaptable to the changes that arise from these four categories, as they are inevitable in different contexts, either at the level of the single individual household or as society influences groups of individual households. Such adaptability will enable the household to stay in their dwelling and community for a long period of time, and enable the dwelling to accommodate a variety of people and thus the building will last longer. Therefore, in so far as the building can respond to the changing needs scenarios associated with these categories, a diversity of possible human actions, needs and patterns can be accommodated in the building, and thus its design can be considered as having flexibility in use.

Based on this premise, the research suggests four key indicators for flexibility in use according to the four categories of households' changing needs: demographic, cultural, economic and technological, in order to examine the ability of designs to respond to a diversity of possible changing needs. Therefore, four key dimensions are identified as important for achieving flexibility in use: flexibility towards the household's changing demographic characteristics, cultural flexibility, economic flexibility and technical flexibility.

3.5.1 Flexibility towards the household's changing demographic characteristics

This type of flexibility in use can be defined as the capability of the housing to cope with changes emerging from human demographic changes within the household over time. This requires the dwelling to adjust to: 1) changes in household size as it grows or shrinks, 2) children growing up at home, 3) children's gender determined requirements, 4) ageing and disability needs at home. The discussion in Chapter 2, section 2.7.1 of key changes in households' demographic characteristics and their influence on housing highlighted the importance of housing having this flexibility as it addresses inevitable changes that frequently happen in any household.

3.5.2 Cultural flexibility

Cultural flexibility considers the ability of the dwelling to accept differences or changes in the household's cultural needs. This flexibility can be explained through the ability of the dwelling to: 1) accommodate cultural differences and changes in household activities, 2) accept a variety of living patterns, 3) meet the need of the household to project their identity on their home, 4) respond to cultural diversity or change in the household's desire for privacy, 5) respond to cultural variety in the household's perception of crowding, 6) consider household differences in members' preferences regarding comfort. Al-Dakheel (2006, p. 554), meanwhile, used cultural flexibility as an "index combining the ability to personalize the dwelling as well as the ability to improve privacy components". In this sense, the concept of cultural flexibility is confined to addressing two cultural aspects, which have a clear influence on his studied context (Saudi Arabia). The importance of the dwelling being adaptable in use to serve the household's cultural needs stems from the imperative of cultural diversity and cultural change in every context, which affects housing, as both bring about differences and changes in the household's perceptions and desires regarding their dwelling.

According to Rapoport (1998), the household's social aspects and norms such as kinship, social links, social roles and so on are the higher-level elements of culture, which form the household's socio-cultural aspects. Cultural flexibility in its social dimension is the household's ability to use the house in a manner that accommodates differences and changes in these socio-cultural aspects. Differences and changes in relations among household members, relatives, friends and neighbours, as well as their social roles are all aspects relevant to this flexibility.

3.5.3 Economic flexibility

Economic flexibility concerns the ability of the dwelling to respond to changes emerging from fluctuations in the household's economic circumstances over time. This type of flexibility relates to: 1) the ability of the dwelling to adapt in accordance to changes in the household's income, 2) the possibility to adapt the dwelling in relation to employment status within the household. The literature review in Chapter 2, section 2.7.3 identified the need for such flexibility in housing in terms of responding to inevitable changes in economic circumstances that occur in any household over time, thereby avoiding household mobility, and thus contributing to creation of stable and sustainable communities.

3.5.4 Technical flexibility

Technical flexibility refers to the ability of the dwelling to accommodate new and upgraded technical systems. This relates to the potential of the dwelling to: 1) accommodate new technologies as they are introduced, 2) accommodate changes in safety and security requirements. The importance of technical flexibility in housing arises from the rapid development of technologies in this era, which impose a constant need for housing to keep up with these developments, and thus prevent building obsolescence, as has been discussed in Chapter 2, section 2.7.4.

Table 3.4 summarises the different dimensions of flexibility in use and their different indicators.

Demographic	Accept variation in household size as it grows or shrinks.
	Meet the requirements of children growing up at home.
	Meet children's gender determined requirements.
	Accommodate the requirements of people as they grow old at home or become less physically able.
Cultural	Accommodate cultural differences and changes in household activities.
	Accept a variety of living patterns.
	Meet the need of households to project their identity on their homes.
	Respond to cultural diversity or changes in the household's desire for privacy.
	Respond to cultural variance in household perceptions of crowding.
	Consider household differences in preferences for comfort.
	Accommodate different patterns of relations among household members.
	Accept variety of kinship patterns.
	Respond to variation in social linkage patterns with friends and neighbours.
	Accept the variety of social role patterns among household members.
Economic	Accommodate changes in the household's income.
	Accommodate changes in household employment status (ability to provide economic activities in the home, i.e. workspace).
Technical	Accommodate new technologies as they are introduced.
	Accommodate changes in security requirements.
	Accommodate changes in safety requirements.

Table 3.4: The different dimensions of flexibility in use and their indicators.

3.6 User empowerment

Empowering users in their dwellings is another issue that flexible housing can address. Schneider and Till (2007) indicated that flexible housing empowers the users in their dwellings, since it allows them to make modifications to respond to their changing needs.

However, the level of user empowerment differs from one project to another according to the flexible design strategies applied and to what extent they allow the users to adapt their dwellings based on their own terms.

In this respect, Schneider and Till (2007, p.7) distinguish between two types of flexibility – soft and hard – by which flexible housing, in terms of use and form, can provide different levels of user empowerment. Hard use refers to “elements that more specifically determine the way that the design may be used”. Therefore, this type of flexibility extends the architect’s influence and control over the design, determining how the space could be used over time. Thus, user empowerment only allows the user to accommodate their changing needs in their dwelling through scenarios imposed by the architects. On the other hand, soft use refers to “tactics which allow a certain indeterminacy” in the use of the plan, which enables the users to occupy and use the space as they see fit. Therefore, the user is put in charge and the architect’s control over the design is reduced, moving them into the background. This type of flexibility therefore maximises user empowerment, since it allows the users to meet their changing circumstances based on their own terms.

In terms of form, the relation between user empowerment and flexibility lies in the methods of construction used in flexible housing. Hard form refers to methods of constructions that have been developed specifically to achieve flexibility, which act in a determinist manner to the level where the technological system shapes the patterns of living within. This gives the user less control over potential adaptation of their dwelling, and thus less empowerment. On the other hand, the soft form is “the stuff that enables flexible housing to unfold in a manner not completely controlled by the foreground of construction techniques”. It therefore keeps the users in mind and puts them in charge, which gives users more empowerment in adapting their dwellings.

Consequently, two key indicators emerge regarding the level of user empowerment through flexible housing: 1) the ability of the flexible plan to allow the users to use and occupy the space as they see fit, 2) and the appropriate use of building technologies to allow the users to make adaptations according to their needs and wants.

3.7 Financial considerations

The argument here centres on the economic character of flexible housing. Schneider and Till (2007) highlight two key concepts – upfront cost and cost benefits – that can inform the economic nature of flexible design principles. According to indications provided by Schneider and Till (2007) of the cost of the design strategies, the upfront cost of incorporating flexible housing techniques can range from no cost to medium initial cost. For example, a divisible room strategy is identified as having no upfront cost, whereas a shared room design approach has medium cost implications. Therefore, the upfront cost is a matter of choice of flexible strategies in the design that could incur some or no cost. According to Schneider and Till (2007), this also relies on whether flexibility strategies are implementations of design intelligence or technologies with direct cost. The research therefore adopts this concept to formulate an equation of flexibility and upfront cost with a focus on its implications for deliverability. Schneider and Till (2007) draw attention to the concept of cost benefits, which refers to potential savings by flexible housing strategies in the long term, but it is difficult to quantify these exactly if the whole life cost is not considered. The research focuses on investigating the first concept through case studies analyses.

Schneider and Till (2007) also discuss a number of financial benefits that flexible design of housing can achieve. In market terms, they argue that flexible design of housing leads to higher consumer satisfaction at the point of purchase, therefore it is a selling point, particularly in the private sector, and these houses can be sold faster. They present some examples that show how flexibility in the design has led to units being sold faster than expected. For instance, in the Millennium Village development, as the flexible units were seen as more desirable by potential buyers, the developer decided to cover the additional cost of sliding walls to provide flexibility in the designs. In the same way, the consumers of the development at St James Urban Village preferred the flexible units, therefore they were sold faster than inflexible ones.

Another predicted financial benefit of flexible housing is the reduction of maintenance costs of services, since it facilitates accessing and upgrading the servicing system without major work. Schneider and Till (2007) argue that the cost of installing the services systems in housing is not a major part of the upfront cost. However, considerable cost is incurred during the cycle of maintenance and upgrading of services over time. Therefore, a small investment upfront in providing flexibility in services will save over the long term. An additional financial point that offers an economic return for the user is that flexible housing limits the need for users to relocate. Friedman (2002) simply argues that relocation incurs significant costs such as legal fees, expenditure on moving companies, the cost of fitting the new home and so on; he goes on to conclude that adaptable housing can be seen as a viable alternative to the expense of relocation.

In physical terms, Schneider and Till (2007) argue that flexible housing is a viable economic strategy in the long term since it reduces obsolescence of the housing stock. The financial consideration in this respect relates to the "long-term capital cost" that flexible housing can avoid due to its ability to adapt to different circumstances. Therefore, the buildings will be cheaper in the long run as wholesale refurbishment is not often required, and thus the buildings can last longer and their useful life will be increased. However, the higher upfront cost that could arise from creating the long span and frame structure frequently needed to build flexible housing cannot be ignored, which makes this assumption questionable.

The research focuses primarily on investigating the potential financial benefits of flexibility in market terms through the selected case studies as a method of exploring the deliverability of flexible housing as a new phenomenon in the housing market.

3.8 Conclusion

The analytical framework was developed by using different concepts learned from the literature with regard to physical, social and economic aspects as a practical tool to evaluate flexible housing case studies. In physical terms, the learned concepts regarding the plan, construction and services were considered to enhance the way in which the design provides flexibility in the living environment. The plan was conceived at three levels – building, unit and room – and on each level a range of concepts and evaluation criteria were developed. Construction was conceptualised based on the different structural elements of the building that form the analytical concepts for flexibility in construction. Services, on the other hand, focused on concepts relevant to services distribution and appliances. In social terms, the concepts of use and user were considered to explore how the design can respond to different users' needs and user empowerment. Scope and applications were analysed by looking at the ability of the plan's design and the construction to respond to the household's changing needs, in terms of demographic, cultural, economic and technical characteristics. User empowerment was analysed by looking at the ability of the building in use and as a form to provide the user with control over their dwelling. In economic terms, two key financial aspects – upfront cost and the market – were considered to analyse the economic impact of incorporation of flexibility into housing design.

Chapter 4: Research Methodology

4.1 Introduction

The previous chapter presented a review of the key issues surrounding the main theoretical framework of flexible housing practice adopted for this research and the formulation of the conceptual framework. This chapter discusses the overall methodology adopted by the researcher in order to achieve the main aim and key objectives, and answer the research questions. It firstly explains the theoretical perspective of the research in terms of research paradigms and their relevant qualitative and quantitative approaches, including the case study research method. Secondly it describes the different methods for data collection adopted in the research according to the theoretical background of the methodology of the research. This involves literature review, in-depth/semi-structured interviews, fieldwork and case study approach, including an explanation of the background and justification for the case studies selected for this research. Methods for analysing the data are then discussed, including thematic, document and morphological analysis. Finally, the research limitations are explained.

4.2 Theoretical perspective of the research methodology

4.2.1 Epistemological considerations and research paradigms

Epistemology reflects how knowledge evolves, how it is accumulated and how knowledge is accepted. Epistemology and other knowledge traditions such as ontology, which deals with the nature of reality, govern the theoretical perspective of any research. Therefore, every research has its own epistemology and ontology considerations. The different approaches to these traditions provide the basis for several research paradigms, of which two are key: positivism and interpretivism (Crotty, 1998).

Positivism is an epistemological position that advocates application of the methods of the natural sciences to the study of social reality and beyond. Positivism considers that the researcher should emphasise “facts” more than “values”, therefore it links up to the perspective that only “factual” knowledge should be obtained through data collection, including measurement that is trustworthy (Hennink et al., 2011).

During the 1970s, positivism faced strong criticism from many social scientists who argued that the ability to know all aspects of the social world by employing a purely positivist approach is questionable (Hasan, 2016). The limitations of the positivist approach were therefore seen as arising from it being unrealistic to consider society as an objective reality. The view of it as being unrealistic comes from the complexity of social phenomena that the positivist tradition seeks to understand by using a value-free and scientific approach. Therefore, the scientific method which positivism adopts was seen as having limitations when the target is to examine how people live and experience the world (Rodwell, 1987). Because of these limitations of positivist approaches to social research, an alternative approach was developed (interpretivist) by anti-positivists and post-positivists who reject using the traditions of the natural sciences in the study of social reality. The interpretivist approach, in contrast to positivism, views reality as something subjective and not value-free. Interpretivists believe that the world does not exist independently of our knowledge of it, and reality is embedded within the minds of individuals. Therefore, it is only through the subjective interpretation of reality that reality can be fully understood (Grix 2004).

In addition to the positivist and interpretivist approaches, there are other broad epistemological traditions that are located between the previous approaches. Realism, one such tradition, is defined as "the view that entities exist independently of being perceived, or independently of our theories about them" (Philips, 1987, p.205). In the social sciences, the most prominent manifestation of realism is the "critical realist" tradition that shares features of positivism and interpretivism and thus provides an alternative to both approaches. Therefore, critical realist researchers use a combination of the two approaches to understand and explain social phenomena.

Since this research seeks to study the physical approaches of the selected flexible housing experiences, their motivations and the potential impact of policy context on practice, the research tends toward a binary approach that combines positivism and interpretivism, such as the critical realistic approach. This approach allows the research to combine an objective method that depends on measurement of certain elements of flexible housing and analysis of documents to evaluate these components, with a subjective approach that relies on in-depth/semi-structured interviews in order to understand the perceptions and experiences of key actors in these practices.

4.2.2 Qualitative research approach

Two key methods can be recognised for social science research: quantitative and qualitative. Quantitative research relies on numerical methods such as measurement and use of standard statistics for the collection and analysis of data. On the other hand, qualitative methods place emphasis on descriptive data. It is an inductive approach, and its goal is to gain a deeper understanding of a person's or group's experience. According to Ross (1999), qualitative approaches to research are based on a "world view" which is holistic and adopts the following perspective: reality is not a single fact, but depends on perceptions of individuals and change over time; therefore, what is known has meaning only in a particular context. The qualitative approach involves gathering rather than collecting data, using methods that are non-numerical. Sources include interviews, documents, images and so on, chosen on the basis of an epistemological position that directs the researcher to identify how the information of the study should be gathered.

Both strengths and limitations of qualitative research have been identified by researchers. The strengths of such an approach are that it is naturalistic and flexible in design, thereby allowing the researcher to undertake changes throughout the research process (Groat and Wang, 2002). Disadvantages include the difficulty in finding guidelines in the literature for qualitative research design, and the consequent requirement for extra awareness and contemplation throughout the study. Another weakness of qualitative research stems from the unstructured nature of the collected data often creating a need for coding and analysing. Some scientists argue that reliability and validity are difficult to prove when doing qualitative research. Therefore, the trustfulness of qualitative information may remain questionable, despite the "efforts of qualitative methodologists to show that such research can be systematic" (Groat and Wang, 2002, p. 199).

There is an argument that there is no right or wrong method for data collection, as the research itself will make some methods more suitable for achieving the main aim and answering the key questions of the research (Grix, 2004). According to Crotty (1998), qualitative methods or quantitative methods or both can be used to achieve the purpose of the research, whether it is objectivist or subjectivist. This research mainly adopts qualitative methods for data collection and analysis, as it is studying flexible housing practices in relation to the policy and regulatory environment in different contexts and investigating stakeholders' perceptions and experiences in terms of these practices. Thematic analysis was used for analysing qualitative data, implementing a reduction process that enabled classification and categorisation of the collected data. In addition, the researcher applied triangulation by comparing different sources of information such as interviews, documents, photographic documentation and plans.

4.2.3 Case study approach

The case study approach was defined by Gillham (2000) as a method by which an individual, a group, an institution, community or number of cases can be explored. The research question determines what information needs to be collected from the case study. This approach allows investigation of different kinds of evidence that exist in the case setting and need to be collected in order to provide the best answers to the research question. In addition, Robson (2002, p.178) defines the case study approach as "A strategy for doing research which involves an empirical investigation of a particular contemporary phenomenon within its real life context using multiple sources of evidence". Therefore, the case study approach is useful in exploring causal relationships between the phenomenon and the context in which it takes place, while the use of multiple sources of data and a range of research methods to address the research question allows data validation. Morris and Wood (1991) argue also that case study is the best method for obtaining in-depth understanding of the issue being investigated.

However, case study has been criticised for having certain weaknesses and limitations, particularly in terms of possibility to generalise the findings to a large population from a single case (Yin, 2003 and Thomas, 2006). Flyvbjerg et al. (2004) argue that this limitation can be solved by considering more than one case study. In this regard, the most important step is careful selection of suitable case studies that will allow generalisation of findings. For example, investigating extreme cases or extraordinary case studies offers a great opportunity to obtain more information about the phenomenon compared to a typical case. Therefore, a few carefully selected cases can be more useful than randomly selected samples in exploration of latent reasons within the particular setting. Therefore, the current research sought to selected case study projects that would reflect unique aspects of flexible design, so that generalisation of the findings could be achieved.

There are many examples of flexible housing experiences in different developed countries, particularly in such as Germany, the Netherlands, Japan, France, Sweden, the USA and the UK. However, it was considered important to choose examples from both developed and developing countries, to enable different housing environments, policy and regulations contexts to be studied, and thus the findings would be generalizable to wider contexts.

The UK is a developed country that has a wide range of flexible housing developments such as Alexandra Road[1], designed by Neave Brown for GLC in 1969-78, Greenwich Millennium Village (II),[2] designed by Proctor and Matthews Architects in 2001, Silvertown,[3] designed by Ash Sakula in 2004, Cala Domus,[4] designed by PCKO in 2005, and among the most recent projects, The WholeLife House, designed by Brennan and Wilson Architects in 2007 and Tattehoe Park development, designed by IDP Midland Architects in 2012. In addition, it is probable that the policy context supports flexible housing provision and that different national housing programmes promote housing design that can be adapted to the household's changing needs. For example, the Lifetime Homes and Housing for Varying Needs guidelines received support from government and were adopted by different local authorities and have now started to be considered as mandatory requirements in terms of technical standards in the UK.

Meanwhile, Turkey is one of the few developing countries that can provide experiences of flexible housing provision, despite the lack of a regulatory environment to underpin such practices. Examples in this context, which are still few in number and limited in nature, include such as Eryaman Third Stage project, designed by Ahmat Gulgonen and Tuncay Cavdar in 1993, Misir Loft, designed by Autoban Architects in 2002, Levent Loft 1, designed by Tabanlioglu Architects in 2006 and Goksu Rope Factory Loft,[5] designed by A. Suyabatmaz, H. Demirel Architects in 2010. Moreover, Turkey is a Middle Eastern country that has geographical proximity to Syria, the country that originally inspired the researcher to embark on this study, and the similarities in terms of social and cultural context provide the possibility to generalise the lessons learned to different contexts, including Syria. The research topic has a particular relevance to these contexts because rapid social and cultural change in these societies has resulted in widespread adaptations of their housing fabric.

Four important case studies were chosen, two from each country, to examine different aspects of flexibility in housing in their particular cultural and design contexts, and policy

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[1] Alexandra Road addresses flexibility in the design through dividing up strategy by creating zones and prepping the ground floor to be cut off (www.afewthoughts.co.uk).
[2] Greenwich Millennium Village (II) generates flexibility in the plan through the use of sliding walls that allow a variety of layouts (www.afewthoughts.co.uk).
[3] Silvertown considers flexibility in the plan through design of communal spaces (circulation and kitchen living) to accept mixed use (www.afewthoughts.co.uk).
[4] Cala Domus is an award winning residential scheme which is designed to allow flexibility in provision and alteration of services (www.afewthoughts.co.uk).
[5] Goksu Rope Factory Loft was used for many years for industrial production and then turned into a high-end residential project; it was recycled for use in the new construction (Hizil and Mizrak, 2015).

and regulatory environment. The first case study is the Whole Life House in Scotland, UK that represents an example of housing flexibility in terms of the individual home. The second case study is Tattenhoe park development project in England, UK that achieved flexibility in housing through extensions backed up by a supportive design code and policy context. The third is Levent Loft project in Istanbul, Turkey, where flexibility in housing design was produced through adaptive re-use, and the last case is Eryaman third stage project in Ankara, Turkey, where flexibility in housing design was considered through appropriation.

The variety of cases studies on addressing flexibility in housing design allows identification of the possibilities and constraints of different flexible housing approaches. Furthermore, the differences between case studies in terms of the relevant policy and regulations allow understanding of how such design practices can grow in different environments, and thus the research findings could potentially be generalised to different contexts, including Syria. The following paragraphs provide detailed information about the selected flexible housing projects and reasons for their selection.

The Whole Life House project in Scotland, UK as a case study

The Whole Life House project was designed and constructed as a demonstration building for Scotland's Housing Expo and completed in 2010. The project is a single detached house located on the southern edge of Inverness, Scotland. The house was winner of the House of the Year prize at the Scottish Housing Awards 2011, as its design can provide adaptability to the complex ways in which families now live and work. Furthermore, the project provides an example of how flexible housing design can respond to changing circumstances and new emerging trends of household patterns and lifestyles in suburban and rural local areas such as in Scotland. This design addresses the challenges of creating resilient and sustainable communities in these suburban local areas that have witnessed a considerable percentage of households moving or considering moving house due to their current dwelling not meeting their evolving needs and aspirations. Another important reason for selecting this case study is the existence in this context of a regulatory environment including such as the Housing for Varying Needs standards that promote housing that can be adapted to households' changing needs over time, and the potential of the policy context to underpin flexible housing provision. This provides an opportunity to explore whether this supportive environment has been able to inspire or influence flexible housing practice in this project.

The Super Flexible housing project in England, UK as a case study

The Super Flexible housing project is a new housing development in Tattenhoe Park, Milton Keynes, England. The project is divided into six phases and every phase was planned to comprise between approximately 100 and a maximum of 280 dwellings, with 30% of houses overall to be designed as flexible. The research studied the first phase of this development as this has been completed. These houses provide examples of how different approaches to extensions could produce housing that responds to the different needs of communities. These designs, in a similar way to the previous case study, address the creation of sustainable communities through enabling people to stay in their dwellings and communities for a long period of time. Another reason for the importance of this case study is that the Lifetime Homes national standards were applied throughout the project and there is reference to the policy context throughout the development framework document. This allows investigation of how the policy and regulation environment affected flexible housing practice in this case study.

The Levent Loft 1 project in Istanbul, Turkey as a case study

Levent Loft 1, which is a loft project located in the business centre of Istanbul, Turkey, addresses the issue of flexibility through adaptive reuse strategy. This project is notable for gaining awards at the Cityscape Awards 2010, CNBC Awards 2009 and Cityscape Architectural Awards 2008. Its function has been transformed from that of an (unfinished) office building to residential occupation, and the existing concrete construction has been employed as a basic structure for this new use. The units were designed around the loft concept of flexible space for living and working, which is regarded as a desirable living pattern by many inhabitants in the area.

The Eyraman Third Stage in Ankara, Turkey as a case study

Eryaman third stage is a mass housing development located in the expansion area of Ankara, and flexibility was generated primarily through structure allow variability in the plans. Therefore, the project can be considered as an example of flexibility through personalisation and appropriation. Mass housing is a widespread form of production for residential use in different developing countries, including Syria; therefore, it was important for the research to examine the design strategy in this housing type in order to assess its potential for flexibility.

4.3 Data collection methods

The research now explains the different methods used for data collection: literature review; case studies; fieldwork data including publications and documentation; and in-depth/semi-structured interviews.

4.3.1 Literature review

The literature review plays a very important role throughout the research process. According to Groat and Wang (2002), information emerging from research should fulfil the following criteria:

- The information should deal with a particular topic of research inquiry.
- The research results should make a large contribution (add to, expand) to the domain of relevant information.
- The research findings should be able to stand on their own for use by others.

In this research, an academic literature review was conducted of books and academic journals and articles relevant to the research topic and drawn from different sources such as libraries and the internet, to build up knowledge of the topic and address research objective 1. This review focused firstly on empirical and theoretical studies of housing in different contexts that could provide knowledge on drivers for flexible housing in terms of households' changing needs. Secondly, in order to develop the analytical framework for the research, the literature review focused on key concepts of flexible housing including design approaches and tools identified as important in enabling the home to accept change over time.

The academic literature sources, studies and publications collected through undertaking field trips to different case study sites provided essential information regarding the case studies. Literature relevant to the Turkish case studies comprised English language postgraduate studies and academic journals relating to the housing context in Turkey in general and the selected flexible housing projects in particular. These sources included publications produced by TOKI, which is the main public housing provider in Turkey and the developer of the second case study (Eyraman Third Stage) in Turkey. Sources consulted for the UK case studies included documents and publications associated with flexible housing projects.

4.3.2 Case study as a research method

According to Groat and Wang (2002) case study research is a kind of conceptual container. This research method can itself contain one or more other research approaches, or can be used as a tactic among several devices under the umbrella of a single research design. This research relies on case study as a tactic for taking a close look at flexible housing practices, to understand the motivations, possibilities and constraints of flexible housing applications in different contexts with more and less policy and regulation in order to extract lessons that can benefit further applications of flexible housing in terms of practice and policy. Yin (2003) notes that case study strategy is both inclusive and pluralistic as it can be used for exploratory, descriptive, and explanatory purposes. He cautions that these categories should not be separated or be conceived as a hierarchy, and neither should case study be seen only as an exploratory strategy. Other researchers identify different categories of case study; for instance, according to McDonough and McDonough (1997), case studies can be interpretive and evaluative. Through interpretive case studies, the researcher aims to interpret the data by developing conceptual categories, supporting or challenging related assumptions. In evaluative case studies, the researcher goes further by imposing their judgement on the results emerging from the data. In this research, four flexible housing projects in different contexts were selected as case studies for evaluating physical, social and economic aspects of these projects by means of an analytical framework in order to investigate the reasons behind the incorporation of flexibility into the design and how the policy and regulatory environment affected practice.

Smith (1999) argued that analysis of case studies should be supported by a level of knowledge of the context in which the case studies are located. In relation to this research, investigation was therefore conducted of the policy that were in existence during the development stage of the projects in order to understand their effect on flexible housing delivery

4.3.3 Fieldwork data collection

Three field trips were undertaken to collect the necessary data during this research. Two of these field trips were made within the UK, to Inverness in November 2013 and Milton Keynes in April 2014, and the third, to both Istanbul and Ankara, was made in May 2014. Field trips are an important method for data collection as they allow the use of different methods for obtaining data. In the research, different methods were used throughout the field trips: visiting libraries and local authorities, site visits, conducting interviews with stakeholders and collecting relevant documents including the plans of the projects. Visits to libraries were made to collect information about the housing context in the selected case studies, particularly in the Turkish case studies, to uncover essential information on strategy for housing provision in Turkey, housing adaptations and flexible housing experiences. In addition, secondary data related to flexible housing projects in Turkey was obtained from library sources such as postgraduate works and studies. Site visits provided the opportunity to collect more data about the selected projects through photographs, notes and drawings. This was of particular importance for morphological analysis of the different samples of the selected projects (see section 4.4.3).

The field trips to the case study sites also enabled the researcher to conduct in-depth/semi-structured interviews with the available stakeholders of each project, as well as council officers involved in the policy and regulations context, which was particularly important in the UK case studies due to the potential relevance of the policy environment to flexible housing development in these contexts.

4.3.4 In-depth/semi-structured interviews

For the Inverness case study, three face to face, in-depth interviews were conducted, with a designer, a developer and two planning officers from the Highland Council. The designer (second supervisor of this research) was interviewed at the University of Edinburgh and the conversation revolved around flexible design strategy in this project in terms of the key issues covered by the analytical framework of the research. The collected data provided more information about the design approach and the motivations for flexibility in a design, as well as possibilities and constraints emerging during the design stage. During the field trip to Inverness the other two interviews were undertaken. The first interview was conducted with a participant from the Highland Housing Alliance[6], the developer of the project, and was initially arranged with the aid of the designer, and it focused on their involvement in the project, the customers' feedback at the selling point and advantages and disadvantages arising in terms of flexibility throughout the development process. The interview with planning officers from the Highland Council focused on current and previous national planning and local authority policies and housing standards in Scotland, to understand their potential role in underpinning housing

[6] Highland Housing Alliance (HAA) is a development company dedicated to building and managing a wide variety of good quality homes for people in the Highlands.

approaches that are adaptable to households' changing needs. It was not possible to conduct the planned interview with a current user (tenant) of the project, as despite the developer attempting to arrange this several times, the user decided not to be involved.

For the second case study, the Tattenhoe Park development, Milton Keynes, six interviews were conducted. During the field trip to Milton Keynes, three people were interviewed face to face, two were officers from The Home and Community Agency[7] (the landowner of the project) who are the area managers of the development and responsible for planning, designing and delivering the project to the market together with the designer and developer. The interview concerned the motivations and role of the policy environment in delivering flexible housing in this project, and the financial implications and advantages and disadvantages of developing the project to incorporate flexibility. The other interviewee was a planning officer from Milton Keynes Council, with responsibility for approving planning applications, producing the design code and working with the landowner and housing builder on the Tattenhoe Park development. The interview focused on current and previous national and local policies and other housing legislations and how those potentially promote flexible housing in the context in general, and might have encouraged flexible housing provision in the Tattenhoe Park development in particular. Although it was not initially possible to contact the designer (Id partnership Midlands) and developer (David Wilson Homes) to arrange face to face interviews, contact was subsequently made through the landowner and telephone interviews were conducted instead. The interviews provided more information on the designs of the flexible housing samples, customers' feedback, and obstacles faced during the development process, as well as aiding the investigation of possibilities and constraints during the design and development stages. It is important to note that the project was still under construction when these interviews were conducted, and the only completed houses were a few show samples. Therefore, it was not possible to conduct interviews with users in this case study.

During the field trip to Turkey a total of twelve interviews were conducted for the two projects. For the Istanbul case study, six interviews were conducted, the first being with a participant in the design from Tabanlioglu Architects[8] who provided the researcher with the plans of the project. Another interview was conducted with a representative from

[7] The Home and Community Agency (HCA) is the government housing, land and regeneration agency, and the regulator of social housing providers in England.

[8] Tabanlioglu Architects is an architectural firm based in Istanbul, established in 1990 by Murat Tabanlioglu. Tabanlioglu's projects comprise a wide range of building types including residential buildings, which have won various awards such as RIBA International in 2011 and 2013.

VAA, the real estate agency for the project, who facilitated viewings of some housing units and arranged interviews with some users. Also, there was a meeting with a representative of Akfen Holding[9], the developer of the project, to obtain some information about the construction and financial aspects of the project. The four final interviews were conducted with users. The semi-structured interviews with users provided an opportunity to obtain some information about the post-occupancy phase and to examine their perceptions of flexible housing. For the Ankara case study, six interviews were conducted in relation to the Eryaman Third Stage project. The first was with the architect who was commissioned by TOKI[10] (developer and landowner) to develop a design proposal for one of the zones of the project. The second was with a sales manager who provided some information relating to the market. Three interviews were held with users and one with a city planner from TOKI who is head of the strategic planning department, but is not involved with the selected project. However, the interview with the planning officer provided useful information about the company's previous and recent strategies on housing provision and whether flexible housing provision was a strategy consideration during the development of Eryaman Third Stage project.

Table 4.1 presents the different stakeholders of each project who were interviewed during the different field trips to the selected case studies.

[9] Akfen Holding is a Turkey-based and infrastructure oriented holding company which was founded in 1976, gained holding status in 1999.

[10] TOKI (Housing Development Administration of Turkey) is a single public authority, established in 1984 and becoming a separate body in 1990, which has been responsible for providing social housing to low and middle income groups for 25 years. It currently operates directly under the Prime Ministry and special law regulates its activity.

The case study	**Project**	**Interviewee**	**Position**
The UK case studies	The Whole Life House	Architect	A lead architect from Brennan & Wilson Architects and a professor from Edinburgh College of Art, University of Edinburgh.
		Planner	Planning officer from Highland Council.
		Developer	The chief executive of Highland Housing Alliance.
	Tattenhoe Park Site 1 development	Landowner	Two area managers from The Home and Communities Agency dealing with Tattenhoe Park development. One of the agency participants was previously a design and planning manager.
		Planner	Planning officer from Milton Keynes Council responsible for determining applications in the expansion areas in Milton Keynes.
		Architect	Two design directors from Id partnership Midlands, leaders of the Tattenhoe Park design regarding both Urban Design and Architecture.
		Developer	Managing director of David Wilson Homes.
Turkish case studies	Levent Loft 1	Architect	An architect from Tabanlioglu Architects, member of the project design team.
		Developer	A participant from Akfen Holding.
		Sales agent	An agent from VAA real estate agency.
		User	three homeowners from types 1 and 2 who had converted their units into offices and one occupant from type 3.
	Eryaman third stage	Architect	The architect who established and leads Atelier T and the author of a series of architectural oeuvres. The main architect of the project.
		Sales agent	Real Estate Investment consultant from Evinbizden Real Estate.
		User	Six homeowners from types 1, 2, 3, 4, 5and 8 who had adapted their dwellings.

Table 4.1 Stakeholders interviewed for the selected case studies. Source: the researcher.

4.4 Data analysis methods

This section discusses the following methods that were adopted for data analysis: thematic analysis, secondary analysis and morphological analysis.

4.4.1 Thematic analysis

Braun and Clarke (2006, p. 79) define thematic analysis as: “a method for identifying, analysing and reporting patterns within data”. Thematic analysis is a widely used method for analysing qualitative research. It is a process of segmentation, categorisation and relinking of aspects of the database prior to the final interpretation. The researcher adopted thematic analysis for analysing the in-depth/semi-structured interviews. This process involved listening to the recorded interviews several times in order to reduce the amount of descriptive data. This listening process was important in building up a comprehensive picture of the stakeholders’ experiences and perceptions of flexible housing projects, while the reduction process enabled classification and categorisation of the collected data in order to identify shared themes.

4.4.2 Document analysis

Document analysis was defined by Bowen (2009, p.27) as a “systematic procedure for reviewing and evaluating documents-both printed and electronic material”. Document analysis is an extensively adopted method in qualitative research and involves examining and interpreting data in order to extract meaning and understanding and develop empirical knowledge (Corbin and Strauss, 2008 cited in Bowen, 2009). This method has been used throughout the research, but specifically in chapters 5, 6 and 7 to gain knowledge about the policy and regulations context in the UK as well as detailed information about flexible housing in relation to the case studies, and it was employed here also for triangulation of data. The analysed documents included national planning policy statements for England and Scotland, housing programme guidelines such as Lifetime Homes and Housing for Varying Needs, local plan policies and publications, and documents and reports relevant to the case studies.

4.4.3 Morphological analysis

For the morphological analysis, the researcher redrew most of the plans of the selected projects (floor plans, sites, sections and elevations) using AutoCAD, as digitised data (such as AutoCAD drawings) were not available for all the projects. The data collected through the site visits, such as notes and sketches, were added to the plans. In some cases, different plans were investigated to provide the information needed to draw the layouts which were used for the analysis. This analysis was useful to illustrate the different possibilities for flexibility in each project, such as in relation to floor plans, construction and services, as well as the adaptations that were made by the users post occupancy, specifically in the case studies in Turkey. Analysing the photographs obtained from the site visits, interviewees or websites also helped the researcher to illustrate the flexible design techniques used in each project and the current situations of some housing units post-occupancy.

4.5 Limitations of the research

Different limitations arose during the undertaking of this research. The main restriction related to the original intention to base a case study on Lattakia-Syria, the context that initially motivated the researcher to conduct this study, due to the uprising and ongoing crisis since 2011. This prevented the researcher from undertaking fieldwork in Syria to collect necessary information about the housing policy context, design legislation and housing transformations in this context.

In Turkey, certain hindrances emerged in relation to survey of the selected case study sites. First, because of financial and practical limitations it was possible to make only one short field trip to Turkey to investigate the two projects, located in two different cities, Istanbul and Ankara. This made it difficult to arrange separate interviews with stakeholders from each project, as well as limiting the number of interviews with users in both case studies. Another limitation was that some interviews, specifically with users, were conducted in Turkish or in very basic English, with the aid of a translator, which restricted the length and timing of interviews further and thus made it more difficult to obtain clear and in-depth information from the interviewees. The lack of available literature in English about flexible housing in Turkey and the selected projects also made it more difficult to gain the information needed to build up theoretical background about this context in general in terms of flexible housing experiences. Furthermore, it was not possible to hold interviews with certain stakeholders of Eryaman Third Stage development in Ankara, as the project was built in 1990 by TOKI, a governmental company, and most of the people who were involved in constructing and delivering the project are no longer working for the company.

The main limitations faced by the researcher in terms of the UK case studies were restrictions on viewing the projects and conducting interviews with users. In the first project, interviewing the selected user was not possible as she/he preferred not to be involved. In the second case study, no users were available as the project was still under construction, which also restricted visits to the site, due to safety concerns on the part of the developer. Therefore, no information was available about the post-occupancy phase of either project.

4.6 Conclusion

This chapter has explained theoretical perspectives of the research including the data collection methods and analytical approaches adopted in this study. Mainly qualitative but also quantitative methods were employed to achieve the research's main aim and objectives. Four flexible housing projects that address different aspects of flexibility in different contexts with more or less housing policy and regulation were selected as case studies for the research in order to conduct a deep investigation of practice and policy issues. Field trips were undertaken in the UK and Turkey to gather information about the selected experiences of flexible housing, through conducting interviews and site visits. The collected data were analysed by means of different methods, which have been explained in this chapter. The results and findings that emerged from this process are demonstrated in the following chapters.

Chapter 5: The national planning policy of housing and housing standards relevant to flexibility in the UK

5.1 Introduction

In this chapter, the research seeks to examine national planning policies in the UK in terms of flexible housing and national housing programmes that have relevance to flexibility in housing design. This addresses objective 3 of this research, which is to study the housing policy context in the UK and how its objectives and strategies for housing provision promote flexible housing. It will also contribute to achieving the main research aim, which is to discover how policy has affected practice, through analysing the relation between policy and practice in this context.

The examination of the UK's national planning policies is mainly concerned with identifying the motivations that drive flexible housing provision, and the tools and strategies used for delivery of flexible housing. Planning policies for both England and Scotland will be considered, as they represent the geographic and political contexts of the selected flexible housing projects. Since the national planning policies set out principles and objectives, the examination was undertaken in the light of the key definition of flexible housing discussed in Chapter 2 section 2.3, rather than using the analytical framework themes that provide the evaluation criteria for flexibility in housing design.

Moreover, the research examines national programmes and standards that promote flexibility in housing design in both contexts, in terms of the key themes (plan, construction, services, use, user empowerment and financial aspects) of the research analytical framework developed in Chapter 3. Here the main target is also to explore the key reasons that drove such housing programmes to include flexible design solutions among their criteria and standards, and examine how these programmes provide flexibility in housing design, with a focus on the related possibilities and constraints.

5.2 National planning policies of housing in England

Historically, Planning Policy Guidance Notes were statements of the government's national policy and principles regarding certain aspects of the town and country planning framework. These national policy documents were originally known as PPGs and introduced under the provisions of the Planning and Compulsory Purchase Act. From 2004, they were gradually replaced by Planning Policy Statements (PPS), which addressed different aspects of land use planning, including housing, that should be considered by local authorities in preparing their development plans. In March 2012, all planning policy statements (PPS) and remaining PPGs were replaced by the National Planning Policy Framework (NPPF) and on publication became a material consideration in planning matters. Since the main aim of this research is to study how policy has affected practice and one of its objectives is to investigate the planning policy context in the UK, the research focuses on examining the promotion of flexible housing through the Planning Policy Statements (PPS), due to their relevance to the selected case study in England, and the National Planning Policy Framework (NPPF), as this is the current planning policy for housing.

Planning Policy Statements set out the national planning policy framework for delivering the government's housing objectives and include such as *PPS3: Housing*, which was published in 2006. It complements other relevant statements of national planning and housing policy, in particular *PPS1: Delivering Sustainable Development,* which was introduced in 2005. PPS3 sets out planning objectives and policies that focus on different strategies for housing provision, which include the delivery of "high quality housing" and "a mix of housing" (Communities and Local Government, 2011, p.9). Mix of housing requires the delivery of a variety of dwellings in a development, particularly in terms of tenure, price and different household types such as families with children, single person households and older people. Although the mix of housing approach seeks to respond to households' different needs, it cannot necessarily be linked to a strategy of flexible housing, since it does no more than call for the delivery of different housing choices pre-occupancy. Flexible housing academics view flexibility in housing as a generic term that allows the users to adapt their dwelling either pre-or post-occupancy. In policy terms, however, a mix of housing approach seeks to provide pre-designed choices for potential users to choose between, with no reference to the possibility of adapting such housing. This is corroborated by the opinion of one of the interviewed planning experts that "PPS1 and PPS3 encourage a range of different houses types but do not go as far as making specific reference to flexible housing" (interview no. 3).

Despite PPS3 identifying creation of sustainable, inclusive, mixed communities as one of its strategic housing policy objectives (Communities and Local Government, 2011, p.9), and PPS3's support for development of strong, sustainable and cohesive communities (Communities and Local Government, 2005, p.7), neither went beyond advocating mix of housing to achieve this key target. The policies stressed that a mix of housing approach contributes to the creation of socially inclusive communities and thus embeds social sustainability in communities. In this regard, Schneider and Till (2007) argue that socially sustainable communities can be achieved in housing terms through incorporating flexibility to design housing that has the capacity to accept demographic change. Therefore, reinforcement of social sustainability in the community requires a variable approach to housing that can cater for the evolving needs of households over time, rather than a strategy that views housing as a physically and intellectually fixed asset, as promoted by the mix of housing approach.

Regional Spatial Strategies, Local Planning Authorities and developers are all required by PPS3 to consider mix of housing as a regional policy approach, in the local development document and in proposals for the housing market respectively. In this regard, mix of housing should be considered on the basis of the different types of household, having particular regard to "current and future demographic trends and profile" (Communities and Local Government, 2011, p.9). The requirement to look at future household demographics highlights the long term vision of the policy in terms of considering people's future needs in their dwellings. However, this approach comes up against a housing approach that reflects a short term vision in responding to households' needs, focusing on immediate needs rather than changing needs in the long run. Schneider and Till (2007) consider that one of the problems in dealing with housing as fixed design elements is the failure to allow for unseen and uncertain demographic developments. Therefore, they argue that "a mix of units that meets immediate demand might well be inappropriate in thirty, let alone one hundred years' time" (Ibid, p.37). In addition to advocating mix of housing policy, PPS3 promoted a policy of high quality housing which, although required good design of housing to make places better for people, and innovative approaches to help deliver high quality housing and sustainable new housing developments, did not offer any advice regarding the relevance of flexibility in housing design to delivering high quality housing developments.

PPS1 highlighted the ideas of the *Sustainable Communities: building for the future* policy, the Government's vision for sustainable communities. This policy was launched in 2003 by the Office of the Deputy Prime Minister. It provides an action programme that sets out advice on developing new sustainable communities in England. This advice states the need for "buildings, both individually and collectively, that can meet different needs over time" (Office of the Deputy Prime Minister, 2003, p.5). This statement can be interpreted as favouring flexible housing, since it calls for a response to the future needs of users in their buildings, particularly at individual level, in the long term. Accommodating people's future needs over time in their dwellings requires an adaptable approach for housing that allows for change over time. Therefore, one can say that this advice implicitly promotes flexibility in housing. Similarly, this policy includes "a well-integrated mix of decent homes of different types and tenures to support a range of household size, ages and income" among its requirements for sustainable communities, but this is not necessarily of relevance to flexibility as explained previously (Office of the Deputy Prime Minister, 2003, p.5). Although this document focuses on building for the future and the creation of sustainable communities, it makes only this one reference to flexibility.

The National Planning Policy Framework published in 2012 set out planning policies for delivering sustainable development and highlighted two important policies that are relevant to housing provision and design, including "delivering a wide choice of high quality homes" and "requiring good design" (Communities and Local Government 2012, p:13&14). However, neither policy makes any reference to the issue of flexibility, either regarding choices for high quality homes or the creation of good design. The first policy focuses on the promotion of a mix of housing based on current and future demographics, which does not necessarily relate to flexible housing, as explained above. The second policy promotes inclusive design for all developments, including individual buildings, and the emphasis is therefore on buildings being usable by everyone.

In summary, the examination of previous and current national planning policies PPS1, PPS3 and NPPF in terms of the provision of flexible housing showed little reference to flexible housing. Despite the fact that the policies require the relevant parties to respond to people's different needs in their dwellings and take into account the future demographic trends in the regional and local contexts, and housing markets, their recommendations were confined to the support of a mix of housing, a policy that responds only to immediate household needs while neglecting the accommodation of people's future needs. This disjuncture between the means and the end can be seen also between the strategic objective of creating sustainable communities and the promotion of a mix of housing policy that does no more than meet the current demand. Achieving social sustainability at community level requires an approach based on adaptable housing that has the ability to respond to households' changing needs over time and thus to stabilise communities. In this regard, an implicit reference found in *Sustainable Communities: building for the future* policy, which required the individual building to accommodate people's changing needs over time, was the only reference made to flexibility in housing.

Evidence tells that housing quality is maximised by incorporating flexibility into its design because it allows the dwelling to respond to the household's changing needs. Despite this fact, the planning policies intended to underpin high quality design have failed to consider how flexibility can increase the quality of housing. This omission is clearly evident in previous national planning policies PPS1 and PPS3, as well as the current NPPF. In policies on mix of housing and housing quality, where flexibility could potentially play a role, there is no clear evidence of consideration of flexibility in housing design.

5.3 National housing programmes with relevance to flexible housing in England

The research in this section focuses on a well-known national housing programme in England - Lifetime Homes (LTH) - that provides design criteria and standards for delivering adaptable housing. The research examines the design standards presented in this programme against the criteria developed for the analytical framework of this research.

5.3.1 Background of Lifetime Homes (LTH)

According to the Lifetime Homes website, LTH are defined as "ordinary homes designed to incorporate 16 design criteria that can be universally applied to new homes at minimal cost" (LTH). Lifetime Homes are "all about flexibility and adaptability; they are not 'special', but are thoughtfully designed to create and encourage better living environments for everyone" (LTH).

The concept was initially developed in 1991 by the Joseph Rowntree Foundation (JRF) and Habinteg Housing Association (HHA), who worked together to produce a set of design standards for general needs housing, which can improve access and adaptability for a wide range of households with different needs. In 2008, the UK government announced its intention to work towards all new homes in the private sector in England being built to Lifetime Home Standards by 2013. In 2010, the last version of the LTH standards was included by Communities and Local Government among the national standards of the Code for Sustainable Homes.

HHA has undertaken a number of revisions to the 16 design criteria over time, and the last proposed revisions to the original LTH standards were issued in 2010. In 2011 technical guidance was developed by HHA in relation to the 2010 standards. The research focuses on this guidance and other related documents including the official website published by HHA to explore why and how the LTH design guidance provides flexibility in housing design.

5.3.2 Motivations driving LTH towards flexibility in housing design

The LTH programme explains the different motivations behind the adoption of flexible design solutions in housing. The key motivation is to allow homes in general to accommodate the different needs within the community, particularly those of elderly and disabled people in light of the dramatic increase of these groups as a proportion of the population. The principle is that rather than providing pre-designed special needs homes, the generality of homes should be maintained.

A purely economic motivation relates to reducing the future need for specialised housing among elderly and disabled people through designing all new homes to have flexibility from the outset so that they can be adapted to the needs of these groups as necessary. The design standards of the LTH programme also identify sustainability as a motivation for the adoption of flexible design strategy. In this respect, flexibility is seen as contributing to long-term viability of the community, since it helps to ensure that different sections of community will want and be able to live in their dwellings in the long term. This in turn contributes to the creation of stable and popular neighbourhoods and communities, and thus enhances communities' sustainability.

Moreover, Godman (2011, p: 2) clearly states that "non-apparent integral design features are ready to assist adaptation for a household that has a family member with a temporary or permanent disability or a progressive condition that is making movement around the home or between floors difficult". Therefore, the development of the LTH standards in terms of household's changing needs represents a response to the needs of the household as they grow older or become less physically able. These can be classified as changes in the household's demographic characteristics according to the research framework in Chapter 2, section 2.6 (see table, 5.1).

Household need	Sub-source of the household need	Main sources of the household need
Household growing old at home	Ageing process	Demographic
Household become less physically able	Disability	Demographic

Table 5.1: Motivations for flexibility in LTH standards in terms of household's changing needs.

5.3.3 LTH standards

LTH standards include 16 design criteria that need to be met in designing housing that can respond to different and changing needs of households. These standards can be divided into two main categories: standards that apply outside the home, and criteria to be met inside the home. The former refers mainly to access elements such as parking space, communal circulation and the main entrance. The latter criteria include design considerations that address accessibility and usability issues within the home. Although the issue of adaptability is among the main principles of LTHS, not all the standards relate to future adaptability of the home, as the physical approach of LTH is conceptualised in 16 standards providing a mix of flexible and non-flexible design solutions. The main focus in this research is to examine those standards that allow design solutions through flexibility, in the light of the research analytical framework set out in Chapter 3. Table 5.2 presents the 16 LTH standards according to their ability to allow for adaptations.

Flexible standards	
Criterion 9	In houses of two or more storeys, there should be space on the ground floor that could be used as a convenient bed space.
Criterion10	There should be a downstairs toilet that should be wheelchair-accessible, with drainage and service provision enabling a shower to be fitted at any time.
Criterion 11	Walls in bathrooms and toilets should be capable of taking adaptations such as handrails.
Criterion 12	The design should incorporate provision for a future stair lift and a suitably identified space for potential installation of a house lift (through-the-floor lift) from the ground to the first floor, for example to a bedroom next to the bathroom.
Criterion 13	The bath/bedroom ceiling should be strong enough, or capable of being made strong enough, to support a hoist at a later date. Within the bath/bedroom wall provision should be made for a future floor to ceiling door, to connect the two rooms by a hoist.
Non-flexible standards	
Criterion 1	Where car parking is adjacent to the home, it should be capable of enlargement to attain 3.3m width.
Criterion 2	The distance from the car-parking space to the home should be kept to a minimum and should be level or gently sloping.
Criterion 3	The approach to all entrances should be level or gently sloping.
Criterion 4	All entrances should be illuminated and have level access over the threshold, and the main entrance should be covered.
Criterion 5	Where homes are reached by a lift, it should be wheelchair-accessible.
Criterion 6	The width of the doorways and hallways should accord with the Access Committee for England's standards.
Criterion 7	There should be space for the turning of wheelchairs in kitchens, dining areas and sitting rooms and adequate circulation space for wheelchair users elsewhere.
Criterion 8	The sitting room (or family room) should be at entrance level.
Criterion 14	The bathroom layout should be designed to incorporate ease of access, probably from a side approach, to the bath and WC. The washbasins should also be accessible
Criterion 15	Living room window glazing should begin at 800mm or lower, and windows should be easy to open/operate.
Criterion 16	Switches, sockets and service controls should be at a height usable by all (i.e. between 600mm and 1200mm from the floor).

Table 5.2: LTH design standards. Source: Joseph Rowntree Foundation, (2003).

5.3.4 Flexibility in plan through LTH standards

Criterion 9 of the LTH standards calls for a place somewhere on the entrance level of houses with two storeys to be convertible for use as a bed space when necessary (JRF, 2003) (see table 5.2). In addition, criterion 10 of the LTH standards recommends provision of a ground floor toilet and a space that has the ability to accommodate a shower at any time. In this regard, it is advised that drainage is considered from the outset in this space, in order to facilitate future installation of a shower. This would enable the service space to be furnished in another way; therefore, applying these standards in housing design would give the plan some flexibility in function at room and furniture level. Building regulations (2010, edition 2015, p.21) indicate that compliance with criterion 10 is optional through standard 2.29 requiring that "provision for a potential level access shower is made within the bathroom if not provided elsewhere within the dwelling".

The possibility for flexibility in furniture is also promoted by LTH standards 11 and 13 advising that walls in bathrooms and toilets of the dwelling should accept future adaptations for installing fixtures such as handrails, and bathroom/bedroom ceilings should be able to support a hoist at a later date. Again, these criteria are included in standards 3.35 note 2 and 3.36.d of Building Regulations (2010, edition 2015, p.39,40) as optional requirements that "the loading for strengthened ceilings is considered suitable for many types of adaptations" such as high point loads and that "all walls, ducts and boxing of every WC/cloakroom bath and shower are strong enough to support grab rails, seats and other adaptations".

In terms of internal circulation, criterion 12 of the LTH standards requires dwellings with two storeys to allow for future provision of a stair lift and floor lift (JRF, 2003), (see table 5.2). To facilitate convenient use of a future stair lift, an adequate width of stair is required, while for a potential floor lift, it is necessary to provide an invisible "knock out panel" somewhere on the first floor that could be removed at a later date (JRF, 2003), (see table 5.2). Building Regulations (2010, edition 2015, p.18) refer to this criterion through standards 2.23 and 3.2.8 that respectively require the building "to allow a stair-lift to be fitted to the stairs from the entrance storey to the storey above" and provision to be made in the plan for potential installation of a lift for wheelchair users, in all new dwellings as optional requirements.

Therefore, the key possibilities for flexibility in the plan in the LTH housing standards are limited mainly to flexibility to use some rooms for other functions, flexibility in furniture in certain rooms (bathroom, WC and bedroom) and flexibility in vertical circulation to allow for future access means (see table 5.3).

<table>
<tr><th>Category</th><th colspan="3">Indicators</th><th>Evaluation</th></tr>
<tr><td rowspan="2">Building</td><td colspan="3">Unit mix</td><td>X</td></tr>
<tr><td colspan="3">Use</td><td>X</td></tr>
<tr><td rowspan="5">Unit</td><td colspan="3">Size</td><td>X</td></tr>
<tr><td rowspan="4">Layout arrangement</td><td colspan="2">Functional flexibility</td><td>X</td></tr>
<tr><td colspan="2">Spatial flexibility</td><td>X</td></tr>
<tr><td rowspan="2">Internal circulation</td><td>Horizontal</td><td>X</td></tr>
<tr><td>Vertical: the possibility of adding lift as an additional vertical access means.</td><td>✓</td></tr>
<tr><td rowspan="3">Room</td><td>Function</td><td colspan="2">Accept change in function: convertible space for bedroom at ground floor.</td><td>P</td></tr>
<tr><td colspan="3">Connection</td><td>X</td></tr>
<tr><td>Furniture</td><td colspan="2">Accept additional furniture: bedroom and bathroom.</td><td>P</td></tr>
</table>

✓: Achieved **P**: Partly achieved **X**: Not achieved

Table:5.3 Possibilities in LTH standards for flexibility in the plan. Source: the researcher.

5.3.5 Flexibility in construction through LTH standards

Flexibility in construction is referred to in criterion 12 of the LTH standards that requires placement of an invisible knock out panel somewhere in the first-floor construction to allow a lift to pass through in the future. Criterion 11 provides further consideration of flexibility in construction through recommending that bathroom walls are strong enough to support grab rails and other fixings. Therefore, opportunities for flexibility in construction through applying LTH standards are confined to flexibility in floor structure to accept an opening in a pre-defined location and flexibility in the structure of particular walls to enable them to accept additional load (see table 5.4).

Indicators		Evaluation
Structure	Ceiling structure for bathroom, toilet and bedroom to accept additional load for future hoist.	**P**
	Knock out panels in floor structure to accept future opening for lift.	
Internal partitions	Wall structure of bathroom and toilet can support additional fixtures.	**P**
External walls		X
Foundations		X
Roof		X

P: Partly achieved **X**: Not achieved

Table:5.4 Possibilities in LTH standards for flexibility in construction. Source: the researcher.

5.3.6 Flexibility in use through LTH standards

As explained in section 5.3.4, LTH standards provide for certain future adaptations of the plan to accommodate the household's changing needs. One such adaptation is to provide new vertical access means such as a stair lift and ground lift to allow the elderly and wheelchair users to access the upper floor of their dwelling. Another possible adaptation is to provide bed space on the ground floor or access level that can be used temporarily or permanently as a sleeping place for elderly household members who cannot access the second floor or to accommodate a visiting relative. Future adaptation to provide a shower place on the ground floor would allow elderly household members with less physical ability to take a shower at the entry level without the need to access the second floor. Use of this facility by the elderly or disabled can be enhanced by enabling future installation of fixtures such as grab rails.

Consequently, LTH standards offer the plan little opportunities for flexibility in use. Changes in household demographic characteristics in terms of household members grow old at home and become less physical able are the only aspects of flexibility in use considered by the LTH standards, according to the research analytical framework in Chapter 3, section 3.5.1.

5.3.7 User empowerment through LTH standards

By recommending the possibility of making certain adaptations after occupancy, the LTH standards potentially hand over to the users some control over their dwellings. This can be seen through the recommendations on access and use of dwelling spaces, relating to such as the possibility to provide a shower and bed space on the ground floor, to allow the household to use the ground level for sleeping and bathing activities, without the need to access the upper level. However, it can be argued that LTH standards limit the scope of user empowerment by determining how spaces can be used over time. In this respect, Imrie (2006) argues that part of this problem lies in the failure to gather users' views and the poor connection between professionals and users during the development of these standards, which led King (1996, p.9) to describe LTH as "equipped by others according to standards made by others".

5.3.8 Conclusion

It can be concluded that LTH standards exhibit a narrow conception of flexibility in design. Provision by these standards for flexibility in housing design was confined, in a large part, to a few technical design applications rather than thoughtful flexible design solutions, and the causality behind technical solutions is deterministic. Therefore, the design criteria were manifested as a set of implementations that frame the user as an operator of architectural tools, rather than allowing the users to appropriate the space as they see fit. The technical form of these standards can also be seen behind the inability of LTH standards to provide housing design that is flexible in use to a broader social context. The investigation of building regulations of England revealed that most of the flexible design solutions in LTH standards were considered through technical standards, and as optional rather than mandatory requirements.

5.4 Flexible housing and the relevant national planning policies in Scotland

The Scottish Government's planning policies for housing are set out in Scottish Planning Policy (SPP), National Planning Framework (NPF), Circulars and Planning Advice Notes (PANs). SPP is a statement of Scottish Government policy on national land use and other planning issues, and is a set of policies, including housing policies, for Scotland in general. NPF, meanwhile, sets the context for development planning in Scotland and provides a framework for long term spatial development in Scotland as a whole. Circulars, which also contain statements of the Scottish Government's policy, provide guidance on policy implementation through legislative or procedural change. Finally, PANs provide advice and information on technical planning matters. The main focus in this part is on

Scottish Planning Policy SSP, particularly *SPP3: Planning for Homes,* which includes the Scottish Government's strategies for housing.

SPP3: Planning for Homes (2008) set out the Scottish Government's policy on identification of housing requirements and provision of land for housing and the delivery of homes through the planning system. This SPP highlighted that the planning system should, as one of its objectives, seek to produce "good-quality housing" (The Scottish Government, 2008, p.4), and stated that the main target of development plans in relation to housing should be "the creation of sustainable mixed communities" (The Scottish Government, 2008, p.9). In the latter case, the Scottish Government requires local authorities to include in their developments plans "mixed-use residential communities in terms of tenure, demographic and income". A range of housing types is therefore required to underpin the mixed-use housing policy and provide different choices for the whole community and all segments of the housing market, including houses for families and older people with particular housing needs. In addition, the policy highlighted that creating housing for mixed communities requires providing "opportunities for households to continue to meet their changing needs over time" (The Scottish Government, 2008, p.9). This involves the delivery of "flexible living space" which allows accommodation of the changing needs of households. The latter requirement can be seen as supporting an adaptable approach for provision of a housing product that can respond to changing needs of households over time post-occupancy. On the other hand, the requirement for a range of housing types, as explained through the discussion of planning policy of England, cannot necessarily be linked to flexible housing strategy, as it does no more than imply the need for providing pre-designed choices for potential users. Therefore, the endorsement of flexible housing through this policy is more about pre-occupancy flexibility, with little reference to post-occupancy in this context. As the main aim of the mixed-used residential policy is the creation of sustainable communities, flexibility is seen by this SPP as a means for achieving this target.

In terms of housing quality, SPP3 indicated that the creation of high-quality residential communities supports the development of sustainable communities, and quality of design is an important factor in this. In this respect, SPP3 highlighted provisions of *Designing Places* and *Planning Advice Note 67: Housing Quality*, which set out the issues to be considered in planning for a high quality residential environment. The former is a Scottish Executive planning policy document which identifies a range of qualities characterising successful and sustainable places, including adaptability. The qualities identified in *Designing Places* contribute to making places that are socially, economically and environmentally successful. Those qualities are interpreted and applied to new housing by *PAN 67 Housing Quality* (2003), which highlighted "adaptable" among the descriptions of successful housing. Successful homes in terms of adaptability are necessary because people "may want a home that will prove adaptable as their household and other circumstances change" (2003, p.8). According to this statement, adaptability is seen as a quality aspect of housing, since it enables the houses to respond to the changing needs of the household, which in turn can contribute to creating successful places socially, economically and environmentally. Despite the acknowledgement of the importance of adaptability to achieving a high-quality residential environment, the means to achieve adaptability are not really made evident in this policy as it specifies only an approach based on a mix of dwellings. This approach does no more than provide certain choices for occupants prior to occupancy, which, according to this research, cannot be considered as a strategy for flexible housing. According to the interview with the architects of the WholeLife House project in Scotland, flexibility in housing in Scotland is often dependent on the ability to extend beyond the existing housing envelope; therefore, policy and regulation in regard to extensions is vital in terms of determining a supportive environment for flexible housing (interview no.1).

In summary, the national planning policies for Scotland draw attention to the issue of flexible housing through policy advocating mixed-use residential communities, thereby they give endorsement to a flexible living space approach that responds to people's changing needs. Whilst the creation of sustainable communities can be considered the key motivation driving such endorsement, flexibility is not included among the key policies for housing provision. Instead, the policy does no more than advise its use in underpinning a mixed-use residential approach, according to the interviews with two housing experts from the Highland Council (interview no.1).

Examination of these policies revealed further encouragement for flexible housing design through the policy for high-quality residential communities. In this respect, flexible housing design was not a direct policy requirement, but was highlighted through a relevant policy for delivering housing quality (PAN 67). Although there is reference to flexibility, it is only considered in terms of provision of a range of housing types pre-occupancy.

5.5 National housing standards that are relevant to flexible housing in Scotland

The main focus in this part is on a well-known national housing programme in Scotland: Housing for Varying Needs (HVN), which takes account of flexible design solutions in its design standards. Therefore, the research examines these design criteria in the light of the main concepts of the research analytical framework to discover how these design solutions contribute to providing flexible dwellings.

5.5.1 Background of Housing for Varying Needs (HVN)

HVN standards were developed by Scottish Homes at the request of The Scottish Office. The request was for review and updating of Scottish Housing Handbooks 5 and 6, *Housing for the Elderly* and *Housing for the Disability,* to create barrier free standards and to include further consideration of people's housing needs. The Scottish Office requested that the update should cover the forms of accommodation introduced in Scottish Housing Handbook 7, Housing for Single People, Shared Accommodation and Hostels. The review strongly suggested that people's housing needs should to a large extent be accommodated by "housing in general" that is designed to fit a diversity of users (Scottish Homes, 1998).

The guidance was developed in two parts. Part 1 focused on the design of self-contained houses and flats to meet households' diverse and changing needs over time, whereas Part2 covered the design of grouped housing with some shared space and facilities. The standards provided by both parts are only advisory and have no mandatory power. The research focuses on Part 1 that sets out the design standards for general and special housing types. The guidance in Part1 indicates that it does not intend general housing to be an alternative to houses designed specifically for use by people with specific needs. Instead, it provides additional design criteria that should be incorporated into ordinary houses to accommodate people with special needs. The research is concerned mainly with design standards that are required to be implemented in general housing for accommodating users' different and changing needs.

5.5.2 Motivations driving HVNS towards flexibility in housing design

HVNS guidance referred to different reasons for the adoption of certain flexible design solutions in its standards. The key motivation is that "people have various housing needs and these will almost certainly change through a lifetime" (Scottish Homes, 1998, p.3), therefore the built form of all housing should be flexible enough to accommodate these varying needs. This is of particular importance for such groups as elderly and disabled people who wish to live independently.

Another reason behind the adoption of flexibility in HVNS is the considerable demand from households for adaptations to existing housing that is unsuited to meeting their changing needs, in particular those of older and less able households. This need is confirmed by statistical data that highlighted a big gap between the number of occupants with limited physical ability and the available homes suitable for their use (Scottish Homes, 1998).

An additional motivation found in the guidance is that the majority of people with special needs prefer to live in ordinary housing rather than what is commonly known as special needs housing (Scottish Homes, 1998). Therefore, it is vital that housing design should always consider households' changing needs as they grow old at home or become less able, which constitute changes in households' demographic characteristics, according to the research framework as set out in Chapter 2, section 2.6 (see table, 5.5).

Household need	**Sub-source of the household need**	**Main sources of household need**
People growing old at home	Ageing and disability	Demographic
People becoming less physically able	Ageing and disability	Demographic

Table 5.5: Motivations for HVNS to incorporate flexibility in terms of households' changing needs. Source: the researcher.

5.5.3 HVN standards

HVN design criteria are interpreted as standards that can be applied differently to three broad categories of housing: housing in general to suit varying needs, dwellings specifically for older and ambulant disabled people and dwellings specifically for wheelchair users. Some design criteria can be seen as being common to all three categories, while others relate specifically to one particular housing category.

Furthermore, the design criteria were divided into categories that represent the different entities comprising the flat or house, externally and internally. The categories of external entities include such as means of access to dwellings and access to communal areas, stairs and lift. Meanwhile, categories of internal entities include the entrance doors to individual houses or flats, internal circulation and doors, living and sleeping spaces, storage, kitchen area, bathroom, additional WC, windows, heating and water services, and finally, power and communication.

The guidance provides some flexible design solutions that allow future adaptations (see table 5.6), which are a research focus for analysis based on the main concept of the research analytical framework in Chapter 3. Since the documentation provides only advisory design guidance, the research undertakes a review of Technical Standards guidance to assess whether these design criteria were adopted as mandatory requirements for housing design in Scotland.

Examination of Technical Standards guidance (2016, p.182 and 183) showed that standard 3.12.3, adopts criteria 6.2.4, 6.2.5 and 14.2.2 as mandatory requirements in provision of accessible sanitary accommodation. In this respect, the standard calls for the possibility to provide an additional accessible toilet at entrance level and an alternative space on the living level of the dwelling for adaptation as a future shower room. This standard also requires the walls adjacent to any sanitary facility to be of robust construction to allow future "secure fixing of grab rails or other aids", which is covered in criterion 14.2.2 of HVNS guidance. Moreover, standard 4.2.8, on unassisted access between storeys in a dwelling, requires the possibility of future installation of a stair lift in any stairway giving access to a principle living level (Technical Standards guidance 2016, p.271), which means that criterion 6.2.2 of HVNs is mandatory in terms of Technical Standards guidance.

Designing for future adaptability		
6.2	6.2.1	Load bearing partitions should be kept to a minimum as they can make adaptations difficult and expensive.
	6.2.2	Stairs should be able to take a stair lift and allowance should be made for the possible installation of a through floor lift.
	6.2.3	In two storey houses an area at ground level that could accommodate a bed also adds to flexibility of use.
	6.2.4	Lack of a WC at ground floor level can makes a house unusable, and even 'unvisitable', by a person who cannot climb stairs.
	6.2.5	Bathrooms at ground level that allow for a floor gulley are less costly to adapt for a walk-in shower.
Bedrooms		
11.4.2		Double bedrooms should be able to accommodate two single beds to allow for different types of households.
General requirements for bathrooms		
14.2.2		Walls adjacent to the WC and around the bath should be of a construction that allows for the secure fixing of grab and support rails should these be needed.
Power and communication		
18.1.2		The use of technology within the home is likely to increase in future and allowance should be made for future wiring, for example by allowing space behind skirting boards.

Table 5.6: HVN design standards for adaptations. Source: The Scottish Homes, 1998, p.21.

5.5.4 Flexibility in plan through HVN standards

Criterion 6.2.2 in the HVN standards recommends that two key adaptations are taken into account regarding flexibility of vertical circulation in two storey dwellings: first, the design of internal stairs should allow future installation of a stair lift, and second, future installation of a floor lift should be considered. Furthermore, criterion 6.2.3 calls for provision of a single space on the ground floor that is convertible into a bedroom. Therefore, this standard allows the plan some flexibility in function at room level (convertible room at ground floor). In addition, criterion 6.2.4 considers future provision of a WC on the ground floor, which offers a new function in the plan's layout arrangement, and thus the possibility for functional flexibility at unit level. Criterion 6.2.5

requires that dwellings with two storeys have an adaptable bathroom on the ground floor for future provision of a "walk in shower". In order to achieve this, a "floor gulley" should be installed in the bathroom, so a shower can be fitted easily at a later date, meaning that this space could accept a change in furniture. The possibility for flexibility in furniture is also promoted by criteria 11.4.2 and 14.2.2. The former relates to designing a double bedroom in the dwelling to accept two single beds, whereas the latter again refers to the bathroom's flexibility to accept new fixtures such as grab and support rails.

It can be concluded that the main opportunities for flexibility in the plan deriving from implementation of HVNs standards comprise flexibility in terms of internal vertical circulation, flexibility in the functions of particular rooms, flexibility in the bathroom, WC and bedroom furniture and flexibility in layout arrangements to accept adding new functions to the plan (WC) (see table 5.7).

<table>
<tr><th>Category</th><th colspan="3">Indicators</th><th>Evaluation</th></tr>
<tr><td rowspan="2">Building</td><td colspan="3">Unit mix</td><td>X</td></tr>
<tr><td colspan="3">Use</td><td>X</td></tr>
<tr><td rowspan="5">Unit</td><td colspan="3">Size</td><td>X</td></tr>
<tr><td rowspan="4">Layout arrangement</td><td colspan="2">Functional flexibility: possibility to add future toilet on the ground floor level.</td><td>P</td></tr>
<tr><td colspan="2">Spatial flexibility</td><td>X</td></tr>
<tr><td rowspan="2">Internal circulation</td><td>Horizontal</td><td>X</td></tr>
<tr><td>Vertical: the possibility of adding lift as an additional vertical access means.</td><td>✓</td></tr>
<tr><td rowspan="4">Room</td><td>Function</td><td colspan="2">Accept change in function: convertible space for bedroom on ground floor.</td><td>P</td></tr>
<tr><td colspan="3">Connection</td><td>X</td></tr>
<tr><td rowspan="2">Furniture</td><td colspan="2">Accept additional furniture: bedroom and bathroom.</td><td rowspan="2">P</td></tr>
<tr><td colspan="2">Accept another way of furnishing: double bedroom to be furnished with two single beds.</td></tr>
</table>

✓: Achieved **P**: Partly achieved **X**: Not achieved

Table:5.7 Possibilities for flexibility in the plan through HVNS. Source: the researcher.

5.5.5 Flexibility in construction through HVN standards

The main advice in HVN standards regarding flexibility in construction is contained in criterion 6.2.1 and relates to minimising the use of loadbearing internal partitions within the plan to allow future adaptations. This would allow the internal partitions to be removed in order to create clear space across the width of the plan. Other possibilities for flexibility in construction can be seen through criteria 6.2.2 and 14.2.2 that call, respectively, for the first floor structure to be able accept future openings and the bathroom wall structures to be able to accept additional load for future fixtures installation (see table 5.8).

<table>
<tr><th colspan="2">Indicators</th><th>Evaluation</th></tr>
<tr><td rowspan="2">Structure</td><td>Ceiling structure for bathroom, toilet and bedroom to accept additional load for future hoist.</td><td rowspan="2">P</td></tr>
<tr><td>Floor structure to accept creation of future opening for lift.</td></tr>
<tr><td rowspan="2">Internal partitions</td><td>Wall structures in bathroom and toilet to support additional fixtures.</td><td rowspan="2">P</td></tr>
<tr><td>Minimise the use of internal loadbearing partitions.</td></tr>
<tr><td colspan="2">External walls</td><td>X</td></tr>
<tr><td colspan="2">Foundations</td><td>X</td></tr>
<tr><td colspan="2">Roof</td><td>X</td></tr>
</table>

✓: Achieved **P**: Partly achieved **X**: Not achieved

Table:5.8 Possibilities for flexibility in construction through HVNS. Source: the researcher.

5.5.6 Flexibility in services through HVN standards

HVN standards promote flexibility in services mainly through criterion 18.1.2 that calls for design of the wiring services to accept future change through providing extra space behind "skirting boards". This would give the horizontal wiring runs flexibility in terms of accommodating future technologies as required (see table 5.9).

Category	Indicators		Evaluation
Pipes and wires	Horizontal runs	Pipes	X
		Wires: over capacity of the distribution systems to accept future technologies.	**P**
Appliances	Heating and cooling		X
	Lighting		X
	Outlets		X

P: Partly achieved **X**: Not achieved

Table5.9: Possibilities for flexibility in services through HVNS. Source: the researcher.

5.5.7 Flexibility in use through HVN standards

The flexible design solutions of HVN standards enable the plan to be flexible in use in a number of ways. First, the standards increase the scope of accessibility in the plan through the possibility for installing future lifts to allow the elderly with less physical ability or wheelchair users to access the upper storey of their dwelling. Second, the standards call for preparation of the ground floor for independent living in case household members are unable to access other storeys, as well as for accommodation of visiting relatives through providing a future bed space, WC and bathroom with shower. Third, the standards allow response to dexterity needs of elderly or disabled household members through requiring that wall construction in the WC and bathroom is suitable for future secure fixing of grab and support rails. Fourth, the standards create opportunity for flexibility in use through accommodation of different needs of the household by furnishing a double bedroom in another way (two single beds). Finally, the suggested ability of services to accept future wiring needs gives the dwelling flexibility to accommodate changes in the household's technical needs.

Consequently, HVN standards provide flexible design solutions that allow the plan to have a scope of flexibility in use in terms of households' changing demographic characteristics and changing technical needs according to the research analytical framework in Chapter 3, section 3.5.

5.5.8 User empowerment through HVN standards

HVN standards offer flexible design solutions that pass on to the users some control over their dwellings. This can be seen through standards that enable the user to make simple adaptations to their dwellings to meet their future needs in terms of access, social and use after occupancy. Similarly, to LTH standards, these standards limit the scope of user empowerment in their dwellings due to their determinate solutions for change, which treat users as operators of architectural equipment.

5.5.9 Conclusion

In HVN standards flexibility in design is limited to a few architectural and technical aspects of the plan, construction and services that allow some adaptations to be made after occupancy. These standards provide determinate solutions for change that reduce the scope for user's empowerment to adapt their dwelling based on their own terms. These standards only consider the particular social needs of the elderly and disabled in terms of access, use and social needs, while neglecting to think about and respond to a broader social context. Some of these criteria have become mandatory requirements through their adoption as technical standards. Overall, these HVN standards for general dwellings offer certain scope for flexibility, but the opportunities for flexibility at the same time impose certain limitations.

5.6 Final conclusion

In both contexts, England and Scotland, planning policy does little to promote flexibility in housing design at a strategic level. Whilst in Scotland there is more reference to flexibility, as in England such references are confined to the mixed-use approach to provide different choices pre-occupancy, rather than considering the potential of policy to underpin implementation of change post-occupancy as a determinant of a supportive environment for flexible housing. Moreover, there is little in terms of guidance or regulation on what the research identifies as flexible design criteria and much of what is contained in LTH provision is now mandatory in English building regulations.

Chapter 6: The UK case studies

6.1 Introduction

This chapter analyses the selected case studies of flexible housing in the UK, which includes the Whole Life House project in Scotland (Inverness) and Tattenhoe Park development in England (Milton Keynes). This addresses objective 3 of the research: to analyse selected flexible housing projects in the UK in order to explore the motivations, how policy could affect practice and the opportunities and constraints of the flexible design approaches used in these projects. This also contributes to achieving the main research aim, which seeks to extract lessons about flexible housing experiences in terms of policy and practice. The analysis of flexibility in the projects' design is undertaken according to the research analytical framework and the evaluation criteria in order to explore the possibilities and limitations of these approaches in delivering a flexible design.

6.2 The Whole Life House project, Inverness, Scotland, UK

6.2.1 Background of the Whole Life House project (WLH)

The WLH project was built as part of Scotland's Housing Expo, which is located on the southern edge of Inverness, Scotland (see figure 6.1). Scotland's Housing Expo is a diverse set of innovative and exemplary solutions embodied in 52 building designs chosen from an architectural competition. The project was completed in July 2010 and won the House of the Year prize at the Scottish Housing Awards 2011.

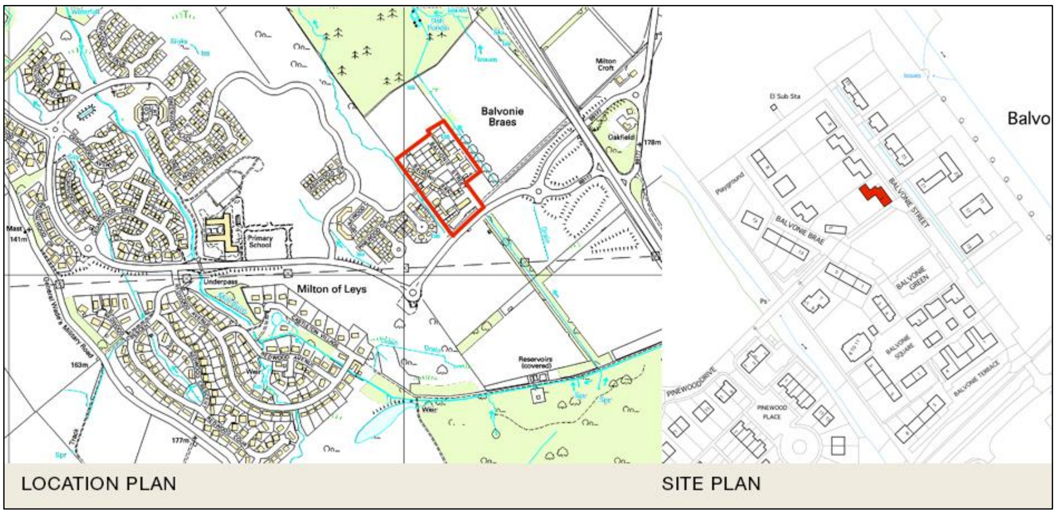


Figure 6.1: The site plan forHousing Expo including the location of the WLH project. Source: Brennan and Wilson, (2010)

The project was designed by Brennan and Wilson Architects and it was influenced by the architects' interest in how design can provide adaptable solutions to complex styles of living and working. The Whole Life House project was developed by the Highland Housing Alliance (HHA), the owner of the project. The HHA is a unique development company owned by five housing associations working in the Highlands, as well as two housing trusts and the Highland Council. Its key responsibility in this project included building the architectural design and delivering it to customers. It engaged in this project after the design had already been completed and the design specifications of this house were then given to the company. Therefore, there was no input from the developer in what they wished to see. As the chief executive of HHA put it: "the house chose us and we did not choose the house because the design was already there" (interview no. 3).

The project consists of a single detached house with an annexe attached to the main body through a shared entrance. The annexe's design incorporated concepts of flexibility and adaptability to allow a number of different layouts to be used for multiple purposes, working with the life cycle of a household (see figure 6.2).

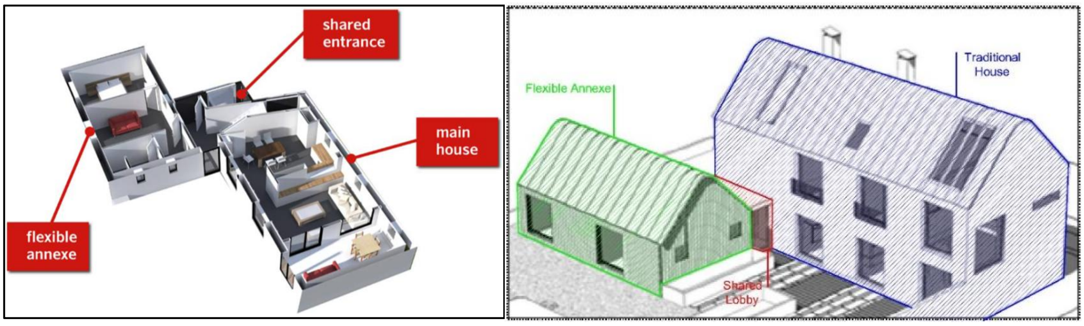


Figure 6.2: The perspective and section of the WLH project. Source: Brennan and Wilson, (2010), adapted by the researcher.

6.2.2 Planning policy and the design for flexibility in the WLH

Since this project is located in Inverness, where the Highland Council is the relevant local authority, the research undertook a review of this local authority's housing policy to discover whether the policy context can potentially support the provision of flexible housing.

According to the interview with an area manager and an architect from the Highland Council, the council seeks to promote adaptable housing wherever possible through demanding new affordable housing design that complies with the 'Housing for Varying Needs' requirements (interview no. 2). Through policy 32 – Affordable Housing – the local development plan of the Highland Council clearly requires the delivery of affordable housing in no less than 25% of builds, but makes no reference to Housing for Varying Needs' requirements (The Highland Council, 2001, 2012). Nonetheless, the policy does draw attention to supplementary guidance on affordable housing, which can be consulted in the delivery of affordable housing. The guidance is intended to expand on the policy or provide further details with respect to the Affordable Housing Policy. In this regard, the guidance refers to the need to build an agreed number, type and mix of affordable housing units on site to Housing for Varying Needs standards as issued by the Housing and Regeneration Division of the Scottish Government (The Highland Council, 2008).

Housing for Varying Needs, as explained in section 5.4.1, is a government-endorsed requirement for housing that can accept adaptations from the outset, which seeks to address particular scenarios of households' changing needs in terms of people growing old at home or having limited abilities. Therefore, in its housing policy the local plan goes no further than the government requirements for flexible housing, which only stipulate incorporation of some affordable housing in new developments.

According to the interviews with the architects, there was nothing in the local or national policy context to drive flexibility in the design strategy for this project (interview no. 1). The only relevant information in terms of this project was the statistical indicators in *Reason to Move* and *Housing Standards for Scotland,* published by the Scottish Government in 2006 and 2008 respectively (see section 6.2.3). Moreover, the policy context had no influence on this project, as the design emerged as the result of a competition.

6.2.3 Motivation for flexibility in the design of the WLH project

According to the interview with the architects, adaptability was identified as a theme to pursue in the WLH project because the competition was looking for new ideas in housing (interview no 1). Another key motivation for incorporating flexibility in the design of this project was to achieve social and economic sustainability in housing; as they put it: "the challenges to make housing more sustainable through designing in adaptability and flexibility from the outset" (Brennan, J. and Brennan & Wilson Architects, 2010, p. 21). This intention developed from the architects' interest in affairs relevant to "adaptability", both in research and practice and particularly in rural areas. The architects viewed this initiative for flexible design as an opportunity to incorporate "concepts that are quite difficult to define, such as architectural quality", and at the same time to permit adaptations over time (Brennan, J. and Brennan & Wilson Architects, 2010, p. 22).

Another key motivation for the adoption of flexibility in this project is the architects' consideration of related statistical indicators. The statistical data generally showed that the majority of suburban housing stock being constructed in Scotland is not fit for purpose with regard to anticipating household change. One of the statistical indicators obtained from *Reasons to Move* (published by the Scottish government) revealed that 43% of households have moved or considered moving house due to their current dwellings not meeting their changing needs and desires ((Brennan, J. and Brennan & Wilson Architects, 2010, p. 22). Another statistical indicator noted by the architects showed that "three to four-bedroom family housing directly addresses only 7% of households in Scotland" (Brennan, J. and Brennan & Wilson Architects, 2010, p. 22). The architects also drew attention to another statistical indicator obtained from recent research, which showed that "2% of 18-34 year olds live with their parents, often out of necessity rather than choice" (Brennan, J. and Brennan & Wilson Architects, 2010, p. 22).

Despite the architects' use of statistical indicators, which highlighted some households' changing needs in this context, their flexible design did not focus on any particular group of households' changing needs, as they consider that: "all buildings are predictions and all predictions are wrong" (Brennan, J. and Brennan & Wilson Architects, 2010, p. 22). In this respect, the architects indicate that "because in a lightly regulated housing market there are very few barriers to acquisition except financial means, therefore, prediction is difficult" (Interview no.1). Therefore, the actual motivations for flexible housing in terms of households' changing needs lie in the broader social needs of the household. Since the architects provided some scenarios of use that can be accommodated by the flexible design, such as large families, young adults at home, elderly relatives and working from home, the research adopts these scenarios to discover the changing needs and how they may have driven the flexible design in this project. Different changing household needs were considered, such as families who might need to accommodate elderly relatives, people who might need space to work from home, growth in family size, and families who might need to accommodate young adults (Brennan, J. and Brennan & Wilson Architects, 2010). According to the findings in Chapter 2, these scenarios can be related to changes in household resources and sub-resources of the household (see table 6.1).

Household need	Sub-source of the household need	Main-source of the household need
Home-office	Household income	Economic
Large family	Household structure	Social
Accommodating an elderly relative	Household relation with relatives	Social
Accommodating a young adult	Household economic power	Economic

Table 6.1: Motivations for flexible design of the WLH in terms of people's changing needs. Source: the researcher

From the table above, it can be concluded that the architects' motivation to deliver flexible design in this project was primarily to response to social and economic household changing needs.

6.2.4 Flexibility in the plan

In the design of the project, flexibility was incorporated through adding a flexible annexe to the traditional part of the building. Therefore, the analysis of flexibility in this project focuses on the design of this annexe and its impact on the main body of the building, to discover the different possibilities and limitations regarding flexibility in the plan.

A- Building

As explained above in the introduction, the WLH project is based on single detached houses with an annexe. The plan of the house consists of two parts: the first is the main body of the building, which forms the core dwelling and has two storeys; the second is a partly attached annexe block of one storey. The two parts are connected via a shared entrance and lobby (see figure 6.3).

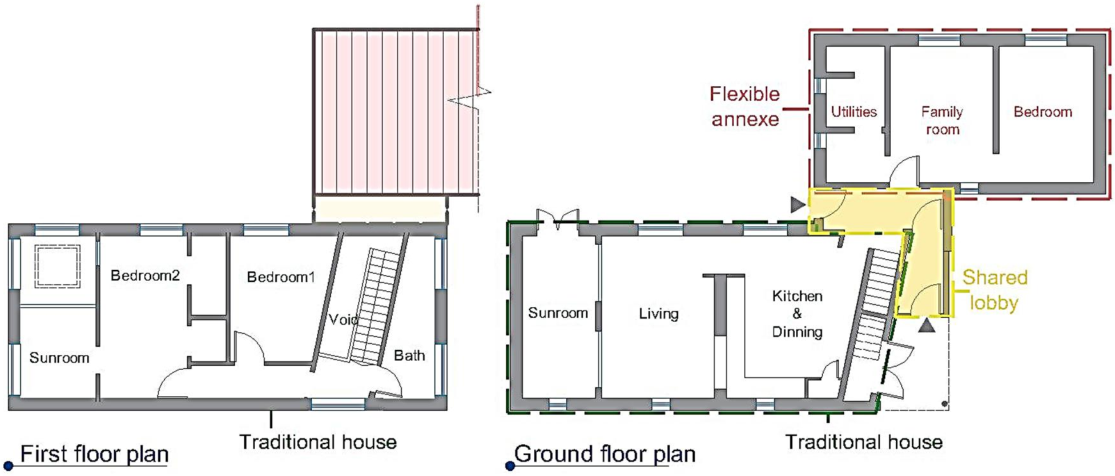


Figure: 6.3: The original layouts of the WLH project. Source: Brennan and Wilson, (2010), re-drawn and adapted by the researcher

1- Flexibility in unit mix

The plans show the possibility of separating the annexe from the main body of the house to function as an independent unit if necessary. To facilitate this, the architects considered a separate services space in the design of the annexe and developed the shared entrances to facilitate independent access to the annexe (see figure 6.4). Therefore, the plan of the house is seen to accept changes in a number of units, which is one of the flexibility requirements at building level according to the analytical framework in Chapter 3, section 3.2.1 (see table 3.1).

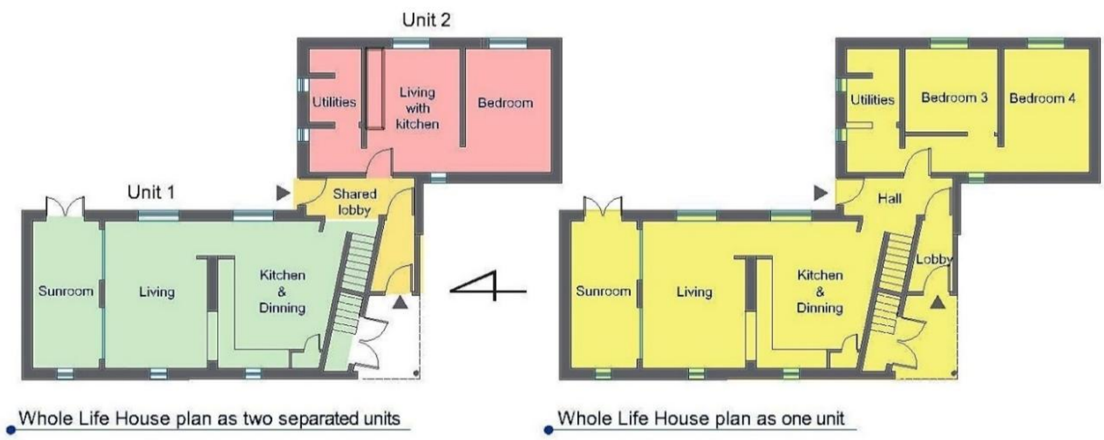


Figure 6.4: The different unit mix scenarios of the WLH. Source: Brennan and Wilson, (2010), re-drawn and adapted by the researcher.

2- Flexibility in building use

The plan shows that the annexe has potential to be used as independent space for non-residential purposes such as to provide an office or workspace suitable to accommodate employees. This can be achieved through the ability of the annexe space to be converted into a large open space by removing the lightweight partition within the space and to be functioned as independent part in terms of access and services. The design of the shared entrance can be seen to facilitate the ability of the building block to accept a mix in use. In this respect, the location of this entrance between the two different parts of the building allows segregation of the annexe from the rest of the house so it can be accessed from the central hall without causing disturbance to the other part. Moreover, the multiple access points to the hall from two different sides mean that the annexe can potentially be entered independently from one of these access points, which might be important when converting the space into non-residential use. In addition, the size and proportions of the openings (windows) provide ample light for non-residential occupation (see figure 6.5). Therefore, the design can be considered as having flexibility in building use as the its envelope can accommodate mixed use.

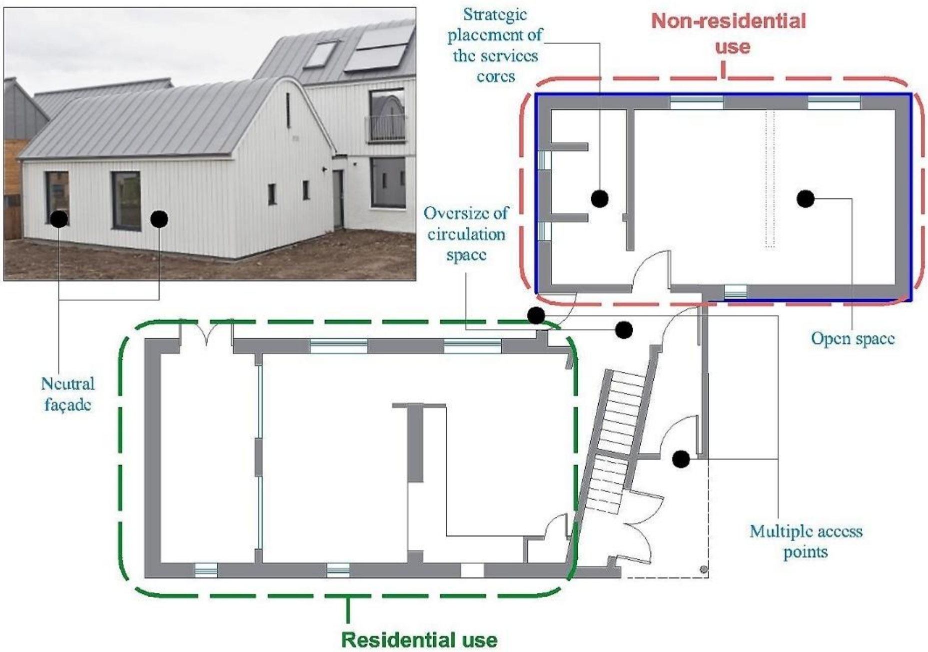


Figure 6.5: Flexibility in building use of the WLH. Source: Brennan and Wilson, (2010), re-drawn and adapted by the researcher.

B- Unit

1- Flexibility in size

The house as a whole was delivered with an internal floor area of 165m^2. As the annexe can be separated from the main body of the building, the size of the plan can potentially be decreased to around 100 m2 (see figure 6.4). This possibility derives from the location of the shared hall in order to facilitate an independent access to each part of the plan and the provision of two separated services spaces in the plan that can serve each building part independently after division. However, the plan does not allow for the project to grow in size as the annexe cannot accept addition in the future. This can be attributed to the conventional method of timber construction that depends on loadbearing external walls to transmit the load (see section 6.2.5). Therefore, regarding flexibility in size, the plan can be considered as having a design limitation in terms of growth according to the analytical framework of this research in Chapter 3, section 3.2.2 (see table 3.1).

2- Flexibility in layout arrangement

Functional flexibility

The plan shows that the annexe spaces were designed with appropriate dimensions and proportions to allow different functions to take place over time. The simple and clear form of the room layouts and the independent ways of accessing the spaces enhance its ability to be interpreted and occupied in different ways according to the users' own terms. This enables the plan to accept different layout arrangements through non-physical adaptations, and thus gives it functional flexibility (see figure 6.6). The architects clearly indicated that in the design the annexe's spaces were deliberately unclearly defined to allow different occupations over time. Therefore, this opportunity for flexibility in the plan derives from the architects' intention to design in functional flexibility through allowing adaptations without physical change.

Figure 6.6 : Functional flexibility of the WLH. Source: the researcher.

Spatial flexibility

The design of the annexe also enables physical change of layout configurations to take place over time. This is made possible by considerable location of the wet spaces on one side of the annexe, thereby providing open space that can be divided in different ways over time. Additionally, in this regard, the internal walls can be moved around easily. Here the architects built flexibility into the wall structure to allow easy movement of the partitions, rather than considering architectural techniques such as sliding or movable walls, as is discussed in detail in the next section (flexibility in construction). In addition, the location of the access point to the annexe from the common part of the wall between the two building blocks allows the different annexe façades to provide different sources of light that can serve different ways of internal partitioning (see figure 6.7). Therefore, since the annexe fulfils all the principles of spatial flexibility in terms of the house accommodating different layout forms, the plan can thus be considered flexible in internal configuration according to the research analytical framework in Chapter 3, section 3.2.2. The architects presented some proposals for internal re-configuration through their scenarios for the annexe, such as adding a partition to create a new bedroom, so the plan can be re-configured as a four-bedroom house, or removing the internal partition so the plan can be re-arranged as a two-bedroom house with a granny flat (see figure 6.5).

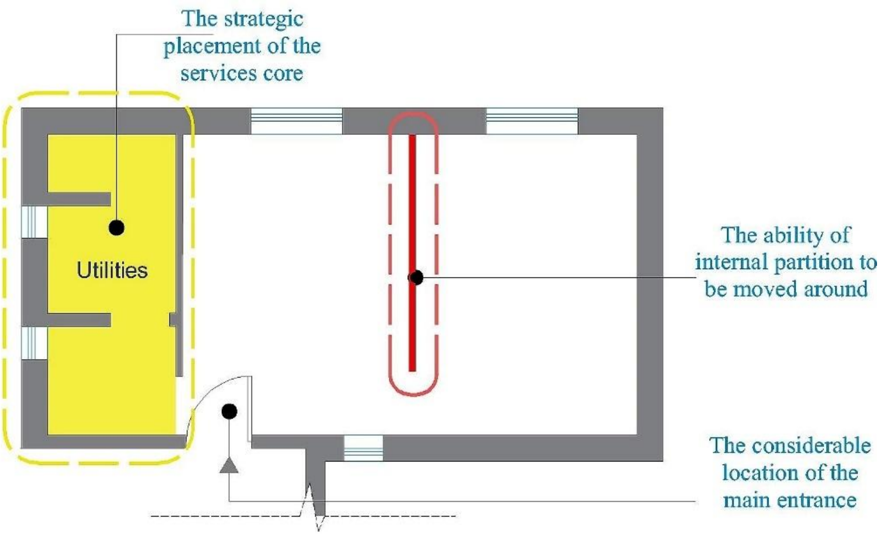


Figure 6.7: Spatial flexibility of the WLH. Source: the researcher

Internal circulation

The internal circulation of the WLH is the vertical access (stairs) in the traditional part of the house and the horizontal access (shared entrance and lobby). In terms of vertical circulation, it would be possible in future to provide a stair lift as the house has a straight flight staircase with enough space for landings at the top and bottom, and good dimensions, which is a compulsory requirement in the design regulations according to the architects (see figure 6.8). On the other hand, the plan shows that the dimensions of the main entrance and lobby spaces are sufficient to accommodate additional future uses, such as using the lobby for storage. In addition, these dimensions mean the space can also be used by wheelchair users, which is again a mandatory requirement. Therefore, flexibility according to the analytical framework in internal circulation is achieved in this project, deriving from compliance with design regulations and the architects' initiative.

Figure 6.8: The internal circulation of the WLH project. Source: Brennan and Wilson, (2010).

C- Room

1- Flexibility in function

As explained under the title of unit-functional flexibility, each room of the annexe has a simple form and suitable size that allows it to accept multiple occupations. In addition, the windows in each room are sufficiently large to provide ample natural light for different functions (see figure 6.6). Therefore, each room of the annexe can be considered as having flexibility in terms of function.

2- Flexibility in connection

The plan shows that each room in the annexe can potentially be connected to another when needed. The flexible structure of the internal partition between the two rooms of the annexe means that it can be removed or subdivided easily (see section 6.2.5), which enables adjacent rooms to be connected either through creation of a new door for intermittent connection or providing a large opening by removing part or the whole of a wall for permanent connection (see figure 6.7). Therefore, each room has flexibility in connection according to the research analytical framework in Chapter 3, section 3.2.3.

3- Flexibility in furniture

As mentioned above, the good dimensions and proportions and simple form of the room layouts allow each room to be furnished in different ways. In addition, the rooms were designed with no fixed furniture and the architects located the heating system within the floor (see section 6.2.6), which also increased the scope for different furniture arrangements. The plan also shows that the entry door of one of the rooms was placed very close to the side wall, freeing the opposite wall area for placement of furniture. Provision of individual windows of average size avoids restricting the way in which the room can be furnished. Therefore, the room design can be considered as having flexibility in furniture according to the research framework in Chapter 3, section 3.2.3. This result is clearly reflected in the scenarios of use suggested by the architects, which showed the ability of the rooms to accept different uses and furniture layouts.

Conclusion

The analysis has shown that the design of the WLH generally incorporated different possibilities for flexibility in the plan in terms of building, units and rooms, which can be attributed to certain key factors: first, the architects' design approach considers incorporation of flexible space (annexe), which is indeterminate in use, alongside another building block that it is traditional in design, which provides breadth and flexibility of space. Therefore, flexibility in this project relies primarily on the indeterminacy achieved through provision of generous space and design intelligence rather than flexible architectural features such as sliding, movable or foldable walls or the use of furniture. The second and more minor factor is that design regulation requirements enhance the scope of flexibility in the plan in terms of circulation. However, there is a limitation on the flexibility of the plan in terms of its ability to grow in size. Here it can be argued that capacity for growth in the size of the plan is not particularly important as the current house size is large enough to accommodate the needs of a large family, which is among the key targets of this flexible design.

Table 6.2 summarise the different possibilities and limitations for flexibility in plan of the Whole Life House project.

<table>
<tr><th>Category</th><th>Indicators</th><th colspan="4">Criteria</th><th>Evaluation</th></tr>
<tr><td rowspan="6">Building</td><td>Unit mix</td><td colspan="2">Can accept different number of units</td><td colspan="2">The building can accept division of some units into two small independent units.</td><td>✓</td></tr>
<tr><td rowspan="5">Use</td><td colspan="2" rowspan="5">Can accept mixed use</td><td colspan="2">Building layout is an indeterminate large open space.</td><td>✓</td></tr>
<tr><td colspan="2">Oversizing of circulation space.</td><td>✓</td></tr>
<tr><td colspan="2">Strategic placement of the services cores.</td><td>✓</td></tr>
<tr><td colspan="2">Neutral façade in terms of opening and fashion.</td><td>✓</td></tr>
<tr><td colspan="2">Multiple access points.</td><td>✓</td></tr>
<tr><td rowspan="7">Unit</td><td rowspan="4">Size</td><td rowspan="4">Can accept change in size</td><td rowspan="3">Division</td><td rowspan="2">Design</td><td>Independent access to the divided units.</td><td>✓</td></tr>
<tr><td>Independent services spaces in each unit.</td><td>✓</td></tr>
<tr><td>Construction and services</td><td>Independent services systems for the divided units.</td><td>✓</td></tr>
<tr><td>Growth</td><td colspan="2"></td><td>X</td></tr>
<tr><td rowspan="3">Layout arrangement</td><td colspan="2" rowspan="3">Functional flexibility</td><td colspan="2">Layout spaces of adequate size.</td><td>✓</td></tr>
<tr><td colspan="2">Simple forms of layout spaces.</td><td>✓</td></tr>
<tr><td colspan="2">Independent access of the layout spaces.</td><td>✓</td></tr>
</table>

		Spatial flexibility	Strategic placement of the services core in the layout to allow different configuration forms to be developed.		✓
			The internal partitions can be moved around easily and in different ways.		✓
			Considerable location of the main entrance to facilitate different layout configurations.		✓
		Internal circulation	Horizontal	Appropriate size of access spaces to permit an additional use.	✓
				Suitable dimensions of circulation spaces for use by different groups of people.	✓
			Vertical	Possibility of adding a lift as an additional vertical access means.	✓
Room	**Function**	Can accept change in function	Room is of suitable size and simple form.		✓
			Ample light to fit different functions.		✓
	Connection	Can accept connection with other rooms	Potential to provide new connections in the future.		✓
	Furniture	Can accept various forms of furniture arrangement	Room has adequate dimensions and proportions.		✓
			No fixed built in furniture or heating elements.		✓
			Considerable location of the door.		✓
			Appropriate for size and number of windows in the room.		✓

Table 6.2: Evaluation of flexibility in plan in the Whole Life House project. Source: The researcher.

6.2.5 Flexibility in construction

Structure

The WLH is of conventional timber frame construction and the structure consists of a timber kit system forming the external walls of the house and an exposed glulam beam floor system (Brennan & Wilson Architects, 2010). This system works on the principle of transmitting the load across the external walls; therefore, as the internal walls are non-loadbearing, the structure can be separated from the internal partitions of the plan. In addition, the services systems are distributed across an independent layer within the external walls (see section 6.2.6), which means that the main structure can be also separated from the building services. In addition, the plan shows that there are clear spans across the width of the annexe with dimensions of 4.5m, which provide open space between the structural elements (see figure 6.9). Therefore, the design of the annexe structure takes account of different principles of flexible structure according to the analytical framework in Chapter 3, section 3.3.1.

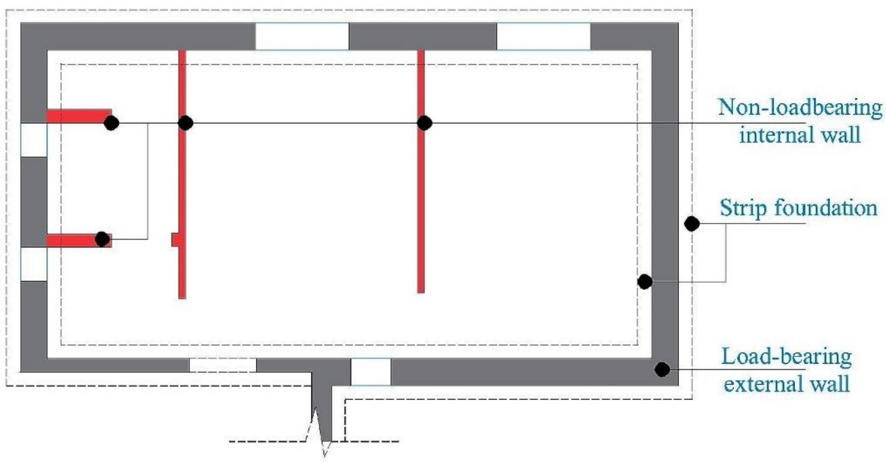


Figure 6.9: The main structure of the WLH project. Source: the researcher.

Foundations

The plan shows that while a strip foundation system follows the line of the loadbearing external walls, there are no foundations under the internal wall of the annexe (see figure 6.9). The ground floor consists of150mm hardcore, 150mm dense flooring grade mineral fibre insulation, 125mm concrete site slab with power floated finish c/w, heating coils tied to reinforcement mesh and Caithness stone slabs as floor finish (Brennan & Wilson Architects, 2010). This ground floor design and the use of lightweight stud walls removes the need for the structure to have foundations under the internal wall or elsewhere within the floor. This in turn allows the internal partition to be altered and placed anywhere within the annexe space. On the other hand, no provision is made for installing oversized foundations that would allow the building to accept an additional floor. Therefore, the foundation construction only supports internal change rather than any future addition, as the plan was not designed to take upward extension at a later date.

Roof

The roof is constructed from timber/ply lightweight attic trusses, partly filling the roof space, and finished with zinc metal sheeting (Brennan & Wilson Architects, 2010) (see figure 6.10). Therefore, this form of roof construction cannot accept upward extension into the roof space, and thus the roof cannot be considered as having flexibility. The adopted design did not include provision for upward extension into the pitched roof space. Moreover, the onerous regulations on stair enclosure and fire protection relating to houses of three storeys meant that the architects focused on protecting means of escape (interview no.1).

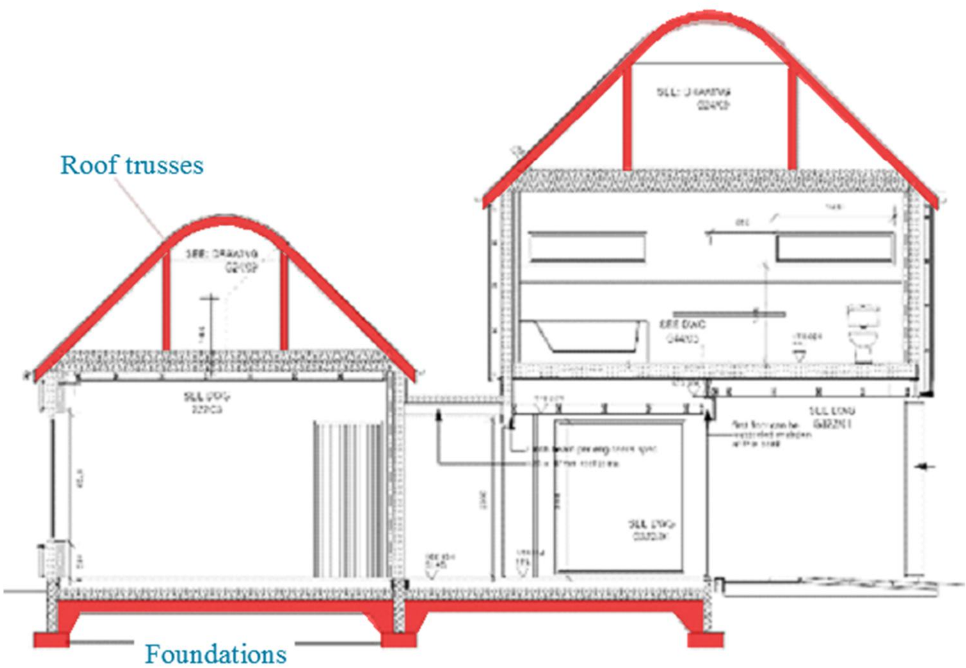


Figure 6.10: Section of the WLH project showing the roof and foundation construction. Source: Brennan and Wilson, (2010), edited by the researcher.

Internal walls

The internal walls were generally designed as non-loadbearing stud partitions. However, the architects highlighted also that the internal walls of the annexe, in particular, had no services located within, and the floor under the internal wall was deliberately continued to allow for easy dismantling at a later date (interview no. 1). Here the architects clearly used their initiative to adapt the conventional form of construction of internal stud walls in order to incorporate flexible design principles. It is also clear that the architects worked within the mentalities of the building industry, rather than using a specialist form of construction to achieve this, which complies with their principle of adopting a relaxed attitude toward technologies. The use of internal partitions that can support change can be considered as a flexible construction method according to the research framework in Chapter 3, section 3.3.

External walls

The external walls are generally timber stud loadbearing walls, and thus they have no ability to be separated from the main structure. Conversely, the plans show that the walls were developed using a layering system, and four main layers can be seen. In terms of the external layer, two types of cladding were used: rendered concrete block and timber Scottish larch. The next layer is timber 140mm studs filled with blown cellulose insulation, then a 75mm battened service layer with sheep's wool insulation, and finally plasterboard internal finish (Brennan & Wilson Architects, 2010). As these layers make it possible to replace some parts without affecting the rest, this form of construction enables some degree of change. However, this system mainly benefits the maintenance process rather than making the external walls flexible in terms of allowing future openings, changing infill elements such as windows and doors, and ease of dismantling, as addressed in the research framework.

To sum up, the structural systems of the project include some possibilities for flexibility and also some limitations on potential change. The use of a conventional timber frame, based on the architects' initiative but also following the Housing Expo recommendation for general timber construction use, offers a key opportunity for developing a structure that can cope with change, as it can be engineered to shape and its strength enables it to span large open spaces. Another key advantage of the construction method is that the internal partition (stud wall) has the ability to be developed to accept change; the architects took the initiative in adapting these to be demountable walls without employing specialist forms of construction. The architects also showed initiative in terms of the design of the foundations and ground floor construction to facilitate their approach in terms of internal change. However, this led to some limitations in terms of the construction of external walls, as the system relies on spreading the load across the external wall studs, which means such elements cannot be altered in the future. In terms of roof construction, the limitations derive largely from the design not considering future vertical extension into the roof space due to the onerousness of the relevant regulations.

Table 6.3 summarise the different possibilities and limitations for flexibility in construction of the Whole Life House project.

Indicators	Criteria		Evaluation
Structure	Ability of the structure to allow different layout forms	The structure's ability to be separated from the infill parts.	✓
		The structure's ability to generate open clear space between the structural elements.	✓
		Simplicity and legibility.	✓
External walls	Ability of external walls to accept change	Ability to disconnect the external walls from the main structure and services of the building.	X
		Possibility for the external walls to accept future openings and change in the infill elements.	X
		External walls can be dismantled.	X
		Simplicity and legibility.	X
Internal partitions	Ability of internal partitions to accept change	Non-load bearing construction of the wall.	✓
		No services located within the partitions.	✓
		Can be disassembled.	✓
		Potential to create openings.	✓
		Simplicity and legibility.	✓
Foundations	Ability of the foundations to accommodate future change	Overcapacity of foundations to accept additional floors.	X
		The foundation system allows variations in the layout configuration on the ground floor.	✓
Roof	Roof can accept future extension	Use of open roof structure that allows the roof to be occupied in the future.	X
		Pre-cut joints for future provision of roof lights.	X
		Pre-framing of the floor for future extension of the staircase.	X
		Simplicity and legibility.	X

Table 6.3: Evaluation of flexibility in construction in the Whole Life House project. Source: The researcher.

6.2.6 Flexibility in services

1- Pipes and wires

In this project, the incorporated services systems include heating, plumbing, electrical, gas and information systems. Since the annexe has one storey, the analysis focuses on the horizontal distribution of the services.

Horizontal distribution

According to the interview with the architects, the method of chasing conduits in the floor with plastic tubes is used for horizontal services runs in the flexible annexe, which allows wires to be put in and taken out easily (interview no. 1). A separate services cavity in the external walls was also considered, as explained in the previous section, to allow retrofitting without disturbing the external wall layers (Brennan & Wilson Architects, 2010). Here it is clear that the architects considered how to provide and distribute the wiring system with a view to how it might be changed in the future and how it might support future technologies; hence a dedicated layer for this system was adopted for relatively easy access and maintenance. Another aspect of the horizontal distribution is the considerable location of the services run to facilitate future adaptations. This can be seen through the avoidance of locating services such as electrical and information wires and water pipes within the internal partition to the annexe that is intended to be movable over time. Regarding the heating system, the building is heated with underfloor heating pipes laid in an insulated concrete slab and covered with Caithness stone slabs as floor finish (Brennan & Wilson Architects, 2010). It seems that in this case reaching services for maintenance or upgrading will be relatively difficult and may have additional labour implications. However, this method avoided the need to locate heating pipes within the internal partition.

2- Appliances

While the underfloor heating may present relative difficulties in terms of access, this system avoids the need for appliances that may pose obstacles to internal changes, such as a wet system of radiators. The architects similarly highlighted the benefit for flexibility of using such a system in the project, stating that “underfloor heating negates the need for radiators, and thus gives freedom in respect of room layout” (Brennan & Wilson Architects, 2010, p.25).

Regarding outlets such as sockets, TV, etc. and lighting elements, the architects pointed out that wherever possible they were not placed on elements that could be changed in the future, such as the annexe's lightweight internal partition. In addition, services controls such as sockets and switches were placed at heights of between 45cm and 120cm (interview no.1), which means that they can be used and accessed by people with limited physical abilities. Therefore, the location of the appliances generally was considered in a manner that does not inhibit future change, which is the key flexibility requirement in terms of appliances according to the research analytical framework in Chapter 3, section 3.4.1.

Consequently, the various advantages regarding flexibility in the design of services derive from the architects' willingness to provide what actually facilitates flexibility in a services system. In this respect, the architects adopted thoughtful design methods for services distribution, rather than a specific technology approach, which reflects the architects' generally relaxed attitude to space planning and technologies. On the other hand, while the chosen heating system has the advantage of offering sustainable and affordable choice and facilitates flexibility in terms of hiding heating elements under the floor, it has the limitation of restricting easy access in the future for change or adaptation, which is a key flexibility requirement in terms of services (see table 6.4).

<table>
<tr><th>Category</th><th colspan="2">Indicators</th><th>Criteria</th><th>Evaluation</th></tr>
<tr><td rowspan="7">Pipes and wires</td><td rowspan="7">Horizontal runs</td><td rowspan="3">Pipes</td><td>Disconnection of the pipes from the construction elements.</td><td>✓</td></tr>
<tr><td>Easy access to the pipes.</td><td>X</td></tr>
<tr><td>Considerable location of services to facilitate future adaptations.</td><td>✓</td></tr>
<tr><td rowspan="4">Wires</td><td>Disconnection of the wiring system from the construction elements.</td><td>✓</td></tr>
<tr><td>Easy access to the wiring system.</td><td>✓</td></tr>
<tr><td>Overcapacity of the distribution systems to accept future technologies.</td><td>✓</td></tr>
<tr><td>Considerable location of services to facilitate future adaptations.</td><td>✓</td></tr>
<tr><td rowspan="3">Appliances</td><td colspan="2">Heating and cooling</td><td>Location of the heating and cooling appliances and their controls in a manner that allows future change.</td><td>✓</td></tr>
<tr><td colspan="2">Lighting (switches and lights)</td><td>Location of the lighting appliances and their controls in a manner that allows future change.</td><td>✓</td></tr>
<tr><td colspan="2">Outlets (sockets, TV and phone)</td><td>Location of the outlets in a manner that allows future change.</td><td>✓</td></tr>
</table>

Table 6.4: Evaluation of flexibility in services of the Whole Life House project. Source: the researcher.

6.2.7 Flexibility in use

According to the architects' interviews, "how a family would choose to live is intentionally not predictive" in this project (interview no. 1). Therefore, the scenarios of use were not clearly defined by the architects, but left to the users' own choice. However, the architects provided some examples to clarify how the flexible design of this project could respond to people's changing needs over time. The research examines these scenarios and other potential for flexibility in use based on the analytical framework in Chapter 3, section 3.5, in order to discover the opportunities for flexibility in use provided through this design.

Flexibility to respond to changes in the household's demographic characteristics

Different changes in the household's demographic characteristics can be accommodated by the flexible design of the WLH. The architects suggested one such change scenario by utilising the flexible annexe to provide two extra bedrooms, which allows the house as a whole to accommodate a large family or an increase in the family number (see figure 6.11). In addition, the ability to provide more bedrooms can respond to other changes in household demographics, such as children of different gender growing up at home, which may require them to have separate sleeping spaces at a certain age. This project also responds to children's changing requirements as they grow up, such as by providing teenagers with independent space to respond to an increasing need for privacy and to pursue their individual activities or be with their friends. This can be achieved through the possibility to re-configure the annexe space and provide one or two independent spaces. Since the design can be divided into two parts (main house and annexe) as explained in section 6.2.4, the house can be seen as responding to changes in household size as it shrinks in the course of time. Therefore, the house has the flexibility to accept change in the household's size as it increases or decreases over time. Moreover, the house can be seen as sufficiently flexible to accommodate the requirements of people as they grow old at home or become less physically able. This is possible because the vertical circulation is sufficiently spacious to accept a future stair lift for use by older inhabitants in accessing the first floor, or the annexe can be converted into an en suite space with built-in shower at ground floor level to provide independent accessible space for wheelchair users or elderly household members who cannot access the first floor.

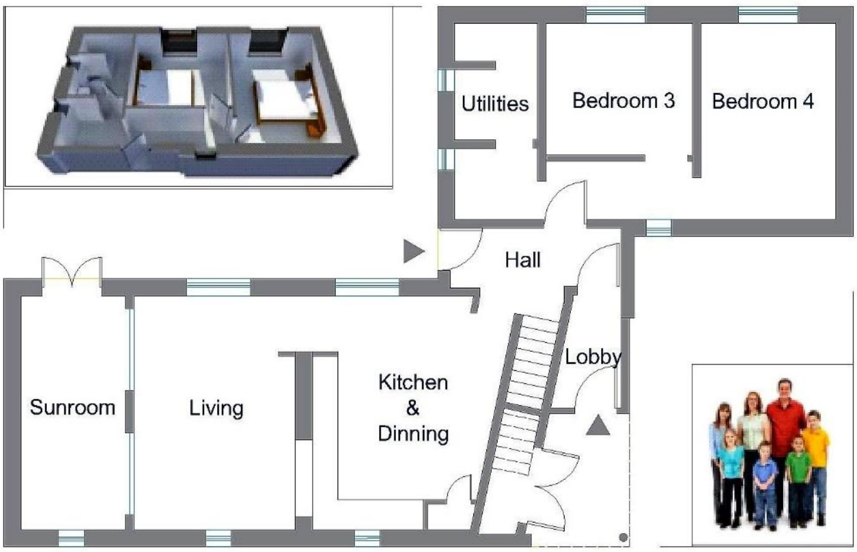


Figure 6.11: Large family scenario. Source: Brennan and Wilson, (2010), re-drawn and edited by the researcher.

Cultural flexibility

In this case, flexible design of a house refers to its ability to respond to differences and changes in the household's cultural need from their dwellings. One of the scenarios suggested by the architects is to convert the annexe into a granny flat in order to accommodate an elderly relative. The annexe space could be adapted to form a large single room with separate bathroom and kitchen and could be accessed independently from the shared entrance, thereby giving it the accessibility, independency and suitability to be used as a granny flat (see figure 6.12). In this regard, the flexible design can respond to the need emerging within the household's kinship pattern to accommodate an elderly relative in the dwelling, which according to this research represents a socio-cultural need within households (Chapter 2). Other scenarios of use can also be supported by the flexible design, such as the use of the annexe as a large family room to accommodate the household's need for a place to hold large social gatherings. This socio-cultural need can be associated to the household's pattern of extensive social links with, for instance, relatives, friends and neighbours. Moreover, through the ability to convert the annexe into a workspace, as explained above, the flexible design can respond to differences or change in the household's living patterns by accommodating household members who wish to work from home.

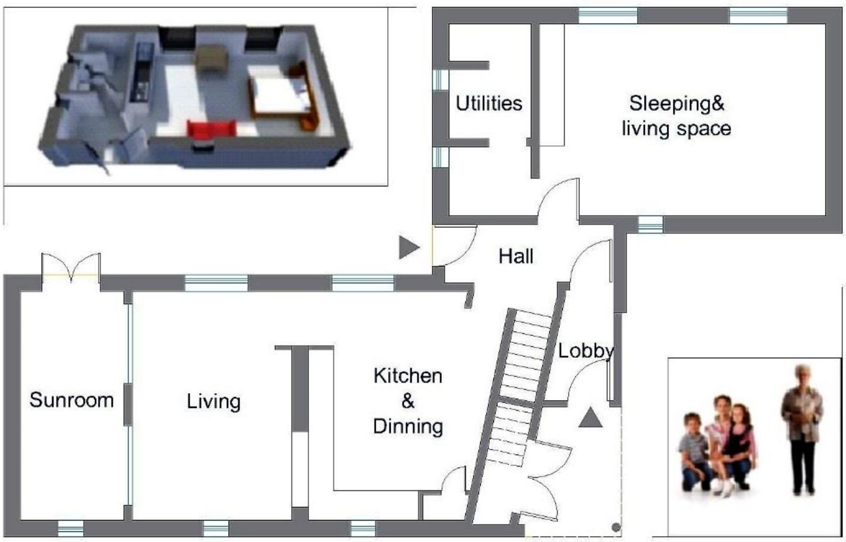


Figure 6.12: Elderly relative scenario. Source: Brennan and Wilson, (2010), re-drawn and edited by the researcher.

Economic flexibility

The capacity of the flexible design to respond to changes emerging from the household's economic circumstances is investigated here. The plan shows the ability of the annexe to be used as space for rent. The independent services space (shower, toilet and utilities) and shared entrance, which can allow people to come and go without disturbing the remainder of the home, are the key design aspects that make this space sufficiently flexible to be used for this purpose when needed. Therefore, the flexible design can be considered as accommodating change in household income, through employment of the annexe space as an income generator. The flexible design can also respond to a change in the household economic situation such as a change in employment status through use of the annexe as an office or workspace. The architects' design of the annexe to function as an independent accessible open space clearly allows for this scenario of use. In their publication, the architects suggest also that the house can respond to the household's economic circumstances through utilisation of the annexe wing as a small self-contained flat with a galley kitchen and a separate bedroom to accommodate a young adult who chooses to stay at home due to high rents and house purchase costs (see figure 6.13). All of these possibilities enable the house design to respond to variations in the household's economic situation, and thus reflect the design's economic flexibility.

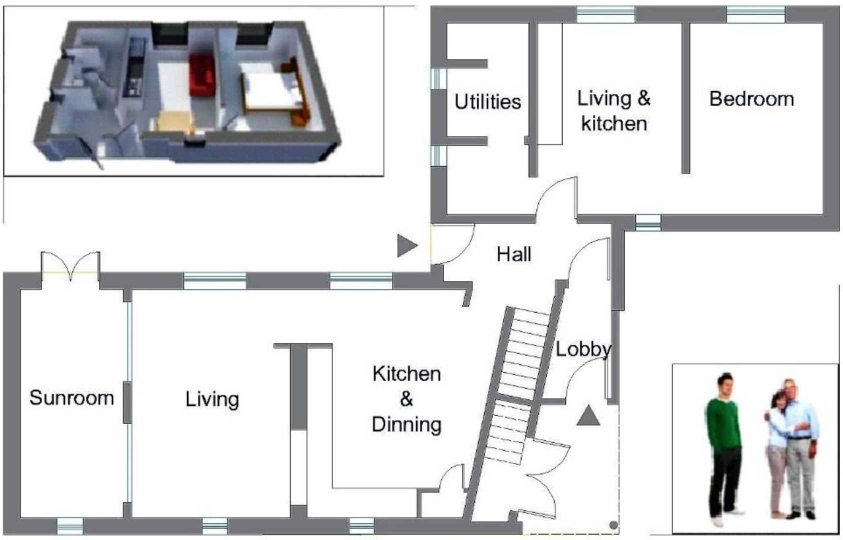


Figure 6.13: Young adult scenario. Source: Brennan and Wilson, (2010), re-drawn and edited by the researcher.

Technical flexibility

The flexible design of the house also takes into account technical issues that could arise over time. For example, the dedicated services layer attached to the external wall allows easy access to the services for upgrading and excess space for fitting additional technologies as required, as explained in section 6.2.6. This ability enables the design to accommodate changes in the household's technical needs in relation to their dwelling that could emerge from technological developments over time.

Table 6.5 summarises the different possibilities for flexibility in use and corresponding flexibility categories, which this flexible design can accommodate.

Demographic	Accept variation in household size as it grows or shrinks.
	Meet the requirements of children growing up at home.
	Meet children's gender determined requirements.
	Accommodate the requirements of people as they grow old at home or become less physically able.
Cultural	Accept a variety of living patterns (work from home scenario).
	Accept variety of kinship patterns (granny flat scenario).
	Respond to variation in social linkage patterns with friends and neighbours (large family room for social gathering in a large group).
Economic	Accommodate changes in the household's income (a space for rent scenario).
	Accommodate changes in household employment status (workspace scenario).
Technical	Accommodate new technologies as they are introduced.

Table 6.5: The different possibilities for flexibility in use and corresponding flexibility categories. Source: the researcher.

Consequently, as the table above clearly illustrates, the flexible design approach can achieve different dimensions of flexibility in use, and thus accommodate a wide range of social needs in the household over time. This can be attributed to the architects' generation of a flexible approach by borrowing ideas from soft flexibility, to provide a breadth of indeterminate large space that can be adapted according to the users' own terms. In addition, the independence of this space in terms of access and services enhances the ability of the design to support broader social uses.

6.2.8 User empowerment

From the flexible design of the project it can be seen that it empowers the users to occupy the house as they see fit and to make adaptations based on their own terms. This is possible because of the soft techniques in use and form employed by the architects to achieve flexibility in the design. In terms of use, the flexible design relies primarily on providing a breadth of space which allows a certain indeterminacy through providing spaces that are deliberately unclearly defined in their functions, so that the users are in full control of how they occupy them. In terms of form, the architects adopted a relaxed attitude towards technologies by providing an annexe with a simple form and clear span structure with non-loadbearing internal walls, which again allows the users to control how they fill and adapt the space. This reflects the architects' attitude of relinquishing of their presumed control to enable the users to adapt their dwelling, as they clearly suggested in their *The Whole Life House at Scotland's Housing Expo* publication: "the architects should not control how a house is to be occupied" (Ibid, 2010, p. 23).

6.2.9 Financial aspects

Cost

The interviews with the architects and the developer revealed contradictory views in terms of the impact of flexible design on the initial cost of the project. While the architects did not view the incorporation of flexible design intelligence as leading to an increase upfront costs, the developer considered that cost implications for this project arise from the requirement to build to a size that allows internal flexibility (interviews no. 1 and 3). The research focuses on the architects' perspective that the incorporation of flexibility in this project had little or no impact on initial cost, as no specialist technologies, which usually have additional cost implications, were used or developed to achieve flexibility in the design of the building. This is clearly illustrated by the fact that no differences in cost become apparent when comparing the WLH with a standard development of a similar size.

From the architects' perspective, the key advantage of the WLH design in economic terms lies in its ability to be adapted for different households' changing needs post-occupancy at marginal or no cost. The architects attributed this to the use of very standard design tools and techniques to create adaptations at scheme design level (interview no. 1). However, it is notable that little or no work was done on calculating the cost benefits of the flexible design in the long term. In this respect, the architects pointed out that it is "very difficult to measure value on basis of capital cost as long term savings are down to reductions in recurring costs" (interview no.1).

Market

According to the interview with the developer, the design of the project achieved high consumer satisfaction; consumers liked the fact that there was an annexe as a spare space, and its use was depicted differently by each of them based on their current desires or future needs. However, the size of the construction, which increased the house cost, limited their availability to people with less favourable economic circumstances, such as young households just starting out (interview no. 3). The developer drew attention to the fact that a household's typical income will increase throughout their life, while their need for space will go down eventually; therefore, the value of the WLH is not necessarily tied in with household income (interview no. 3). In this light, while flexibility in the design of this project achieved higher consumer satisfaction at the point of delivery, flexibility of delivery to people in different financial situations was restricted by the cost implications of the houses' size.

6.2.10 Conclusion

It is clear that the policy context in this project had no influence on flexibility practice, as the chosen design was the result of a competition regarding best practice for sustainable housing design. However, the competition's pursuit of new ideas in housing design, the architects' interest in addressing wider sustainable indicators such as adaptability in housing design, and statistical indicators revealing the failure of the housing stock to respond to people's different and changing needs were the key factors in bringing this initiative to the fore. It was notable that the final flexible design for this project was not wedded to particular changes in household needs as such prediction is difficult in this context due to acquisition being limited only by potential buyers' financial means; therefore, the motivation for implementing flexible design in terms of households' changing needs was to respond to wider social needs of the household in relation to their dwelling.

The analysis of flexibility in the design against the concepts of the research framework showed different possibilities and some limitations. It was clear that the architects' interest in employing ideas of soft flexibility, embedded physically through an annexe design left indistinct and vague both in character and technology, alongside some regulations requirements in terms of circulation led to the different possibilities for flexibility being incorporated in the plan at different levels and the ability of the design to be flexible in use in response to the wide social needs of the household. User empowerment is another key issue positively affected by the design's soft approach to flexibility as this delivered to potential users some control over their use of the house after occupation.

The analysis revealed that in conjunction with the architects' initiative the method of house construction delivered certain advantages regarding flexibility, as exhibited in the clear spans, foundation system and non-loadbearing and demountable internal walls. The disadvantages in relation to flexibility, on the other hand, were the construction method and architectural design approaches for the external walls and roof, together with the onerous regulations that restrict possibilities of flexibility. In terms of services provision, it was clear that the architects' initiative in challenging the common practices of the housing industry was the source of flexibility in the services distribution and services elements.

Financial assessment of the flexible design also manifested key opportunities regarding upfront cost, cost of adaptations and user satisfaction at the point of purchase. These possibilities derive from such as the adoption of a soft approach to flexibility that underpinned the relaxed attitude towards space planning and technology, and the consumers' positive reaction to the flexible design. However, in market terms, the design of the project a limited delivery to households with less favourable economic circumstances due to the building cost associated with the size of the houses.

6.3 Tattenhoe Park Development, Milton Keynes, England, UK

6.3.1 Background to the Tattenhoe Park Development

Tattenhoe Park is a strategic development site on the western edge of Milton Keynes, located approximately 6.5km from the town centre (see figure 6.14). It comprises 56.9 hectares of land, and the site is capable of accommodating an estimated 1310 new dwellings. The development as a whole was divided into six phases, with the size of the phases ranging from approximately 100 to a maximum of 280 dwellings. Every phase aims to accommodate a range of house types, from one-bed flats to large family dwellings, including 30% affordable housing, with up to 30% of all houses being super-flexible.

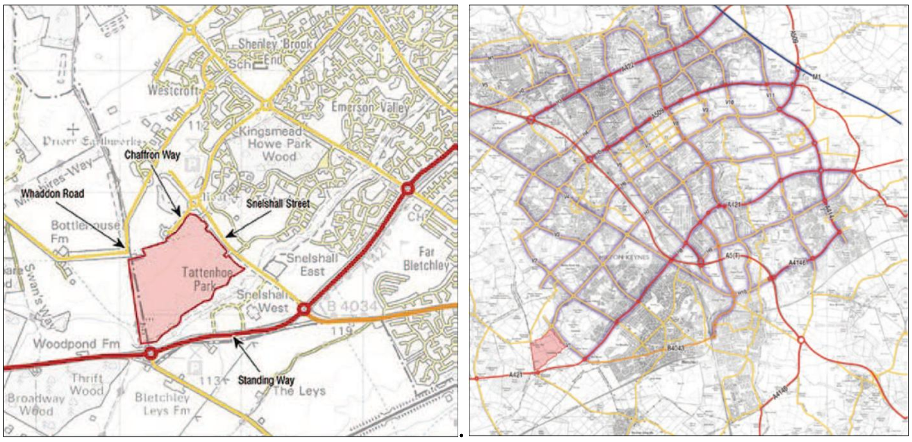


Figure 6.14: The location of Tattenhoe Park development. Source: MKP (2006, p.11, 25)

The first phase of this development, site 1, is the focus of the current research as its design has been completed. Tattenhoe Park site 1 encompasses the joint master plan of both Kingsmead South and Tattenhoe Park (see figure 6.15). The design proposal for this development phase was provision of 163 dwellings, 147 units located on the Tattenhoe Park site and 16 units on the Kingsmead site, with overall 27 different dwelling types across this site. All dwellings were designed to meet LTH standards, and 30% of the houses in this development have been designed to super-flexible standards.

Figure 6.15: The site of Tattenhoe Park site 1 development. Source: the architects (id:Partnership Midlands).

Different parties have been involved in the development process for Tattenhoe Park as a whole and the Tattenhoe Park site 1 phase. Among these is English Partnerships (EP), now known as the Homes and Communities Agency (HCA), which is a governmental social body that owned this land and led the initiative for the provision of flexible housing in the Tattenhoe Park development to respond to a request from a community group for provision of housing that they could adapt to their changing needs and which would build in best practice of adaptable housing design as discussed in section 6.3.3. This led to production of an SFH discussion paper in collaboration with Milton Keynes Partnership (MKP), in line with the Urban Regeneration Agency's aim to promote growth and development in Milton Keynes. In the Tattenhoe Park development, MKP was essentially responsible for preparing the development framework for the site as an integral part of a master-planning process. In collaboration with EP, MKP produced the design code for the project, which set out the design principles as means to achieve the vision for Tattenhoe Park. David Wilson Homes (DWH) was the developer for the Tattenhoe Park site 1 development, as commissioned by EP (the landowner). The developer was required by the design code to continue the collaboration process and form a multi-disciplinary team to devise the design schemes. IDP Midland Architects, a team of architects and urban designers, was commissioned by DWH to produce and deliver the designs for Tattenhoe Park site 1 development.

The project, as mentioned above, aims to deliver dwellings that meet LTH standards and 30% of all houses need to incorporate super-flexible house design principles (see section

6.3.4). Therefore, flexibility requirements are not only about LTH standards, but also about incorporating additional standards which contribute to flexibility in dwellings. According to the interview with the planning officer from MKC, super-flexible standards emerged through an initiative promoted by the landowner, HCA or EP, rather than through the local authority (interview, no. 5).

6.3.2 Planning policies that endorse flexibility requirements in the Tattenhoe Park -development

According to the interview with a planning officer from Milton Keynes Council (MKC), the council supports housing projects that accept adaptations from the outset through the Lifetime Home Standards as set out in two key policies, Policy H9: Housing Mix and D2A: Urban Design Aspects of New Development. These policies encourage developers to incorporate these standards in the new development, but they do not constitute mandatory requirements; as explained by a Milton Keynes planning officer: “the existing policies only seek towards an encouragement to provide LTH standards” (interview no. 5).

Lifetime Homes Standards, as explained previously in section 5.3.1, represent a government-endorsed standard for sustainable homes. Therefore, the housing policy incorporated in the Milton Keynes local plan does not go beyond the requirements of government guidance. In this respect, the interviewed planning officer from the Milton Keynes Council pointed out that “in formulating policies in Milton Keynes they have to accord with national government guidance, and Milton Keynes Council cannot produce policies particularly to go above what national planning policy requires” (interview no. 5).

As explained in the previous section, flexibility requirements in the Tattenhoe Park development are represented primarily by SFH principles and secondary LTH standards, therefore the discussion here centres on discovering the possible effect of the policy context on the incorporation of these requirements in the project. The analysis of the *Tattenhoe Park Development Framework* document, produced by MKP in 2006 as an integral part of a master-planning process and setting out the policy context for the Tattenhoe Park development, reveals that adoption of local policy H9: Housing Mix and D2A: Urban Design Aspects of New Development was among the key policy considerations, thereby clearly encouraging incorporation of LTH standards. According to the interview with the planning officer from MCK, in the case of the Tattenhoe Park project the willingness of the landowner to consider LTH standards in the housing design as best practice is underpinned by the local policy context (interview no. 5). Therefore, in this project both the local policy context and the landowner's wishes served to bring about implementation of these standards in practice.

The analysis of the *Super-Flexible Housing* document produced by MKP in 2006, which highlighted issues around SFH in more detail than the master-plan, referred to *Sustainable Communities: Building for the Future* as a relevant policy (MKP, 2006, p. 4). Two key requirements of this policy were in place, the first of which is to create "buildings, both individually and collectively, that can meet different needs over time" (MKP, 2006, p. 4); the second is to achieve "an integrated mix of good homes of different types and tenures to support a range of household sizes, ages and income" (MKP, 2006, p. 4). However, the document did not reveal how this policy underpinned and connected to SFH provision in this project. According to the interview with representatives (area and planning managers) from HCA (the landowner), the ideas of SFH were connected to the policy through taking account of issues of social sustainability and communities' cohesion, which were the key objectives of the policy. Moreover, the interviewees pointed out that the Sustainable Communities policy was a government publication used during the design stage as a "hook" for getting government funding for SFH requirements, as SFH can achieve sustainable community planning through encouraging cohesion in the community by enabling people to stay within their dwellings for a long period, because when people are enjoying living in a particular space and children or elderly relatives come to live with them, they do not have to move (interview no. 4). The interviewees explained further that providing funding for these additional requirements was important because the perfect economic decision might not include flexible housing and there is no evidence that it would demonstrably increase the financial return. They further drew attention to the importance of the HCA, as the landowner, being a government body with links to the office of the deputy prime minster (interview no. 4). Therefore, in this particular case financial support was forthcoming because the policy had a key influence on the practice.

The interview with the planning officer from MKC revealed another factor that contributed to the provision of SFH requirements in this project. In this respect, the interviewee indicated that although SFH was a new set of requirements for the council, the council encouraged this initiative and provided for it within the design code and development framework document for the project. So the council was able to ensure the developer achieved these standards in this project (interview no. 5). The interviewee also pointed out that meeting these requirements is very much a site-specific and unique initiative for this location; if any developer wished to apply these requirements in another site, the council could support such an initiative, but would not be actively required to do so (interview no. 5). This finding clearly reveals the encouragement given by the local authority, as a contribution to this project meeting these flexibility requirements, despite the standards not being generally applied by the council.

6.3.3 Motivations for flexibility requirements in the Tattenhoe Park development

The analysis of the role of policy in contributing to flexible practice showed that the decision to include LTH standards, which can be considered as among the flexibility requirements for this project, was partly local policy-driven, as the landowner favoured following the local policy requirements and encouraging the providers to incorporate LTH standards into this development to build in best practice. Therefore, local policy can be considered as one of the factors contributing to inclusion of LTH requirements in this project.

The interview with the representatives (area and planning managers) from HCA also revealed that the initial motivation for providing flexible housing in the Tattenhoe Park project was the landowner’s initiative as a social body to respond to a request from a particular group of people who wanted to purchase dwellings in the area that were capable of accommodating their changing needs, so they could live in the community for a long period of time (interview no. 4). The analysis of the *Super-Flexible Housing* document also revealed criticism by the landowner and MKP of the design of UK housing as currently being too stereotypical to suit all sections of the community in Milton Keynes or elsewhere in the UK, where social demographics and living patterns vary considerably. Therefore, they viewed the provision of flexible housing as important because of its ability to consider different community needs (MKP and EP, 2006, p. 2). It seems that the main focus in this project is on responding to household differences in cultural resources, which could emerge from the differences between the communities in this context, creating users’ different requirements of their dwellings. The analysis of the *Super-Flexible Housing* document presented different scenarios comprising needs that can be considered as key drivers for flexible housing in the project, such as people who need to work from home, large families, families who need to accommodate an elderly relative and people who need additional space to hold large social gatherings in their dwelling (MKP and EP, 2006, p. 2). According to the framework set out in Chapter 2, these changing needs can be related to the following sources and sub-resources affecting the household (see table 6.6).

Changing need	Sub-source of changing need	Main source of changing need
People who might need to work from home	Lifestyle	Culture
Large family	Household structure	Culture
Families who might need to accommodate an elderly relative	Powerful extended family relationships	Culture
People who might need additional space in their dwelling for large social gatherings	Powerful relationships with family members, relatives, friends or/and neighbours	Culture

Table 6.6: Key drivers of flexibility in response to households' changing needs. Source: the researcher.

Meanwhile, the interview with the planning officer from MCK indicated that another motivation for flexible housing provision in this project derived from the landowner's willingness to implement best practice through flexible design in order to respond to people's different and changing needs from their housing. This can also be clearly seen in the *Super-Flexible Housing* paper produced by the landowner and MKP, which considered flexibility requirements (LTH and SFH) in relation to best practice (MKP and EP, 2006, p. 4). The document clearly reflected the landowner's perspective, that flexible design of housing as important to achieve a "high-quality, cutting edge, imaginative and well-designed solution for new homes" (MKP and EP, 2006, p. 2).

6.3.4 Flexibility requirements in relation to the Tattenhoe Park development

In this section, the research discusses different flexibility requirements that were applied in the housing designs of the Tattenhoe Park development. The discussion, however, is confined to outlining these different requirements rather than examining them in detail, as the research seeks to focus on analysis of flexible samples from the project. As was noted above in Section 6.3.3, flexibility requirements for super-flexible homes (SFH) comprise both LTH standards and super-flexible design criteria. In the *Tattenhoe Park Design Codes* document (2006), MKP and EP required that the 16 LTH standards be considered in the design of different housing types for Tattenhoe Park. As the flexible design criteria of LTH have already been explained in Chapter 5, Section 5.3 the main focus in this part is on presenting SFH standards and the main considerations. This helps to provide understanding of how the design code of SFH guided the design practices to produce flexible housing in the Tattenhoe Park site 1 development.

Flexibility requirements of SFH were provided and detailed in the *Tattenhoe Park Design Codes* document produced by MKP and EP in 2006, which provided guidance to the developers, architects and MKP as the local planning authority, on developing flexible/extendable home (FEH) designs, as they were known in this document. The design codes provided four flexible design criteria as mandatory requirements, and at least two of the four requirements needed to be considered in the designs of FEH. In addition, the design codes required 30% minimum of the total units to be FEH across all house types, sizes and tenure arrangements within the development.

The four key requirements of flexibility are presented here briefly. This is particularly important in understanding how these criteria affected the design practice of flexible samples in this project.

1- The first principle requires provision of "internal space flexibility" (MKP and EP, 2006, p. 16), in which the floor layout of each dwelling of over 76 sq. m needs to allow for three different layout configurations.

2- The second criterion is concerned with the means of horizontal extension. In this respect, the design codes refer to preparing the plan for future extension or additions other than a conservatory, and the following planning and construction considerations should also be taken into account:

- Creating a logical relationship between future additions and the main dwelling.

- Foundation and walls should be built in from the outset to accommodate future extensions.

3- The third requirement also promotes the possibility of future extension, but vertically. In this respect, upwards extension can be achieved either through loft conversion or by extending the top floor. In this regard, the design codes refer to different requirements that need to be taken into account:

- In terms of planning
  - Sufficient size and height for a habitable room
  - Space for a new or extended staircase from the existing dwelling
  - Fire protection in order to provide a route for escape.
- In terms of construction
  - Open roof trusses
  - Over-sized floor joists
  - Structure for new or extended staircase
  - Foundations and walls in the space, such as for a garage, designed to accommodate possible vertical extension.

The following considerations highlighted by the codes relate to building any type of extension:

- Any extension or addition needs to be considered as subservient to the main dwelling.
- The provision of extensions is not permitted forward of the main front building line.
- All extensions must be designed in a manner that does not influence the privacy of adjacent dwellings.
- Future additions should be considered as clusters for visual coherence.
- The size of the plot must be sufficient to accommodate a future extension.
- The influence of any extension on the space between the buildings must be considered.

4- The fourth principle relates to provision of dwellings with internal or external un-allocated space that can have different uses, such as home office, additional bedroom, ‘granny flat’ and so on.

In summary, the design codes promoted four key flexible design approaches to achieve flexibly designed houses. The design codes required at least two flexibility requirements to be considered in the housing design.

6.3.5 FEH samples of the Tattenhoe Park site 1 development

Different FEH samples were developed by the architects in the Tattenhoe Park site 1 development. The samples can be considered in three key groups: FEH types with extension into the pitched roof space, rear extension, and vertical extension over double garage. Generally, internal re-configuration was applied to follow the extension process (see figure 6.16). Table 6.7 outlines these types in this development along with the flexible design approaches integrated into each design

Figure 6.16: FEH types of Tattenhoe Park site 1 development. Source: the architects (id: Partnership Midlands) edited by researcher.

Type	Attachment condition	Original			Integrated flexible design approaches		Adapted		
		Number of storeys	**Size sq. m**	**Number of bedrooms**			**Number of storeys**	**Size sq. m**	**Number of bedrooms**
G	Detached	2	116	3	Extension into attic	Internal re-configuration	3	166	5
L	Detached	3	168	5	Vertical extension	Internal re-configuration	3	200	6
K	Detached	2	158	4	Vertical extension	Internal re-configuration	2	190	5
X	Detached	3	125	4	Internal re-configuration		3	125	3
O	Semi-detached	2	78	2	Horizontal extension	Internal re-configuration	2	90	2
O Var	Semi-detached	2	78	2	Horizontal extension	Internal re-configuration	2	90	2
T	Semi-detached	3	98.5	4	Horizontal extension	Internal re-configuration	3	110.2	4
V	Semi-detached	3	112.5	4	Horizontal extension		3	124	4
U	Attached	3	119	4	Horizontal extension	Internal re-configuration	3	131	4
E	Attached	3	110	3	Horizontal extension	Internal re-configuration	3	122	3

Table 6.7: FEH types of Tattenhoe Park site 1 development. Source: the researcher.

6.3.6 Flexibility in the plan

The table above showed that most FEH samples were considered to accept an extension, followed by those allowing internal re-configuration of the plan; therefore, the focus here is on analysis of how the extension approaches provide flexibility in the plan at different levels, to discover the possibilities and constraints of this approach in relation to achieving best practice. The analysis is carried out according to the research analytical framework developed in Chapter 3.

A- Building

As indicated in Table 6.6, in the original plans the FEH samples were designed as single houses ranging from detached and semi-detached dwellings to attached blocks with two or three storeys. The flexible design scenarios for the blocks show that these homes were generally designed to remain as single family dwellings after change and over time. Therefore, the design of this project does not allow for flexibility in unit mix.

1- Flexibility in building use

The flexible design scenarios for the houses reveal a few possibilities for change in building use. In type G, despite the dwelling potentially providing a generous space through extension into the attic, of sufficient size for non-residential use, the inability to provide independent access to the space precludes such planning flexibility with this type. Moreover, in the types with rear extensions, the limited amount of size in this extension means that change of use is not a viable option. In types K and L, this possibility was considered through vertical extension over a double garage that would allow creation of an open space with a generous size of around 32m², which could be used for non-residential purposes such as an office or workspace. In this case, the architects considered the possibility of creating independent services and access through possible future provision of a side wall staircase to access the space above the garage. In addition, the future plan of the garage shows the incorporation of one sizable window on the front façade, which may not provide sufficient light for non-residential purposes (see figure 6.17). According to the interview with the architects, openings in the atelier space of the double garage required careful location in order to prevent people inside from seeing over into other gardens (interview no.6). Therefore, the possibility to provide different openings for natural sources of light is restricted by site-specific privacy considerations.

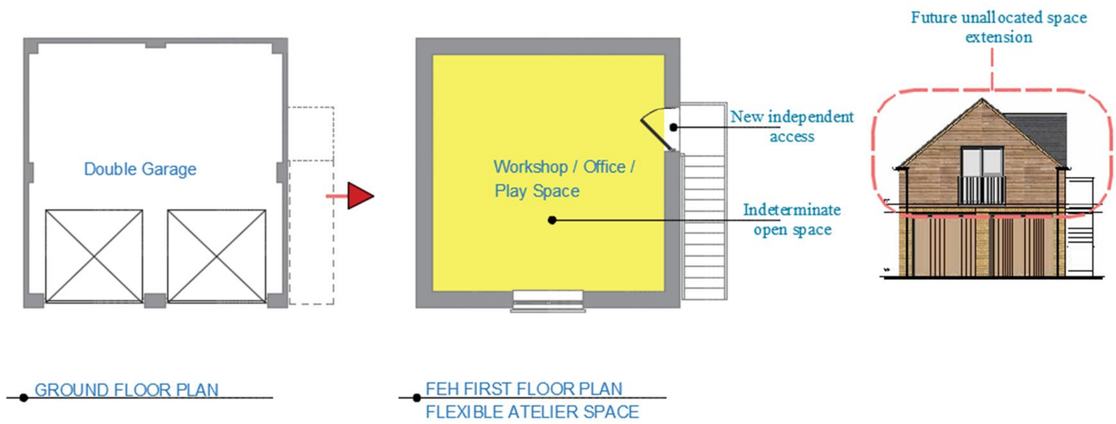


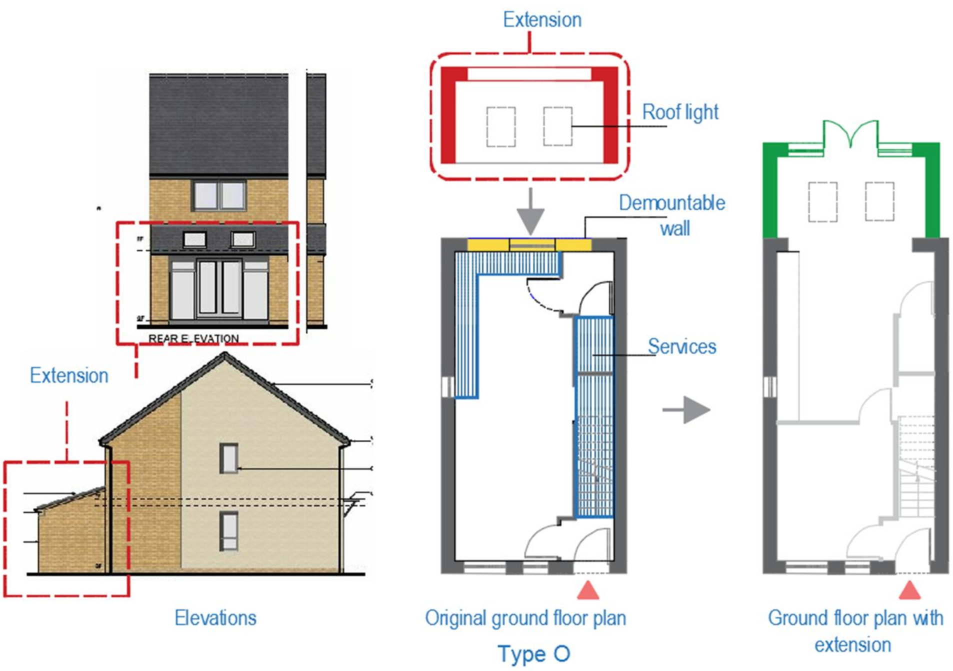
Figure: 6.17. The vertical extension over double garage in types K and L. Source: the architects (id: Partnership Midlands), re-drawn and adapted by the researcher.

B- Unit

1- Flexibility in size

Flexibility in size in this project was achieved mainly through designing the plans to enlarge in different ways. In types O, O Var1, T, U, E and V, the plans were designed to accept horizontal rear extension across the full width of the house on the ground floor. The architects designed this flexibility into the plans for the semi-detached and attached dwellings of small size, to enable their ground floor area to be extended by up to 12 m2. In types T, U and E, the extension would allow an increase in different layout spaces, particularly the family room, whereas in types O and OVar1, it would add new space to the ground floor (family room). In both cases, the architects considered how the layout or the extended space could be used.

To facilitate this process, different design and site considerations were taken into account by the architects. In terms of design, the plans show that the architects designed the extension to have a logical relation with the adjacent space through a large opening between them. The services space and internal circulation, moreover, do not restrict the design's capacity for future extension as they are generally placed on the common side walls, freeing the rear façade for extension. In types O and OVar1, as the kitchen was placed on the rear demountable external wall, adaptation may necessitate additional work. However, the architects designed the rear wall with no services located within so the kitchen can be removed easily. In order to achieve good light in the space after extension, the architects incorporated two potential sources of light in the roof of the extension (see figure 6.18). In terms of the site, the architects pointed out that "the units that were to allow future additional extensions were given garden sizes that were functional after the extension was added" (interview no.6).



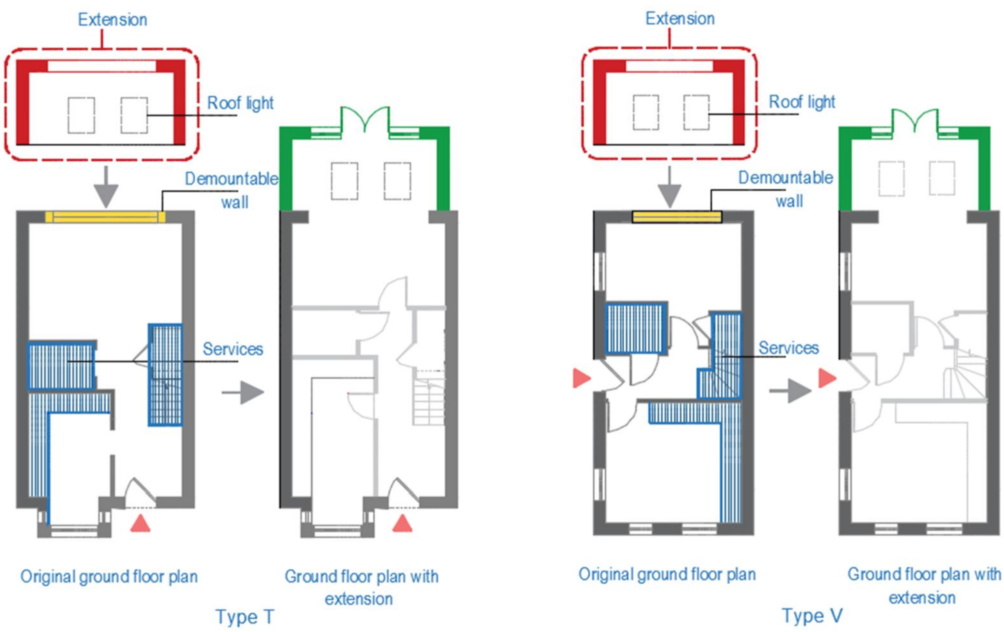


Figure 6.18: Horizontal rear extensions of types O, T and V. Source: the architects (id: Partnership Midlands), re-drawn and adapted by the researcher.

In types K and L, growth in size could be achieved through the possibility to add vertically over a double garage, which could provide an internal floor area of around 32m2. As explained in the previous section (flexibility in building use), the architects designed the extension to provide indeterminate space that can be used for different purposes. The architect made provision for adding a separate access to the addition through a staircase in the future (see figure 6.17). In this respect, the architects pointed out that “the stairs that would be added later wouldn’t allow people to be able to see over into other gardens” (interview no.6).

In type G, on the other hand, potential for growth in size was provided through an expansion into the roof space, which adds around 50m2 in area to the plans. The architects here considered possible access to the space through future extension of the staircase to the roof space, and provision of two dormer windows and sufficient height in the attic space at both the ridge (2.5) and edge (1.5) to enable the space to become habitable in the future (see figure 6.19).

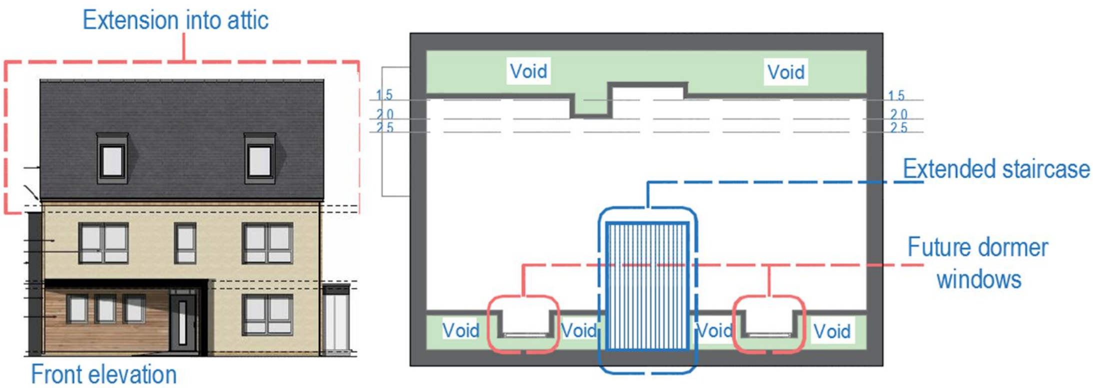


Figure 6.19: Extension into the attic space in type G. Source: the architects (id: Partnership Midlands), re-drawn and adapted by the researcher.

These design strategies for extensions are promoted clearly by the design codes of flexible extendable home principles. Therefore, these opportunities for flexibility derive from flexibility requirements in the design codes that call for incorporation of one or more of these design approaches in the FEH sample designs. Considerations from the design codes needing to be taken into account when designing for extensions were presented in section 6.3.4. However, the plans show implementation by the architects of other design principles such as future installation of roof lights and avoiding placement of services within the rear demountable wall that facilitated further applications of flexibility in the actual design. Therefore, the methods used in application of the different extension strategies derived from the architects’ consideration of the design codes and what they described as their “effort to provide something that could actually be of use to real people” (interview no.6). The architects clearly indicated that the design code had limitations in relation to meeting flexibility requirements for such as extensions, commenting that “it simply made the requirement, but did not say exactly how it should be carried out” (interview no. 6).

2- Flexibility in layout arrangement

The plans of the FEH sample show the ability of the designs to achieve more than one layout arrangement, primarily through extension and possible internal changes to these plans. This was achieved in types (O, OVar1, T, U, E) at ground floor level, where such horizontal extension and internal change can be applied. These strategies could create another layout form and accommodate additional functions for the houses. In types O and OVar1, rear extension across the full width of the plan and internal change would allow creation of new layout forms and layout functions, such as by making a large opening in the rear external wall to connect the extension with the main layout space, adding a new partition between the sitting room and the kitchen/dining space, and removing the partition between the lobby and kitchen/dining space. In terms of layout functions, new functions such as a family room could be added to the ground floor layout (see figure 6.20).

On the other hand, the plans show certain limitations in the design’s ability to accept a variety of functional layouts. One key limitation is the limited size of layout spaces such as the family room that was delivered as an addition with area of around 9 sq. m, which restricts the ability of the plan to be occupied in different ways. Another restriction is the inability to access the layout spaces of the ground floor independently from the main entrance. For instance, the family room can only be accessed from the main entrance through the sitting and kitchen/dining spaces. Therefore, functional flexibility in this plan is limited to the architects’ scenario of change in function rather than providing for variety of functional layouts (see figure 6.20).

In terms of spatial flexibility, the placement of services such as a kitchen in the central zone of the plan and the location of the WC and internal staircase on the opposite side restrict the ability to re-configure the plan in different ways. Other restrictions are that the limited sources of light and lack of layout width reduce the possibility to create different forms in the plan. On the other hand, location of the entry door on the side common wall and the design of the internal partition as a demountable lightweight wall that can be removed easily permit creation of another layout form in the future. However, this potential is limited to the architects' view of scenarios of change in internal configuration (see figure 6.20).

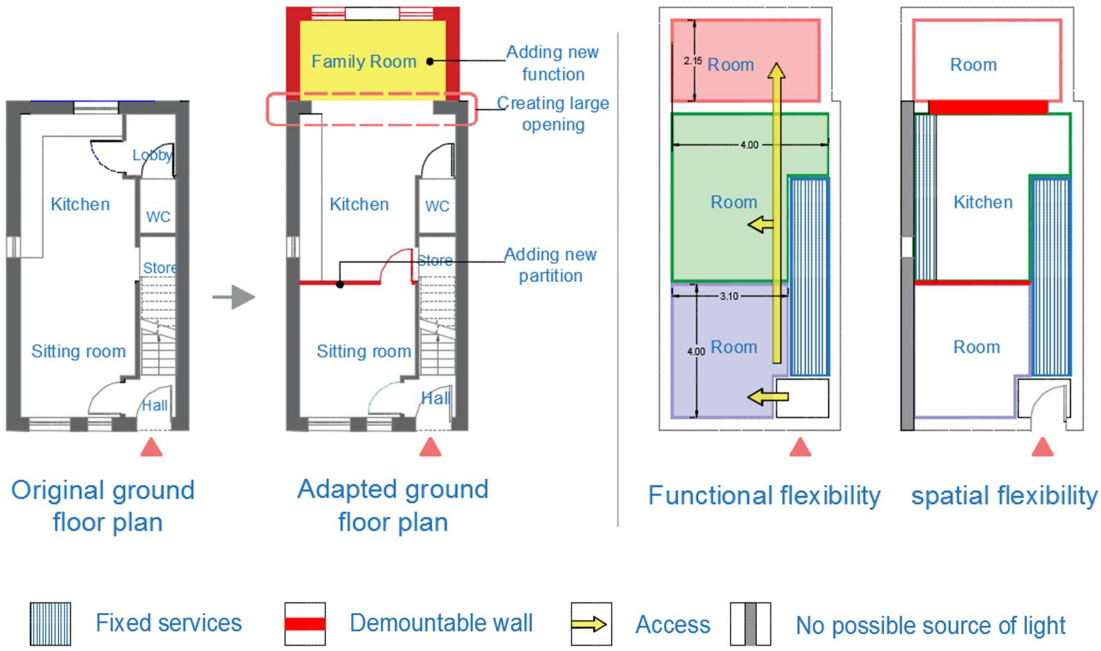


Figure 6.20: The layout arrangement of type O before and after the extension. Source: the architects (id: Partnership Midlands), re-drawn and adapted by the researcher.

In types T, U and E the rear extension and internal change similarly allow re-configuration of the internal partitions, such as by creating a large opening between the extension and internal layout space to enlarge the family room and moving some partitions to enlarge the kitchen space, which would add new functions to the ground floor, such as by creating a work place for children in the adapted kitchen and converting the family room to a sitting/dining/desk space. Differently, in type V, the new layout arrangement was achieved through rear extension, which allows new layout configuration only through removing a large part of the external wall to enlarge the sitting space (see figure 6.21).

On the other hand, the plans of the previous types show that the differences between the layout spaces in terms of sizes and proportions prevent any attempt to interpret them in different ways. This derives from the extension leading to an unbalanced increase in the sizes of layout spaces that were originally designed differently in terms of their size and proportions in most types. The location of the entry door and the narrow width of the layout reflect this restriction as they prevent any attempt to design layout spaces of adequate size and proportions. In type V, location of the entry door at the long side of the plan and the rear horizontal extension that increased the originally small sized sitting room allows to create layout spaces relatively adequate in size and proportions. This was facilitated through providing separate access to the layout from the central hall, thereby allowing these spaces to be occupied in a variety of ways (see figure 6.21).

In terms of spatial flexibility, in types T and U, the location of services in the central zone, particularly the bathroom, minimises the ability to change the layout configuration. Again the restrictions of the plan in terms of width and provision of more sources of light, particularly in type U as an attached block, are other factors that reduce the capacity to re-partition the plans in different ways. In type E, the side position of the bathroom can be seen as relatively freeing up the internal space and allowing the kitchen to be enlarged or opened up over time, as the internal partition is a demountable wall that can be altered easily in the future. In type V, the location of the services core in the central zone of the ground floor layout restricts the ability of the plan to accommodate different layout forms. On the other hand, the location of the main entry on the side wall frees the space on main façade for division in the future (see figure 6.21).

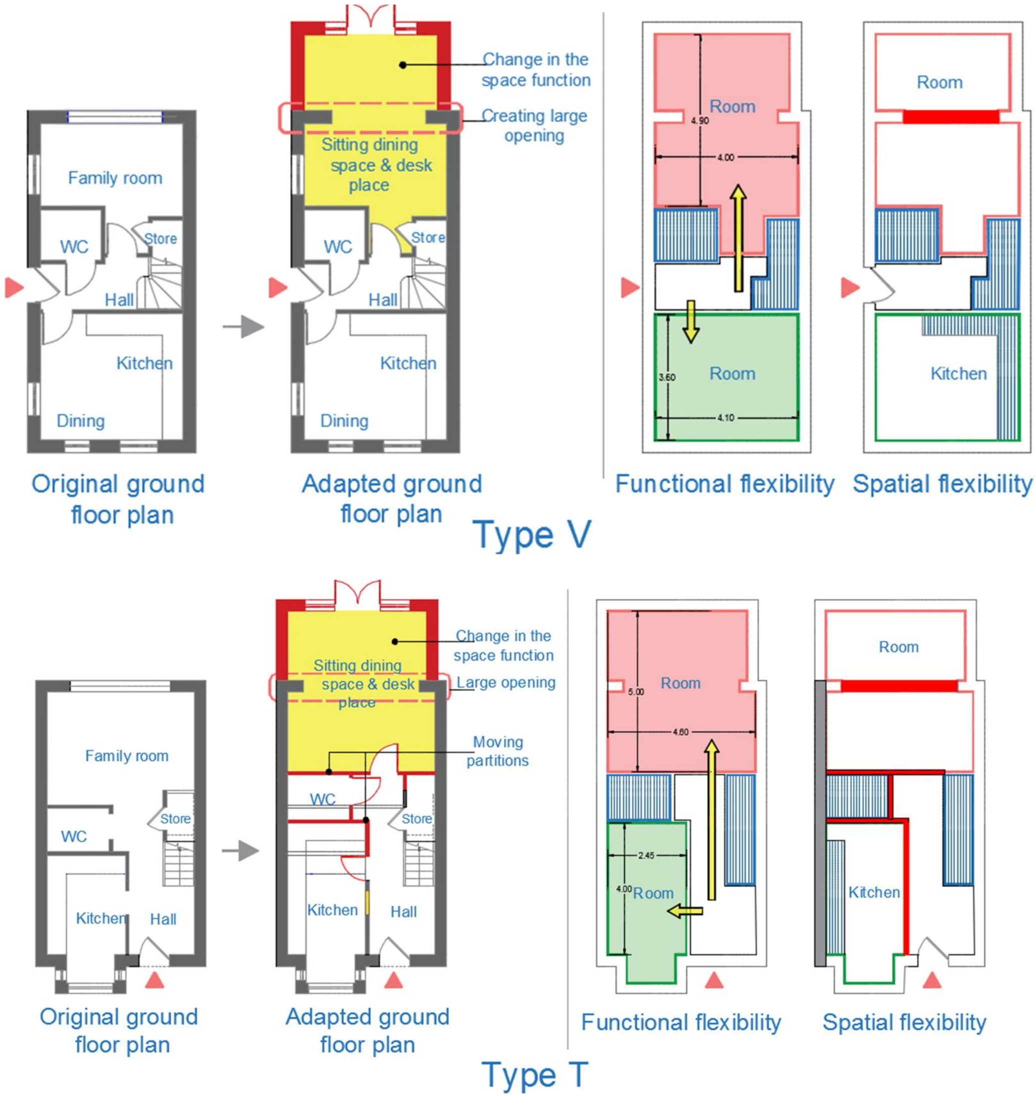


Figure 6.21: The layout arrangement of types T and V before and after extension. Source: the architects (id: Partnership Midlands), re-drawn and adapted by the researcher.

In type G, the new layout arrangement was achieved through expansion into the roof space and internal change, which resulted in new layout forms and functions. This was achieved through extending the internal stairs into the roof space and re-partitioning the attic space to create two rooms and services. This added new layout functions to the dwelling, such as two bedrooms with a bathroom.

On the other hand, the plan displays a separated access from a central core to spaces of adequate and nearly equal size, with relatively similar simple forms that allow these layout spaces to accept various functional layouts. In terms of spatial flexibility, the location of the services core (staircase and bathroom) in the middle of the plan and the lack of different sources of light reduce the potential for the plan to be re-configured in different ways.

To sum up, the analysis of the different flexible types showed that designing the layout for extension provided the possibility to create layouts with other arrangements of function and configuration in most cases. However, a large number of these types exhibit no significant evidence of flexibility for different functional layout arrangements, particularly the samples with rear extensions. This is in some cases because of the imbalance in the sizes and proportions of the layout spaces, or in other cases the limited sizes of the spaces created by the extension, or other factors such as the location of the main entry.

In terms of spatial flexibility, the plans showed some potential for another layout configurations because the extensions allow the plan to grow in size and some partitions are designed as demountable walls which provide opportunity for internal change. However, this ability is limited primarily by the plan's positioning of the services preventing, in some cases, any possibility for internal change, also by the lack of width and sources of light on the side façade.

Internal circulation

The plans of the flexible building types with rear extensions show that their internal circulation was generally designed with good dimensions that would allow the spaces to be accessed by different people, including wheelchair users. This can be attributed to the incorporation of LTH standards that call for sizable circulation spaces, so they can be used by a variety of people with different physical abilities. However, these spaces cannot be considered as being usable for additional purposes, as their dimensions are still too limited.

C- Room

1- Flexibility in Function

The plans of types T, U and E show that the room layouts can accept additional functions after extension due to the enlargement of their spaces. For example, the kitchen room has the ability to accept additional uses such as work place for children; however, its proportions and size are still too limited to allow acceptance of different functions.

Differently, the layouts of the new family rooms of these types and type V appear to be of generous size and dimensions because of the direct relation with the extension that allows the new space to accommodate different functions such as sitting, dining and desk space according to the architects' design scenario. However, the ability for interpretation in different ways is reduced by other factors such as the unclear form of the space and the relation of the room with the external and rear garden (see figure 6.22).

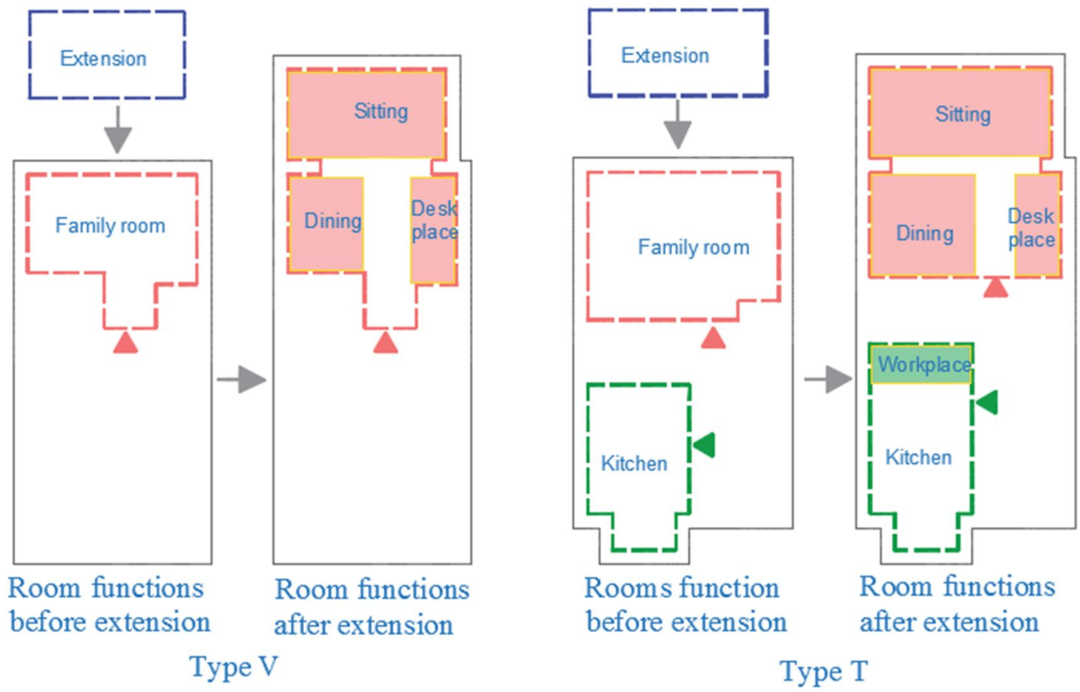


Figure 6.22: Flexibility in room function in types T and V. Source: the researcher

In types O and OVar1, the extension adds a space of small size to the plan, but creating an internal large opening with the adjacent room, may enable the space to be occupied in other ways (see figure 6.23).

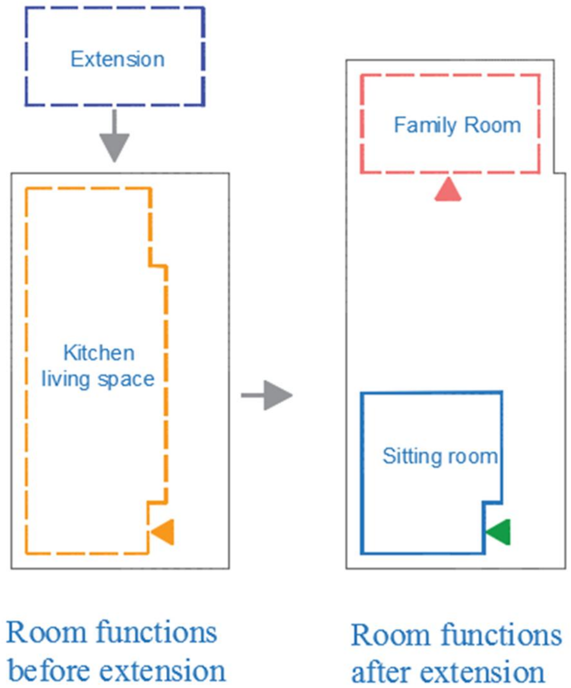


Figure 6.23: Flexibility in room function in types O and OVar1. Source: the researcher

In type G, where there is vertical extension into the roof space, the resulting rooms can be considered as being of good size and proportions, with simple forms that allow their spaces to be occupied by different functions. Again, this ability is reduced by the limited light sources (the architects included one possible dormer window in each room to provide a natural source of light). Here site-specific considerations can be seen as potentially restricting creation of different openings in the roof space (see figure 6.24).

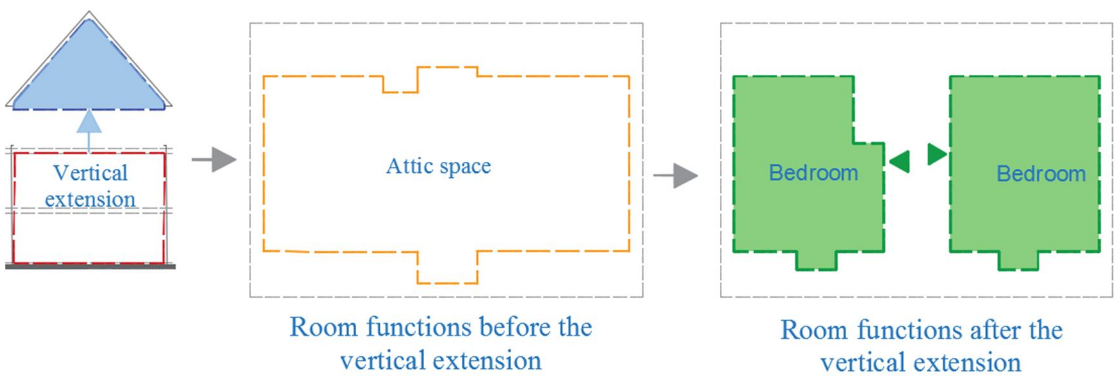


Figure 6.24: Flexibility in room function in type G. Source: the researcher

In types K and L, the rooms resulting from extension over a double garage are of good sizes and proportions and have a simple square form with a single sizable window, although the latter can be seen as a limitation on the room's potential to function differently, particularly as a non-residential space. Here the limitation results from a requirement to prevent the extended space affecting the privacy of adjacent and nearby dwellings (interview no.6).

Consequently, the analysis reveals that in the types with rear extensions, flexibility in room function is possible in the extended rooms rather than in cases where the extension is provided as an addition to the plan, such as in O and O Var1, due to the limited size of the extension making it more effective to generate flexibility through extension of a current room. This flexibility was, however, restricted by the design of a large external opening and the relation of the space with the external area, which makes its use more deterministic for particular kinds of occupation (daylight functions). Here the design code is seen as being behind the architects' limited application of flexibility in room function, due to the lack of provision of different approaches to flexibility, such as using foldable built in furniture that would allow the space to function differently, for example, during the day and at night. On the other hand, the rooms resulting from vertical extension were more spacious and appropriate for different functions but also restricted by the lack of light sources because of site privacy considerations.

2- Flexibility in connection

The plans of types T and U show that the family rooms were designed to accept connection with future extension. To facilitate this, the external wall of the room was designed as a non-loadbearing demountable partition, so a large opening can be created in the future for possible connection between the spaces. On the other hand, ability to connect the room from the other side was restricted because of the location of the bathroom between the room and kitchen space. In type E, connecting the family room in both directions is made possible (with future extension and kitchen space) through the room's internal and external non-loadbearing demountable walls. The architects selected the demountable design of the internal partition to facilitate future enlargement of the kitchen, which at the same time can enable the room to be connected with the adjacent kitchen in the future. In types O and OVar1, the kitchen space was designed to accept future connection with an extension through designing its external walls and units for easy disassembly. Another possibility for such flexibility was provided by enabling the sitting room to be connected to the kitchen space by opening up the non-loadbearing demountable partition that the architects used to separate the sitting room and the kitchen space after the extension. In type G, the central location of the internal circulation and services means that flexibility to connect the rooms is not possible with this type (see figure 6.25).

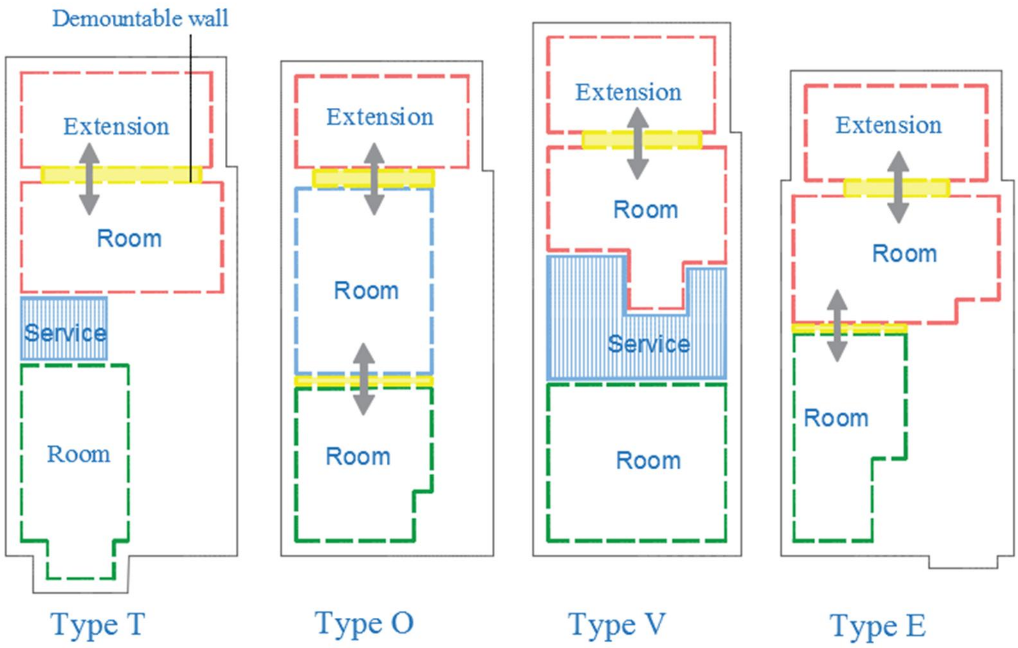


Figure 6.25: Flexibility in room connection in types T, O, V and E. Source: the researcher

The analysis shows that a large number of the different types of homes have flexibility in connection because of the use of horizontal extension and internal re-configuration approaches, which means that the internal partitions and some external walls were designed as non-loadbearing with the ability to be dismantled in the future. However, this possibility for flexibility at room level was restricted in some cases by inappropriate location of the services in the plan.

3- Flexibility in Furniture

In types T, U, E and V the plans show that the enlarged family rooms have adequate dimensions and proportions to allow the room to be furnished in more than one way. In addition, location of the door nearly on the side wall with space at the back for placement of furniture enables the room to be furnished in different ways. This can be seen through the architects' suggestion of placing a desk in this space. On the other hand, the large opening stretching almost right across the full width of the external wall and the two parts of the wall remaining after partial opening of the wall between the family space and extension reduce the ability of the space to be furnished in a variety of ways (see figure 2.26).

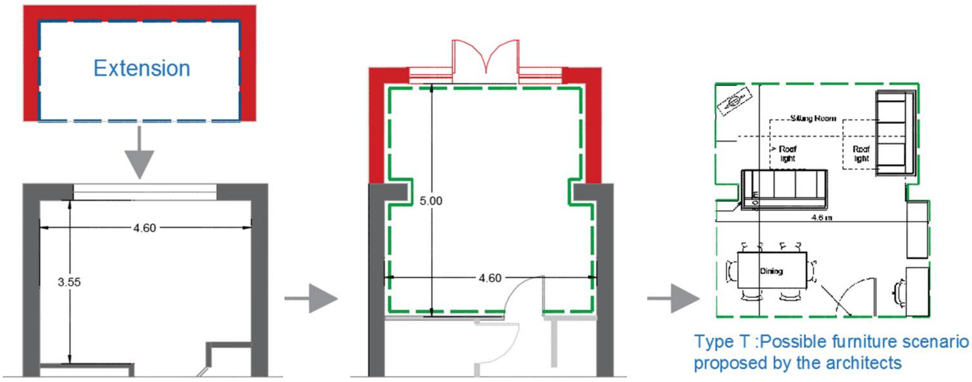


Figure 2.26: Flexibility in furnishing the living room-type T. Source: the research

In types O and OVar1, the size of rooms such as the family room that was added to the plan through extension and the separated sitting room restrict the ability for either space to be furnished in different ways. In the family room, the large openings in both sides mean that furniture can only be placed on the other two sides (see figure 2.27).

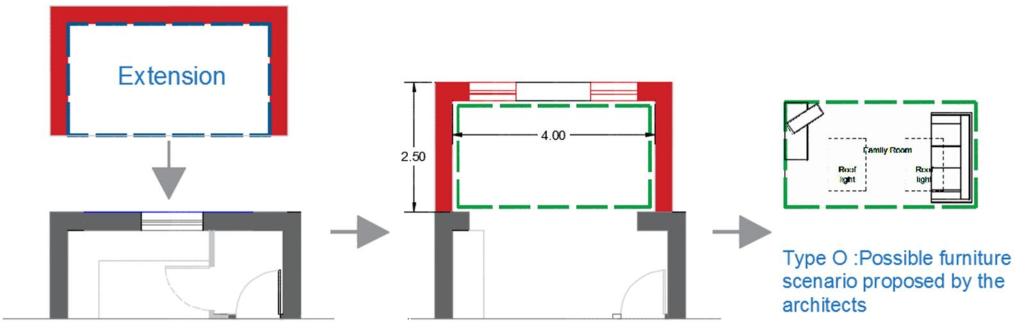


Figure 2.27: Flexibility in furnishing the family room-types O and OVar1. Source: the researcher

In type G, the rooms resulted from vertical extension into the attic and the re-configured internal scenario can be considered as being of good size and proportions for accepting different ways of furnishing it. In room A, the built in store with a door nearly in the middle may restrict the ability of the space to accept a variety of furniture layouts (see figure 2.28).

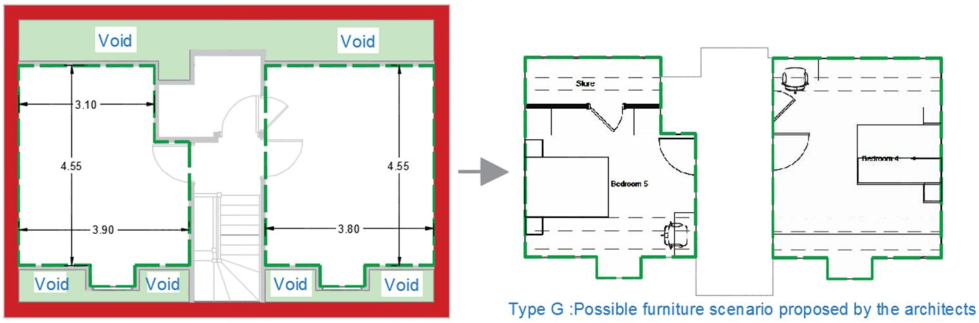


Figure 2.28: Flexibility in furnishing the attic rooms -type G. Source: the researcher

The analysis presents some possibilities for flexibility in furnishing the rooms. This is reflected primarily in the living rooms of some types with rear extensions that made the original spaces of sufficient size to accept change in the ways of furnishing them. However, this capacity is limited by the inability to create full opening across the width of the original rear façade and the large external opening of the room. In the other types, the small size of horizontal rear additions was the key limitation to flexibility in the rooms furniture. Again it can be seen that flexibility in furnishing is limited by the lack of different furnishing approaches in the design codes, such as the use of foldable built in furniture where space is limited. Differently, in the case of vertical extensions either over a double garage or to the attic space, more generous room spaces can be created, providing more flexibility in furnishing these rooms.

Conclusion

Flexibility in the plans of this project emerged mainly as a result of incorporating extension approaches proposed by the design code and internal re-configuration into the design. The different extension strategies led both to possibilities and limitations for flexibility in the plan at different levels due to different factors such as the ability of the extension approach to provide additional size in the plan, the connection between the extension and the plan and the relation with the external. For instance, vertical extensions over a double garage provided space of good size with a simple form and independent relation with the plan led to different possibilities for flexibility at different levels. However, the site-specific restriction in terms of privacy requirements reduced the ability of this type of extension to achieve best practice in functional flexibility.

In the case of extension into pitched roof spaces, where rooms of generous size could be created, the key limitation on flexibility in the plan emerged from the plan's inability to provide independent access to the extended space, which restricted its ability to provide flexibility at building level. The access and privacy issues can be also be seen as playing a role in restricting the functional and spatial flexibility of the extension at layout and room level.

In terms of rear extensions, where the provided space is limited, the extension has a direct relation with the plan and the location of the extension is determined by the landscape and the relation with the external, different limitations emerged in the plan at both building and unit level in terms of functional flexibility. However, the direct relation of the extension with the plan provides some possibilities for flexibility at room level in terms of function, connection and furniture where the addition extended the space of the room. These opportunities were restricted by other factors such as the form of the extended space, size of the opening and again the relation of the space with the external. In the case of addition, where the space is of limited size this restricts flexibility in the plan at different levels. Here, the design code can be seen as contributing to this limitation due to the limited options regarding flexible design approaches that are particularly appropriate when dealing with tight spaces.

Table 6.8 summarises the different possibilities and limitations of flexibility in plan for the different unit types of Tattenhoe Park site 1 development project according to the research analytical framework in Chapter 3, section 3.2.1.

Category	Indicators	Criteria			Evaluation					
					G	O &O Var	T & U	E	V	Extension over garage
Building	Unit mix	X								
	Use	Accept mixed use		Indeterminate open space.						✓
				Independent services.						✓
				Independent access.						✓
				Considerable openings.						X
Unit	Size	Growth	Horizontal	Access to the addition.		✓	✓	✓	✓	
				Considerable location of the services.		X	✓	✓	✓	
				Sufficient light.		✓	✓	✓	✓	
				Plot size.		✓	✓	✓	✓	
			Vertical	Separated access to the addition.						✓
			Into attic	Ability to extend the staircase.	✓					
				Sufficient height for habitable use.	✓					
				Suitable sources of light.	✓					
		Division	X							
	Layout arrangement	Functional flexibility	Layout spaces of adequate size.		✓	X	X	X	✓	
			Layout spaces of adequate proportions.		✓	X	X	X	✓	
			Independent access to the layout spaces.		✓	X	✓	✓	✓	

		Spatial flexibility	Strategic placement of the services core.	X	X	X	✓	X	
			Ability of internal partitions to be moved around.	X	✓	✓	✓	X	
			Considerable location of the main entrance.		✓	✓	✓	X	
		Internal circulation	Appropriate size of access space to permit an additional use.	X	X	X	X	X	
			Suitable dimensions of the circulation space for use by different groups of people.	✓	✓	✓	✓	✓	
			Possibility of adding a lift as an additional vertical access means.	✓	✓	✓	✓	✓	
Room	**Function**	Room is of suitable size and proportions.		✓	X	✓	✓	✓	✓
		Room is simple in form.		✓	✓	X	X	X	✓
		Ample light that suits different functions.		X	X	X	X	X	X
	Connection	Potential to provide new connections in the future.		X	✓	✓	✓	✓	
	Furniture	Room has adequate dimensions and proportions.		✓	X	✓	✓	✓	✓
		Clear internal space.		X	✓	X	X	X	✓
		Considerable location of the door.		✓	X	✓	✓	✓	✓
		Appropriate size and number of windows in the room.		✓	X	X	X	X	✓

Table 6.8: Evaluation of flexibility in plan of FEH samples of Tattenhoe Park site 1 development project. Source: the researcher

6.3.7 Flexibility in construction

Structure

According to the FEH plans, the structure of the FEH samples consists of cavity brick walls located on the periphery of the blocks and a conventional floor joist system with a 220mm deep joist platform built into the brickwork. In the types with rear extensions, O, OVar1, T, U, E and V, it is notable that the internal partitions are non-loadbearing (see figure 6.16), which means that the structure of these samples can be separated from the internal partitions of the plan. In addition, the structure of these samples creates clear spans across the width of the plan, ranging from 4.1 to 4.7m, which provide open space between the structural elements. Another important consideration is that the structure of these blocks was designed by the architects with non-load bearing rear external walls and no services located within the walls. In addition, cavity trays were pre-installed into the rear wall in locations where lean-to roofs would later be fitted (interview no.6). This enables the structure to accept additions in the future. Therefore, the design of the structure of these samples considers the different principles of flexible structure according to the analytical framework in Chapter 3, section 3.3.1. This can be attributed to the simple form and adequate width of the plans of these samples that allow them to be constructed without internal loadbearing located within, which facilitated the internal re-configuration approach applied by the architects on these types.

In the large detached units, such as type G, the plan displays some internal loadbearing walls within the layouts (see figure 6.16), which means that the method of construction cannot provide a structure that can be separated from the internal walls. The existence of these internal load bearing walls within the plan also restricts the ability of the structure to provide clear spans across the width of the plan, and thus the creation of open space within the structural elements. The architects, in designing this type, did not consider an approach to internal change that would require such possibility for flexibility in structure. On the other hand, the structure is designed to accept additional dead and live loads, which means it can accept addition vertically into the roof space. This possibility for flexibility in structure emerged from the architects’ design considering vertical extension into the roof space in the future.

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Foundations

The plans of types with rear extensions (O, OVar1, T, U, E and V) show that a strip system of foundations is mainly used, following the line of loadbearing external walls. In other types, such as G, the foundations were also installed under some internal walls delivered as loadbearing brick walls. Since the internal non-loadbearing walls are lightweight stud wall partitions, the foundations system and their location have no impact of the ability of the ground floor to accept different locations of the internal partitions within the plan.

The flexibility requirement to construct foundations for overcapacity can be primarily noticed in the double garage designed to accept upward extension in the future. According to the interview with the architects, the foundations were oversized to accept an additional 0.5 of floor (interview no. 6). The design code clearly indicated that oversized foundations are necessary to facilitate flexible upward extension strategy, as mentioned in section 6.3.4. This means that the flexibility requirement of the foundations in terms of overcapacity derived from the design code recommendations.

Roof

Flexibility in the roof construction can be seen in types such as L, T and G where the roof construction was designed to facilitate occupation of the roof space. In types L and T, this was designed for immediate occupation after moving in, whereas in type G the roof construction was designed to accept future upward extension into the roof as explained in section 6.3.6. To facilitate this, the architects designed the roof construction with open trusses and pre-cut roof joists for future installation of two dormer windows so the roof can be adapted easily and occupied in the future (interview no. 6). As presented in section 6.3.4, the design codes clearly referred to some of the considerations which need to be taken into account in the construction of an upward extension. Here it can be argued that although the design code drew attention to such constructional practices, they are already common practices for roof construction in the context, as has seen in type T where the construction of the attic was designed with open trusses to allow occupation of the space. Therefore, this possibility for flexibility in roof construction emerged as a result of the conventional method of roof construction that was employed by the design code to allow future extension into an attic space.

Internal walls

The plans show three different forms of construction of internal partitions across the different FEH samples. The first form is loadbearing brick walls that can be seen in type G, which was designed to support the main structure of these buildings, giving the construction of these walls no flexibility. The second form is non-loadbearing stud walls, which were used as the main type of internal partition to separate the different spaces of the FEH layouts. This form of internal partition construction satisfies one flexibility requirement, according to the research analytical framework in Chapter 3, section 3.3, in that the resulting walls have a separate structure from the mainframe, so they can be removed as required. The third form is demountable partitions, designed by the architects using stud partitions; these “were useful for dismantling”, as the architects pointed out (interview no. 6), without services located within. Therefore, it was the architects’ initiative that led to this practice, rather than the design code. It seems that in using stud walls, a conventional method of internal partitioning, the architects sought to work within the rationality of the building industry and related practices, rather than using specialist forms of construction. In this respect, the architects followed the design code’s statement that construction work should not be over-reliant on any specialist form of construction or components (MKP, 2006, p. 17). The construction of these internal partitions meets the main requirements of flexibility according to the research analytical framework, as it means the walls can be separated from the main structure and therefore easily changed in the future.

External walls

Two forms of construction can be seen across the different types of FEH. The first form consists of two layers of masonry with a cavity between them, which is a conventional method of constructing external walls for housing in the context, and the main form of external walls delivered in the different FEH types. This construction type has no scope for flexibility, according to the analytical framework, since it forms part of the support structure and thus cannot be adapted or removed in the future. The second form is demountable stud walls, which were primarily used in types O, OVar1, T, U, E and V to facilitate rear extension. These walls can be considered as having flexibility in construction because of their ability to be separated from the main structure and the easy disassembly. In this case, the design code included the requirement for built-in walls to allow for future extension, which was adopted and developed by the architects in these types as demountable stud walls without services located within. Therefore, both the design code and the architects' initiative underpin practice in these designs. Again, the architects are seen to employ a common construction method to develop flexible construction in the external walls, through built-in lintel and frame openings to allow extension in the future.

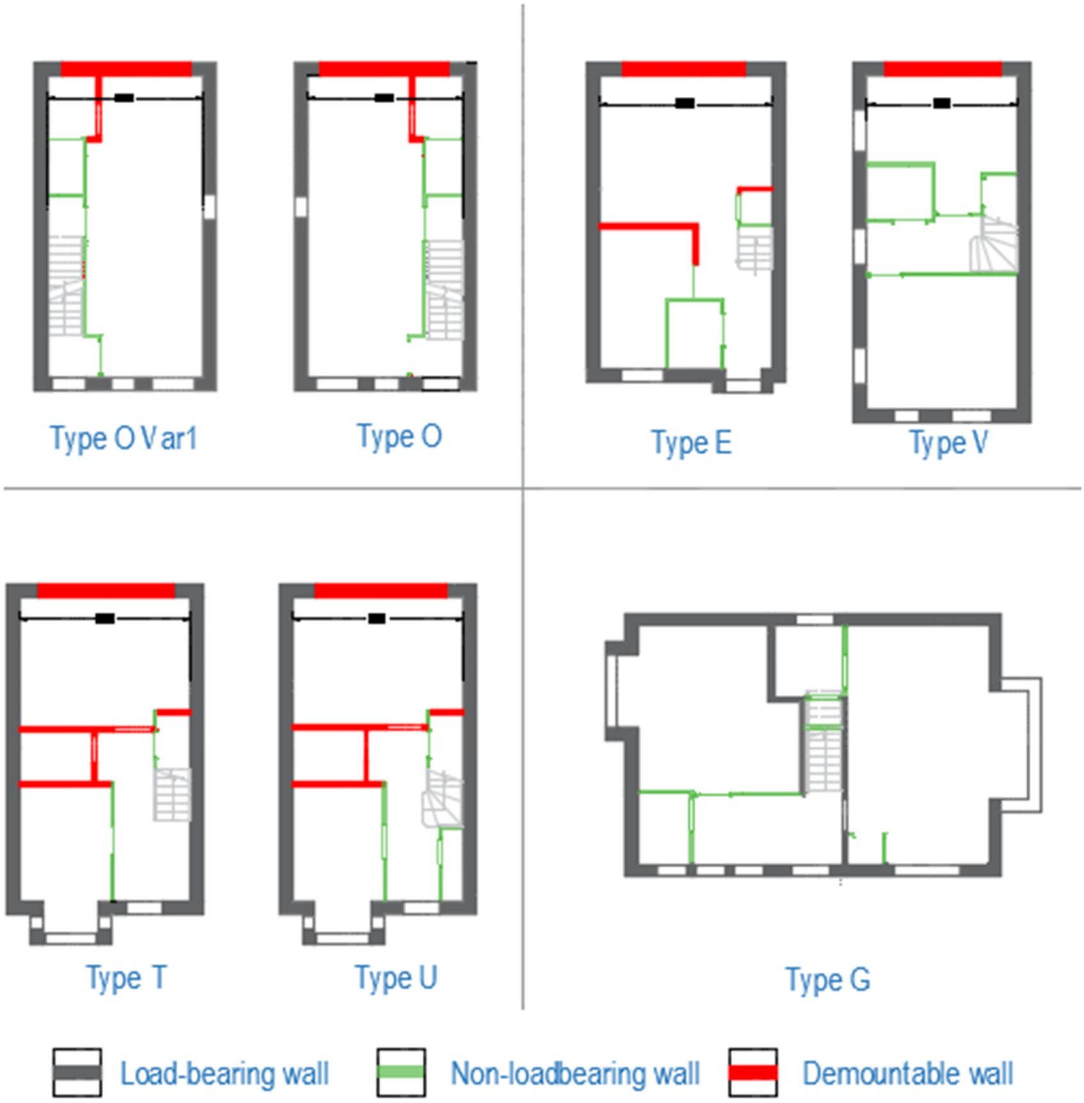


Figure 6.29: Different types of walls structure of the FEH types. Source: the architects (id Partnership Midlands) re-drawn and adapted by the researcher

Approaches		Criteria	Evaluation					
			G	O &O Var	T & U	E	V	Extension over garage
Extension into attic	Structure	Oversized floor to accept additional dead and live loading.	✓					
		Pre-framing of the floor for future extension of the staircase.	✓					
	Roof	Open roof structure.	✓					
		Pre-cut joints for roof lights.	✓					
	Foundation	Over capacity of foundations to accept additional floors.	✓					
Horizontal extension	External walls	Disconnected from the main structure.		✓	✓	✓	✓	
		Can accept future openings		✓	✓	✓	✓	
		Easily dismantled.		✓	✓	✓	✓	
	Foundation	Pre-installing foundations		✓	✓	✓	✓	
Vertical extension	Structure	Oversized floor to accept additional dead and live loading.						✓
	Foundation	Overcapacity of foundations to accept additional floors.						✓
Internal re-configuration	Structure	Separating structure from the infill parts.		✓	✓	✓	✓	✓
		Generating open clear spans.		✓	✓	✓	✓	✓
	Internal walls	Non-load bearing construction of the walls.		✓	✓	✓		
		No services located within.		✓	✓	✓		
		Ability for disassembly.		✓	✓	✓		
		Potential to create openings.		✓	✓	✓		
	Foundation	Allowing variations in the layout configuration on the ground floor.		✓	✓	✓		

Table 6.9: Evaluation of flexibility in construction of FEH samples of Tattenhoe Park site 1 development project. Source: the researcher

The analysis of flexibility in construction shows that the method of constructing FEH samples can be seen as fulfilling important requirements of flexible construction and facilitated the design approaches proposed by the architects, as the results show in table 6.9. However, it can be argued that such forms of construction cannot cope with unpredicted change due to certain limitations in terms of clear span and keeping separation between main structure and infill parts. While the method of construction allows creation of a main structure that can be separated from the internal partitions and provides clear spans in units of limited width (types with rear extension), it restricts such possibilities in the types of larger width (type G) as some internal loadbearing partitions are needed to support the structure, thereby limiting possibilities for future unpredicted change. In terms of external walls, the majority of these are constructed using loadbearing cavity brickwork, which means that these walls are unable to accept change over time.

On the other hand, the construction of internal partitions as stud walls allows the possibility of flexibility, and was used by the architects as a method to enable change without the need for specialist input. Conventional methods of construction also clearly enable installation of over-capacity of foundations and installing open roof trusses that allow flexibility for future vertical extension of the plan.

6.3.8 Flexibility in services

1- Pipes and wires

According to the interview with the architects, the only consideration regarding flexibility in services was to avoid services installation within walls that could be demounted for future adaptation (interview no. 6). In the FEH samples, the method of services distribution was conventional relays on, inserting the services within other construction elements such as floors, ceilings and non-demountable walls since there is no reference to a laying system, either horizontal or vertical, that could contain these different services. This means not only that the services systems were designed without considering whether they could be changed easily in the future, but also without consideration of future-proofing the building in terms of future technologies. The plans show that there is no space specified for installation of new technological developments. The design codes drew attention to the need for services and communications to be made ready for adaptation in the future (MKP, 2006, p. 17). In this regard, the architects noted that such considerations can add more cost to the building, which the developer was unwilling to contemplate (interview no. 6).

2- Appliances

According to the FEH plans, a wet system of radiators is the means of heating in this project. Theoretically, using radiators restricts the possibility for adapting the plan, whether in terms of internal configuration or furniture layout. However, since the services systems were not located on internal stud walls that could be demounted, as mentioned in the previous section, and the scenarios of change were worked out by the architects, the use of radiator elements can be considered in this particular case to have no restriction on the internal change of the FEH plans. The design codes show no flexibility requirements in terms of heating elements, therefore the architects decided to distribute the heating elements in a manner that would facilitate flexible design without the need to introduce a new system.

Since the LTH standards were among the design criteria followed by the architects in the designs of the FEH types, services controls such as switches, sockets, lift controls and so on were considered in terms of flexibility. In this respect, the plans clearly show, in the notes provided with the drawings, a requirement to locate the services controls at a height of 450-1200mm from the floor, so they can be used and reached by everyone, including wheelchair users. According to the analytical framework in Chapter 3, section 3.4, this directly addresses flexibility requirements in terms of services controls.

Consequently, there is no significant evidence of flexibility in services in the FEH samples, particularly in terms of the servicing system, due to the use of the conventional method of services distribution that tends to include the services within the structural elements rather than as a separate layer. This difficulty could not be surmounted by the architects, despite the design codes' attention to the need to provide services ready for adaptations in the future; this was because the cost implications were not welcomed by the developer. On the other hand, some possibilities for flexibility emerged in services elements because of the design codes' requirements to meet the LTH standards, including flexibility in consideration of services controls, and the architects' initiatives regarding flexibility in heating elements.

Category	Indicators	Criteria	Evaluation					
			G	O & O Var	T & U	E	V	Extension over garage
Pipes and wires	Pipes	Easy access to pipes.	X	X	X	X	X	X
		Location of services for future adaptations.	✓	✓	✓	✓	✓	✓
	Wires	Easy access to wires.	X	X	X	X	X	X
		Over capacity of services.	X	X	X	X	X	X
		Location of services for future adaptations.	✓	✓	✓	✓	✓	✓
Appliances	Heating and cooling	Suitable location of the heating and cooling appliances.	✓	✓	✓	✓	✓	✓
	Lighting (switches and lights)	Suitable location of the lighting appliances and their controls.	✓	✓	✓	✓	✓	✓
	Outlets	Suitable location of the outlets.	✓	✓	✓	✓	✓	✓

Table 6.10: Evaluation of flexibility in services of FEH samples of Tattenhoe Park site 1 development project. Source: the researcher.

6.3.9 Flexibility in use

The architects defined a range of scenarios of use that can be accommodated by their flexible designs of the samples. However, the samples differ in their ability to respond to the household's changing needs according to their flexible designs.

Flexibility in response to changes in households' demographic characteristics

Different opportunities for flexibility in response to changes in households' demographic characteristics can be seen through different FEH samples. According to interviews with the architects, the loft conversion units, such as type G, were designed to create additional bedrooms to support family growth in number (interview no. 6). The *Tattenhoe Park Design and Access Statement* document also explain that this type was designed to work on the principle of accommodating six people, and with the possibility for future extension into the attic space to accommodate four additional occupants (DWH and Idp, 2012, p. 63). In addition, the ability of flexible design of this type to provide more bedrooms in the future can be seen as responding to other demographic changes in the household, such as the need to give children of different gender separate sleeping spaces at a certain age. This also allows the design to respond to privacy requirements as children become teenagers, through providing more space so that children can independently pursue their own activities.

In the samples with rear extensions, such as types T, U, E and V, the *Tattenhoe Park Design and Access Statement* document states that the flexible designs of these types can allow creation of "more living spaces for a family growing in physical size", so the extra space can enable a family to carry out different activities at the same time (DWH and Idp, 2012, p. 64). In types T, U and E, the document explained that "there will be a particular benefit for children's homeworking in the kitchen being separated from the living room" (DWH and Idp, 2012, p. 64). Therefore, the flexible designs of these types were considered to respond to some changing requirements of children as they grow up at home.

In types L and K, the ability to create separated sections on the ground floor, thereby providing an en suite room with its own access, means the design has the flexibility to provide independent space teenagers can claim as their own, and responds to their increased requirement for privacy. With the ability to create future space through extension over a double garage in these types, additional play space can also be provided for children.

Since LTH standards were incorporated into the designs of different FEH types, these types can accommodate additional scenarios of use as household members grow older at home or become less physically able.

Cultural flexibility

According to the interview with the architects, the types with rear extensions such as T, U, E and V allow improved living space, so can accommodate the needs of community groups for additional space in their dwelling for large social gatherings. (interview no. 6). Therefore, the flexible design of these types through rear horizontal extension enables these dwellings to respond to different groups' socio-cultural needs based on patterns of kinship and social links.

The interview also revealed that internal adaptations in the large detached units, such as L and K, that enable creation of a separated ground floor en suite room with its own access in the future, can accommodate the socio-cultural need created when several generations of the same family want to live together. In addition, the architects pointed out that in these types the future atelier space, which can be obtained through creating a new space over the garage with its own access, gives households the flexibility to create a work space in order to work from home (interview no. 6). Therefore, the flexible designs of these types can be seen as responding to households' lifestyles in terms of live/work.

Economic flexibility

In types L and K, the ability to provide unallocated space with its own access through vertical extension over a double garage for potential non-residential uses such as an office or work place, as explained above, allows the design to respond flexibly to the household's future need for work space as their employment status and economic circumstances change.

Table 6.11 summarises the different possibilities for flexibility in use, along with the corresponding flexibility categories, which different FEH types can fulfil.

Flexibility in use	Scenario of use	Units type				
		G	O & O Var	T, U & E	V	L & K
Demographic	Family growth in size.	✓				
	Children development (privacy).	✓				✓
	Children development (activities).		✓	✓	✓	✓
	Gender structure.	✓				
	Ageing and disability.	✓	✓	✓	✓	✓
Cultural	Social gathering		✓	✓	✓	✓
	Accommodate elderly relative					✓
	Lifestyle (live/work)					✓
Economic	Space for economic activities					✓
Technical	X					

Table 6.11: The different possibilities for flexibility in use along with the corresponding flexibility categories. Source: the researcher.

Comparison of the results in the table above along with the main table on flexibility in use in Chapter 3, section 3.4, shows that a large number of the FEH types can only respond to a few of the household's changing needs. The types with rear extensions are the samples least able to respond to the household's changing needs. The limited size that such extensions can add to the plan alongside their location at the rear of the building and their relation with the external and the landscape all reduce their capacity to be occupied in different ways. The type with extension into the attic space (G) can accommodate only some demographic changes in the household, despite the generous space that can be added to the block, because of the architects' determination of how the space could be configured and used over time. Differently, the types with future unallocated space through vertical extension over a double garage present the ability to respond to more scenarios of flexibility in use because of the large amount of space that the extension could add to the house and the architects' strategy of keeping the space indeterminate in use, which allow the space to accommodate different scenarios of use. However, this type is limited by the absence of a direct connection between the space and the house, which minimises its potential for some scenarios of use, such as use as a bedroom to accommodate, for instance, growth in family size.

From the architects' perspective, such limitation is due to flexibility requirements of the design code that are more predictive of what people will need to do, rather than giving utmost flexibility for any number of changes to be made (interview no. 6). Despite the fact that the design codes may be built on the basis of a predicative approach in terms of the household's changing needs, as can be seen through matching of its flexibility requirements to suggested scenarios, the architects delivered flexibility in most FEH designs in a way that was deterministic in use, which limited the ability of different samples to accept different uses.

6.3.10 User empowerment

The flexible designs of the FEH samples allow the users to change their dwellings in the future so they can respond to changing needs after occupancy as they emerge. However, such user empowerment is limited across the different FEH types as the design approach that underpins flexibility in most of the samples is deterministic in use and form. For instance, in type G, where flexibility is achieved through an extension into roof space, the architects' scenarios for change considered how the roof space could be occupied by the user in the future. Therefore, the user has no say in how the space as a whole could be adapted or reused over time. In the types with rear extension, the deterministic design is reflected in use and form. The architects here considered a programmed approach that gives these extensions a determinate form and leaves the user with no choice as to how they want the extension to be used. In addition, despite the spaces that emerge from rear extension having a level of indeterminacy because of their size and proportions, the plans show that the architects determined how the spaces could be used over time in their scenarios of change. This reflects the architects' desire to maintain control over their designs, with the users acting as operators of architectural equipment rather than as determinators, which reduces the level of user empowerment. The design codes can be seen as contributing partly to this restriction of user empowerment due to their design approaches promoting hard forms of flexibility, such as through extension strategy that clearly suggested programmed forms of extension which impacted on the architects' designs.

On the other hand, in types L and K, while the architects determined how the extension over a double garage could be achieved, so flexibility is hard in form, they designed the space to be indeterminate in use, so it can be occupied according to the user's own terms, which reflects an approach of soft flexibility in use. This result can be referred back to the design code's indication that creating multi-purpose space is a key approach to achieving flexibility (see table 6.12).

Flexible Approaches	Unit Type	Type of flexibility	
		Form	Use
Extension into attic	G	Soft	Hard
Horizontal extension	O O Var1	Hard	Hard
	T	Hard	Hard
	V	Hard	Hard
	U	Hard	Hard
	E	Hard	Hard
Vertical extension	K	Hard	Soft
	L	Hard	Soft

Table 6.12: The different flexibility types in the FEH samples in terms of use and form. Source: the researcher.

6.3.11 Financial aspects

Cost

Interviews with the landowner and the developer both revealed that the incorporation of flexible design requirements into the construction work had cost implications (interview no. 4 and 7). The interviewees from HCA pointed out that the developer has set no material difference in price between the two house types (flexible or non-flexible), and the developer does not use flexibility as integral sales strategy in the market (interview no. 4). In this regard, they stated that FEHs are more expensive to build, but as this makes no difference to the price set by the developer, who is normally unwilling to use methods that add to the cost, this has an effect of depressing the land value, which in turn incurs cost for the landowner (interview no. 4). Hence, there is an economic limitation to flexibility related to land value and the developer's unwillingness to meet the upfront cost of building in flexibility. However, in this particular case the landowner was a social body with a motive other than financial return, which meant that such financial considerations had no impact on the landowner's willingness to continue delivering these requirements in future phases of the project, as the interviewees pointed out (interview no. 4).

The adaptations proposed in the FEH samples indicate the need for some construction work, particularly in terms of extensions, which means there will be a considerable cost to implementing these adaptations after occupancy. According to the interview with the landowner, the cost implications have been quantified only on the basis of immediate expenditure or initial cost (interview no. 4); therefore, the relation between the upfront cost and long term benefits of these adaptations cannot be determined.

Market

In terms of consumer satisfaction and the selling process, the developer pointed out that the customers had not expressed any interest in the flexible design of the homes either at the initial enquiry stage and/or at point of reservation, therefore at the time of the research it was not really a unique selling point (interview no. 7). According to the interview with the developer, customers are specific only regarding their current needs and generally not about those they may have in the future; they tend to move rather than adapt internal layouts. Therefore, the house's adaptability is not their main reason for purchase, which is still largely based on affordability, location, layout and current housing needs (interview no. 7). From the landowner's point of view, the developer also contributed to such an attitude by not considering flexibility as a selling point and not marketing the houses as flexible (interview no. 4). It can be concluded here that the flexible design of the housing in this project was not a cause of consumer satisfaction at selling point, and thus flexibility in the design had no impact on the selling process. This can be attributed to the consumers' interest being focused on their current needs rather than future ones, and their perception of adjustment through relocation rather than adaptation of their current home. Furthermore, the developer did not see flexibility as a means to increase the value of the houses and therefore did not promote it as an integral part of the selling recipe.

6.3.12 Conclusion

It is clear that the policy context has an influence on flexibility practice in this project. However, this factor was not sufficient to bring this initiative to the fore without other factors also playing a key role in delivering flexibility in housing designs in this project. In this particular case, national policy affected practice as it provided financial support from the government, which was possible as the landowner was a government body with links to the ODPM. Local policy, meanwhile, affected practice through encouraging and supporting the landowner's willingness to build according to certain standards for future adaptations (LTH standards).

Different motivations were found for the flexible design of housing in this project. In terms of policy, the local context motivated the implementing of some flexibility requirements (LTH standards) underpinned by local policy. The landowner's willingness, due to its social role as a public body, was also a key motivation to deliver these flexibility requirements as a response to a particular group who wished to own flexible housing. Another key motivation was the households' different and changing needs arising mainly from changes in household cultural resources within the different community groups in the context.

The analysis of flexibility in the design against the different concepts of the research framework revealed different possibilities and limitations regarding flexibility in the plan, construction, services user, and user empowerment across the different FEH types. The first possibility for flexibility is provided by the design code that set out the different principles and requirements for flexible extendable homes in this project, which provided guidance that aided the architects' efforts to achieve flexible design. However, the architects needed to create designs that could actually be of use to real users, which was a reason for turning to the different flexible design strategies of the design code. On the other hand, the design code was more about the promotion of design strategies that lead to flexibility in its hard guise, which the architects interpreted through applications that were deterministic in use and may reduce user empowerment in these dwellings.

The second opportunity for flexibility in the plan derives from the extension approaches that provide additional space to the plan, allowing the layout spaces in different cases to accept other forms and functions. In this respect, the analysis showed that an extension that provides more space with a level of independency and strategic location of the access to the addition has more possibilities for flexibility. However, the flexibility of the extension approaches was limited by site-specific privacy considerations regarding restriction on the number of openings allowed in the plan to provide light, which reduced the scope of functional and spatial flexibility in different cases.

Other opportunities and limitations emerged from design issues such as the need to change the central location of services in the plan, which may require additional work and restrict the potential of the plan. In addition, the limited width of the different layouts could restrict development of unpredicted scenarios for change in the future. On the other hand, the location of the entry door provided opportunity in different cases for a variety of layout forms. Moreover, the methods of construction provided various advantages that facilitated the architects' different scenarios for flexibility; in particular, the demountable stud partitions of the plan could be installed without using specialist techniques.

Financial assessment of the flexible housing in this project revealed a key limitation in terms of a reduction in land value because of the increase in upfront cost covered by providers. In market terms, flexibility in the housing design did not lead to higher consumer satisfaction or rapid sales of these houses at the point of purchase as the users' interest was focused on their current rather than their future needs and the developer did not consider flexible design to be a selling point.

6.4 Final conclusion

The debate about the motivations for adoption of flexibility in the case studies indicated that the flexibility initiatives in housing design were driven by different reasons. In the first project, flexibility in design was stimulated by a competition seeking new ideas for sustainable home and by the selected architects' interest in addressing the social and economic dimensions of sustainable design. Meanwhile, in the second project, the demand from a community group for housing that could cope with their changing needs and the developer's willingness to build high quality and well-designed housing were the key motivations for incorporating flexibility in the design. In both case studies, the flexibility initiative was linked to households' different and changing needs in the context. In the first project these were represented by social and economic household needs, whereas in the second case study the main focus was on households' cultural needs. There was little evidence in the first case of policy playing a role in motivating flexible design practices; however, in the second case study, policy appeared to have a greater influence in driving some flexibility requirements (LTHs) into practice.

In both projects, incorporating flexibility into the design depended on the delivery or the potential for delivery of more space through different means of extension that would allow the plans to be extended in size. The analysis showed that there was more scope for flexibility in plans where there was generous provision of space, a certain level of indeterminacy and independency in access and services and careful relation of the extension with the plan. On the other hand, potential for flexible design through extension in the second case study was constrained by considerations of land cover in terms of garden size and privacy considerations at site level. Another limitation related to the design code's lack of guidance on flexible design approaches appropriate for dealing with tight spaces.

Both projects fulfilled requirements for flexibility in construction through separating the main structure and infill parts and providing a clear span between the structural elements. This was possible because of the limited width of the housing types and the use of design approaches that avoided the need for external adaptations, as in the first case study. The key opportunities for flexibility in construction in both case studies arose from their use of light stud walls as internal partitions that can be easily dismantled, and the methods used to construct the foundations and roof structure. Meanwhile, in both projects it was found that the external walls generally cannot accept change because of the way in which the load is transmitted to the foundations across these walls. However, in the second project there was the opportunity to develop the construction to accept change in the area of the extension. In relation to services distribution, the design of the changeable internal partitions without services located within promoted flexibility. Moreover, in the first project the services were located in a separate layer attached to the permanent structure of external wall and therefore easily accessible for future change. However, in the second project, the conventional method used for services distribution would limit flexibility. In terms of appliances, the first project encouraged flexibility through the use of an underfloor heating system that avoided the need for location of heating appliances in the plan, while in the second project flexibility was considered through avoiding locating these appliances on the internal walls designed for change.

Both projects were found to offer potential for more scope for flexibility in use and user empowerment through their provision of generous additional space, with indeterminate use and with potential for independent access and services, such as in the first project, and extension over garage. However, the first project was found to offer more scope for user empowerment due to the soft form of construction that enables users to fill the space as they see fit, whereas extensions over garages have to be extended based on the architects' terms. On the other hand, the small amount of space provided by rear extensions was found to limit flexibility in use in these types, whilst in addition, the architects' delivery of flexibility by applying a scenario approach was deterministic of use of the space.

Regarding the financial implications of flexibility, assessment of cost of adaptation and deliverability of the two projects produced different results. In the first, the provision of ready to use space and internal light stud wall partitions of non-specialist construction methods and without services located within indicated that little or no cost would be involved in making adaptations over time. Meanwhile, in the second project, incorporating flexibility would incur cost mainly through future extension, due to construction requirements such as the pre-installation of foundations and the potential construction work involved in carrying out adaptations after occupancy. In terms of market, the main focus of the consumers on their current needs and the lack of the developer promotion of houses as flexible in the second project touch on key aspects of a lack of market awareness in regard to building performance as opposed to location, size and cost.

Chapter 7: Turkey case studies

7.1 Introduction

This chapter presents and analyses the selected flexible housing examples in Turkey: the Levent Loft 1 project in Istanbul and the Eayrman Third Stage development in Ankara. As explained in Chapter 4, section 4.2.3, these projects were chosen among some examples of flexible housing designs in the context, as they represent two unique projects that address the issue of flexibility in housing design differently according to the housing types in different contexts, and can therefore contribute valuable results for this research. This research task directly addresses objective 4, which is to analyse flexible housing experiences in Turkey, to explore the motivations for such practices in a context with less policy and regulation, and to discover the possibilities and limitations of flexible housing examples in this context. This is also of particular importance in addressing the main research objective, namely to identify lessons and relevant best practice in relation to procurement of flexible housing.

As the research in this context focuses on users' flexible housing experiences, a post-occupancy investigation of the projects was undertaken, given that the projects were complete and had been occupied for a period of time. The investigation included site observations and interviews with users as explained in Chapter 4, section 4.3. This is particularly important in discovering how the flexible design of the project has responded to the users' different and changing needs over time and to what extent the incorporation of flexible design principles was successful in achieving this end in a context where there is less policy and regulation to underpin these practices, but where the architects and developers took the initiative.

7.2 Housing provision in Turkey

In order to understand housing provision in Turkey, it is necessary to trace the development of the housing supply system through different stages from 1950. Three periods can be identified in the provision of housing supply in Turkey. During the first period, lasting from 1950 to 1984 and characterised by rapid industrialisation, fast growth in population and unprecedented migration from the countryside, the central government acted as a regulator rather than a direct provider, (Boratav, 1998). The public sector took responsibility only for disaster housing and lodging for public servants, whilst the private sector provided 95% of housing within the housing market throughout this period (Bolen, 2004, p. 17). Three forms of private sector providers were the source of formal authorised housing supply during this period.

Housing cooperatives were responsible for only 10% of the total housing production during this period due to the difficulties of finding serviced land within municipal territories. However, they were encouraged to respond to the housing needs of middle and lower-middle income people who were already integrated within the city and had regular salaries, using a system of credits from the Social Security Association. The Housing Estate Bank was responsible for only 1% of the total housing provision and targeted middle and higher-middle income people who had the ability to pay (Bolen, 2004, p: 18). Build-and-sell type housing provided the major method of formal housing production in this period, mainly catering for middle-income people. The process was based on partnership between small-scale builders and landowners of small sites, which made it possible to build and sell houses without the need to pay for the land. In this form of housing provision, stakeholders would attempt to maximise the total floor area, and thus increase the number of housing units on the plots (Bolen, 2004; Ozdemir, 2011).

Consequently, the different forms of private sector production were only able to provide for the housing needs of middle and higher income people, whilst the housing needs of lower income families were normally met through unauthorised buildings or squatter housing. Squatter housing refers to "houses that are constructed on mostly public and in some cases private land, without the prior permission of the authorities and without any regard to development plans" (Ozdemir, 2011, p. 1102). In 1966, the Squatter Housing Law was passed to reduce the prevalence of squatter settlements in urban areas; this provided the legal base for existing housing and increased economic interest in the urban land market. During this period, both authorised and unauthorised types of housing provision proliferated in an environment that lacked policy to underpin social housing supply and financial support for housing provision.

Between 1980 and 2000, the different sections of the private sector, such as middle-scale developers, large-scale construction firms, private individuals and housing cooperatives, and the public sector were all active in housing provision. Therefore, the government played an active role in housing supply in this period. This was underpinned by the Mass Housing Law that was amended in 1984 and the establishment of the Mass Housing Administration (TOKI), attached directly to the Prime Ministry, with an independent budget and financial support, and the objective of participating in house production (Ozdemir, 2011).

The number of houses built by housing cooperatives in relation to the total number produced was remarkable in this period, rising from 8.7% in 1980 to 25.2% in 1990 (Berkman and Osmay, 1996, p. 6). Build-and-sell housing provision, on the other hand, reduced dramatically due to the deficiency of serviced plots within the existing urban areas, the tendency of middle-income people to invest in the money market rather than real estate and the lack of financial support for small enterprises compared with large-scale construction firms. Priority was given to funding large-scale construction firms in partnerships with the Real Estate Bank (Emlak Bankası) to produce large-scale housing developments with multi-storey housing and high residential density (Ozdemir, 2011).

During this period unauthorised dwellings were still a source of housing for low income people who could not access the formal housing market. However, “the general pardon for unauthorised buildings which was issued in 1984” provided legal titles for these houses and contributed to turning these buildings into four storey apartments, thereby encouraging more illegal construction around major cities, covering 50% of their area (Bolen, 2004, p. 22).

Consequently, both legal and illegal developments were sources of housing in this period. The public sector intervened directly in the housing supply system through the establishment of TOKI for mass housing provision, whilst large construction firms were encouraged to provide large-scale housing settlements. Research conducted by the Turkish Undersecretary of Housing indicated that both legal and illegal housing contributed to the housing stock in the cities, and that without illegal housing there would be an acute deficiency of housing in most provinces of Turkey (Çanga, 2002).

In 2001, public sector housing delivery in Turkey was still negligible. In this period, TOKI lost its funding, which was completely transferred to the national budget. However, two years later various laws were amended by the government, and the concept of “urban regeneration” was introduced into Turkish planning legislation and this became popular with the public authority as a solution to problems of squatter housing through clearance and renewal. During this period, TOKI was directly administrated by the Office of the Prime Minister and all assets and duties of the former Land Office were transferred to

TOKI. Consequently, central government, which had acquired a strong stake in housing provision following the establishment of TOKI in 1984, now became a direct provider of housing (Ozdemir, 2011).

The concept of urban regeneration was also included in the administration's planning policy, and an Urban Regeneration Department was established within TOKI to accelerate urban regeneration projects. As a result, 295,000 housing units were built between 2003 and 2008 by TOKI and in the period up to 2011, 500,000 housing units were completed. Moreover, since 2004 TOKI has made great effort in urban regeneration of squatter housing areas, which has contributed to it becoming more directly involved in the provision of housing. During this period, TOKI gained more power in housing provision than the local authorities, since its relationship with central government gave it the right to use its own initiative to consider development plans in cases where they were rejected by the local authority. This housing supply system contrasted with housing provision throughout Europe as a whole, where housing policy had been decentralised to ensure a closer relationship with local actors, users and social housing providers (Ozdemir, 2011, p. 1106).

Overall, from 1950 to 2000, the public sector was not a major direct provider of housing in Turkey, and the private sector still played the main role during this period. However, at the beginning of the twenty-first century, the central government decided on policy that would encourage public sector housing provision, implemented mainly by large-scale construction firms and using the powers given to TOKI and local municipalities, to enable the public sector to become a direct provider alongside the private sector.

7.3 Planning system in Turkey

There are three broad levels of planning development in Turkey: national, regional and local. At each level, the development plan sets out land use policies, strategies that consider planning priorities and operational processes for completing the work. The degree of detail required increases from the top level downwards. Plans are prepared at regional and local levels in terms of area coverage and purpose, and "master plans" and "implementation plans" are considered at local level (Uiger and Yomralioglu, 2014).

At the national level, national objectives, the allocation of resources and priorities for district-level projects are considered in the development plan, whilst national land use planning does not include actual allocation of land for different uses. The national development plan includes the following three main components:

- Land-use policies, identifying the demand for land from different sectors including housing.
- Allocating national budget for implementing the development plan and distributing the different resources for national development.
- Considering legislation on matters such as land tenure, forest clearance and water rights.

The regional plan covers administrative districts and also the land areas that fall between national and local levels. The Ministry of Development is responsible for developing and preparing the regional plan, which in some cases has to resolve conflicts arising between national and local interests. The regional plan "is the plan that lays down settlement and land use decisions such as housing, industry, agriculture, tourism, and transportation in compliance with regional and national planning decisions" (Uiger and Yomralioglu, 2014, p. 5).

The local development plan, meanwhile, fits the plan to the details through the "master plan" and the "implementation plan". The master plan provides details on "things done on particular areas of land, what shall be done where and when, and who will be responsible" (Uiger and Yomralioglu, 2014, p. 5). The plan forms a basis for the development of the implementation plan and outlines different issues such as general land use, potential densities of the zones and building, development direction and magnitude and principles of various settlement areas, transport systems and solutions to transport problems. The implementation plan sets out the details of building blocks in the different zones, their density, streets, and implementation phases, to form the basis for land development implementation programmes (Uiger and Yomralioglu, 2014).

Consequently, the planning system in Turkey anticipates a sequence of plans ranging from national development plans, to regional plans and then local plans. Therefore, the flow of information is generally in an upper-to-lower-scale direction, with the level of detail increasing from the upper to the lower level, and thus the main policy determining the major lines of housing provision follows the same hierarchy.

7.4 The first case study in Turkey, Istanbul (Levent Loft 1 project)

7.4.1 Loft concept in Turkey

Loft buildings, which came about with the transformation of industrial structures into residential buildings, gradually began to be developed in Turkey at the end of the 19th century (Hizli and Mizrak, 2015). Loft buildings embody the characteristics of the open building concept – adaptability and flexibility – and thus have the ability to respond to the changing needs of users over time. According to Hizli and Mizrak (2015), there are different reasons to explain the evolution of the loft concept in Turkey, for example, the increased demand for residential use, de-industrialisation, rent increases, and the trend of designers and artists moving in to these old factories. This concept, which was developed after the industrial revolution in Turkey, gained much importance under the "loft style" notion, and has recently become a type of luxury housing. However, Hizli and Mizrak (2015) highlighted that many industrial buildings were destroyed due to the lack of relevant policies from local government. Thus it is possible to conclude that the policy and legislation contexts do not promote such types of accommodation; this concurs with the perspective of the participants in the design of the Levent Loft project. In Istanbul, the location of industrial structures within inner city spaces is one of the most important reasons for their recent transformation; second to this is the growth in renting of these construction skeletons for residential purposes. The loft concept has since become an inspiration for many architectural projects (Hizli and Mizrak, 2015). Among these projects, the Levent Loft 1 building in Istanbul, a focus of this research, is an example of flexible residential design in Turkey. So a key difference from the UK examples is that this involves adaptation of different building types.

7.4.2 The background of the Levent Loft 1 project

The Levent Loft 1 project is situated on Buyukdere Street, on Maslak-Levent axis, Istanbul, Turkey, which has been the business centre of Istanbul for the last decade (see figure 7.1). The building was converted from an unfinished office building to a residential block and the existing construction has been used as a basic structure for this purpose. The project was designed on the basis of the loft concept, offering together the functions of living and working within the same space and providing flexibility with regard to interior space. The first phase of the project, which included constructing the basic structural framework, was completed between 2003 and 2004 by Lnanlar Construction.

Transforming the project for residential use was the next step, which was undertaken by Tabanlioglu Architects, the designers for the project, and was achieved between 2005 and 2006. The project was built in phases from 2006 to 2007 and the construction was completed in February 2007 by Akfen Holding Co. Inc and Saglam Construction. On the plot behind is Loft 2, which was designed and developed by the same parties. The building was similarly designed based on the loft concept, but from the outset rather than as a transformation project.

Figure 7.1: Site plan of the Levent Loft 1 project. Source: www.open building.com, edited by the researcher.

The plans for the project show that the building consists of two towers with connections between them. The first construction faces the main street, and comprises 12 storeys, with a structure behind consisting of 8 levels, while the link has only 5 storeys (see figure 7.2). The building as a whole provides 146 units based on 21 different types in total, all of which have one or two storeys. The design of the units was based primarily on a modular system, and thus the units varied in size, ranging between 68 sq. m and 182 sq. m. They were built through attaching the modules differently (see figures 7.3 and 7.4). In addition, the building was designed to serve other purposes; the lowest basement levels accommodate parking and services and the ground floor has a restaurant in the front lobby and a gym, swimming pool and hammam (steam room) at the rear.

Figure 7.2: North elevation and external view of the Levent Loft 1 project. Source: Tabanlioglu Architects and www.architravel.com

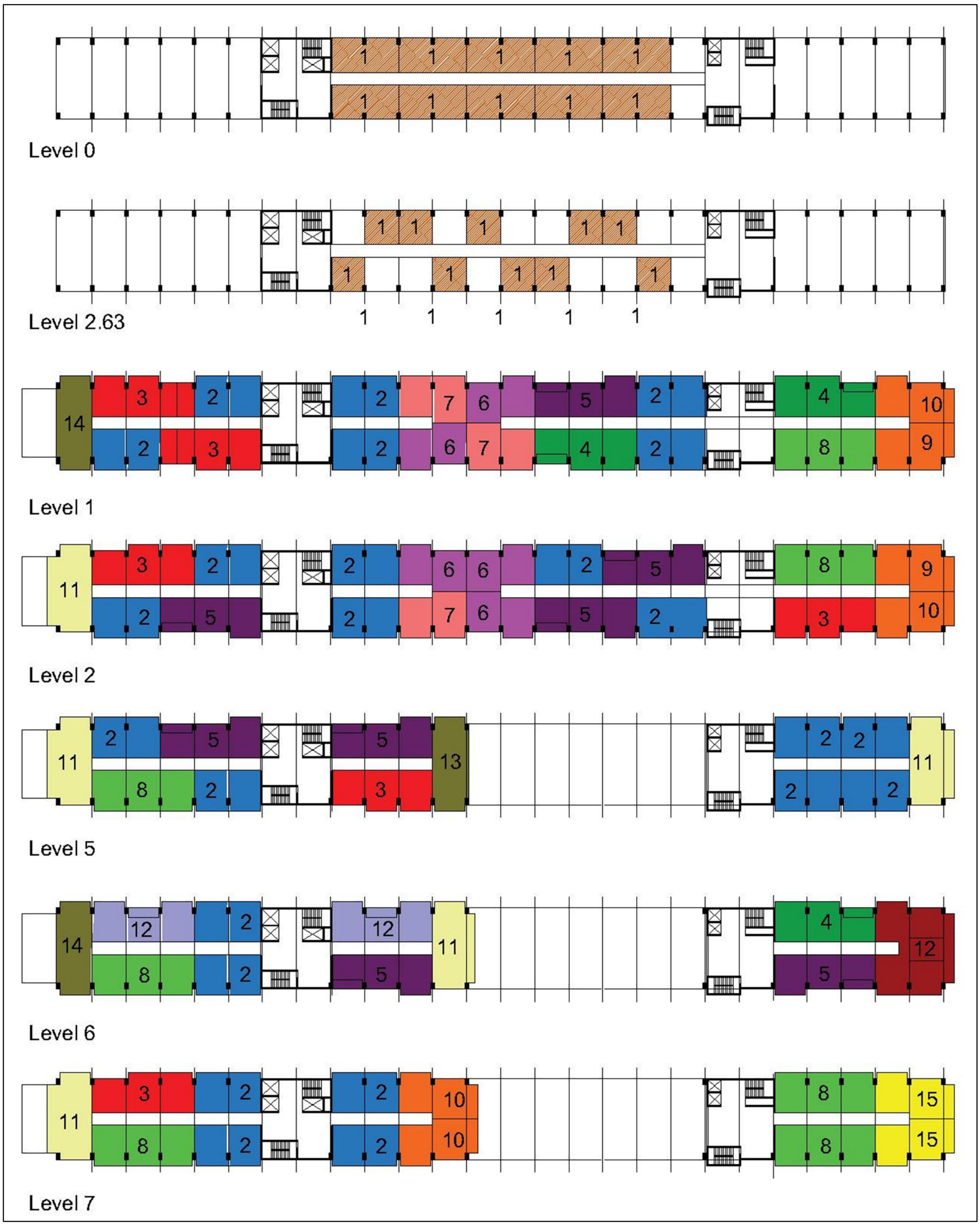


Figure 7.3: The distribution of unit types in the different floors of the Levent Loft1 project. Source: Tabanlioglu Architects, re-drawn and edited by the researcher

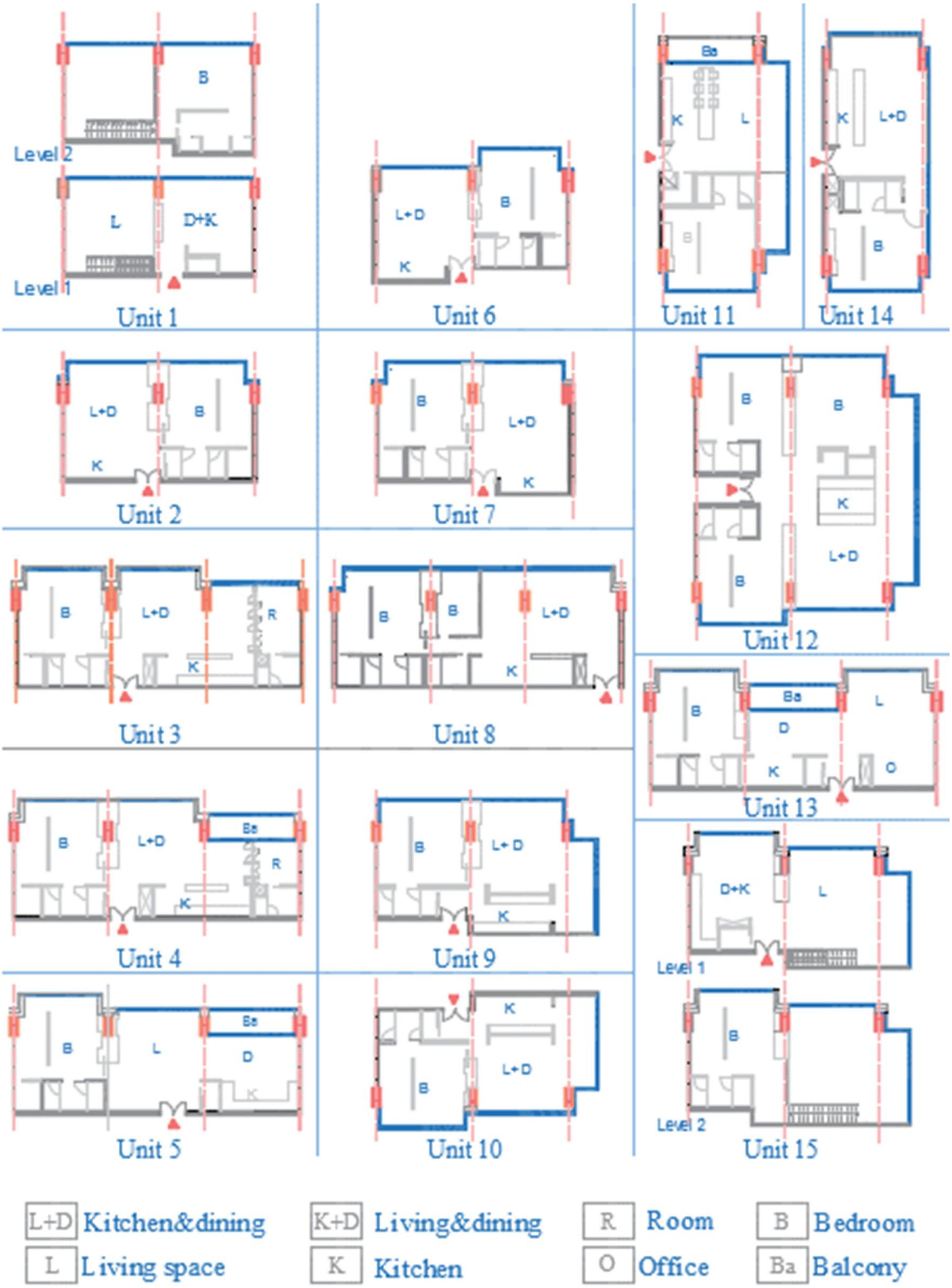


Figure 7.4: The different unit types of the Levent Loft1 project. Source: Tabanlioglu Architects, re-drawn and edited by the researcher.

7.4.3 Motivations for flexibility

There were different reasons for adoption of the loft style of flexible design in this project. One such motivation, according to the interview with one of the project team design, was the project's location in a business area of the city with increasing demand for residential use, an area moreover where many people desired live/work accommodation as a living pattern (interview no.8). The interview with the sales agent revealed that financial return on the investment was another motivation for using loft design in this project, deriving from the demand for such accommodation (live/work) on the market (interview no.9). It also seems that the architects' interest in innovative design of residential buildings was a motivation to design using this concept, according to the following comment: "Tabanlıoğlu Architects develop innovative, yet efficient and economically viable design alternatives for residential buildings…...and transformation projects considering the uniqueness of the place and the individuality of requirements" (www.tabanlioglu.com).

Therefore, the users' demand for living accommodation in the area that is adaptable for live/work scenario was the key driver for adaptive reuse of the building and using loft style of flexible design in this project, which can respond to the household's desire of live/work lifestyle and need for accommodating economic activity within their homes. According to the finding in Chapter 2, section 2.6 this scenario can be related to households' cultural and economic characteristics (see table 7.1).

Household need	Sub-sources of household need	Main sources of household need
Live-work	Economic activity	Economic
	Lifestyle	Culture

Table 7.1: Motivations for incorporating flexible design in the Levent Loft 1 project to address household's changing needs. Source: the researcher.

7.4.4 Flexibility in the plan

A- Building

1- Flexibility in unit mix

As mentioned above, the building's dwellings were arranged as two rows of units within an open structure in the building and along a longitudinal corridor placed in the middle. Meanwhile, the services zone for the units was placed on one side along the communal corridor, which freed up the internal space and shared walls between the units. This means that each unit can potentially be joined to another, and thus the building has the ability to accept change in its unit mix over time (see figure 7.5). The possibilities and constraints on this flexibility are explained in detail in the following sections (Flexibility in unit size).

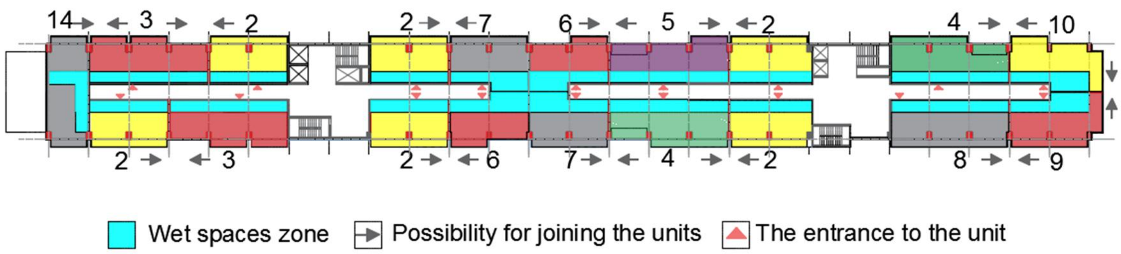


Figure 7.5: The different possibilities for joining units together in the Levent Loft 1 project. Source: the researcher.

2- Flexibility in building use

Since the building was an unfinished office building that was converted to residential use, this indicates that the design of the building has potential for flexibility in terms of building use. The research analyses the different possibilities and potential limitations regarding such flexibility in the design of the building.

The plans show that the basic floor plan of the building provides an indeterminate large open space without structural elements located within, which means that the plan can be functioned in different ways. This can be attributed to the beams and columns construction that spans large distances between the structural elements and provides for such open floor plans. This form of construction allowed the architects to create units with open space, different sizes and configuration rather than dividing the space rigidly into sections.

In addition, the two separated services cores, one in each building tower, provided two access points to the building, which can be seen that facilitating the use of building structure to accommodate different building types. The generous dimensions and different means of vertical access to the building via two staircases and two or three lift shafts in each services core make the building able to respond to access requirements of different building types, as well as the potential of separate means of escape (staircase) that residential and non-residential buildings require to comply with fire regulations, as an interviewee pointed out (interview no.8).

The simple form of the building, long and thin like a train, can also be seen as facilitating the ability of the building to accept different building types. In a case of building conversion into housing, it allowed to introduce natural lighting and ventilation into all habitable areas. However, the limited depth of the existing structure required making extensions beyond the building shell to facilitate providing the units with suitable width. The two services cores in the basic structure of the building were designed with shafts for vertical services distribution; therefore, the services are limited to these core areas. In this respect, the interviewee pointed out that adding an additional vertical shaft to serve the habitable space was not possible due to the difficulty in penetrating the floor structure (interview no.8). However, the architects reused the existing central shafts to distribute the services vertically to each floor and then the distribution of the horizontal runs through suspended ceiling in the communal corridor and over the services zone of the units, which was possible because of the sufficient height of the building storey (3.1m).

Since the building was previously unfinished offices, there was no need for conversion work on the façades. Along with the structural system of beams and columns this gave the architects a certain freedom in designing the external appearance. In this respect, the architects integrated extensions into the basic structure that inserted an assortment of boxes into the building façade. According to the interviewee, this allows the occupants to identify their own dwelling from the outside. However, due to the curtain system and floor to ceiling operable windows, the building façade was not strongly identifiable as a residential building, which means that it could support future conversion of the building into non-residential use, without major interventions (see figure 7.6).

Figure 7.6: Flexibility in building use of the Levent loft 1 project. Source: the researcher.

B- Unit types

The plans show different types of units across the different floor levels, designed according to a modular system. Generally, three different types of units can be recognised: 1) units with two modules that consist of a separate double bedroom and living dining kitchen space, such as types 2, 6, 7, 9, 10, 11 and 14, 2) units with three modules and either one or two bedrooms, such as types 1, 3, 4, 5, 8, 13 and 15, and 3) units with four modules that provide three double bedrooms, such as type 12. The architects designed the units around the loft concept to create adaptable space for live/work occupation. Therefore, the research examines this designing approach to discover the possibilities and constraints regarding its ability to achieve the different types of flexibility.

1- Flexibility in size

Since the building is a multi-storey block and each floor contains a number of units, some of which have external open areas (balcony), this means that there may be opportunities to change the size of the units in ways such as joining units to each other or adding the external open area (balcony) to the interior space of the unit layout. Therefore, the research examines the ability of the units to accept such change through discussing the opportunities and obstacles regarding flexibility in size in this project.

In terms of joining units together, the plans show some possibilities for combining two adjacent units, such as in types 2, 3, 4 and 6. First, placement of the services core (kitchen, bathroom and toilet) as a linear band along the shared wall with the external corridor on the side of the unit means that it will not restrict the combining process. Second, after joining of the units, unneeded services such as the second kitchen can be removed easily as the parts were designed for disassembly. In addition, the open space design of the unit around a modular system allows the internal space of combined units to be reused in different ways. On the other hand, the design of the partitions between the units may both facilitate and constrain the joining process. Whereas the partition is a non-loadbearing wall because of the open structure of beams and columns, and it can therefore be removed or adapted when necessary (see figure 7.7), the blockwork design of the wall with services located within would make any adaptation a complicated process requiring additional constructional work. In this respect, the interviewee from Tabanlioglu Architects pointed out that some units can be joined because of the way they are arranged in the plans and the use of the modular system, although achieving this was not a key target of the project, and the party walls were designed with a blockwork for the requirement of fire and acoustic requirements (interview no. 8).

In terms of the dividing up process, there are a few samples that would accept division into two smaller units, while the limited size of other units means that this is not a viable option. However, in large units such as type 12 combining units is a possibility. The plan shows that the design of the communal corridor in the middle of the building and the central location of the large hall would facilitate this process, as it would enable the provision of an independent entry door to the units after division. Moreover, the plan could provide two independent services spaces to serve the two divided units because the kitchen's central location allows its division into two separate kitchens. This possibility for division can be seen in type 9, which has already been delivered as two separated units.

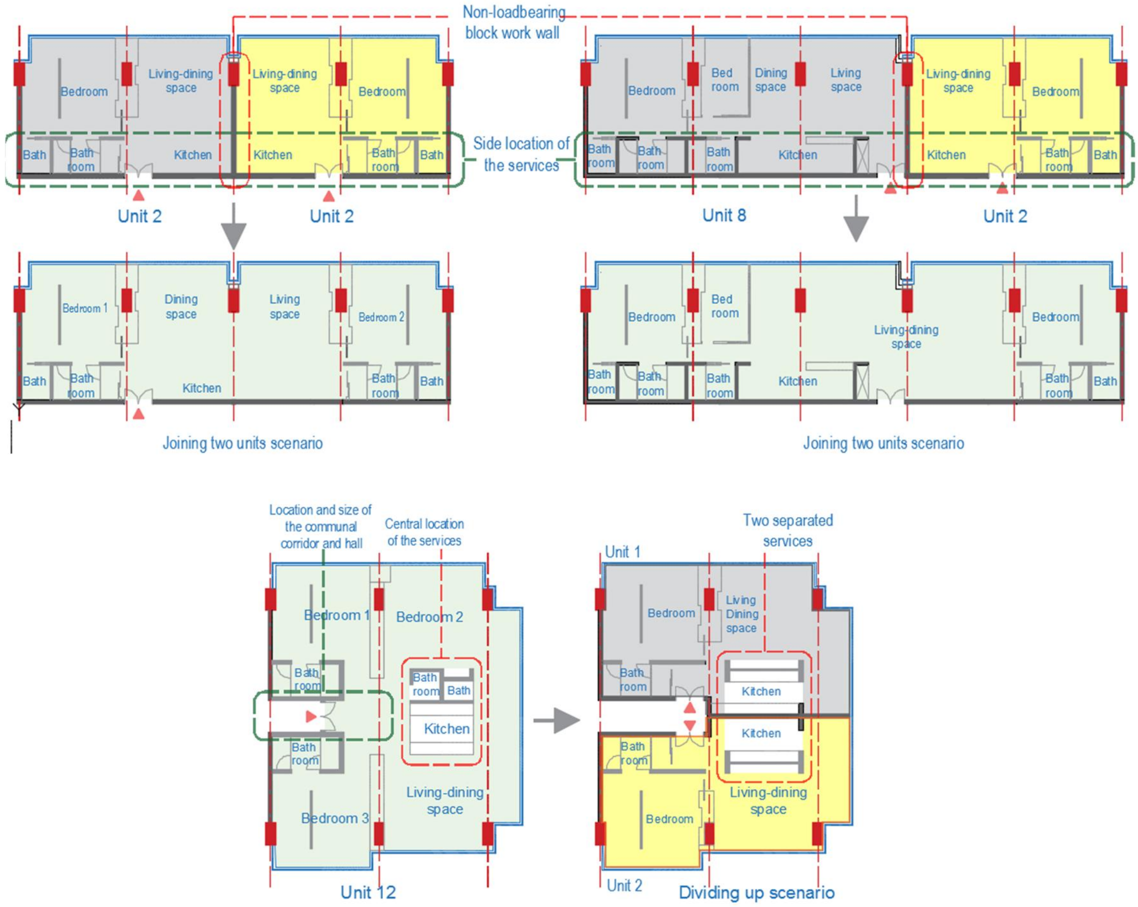


Figure 7.7: Scenarios showing flexibility in unit size through joining and division in the Levent loft 1 project. Source: the researcher

Regarding the possibility of adding external open spaces such as the balconies in unit types such as 5, 11 and 13, the plans show that this could be facilitated by use of the floor to ceiling operable windows as an external shared wall along the balcony, as these could be removed easily as required. The logical relation between the balcony space and internal unit space is another factor that would serve this form of extension. Despite these design considerations and the building's structure indicating the above possibilities, balcony enclosure is prevented by building regulations and by the architects' desire to prevent users from interfering with external appearance of the building, as an interviewee pointed out (interview no. 8).

Consequently, changing the size of the units can be potentially achieved only through joining units together. This was possible due to the beams and columns structure that provides a large open floor space that allows the units to be attached through non-loadbearing party walls. Another reason resulting this possible for change is the architects' design approach that considered strategic placement of the services as a linear band along a central corridor, thereby freeing the party walls between the different unit types for change. However, the key limitation arose from the use of blockwork in the unit to unit walls, which means that knocking out the party walls would require major construction work.

Moreover, increasing the size of the unit through adding the available external open space is not a viable option in this project because of building regulations and the architects' desire to maintain control over the external appearance of the building. On the other hand, dividing up the units is not really a viable option in this design as many of the units are of limited size and the design approach is not conducive to this kind of change in the building.

2- Layout arrangement

Functional flexibility

The plans show that a small number of the units has equal sizes of spaces such as types 2, 6 and 7 that consist of two modules, whereas the layouts of the other units, particularly the units with three modules such as types 3, 4, 5, 8 and 13, generate different room sizes and proportion, which means that their plans are more appropriate for particular functional layouts. In the types, such as 9 and 10, the different forms of the layout's spaces are seen that make the plan of these units are more predetermined in functional layout. On the other hand, the limitation of the plans to achieve functional flexibility in the other types such as 1, 11, 13, 14 and 15 can be seen due to the lack to independent access to some layout spaces, which restrict the ability of the plan to accept different way of occupation. Therefore, the beat practice for functional flexibility through the layouts of the units is limited to a few opportunities in the units with two modules that also allows independent access to the different layout spaces. This can be attributed to the architects' design approach that specifically focused on the provision of adaptable space to facilitate live/work occupation which defined the layout of the units as adaptable space for live and work (living space) and space for residential use (bedroom)

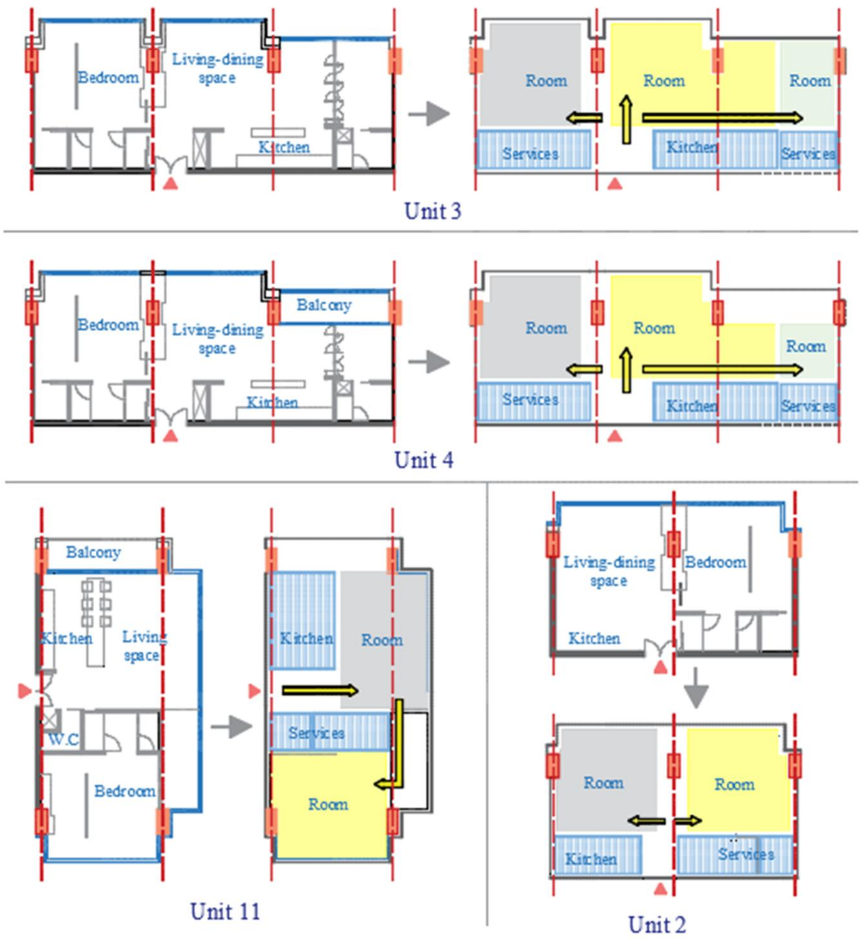


Figure 7.8: Analysis of functional flexibility in selected units of the Levent loft 1 project. Source: the researcher

Spatial flexibility

Although the architects did not consider any particular scenario for internal re-configuration, the plans show that the design has ability to accept change in the internal space arrangement. This can be achieved because of the large clear spans of the structural system that freed the internal space of the unit form the potential of loadbearing walls and the use of light internal partitions such as wall as furniture, sliding walls and stud walls that can be removed or moved around easily when needed, and thus the creation of another layout configuration either on a permanent or a temporary basis. In addition, the location of services spaces as a linear zone on one side along the central corridor of the building permits internal change without restriction. Therefore, the creation of different internal configurations of the units is possible through the design of the different units' layout, and thus the plan can be considered as having spatial flexibility at the unit level (see figure 7.9).

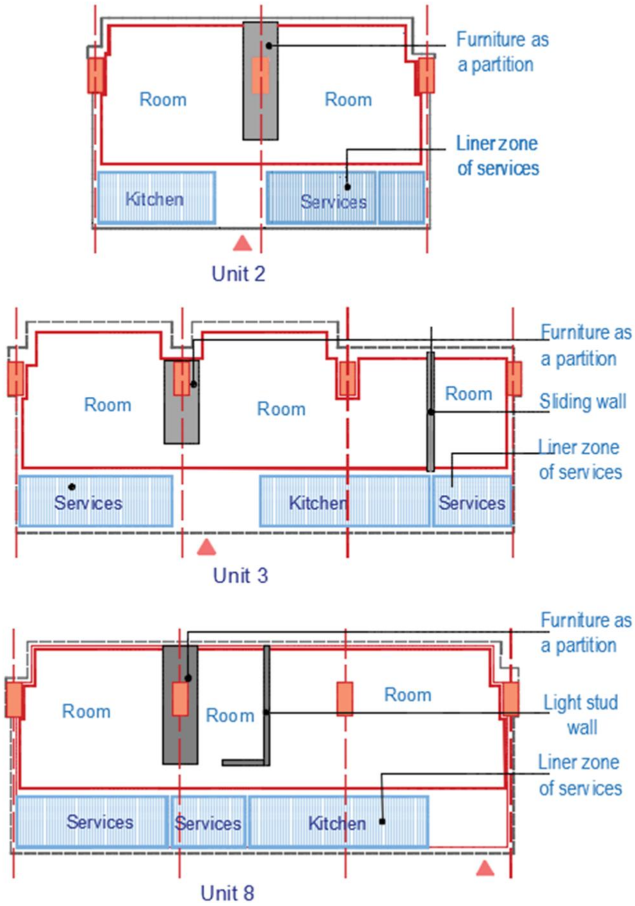


Figure 7.9: Analysis of spatial flexibility in selected units of the Levent loft 1 project. Source: the researcher

Internal circulation

The plans show that only a few building units such as types 3, 4, 8 and 13 were designed with a main entrance, whereas in other units the main door opens directly onto the living space. However, in the units, which have a main entrance space, this space is designed with a view to it having another use, such as for storage (see figure 7.7), which means that the design approach considered alternative uses for the horizontal access spaces, where this possible. The vertical access of the duplex types only allows for an internal staircase, without any reference to potential for future installation of a lift, meaning that the plans of these units cannot be considered as having flexibility in vertical circulation. According to the interview with one of the project team members, there is no building regulations requirement to consider such provision in the design (interview no. 8).

C- Room

1- Flexibility in function

The plans show that the sizes and proportions of the live/work room's spaces in the units were developed using a modular system based on a structural grid of (5.45m). This resulted in the size of room spaces varying from one module, one and a half modules and two modules. To increase the size of the rooms' spaces, the architects added an extension of around 1.3m to most of the rooms across the full width of the module to make the sizes and proportions of the spaces more appropriate for accommodating a live/work activity. Therefore, the spatial design of the adaptable space in terms of size, proportion and form allows the space to accept different way of occupations. The plans also show that the adaptable space of some units such as types 3 and 4 was designed with the ability to be increased in size temporarily through the possibility of adding half module by using sliding walls between the spaces, which increase the functional flexibility of the space when this needed. In addition, the design of the external walls as floor to ceiling operable windows provided an ample source of light to allow the living room to function as a work space.

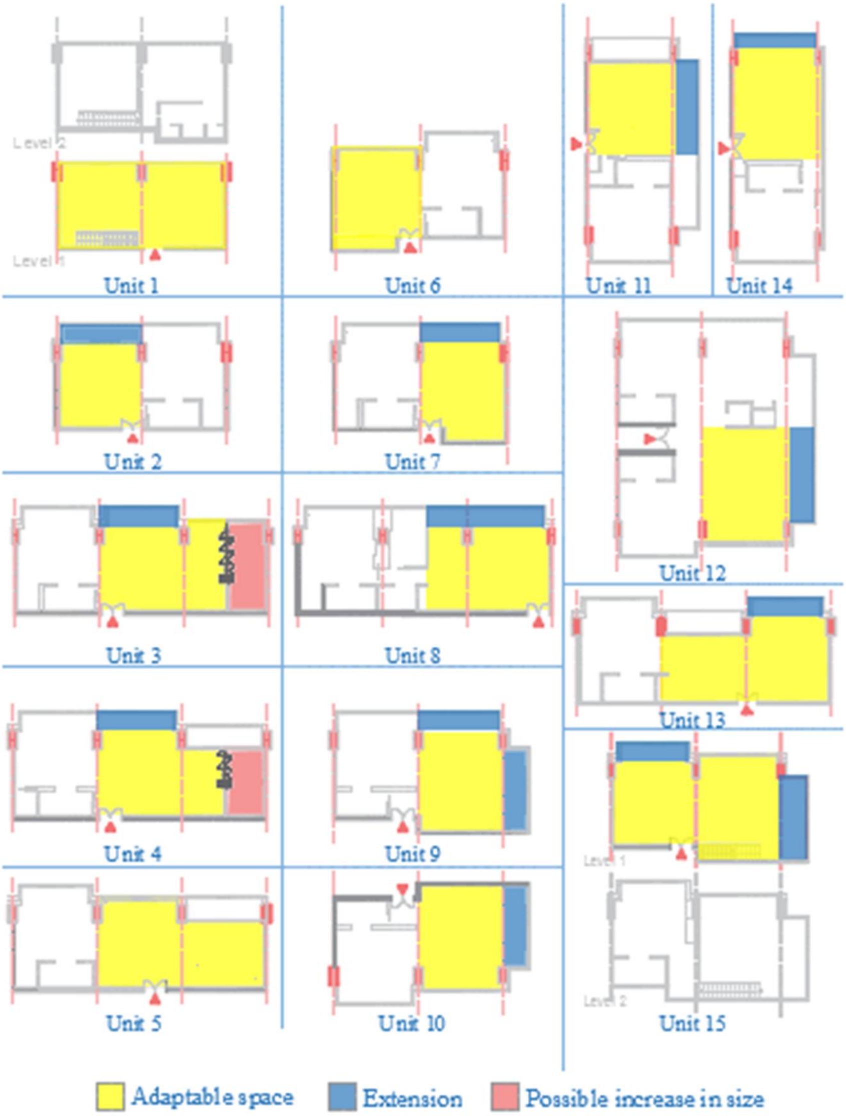


Figure 7.10: Different types of adaptable rooms in the Levent loft 1 project. Source: the researcher.

2- Flexibility in connection

The plans show different possibilities for flexibility in room connection. This can be attributed to the design of the units' internal partitions as sliding walls, wall furniture and lightweight dividers that can be changed, removed or moved around easily as required. For instance, the use of wall furniture as a divider between the bedroom and living space in such as type 2 allows these rooms to be connected to each other because the wall furniture can be disconnected from the floor and ceiling for easy dismantling. In the case of the sliding wall used in such as types 3 and 4, the room can be connected to the adjacent space via a large opening on a temporary basis (see figure 7.11). However, this type of sliding wall does not permit creation of a completely open space between the rooms as it cannot be hidden in a wall pocket. The location of the services on one side also facilitates the ability of adjacent rooms to be connected to one another as explained in the section on spatial flexibility.

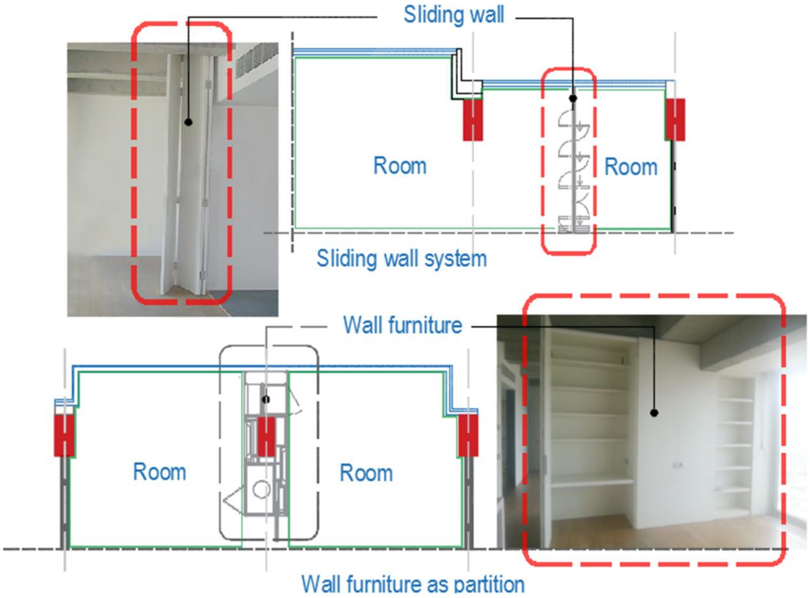


Figure 7.11: Flexibility in connection between rooms in the Levent loft 1 project. Source: the researcher.

3- Flexibility in furniture

Despite the good sizes and proportions of the adaptable room spaces of the units, flexibility in room furniture is restricted in the design for two key reasons. As mentioned above, fixed wall furniture was used in unit types such as 2, 3, 4, 5, 6, 7, 8, 9, 10 and 13 as a divider to separate the spaces. This wall furniture contains storage units to facilitate live/work scenario (see figure 7.12), which constitute determinate elements and therefore reduce the ability to furnish the room in different ways. Another restriction on the flexibility of room furniture is the floor to ceiling curtain wall or operable window that forms the external wall of each room, which restricts placement of furniture on this wall. Therefore, the room designs cannot be considered as providing flexibility in furniture placement. It is clear that flexibility in furniture was limited by the design practice applied to this non-residential building of using curtain walls and certain flexible features (internal walls as furniture) that determined the way in which the room could be furnished.

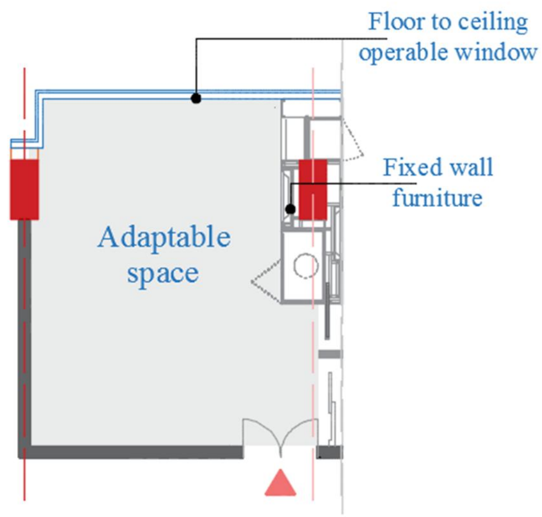


Figure 7.12: Flexibility in room furniture in the Levent loft 1 project. Source: the researcher

In summary, flexibility in the plan for this project is embodied mainly in the ability of the design to be adapted for different building types (residential and non-residential). The analysis identified different factors in the design of the building that facilitated this ability for change. The first is the columns and beams construction that allows a separation between the main structure and infill parts. The second is the ability of the structure to span large distances without requiring internal loadbearing. Another factor is that the simple form and adequate depth of the building render it suitable for different building types. The non-residential standards on storey height and presence of a services core with a possible means of escape for fire protection are other factors that rendered the building suitable for conversion. However, a limitation emerged from the difficulty in penetrating the building floor to add vertical shafts, which meant that vertical distribution of the services required reuse of the central shafts.

Despite the different opportunities that the building could provide for change in unit size, the architects did not consider such flexibility in the plan. While possibilities such as joining two units together may be available, there is a key restriction in terms of the ease of creating an opening within the party walls between the units. On the other hand, the possibility for extension into external open areas was restricted not only by the architects' desire to maintain control over the external appearance of the building, but also by building regulations that would prevent such change in the building.

The design's potential flexibility in function was seen clearly at room level through the design of the adaptable living space with a generous size and proportion that allows space to be occupied in different ways; however, the analysis revealed that the extent to which the different units can accommodate a variety of functions is limited due to the design approach that sought to defined the layout's spaces of the units' in term of the scenario approach of the design. Nonetheless, the plans show the ability of the units' design to achieve the best practice of spatial flexibility due to the strategic location of the services and internal light weight partitions (see table 7.2).

<table>
<tr><th>Category</th><th>Indicators</th><th colspan="2">Criteria</th><th colspan="15">Evaluation</th></tr>
<tr><td rowspan="9">Building</td><td rowspan="2">Unit mix</td><td colspan="2">Can accept joining together of some units.</td><td colspan="15">P</td></tr>
<tr><td colspan="2">Can accept division of some units.</td><td colspan="15">P</td></tr>
<tr><td rowspan="7">Use</td><td colspan="2">Indeterminate open space.</td><td colspan="15">✓</td></tr>
<tr><td colspan="2">Adequate floor height.</td><td colspan="15">✓</td></tr>
<tr><td colspan="2">Appropriate building form.</td><td colspan="15">✓</td></tr>
<tr><td colspan="2">Services core.</td><td colspan="15">✓</td></tr>
<tr><td colspan="2">Services system.</td><td colspan="15">P</td></tr>
<tr><td colspan="2">Building façade.</td><td colspan="15">✓</td></tr>
<tr><td colspan="2">Means of escape for fire protection.</td><td colspan="15">✓</td></tr>
<tr><td rowspan="10">Unit</td><td rowspan="10">Size</td><td rowspan="5">Joining</td><td>Criteria</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td><td>11</td><td>12</td><td>13</td><td>14</td><td>15</td></tr>
<tr><td>Generous shared access.</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>Careful location of services space.</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>Connection between units.</td><td>P</td><td>P</td><td>P</td><td>P</td><td>P</td><td>P</td><td>P</td><td>P</td><td>P</td><td>P</td><td>P</td><td>P</td><td>P</td><td>P</td><td>P</td></tr>
<tr><td>Logical combination</td><td colspan="4">2&2</td><td colspan="4">2&5</td><td colspan="4">2&8</td><td colspan="3">2&13</td></tr>
<tr><td rowspan="5">Division</td><td>Criteria</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td><td>11</td><td>12</td><td>13</td><td>14</td><td>15</td></tr>
<tr><td>Suitable size.</td><td>X</td><td>X</td><td>✓</td><td>✓</td><td>✓</td><td>X</td><td>X</td><td>✓</td><td>X</td><td>X</td><td>X</td><td>✓</td><td>✓</td><td>X</td><td>X</td></tr>
<tr><td>Independent access for the divided units.</td><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td><td>✓</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>Independent services spaces in each unit.</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>Considerable location of the windows.</td><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td><td>✓</td><td>X</td><td>X</td><td>X</td></tr>
</table>

		Criteria		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Layout arrangement	Functional flexibility	Layout spaces of adequate size.	✓	✓	X	X	X	✓	✓	X	X	X	✓	✓	X	✓	✓
			Adequate proportions for the layout spaces.	✓	✓	X	X	X	✓	✓	X	X	X	✓	✓	X	✓	✓
			Independent access to the layout spaces from the main entrance.	X	✓	✓	✓	✓	✓	✓	✓	✓	✓	X	✓	X	X	X
		Spatial flexibility	Strategic placement of the services core.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
			The ability of internal partitions to be moved around.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		Internal circulation	An appropriate size of access space.	X	X	✓	✓	X	X	X	✓	X	X	X	✓	✓	X	X
			Suitable dimensions of space to enable its use by different groups of people.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
			The possibility of adding a lift as an additional vertical access means.	X														X
Room (live/work) space	**Function**	Suitable size and proportions for the room.		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		Simple form for the room.		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		Ample light that fits different functions.		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Connection	The potential for providing new way of connection in the future.		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Furniture	Adequate dimensions and proportions for the room.		✓	✓	P	P	P	✓	✓	P	✓	✓	✓	✓	P	✓	✓
		Clear internal space.		P	X	X	X	X	X	X	P	X	X	X	P	P	X	P
		Size and number of windows for the room.		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Table keys ✓: Achieved X: Not achieved P: Partly achieved

Table 7.2: Evaluation of flexibility in the plan of the Levent Loft 1 project. Source: the researcher

7.4.5 Flexibility in construction

Structure

The main structure of the building consists of reinforced concrete columns, beams and slabs, and two services cores enclosed by reinforced-concrete loadbearing walls which contain vertical shafts for services distribution. Thus, all the external and internal walls are non-loadbearing, except the walls around the vertical services cores, which means that the main structure can be separated from the different infill parts of the building including the internal and external walls and services systems. In addition, the plans show that the columns are located on the periphery of the building and have a span of 13m through a structural grid of 5.45 m. This enables the building structure to provide clear large spans across its width. Another important aspect of the structure is that it was extended by adding aluminium projecting bays placed on a steel structure reaching across the main floor of the building, which means that the structure is capable of accepting additions. Therefore, the structure of this project complies with different principles of flexible structures according to the analytical framework in Chapter 3, section 3.3. This can be attributed to the skeleton system of the structure that keep a separation between main structure and different infill parts including external walls. Another advantage regarding flexibility is that the non-residential standards applied to the original structure provided large clear spans between the structural elements, thus creating an indeterminate open space suitable for different layout configurations.

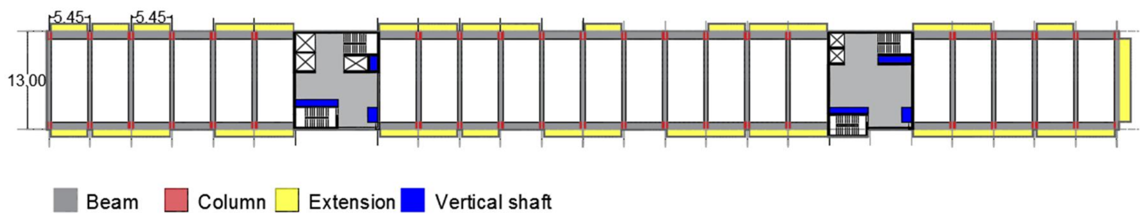


Figure 7.13: The support structure of the Levent Loft 1 project. Source: the researcher.

Foundations

Since the building was designed with several underground levels for services, the foundations have no link with residential floors. Therefore, in this project the type of foundation has no impact on internal change of the ground floor (see figure 7.14). In terms of over-sized foundations, this is a possibility here because this formerly non-residential building has foundations that can accept overload in relation to residential use. This factor permitted the architects to add an upward extension over the top roof prior to occupancy, as is explained in the following section.

Roof

The plans show that the top roof has been partly covered with a flat concrete slab that has been extended by metal slab construction to cover an extension in the top roof (see figure 7.14). Therefore, the existing construction of the top floor is capable of accepting upward extension. This can be attributed to the fact that non-residential buildings are generally constructed to accept more dead and live load on their floors than residential buildings, which thus allowed for the vertical extension made by the architects prior to occupancy.

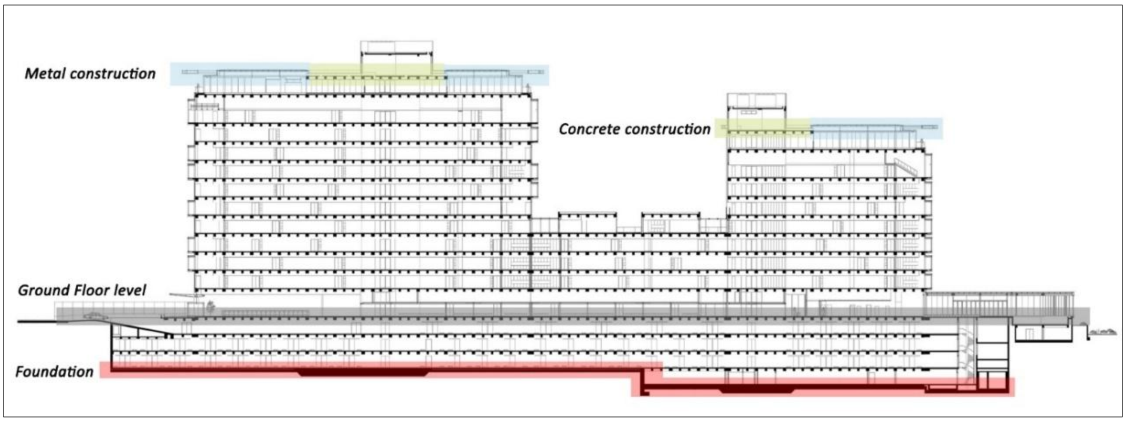


Figure 7.14: Section and external views of the Levent Loft 1 project. Source: Tabanlioglu Architects, edited by the researcher.

Internal walls

According to the plans, different types of internal walls were used to achieve separation between the units and their internal spaces. Unit to unit party walls were incorporated as non-loadbearing blockwork as mentioned in section 7.4.4. While such construction meets the key requirement that flexible internal wall structures should be non-loadbearing, it does not consider the need for easy dismantling of the partitions. This can be attributed to regulations on fire and acoustic separation requiring more robust internal wall structures. The architects' use of conventional blockwork construction for these partitions limited the walls' potential for flexibility.

Three different types of internal partitioning were used to separate the interior spaces of the units. The first main design type was wall furniture that was generally incorporated between the bedroom and living dining area and which can be used as storage space and includes a TV unit in some cases. This partition was designed as a kit of parts (shelves, storage doors, etc.) that can be easily dismantled when necessary. However, some electrical services such as outlets were located in the partition, and dismantling these may not be straightforward. The second type is a sliding wall that was used as a divider between some small rooms and the living dining space in units such as types 3 and 4, and which can be moved around easily to create different ways of connecting spaces. The last internal partition type is a light stud wall that was used to separate the single bedroom and the living space in such as type 8. This partition is more difficult to disassemble as it is connected to the floor and ceiling and some electrical services were located within, which means that it is a less flexible than the other internal wall types.

To sum up, as a result of the skeleton structure of the building, the internal partitions, including the party walls and the dividers between the units' spaces, are not required to be loadbearing. However, these partitions differed in their structure, material and ability for change according to fire and acoustic separation requirements and the architects' design approach.

External walls

The external walls of the building are also non-loadbearing, consisting of a mix of curtain walls and floor-to-ceiling operable windows fixed on an assortment of aluminium-framed boxes that have been added to the basic structure of the building to extend the volume of the construction (see figure 7.15). They have the ability to be separated and disassembled from the main structure in the future, which fits with the requirements of flexible structure of external walls. The architects were able to use this method because the existing construction of columns and beams released the building's façade from any construction elements. The external walls were not, however, designed with flexibility in mind (extension), but rather to facilitate the proposed scenario of live/work units.

Figure 7.15: External view and section of the external wall of the Levent Loft 1 project. Source: www.openbuildings.com

Consequently, the construction of this project fulfils different criteria of flexible construction in terms of the main structure, foundations, roof construction and external and internal partitions, which allow conversion of the plan to different building types. This was primarily due to the skeleton system of the structure, which allowed for provision of clear spans, a principal layering system and oversized structural elements for potential addition. The use of flexible or lightweight internal partitions that can be easily removed or adapted in the future offered a further opportunity for flexibility. However, fire and sound separation regulations required the use of a more robust and less flexible form of partitioning in such as the party walls between the units. Finally, the flexibility of the building was enhanced by the use of curtain walls and floor to ceiling windows to form external walls, as they can be dismantled easily in the future. Table 7.3 summarises the different possibilities and limitations regarding flexibility in the construction of the Levent Loft 1 project.

Indicators	Criteria			Evaluation
Structure	The ability of the structure to allow different layout forms		The ability of the structure to be separated from the infill parts.	✓
			The ability to generate open clear space between the structural elements.	✓
			The ability of the structure to accept additions.	✓
			Simplicity and legibility.	✓
External walls	The ability of the external walls to accept change		The ability to disconnect the external walls from the main structure and services of the building.	✓
			The ability to dismantle the external walls.	✓
			Simplicity and legibility.	✓
Internal partitions	The ability of the internal partitions to accept change	Party walls between units	Non-load bearing construction of the wall.	✓
			No services located within the partitions.	X
			The ability for disassembly.	X
			Simplicity and legibility.	X
		Internal partitions within the units	Non-load bearing construction of the wall.	✓
			No services located within the partitions.	P
			The ability for disassembly.	✓
			Simplicity and legibility.	✓
Foundations	The ability of the foundation to accommodate future change		Over capacity of foundations to accept additional floors.	✓
Roof	Accept future extension		The structure of the roof to be appropriately sized to bear potential dead and live loads.	✓

Table keys ✓: Achieved **X**: Not achieved P: Partly achieved

Table 7.3: Evaluation of flexibility in the construction of the Levent Loft 1 project. Source: the researcher

7.4.6 Flexibility in services

1- Pipes and wires

Vertical distribution

As mentioned previously, the services cores of the basic structure contain vertical shafts, which were used by the architects for vertical runs distribution, as the interviewee stated (interview no.8). As the plans show, the vertical shafts were provided with an opening in each floor to allow access to the services located within, for maintenance and upgrading (see figure 7.16). In addition, the interviewee pointed out that the shafts can take additional services in the future because of their oversized dimensions (interview no.8). The architects re-used the central vertical shafts located with the services cores to distribute the services system vertically because of the difficulty in creating new shafts within the existing floors, explained previously in section 7.5.4. Such vertical distribution of the services can be considered as complying with the key principles of flexible vertical distribution of services because this system's separation from the structural elements of the building enables easy access and installation of future technologies as required.

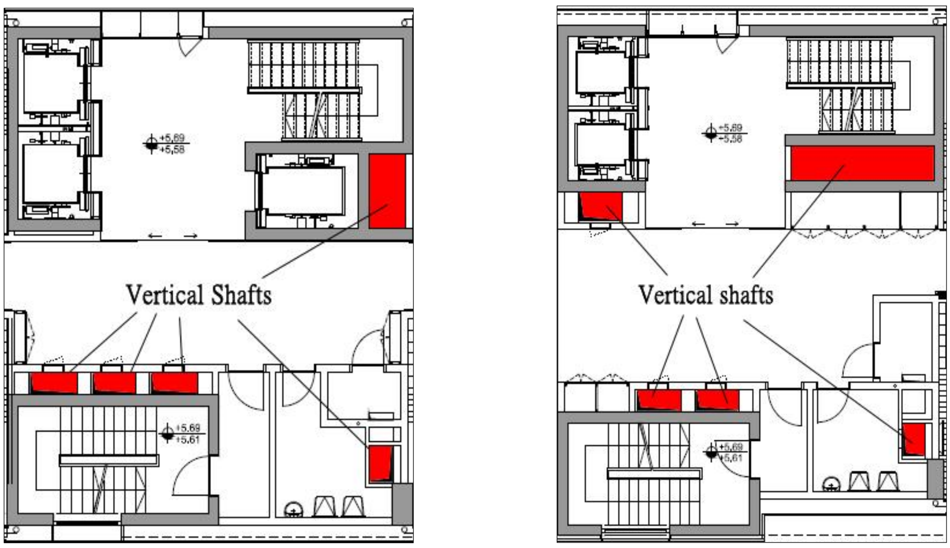


Figure 7.16: The vertical shafts in the services cores of the Levent Loft1 project. Source: Tabanlioglu Architects, edited by the researcher

Horizontal distribution

According to the interview with a member of the project team, services were distributed in each floor to the units through the communal corridor ceilings, and covered by using a suspended ceiling (interview no. 8). The different services are distributed within the unit in different ways. The air-conditioning system is distributed through a gypsum panel suspended ceiling that has an opening for future access. The wiring system is distributed to each room of the unit through pipes over the concrete slab within the floor. Finally, the plumbing system is accommodated within the common wall between the units and external corridors. These methods of horizontal services distribution reflect different possibilities and limitations in terms of flexibility. In the cases of the air-conditioning and wiring, these services were housed in a separate layer, which means that it is possible to maintain and upgrade these services without disturbing the other layouts. However, while the air-conditioning system can be accessed easily, the wiring cannot be so easily reached for adaptation and maintenance. In the case of the plumbing system, as it is not housed in a separate layer, access and maintenance are again more difficult (see figure 7.17).

It can be concluded from the analysis above that flexibility in the distribution of horizontal runs derives from the use of non-residential methods such as housing them in a suspended ceiling, which was made possible because the building had sufficient storey height for this method of distribution. The location of the central services core in the basic structure of this non-residential building contributed to the use of flexible methods of services distribution. However, in the case of the plumbing system, its location within a structural wall means that accessing it for maintenance is difficult.

Figure 7.17: Suspended ceiling in the main corridors and the units of the Levent Loft1 project. Source: the researcher

2- Appliances

A centralised air-conditioning system was used in the building for heating and cooling. For this purpose, a ducting system was installed partly into the units' ceilings over the services zone (see figure 7.17). In line with the non-residential methods used in this project, the air-conditioning units were placed on the top floor over the two services cores. Therefore, there are no air-conditioning appliances or machines to restrict internal change. Regarding other appliances, such as lighting controls, these were not particularly designed to allow for future change. According to observations made during the 2013/2014 field trip, the services controls and outlets were located generally at different heights, not necessarily between 0.45m and 1.2m, and in different locations, either on light partitions or permanent structures; therefore, people with limited physical abilities might have difficulty using these services. Moreover, the location of services could hamper internal change in the future.

In summary, the possibilities for flexibility in services derived from the use of non-residential building technology for distributing the services vertically and horizontally (suspended ceiling and ventilation air system), which was enabled by the building's appropriate storey height. On the other hand, because of the central shaft system, some services had to be distributed within structural elements of the building. Table 7.4 summarises the different possibilities and limitations regarding flexibility in services in the Levent Loft 1 project.

Category	Indicators		Criteria	Evaluation
Pipes and wires	Horizontal runs	Pipes	Separation of the pipes from the construction elements.	X
			Ability to access the pipes easily.	X
			Careful location of services to facilitate future adaptations.	✓
		Wires	Separation of the wiring system from the construction elements.	✓
			Ability to access the wiring system easily.	P
			Careful location of services to facilitate future adaptations.	X
		Ducts	Separation of the ducts from the construction elements.	✓
			Ability to access the ducts easily.	✓
			Careful location of services to facilitate future adaptations.	✓
	Vertical runs		Separation of the services from the construction elements.	✓
			Ability to access the vertical runs easily.	✓
			Over capacity of the distribution systems to accept future technologies.	✓
Appliances	Heating and cooling		Appropriate location of the heating and cooling appliances and their controls to allow future change.	✓
	Lighting (switches and lights)		Appropriate location of the lighting appliances and their controls to allow future change.	X
	Outlets (sockets, TV and phone)		Appropriate location of the outlets to allow future change.	X

Table keys ✓: Achieved X: Not achieved P: Partly achieved

Table 7.4: Evaluation of flexibility in the services of the Levent Loft 1 project Source: the researcher

7.4.7 Flexibility in use

The key scenario of use considered by the architects in this project was that of live/work units. The essence of a loft apartment is that it can provide an adaptable space for live/work accommodation. Therefore, the architects only considered the issue of flexibility in use in their project through the concept of loft living that inherently responds to the live/work scenario (see figure 7.18). To respond to this concept, instead of rigidly dividing the units into definite sections the architects designed them as an open space with demountable partitions and floor to ceiling operable windows. According to the interview with the real estate agent firm VAA (who sell and rent out the units), a considerable number of users have adapted their units for non-residential purposes; for example, there are many offices, particularly on the ground floor as these units have direct access to the main entrance (interview no. 9). According to interviews with some users who have converted their units into offices, their main reasons for doing so were the financial benefits and the need for workspace (interviews no. 11.12 and 13). Therefore, the design can be considered as having flexibility in use to respond to households' changing economic circumstances and needs.

Figure 7.18: Units converted into offices post-occupancy. Sources: the real estate agent.

The analysis of flexibility in the plan revealed the ability of different units to be joined together, thus improving the units' space and creating additional bedrooms to accommodate, for instance, large families. According to the interview with the real estate agent, very few consumers sought to purchase two units to join them together at the point of purchase, and at the moment there is no evidence that users are seeking to do this after occupancy. From the real estate agent's perspective, this might be due to the variety of unit types in terms of design and size, which gives consumers plenty of options when purchasing. In addition, the interviewee drew attention to the difficulty of acquiring ownership of the adjacent unit at the right time after occupancy as another reason that might explain the lack of cases of two units being joined together (interview no. 9).

On the other hand, the installation of sliding walls in a few units such as types 3 and 4 was seen that provides an opportunity for flexibility in use. One of these scenario, according to the interview with an occupant of type 3, is to increase the living area of the dwelling for social event when there is a need for more space and reuse the single space again for other activities on a later data (interview no.14). Therefore, the flexible design of these units through the potential of sliding wall allows the occupants to improve the living space on a temporary basis and accommodate their evolving need with more space for social gathering (see figure 7.19).

Figure 7.19: Unit 3 with sliding wall. Sources: the researcher.

Consequently, the flexible design of the units has a scope of flexibility in use for more than the pre-established scenario of live/work considered by the architects. This can be attributed to a large grid structure of the existing non-residential construction which allow the design approach to create non-residential standards of layout spaces suitable for unit conversion into non-residential use. The use of flexible features such as sliding wall was also behind another opportunity for flexibility in use which allowed the users to accommodate their evolving socio-cultural need in their homes. However, the scope of flexibility in use can be still seen that is limited to particular changing needs, which can be attributed to the high specific nature of the design approach that sought mainly to respond to live/work scenario rather than unpredicted change. The architects were clearly referring to this point when stating: “this kind of layout in turn determined the profile of the people who would live here. The elongated apartments are unsuited to the sprawling requirements of family life, but are ideal for single people or couples without children” (www.archdaily.com). (see table 7.5).

Flexibility in use	Scenario of use	Units type														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Cultural	Social gathering			✓	✓											
	Lifestyle	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Economic	Change the use of the unit for economic activities	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Table 7.5: The different possibilities for flexibility in use and corresponding flexibility categories. Source: the researcher.

7.4.8 User empowerment

User empowerment in this project can be seen through the adaptable design of the units that allows the users to occupy and use their units’ spaces as they see fit in terms of the live/work scenario. This was achieved through adoption of a loft design for the unit space and a modular system based on a large structural grid, which produced large open spaces that were not strictly divided into sections and were thus suitable for live/work occupation. However, the potential of the design for user empowerment varies across the different unit types according to their size and the adaptability of the space for live/work. Therefore, in generously sized units such as types 1, 5, 13 and 15, or where additional area can be added to the living/working space through sliding walls, such as in types 3 and 4, the greater the degree of user empowerment achieved, as the design could allow the users to occupy the space in different ways. However, in types with two modules, such as 2, 6 and 7, their limited size may reduce the users’ empowerment to adapt the space in their dwelling for a live/work scenario.

7.4.9 Financial considerations

According to the interview with the developer, the adaptive reuse of the building and the loft design of the units had particular cost implications. In this respect, the developer pointed out that the cost of the building was considerably increased because of the shell cladding and services core. In relation to the former, the steel work for additions and the use of floor to ceiling operable windows and curtain walls led to the high cost of the shell cladding. Regarding the latter, the central location of the shafts in two services cores led to distribution of services from this central location and installation of suspended ceilings to cover the services along the communal corridors, which added to the initial cost of the project. At unit level, the increase in cost was due to the installation of wall furniture and sliding walls as partitions between the interior spaces of the units to facilitate the design (interview no.10). This, however, failed to have a knock-on effect at the point of purchase because of the luxurious standard of the units, the location of the project, and the need for live/work accommodation in the area, as the interviewee pointed out.

According to the interview with the real estate agent, the purchasers valued the open space design of the units, their contemporary architecture and luxurious living style, which made them desirable and sellable to potential purchasers who seek such accommodation that, moreover, offers easy access to the city (interview no. 9). Similarly, the user interviewees asserted that the particular design of the units, offering a place in which they could live and work in this central location, was their primary motivation for purchasing at selling point. From their perspective, this accommodation is affordable as it allows them to use the same space for living and working (interviews no. 11, 12 and 13). Therefore, in this project, the units' adaptable space for living and working contributed to the users' satisfaction at the point of purchase and had the effect of ensuring the units sold faster.

7.4.10 Conclusion

The discussion on motivations for the adaptive reuse of the building for residential use and implementation of an adaptable design for live/work accommodation showed that the location of the building in the business centre of the city and the users' desire to have an adaptable place for live and work were the key reasons inspiring the providers to undertake this housing design initiative. The architects' enthusiasm and the developer's expectation of financial return were also factors in driving the providers forward to implement this design. These motivations led also to repetition of this design initiative in the same area.

The analysis of flexibility in the design in terms of the plan, construction and services revealed different possibilities and limitations affecting achievement of such flexibility. Possibilities for flexibility emerged from a variety of factors. First, the structural system of beams and columns allowed the installation of lightweight internal partitions and external walls that can be separated from the main structure. Second, the non-residential standards of the structure provided storey height sufficient for horizontal run distribution and large open spans between the structural elements that created indeterminate open space that can accommodate different layout forms. Third, the building form facilitated introducing natural light and ventilation for different habitable spaces. Fourth, the use of a modular system that followed a grid structure led in different cases to internal spaces adequate in size and proportions for live and work scenarios, but also other uses. Finally, flexible features were installed that can allow for different layout configurations, although these may limit functional use of the space.

On the other hand, limitations on flexibility were imposed by factors including: 1) central location of the services core that led to installation of some services within structural elements, 2) the depth of the existing structure that required adding extensions to facilitate residential user of the building, 3) the use of large operable windows and curtain walls as external walls of the building, which might restrict the ability to furnish the space in different ways, 4) fire and acoustic separation requirements that required robust construction of party walls between the units, thus making it difficult to join two units together, the latter task also being restricted by being the adjacent unit needing to be free at the right time, and 5) building regulations that restrict the addition of adjacent external open space (balcony).

Financial assessments revealed different equations of flexibility and cost, and while the incorporation of flexibility increased the upfront costs, this did not influence either the deliverability of the building units at the point of purchase (as purchasers valued the design because of its location and affordability), or the developer/landowner's willingness to develop again using this design concept (due to the financial return).

7.5 The second case study in Turkey-Ankara (Eryaman Third Stage project)

7.5.1 The background of Eryaman Third Stage project

Eryaman housing project is a large scale mass housing development in the Eryaman district; it was developed by the Housing Development Administration (HDA) in the growth plan for Ankara towards the western corridor, and is located at a distance of 18km from the centre of Ankara on 953.5 hectares of land provided by the state treasury (see figure 7.14). The project was initially planned as ten stages with around 4,000 housing units for each stage. The HDA, a governmental body, was seeking to respond to urban growth and control rapid urbanisation via mass housing provision, which was the policy of the government at that time. Therefore, the main focus in Eryaman housing development was initially to provide shelter as fast and as cheaply as possible. However, the Eryaman housing project was centrally organised, and HDA, as a governmental institution, was in the position of making all the decisions as to how each stage would be established, and thus the differences in each stage were as a result of HDA's own policies (Altay, 2004). This can be seen in the attempt to integrate particular values in certain stages, such as the third stage, where policy makers had a further agenda in experimenting and demonstrating an appropriate model for mass housing, physically and spatially. In this stage, the values of flexibility and adaptability were applied as quality concepts to develop the physical and spatial elements of mass housing design. According to Altay (2004), the changes implemented at certain stages were in response to issues experienced at previous stages, such as physical problems, maintenance issues and complaints from occupants, which drove the HDA policy makers to take the initiative and incorporate new values into mass housing design through their own policy.

The Eryaman Third Stage, as mentioned above, reflects the approach by HDA policy makers of incorporating flexibility and adaptability into mass housing design. To achieve this end, the policy makers were required to obtain the design for this stage through holding an urban design competition rather than by developing it in-house. The brief was to design quality-based collective housing rather than quantity-based supply to meet demand. Design proposals by architects Ahmat Gulgonen and Tuncay Cavdar, which offered spatial alternatives to collective living outside of regularised residential models, were chosen for implementation on this site. HDA divided the project region into two areas, one larger than the other. Gulgonen's proposal was applied to the large zone, whilst Cavdar's design was constructed in the second area (see figure 7.20). The architects paid attention to providing as many unit types as possible within the constraints of standardised mass-housing. The research focuses entirely on Cavdar's design as there are different opportunities for flexibility in this design, both internally and externally.

Figure 7.20: The site plan of the Eryaman Third Stage project. Source: Google map, edited by the researcher

In the second zone of this project, two different types of housing blocks were developed by the architect, which provided 515 units of 11 different types in total. Building type (A) includes six different types of housing, comprising one or two storeys attached or detached units with from one to three bedrooms. Block (B), on the other hand, contains five one or two storeys attached units with either two or three bedrooms (see figure 7.21).

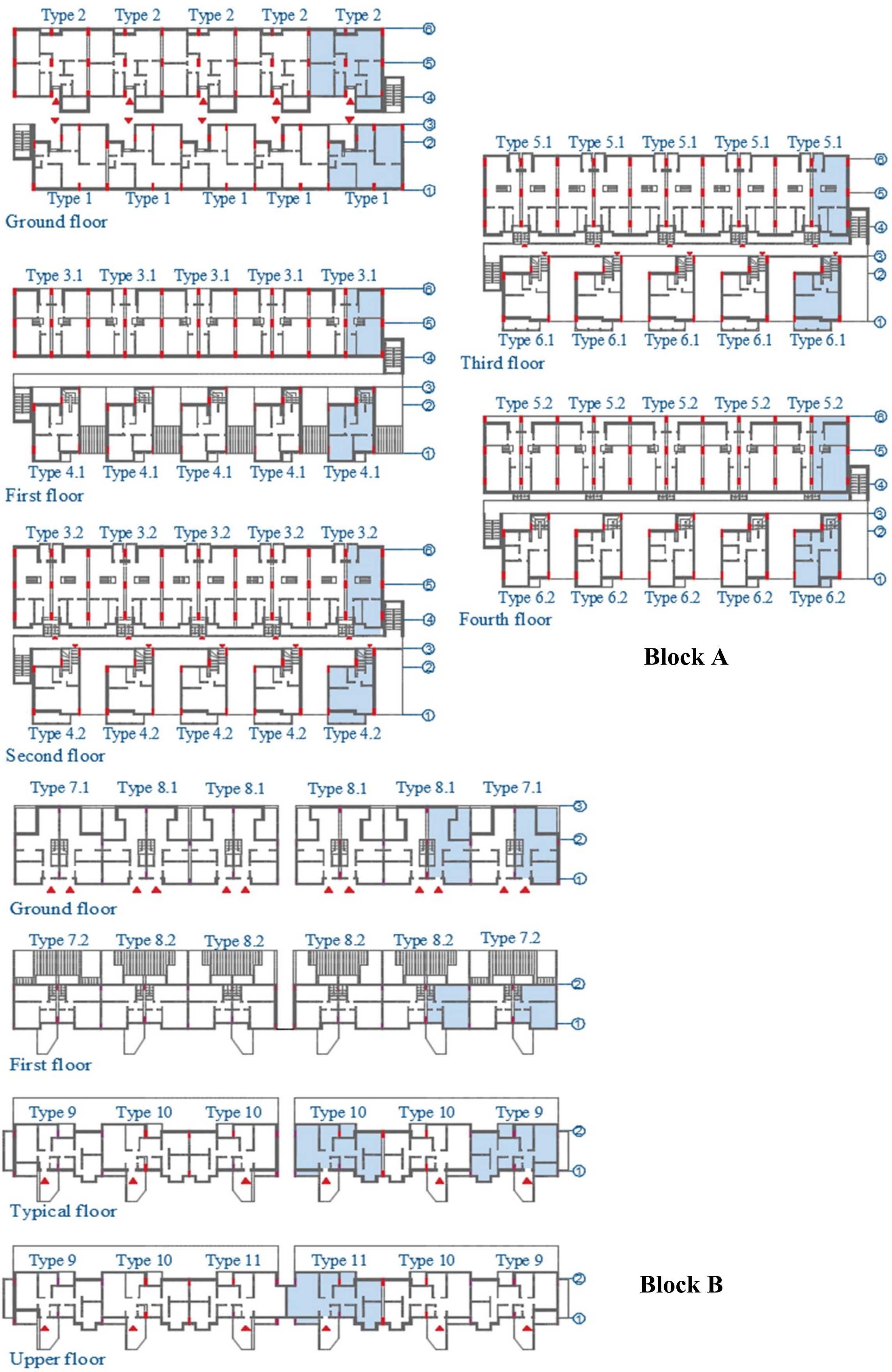


Figure7.21: The plans of the Eryaman Third Stage project. Source: Atelier T, re-drawn by the researcher.

7.5.2 Motivations for flexibility

Due to the difficulty of undertaking interviews with stakeholders from HDA who participated in the development of this project, the research relies on secondary data obtained from other academic research and the interview with the architect to present the motivations for the delivery of flexible housing in this project.

According to Altay (2004, p. 50), in the Eryaman First and Second Stage project, the policy makers of HDA adapted their previous agenda in terms of design and construction, which had relied primarily on the delivery of uniformity in housing plans and potential for repetition "as cheap and as fast as possible" through the use of a tunnel formwork structure as a construction method that allows easy and rapid production. This led to plan layouts that did not permit change or adaptations due to restrictions of the structural system and the difficulty and high cost of altering technical systems such as plumbing, wiring and so on.

According to Torus and Sener (2013), TOKI and many other construction firms in Turkey used this construction system for mass housing production. This system is usually implemented by pouring concrete into two half-tunnel forms to provide load bearing walls and floor slabs on site at the same time. This allows an apartment to be built up in a 24-hour cycle per floor, thereby making this construction method an attractive proposition for mass housing projects with repetitive elements or layouts. Torus and Sener (2013, p. 51) explain that the tunnel formwork construction can be seen as "a rigid and modular system" which is usually chosen to create repetitive spaces.

Therefore, in Eryaman's third stage, the policy makers recommended the use of a conventional construction system of columns and beams, allowing flexibility to be incorporated via the infill parts (internal and external) as a means to enhance variety of choice before occupancy and the potential for internal change after occupation in response to people's different needs. This was intended as a response to complaints by occupants from previous stages that limitations in the design and construction of their units precluded them from changing their homes in response to changes in their needs (Altay, 2004). It can be concluded here that the people demand for housing can reflect their different and changing needs, which was restricted by the rigid construction system used in housing project that can only allow uniform and repetitive spaces, and the developer's desire to provide exemplary work of mass housing that could respond to people's changing needs were the main reasons behind this project's flexibility initiative.

Despite their request for incorporation of flexibility in this stage, the HDA policy makers did not identify particular scenarios and needs, but left these decisions open to the architects in their design proposals. Therefore, the architects were in a position to decide how their designs could respond to the different users' needs. According to the interview with the architect, the user profile for this project was considered according to data collected from Izmit housing development, where a large number of households were interviewed individually and collectively, providing a database of the users' different and changing needs (interview no.15). According to this information, the main household profiles considered in delivering the different unit types in this project were, first, couples with children and, second, couples without children, along with taking into account changes that might occur in the family's structure and lifestyle. Therefore, the drivers for flexibility in response to households' changing needs can be related to changes in users' demographic and cultural resources (see table 7.6).

Household need	Sub-source of household need	Main sources of household need
Left open to the user	Family structure	Demographic
	Lifestyle	Culture

Table 7.6: Motivations for flexible design in the Eryaman Third Stage project in response to households' changing needs. Source: the researcher.

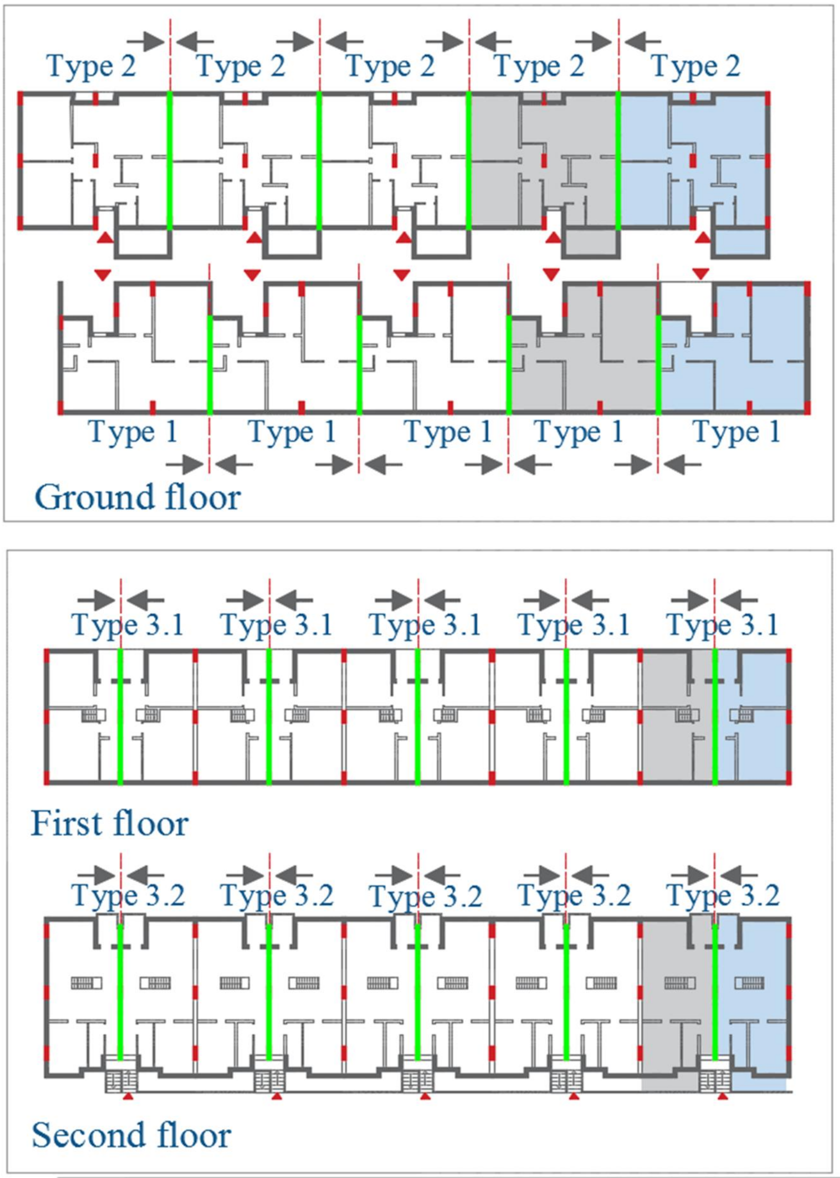
7.5.3 Flexibility in plan

As mentioned previously, the architect did not consider particular scenarios for change, but left this open for users to change their dwellings as they saw fit by incorporating a flexible approach through adopting a structural system and design principles that would allow the units to accept change. Therefore, the research examines the design of the different units against the concepts of flexibility addressed in the analytical framework to discover the possibilities and limitations of this approach.

A- Building

1- Unit Mix

As mentioned in section 7.3.1, there are two types of housing blocks in this project. The potential for changing the unit mix derives from the possibility for joining units together, primarily in building block A at ground level, that contains two rows of attached units with a passage between them which offers the opportunity for combining two adjacent units together on each side. This possibility can be also seen in the upper floor but on one side due to the attached unit separated by non-loadbearing party walls, enabling openings to be created in them when needed. (see figure 7.22). The possibilities and constraints regarding this form of flexibility are explained in detail in the following sections (Flexibility in unit size).



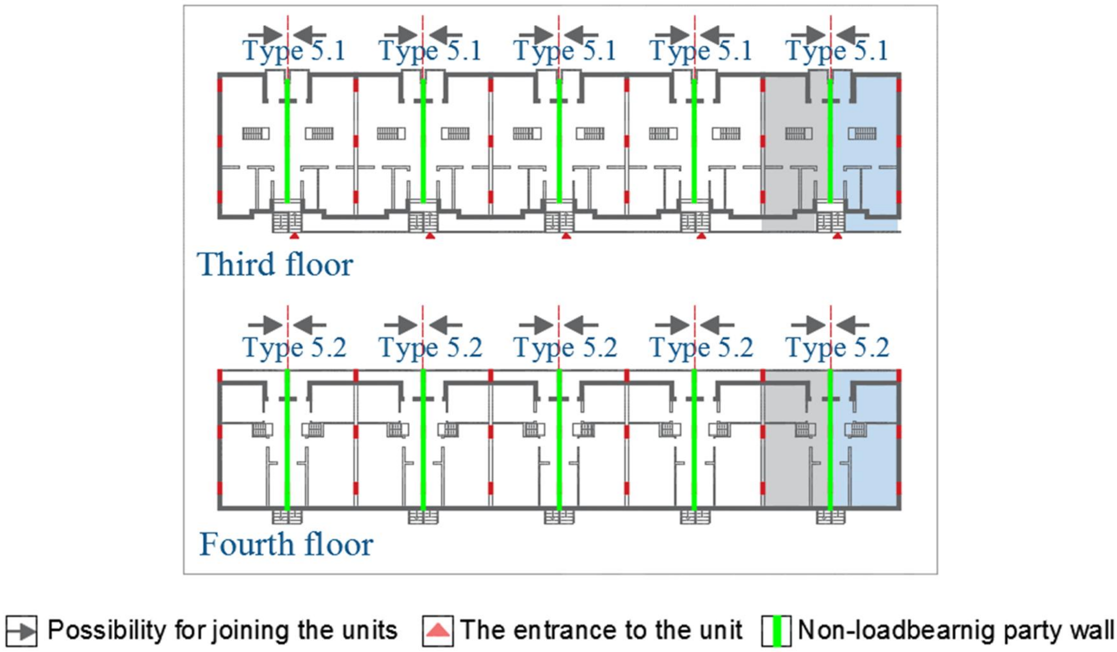


Figure 7.22: The different possibilities for joining units together in the Eryaman Third Stage project. Source: the researcher

1- Flexibility in building use

The design of the building indicates that as a whole it cannot accept change in its use. This can be attributed to factors such as the storey height of between 2.7m and 2.5 on the upper floor preventing the installation of horizontal runs distribution through the ceiling or floor, the vertical shafts in terms of size and location being of suitable design only to serve residential use of the building, the structure's compliance with residential standards in terms of the dimensions between the structural elements (such as 5.65*5.3), the façade's design clearly reflecting the residential use of the building, and the size and dimensions of the vertical circulation being too limited to accept non-residential use, with a staircase providing the only means for access. However, it can be argued that the building can accept a mix of use through changing the units on the ground floor for non-residential use, particularly such as type 2 units that are located on the main street. This is possible because the building's "street in the air" design can provide an independent entrance to the units without disturbing the rest of the building and there is also potential to re-arrange the internal partitions to suit non-residential use of the units (see figure 7.23).

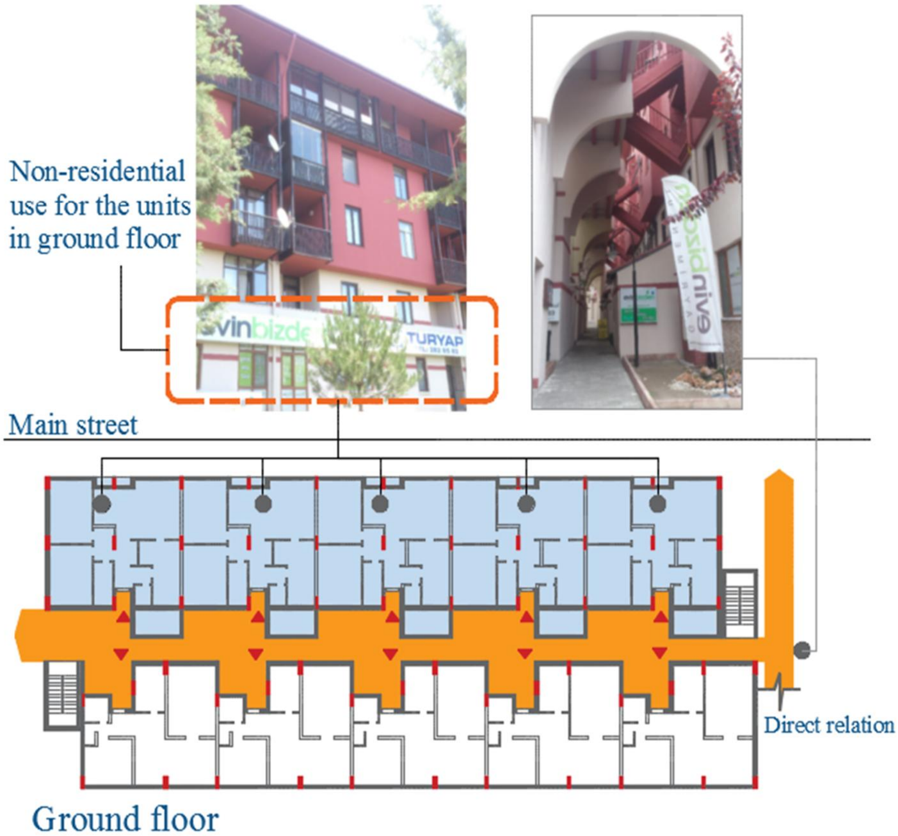


Figure 7.23: Possibilities for flexibility in building use in the Eryaman Third Stage project. Source: the researcher.

2- Communal circulation

According to the interview with the architect, the horizontal access points for block (A), which are centrally located between the two rows of housing units on every floor, were designed around the street in the air concept to enable independent entrance to the units and to increase the sociability of the building (interview no. 15) (see figure 7.24). The plans show that the size of the horizontal access space was marginally increased through providing small bays between the access points, so it can be used by households to personalise the area in the front of their dwellings. Therefore, it is apparent that the horizontal access space of this part of the building was designed for more than access purposes, and thus provides opportunity for flexibility according to the analytical framework in Chapter 3, section 3.2. Here it can be concluded that the architect's innovation in designing for flexibility resulted in implementation of flexible design practice.

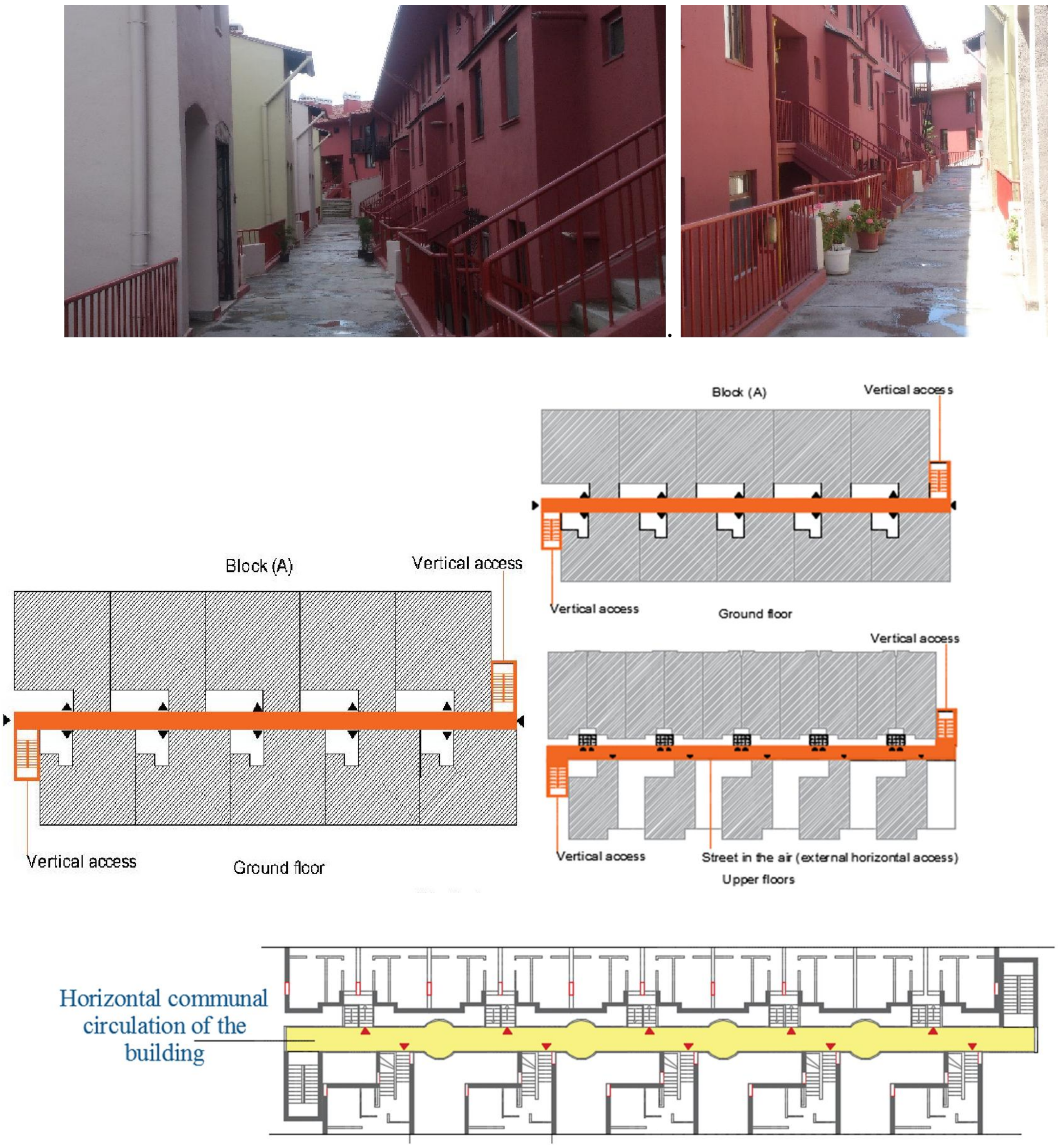


Figure 7.24: Communal circulation in the Eryaman Third Stage project. Sources: the researcher.

B- Unit

1- Flexibility in size

The plans show different potential for joining various units together, such as type1 to type 1, type 2 to type2, type3 to type 3 and type 5 to those similar. The way of attaching the unit, the shared space of the external access to these units and the non-loadbearing of the party walls between the units, that offer the possibility to provide an opening between units are the key factor that facilitate such opportunity for flexibility in the plan. However, the blockwork of the party walls and the internal partitions can complicate this process because of the need for specialist input in altering the walls or creating an opening within (see figure 7.25). Meanwhile, the potential of dividing up can be seen in duplex types such as 4 and 6 because the design of the internal access enables the provision of an independent entrance to each divided unit on each level, while the potential for internal change allows for re-arrangement of the new layouts (see figure 7.25).

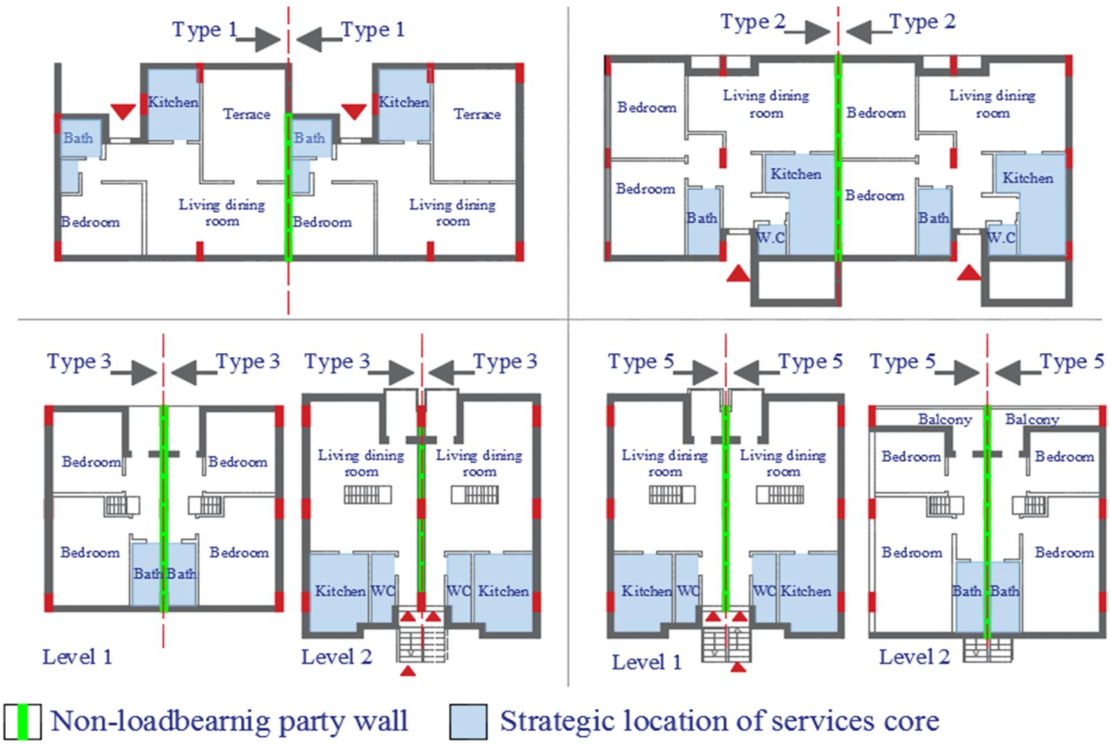


Figure 7.25: Flexibility in unit size through joining units together scenarios in the Eryaman Third Stage project Source: the researcher

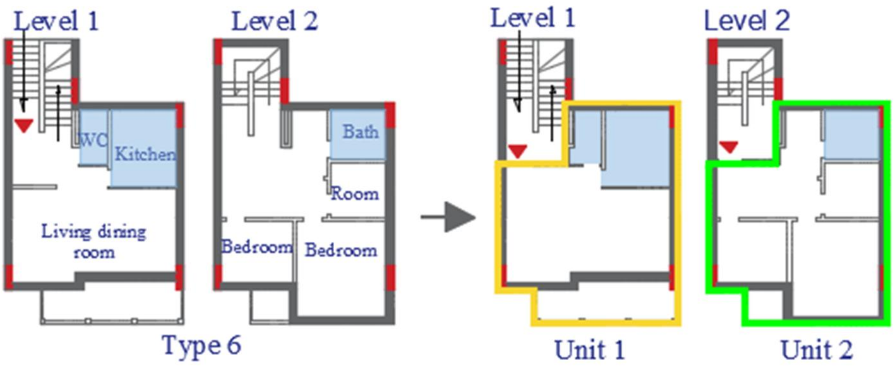


Figure 7.26: Example of flexibility in unit size through dividing up scenario in the Eryaman Third Stage project Source: the researcher

Moreover, the external open area, in the form of either a balcony or a patio, can be seen as un-programmed space, which can be filled partly or completely according to the users' will, often by using light materials, as explained in section 7.5.6. Joining these spaces to the internal spaces is also possible as the external walls are non-loadbearing blockwork, and can therefore be altered when needed (see figure 7.27). Table 7.7 illustrates how adding the exterior areas can potentially increase interior size of the different unit types in this project.

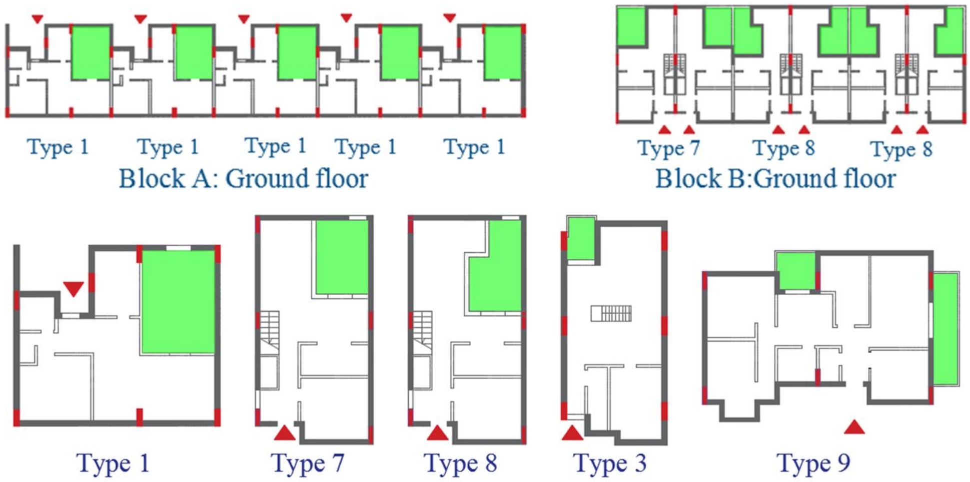


Figure 7.27: Different opportunities regarding un-programmed spaces *in the units of the Eryaman Third Stage project Source: the researcher.*

Block	Type	Size sq. m		
		Interior area	External open area	Total
A	1	125	0	125
	2	75	23	98
	3	118	14	132
	4	130	11.6	141.6
	5	125	18.2	143.2
	6	130	11.6	141.6
B	7	110.3	18.5	128.8
	8	110.4	18.4	128.8
	9	90	21.6	111.6
	10	90	8	98
	11	100	8	108

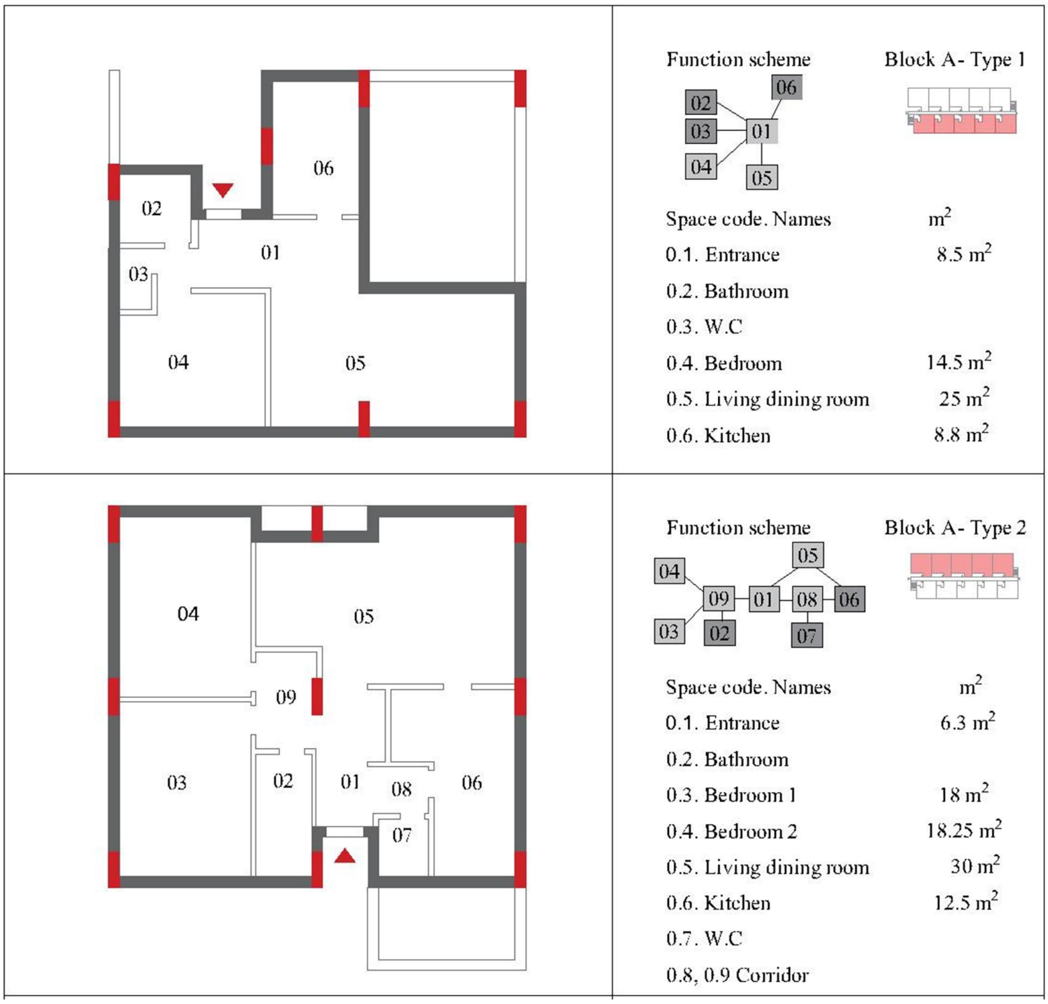
Table 7.7: Size of interior and exterior area of the different unit types, Eryaman Third Stage project. Source: the researcher.

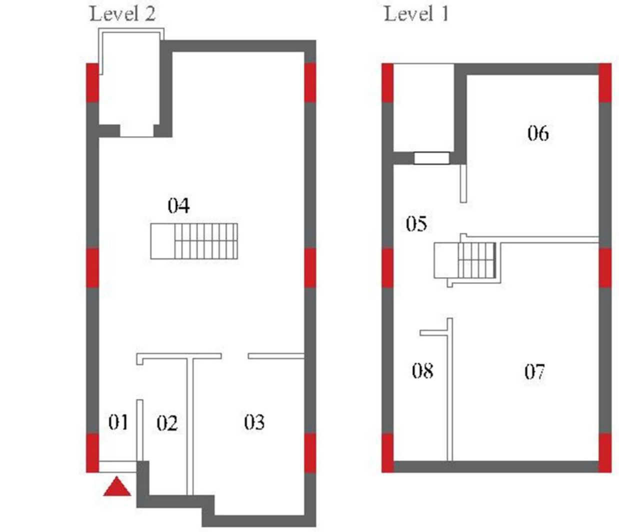
2- Layout arrangement

Functional flexibility

The plans of the different units show that their layout spaces vary in size and proportions. For example, in type 6 the room sizes and proportions range between 23m2 (3.5*6.5), 14m2 (3.6*3.65), 8m2 (3.1*2.65) and 5m2 (2.15*2.25), which means that the layout spaces of the unit are more appropriate for particular functional layouts. This can be also seen through the layouts' spaces of the other units that were designed with different sizes and proportion that make the plan of these unit predetermined in functional layout.

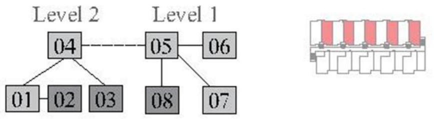
In terms of access, the plans show that some of the layout spaces can be accessed independently from a central hall, such as types 1, 2, 4 and 6, or from corridors, such as types 9, 10 and 11, whereas in the other samples, such as types 3, 5, 7 and 8, the layout spaces can only be accessed via the living dining space (see figure 7.28). Therefore, the fixed structures of these layout spaces do not permit the units to be occupied in different ways, because of the differences in their sizes and proportions and the inability for some spaces to be accessed independently in some types, and thus the design of the units cannot be considered as having functional flexibility through non-physical adaptations at unit level according to the research's analytical framework as set out in Chapter 3, section 3.2.





Function scheme

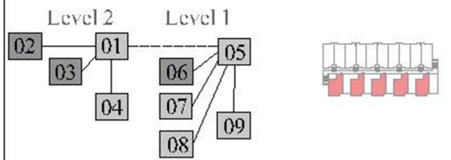
Block A- Type 3



Space code. Names	m^2
0.1. Entrance	2.8 m^2
0.2. W.C	
0.3. Kitchen	11.5 m^2
0.4. Living-dining room	37.55 m^2
0.5. corridor	
0.6. Bedroom 1	14.5 m^2
0.7. Bedroom 2	20 m^2
0.8. Bathroom	

Function scheme

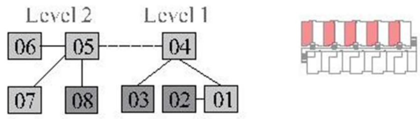
Block A- Type 4



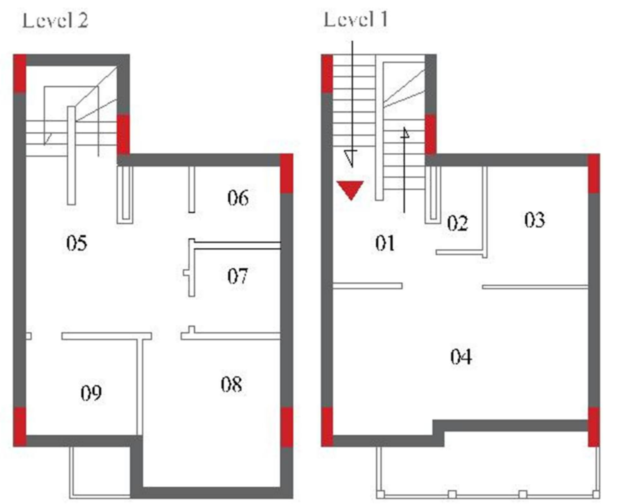
Space code. Names	m^2
0.1. Entrance	6 m^2
0.2. W.C	
0.3. Kitchen	8 m^2
0.4. Living-dining room	23.5 m^2
0.5. corridor	
0.6. Bathroom	
0.7. Bedroom 1	10 m^2
0.8. Bedroom 2	14 m^2
0.9. Bedroom 3	7.25 m^2

Function scheme

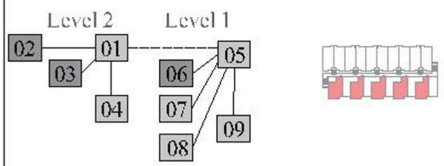
Block A- Type 5



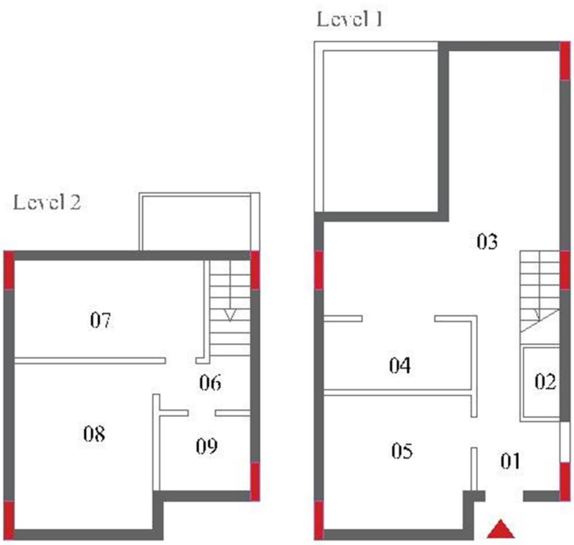
Space code. Names	m^2
0.1. Entrance	2.8 m^2
0.2. W.C	
0.3. Kitchen	11.5 m^2
0.4. Living-dining room	37.55 m^2
0.5. corridor	
0.6. Bedroom 1	11 m^2
0.7. Bedroom 2	25.4 m^2
0.8. Bathroom	



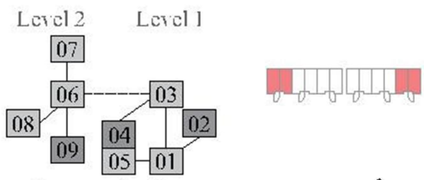
Function scheme — Block A- Type 6



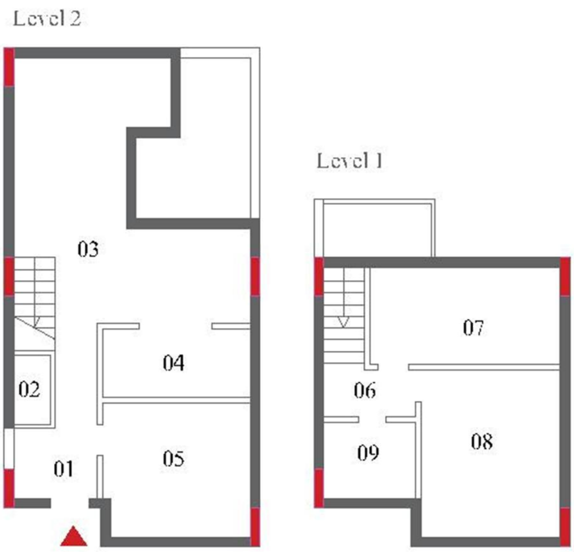
Space code. Names	m^2
0.1. Entrance	6 m^2
0.2. W.C	
0.3. Kitchen	8 m^2
0.4. Living-dining room	23.5 m^2
0.5. corridor	
0.6. Bathroom	
0.7. Room 1	5 m^2
0.8. Bedroom 2	14 m^2
0.9. Bedroom 3	7.25 m^2



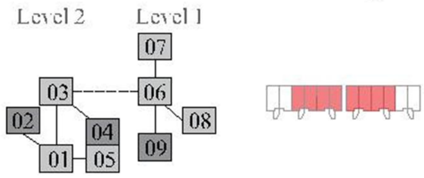
Function scheme — Block B- Type 7



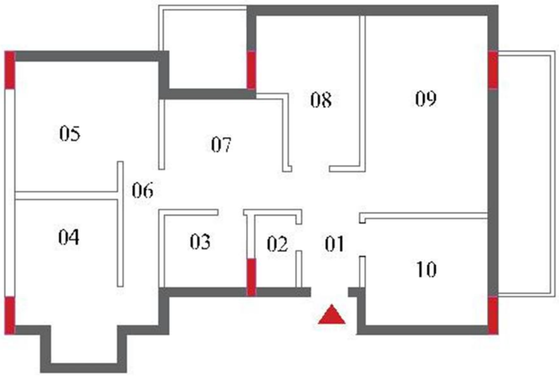
Space code. Names	m^2
0.1. Entrance	4 m^2
0.2. W.C	
0.3. Living-dining room	26 m^2
0.4. Kitchen	6.5 m^2
0.5. Room	15 m^2
0.6. Corridor	
0.7. Bedroom 1	12.25 m^2
0.8. Bedroom 2	15.5 m^2
0.9. Bathroom	



Function scheme — Block B- Type 8

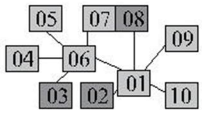


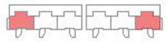
Space code. Names	m^2
0.1. Entrance	4 m^2
0.2. W.C	
0.3. Living-dining room	28 m^2
0.4. Kitchen	6.5 m^2
0.5. Room	15 m^2
0.6. Corridor	
0.7. Bedroom 1	12.25 m^2
0.8. Bedroom 2	15.5 m^2
0.9. Bathroom	



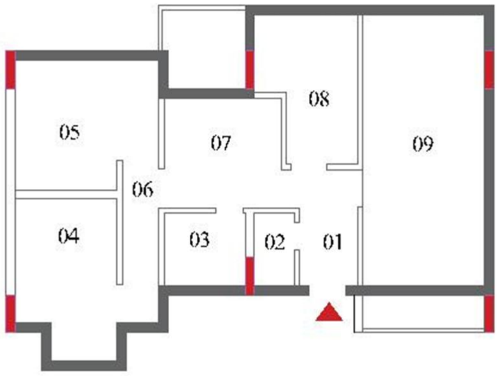
Function scheme

Block B- Type 9



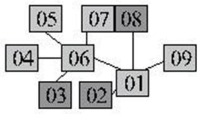


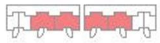
Space code. Names	m^2
0.1. Entrance	4.5 m^2
0.2. W.C	
0.3. Bathroom	
0.4. Bedroom 1	11.6 m^2
0.5. Bedroom 2	12.5 m^2
0.6. Corridor	
0.7. Dining room	6 m^2
0.8. Kitchen	9 m^2
0.9. Living room	16.5 m^2
10. Room	9 m^2



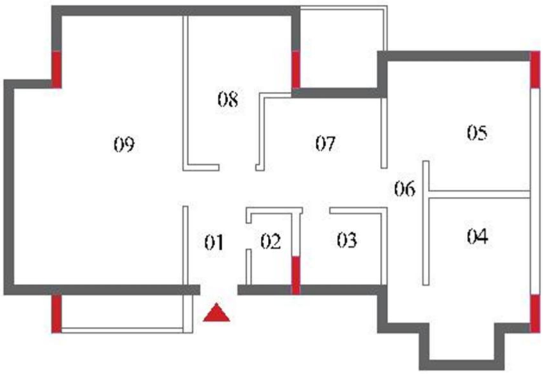
Function scheme

Block B- Type 10



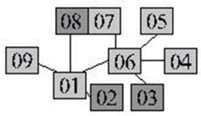


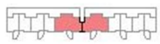
Space code. Names	m^2
0.1. Entrance	4.5 m^2
0.2. W.C	
0.3. Bathroom	
0.4. Bedroom 1	11.6 m^2
0.5. Bedroom 2	12.5 m^2
0.6. Corridor	
0.7. Dining room	6 m^2
0.8. Kitchen	9 m^2
0.9. Living room	23 m^2



Function scheme

Block B- Type 11





Space code. Names	m^2
0.1. Entrance	4.5 m^2
0.2. W.C	
0.3. Bathroom	
0.4. Bedroom 1	11.6 m^2
0.5. Bedroom 2	12.5 m^2
0.6. Corridor	
0.7. Dining room	6 m^2
0.8. Kitchen	9 m^2
0.9. Living room	30 m^2

Figure 7.28: The different layout spaces of the units in terms of their area and means of connection, Eryaman Third Stage project. Source: the researcher.

Spatial flexibility

The plans show that the internal partitions of all units are non-loadbearing walls, so there is potential to change and alter the partitions as needed. Moreover, wet spaces such as kitchens, bathrooms and toilets in the plans for different units such as types 1, 2, 3, 4, 5, 6, 7 and 8 are strategically placed in one zone near the main entrance, freeing the entire interior space of the unit for change. The placement of the internal staircase on the side wall in units with two storeys, such as types 4, 6, 7 and 8, can be seen as facilitating potential internal change in these types (see figure 7.29). On the other hand, in types 3 and 5 the services are not strategically placed, but instead are centrally located in the plan. Therefore, it can be concluded that a large number of the units in this project meet different requirements for spatial flexibility in design according to the analytical framework in Chapter 3, section 3.2, thereby allowing changes in the layout arrangement and functions of the space.

Figure 7.29: The analysis of spatial flexibility in the units of the Eryaman Third Stage project. Source: the researcher

Internal circulation

In terms of horizontal circulation, the plans of some units show that the horizontal access spaces are of sufficiently generous size and proportions to allow them to be used for additional purposes. This can be seen in the main entrance spaces in some samples, such as types 1, 2, 4, 6, 7 and 8 (see figure7.30). According to the interview with the architect, the main entrance is of sufficiently generous size where this possible to enable social activities to be held in the units. Therefore, the design of the internal circulation can be considered as offering flexibility, due to the access spaces being of sufficient size to accommodate users' needs arising from their social activities, which would at the same time allow additional use of the space. On the other hand, the plans show that unit with two storeys were not designed with the potnaitl for floor or stair lift for another access means. Acoording to the interview with the architects, providing the plans with the possibility for future lift is not among the project design or regulation requirements at the time of the project (interview no 15).

Figure 7.30: Analysis of flexibility in internal circulation in the units of the Eryaman Third Stage project. Source: the researcher.

C- Flexibility of rooms

1- Flexibility in function

The plans show a few opportunities for flexibility in rooms' function. This can be seen mainly in the types 7 and 8 that were designed with the potential of multipurpose room in the ground floor near the entry door, so it can be accessed directly without disturbing the rest of the unit. The good size, appropriate proportions and simple form of the room with two source of light allow to be occupied in different ways such as an office, guest room and so on (see figure 7.31). Therefore, the opportunities for flexibility in room function are limited across the different units' types, which can be attributed to the deterministic approach of the design that based on designing the space for it to be used in a specific way.

Figure 7.31: Flexibility in room function in the different units of the Eryaman Third Stage project. Source: the researcher.

2- Flexibility in connection

Flexibility in connection between rooms was achieved through enabling the internal partitions to be changed through removing, subdividing or creating an opening within them. This can be attributed to the beams and columns structure used in this project, which avoided the need for the internal partitions to be fixed loadbearing walls. Therefore, this possibility for flexibility derives from the use of a skeleton system instead of tunnel formwork construction, where the latter generally necessitates the use of load bearing walls that would restrict such possibilities.

3- Flexibility in furniture

The design of the rooms reveals some opportunities for flexibility in furniture. These opportunities are, however, limited to rooms that are of good size and proportions, such as in types 1 and 2 and some other types that contain such rooms. In other samples, such as types 9 and 10 and some bedrooms on the second floor of types 4 and 6, such flexibility is restricted by the limited size and proportions of the rooms. In types 9 and 10, flexibility in room furniture is restricted not only by the rooms' inappropriate size and dimensions but also because fixed built-in furniture, such as cupboards, and the unclear form of the room's space reduce the rooms' ability to accept different layouts of furniture. The windows can be generally seen as being of appropriate size and number to allow different furniture arrangements, except for rooms such as the bedrooms in types 9, 10 and 11, which have a large window. Therefore, only a few possibilities for flexibility in room furniture emerged across the different unit types in this project, which can be attributed again to the size and proportions of the rooms' spaces being designed with a specific function in mind.

To sum up, the key possibilities for flexibility in the plan derive from spatial flexibility that was facilitated by the provision of non-loadbearing internal partitions and strategic placement of the services core that allow the plan to be re-configured in different ways. There is also potential for flexibility in the size of units, primarily through adding the external open areas, namely balconies and terraces to the units, and joining and dividing up spaces, which offers the capacity to change the number of units in the building and thus achieve flexibility in unit mix. Here, the structural system of beams and column can be seen as playing a key role as it offers the potential to alter the internal partitions, party walls and external walls. Moreover, the design of the external circulation and some internal circulation provided further possibilities for flexibility arising from the architect's concern that the spaces should be designed to be flexible in use in terms of households' social and access needs.

On the other hand, the building as a whole lacked the flexibility to accept change in use due to the restrictions imposed by the adherence of the main structure to residential standards regarding storey height and dimensions between structural elements. Furthermore, the specific nature of the functional design of the layout spaces in the different units restricts their interpretation or occupation in different ways due to the size and proportions of these layout spaces being conceived in terms of a specific function. Table 7.8 summarises the different possibilities and limitations regarding flexibility at different levels of the plan of the Eryaman Third Stage project.

Category	Indicators	Criteria	Evaluation	
			Block A	Block B
Building	Unit mix	The building can accept joining of some units together.	P	P
		The building can accept division of some units into two small independent units.	✓	X
	Mixed use	Building layout is an indeterminate large open space.	X	X
		Strategic placement of the services cores.	✓	X
		Multiple access points.	✓	X
	Communal circulation	Can accept more than access use	✓	X
		Can accept additional access means	X	X

Category	Indicators	Criteria		Unit type										
				1	2	3	4	5	6	7	8	9	10	11
Unit	Size	Division	Independent access to the divided units.				✓		✓					
			Independent services spaces in each unit.				✓		✓					
		Joining	Generous shared access.	✓	✓	✓		✓						
			Careful location of services core.	✓	✓	✓		✓						
			Possible connection between units.	P	P	P		P						
		Unprogrammed spaces	Patio	✓						✓	✓			
			Balcony		X	P	P	P	P			P	P	P

	Layout arrangement	Functional flexibility	Layout spaces of adequate size.	X	X	X	X	X	X	X	X	X	X	X
			Simple forms of layout spaces.	X	X	X	X	X	X	X	X	X	X	X
			Independent access of the layout spaces.	✓	X	X	✓	X	✓	X	X	✓	✓	✓
		Spatial flexibility	Strategic placement of the services core.	✓	✓	✓	✓	✓	✓	✓	✓	X	X	X
			The internal partitions can accept change.	P	P	P	P	P	P	P	P	✓	✓	✓
		Internal circulation	Appropriate size of access spaces to permit an additional use.	✓	✓	X	✓	X	✓	✓	✓	X	X	X
			Possibility of adding a lift as an additional vertical access means.			X	X	X	X	X	X			
Room	**Function**	Room is of suitable size and simple form.		X	✓	P	X	P	X	✓	✓	X	X	P
		Ample light to fit different functions.		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		Independent and direct access from the main entrance.		X	X	X	X	X	X	✓	✓	X	X	X
	Connection	Potential to provide new connections in the future.		P	P	P	P	P	P	P	P	P	P	P
	Furniture	Room has adequate dimensions and proportions.		✓	✓	P	P	P	P	P	P	P	P	P
		No fixed built in furniture or heating elements.		X	X	X	X	X	X	X	X	X	X	X
		Considerable location of the door.		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		Appropriate for size and number of windows in the room.		✓	✓	✓	✓	✓	✓	✓	✓	X	X	X

Table keys ✓: Achieved X: Not achieved P: Partly achieved

Table 7.8: Evaluation of flexibility in the plan of the Eryaman Third Stage project. Source: the researcher.

7.5.4 Flexibility in construction

Structure

In both residential buildings, the main structures consist of concrete columns, beams and slabs, as well as loadbearing walls enclosing the staircases. Therefore, as the internal and external walls are both non-loadbearing, the structure of both blocks can be separated from the infill parts of the building (the external and internal walls).

In addition, the plans show that the columns in block (A) form three rows in one part of the building, two rows located on the periphery and one in the middle of the block, spanning 5.3m through a structural grid of 5.65m. This system produced unclear spans across the width of the units (type 2) on the ground floor, where there was one row of columns in the middle, while clear spans were produced across the width of the units on the upper floors, as all units on these floors are located between two rows of columns (see figure 7.31). In the other parts of the building, columns with spans of 7.4m and 2.8m were placed on the periphery of the building by means of two alternate structural grids of 4.35m and 6.95m, thereby providing clear spans across the width of the units on each level.

In block (B), there are three rows of columns on the ground floor, two rows at the periphery of the floor and one row located in the middle, which have spans 6.45m and 5.4 through a repetitive structural grid of 6.35m. This system provides clear spans across the width of the different units at different building levels (see figure 7.32).

Therefore, there are in general clear spans across the width of the different units that allow the different structural elements (internal and external walls) to work as infill parts, thereby facilitating the ability to create different floor plans for the units over time.

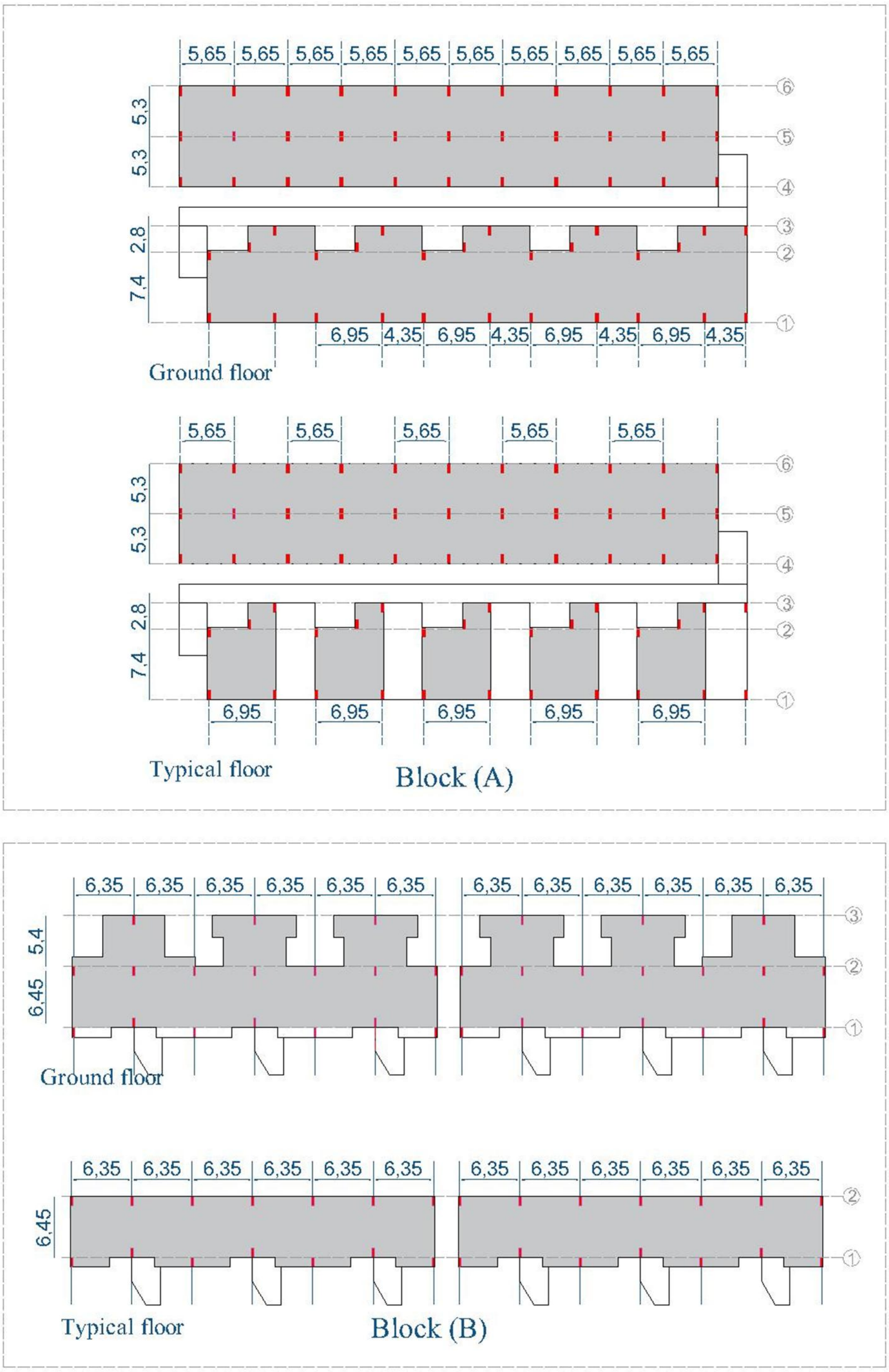


Figure 7.32: The support structure of the Eryaman Third Stage project. Source: the researcher.

Roof

According to the interview with the architect, the top roof is a flat concrete slab, finished with a sloped brick tile roof, and it was not designed to take upward extension (interview no. 15). The observations made during the field trip to the site in 2013/2014 showed that the roof is pitched and was designed only to finish off the building (see figure 7.33). Therefore, the roof structure of this building does not have design flexibility.

Figure 7.33: The top roof form of the Eryaman Third Stage project. Source: the researcher.

Internal walls

The internal partitions of the units in this project are non-loadbearing walls, constructed as thin block walls using hollow blocks with a thickness of 100mm. Therefore, they can be demolished without affecting the main structure of the building. In addition, creating an opening within the wall is possible by using a drill, then a hammer and bolster. These walls can accept change, and thus allow for flexibility according to the analytical framework in Chapter 3, section 3.3 of this research, but this possibility is restricted by the difficulty of making changes without the need for specialists. In addition, as services such as electrical wires are located within the partitions, these would need to be removed before implementing any change. According to the interview with the architect, the use of hollow block walls reduces construction and labour costs as this is a faster and easier construction system, which is an important consideration in a project designed for social housing provision (interview no.15).

External walls

The external walls and the party walls between the units are also non-loadbearing, and similarly constructed as block walls using hollow blocks, but with a thickness of 200mm for thermal and sound insulation. Therefore, these walls offer the same opportunities for change, but more additional work would be required due to their greater thickness. The external walls are finished with plaster with paint, which again does not restrict opportunities for changing these walls.

In summary, flexibility in this construction system is largely provided through the main structure allowing structural elements such as internal and external walls to act as infill parts of the building, which is made possible by the skeleton structure based on beams and columns. Further opportunity for flexibility derives from the clear spans across the width of the different unit types that free the internal layout of the units from the structural elements. Meanwhile, the difficulty in adapting the infill parts of the building (internal and external walls) without the input of specialists, because of their blockwork construction, represents a key restriction on flexibility.

Table 7.9 summarises the different possibilities and limitations regarding flexibility in construction of the Eryaman Third Stage project.

Indicators	Criteria		Evaluation	
			Block A	Block B
Structure	The ability of the structure to allow different layout forms	The ability of the structure to be separated from the infill parts.	✓	✓
		The ability of the structure to generate open clear space between the structural elements.	**P**	✓
External walls	The ability of the external walls to accept change	The ability to disconnect the external walls from the main structure of the building.	✓	✓
		The ability to alter the external walls.	**P**	**P**
		Simplicity and legibility.	**X**	**X**
Internal partitions	The ability of the internal partitions to accept change	Non-load bearing construction of the wall.	✓	✓
		No services located within the partitions.	**X**	**X**
		The ability for altering.	**P**	**P**
		Simplicity and legibility.	**X**	**X**
Roof	Can accept future extension	The structure of the roof to be appropriately sized to bear potential dead and live loads.	**X**	**X**

Table keys ✓: Achieved **X**: Not achieved P: Partly achieved

Table 7.9: Evaluation of flexibility in construction of the Eryaman Third Stage project. Source: the researcher.

7.5.5 Flexibility in services

1- Pipes and Wires

Vertical distribution

According to the interview with the architects, vertical shafts were installed in the building for vertical distribution of service elements such as water pipes and electrical wires to different building storeys (interview no. 15), which means that the vertical services are contained within a separate layer and can be adapted without disturbing other building layers. According to the plans, the vertical shafts are placed within services spaces such as kitchens, bathrooms and toilets, so their placement does not restrict future internal change of the units (see figure 7.29). However, the plans show that these shafts are of limited size and the services are difficult to access as there are no openings on individual storeys to enable them to be reached easily. Therefore, these vertical shafts cannot easily accommodate adaptation or maintenance of services over time.

Horizontal distribution

The horizontal runs of water pipes and electrical wires were distributed conventionally within the units from the shafts by passing them over the concrete slab within the floors and walls, with the electrical wires fed through plastic pipes to serve the different rooms and wet spaces (interview no. 15). Therefore, accessing the wiring would be viable but not particularly easy. Meanwhile, as the water services were not housed within a separate layer, maintenance and upgrading, as well as adapting the location of these services, would all be difficult and require additional work. It is clear that the conventional method of distributing the services in this project limited flexibility in terms of water services as these services were buried within the structural elements, whereas the design of the electrical services created both possibilities and limitations as whilst the wiring was located in a separate layer, it was also placed within the structural elements, making it difficult to fully uncover.

2- Appliances

A conventional wet system of radiators, which were generally fixed on external walls, was used as the primary means of heating in this project (interview no. 15). Meanwhile lighting system appliances were generally placed in a fixed place on the ceiling, and therefore were not designed for future internal change. Electrical outlets such as switches, sockets, TV and phone were also located in a fixed place, either on internal or external walls according to the functional layout of the unit, and thus they too were not designed to accept change in the future (observation made in the 2013/2014 field trip).

Consequently, the design of this project allows a few possibilities for flexibility in services in terms of vertical distribution based on consideration of the building shafts, horizontal distribution of the wiring system through plastic pipes and appropriate placement of the heating appliances to facilitate internal change, which are all conventional practices for services distributions in this building context. On the other hand, the traditional methods used for vertical and horizontal distribution of services limit such flexibility as they do not facilitate easy access in the future for maintenance and upgrading of these services (see table 7.10).

Category	Indicators		Criteria	Evaluation
Pipes and wires	Horizontal runs	Pipes	Separation of the pipes from the construction elements.	X
			Ability to access the pipes easily.	X
			Careful location of services to facilitate future adaptations.	X
		Wires	Separation of the wiring system from the construction elements.	✓
			Ability to access the wiring system easily.	P
			Careful location of services to facilitate future adaptations.	X
	Vertical runs		Separation of the services from the construction elements.	✓
			Ability to access the vertical runs easily.	X
			Over capacity of the distribution systems to accept future technologies.	X
Appliances	Heating and cooling		Appropriate location of the heating and cooling appliances and their controls to allow future change.	X
	Lighting (switches and lights)		Appropriate location of the lighting appliances and their controls to allow future change.	X
	Outlets (sockets, TV and phone)		Appropriate location of the outlets to allow future change.	X

Table keys ✓: Achieved X: Not achieved P: Partly achieved

Table 7.10: Evaluation of flexibility in services of the Eryaman Third Stage project. Source: the researcher

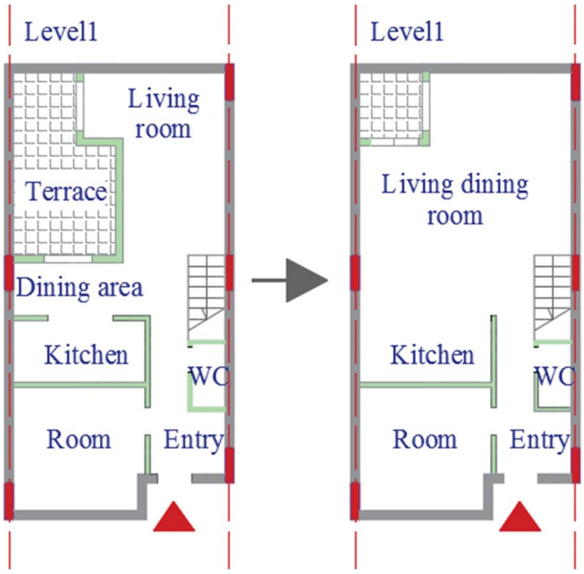
7.5.6 Flexibility in use

According to the interview with the architect, the designs of the units generally seek to enable flexible response to changes in household structure, such as changes in family number and growing children, and to accommodate different household lifestyles (interview no.15).

This project is able to meet the need to accommodate a growing or extended family mainly through joining together two attached units such as type 2, 3 and 5, as these permit an opening to be created between the units to provide a large unit with four or five bedrooms, thereby improving the living space to accommodate the different activities of family members. In cases of a decrease in household size, for example when of children grow up and decide to leave home, units with two storeys such as types 4 and 6 allow creation of two separate units on each floor, both with independent access and services. However, according to the interview with a sales manager responsible for selling and renting some of the units in the project, cases of users joining adjacent units after occupancy are very rare due to the unlikelihood of the required adjacent unit being free at the right time (interview no. 16).

Accommodating increases in family number due to such as a couple having a new child is possible, for instance, in the sample units with external open space (patio) that can be added to the interior space of the dwelling as a new bedroom. The investigation of users' adaptations in this project showed such possibility for change in type 1. According to the interviewee, this was done to provide an additional sleeping space for children, which required primarily installation of a new light roof (sandwich panel) to cover the space (interview no 17). This form of adaptation can respond also to a household's need for more living space to accommodate new social activities and changes in lifestyle, through adding part of or the entire external space to the unit. This form of adaptation was seen in type 8 where the user enclosed a large part of the external open space to increase the living area of the unit and create an open living/dining/kitchen space to accommodate social gatherings with relatives and friends. However, the interviewee indicated that carrying out this adaptation was not simple as it required constructional work and specialist input (interview no.17) (see figure 7.34).

Type 1 before and after adaptation



Type 8 before and after adaptation

Figure 7.34: Examples of adaptations of unit types 1&8 in the Eryaman Third Stage project. Source: the researcher.

The observations made during 2013/2014 showed that a large number of the occupants created different forms of enclosures of the units' external open spaces (balcony). According to the interview with the sales manager, the balconies can be enclosed only by using light material, whilst using a permanent material such as a blockwork is forbidden by building regulations (interview no. 16). The investigation of two cases of balcony enclosure in types 4 and 5 revealed that the key reason for making this adaptation was to make the space usable in different weather conditions. In this respect, the users indicated that joining these areas to the interior space is restricted by the beams under the ceiling that create visual separation between the two spaces, while building regulations prevent enclosure of the balcony by using blockwork because the structure cannot carry the additional load (interviews no19 and 20) (see figure 7.35).

Type 4 Type 5

Figure 7.35: Balcony enclosures in units of type 4&5 in the Eryaman Third Stage project. Source: the researcher.

Moreover, the ability to change the units internally offers users the opportunity to re-configure the plans of their units to accommodate their lifestyles. In this respect, the sales manager stated that internal adaptations were primarily carried out to create an open plan kitchen with a dining/living area (interview no. 17). The interviews with occupants who had carried out such adaptations of unit types 8 and 3 revealed two key reasons for making this change: first, in type 8, it was done to increase the size of the kitchen, to accommodate different daily activities, such as cooking, family gatherings, eating, children's homework, etc. (see figure 7.34) (interviews no.18), and second, in type 3, the reason was to provide modernity of living (see figure 7.36) (interviews no.21).

Figure 7.36: Adaptation of unit type 3 in the Eryaman Third Stage project. Source: the researcher.

Finally, the observations revealed that a large number of units that were located on the ground floor and had a direct relation with the main street were converted for non-residential purposes (see figure 7.23). An interview conducted with a user who had converted their type 2 dwelling to accommodate a real estate agent business revealed that the need for place in which to start up the business was the key reason for this conversion, with this unit being appropriate for such conversion because of its location on the main street and its independent means of access (interview no.22).

Consequently, the units vary in their potential for flexibility in use according to their capacity for change. In this respect, the units with large external areas can be seen as having the flexibility to accommodate some changing household needs in terms of demographic and socio-cultural aspects, despite the difficulty of carrying out this adaptation, due to the ability to increase the interior area of the unit. Whereas, those units that can only accommodate internal change could facilitate scenarios of use such as meeting the socio-cultural needs of the household. Meanwhile, their units' ground floor location and the favourable design of the communal circulation opened up economic possibilities for other users. On the other hand, restrictions on joining external open spaces such as a balcony to the interior area of the unit due to building regulations and structural limitations reduce some units' potential for flexibility in use. Furthermore, joining two units together was also found to be problematic.

7.5.7 User empowerment

By encouraging users to make modifications to their units post-completion according to their desires, the architects handed over control to the users. Thus the users can be considered to have some empowerment and control over their dwellings. This freedom is made possible by the skeleton system of the structure that provides adequate spans and the strategically located columns that allow structural elements such as internal and external walls to work as infill parts of the building and to create clear spans across the width of different units' types. This potential empowerment was enhanced by the architects' strategy of providing un-programmed external open space, which reflects an indeterminate approach to adaptation. This approach can be clearly seen through the design of internal walls without pre-planned openings or adaptations and leaving the design of external space open for users to fill as they see fit. However, this capacity for user empowerment is restricted by building regulations and construction limitations that limit the users' ability to make changes to their external balcony spaces according to their desire and needs, whilst such adaptations also have cost implications as explained in the following section.

7.5.8 Financial aspects of flexibility

Cost implications

Due to the lack of opportunity to conduct interviews with the developer in this project, the research had to depend on interviews with the architect and the secondary data to identify the implications of incorporating flexibility in this project. According to the interview with the architect, the units were designed based on traditional requirements of housing design, therefore there was no difference in the cost of this project compared to other traditional designs (interview no. 15). On the other hand, according to Altay (2004), the structural system of columns and beams increased the construction cost in this stage, compared with the tunnel formwork construction method, due to the extra labour and constructional work and time required to develop the project. Therefore, the incorporation of flexibility in this project had upfront cost implications because of the construction system used to enhance the adaptability of the units, which in turn reduced the willingness of the developer to use this construction method again in the next stages of the project.

According to the interviews with users who had adapted their dwellings, the adaptations of their units incurred considerable cost because of the construction work required to modify the blockwork of the partition and services located within (interview no.18 and 21). Therefore, any adaptations made to units in this project have cost implications due to the construction method, the material used for the infill parts, and the inflexible methods used for distribution of the services systems.

7.5.9 Conclusion

The examination of the motivations for flexibility in this project revealed that there was a demand from users for their housing to respond to the variations and changing needs in their demographic characteristics and lifestyle. As these needs cannot be accommodated by the repetitive design of mass housing production in this context because of the rigid form of the construction method used (tunnel formwork), this was the key motivation for adopting a flexible design approach. Another important motivation was the developer's willingness to present a demonstrable example of how to build using best practice of mass housing production in the particular context.

The analysis of flexibility in the design of this project against the research's analytical framework concepts presented different possibilities and limitations regarding such flexibility. The key possibilities for flexibility emerged in terms of spatial flexibility and user empowerment, as users have the ability to change their dwellings as they see fit. This was underpinned by the skeleton system of the main structure and non-special form of the infill parts and un-programmed external space of the units, which provided soft flexibility in form. This flexibility was however restricted by building regulations and the cost implications of making adaptations to the infill parts due to the use of rigid building materials.

Designing for flexibility was also found to have implications for upfront cost, as is reflected in the developer's unwillingness to develop again using this approach, despite the non-profit target, which set the idea of flexibility against the developer's target to deliver housing as cheaply and quickly as possible in response to the increasing demand from people who are unable to buy property due to the current market situation.

7.6 Final conclusion

The investigation of the motivations for flexible design in the Turkey case studies showed that different factors drove incorporation of flexibility in the housing designs. In the first case study the location of the project in a business centre of the city and the demand in the market for adaptable live work accommodation that created the financial motive for the developer to develop with flexibility were the key motivations for this initiative in seeking to respond to households' economic and cultural needs. In the second project, the motivation was the public sector developer's desire to build in best practice of mass housing production and provide a demonstrable example of housing that can accommodate households' different and changing needs in their dwelling. This was driven by the fact that the mass housing production in the context is of uniform and repetitive design and based on a rigid structural system (tunnel formwork), which prevent the design of the dwelling from responding to the variety of current and potential household needs, which were in this project identified as demographic and cultural needs.

The analysis of both case studies showed that flexibility in the plan was generated differently through the design approaches of the projects. In the first project, flexibility in the plan was achieved mainly at building level. In this respect, the analysis revealed that the plan's ability for flexibility in building use resulted primarily from the non-residential standards of the structural system in terms of span between the structural elements, storey height and vertical access means, secondly, the building's form and façade, and finally, the separate means of escape. However, the only restriction was found related to the creation of openings in the floor structure for additional shafts to facilitate the residential use of the building, which resulted in services installation within the building's structural elements. Meanwhile, flexibility in unit mix was restricted in both projects by the difficulty of making openings within the party walls between the units due to the robust material used to meet fire protection and sound insulation requirements.

In addition, the analysis revealed other possibilities for flexibility in the plan at room and unit level. In relation to the former, the design of the units with an adaptable space (living space) that can be occupied in different ways, mainly for a live and work scenario, provide an opportunity for functional flexibility at room level. However, the analysis displayed that generously sized spaces or those that have the potential to be increased in size can generate more scope for flexibility. Regarding the latter, the design of the units around the principle of space zoning that considered strategic placement of services in one zone and the use of light internal partitions between the unit spaces gave the plan of units spatial flexibility. This potential for flexibility was seen also in the designs of unit layouts in the second project that similarly located the services in one zone in most cases and used non-loadbearing internal partitions, because of the beams and columns structure. This potential was however restricted by the difficulty of altering the internal partitions due to the rigid material (blockwork) used in their construction.

The use of beams and columns construction in both projects provides the structure with potential for flexibility because this method separates the main structure from the infill parts and creates clear spans between the structural elements. However, in terms of infill parts, while the first project provided flexible internal and external partitions in the forms of sliding walls and walls as furniture for internal walls and curtain walls and floor to ceiling windows for external walls, the second project restrict this possibility because of the use of rigid material (blockwork) for both the internal and external partitions. In relation to services, the first project was found to have more scope for flexibility, mainly due to the use of flexible methods for distributing services either vertically through oversized shafts that can be reached easily for change or horizontally through a suspended ceiling along the communal corridor of the building. On the other hand, in the second project flexibility is restricted due to the use of the conventional residential method for services distribution whereby services are located within the structural elements of the building.

Flexibility in use in the first project was seen mainly in terms of scenarios of economic and cultural use that went beyond the architects' pre-established scenario of live and work. However, further flexibility in use was found through the design's provision of units with sliding walls that allow the main space to be increased in size and therefore allow other scenarios of use such as accommodating large social gatherings. In the second project, both the potential in the plan for internal change and the potential for increasing the size through adding balconies and terraces provided possibilities for flexibility in use, mainly in serving the demographic and socio-cultural needs of the household. However, these possibilities were restricted due to the difficulty of changing the internal partitions and joining on the external balcony space because of building regulations and the building's structure.

Different possibilities for user empowerment were seen in the design approaches of the two projects. In the first project, the adaptability of the living space would empower the user to occupy the space in more than one way. However, it was found that this adaptability was limited in some cases due to the inability to change the size of this space and the determinations of the space in terms of floor to ceiling windows and walls as furniture that restricted potential for different ways of occupation. In the second project, whilst control has been passed to the users through encouraging them to make internal adaptations, their freedom to make such changes is restricted by the difficulty and cost of making modifications to the internal blockwork partitions, while making external changes by filling the external open space would be constrained by building regulations and structural limitations as has been explained above.

In both projects, the incorporation of flexibility had upfront cost implications, particularly in the first project due to the building cladding used, flexible features and the services core, which however did not reduce the developer's desire to develop again incorporating flexibility, due to the demand in the market. Meanwhile, the second project was found to present greater cost implications for adaptation after occupancy, mainly deriving from the expense of changing the blockwork in the partitions.

Chapter 8: Discussion and conclusions

8.1 Introduction

The overall aim of this research was to understand the motivations driving flexible housing practices and the possibilities and constraints of these practices in different contexts with more or less regulation or policy environment, with the aim of extracting lessons in relation to policy and procurement of best practice of flexible housing that can potentially benefit further applications of flexible housing in contexts such as Middle East countries, including Syria.

This chapter draws conclusions from the research, and is divided into three main parts. The first part discusses how the key research questions are addressed according to the main findings from the literature review, the examination of the policy context of the UK and the analysis of different case studies in the research contexts of the UK and Turkey. The second part draws conclusions form the discussion outlining the lessons learned on policy and practice from the selected flexible housing experiences. The third section identifies topics for further research.

8.2 Discussion of the main findings in relation to the research objectives and literature

This section discusses the key findings of the research that address the research objectives and questions proposed in Chapter 1.

Obj.1: *To investigate the motivations for flexible housing in terms of households' changing needs and develop an analytical framework for the research that allows analysis of flexible housing practices in different contexts.*

Achieving this objective and the relevant questions was the first stage of the research, and was addressed in Chapters 2 and 3 by reviewing the literature. The review investigated the different definitions of flexible housing, motivations for flexible housing and different concepts relevant to flexibility in housing design.

RQ1.1: *What are the different definitions and forms of flexible housing?*

The review revealed two key concepts – flexibility and adaptability – in the housing context. The discussion in Chapter 2 showed that these concepts are conceptualised in two different ways. The first perspective presented flexibility and adaptability as two separate yet complementary concepts. Flexibility deals with physical change, whilst adaptability is concerned with how the design is manipulated through (non)physical change. The second perspective, which was the stance adopted by this research, suggests that flexibility is inclusive of adaptability and deals with both physical changes and different uses.

The review also advocated that the two terms - flexible and adaptable - can be used interchangeably to refer to housing that can adapt to changing social needs, whether by altering the physical fabric, or through (non)physical change. This position was developed by recent academics such as Friedman (2002) and Schneider and Till (2007), who used these terms to refer to the same notion. Further, it was clear from the definitions of flexible/adaptable housing that this concept is a process within which the physical elements of living environment can be adapted to serve households' changing needs. Therefore, the point of departure of this research was to investigate changing household needs in different contexts that require delivery of flexible housing design.

RQ1.2: *What are the changing needs driving households to adapt their dwellings over time in different contexts?*

In order to investigate the affective household's changing needs that may drive accommodation of flexibility in housing design, the research undertook a wide and deep review of literature dealing with housing design adaptations and relocation in different contexts, as well as the different flexible housing researches and projects that have outlined different drivers for flexible housing design in terms of households' changing needs. The investigation revealed a wide range of changes in household needs that may have implications for housing; these changes were related to demographic, cultural, economic and technical factors that affect the household. Therefore, this research adopted households' changing needs as a basis to classify the different drivers of flexible housing, as this allows to identify the possible changes in households' needs in their dwellings over time, to which flexible housing seeks to respond. This differed from the methods of classification adopted by authors such as Friedman (2002) and Schneider and Till (2007) who identified the drivers for flexible housing by relying on a direct down-to-earth reason-generated approach or developing a systematic framework to classify the reasons as either external or internal factors, as explained in Chapter 2, section 2.7.

Human factors affecting the household relate to the different demographic changes that often occur within households throughout their lifecycle in terms of changes in household size, age of household members, age and gender of children, and physical ability of household members. Cultural factors relate to the household's social norms and perceptions of the physical living environment, which derive from the cultural values of their particular group or community. In this respect, socio-cultural variables explored through the literature review included such as cultural differences between households in their personal relationships, including relationships among household members and social links with relatives, friends and neighbours. In addition, consideration was given to the household's social roles and activities system within their dwelling, lifestyles, and perceptions of privacy, crowding, identity and comfort. Economic factors, on the other hand, were considered in terms of changes in economic circumstances that might influence housing design, such as changes in the household's income and employment status. Finally, technical factors primarily related to household needs deriving from new technological developments and changing safety and security requirements.

R.Q.1.3: *What key concepts can be identified as important for flexible housing? How can these be used as a basis to develop a framework for analysis of different aspects of flexible housing design?*

The literature review revealed various design, social and economic factors that may have an impact on delivery of flexible housing. These included the following key aspects: plan, construction services, use, user and financial consideration, which were used as main concepts to develop the research analytical framework. These concepts represented the collective issues considered by different authors such as Habraken (1972), Brand (1994), Friedman (2002), Leupen (2006), and particularly Schneider and Till (2007), in their key approaches to flexible housing.

Plans were considered at three levels - building, unit and room – borrowing these categories from Schneider and Till (2007) – and for each level various indicators were adopted through reviewing the various approaches to flexible housing. At building level, three key indicators were considered: building use, unit mix and communal circulation, to allow for analysis of flexibility in plans of different types of building, either single dwelling or multiple unit buildings that may exist in different contexts. For analysis of flexibility at unit level, the selected indicators were unit size and layout arrangement in terms of function, spatial and internal circulation. Meanwhile, flexibility at room level was analysed in terms of function, connection and furniture. In addition, the research drew on the literature to develop criteria at each of the different levels for use in evaluating flexibility in the plan.

In order to analyse flexibility in construction, the research used the main building elements such as main structure, foundation, internal and external walls, and roof structure as indicators. These indicators differed from those adopted by authors such as Schneider and Till (2007) who considered particular construction principles such as main frame, layer system, and the structures' simplicity, legibility and ease of disassembly. However, the current research adopted these principles among the evaluation criteria to assess the previous building elements in terms of flexibility, as presented in table 3.2. Services, meanwhile, were considered according to two key types of indicator: 1) vertical and horizontal systems for distribution of pipes and wires, and 2) appliances and outlets for heating, cooling and lighting. These indicators represented a combination of Leupen's (2006) classification of services as pipes and wires and appliances and the Schneider and Till (2007) division of services runs as vertical and horizontal distributions.

In order to analyse flexibility in use, the research adopted four key indicators according to the main categories of the household changing needs identified in Chapter 2, section 2.7, namely, flexibility towards the household's changing demographic characteristics, cultural flexibility, economic flexibility and technical flexibility. This method was used to analyse the ability of the design, in the plan and as a construction, to respond to households' changing demographic, cultural, economic and technical needs. The literature review revealed little information regarding concepts for analysing the capability of flexible designs to respond to different households' changing needs. However, some references were found in works by Al-Dakheel (2006) Schneider and Till (2007), which introduced some indicators of cultural flexibility and flexibility towards households' changing demographic characteristics.

Additionally, the research incorporated user empowerment into the analytical framework in order to evaluate flexible design in relation to users' control over their dwellings. This was considered via two key indicators: "use" and "form", borrowed from Schneider and Till (2007). "Use" indicates the plan's ability to allow the users to occupy their spaces as they see fit, "form", on the other hand, assesses the extent to which the building technologies allow the users to make adaptations on their own terms. In considering financial factors, two key aspects were investigated: adaptation costs and the economic feasibility of delivering flexible housing to the market.

As the above discussion illustrates, concepts drawn from previous literature were integrated into an analytical framework as a practical tool to evaluate flexible housing case studies. This framework was used to consider the following aspects of delivering flexible design in the case study contexts: (1) the physical design in relation to the plan, construction and services; (2) how the design accommodates different users' changing needs and enables users to have control over their dwellings and make adaptations in terms of the architects' scenarios of change; (3) the cost implications of incorporating flexibility in design, and user satisfaction at the point of purchase.

Obj.2: *To investigate and analyse national planning policy and housing programmes relevant to flexible housing provision in the contexts of the UK case studies.*

In order to investigate policies and programmes related to flexible housing, official documents such as national planning statements for England and Scotland, representing the political contexts of the selected case studies in the UK, were examined (see Chapter 5). The general principles and objectives set out in the policies were considered in the light of the key definition of flexible housing discussed in Chapter 2 section 2.2. Finally, data on particular housing programmes with relevance to flexible housing and derived from publications, reports and academic articles were analysed based on the concepts of the research analytical framework developed in Chapter 3.

RQ 2.1: *What planning policies at national level have relevance to flexible housing? How do these policies potentially promote the provision of flexible housing?*

Analysis of the policy context in England focused on national planning statements (such as PPS1, PPS3 and Sustainable Communities: Building for the Future*)* available as governmental publications during the design stage of the selected case study in England. The analysis of planning policy revealed little evidence of strategy to promote flexibility. The only example found was an implicit reference to flexibility in housing in *Sustainable Communities: building for the future,* which called for individual buildings to be able to accommodate people's changing needs over time as policy guidance for creating sustainable communities.

In the Scottish context, more evidence was found of a policy environment supportive of flexible housing. First, national planning policy contained in Scotland SPP3 referred to provision of flexible living space to respond to households' changing needs in order to create sustainable communities. Second, *PAN 67: Housing Quality,* a policy document on designing places, recommends the incorporation of adaptability to create successful living environments. However, in both policy contexts flexibility was addressed mainly in terms of provision of a range of housing types pre-occupancy rather than extending houses beyond the existing housing envelope.

RQ 2.2: *What are the key characteristics of housing programmes that promote the delivery of flexible design in housing* in the contexts of the UK case studies*? How do these programmes promote achievement of flexibility in housing design?*

Two well-known national housing programmes - Lifetime Homes (LTH) in England and Housing for Varying Needs (HVN) in Scotland - were found to promote adaptable solutions in housing design. The evaluation of both groups of standards against the concepts of the research analytical framework, as discussed in Chapter 5, revealed that incorporating these standards into the housing design offers only a few possibilities for flexibility. The main possibilities for flexibility in the plans for both programmes related to functions and furniture at room level, through the requirement for space to be adaptable for use as bed space, bathroom to accept future shower, bathroom and toilet being able to accept additional fixtures, and at unit level in terms of vertical circulation through the requirement for accommodation of a future floor and stair lift. Regarding flexibility in construction, both programmes considered the need for ceilings to have knock-out panels for future lift and hoist installation, and bathroom walls to be able to accept new fixtures. However, HVNs went further by recommending designs that minimise the use of load bearing walls, to facilitate future adaptations. In addition, HVN standards addressed flexibility in services by calling for use of wiring distribution systems that can accommodate future adaptations.

The analysis also indicated that whilst both programmes addressed flexibility in response primarily to changes in households' demographic characteristics, this was addressed only in terms of meeting access and social needs of the elderly and disabled. On the other hand, HVN standards contained a requirement for wiring services to be adaptable in response to future technological developments. Meanwhile, the determinate nature of the design standards of both programmes offered little scope for empowering users to adapt their dwellings according to their own wishes.

Finally, investigation of building regulations in both contexts showed that most design standards of LTHs were included in Building Regulations in England, but as optional requirements, whereas in Scotland, a number of HVN standards were incorporated as mandatory or partly mandatory requirements for use in the Technical Standards. Overall, neither of these documents could be seen as offering much guidance on flexible design according to the criteria adopted by this research.

Obj.3: *To analyse the UK case studies of flexible housing in order to discover the relevant motivations, possibilities and constraints for flexible design, and the relation between policy and practice.*

Document review and stakeholder interviews, as described in Chapter 6, were used to investigate the motivations for adoption of flexibility as a design initiative in the selected projects and to discover the relation between policy and practice. The documents provided background information about the local authority housing policy relevant to each case study. The interviews were used to gain in-depth understanding of the role of the policy context on flexibility practice and to explore key motivations, possibilities and constraints in relation to such practice.

RQ.3.1 *What existing policies have supported flexible housing provision in the selected projects? What role does policy potentially play in delivering flexible design in the selected projects?*

The analysis of the second case study, Tattenhoe Park Development, Milton Keynes, England, discussed in Chapter 6, revealed that this particular case was one of the designated sites in the *Sustainable Community Plan*, a policy document introduced to support the delivery of flexible housing. Financial support for the additional requirements of flexibility was made possible because the landowner was a social body with links to the government. The intention was to show how flexible housing as developed in such a project could enable people to stay within their communities for a long period of time by being adaptable to households' changing needs. At the local level, both policy *H9: Housing Mix* and *D2A: Urban Design Aspects of New Development* contained supportive flexibility standards relating to this project (LTH standards).

***RQ.3.2** What motivations have contributed to incorporation of flexibility into the designs in the case studies? What are the changing needs that drove the adoption of flexible housing strategies in these projects?*

The examination of the two UK projects revealed different motivations for the incorporation of flexibility. The design of the first project, arrived at as a result of a competition looking at new ideas in housing design, was driven by the architects' motivation to achieve sustainability in design through flexibility. Meanwhile, the design of the second project was driven by a community group's demand to purchase dwellings that could cope with change and enable them to stay in their local community for a long period of time, in a project supported by the landowner's willingness to build in best practice for housing design. In both projects, flexibility was also driven by the inability of the existing housing stock to respond to households' different and changing needs. In the first project these needs were primarily economic and social, whereas in the second project they were mainly cultural. Policy appeared to have little influence in motivating flexible design practices in the first case; however, in the second case study there was more reference to policy at both national and local level, which led to a role in driving flexibility initiative but this was not sufficient to bring this initiative to the practice.

***RQ. 3.3:** What are the resulting possibilities and limitations for these flexible housing practices?*

In both case studies, generating flexibility in the plan relied principally on the provision of more space. In the first project this was achieved through flexible design approaches such as built-on space (annexe), while in the second it was achieved through providing unfinished roof space and vertical and horizontal extensions, which meant that the plans for each project contained different possibilities for flexibility. The analysis showed that there was more scope for flexibility in plan where size provision was generous, when independency in terms of access and services was taken into consideration, and the plan provided indeterminacy of space in use and form. On the other hand, flexibility through extension in the second project was constrained by limitations on land cover in terms of garden size and privacy considerations at site level. Another constraint was the lack of guidance in the design code on flexible design approaches suitable for dealing with tight spaces. Design strategies for extensions proposed by different authors such as Friedman (2002) and Schneider and Till (2007) have been concerned primarily with particular design principles relating to access, light and construction of the different types of additions, regardless of their relation with the external and landscape or how coordinating these design methods with flexibility in the plan could lead to best practice in flexible housing. However, Douglas (2002) highlighted the importance of considering the impact of the extension's position, as one of the spatial constraints, in relation to the surrounding or adjoining properties and factors including access, daylight and privacy. The analysis of the case studies similarly highlighted these factors as key limitations on the design of extensions.

In both projects, the conventional construction methods that considered wall-based constructional systems (timber and cross wall structure) provided various possibilities for flexibility, as the structure was separate from the internal partitions, although not necessarily from the external walls, and clear spans across the width of units of small size. Regarding the infill parts, the common practice of using stud walls that are easily demountable emerged as the key opportunity for design flexibility. This method entails the use of non-specialised forms and light material to create internal partitions and therefore does not challenge the technical and economic rationality of the building industry. The methods and standards used for constructing foundations and the roof structure also encouraged flexibility. The second project took advantage of these methods to facilitate a vertical extension approach, whereas the first project was deterred from doing so by onerous building regulations regarding extensions into roof space. Schneider and Till (2007) similarly indicated that the generic principle of a flexible main structure can be achieved across wall-based constructional systems, as long as a separation is maintained between the main structural elements and infill parts, and a generous free span is provided between the walls. The tendency revealed in both projects to use conventional construction methods to develop flexibility reflects the finding by Lovell and Smith (2010) that the cultural economy of the housing construction market has a clear impact on innovation in the home building industry in the UK.

Flexibility in terms of services was in both projects achieved due to the architects' avoidance of locating services (pipes and wires) within the structural elements. In addition, the design of the external wall structure with a separated layer for service runs in the first project allowed for easy access and upgrading without disturbing other layers. On the other hand, in the second project, the conventional method of services distribution within structural elements restricted access to these services for maintenance. In terms of appliance, in the first project the use of an underfloor heating system meant that the need for heating appliances was avoided, although this system is difficult to access for maintenance. Researchers such as Brand (1994), Friedman (2002), Leupen (2006), Schneider and Till (2007) similarly advocated the need to avoid locating the services within construction elements that would likely need to be changed in the future, and the importance of placing them in a separated layer, possibly on permanent fixed elements that can be accessed easily. In terms of appliances, Schneider and Till (2007) clearly indicated that in the interests of flexibility it is necessary to use alternatives to the wet radiator system, which was achieved in the first project through installing an underfloor heating system.

The ability of the plans for both projects to be increased in size was the main advantage regarding flexibility in use. However, the analysis showed that the more scope of flexibility in use was possible to be obtained in the flexible design that provided generous indeterminate additional space with the possibility for a level of independency in terms of access and services such as in the first project and in the types with extension over garage of the second project. On the other hand, the limitation for flexibility in use in the types with rear extension of the second project derived from their limited ability to provide generous size to the plan, alongside the architects' approach of delivering such flexibility through a deterministic scenario. Little reference to how flexible design approaches could expand the scope of flexibility in use was found in the literature review. However, Schneider and Till (2007) proposed a set of indicators categorised into three levels, building, unit and room, to identify the level of flexibility in use in flexible design, although they did not relate them to any particular design strategy or approach. Therefore, the current results provide an illustrative example of how more scope of flexibility in use could be achieved through a particular design approach. In addition, the finding that designing for flexibility on the basis of indeterminacy effectively promotes flexibility in use reflects similar ideas highlighted by Schneider and Till (2007) and Brand (1994), the latter stating: "All buildings are predictions. All predictions are wrong".

Potential for empowerment of users to control their dwellings differed across the two projects according to the flexible design approaches adopted. The analysis showed that where the provision of space was generous, and led to indeterminacy in use and in the way of making adaptation, thereby giving users the more empowerment such as in the first project. Meanwhile, in the second project, methods of making adaptations, such as building horizontal rear extensions, were more pre-determined due to design code advice and the architects' determination of how the space could be used over time. This conclusion concurs with Schneider and Till's (2007) view that more user empowerment can be achieved through soft flexibility, which generally demands more space and is based on a relaxed approach to both planning and technology.

Assessment of the financial implications of flexibility also showed different results across the two projects in terms of cost of adaptation and deliverability. The first project incurs little or no cost in incorporating and making adaptations because the provision of ready to use space and the use of simple construction elements such as easily demountable stud walls. Meanwhile, in the second project, incorporating flexibility incurred costs deriving due to the hard form of flexibility, first, from installation of foundations in preparation for rear extensions, which in turn reduced the land value because of the increase in upfront cost, and, second the potential cost of carrying out adaptations after occupancy.

In market terms, while the WLH design achieved consumer satisfaction due to flexibility in adding to the size (annexe) of the house, the upfront cost restricted the market. In the second project, the focus of the potential consumers on their current needs and the lack of promoting the houses as flexible at the point of purchase reduced the deliverability of the project in the market at premium. These findings differ from Schneider and Till's (2007) argument which assumed that flexibility in housing design is a selling point and will achieve higher consumer satisfaction at the point of purchase, meaning that these houses can be sold faster. However, the current findings can be attributed to factors such as the cost implications and developers' unwillingness to promote the housing product as flexible in these particular cases. Therefore, such factors could reduce the financial benefit of flexible housing in market terms, which could depress its deliverability.

Obj.4 To analyse Turkish case studies of flexible housing in order to explore motivations, possibilities and constraints for flexible design in these practices in a context with less policy and regulation.

In order to discover the motivations for flexible housing in the selected case studies in the Turkish context and analyse the scope of flexibility in their designs, literature relevant to the context was reviewed, interviews were conducted with stakeholders and an observation was undertaken through a site visit outlined in Chapter 7. The literature review provided general information about the housing environment and planning system in Turkey and some secondary data about the selected flexible design experiences. The interviews offered more information and deeper understanding about the motivations, flexible design approaches of each project and stakeholders experiences throughout the development processes and after occupancy. Chapter 7 provided findings from the evaluation of the different aspects of flexible design approaches according to the analytical framework of the research. The findings ultimately presented the resulting advantages and disadvantages of these flexible housing experiences in this context.

RQ.4.1 What are the key reasons for flexible design in these practices in the absence of such legislation and regulation? What are the drivers for flexible housing provision?

The discussion on the motivations for flexible design in Turkey case studies revealed different reasons in each project for the flexibility initiatives. In the first case study the location of the project in the business centre of the cite and the demand in the market for adaptable live work accommodation that created the financial motive of the developer to develop in flexibility were the key reasons of this initiative that sought to respond to the household's economic and cultural needs. The motivation in the second case study was the public sector developer's willingness to provide an example of how to build in best practice of mass housing production that can respond to the different and changing needs of households in their dwellings. In this project, the flexibility initiative was driven by the fact that mass housing production in the context has a uniform and repetitive design and rigid structural system (tunnel formwork), and thus cannot respond to the household's different and changing needs, which were in this project identified as demographic and cultural needs.

RQ.4.2 What are the resulting possibilities and limitations for the flexible housing practices?

The analysis of both case studies showed that the design approaches generated flexibility differently. In the first project, the possibility for flexibility was seen at building level and derived from the ability of the building block to accept different building types, which came as a result of, firstly, non-residential standards of structural system in terms of span between the structural elements, storey height and vertical access means and, secondly, building form and façade, and finally separated means of escape. The sole limitation was due to the difficulty in creating openings in the floor structure for additional shafts for services, which let to services installation within structural elements. In both projects, the possibility for flexibility in unit mix was restricted due to the use of robust material for party walls between the units for fire protection and sound insulation reasons, which limits the ability to change these walls easily. The latter issue highlights another important requirement for joining separate units in order to develop a unit mix in a multi storey building, which has not been highlighted in the literature reviewed by this research. In addition, the results obtained from the first case study that addressed flexibility through adaptive reuse strategy generally reflect relative similar findings by other studies such as Gann and Barlow (1996) and Remoy and Voordt (2014) regarding the possibilities and constraints for adaptive reuse of office buildings by converting them into residential units. However, the main concern of this research was to discover the design principles behind this flexible approach that would benefit future applications of adaptive reuse and conversion of buildings. The findings in this regard reflected similar principles to those set out by MacCreanor (1998) and Schneider and Till (2007), but identified additional requirements in terms of the services core and distribution.

The first project presented other possibilities for flexibility in the plan, primarily at room level and relating to functional flexibility through the units having an adaptable space (living space) that can be occupied in different ways, mainly for a live and work scenario. The analysis showed that generously sized spaces can offer more scope for flexibility. Other possibilities for flexibility at unit level in terms of spatial flexibility derived from the strategic placement of services in one zone and the use of light internal partitions between the unit spaces. These strategies for achieving flexibility were identified frequently in design approaches proposed by different authors such as Friedman (2002), Leupen (2006), and Schneider and Till (2007). However, the current analysis provided further understanding of the possibilities and constraints in seeking to achieve best practice in flexible design at room level as explained in chapter 7. In the second project, the main possibility for flexibility was also found at unit level, because the beams and columns structure allows removal of the internal partitions, and services are located in one zone in most cases. Further potential for flexibility derived from the potential of more size of the units in this project, primarily through the incorporation of external open areas such as balconies and terraces, which can be filled partly or completely according to the users' will.

In terms of construction, the possibilities for flexibility in both projects derived from the separation of the main structure from infill parts such as internal and external walls and the creation of clear spans across the width of the units because of the skeleton system used to form the main structure and the placing of structural elements on the periphery of the building. Regarding the construction of infill parts, in the first project the structure of internal and external walls allowed flexibility because the stud walls, wall furniture, curtain walls and floor to ceiling windows can all be dismantled easily. However, the use of blockwork for the party walls between the units due to fire protection and acoustic insulation requirements restricts the possibility for change. In the second project, the conventional construction of the infill parts as blockwork also restricted the capacity for change. Different researchers such as Habrakan (1971), Leupen (2006) and Schneider and Till (2007) have asserted that the use of column and beam structures is important to the development of flexible housing design as it enables infill parts to be separated from the main structure. However, the current research, like Schneider and Till (2007), also identified an opportunity to develop flexible structures through wall-based structural systems, as mentioned above. In addition, the literature considered flexible internal partitions in housing primarily by focusing on the design principles and paid little attention to the potential limitations created by fire and acoustic requirements.

The first project presented opportunity for flexibility in services mainly through the use of non-residential building technology for distributing the services vertically and horizontally, achieved because of the suitable storey height of the building. However, some services (building sewer) were distributed within structural elements of the building because of the central shaft system of the existing building structure. In the second project, the conventional method of services distribution limited possibilities for flexibility other than in terms of the wiring system and the use of vertical shafts.

Researchers such as Friedman (2002) and Schneider and Till (2007) similarly promoted horizontal distribution methods for services systems in non-residential buildings, such as raised floors, suspended ceilings, and so on. However, these researchers also proposed the use of vertical distribution in the form of shafts to serve the wet spaces of the unit directly.

The analysis showed that the design of the units in the first project created potential for flexibility through particular scenarios of economic and cultural use that went beyond the architects' pre-established scenario. Flexibility in use could be increased further by adding (half modules) to the main adaptable space temporarily through a sliding wall to the adjacent room in some types, thereby making available other scenarios of use such as accommodating large social gatherings. In the second project, the potential of internal change and the provision of a large external open space (patio) in some units were seen as the main opportunities for flexibility in use, mainly in serving the demographic and socio-cultural needs of the household. However, these potentials were restricted due to the difficult of making adaptations of internal partitions because of their blockwork and in the case of balconies due to building regulations and building structure restrictions that prevent joining of these spaces to the interior area by the use of permanent building material. Similarly, the literature concerning the strategy of designing slack space (extension into unprogrammed space) indicated clearly that this design strategy can extend the scope of flexibility in use as this approach allows the users to adapt and occupy the space as they see fit. However, little attention was paid to the constraints of this approach, particularly regarding the potential role of building regulations in restricting the ability of users to make such adaptations, as the analysis of the second case study revealed.

User empowerment was found to vary across the two projects. In the first project, user empowerment was embedded through the adaptable space of the living area with potential to be occupied and used in different ways according to the users' wishes. The potential for user empowerment increased where the space was more generous or in units with sliding walls. Meanwhile, in the second project, control has been passed to the users through enabling them to make their own adaptations in their dwellings through re-arrangement of the unit layout, which was achieved through using a skeleton structural system that released the internal and external walls for adaptation, and the provision of un-programmed external open space. However, user empowerment is reduced by the building regulations and structural limitations as has been explained above, and by the significant cost to the user of making such adaptations. Similarly, the literature on flexible housing, particularly the work of Schneider and Till (2007), suggested that users can gain greater empowerment through flexible design strategies that put the user in charge of either using or adapting the space, through non-spatialised forms of adaptations and the provision of more indeterminate space; however, such potential is very much conditioned by building regulations and cost of adaptations, as this study revealed.

The discussion on financial aspects of flexibility revealed that incorporating flexibility into the design had cost implications for both projects. In the first project, the adaptive reuse of the building and the loft design of the units considerably increased the initial cost of the building due to the shell cladding, services core and the use of flexible elements such as sliding walls, walls as furniture and internal partitions. However, the cost of making adaptations was reduced by the potential to adapt the space easily and simply. In the second project, the upfront costs were increased because of the beams and columns system used to enhance the adaptability of the units, which involved extra labour and constructional work and time compared with using tunnel formwork, the method the developer most commonly uses in construction of housing projects. In addition, the blockwork of the partitions and location of services located within them makes adaptations very costly due to the amount of construction work involved.

In market terms, the flexible design of the first project increased the deliverability of the units due to the high demand in the market for such accommodation in the location. Hence the developer was motivated to develop again using this design concept, despite the cost implications of the design approach; whereas in the second project, the cost implications reduced the developer's willingness to develop again using flexible design.

Obj:5 To identify lessons and relevant best practice from these experiences in relation to policy and procurement of flexible housing that will potentially benefit future applications of flexible housing in different contexts, including Syria.

The discussion above has addressed the research objectives in relation to the literature in order to reveal different key issues relevant to flexible housing and extract lessons in terms of motivations, policy and regulation environment and physical, social and economic aspects of flexibility in housing design that can contribute to developing best practice. The conclusions derived from the above discussion are presented in the next section in the form of lessons learned from the case study contexts, thus addressing the final objective of the thesis.

8.3 Conclusion

Lessons learned from the case study contexts

Lessons relevant to motivations

- The key motive driving incorporation of flexibility into housing design practice is households' demand in the context for housing that can respond to their changing needs and wishes over time, which may derive from such as the household's desire to stay in their dwelling and communities for a long period of time or economic factors.
- The provider's desire to build in best practice and high quality for housing is another motivation for developing flexible housing.
- Competitions to encourage new ideas in design, particularly in terms of sustainability, can stimulate flexibility practices but as one-off project.

Lessons relevant to policy and regulation

- A supportive environment for flexible housing through an appropriate policy context at the local level, including guidance or regulation, can play a role in driving flexible housing practices, but its influence will be insufficient if the requirements are not mandatory.
- A supportive environment for housing through an appropriate policy context at the strategic level, such as promoting sustainable communities and high quality housing, can stimulate flexible housing practices within that local.

Lessons relevant to flexibility in plan

- A flexible plan for housing can be achieved where there is potential for adding further space, either as built-in space or as a future extension. This space needs to be indeterminate and generous in size with strategic location within the main plan, and the possibility for independent access and services and to be re-configured in different ways.
- Designing flexible housing to accept different building types or flexibility in building use involves many of the same structural principles applied to non-residential buildings, such as ample storey height, simple building forms,

indeterminate large open space, different means of escape, multiple access points and standards for vertical circulation.

- Designing for flexibility through joining two adjacent units in a multi-unit building needs to dealing with two key limitations, the adjacent units to be free at the right time and the fire protection and sound insulation requirement relating to party walls between units.
- Designing the plan for future extension has to deal with the external space and landscaping, in terms of privacy requirements and land coverage, as well as building regulations.

Lessons relevant to flexibility in construction

- Construction method to support flexibility, needs to deal with keeping separation between main structure and provide clear space between structural elements.
- Conventional timber frame stud wall and cross wall structures can provide flexible construction for individual homes of limited width. The former can enable changes to be made within the house envelope, whereas the latter can also offer opportunity for external change.
- Beams and columns concrete construction is a flexible building method in terms of allowing internal and external changes to be made in individual and multi-unit buildings.
- Use of rigid material such as blockwork for infill parts reduces the ability of the construction to accept change, whereas structure using light stud walls can provide opportunity to develop flexible internal partitions.
- Consideration should be given to construction methods commonly used in the local housing industry that enable buildings to accept change to develop applications for flexibility in housing design in the context.
- Developers need to play an integral role in all design stages and processes, and have input in particular in developing processes for creating practical solutions to on-site issues relating to flexibility.

Lessons relevant to flexibility in services

- To achieve flexibility in service system, horizontal runs of services should be distributed in an easily accessed layer, potentially located in a permanent structural element. Alternatively, the storey height of the building should be sufficient to accept installation of such a layer.

- For flexibility in vertical runs of services, provision of an oversized vertical shaft that can be accessed easily should be considered. In the case of designing a building that may be adapted for different uses, the possibility develop opening in the floor to provide additional vertical shafts as necessary also needs to be considered,
- Services systems that do not require distribution appliances, such as underfloor heating or central air-conditioning systems, facilitate designing for flexibility; alternatively, appliances should be located in places where they will not restrict change.

Lessons relevant to user empowerment and flexibility in use

- Designing flexible housing for unpredicted change provides an opportunity in the plan to have a greater scope for flexibility in use and user empowerment. On the other hand, plans based on a scenario approach restrict flexibility in use and users' control over their dwellings.
- The potential for additional size allows more flexibility in use, however this is conditioned by the level of indeterminacy in use of the space and independency in access and services.
- Use of non-specialist forms of construction increases users' control over their dwelling, as it encourages them to make adaptations based on their desires and wishes without the need for input from various specialist trades.
- To increase user empowerment through flexible design, there is a need to promote an architect's role that relies on relinquishing presumptions regarding control over design, and an understanding that what unfolds in the space should rely on far more than the architect's own terms.

Lessons relevant to financial aspects

- The use of hard technologies to achieve flexibility increases the upfront cost and probably the cost of adaptations. due to the need for construction work such as building extensions or developing particular technologies such as sliding walls to achieve flexibility.

- Achieving flexibility in building use through adaptation of non-residential buildings for residential use increases the initial building costs.
- Recognising the equation of upfront cost and long-term benefit of flexible design, and communicating this in a transparent manner to the buyers, is important for flexible house deliverability.
- Raising market awareness in regards to building performance is important in making flexible housing deliverable on the market.

8.4 Further research

In responding to the research questions, this research raises new possibilities for further research into flexible housing, particularly in terms of practice within contexts similar to Syria. As the current study had limited opportunity to draw on the perspectives of users with regard to their flexible housing, it would be worthwhile for future research to conduct in-depth study of users' perceptions in order to understand the potential for flexible design to respond to users' changing needs. Moreover, as this research focused mainly on flexible housing as a product, further research in relation to flexible housing as a process is necessary to understand the impact of the incorporation of flexibility on governance processes throughout the different stages of development. Further and wider-ranging research into flexible housing experiences is required in contexts that are witnessing rapid change and transformation in their housing stock, to allow detailed comparative studies. Further research into economic aspects of flexible housing is required in contexts such as the Middle East, including Syria, to examine how this concept might fit into the local economic environment.

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APPENDIX: Semi-Structured Interview Questions

The motivations, possibilities and constraints of flexible housing practices in the UK and Turkey

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Please feel free to contact either of the people above for further information about this research before you make a decision about taking part.

The research has been approved by the School of Built Environment Ethics Committee at Heriot-Watt University.

Appendix A

Interview questions for the designer of the flexible project

You are invited to participate in a study about "The motivations, possibilities and constraints of flexible housing practices in the UK and Turkey". This is part of a PhD research project in the School of the Built Environment, Heriot-Watt University. Overall, the research seeks to investigate flexible housing projects in two different contexts - the UK and Turkey - that have different policy environments, in order to explore the motivations, possibilities and limitations of flexible design practices, and how policy has affected practice.

Through this interview, I intend to develop a better understanding about the motivations to design your project incorporating flexibility, the design approach of the flexible project and the possibilities and limitations you experienced in designing your project flexibly. All data collected through the interview will be confidential and will not be used in any way but for the purposes of the study. Your help will be hugely appreciated and I will be glad to send you the research results if you are interested.

1. What are the key reasons that led to designing the project flexibly?

Prompts

- To what extent did the policies lead to designing the project incorporating flexibility?
- What are the other factors that contributed to designing the project flexibly?

2. Could you explain how the project was designed to offer flexibility?

Prompts

- How was flexibility incorporated into the architectural plan of this project?
- How was the construction system developed to achieve flexibility in the design?
- How was the services system designed in terms of flexibility?

3. **Could you clarify how the flexible design can accommodate people's changing needs and users' desires in the future?**

   Prompts

   - What were the different and changing needs that guided the flexible design of the project?
   - How does the flexible design of the project respond to these changing needs over time?

4. **In your opinion, what are the financial implications that emerged from the flexible design of the project in terms of cost of adaptations and cost benefits?**

5. **What were the possibilities and constraints in designing the project incorporating flexibility?**

   Prompts

   - What opportunities aided to the achievement of flexibility in the design?
   - What are the limitations that restricted the potential to fulfil greater flexibility in the design?

6. **Are there any other important aspects you think we haven't covered?**

Appendix B

Interview questions for the developer/landowner of the flexible project

You are invited to participate in a study about "The motivations, possibilities and constraints of flexible housing practices in the UK and Turkey". This is part of a PhD research project in the School of the Built Environment, Heriot-Watt University. Overall, the research seeks to investigate flexible housing projects in two different contexts - the UK and Turkey - that have different policy environments, in order to explore the motivations, possibilities and limitations of flexible design practices, and how policy affected practice.

Through this interview, I intend to develop a better understanding of the reasons for developing a project incorporating flexibility, the financial implications and deliverability and the advantages and disadvantages of this housing provision. All data collected through the interview will be confidential and will not be used in any way but for the purposes of the study. Your help will be hugely appreciated and I will be glad to send you the research results if you are interested.

1. **What were the main motives that drove developing the project flexibly?**

   Prompts

   - Did the policy context contribute to developing the project incorporating flexibility?
   - Could you explain the other reasons that led to developing the project flexibly?

2. **What financial implications arose from the incorporation of flexibility into the design?**

   Prompts

   - Did the flexible design of the project lead to any additional cost related to incorporating flexibility principles into the design?
   - Did the flexible design of the project increase the selling price of the housing units?
   - Were there any other financial implications due to the flexible design of the project?

3. To what extent was the flexible design of the project a unique selling point?

Prompts

- Did the flexible design of the project lead to higher consumer satisfaction at the point of purchase? Why?
- Did the flexible design of the project make the housing units more saleable? Why?

4. What were the advantages and disadvantages of developing the project incorporating flexibility?

5. To what extent, would this experience encourage you to develop your project flexibly again? Why?

Appendix C

Interview questions for the planning officer of the local authority of the project

You are invited to participate in a study about "The motivations, possibilities and constraints of the flexible housing practices in the UK and Turkey". This is part of a PhD research project in the School of the Built Environment, Heriot-Watt University. Overall, the research seeks to investigate flexible housing projects in two different contexts - the UK and Turkey - that have different policy environments, in order to explore the motivations, possibilities and limitations of flexible design practices, and how policy affected practice.

Through this interview, I intend to develop a better understanding of how the policy context of the local authority underpins an approach for flexible housing in general, and how the local authority supported flexible housing provision in this project in particular. All data collected through the interview will be confidential and will not be used in any way but for the purposes of the study. Your help will be hugely appreciated and I will be glad to send you the research results if you are interested.

1. **How does the local authority support the provision of flexible housing?**

   Prompts

   - What are the local authority policies that support an approach for flexible housing?
   - How do the local policies underpin an approach for flexible housing?
   - What is the role of national or regional policy in supporting flexible housing provision in the local authority policy?

2. **How did the local authority support the flexible housing provision in this project?**

   Prompts

   - What was the role of local policy in supporting the provision of flexible housing in this project?
   - Did the national or regional policy play a role in underpinning the delivery of flexible housing in this project?
   - Could you explain whether the local authority's attitude contributed to the flexible housing provision in the project?

- Are there other local authority tools that supported flexible housing provision in this project?

3. **In your opinion, to what extent is the existence of policy for flexible housing important to support flexible housing provision?**

4. **Are there any other important aspects you think we haven't covered?**

Appendix D

Interview questions for the users of the flexible housing project

Dear Madam or Sir:

Thank you for participating in this interview. The purpose of this interview is to discover how the design of your house has helped to accommodate your future needs and desires in an easy and economic manner. Your participation and response to these interview questions are very important as it is part of a PhD research project in the School of the Built Environment, Heriot-Watt University. All data collected through the interview will be confidential and will not be used in any way but for the purposes of the study. All participants will be anonymous and coded using numbers or pseudonyms when being referred to in reporting and analysing the data.

1. **Could you explain whether flexibility in the design of your house was a reason for choosing it as your home?**

   Prompts

   - Could you describe what features in this house make it adaptable?
   - In your opinion, what are the advantages that you are anticipating from the flexible design of your house?

2. **Could you describe how you have adapted your house?**

   Prompts

   - What are the adaptations that you have made in your home?
   - In your opinion, to what extent did your house allow you to make adaptations?
   - Have you faced any difficulties in making adaptations? If so, what kind of difficulties? For example, technical problems, limitations of design, regulatory restrictions, etc.?

3. **Could you explain what are the reasons that led/could lead you to adapt your house?**

   Prompts

   - Have you had any changes in your family circumstances in terms of size, age structure, gender and disability during your occupancy period that motivated you to adapt your house? To what extent did the house allow you to make adaptations to fit these needs?

- Have you made any modifications or was there a desire for any adaptations due to cultural reasons such as a new lifestyle, a new way of doing activities, privacy need, etc.? To what extent did the house allow you to make adaptations to meet these needs?
- Have you made any modifications or wanted any adaptations due to social reasons such as relations with a family member, relative, neighbour, friend, etc.? To what extent did the house allow you to make adaptations to accommodate these needs?
- Have you had any changes in your economic circumstances due to changes in income, employment, education, etc. during your occupancy period that motivated you to adapt your house? To what extent did the house allow you to respond to these needs?
- Have you created any adaptations or was there a desire for any modification because of technology, safety and security needs? To what extent did the house allow you to make adaptations to meet these needs?
- Have you made any adaptations or was there a desire for any modification due to any other needs? If so, what are these needs? To what extent did the house allow you to make adaptations to respond to these needs?

4. **From your experience, how would you describe the cost of making adaptations in your dwelling? Why?**

5. **Is there anything else you would like to say about the design of your home which we haven't covered?**