Developing a Framework for Assessment of Flexibility in Residential Buildings

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ABSTRACT

Residential buildings in the contemporary life are smaller and more compact due to economic pressures, change in the lifestyle, advancement in technology, population growth and etc. These houses should be able to fulfill the requirements and needs of the users that are rapidly changing in order to improve the quality of life. In recent years, design of small residential buildings, becames a challenge for designers in order to provide a space which can offer maximum satisfaction to users' needs and expectations. Flexibility as a tool was one of the methods which have been practiced in traditional houses and highlighted in the modernism period by many designers. Flexibility in design offers alternatives by providing the ability to change according to users' preferences instead of dictating rigid and defined spaces. In order to have flexibility in design of residential buildings, designers should be aware of components of the buildings. Building components can be classified as building layers. Although these layers seems to be individual parts of a building the fact is all the layers are connected and they have direct effect on each other from the flexibility perspective. Thus any change in one layer, may effect other layers as well. This research tries to illustrate the relation between the building layers and flexibility and improve the knowledge of achieving flexible design.

Analyzing flexibility in buildings, requires to develop a platform which is applicable for the existing buildings by considering the layers. This research has formed an analyzing framework of achieving flexibility based on the different classification of successful scholars and researchers . The achieved results of this thesis determines the level of contribution between dwellers and architects in order to obtain a flexible house

which can increase the living quality in small houses. The result will also show the hidden linkage between building layers and the level of flexibility.

Keywords: human needs, flexibility, building layers, small houses, participation of designers and users

ÖZ

Çağdaş yaşam koşullarında konutlar, ekonomik baskı, değişen yaşam tarzları, teknolojik gelişmeler, nüfus artışı, ve daha bir çok etkenden dolayı küçük ebatlı ve kompak bir bütün haline dönüşmüştür. Bu konutların, yaşam kalitesini iyileştirmek için değişen gereksinimleri ve kullanıcıların ihtiyaçlarını karşılayabilmesi gerekmektedir. Son yıllarda, kullanıcıların ihtiyaç ve beklentilerine maksimum düzeyde cevap vermesi beklenen küçük konutlar tasarımcılar için yepyeni bir tasarım problemine dönüşmüştür. Mekanlarda işlevsel performansı artıran bir araç olarak esneklik, geleneksel konutlarda uygulanmış ve modern dönemde birçok tasarımcı tarafından farklı yöntemlerle yeniden ele alınmıştır. Tasarımda esneklik, sabit ve tanımlanmış alanların dikte etmesi yerine, kullanıcıların tercihlerine göre değişiklik yapma olanağı sağlayarak alternatifler sunması olarak tanımlanmaktadır. Konutlarda esnek tasarımlar oluşturabilmek için tasarımcıların binaları oluşturan farklı bileşenleri anlamaları gerekmektedir. Binayı oluşturan bileşenler (yapı elemanları) binanın katmanları olarak da tanımlanabilmektedir. Bu katmanlar, binanın ayrı parçaları gibi görünse de gerçekte katmanlar birbirine bağlı olup, esneklik açısından birbirlerini doğrudan etkilemektedir. Dolayısıyla bir katmandaki herhangi bir değişiklik, diğer katmanlar üzerinde de etkili olmaktadır. Bu araştırma, yapı katmanları ile esneklik arasındaki ilişkiyi detaylaı bir şekilde tanımlama ve esnek tasarım çözümlerine yönelik yeni bir bakış açısı getirerek kapsamlı bir katkı sağlamayı amaçlamaktadır.

Binalardaki esnekliği analiz etmek, mevcut binalar için katmanları göz önüne alarak uygulanabilir bir yöntem geliştirmeyi gerektirmektedir. Bu araştırmada, tasarımda esneklik, alanında yetkin çalışmaları bulunan akademisyenlerin ve araştırmacıların

farklı sınıflandırmaları temelinde, yeni bir bakış açısı ile, kapsamli bir analiz yöntemi sağlayacak yepyeni bir çerçeve oluşturulmuştur. Araştırma sonuçları, küçük konutlarda yaşam kalitesini arttıracak esnek çözümler elde etmek için kullanıcı ile tasarımcıların rolünü tanımlamaya yönelik çıkarsamaları kapsamaktadır. Sonuç olarak çalışma, yapı katmanları ve esneklik seviyesi arasındaki ilişkiyi ilk defa detaylı bir şekilde tanımlayarak tasarımcı ve kullanıcının tasarım, uygulama ve kullanım süreçlerindeki rollerini tartışmakta; her iki tarafında etkin katılımları ile ürün olarak küçük konutun daha uzun ömürlü performansa imkan vererek esnek bir bütün olarak oluşturulmasına nesnel bir şekilde katkıda bulunmaktadır.

Anahtar kelimeler: insan ihtiyaçları, esneklik, yapı katmanları, küçük konutlar, tasarımcı ve kullanıcıların katılımı

To my mother, who has never lost faith in me…

To my father, who has never stopped supporting me…

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Chapter 1

INTRODUCTION

In recent years arguments about architectural approaches towards residential buildings and future of it became a very important topic among architects and designers. Evolving needs and expectations brought one of the major dynamics on house all through the time. Changing family size and structure with its spatial requirements are the most important factors on definition of those needs.Therefore finding a solution to dispel the changing needs of mankind to improve their satisfaction from their living environment as much as it is possible was a main concern for designers. Quality of living environment plays a very significant role in human lives. Most of the human activities (eating, sleeping, socializing, studying) during life happens in the living environment such as houses (in various types), flats or even temporary tents. Therefore it is very important to understand and analyze the living environment and related activities which happens in it very carefully in order to find the human needs towards the space. This knowledge about human needs help designers to be more aware of how a house should be able to accommodate occurred future changes.

Robert Kronenburg (2007) in his book "Flexible Architecture that Responds to Changes" refers to human being as a "flexible creatures" whom changes and retouches objects and have the ability to work in a wide range of environments. Having the ability to adapt and move (that can be interpreted as flexibility) are the key factors in human being survival in the history (Kronenburg, 2007). For instance, tents which have been

used in different cultures are the perfect example of using flexibility to survive. Tents have some common specifications like being light weight, produced by local materials and being solutions against climatic conditions. The North African Bedouin tents, Tipi tents used by Indians in North America or some other examples from Middle East region were vital solutions for survival of nomads in each culture as they were easy to build and at the same time easy to pack and move to another location. Although having flexibility in living environment in history was the result of the actions for survival, it is still one of the prominent concerns nowadays too.

In the history of housing there were examples of considering flexibility as a tool to improve the functionality of dwellers and extending their duration of occupancy. The reason is that, houses are mainly static and not movable but the users of them can adapt those spaces according to their verified needs. Therefore there were many attempts to change the dwelling setting and arrangement instead of making change in the user attitude towards the space. As it was mentioned, changes in family structure, life style and stages in human life need different requirements. In order to respond those changes houses should have the ability to get modified and developed. There are several intervention methods to provide required charges. Rebuilding, making major changes and renovating can be applied when the new needs occur in long period of time. But those methods are time consuming, difficult and costly.

In twentieth century Modern movement had its influence on many architects to use flexibility as a tool to improve living conditions and increase the functionality of the residential buildings. There are many researches and practices regarding flexibility in those periods which will be mentioned in following chapters. But lack of enough comprehensive study about importance of having flexibility in small living spaces in

order to improve the living quality of dwellers, has encouraged this study to focus and research more in detail about flexibility in small houses.

Increasing environmental consciousness, economic impacts, population growth and change in lifestyle in recent years caused a vast change in housing preferences. A demographic shift from urban centers to suburban which was one of the solutions for housing demand has been stopped in recent years, and it is reversed now due to mentioned factors above (Schatz & Sidhu, 2015). Many people are returning to cities and prefer to live close to the place they work or study or as The Small House British Colombia organization (2015) calls it "Location-efficient" areas. This population shift, caused increase in housing demand in the cities, following the increase in demand, housing prices increased and at a same time number of available houses decreased. Additionally, families are getting smaller and traditional houses are not responding to single, one parent-families and young generation's needs. Therefore as a result many people has chosen to live in smaller houses compare to what they were living in before (Martinson, 2000).

Although many people prefer to live in smaller houses, their expectation from their dwellings has never decreased and vice versa. It keeps increasing when a new need occurs. Therefore small houses should be able to accommodate future changes by the user and propose the best available solution.

Flexibility as a strategy of improving the performance and providing the ability to respond to changing needs of the users can play an important role in residential housing context, especially small houses. Therefore flexibility in small houses offers a great solution to respond the dwellers changing needs by making it possible for users to

adjust their living or working environment according to their certain needs. According to Schneider and Till flexible housing is a kind of house which accepts future changes regarding to new needs of the users (2005, p.154).

1.1 Problem Statement

A flexible house is a house which can cover and meet all its users' needs, these needs classified into two by Abraham Maslow (1943) as "basic needs" of the user and flowingly the "growth needs". These needs also can vary due to physical, social and cultural effects, such as climate, family structure and cultural changes. House and users' needs have direct relation to each other in order to fulfill the requirements and tasks asked by dwellers. Nowadays due to changes in lifestyle, living habits and economical limitations, houses/flats (apartments) offered by the companies in market physically become smaller in size while the expectation from the houses are still the same or even increased. Therefore small houses should have the ability to respond to users' needs no matter how much the physical scale of the house changes. On the other hand newly built houses, especially apartments are mainly designed for responding market demand and are more likely dictated by the architects and builders to users which are not or very little involved in the process of design and building. These problems lead residential buildings to be useable for short period of time and incase of any attempt to live for a longtime, alterations and changes will be needed.

In this study how a small house can respond to the required task of the users and how it can be adapted to users' changing needs will be analyzed due to the flexibility methods of various scholars by taking into consideration the building layers.

1.2 Aim of the study

This study tries to point out the importance of having flexibility in residential buildings, especially small houses in improving the living quality of the dwellers. Developing a framework to analyze the flexibility of existing buildings and provide a reliable flexibility method to be considered while designing new residential buildings by considering all the components of a building is the main aim of this thesis. This framework also will investigate the importance of involvement of users in design and building process of a flexible house.

1.3 Research Methodology

The research literature has been extracted trough online books resources and journals which are main resources for providing necessary information about human needs towards the living spaces, building components, history of flexibility and flexible housing, flexible housing classifications and various methods of achieving flexibility according to different authors. These information that has been surveyed from the literature, forms the main framework of this study to be used for analyzing the existing buildings and provide reliable methods to be considered, in design and building new houses. This study is following qualitative method in order to help the process for reaching the aim and answering the research question (how flexibility in small houses can be used and how it can respond to dwellers needs?) which is based on human life quality and improving the level of success from flexibility point of view based on information achieved from literature. Surveying and analyzing different methods of achieving flexibility and building components by different scholars, helped the author to evaluate existing research methods and develop a new assessment framework for small residential buildings as a special area.

1.4 Limitations of the study

Flexibility studies either cover all type of buildings or in smaller scale all house types. But there is no any study focuses on small residential buildings. In this study small residential buildings especially after occupation period will be focused in order to provide methods of achieving flexibility by considering the building layers classified by Brand (1995).

1.5 Structure of the Thesis

This thesis is formed in five chapters. First chapter is introduction which gives a general idea about the significance of having flexibility in residential buildings and more importantly small residential buildings. This chapter also contains problem definition, the aim of this study, structure and limitation of this study.

Second chapter focuses on importance of knowing the human needs towards the space. Different classification of small houses will be study in this chapter. This chapter also points out the theories about building components and explains these components.

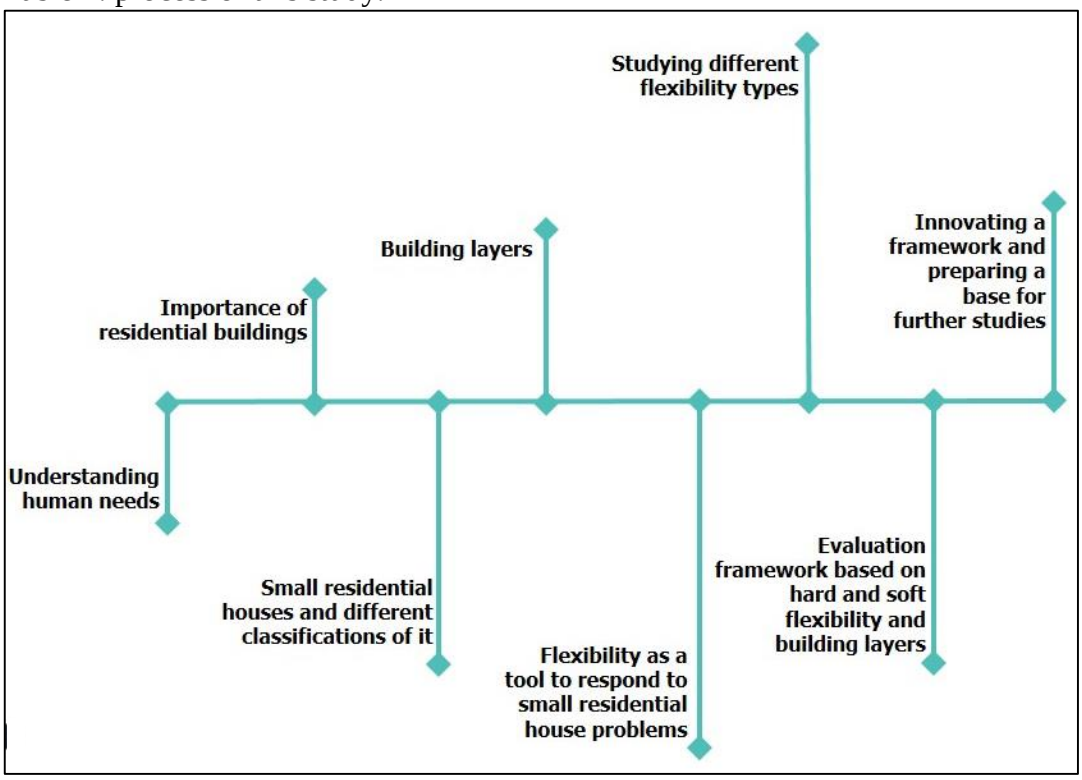
The third chapter which is the base for forming the framework of study, starts with an explanation of flexibility. Explaining the history of flexibility and how houses got influenced by the modern movement will help to explain the importance of having flexibility in the residential buildings. Following that, explanation of flexible housing along with its various classification according to different authors will be studied in more detailed.

The forth chapter focuses on developing a framework of achieving flexibility in residential buildings. Information's gathered from literature review will be analyzed

in this chapter. The developed framework will be based on building layers and role of architects and users in achieving a flexible building. Methods of achieving flexibility in each building layer will be explained in more detail in this chapter.

Chapter five is the conclusion of this study in which final result of the study is reflected. The achieved result will show the important role of users and architects and provides a comprehensive material for further studies.

Table 1: process of this study.



Chapter 2

REVIEW ON HUMAN NEEDS AND VARIOUS DIMENSIONS OF SMALL HOUSES

This chapter explains the need stages of human beings and significant role of Residential buildings in human life, the relation between needs and house; explanation of small houses and types of it. All houses with different sizes and properties have one thing in common and that is meeting the needs of their users. Those needs that a house is expected to cover can be described as the ability of change during various situations that several functions require in different times. Time refers to the changing needs in daily life and several phases in life that the occupants of a house would face during their lifetime. In this chapter human needs and its various dimensions will be explored in relation to houses to illustrate the importance of residential buildings and prove the fact the physical size and properties of house should not affect much on the amount of satisfaction of the dwellers from their dwellings.

2.1 Human needs

One of the main and comprehensive studies about the human needs theory belongs to Abraham Maslow and it is known as “Maslow’s hierarchy of needs theory”. Maslow (1943) stated that a human being has five levels of needs in his/her life which have direct relation with each other in a way that after fully satisfaction in one level of the need another one rises. He also classified these five levels of needs into two categories as “basic needs” and “growth needs” (Figure 1).

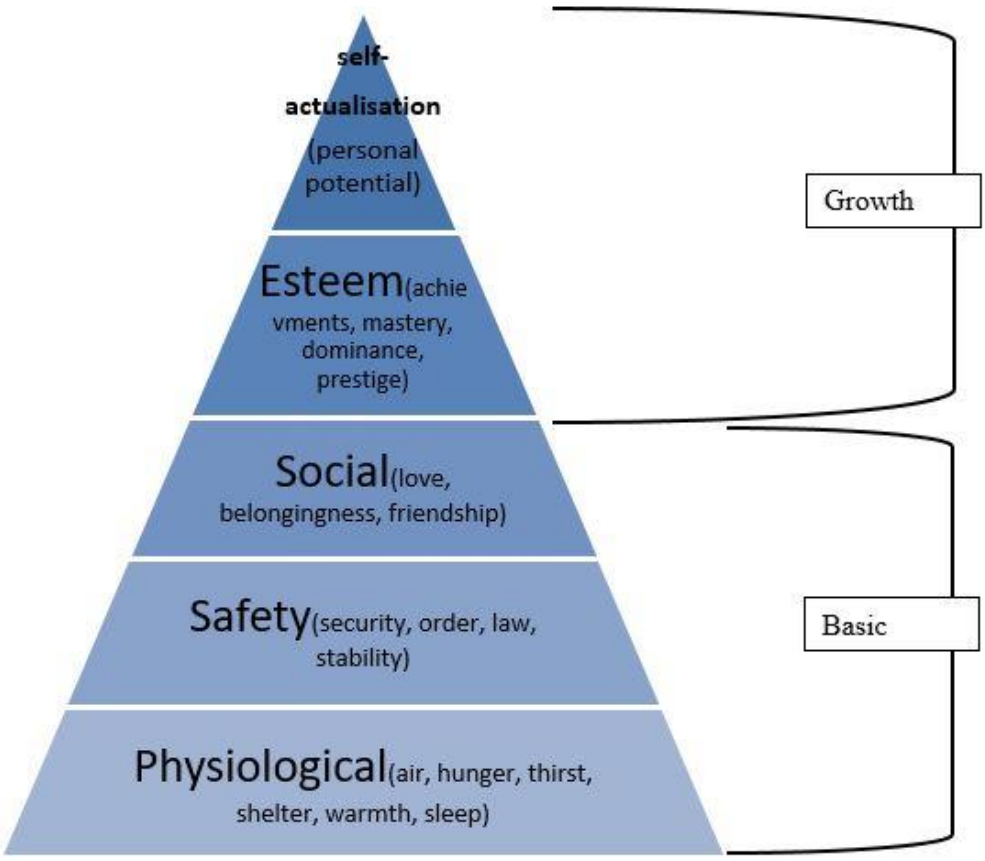


Figure 1: Maslow's Hierarchy of needs (Maslow,1943)

Basic needs which are the foundation of growth needs are those which motivates human to search for them and resolve them in case of missing. In the absence of basic needs such as air, hunger, thirst, shelter, warmth and safety living is impossible. The growth needs are need to socialization, self-esteem and the need to find personal potential. Whittington and Evans (2005) developed this theory by mentioning "Each of these needs operates at all times, although one deficient set dominates the individual at any one time and circumstance" (p.114).

Basic needs are defined as below:

1. Physiological needs: the most basic and important needs of human being which without their existence, it is impossible to satisfy other needs. Physiological needs such as need for air, food, water, sleep and etc. are the foundation of Maslow's need pyramid.

2. Safety needs: feeling of being safe and secure and making sure of all the physiological needs stay satisfied refers to safety need. A significant example of achieving safety is through shelters or houses. Specifying the territory and having privacy can improve human safety.

Growth needs are listed as below:

3. Social needs: communicating and exchanging feelings with others and knowing that he/she is not alone and believe in friendship.

4. Esteem needs: human being always see the need to have a proper social status among others. The individuals should feel the respect from others in its' living environment such as home, or even in work environment.

5. Self-actualization: the final stage of needs in Maslow's hierarchy of needs. Finding the personal potential and focus on personal growth appears by the time all pervious needs have been met. This need reflects the ability of an individual to become what he/she can truly be.

Maslow have modified his previous theory by moving the fifth stage and adding three new stages to the pyramid. In the revised version of his theory, instead of self-actualization, cognitive needs take place (Maslow, 1968)(Figure2).

5. Cognitive needs: need to be aware of surrounding and have necessary knowledge.

6. Aesthetic needs: this need involves valuing beauty and ways of achieving it.

7. Self-actualization: as it was mentioned in previous paragraphs.

8. Transcendence needs: in the revised theory of Maslow, this is the final stage which ends with helping others to find their personal potential.

Figure 2: Maslow's revised theory of needs (URL:1).

2.1.1 Life stages and family structure

Although need theory explains the basic needs and growth needs of an individual human being, but these needs can vary from person to person according to different life stages, family structure and status. For instant needs of a single mother with her kids, varies from a family of four with mother and father or needs of a student living alone can vary from a person who is working. Human life has different developing stages and in each stage needs specific requirements from the house in order to get satisfied. By referring to Erikson's life stages, it can be said that each stage on human being life requires different kinds of needs. In addition to stages of human developing, family structure also is an effective factor in changing users wish from the house they are living in, as the memebrs of the family increase variety of needs from space also increases. According to Erikson (1968), human life develops in eight stages and Maslow hierarchy on needs also develops accordingly, as it is shown in the table below (Figure 3).

Table 1: Table of human life stages and Maslow's hierarchy of need stage

Age range	Life stage	Maslow Hierarchy of Needs stage
0-1	Infancy	Biological & Physiological
1-3	Early childhood	Safety
3-6	Play age	Social (belongingness & Love)
5-12	School age	Esteem
9-18	Adolescence	Esteem
18-40	Young Adult	Esteem
30-65	Adulthood	Self-actualization
50+	Mature Age	Self-actualization

Each life stage has its own requirement and needs but more importantly is the house which has to have the ability to contain all these activities and stages and respond to them (Figure 3). House should be capable of having the ability to be adjusted according to its users, for example needs of a family with kids and old member in it is different than a bachelor person.

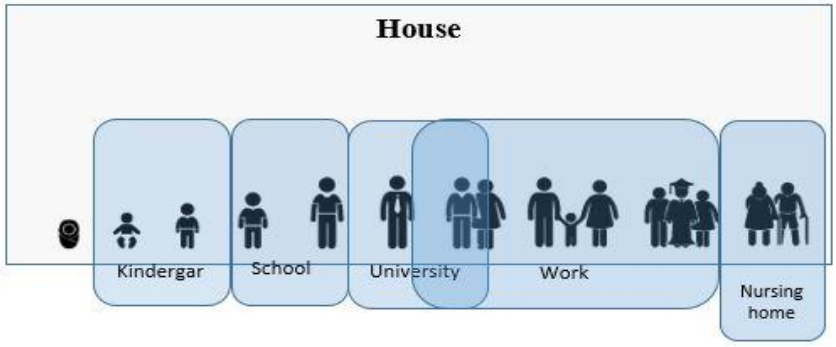


Figure 3: Comparing activity coverage of house with other buildings (Erikson,1968).

Importance of the house compared to other types of building is very obvious due to its significant role in human life which contains all kind of activities such as eating, sleeping, communicating, working, cooking and socializing during life. The amount of time spent in the house is more than any other building. Therefore it is important to have a house which is designed in a way that can meet all the needs of the users (Hillier, 2005) (Figure 4).

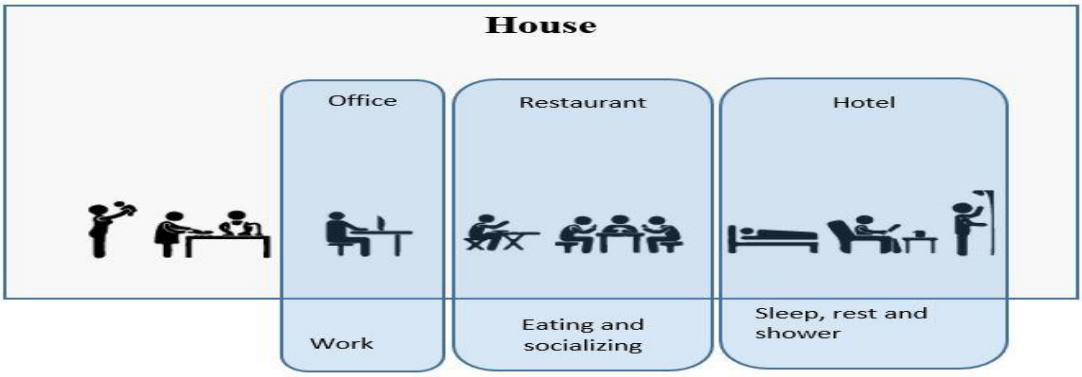


Figure 4: Relation between human daily activities and house (Hillier, 2005).

2.2 Multi task contemporary house

After analyzing the need theory, it can be stated that optimal (ideal) house is a house which can cover all these needs and do not eliminate some of the needs in order to function. Idealness of houses can be measured by the amount of responding to the needs. Depending on which stages of needs has been met, houses are also classified into five different types in functioning regardless of their size. Estaji (2014) classified these types as shelter, usable, livable, satisfying and encouraging (motivational). According to how much a house is meeting the required needs these classification take place (Figure 5).

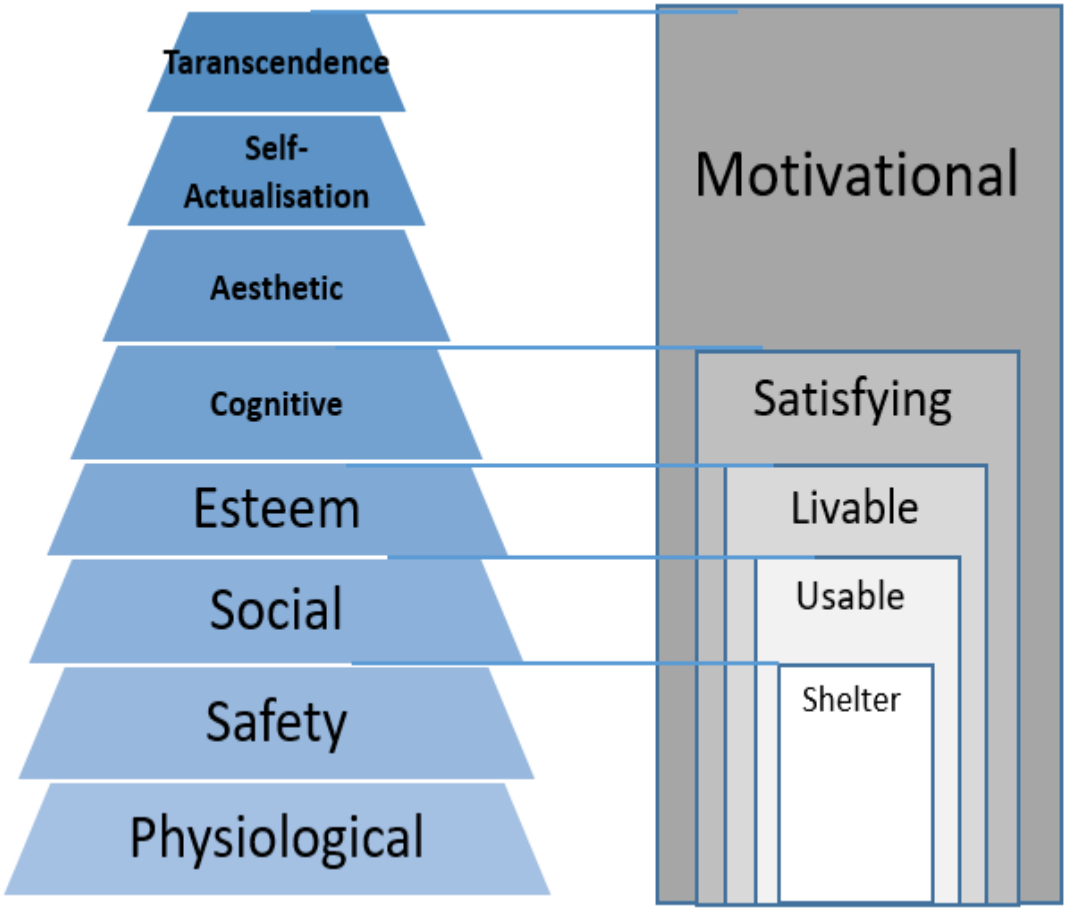


Figure 5: Parallel classification of multi task contemporary house with need theory. (Estaji,2014)

As it is shown the figure 5 a house which meets the basic physical and safety needs of its dweller can be classified as a shelter. Usable house refers to house that can respond to all the previous needs and also esteem needs. Satisfying house can be classified as a house which contain all the previous needs and cognitive needs. The prior to all the perivious houses, is the motivational houses or in another words a house which can respond to all the needs of its users. Therefore it can be said that as the ability of house in meeting the needs increases, quality of the house also increases.

2.3 Small houses

Due to lack of enough space in the cities, suburban sites raised. People were preferring to live in suburbs rather than living in the crowded cities. In recent years this population shift from urban to suburban not only stopped but also this shift is reversed and population of urban centers increased (Kilman, 2016). Economic impacts and changes in life styles and family structures forced many people to move back to city centers. New concepts of family such as single families with no kids, single parenting and partners are reshaped. A normal house with sufficient square meter for a traditional family is practically very big for such new generation families (Susanka, 1998). Therefore many people choose to live in more compact houses in the cities where they can have easy access to the facilities and their work by public transportation or by man-power (cycling, walking) rather than living in far neighborhoods.

Calling a house small can change according to its user and activities in it. A house which is motivational for a couple with no kids, might only meet basic needs of a crowded family with additional members in it (Figure 6), or a house which is only suitable for sleeping and mostly used as a shelter although it provides enough space to sleep in to its members but lack of enough space for other activities like socializing, cocking or services makes the house small.

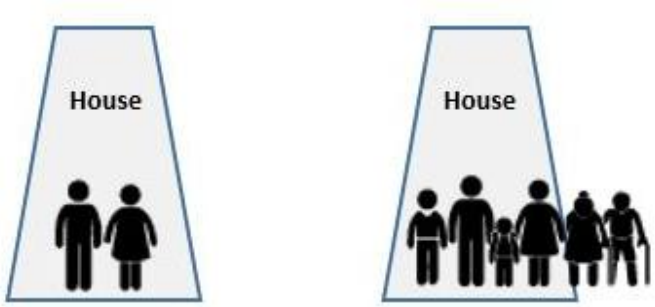


Figure 6: Comparison between the same house with different users. (Drawn by author)

In this study in order to achieve a reliable reference regarding housing standards especially apartments, three different comprehensive reports and analyses chosen to be study in more depth. These reports will help to achieve a specific definition of small houses and their specification.

2.3.1 Small house classification according to Small House British Clombia (SHBC)

There were many attempts by different researchers to define the specifications of the small house. Sara Susanka(1998) defines small house in her book "The Not so Big House" not by size of the house but its quality, and mentions that the quality of house is more important than its quantity and encourages readers to build better not bigger. According to analyses of small house British Colombia (Schatz & Sidhu, 2015) , which have done many researches about small houses, there are ten types of small houses (Figure 7). These houses vary in the form such as apartments, mobile units and detached houses, square meter, functioning and family size. According to SHBC size of small houses can vary from 15 m2 to 110 m2 (Figure 7). Small houses which can be either detached or attached, are showing up in urban centers or in a region which sudden population growth occurs and thus the housing patterns in that area is changing. In following pragraphs different types of small houses in United States of America will be explained, although all the types mentioned below are not existing in the field

study of this research, but these classifications will help to clarify standard dimensions of small houses, advantages and disadvantages of them.

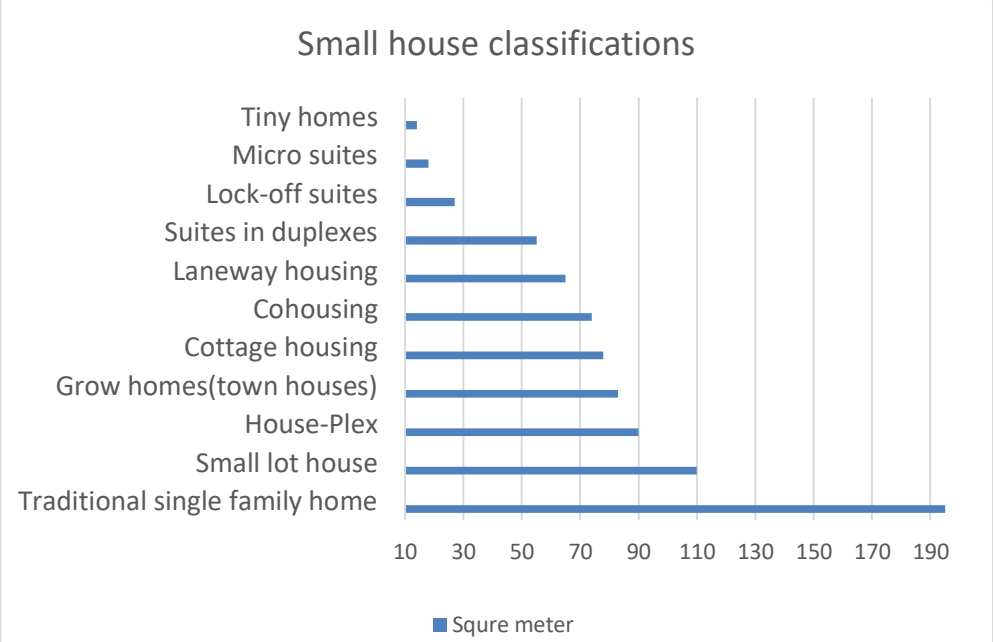


Figure 7: Average size of the small house types compared to traditional single family home. (SHBC)

Small lot house: Due to lack of enough affordable houses in Los Angeles which is the second-largest city in united states, the federal government came up with the idea of allowing fee-simple ownership (fee simple is that you own the whole of the land and are able to make any additions or alterations to your property). As a result many suburb houses added another small houses to the existing houses. These houses which are named as lot houses increased the amount of affordable Residential buildings and many people preferred to live in them although they were smaller than other types of the buildings in that area (Wentling, 1994).

Lot houses accomplished through changes and subdivision of big houses or even commercial buildings in order to give opportunity to young generations and small families to have their own houses. The most important features of these houses are,

shortening the left over lot area with their unique plan types, reduction in frontages and open spaces (Figure 8).

Figure 8: Examples of lot housing (URL:2)

Lot houses are usually detached and may have two or more floors and does not share any common walls with each others.

House-plex: These kind of houses have the appearance of a big single family house but internally they are three or more attached houses which are sharing a single façade (Figure 9). These houses are being built in small lots and by using the advantage of its appearance, it can be built near to single family houses. Specification of house-plexes are similar to detached single family houses such as, not using blank walls facing the street and instead, using windows and doors, having rear parkings and matching the front façade according to neighborhood configurations (SHBC, 2015).

Figure 9: Example of house-plex (URL:3)

Grow homes: Attached grow homes are one of the significant examples which allow the user to make changes according to their needs and desire. Grow houses mostly have narrow plan types and interior parts of the building are often unfinished. Lack of permanent partitions and walls, minimum use of fixed elements and defining a typical plan type allows the user to grow the house by the time it is necessary. These kind of houses are preferred mostly by single parent families and single income users (Friedman,2001) . Grow houses usually have two floors and a basement. Services are located in a way that they can be used in variety of plan settings and basements left to be unfinished and free of any fixture (Figure 10).

Figure 10: Grow homes and their typical plans of each floor. (URL:4)

Cottage housing: There are Series of single family detached homes which are not sharing any walls and have no private yard. These houses unlike the regular single family houses are not facing towards a street but instead positioned around a small court yard and all are facing the court yard or garden, which is common and all the house members can use (Figure 11). These houses are small and they are approximately between 60 to 90 square meter which varies according to the area. For example cottage houses which have been built in urban centers are smaller than those build in suburbs due to change in available lot sizes (McCarthy, 2010).

Figure 11: Example of cottage housing. (URL:5)

Cohousing: Cohouses are numbers of units which mix town houses with apartments. The units are in variety of sizes from 40 sq. m. studio to 120 sq. m. three bedrooms ones. The building which contains these unites surrounds a common yards. Cohouses have a common house which contains a big dining room, play rooms, kitchen and other socialized features. These houses are preferred by families and elderlies with shared values (McCamant & Hertzman, 1994) .

Figure 12: Examples of cohouses and common building. (URL:6)

Laneway houses: Laneway houses refer to kind of houses which are built in back yards of family houses. These houses become popular after the increase in population of industrial cities and it allowed house owners to build a small house in their back yard and help them financially by renting them to those who search for reasonable houses to live. In some cases these houses were used as a place for family extended members like grandparents in order to provide them more private and uniquely designed place to live in. Since last century many different types of laneway houses have been built and had many different names such as coach houses, granny flats and infill houses (Suzuki, Cervero, Kanako, 2013).

Figure 13:Example of a laneway house in the family house back yard. (URL:7)

Suites in duplexes: Duplex houses are two attached dwellings side by side which share a separation wall. These dwellings although look like each other and give a feeling of a single house but they have two separate entrances. After the legalization of adding suites to duplex buildings, many home owners start adding attached suites to the existing buildings from the backside of the building. These suites were designed in order to accommodate bachelors and students (International Association of Home and Services for the Ageing, 2014) (Figure 14).

Figure 14: Example of duplex house and an attached suit. (URL:8)

Lock-off suites: After increase in population of university students and low income bachelors, many builders start offering apartment houses with lock-off suites in them. These suites allowed apartment owners and investors to rent the studios to students and bachelors. This approach helped both home owners and the renters to profit economically and socially. In designing such suits, hotel room designs were taken as a reference by having a separated suits in a unit through lockable doors (Von Hausen, 2013) (Figure 15).

Figure 15: Example of lock-off suit attached to a dwelling unit. (URL:9)

Micro suites: The problem of housing in big industrial cities is not only the availability of empty house to rent but also the prices and fees of them. Therefore micro suits was offred mainly to respond to the needs of those who were searching for affordable houses. Building number of small micro suits instead of single detached family house or big apartments increase the density of the units in similar sized lots, thus the rent prices also reduces. Each micro unite should be equipped with separate services, kitchen, sleeping units and working space. These micro suites are able to meet all the basic requirements of the households but yet to be improved (Maschaykh, 2016) (Figure 16).

Figure 16: Example of micro house. (URL:10)

Tiny homes: Tiny house movement is the origin of small housing. This movement motivated architects to design a house which considers the quality more than quantity. Encouraging people to have minimal life style and reduce their impacts on the environment and in return profit financially and socially. For example tiny homes allowed its' users to have better choice options over the place which they wanted to live, it could be near their work place or far from the crowd and in an empty field (Kahn, 2012).

Average size of a tiny house is 15 square meter and average size of single family house in North America is 195 square meter, the average cost of a tiny house is 23,000 dollars and average cost of a standard house is 272,000 dollars; therefore this vast difference

between tiny house and a standard size house makes people who are searching for cheap and small house to live in rethink (Figure 17).

Figure 17: Example of a tiny house. (URL:11)

Tiny houses are detached and mostly mobile small units, which have a multi-functional space in them and a private service similar to micro suits with a difference of having more reasonable cost to build or even maintain and wide range of locations to be built in (Figure 18).

Figure 18: Interior arrangement of a tiny house unit (URL:12)

Following table shows the major users of the small unit types mentioned in previous paragraphs with their unit siz (Table 2).

Table 2: Small house specifications according to SHBC.

Unit type	Major users	Unit size
Small lot house	First-time home owners, Young professionals and retirees	90 m2-140 m2
House-plex	Retirees, small families and young professionals	90 m2- 130 m2
Grow homes	Low income families and single parents	80 m2-90m2
Cottage housing	Retirees and small families	70m2-110m2
cohousing	Families and senior with shared values	45m2-117m2
Laneway housing	Young professionals, small families and retirees	26m2- 84m2
Suites in duplexes	Students and young professionals	37m2-90m2
Lock-off suites	Students and extended family	Min. 23m2
Micro suites	Singles, high-tech professionals and young generation adults	20m2- 30m2
Tiny homes	Young generation and couples	7m2- 16m2

2.3.2 Space Standards for Homes According to Royal Institute of British Architects (RIBA)

In following the research about apartment sizes in UK will be explained. This research has been done by the RIBA, and tries to illustrate the fact that houses are getting smaller and it is even lower than minimum standard size in more crowded cities like London (Hughes, 2015).

Housing demands increases in th Uk and the failure to keep up with this increasment has influenced the prices and sizes of the houses as well. Increase in the demand of housing market and the rises in prices UK homes kept shirinking. Following this change in housing sizes, different cities in Uk have adopted a minimum space standards.

According to Riba research center in 2011, a new set of space size standards have been defined for apartments. Standard size for one bedroom, one person flat should be minimum of 37m2 and three bedroom, five person homes would be a minimum of 86m2 (Royal Institute of British Architecs, 2011).Following table shows the space standards in apartments in UK which have been done in 2011 by RIBA (Table 3).

Table 3: Flat size standards according to RIBA

Dwelling type (bedroom (b) / persons-bed spaces (p))	Essential Gross Internal Area (m^2)
1p	**37**
1b2p	**50**
2b3p	**61**
2b4p	**70**
3b4p	**74**
3b5p	**86**
3b6p	**95**
4b5p	**90**
4b6p	**99**

2.3.4 Department of the Environment, Community and Local Government of Ireland

Another similar research has been done by department of the environment, community and local government of Ireland as the "Design Standards for New Apartments" in 2015. Significant role of apartments in shaping the form of urban areas in Ireland and other developed countries required some standards and guideline to help the designing and regulation process. Number of small apartments are rapidly growing, the reason of this growth as it is mentioned in DECGI is

> These include on-going population growth, a move towards smaller average household size, an ageing population and a greater proportion of households in the rented sector.

This research provides the minimum space sizes in each apartment types. In addition to overall size of the apartment flats, minimum standard sizes for each flat's subdivisions also have been provided. In the following table minimum standard sizes for each flat will be shown in detail.

Table 4: Standard size of apartment flat types according to DECGI

Flat type	Minimum overall apartment floor areas	Aggregate floor area of living / dining / kitchen area	Minimum bedroom floor areas	Minimum storage space requirements	Minimum floor areas for private amenity space	Minimum floor areas for communal amenity space
Studio	40 sq m	30 sq m	30 sq m	3 sq m	4 sq m	4 sq m
One bedroom	45 sq m	23 sq m	7.1 sq m	3 sq m	5 sq m	5 sq m
Two bedroom	73 sq m	30 sq m	11.4 sq m	6 sq m	7 sq m	7 sq m
Three bedrooms	90 sq m	34 sq m	13 sq m	9 sq m	9 sq m	9 sq m

2.3.5 Definition of small house for this study

Although small houses have many general benefits such as less time consumption in cleaning and maintaining the house, being easy to cool or heat up, better socialization and less economic pressure, however these houses have some disadvantages and problems too. These houses embrace different households while all are having similar and simple plan types, with limited spaces. Therefore it is very challenging to adjust these houses according to different users' desire.

Based on the analyses and studies have been done in previous paragraphs, it can be stated that small houses are classified in two main group of free-standing and attached dwellings. According to the research which has been done by Metropolitan Design Center (2005), apartment buildings are good example of attached dwellings.

In this study small houses are referring to multi-user dwellings/apartment buildings. Apartment buildings are consist of multiple floors and each containing multiple apartments on each floor. Size and numbers of apartments can vary from few apartments to hundreds of apartments in each building. These buildings have often internal hallways and the entrances to each apartments are from inside the building.

Apartment buildings can be classified as five types of small apartments, low-rise apartments, mid-rise apartments, apartment over commercial and high-rise apartments. Standard size of the apartments can vary widely depending on the target market, availability of land and location. Minimum standards which have been provided in previous paragraphs will be the main source in defining the size of apartments.

2.4 Building Layers

In past years many methods related to classification of building construction components have been developed. Components have different life span, different arrangement alternatives and functions in the buildings. Habraken (1972) believed certain needs to change in building elements occur in time therefore it is better to understand these elements and how these changes influences the building. Hence, he proposed a method which divided the building components into two layers, “support” and “infill”. The support layer which contain the structure and construction components, has long life span and decision to have any change in them needs architects, builders and related authorities approval. The infill layer which is referred to all detachable components of the buildings have shorter life span and dwellers can make changes in them according to their wish (Figure 19).

Figure 19: Showing support and infill and their relation (Drawn by author).

Following Habreken’s classification, Brand (1995) introduced new sets of layers according to life time of each building component. Brand considered building as six sets of layers which can change during the time according to request of dwellers instead of seeing it as a whole unit. Brand believed that buildings in order to function and improve according to their users should have the ability to change accordingly. Hence by introducing layers each with their own life span it become easier for both users and architects to change to a specific layer when it is needed.

The six layers of the building according to brand are site, structure, skin, services, space plan and stuff (Figure 20).

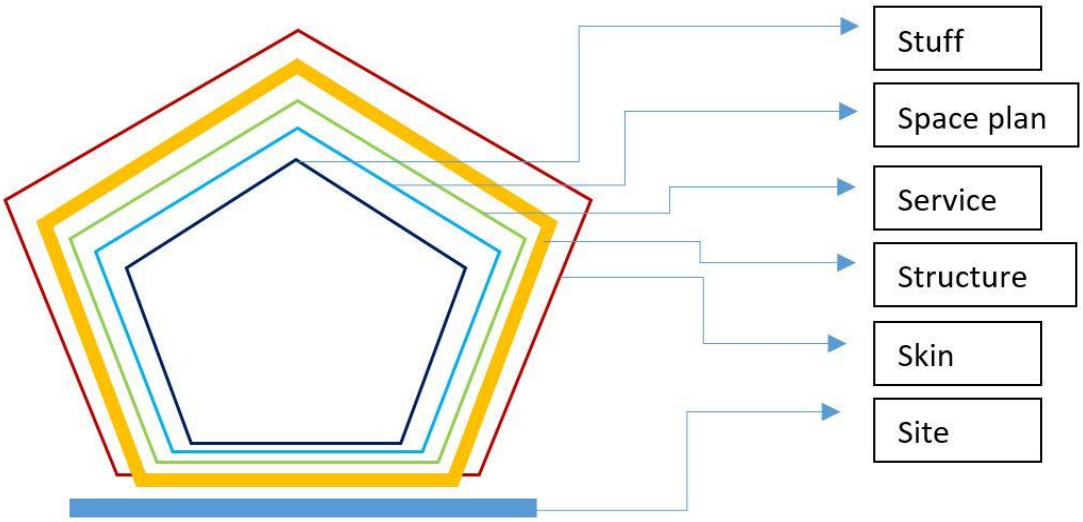


Figure 20: Layers of building design according to Brand (1995).

Brand (1995) describes the layers as following:

Site refers to the base and location of the building which is going to be build. Location of the lot with defined borders can be called the site of the building. According to Brand sites are eternal.

Structure layer is consist of foundation and skeleton of the buildings. Load-bearing columns and walls are part of the structure layer, therefore any change in them needs a professionals and these needs are very expensive. This layer lasts between 30 to 300 years depending on many factors such as climatically issues, material used and build technology.

Skin layer can be explain as the cover for building structure. It contains the exterior finish, roofs and façade. Making change in skin layer is very common by investors in

order to find a better market for the building or due to use of new technologies which improves building sustainability through better isolation. Lifespan of skin layer is approximately 20 years.

Service layer contains all the technical parts of a building, bathrooms and moving facilities like elevators and stair cases. Service layer should change and upgrade because of its important role in a building now a days. Day by day many advanced technologies related to building services comes to market, which are more safe, economic and easy to use. According to Brand service layer should change every 7 to 15 years.

Space plan layer or better say, interior layout of the building is consist of all the vertical and horizontal dividing elements such as partitions, doors, windows, internal walls, floor and ceiling. Lifespan of space plan varies from 3 years to 30years depending on the users and desired activities in the building.

Stuff layer contains all the furniture, daily used equipment's and objects. Having the advantage of being movable, makes stuff layer very easy to have change in them.

By applying the layer approach to design, required changes can happen within the layers and it will not have major effect on other layers (Geraedts, 2009). Although these layers are separated but they work as a whole, therefore a change in one layer may lead to future changes to related layers accordingly when it is needed (Table 4). For example a change in partition wall position which is in "space plan" layer can give new alternatives in choosing new furniture for the new settings which is "stuff" layer.

Table 5: Building layers and their specification (Brand, 1995).

Layer	Specification	Lifespan
Site	Determined lot	Eternal
Skin	Exterior finish, roofs and façade	20 years
Structure	Skeleton of the building, load-bearing columns and walls	30 – 300 years
Service	Access units, bathroom, kitchen, technical parts of the building	7 – 15 years
Space plan	Interior layout of the building, vertical and horizontal dividing elements	3 – 30 years
Stuff	Furniture such as sofa, bed, desk, table, lighting elements and etc.	Depends on the user

In order to indicate whether a building is built by consideration of its layers, an evaluation formula have been made by Geraedts (2013). If a building can respond to required changes in order to meet the needs of the user, builder (real estate) and society it can be called as a flexible building, on the other hand buildings which are designed by taking to consideration building layers can be more adaptive compare to normal buildings. The reason is that, making changes in the building layers in order to respond to new needs is easier and economically logical instead of demolishing the building. Following chapter "what is flexibility and flexible housing?" and classifications of flexible housing, will be studied in more details. The outcome of this chapter related to building layers and application of flexibility in each layers forms a framework of this study.

Chapter 3

FLEXIBILITY

In this chapter definitions of flexibility will be explained. Different definitions of flexible housing along with its classification starting with history of flexible housing in different cultures will be described in more details.

The main aim of this chapter is to analyze and explain the importance of flexible housing and develop an analytical approach which contains layers of the building with related flexibility types in building to find answer for following question:

How can flexibility be applied to a building?

Flexibility is described as “The quality of bending easily without breaking, the ability to be easily modified and willingness to change or compromise” (Oxford dictionaries, 2016).

Flexibility can be explained as ability and capability of having several physical orders (Groák, 1992). Being able to change according to certain need or situation and get adjusted towards it can be called as flexibility. Having flexibility in a design allows designers to be more innovative to design for future and makes the design open for future changes with maximum ability of respond, so user could have be able to modify it according to their wish (Forty, 2000). Majority of the studies about flexibility refers it as the ability to accept changes. Dluhosch (1974) explains flexibility as a term

similar to the adaption but in a more specific manner and wider than what adaption covers. He believed flexibility is the ability to modify and change to respond a need. Additionally, flexibility refers to ability to accommodate change over time and certain needs.

3.1 Flexibility in Architecture

Starting from the nomadic lifestyle in different cultures, human beings are motivated to fulfill the their evolving needs since the early period of civilization. Using lightweight materials such as animals' skin and tree branches for building the living space, having multi-functional spaces which can be adopted to temporary activities such as gathering and celebrating were one of the first examples of having flexibility in living spaces although those days the term "flexibility" was unknown. History of living spaces around the world and the way these houses had the ability to satisfy their users' need will be studied at the following paragraphs.

3.1.1 Flexible Houses in History

Human being is always interested in trying and exploring new things to fulfill their needs and wants. Changing the surrounding and living environment with the available materials were one of the main challenges of human from the very beginning of the existence of mankind. In the past mankind was limited to use the local materials which was the only available material at time.

In addition to the limited construction materials, knowledge of construction and building also was very basic and needed to be improved. Although there were many limitations, but mankind was always able to develop a method to satisfy his/her needs and wants. In following the history of housing, there are many great examples of how human beings dispel their housing needs.

American Indians tents with the ability of ease in setting up and packing, having the ability to adjust its size and being suitable for most of the required functions can be counted as a flexible unit. These tents were used for eating, sleeping, cooking and gathering mostly. Indian tents which also called as “tipi” were free of column in middle, therefore the space inside was free as it is shown in figure 21. Organization of space inside, had the ability to change according to certain need of the users (Campbell, 2009).

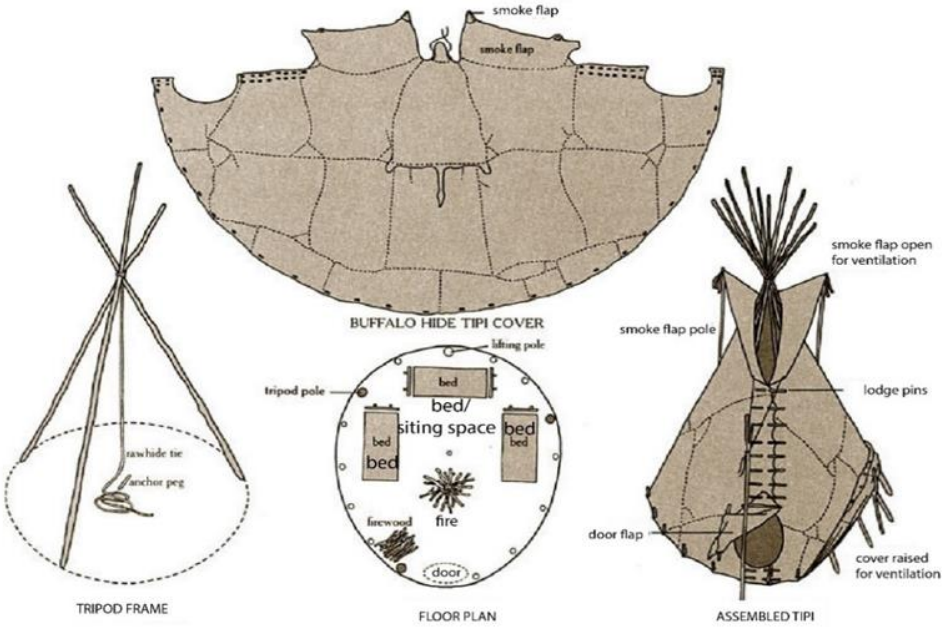


Figure 21: Structure and cover of tipi (Campbell, 2009).

Another method in housing context has been developed in Malaysia, called as “Malay houses”. Malay houses designed in a way that, they were able to easily be adapted to users various needs at a time, ability to extend or shorten easily made these houses useable by dweller with different family size andstructure. As it is shown in figure 22 a core structure named “rumah” is the base for additional components. These houses were able to extend horizontally in all the directions.

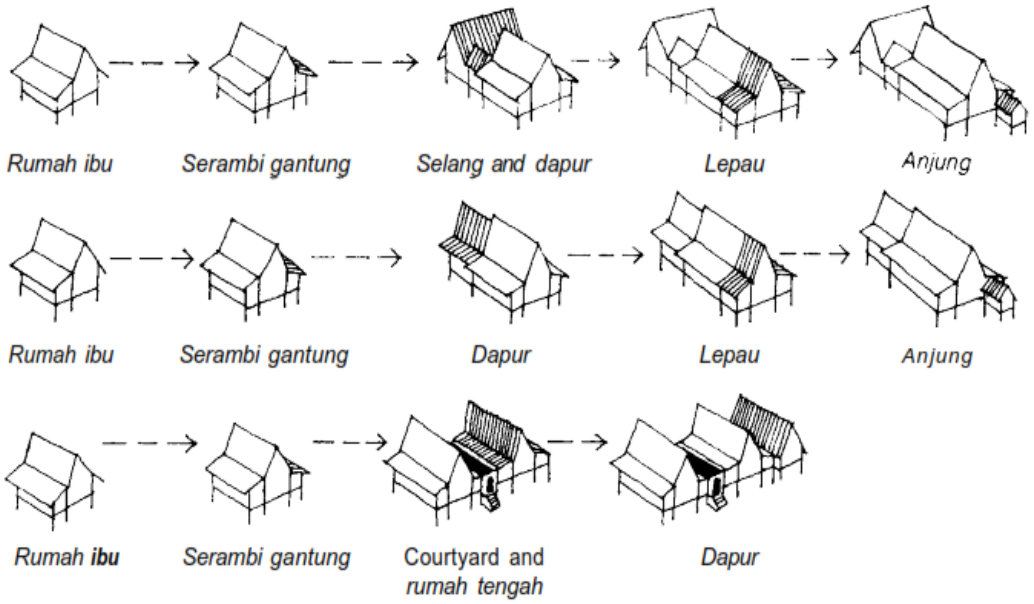


Figure 22: Different alternatives of malay housing extensions (Yuan, 1987).

The interior organization of the malay houses varies according to its users. As it is shown in figure 23, the core unit (rumah ibu) is the multi-functional space which accommodates different kinds of activities such as meeting, sleeping or praying. In case a family needed a more private space for certain activities such as reading or sleeping, another unit was added to the main unit. Although units after the addition were very close to each other but the position of the multi-functional space (rumah) as a core and extension of private units in one direction and extension of common units such as kitchen and dining area in another side, made a very successful spatial organization in these houses (Yuan, 1987).

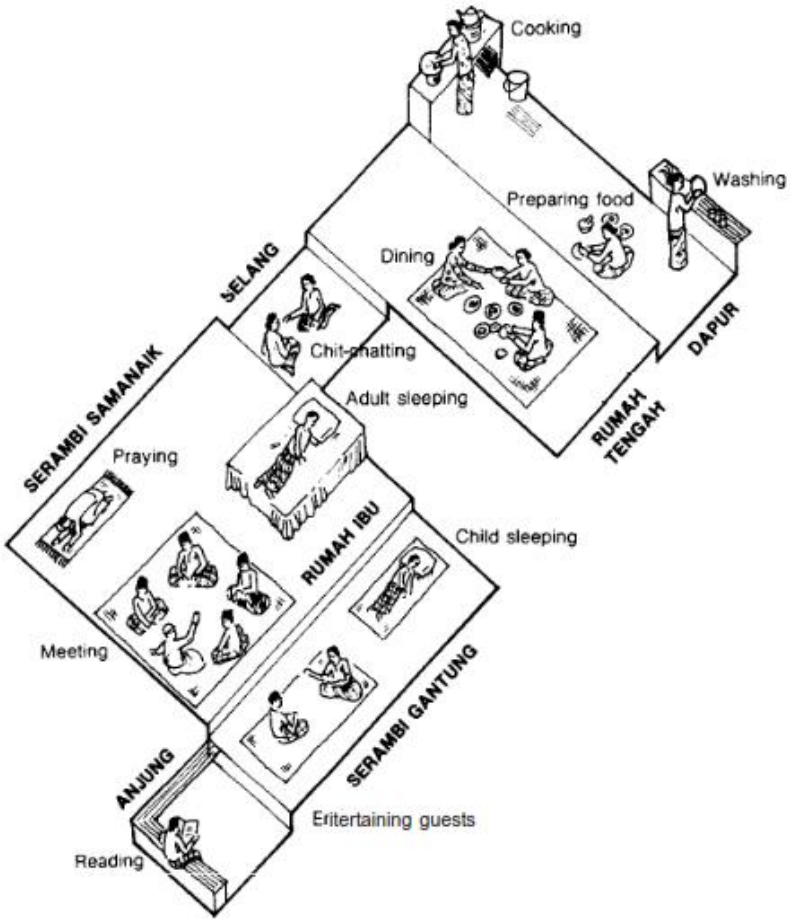


Figure 23: Interior space arrangement of a malay house (Yuan, 1987).

Korean traditional houses also can be a good example of early flexible architecture. Korean traditional houses had two commonly use areas named “madang” which means the courtyard and “maru” which means living rooms as a semi outdoor space (Bongryol, 2005). Madang or the courtyard not only was a place for important family events but also could have adapted for different proposes of uses such as working area or resting (Figure 24). A tight relation between maru and madang gave the ability to users to change function of the spaces by the time it was needed such as dining, celebrating, resting and sleeping.

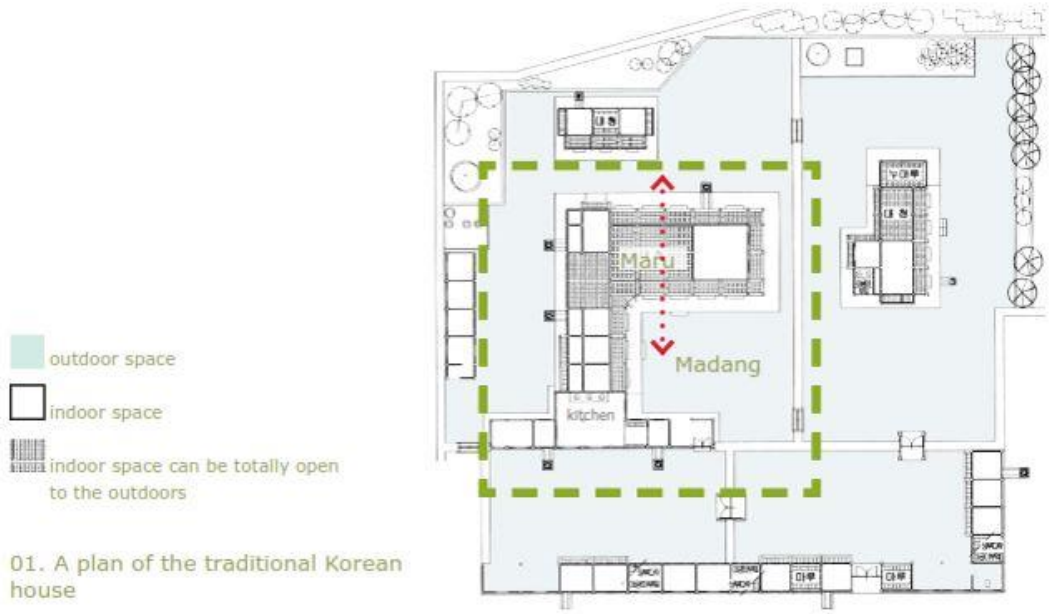


Figure 24: Typical plan of traditional korean house and maru (in the left) and madang (in the right). (URL:13)

Japanese houses are well known examples of houses which could adapt to different types of activities during a day and night. Rooms and units in these houses can be adapted to different kinds of activities without any limitation. Having partitions and sliding walls made the interior of these houses flexible enough that can change its function by adding or subtracting a unit (Figure 25). A big unit can be divided to two completely seperated units with different functions. Using wooden frames which were very light weight and local materials , ease the building process. Using tatami technique in calculating the spaces, made the spaces to be propotionaly related to each other, therefore any addition or subtraction were very easy.

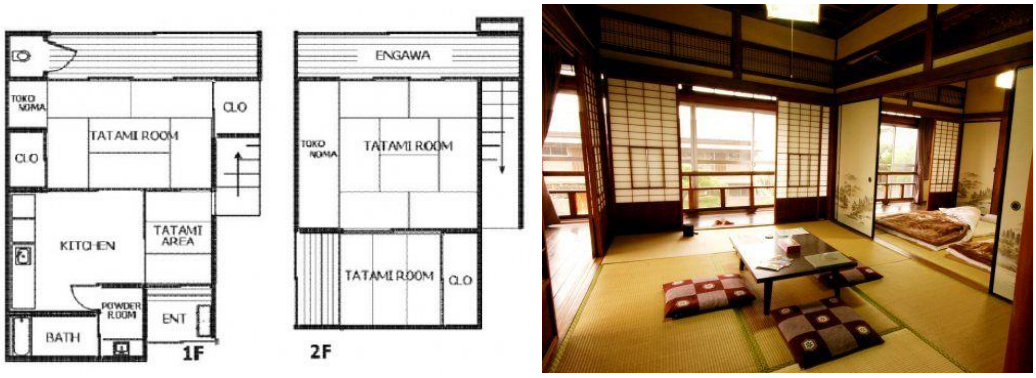


Figure 25: Interior and plans of a traditional Japanese house (URL:14).

To sum up the mentioned examples from the history of housing development in different cultures, it can be said that, mankind in order to satisfy his needs always developed a method to respond its needs and instead of making a change in the way they live, preferred to make changes in his living environment. Finding a solution for the rapid changes in human life style has never stoped, it continued as the technology and knowledge in many fields has been developed and still developing.

3.1.2 Flexible Architecture from 20th Century Onward Influenced by Modernism

> The twentieth-century design breakthrough into modernism can be charted through the design of one-off houses. The progressive British Arts and Crafts movement provided the foundation for a range of European styles that were to follow – Art Nouveau, Art Deco, Jugendstil and the Viennese secession. In the years following the First World War, the house was a crucial model for exploring new ideas about lifestyle and the implementation of innovative technology (Kronenburg, 2007, p.20).

Kronenburg in his book “Flexible Architecture that Responds to Change” mentions about Frank Lloyd Wright as one of the pioneer architects who made a revolution in architecture (Kronenburg, 2007, p.21).

Japanese traditional houses were inspiring start point for Frank Lloyd Wright. Flowing space and its relation with the site which could have been achieved through sliding doors and open plan system, using natural materials and tatami layout system in Japanese houses made its impression on Wright. Wright by considering the Japanese

architectural approach towards the space, adding new built technology and materials caused by modernity period, opened a new area in housing architecture. In his buildings space flowed with no extra disturbing blocking elements around a heart of a place which usually is defined by fire place. The walls although were not completely movable but by the use of glazed materials, view of the surrounding of the building was provided.

In early 1900 Frank Lloyd Wright introduced the term "Usonia". In brief the term Usonia refers to a houses which were small open planed houses that also were affordable and comfortable. Michael Wildman (2000) describes Wright's Usonia houses as:

> To Frank Lloyd Wright the Usonian House had a beating heart, forever fluctuating in time and in motion. The spaces melded together to become one allowing for greater functionality. These spaces contained built-in furniture and were made of an easy construction method. Together with these simplified design strategies they allowed for the deletion of extraneous spaces (Wildman, 2000, p.4).

Wright in his designs of the houses wanted more than a house, a house that can live and breathe. He emphasized the issue that a building in order to be a successful project, needs to be in a relation with the site it is built as well as the people it is built for (Wildman, 2000). Taking to consideration these relations and knowing that the site and users are variable factors, makes each Usonian house different from one another and improves its functionality. He believed that a house should be reflect of its users and resembles to them. Frank Lloyd Wright main principle in his designs was the flow of the space around a main (central) space. Wright believed that a perfect architecture doesn't mean the most expensive architecture, therefore everyone has the right to have a perfect architecture (Twombly, 1979).

One of the good examples of Usonian houses of Wright is Jacob's house (Polliwog Usonian) which was built in 1936 in Madison, America (Figure 26).

Figure 26: Jacobs House, 1936 (Twombly, 1979).

All the Polliwog Usonian houses were rectilinear in their form. This type of Usonian houses only implement in flat sites unlike Usonian houses which have been built on top of the cliffs or site with inclined surface. The Jacob house was almost 475 sq. m. placed in a site and surrounded by a garden. This house had an "L shape" plan which allowed the house to be divided into two parts of private and public and be connected to each other by the services area as a core. Private parts covered the bedrooms, study room and workshop/office in one wing and the public parts of the house such as living area, dining area and terrace in the other wing. In this house the idea of centralizing service area was used as the core. Kitchen and bathroom were in the center, therefore it was accessible from both wings (Figure 27).

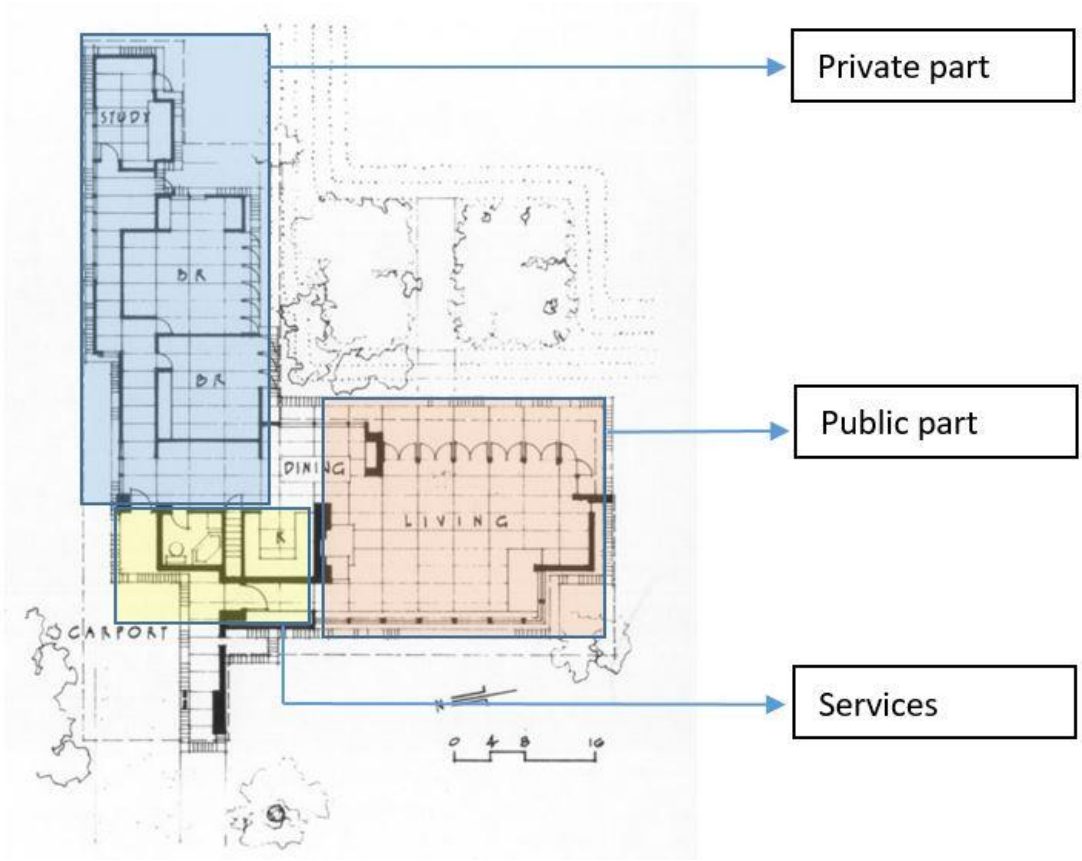


Figure 27: Jacob house floor plan (Twombly, 1979).

Wright by considering the examples of Japanese housing and partitions simply got rid of the permanent dividers between living room and dining room and offered a big space instead. In some of his projects he allowed the kitchen also to be the part of the space with no limitation (Twombly, 1979).

Another important part of his designs was about using permanent walls and dividers at its minimum and instead take the advantage of offering flexible plan by placing movable partitions which can modify and change according to users need. Figure 28 shows the permanent walls of the house which are mainly defining the service areas, dining area and entrance and house territory.

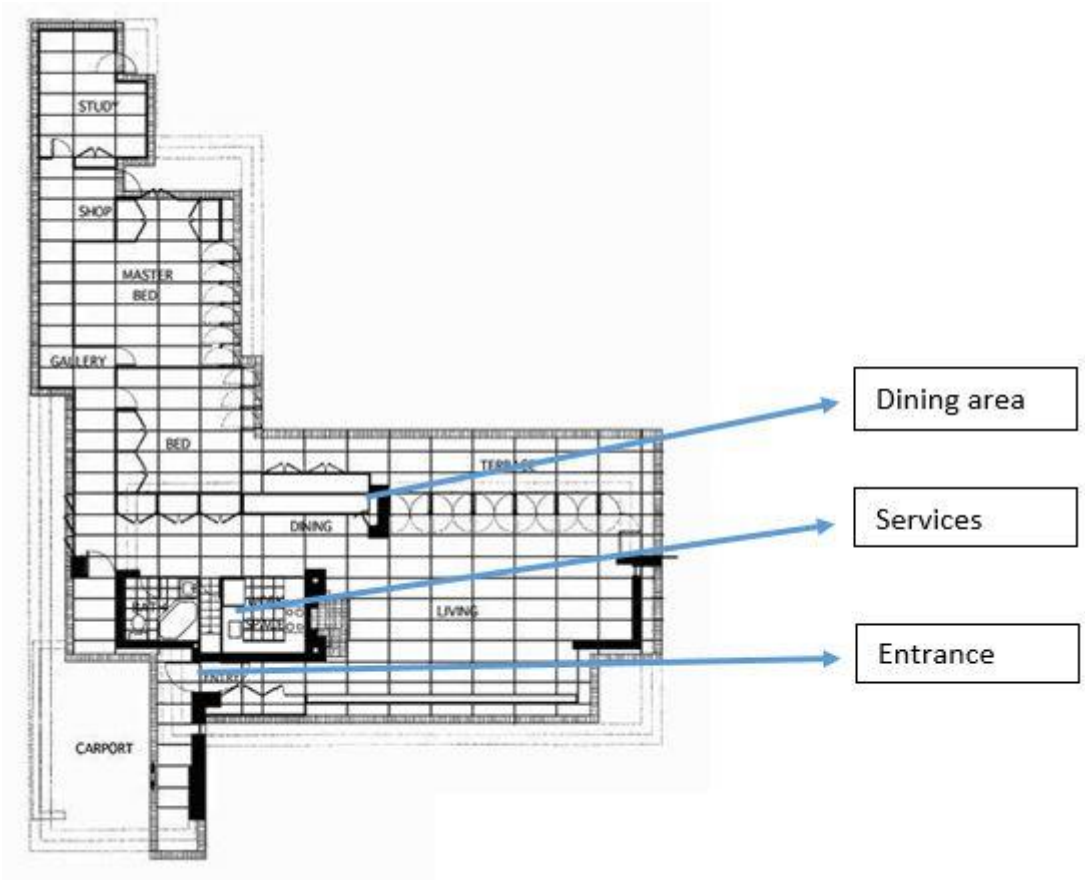


Figure 28: Permanent dividers in Jacobs house plan (Twombly, 1979).

Frank Lloyd Wright ideology and his approaches, influenced many modernist designers such as Le Corbusier, Walter Gropius, Mies van der Rohe and Otto Wagner. In the following paragraphs some works of these architects and their approach towards the houses will be studied in more detail.

Le Corbusier was one of the architects whom by introducing new techniques and style in architecture made a vast change in European architecture. He introduced the ribbon windows and free plan layout with no restricted structure and flat roofs that can be used. Le Corbusier's works, such as Villa Savoye allowed its user to be more adaptable to the house by having the free relation between the spaces. Une Petite Maison is one of the good examples of his attempts for flexible design. He designed this house for his parents, a small and minimal house for two people whom he knew them very well.

In the design of the house he considered the time he wanted to visit his parents, therefore by using some flexible elements, such as sliding and folding screens, house was able to adjust in a way that it can provide privacy for the guests. Used furniture also were flexible and designed in a way that they have relation with the form and elements of the house. For example extension for the dining table so the third person can dine, or elevated working area in order to use the advantage of high level windows and see the surrounding (Figure 29).

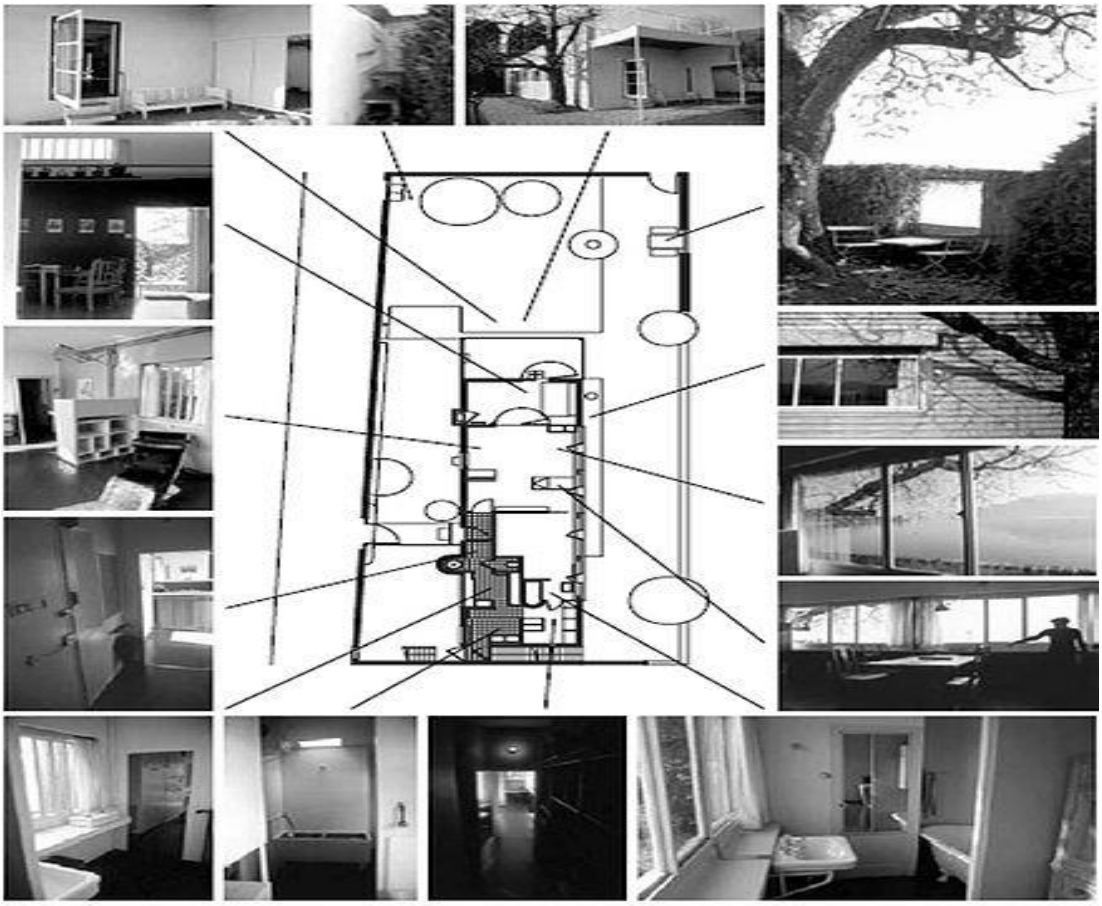


Figure 29: Une Petite Maison's draft plan with related pictures (URL:15).

Schroder house which is designed by Gerrit Rietveld in 1924 is one of the well-known flexible house examples in that period. The ground floor of this house was planned in a very easy way rather than the upper story of the house. The upper floor somehow

reflected Rietveld's feeling towards the house in addition to considering the practical needs of the user by providing dividable spaces that can change by the time it is necessary (Figure 30). Rietveld by taking the advantage of his early training as cabinetmaker created the system of sliding and folding partitions to divide or combine the spaces. Most of the furniture used were built accordingly by inspiring from the DeStijl concepts (Kronenburg, 2007).

Figure 30: The interior of Schroder house, showing the partitions (Kronenburg, 2007).

Fix parts of the building such as load bearing walls and services are located in a way that they won't disturb the interior arrangements, elements inside the buildings are made of flexible elements which can be easily closed or opened (Figure 31).

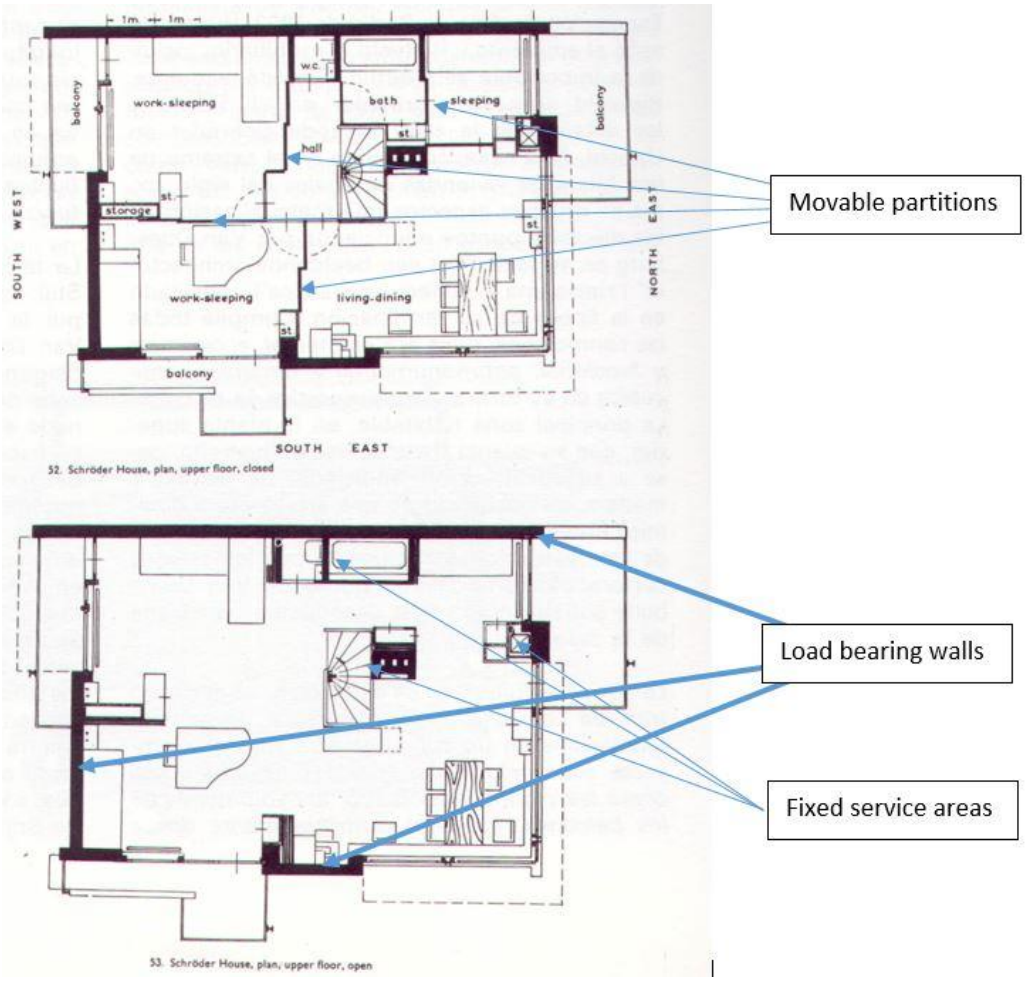


Figure 31: Showing the fix parts and movable parts of Schroder house. (Kronenburg, 2007)

Mies van der Rohe was another architect who changed the perspective view of architects towards the space. He mostly expressed his design in the building by providing free plan with no interrupting walls and elements. Rohe's Tugendhat house was a good example of such approach. Specification of this house such as continuity in the spaces by merging them, chromed columns with no exaggeration in the size, vertical partitions and floor to ceiling glass walls. Internal organization of the house was defined by its furniture and some parts of the living area was separated by heavy curtains which helped to improve the aesthetic, acoustic and privacy of the space. Having full glassed walls improved the relation of house with its surrounding and making the house looks bigger than what its actual size is (Figure 32).

Figure 32: Rohe's Tugendhat house exterior and interior layout (Kronenburg,2007).

Using dividers instead of internal walls and doors, use of thin steel columns, minimal furniture, dividing the house to two part of public and private and placing the services in one side instead of middle of the house freed the interior space plan that can be adapted to variety of activities and uses. As it is shown in figure 33, first floor of the Tugendhat house is divided to three main parts, living and dining area which are free from any load bearing elements (public) in one end of the house, master bedrooms and home office (private) in another end of the house, and the third part consist of staircase and bathrooms (service) in the side. This arrangement and positioning of the spaces allowed the private and public space do not interrupt each other.

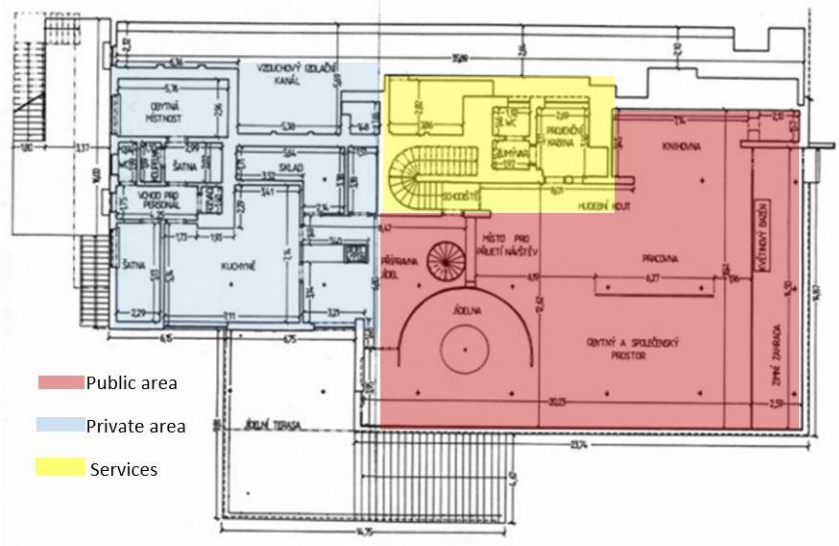


Figure 33: First floor plan of Rohe's Tugendhat house.

Another period of history which had its influences in flexible housing creation dates back to World War Two in the United States of America between 1945 and 1950. Baby boomer generation occurred through the rapid birth rate increase after the war (Figure 34). In addition to the increase in birth rate, increase in number of immigrants from small cities to metropolis and even other countries caused a huge demand for Residential buildings (Murphy, 1990). This sudden demand for new houses and following that shortage of building materials and labors forced governments and many architects to come up with a new solution and building techniques for constructions. Use of new and cheap materials such as concrete, fibro, iron roofs and pre-fabricated homes become very popular. Following is a brief review of different approaches by architects towards the sudden growth of housing demand.

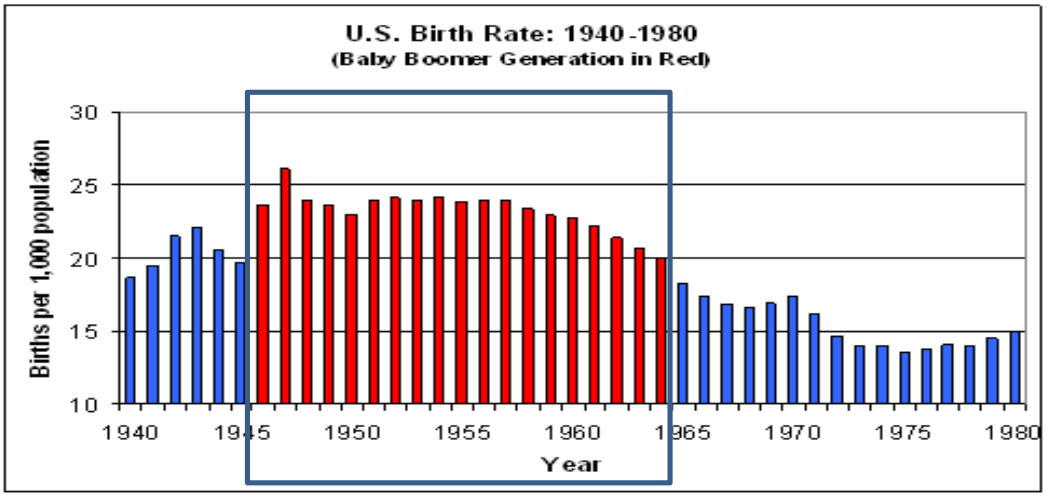


Figure 34: Birth rate of the U.S.A and Baby Boom period (Martinson, 2000).

This vast demand for new houses by people who came from different cultures and communities with variety of family sizes and structures need to be solved in a very short time. After the war and return of soldiers who were excited to start a new life and have a family of their own and immigrants from Europe who moved to U.S.A , in that 5 years alone a sudden increase in population which was up to twelve million

occurs (Martinson, 2000). Lack of enough space in the cities, rising in land prices and vast demand for new houses with very wide range of user's profiles caused a serious concerns for government in order to provide a suitable houses to everyone. Following this event suburbanization become very popular, mass production of simple and single floor plan houses called ranch houses in suburban (Figure 35). These kinds of suburb houses were a well-built and direct answer to needs of American people (Prown, 1982).

Figure 35: Mass production of ranch houses after World War 2 (Prown, 1982).

Ranch houses had three basic design concept along with other concerns such as climate. Peterson (1989) mentiones these concepts of design as livability, flexibility and having a simple character. These concepts were taking to consideration in site location, house organizations and interior layout of the houses. Specification of outdoor garden, due to having same level made it possible to expand the interior of the house and merge it with exterior and only division between the interior and exterior was a large glass window and sliding glass doors. Another characteristic of the ranch houses is their simple plan layouts, rooms are place with a linear organization. Linear organization of the rooms has the advantage of dividing the space into two parts of private and public zones (Hubka, 1995) (Figure 36).

Figure 36: Plan in the left shows the public parts of the ranch house and the plan in the right shows the private parts (rooms) (Hubka, 1995).

In recent years reverse demographic shift from suburbs to urban centers occurred in USA and many other countries (Urban Land Institute, 2012). People preferred to find accommodation near the place they work or study rather than traveling for hours to reach to their destination. Lack of enough residential buildings, high prices and location, encouraged many architects and investors to build small residential apartments or in some cases change the function of the building from commercial to residential.

Nakagin Capsule Tower in Japan designed by Kisho Kurokawa is one of the examples of flexible small Residential buildings which occurred during modernism period .Among many design approaches towards the building influenced by modernism which promote the term flexibility as well, metabolists were one of the most famous one. Metabolism was an architectural movement in Japan in 20th century. They were trying to open new vision towards the architecture and urban life. After the world war two, their mission was to create a harmony between the traditional life style of the Japanese, nature, technology and new living circumstances. Their main idea was that, the cities and buildings in them should develop accordingly and grow accordingly to future needs of those who live in it. Their approaches were starting point for many

projects in Japanese architecture with using flexible and expandable structures. Kisho Kurokawa, one of the members of metabolism movement has been quoted in Henket and Heynen (2002) about the movement as:

> My architecture represents the spirit of the Age of Life Principle, and it aims at the symbiosis between abstraction of modern architecture and cultural identity (Kurokawa, 2002, p. 253).

Nakagin Capsule Tower in Japan designed by Kisho Kurokawa in 1970-1972, which is made of steel and reinforced concrete mainly and consist of functional cores and capsule modules attached to the core, can be one of the most important examples of Metabolist movement.

> The philosophy of metabolic design is based on exchangeability, modular buildings, prefabricated parts and capsules. The units move, change or expand according to the needs of the individual, thereby creating organic growth (Echavarria, 2005, p.24).

In designing the Nakagin Capsule Tower the target users, which were businessmen/women that worked in the city center during the week and had no time for spending on the road to reach their offices was taking in to consideration. The design of this tower was one of the good examples of sustainable architecture because of its ability to recycle and reuse. The capsules were pre-fabricated and each unit could be plugged in to the functional core with ability to change and modify with a new unit by the time of need (Figure 37).

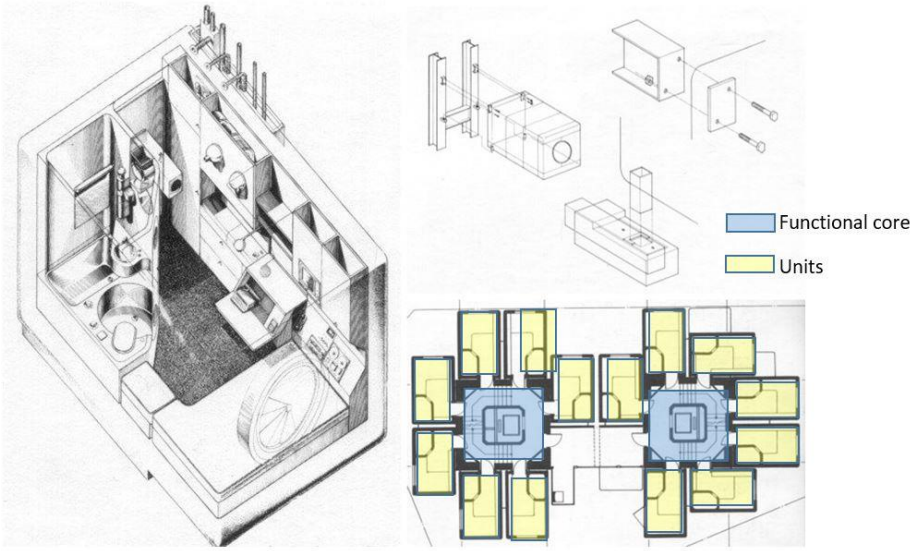


Figure 37: Floor plan of Nakagin Capsule Tower and illustration of attaching method (Henket & Heynen,2002).

Each unit with a dimension of 10m2, consists of all the requirements for living such as toilet and shower, sleeping unit, working desk, small kitchenette, storage, closet and TV. Most of the furniture are attached to a wall and are inbuilt in order to save space (Figure 38).

Figure 38: Interior layout and furniture of Nakagin Capsule (Henket & Heynen,2002).

3.2 Flexible House

Flexible housing is housing that can adjust to changing needs and patterns, both social and technological. These changes may be personal (say an expanding family), practical (i.e. the onset of old age) or technological (i.e.

> the updating of old services). The changing patterns might be demographics (say the rise of the single person household), economic (i.e. the rise of the rental market) or environmental (i.e. the need to update housing to respond to climate change) (Schneider, till, 2007).

A house with the ability of change and respond according to volatility of dwellers can be called as a flexible house. This ability of respond can be achieved through having adaptability or flexibility in the building. These two terms (adaptability and flexibility) although have some similar attitude towards the space but they are different from each other.

Rabeneck, Sheppard and Town (1974) distinguish flexibility from adaptability by claiming that, flexibility is most likely related to physical component of the building like structural parts, services, internal wall organizations and layouts and on the other hand adaptability deals with internal settings of the building such as, room organization and their dimensions, relations between house components and each rooms function.

Steven Groak (1992) supports Rabeneck, Sheppard and town's by stating that, adaptability is "capable of different social use", meaning that adaptability deals with interior settings and configuration, while the flexibility is "capable of different physical arrangements", which means it deals with physical parts of the building both in interior and exterior of the building (Groak, 1992).

Schneider and Till (2007) support Groak definition by claiming that:

> Flexibility, is achieved by altering the physical fabric of building: by joining together rooms or units, by extending them, or through sliding or folding walls and furniture (Schnider and Till, 2007, p.5).

Herman Hertzberger (1991) points out the significant role of flexible housing by stating that:

> Flexibility signifies – since there is no single solution that is preferable to all others – the absolute denial of a fixed, clearcut standpoint. The flexible plan starts out from the certainty that correct solution does not exist, because the problem requiring solution is in a permanent state of flux, i.e. it is always temporary (1991, p146).

Hertzberger believes that, flexibility in houses offers the most suitable solution to the current need although it is not the only solution but the most appropriate. He explained flexibility by introducing the term "polyvalence" as a characteristic of a static form. It refers to a unlabeled form, which can be used in variety of functions without obtaining any major change in itself, therefore by offering a very small flexibility provides a sufficient solution (Hertzberger, 1991).

Maccreanor supports Hertzberger explanation of flexibility by stating that:

> Flexibility is not about the ability of making endless changes by the time it is needed but the most proper one (1998, p. 40).

Maccrenor and Hertzberger believed that misunderstanding flexibility and how it should apply to a building, leads to unsuccessful housing (Albostan, 2009). As Adrian Forty explains, this misunderstanding occurs through two conflicting issues: "[Flexibility] has served to extend functionalism and so make it viable" and "[Flexibility] has been employed to resist functionalism" (Forty, 2000, p.148). Therefore it can be said that flexibility is not a solution for endless changes. In other word as Schnider and Till mentioned the term "open-endedness" which occurs due to allowance of infinity amount of change in the building in different situations for users by the architect. Exaggeration in amount of flexibility in the building by having many technical and movable parts creates false neutrality (Schneider and Till, 2005, p.158).

Maccreanor also as well as Schneider and Till states that flexibility covers the term adaptability. He claimes that the adaptability of a building is another perspective of the flexibility of the building. Adaptable buildings should also be capable of being multi-functional and changeable. Flexibility on the other hand is involved with the basic design of the componenets as well (Maccreanor, 1998, p. 40).

According to all the definitions above it can be said that, the term flexibility is related to both physical and spatial parts of the building and it covers the term adaptability as well. Therefore in this study the term flexibility is going to be used.

3.3. Different Classifications of Flexible Houses

Flexibility in architecture is a very wide field. Different authors categorize flexibility from their own points of view, but in general they are often the same or completing each other in a proper manner. According to Bakkaloglu (2006) cited in Attarzadeh jozdani (2009) flexibility can be classified into two, according to time which can be called as “process flexibility” and according to manner of use, which has been referred as “types of flexibility”.

3.3.1. Process flexibility

Friedman (2002) mentions that process flexibility according to time factor and it is divided to three stages; “design flexibility/initial design”, “production/construction flexibility” and “usage flexibility”.

The first stage “initial design” is mainly designer paced approach, meaning that it occurs due to involvement of the designer. It allows the designer to consider user needs and future circumstances during the design stage and before the construction starts. Friedman (2002) explains the first stage of flexibility as the strategies developed by the architects for before and after occuoancy. “Where the designer employs the

strategies and components during the conception phase to facilitate pre- or post occupancy" (Friedman, 2002).

The second stage is the "construction flexibility", which gives some alternatives to the builders in deciding specifications of units, such as their size and organization. Bakkaloglu (2006) explains this stage as allowing different space organization practice in the construction phase by considering the main construction elements. This methods allows, achieving different organization layouts with the help of same components (Bakkaloglu, 2006).

The third stage "usage flexibility" is user (dweller) based activities, in which the building users adjust the space and interior organization of the building according to their wishes. Friedman (2002) explains this stage by stating that:

> During occupancy, the owners exercise the previously conceived and constructed option for adaptability in the unit (Friedman, 2002).

After studying these classification with considering time factor, it can be said that, flexibility can occur in three stages of before construction (designer base), construction (builder/investor base) and after construction (user base). Each stage has its significant role to improve flexibility in a building and are related to one another.

3.3.2. Types of flexibility

Types of flexibility is based on the way the flexibility is going to be used in the building. Types of flexibility can be evaluated in different stages of the construction. Different authors classified these types based on their own practice. These classifications may contain overlapping or totally different factors. Following, two general types of these classifications will be studied in more detail.

3.3.2.1 Type one: Functional and Structural

Al-Dakheel (2004) divides flexibility into two types of "functional" and "structural" according to their relation with the building and their future impacts on the building.

Functional flexibility:

There are variety of building types with different functions. But all these buildings have some elements like basic function and sub division in common. In some case and according to the needs, basic function of a building may need to be changed or modified. Similar practice occurred in New York, USA, as a "loft program" in which many industrial buildings changed in function to a residential lofts.

The New York City Planning Commission defines "loft" in this way:

> A type of building generally constructed prior to 1930 for commercial and manufacturing use, and which is now or has been occupied by manufacturing tenants. A loft building is constructed such that it covers most of its lot, leaving relatively little open space. The interior has few columns and, therefore, has large unencumbered space" (Hornick & O'Keefe, 1984).

This example showed how a basic function of building can change to new function with some alteration in the building in order to meet the new needs. Functional flexibility can be used in the small scale like building interiors. For example dividing a big living room by the help of the partitions into two, or join a living room with another room to achieve a bigger space.

Gross Murphy (1968) explains the spaces needed for a building to be functionally flexible as "expansible space", "convertible space", "versatile space" and "malleable space".

> Expansible space: it allows for future change and growth. Using structures like frame structure to eliminate internal structure elements is a key development for such space (Rydeen, 2004).

"Convertible space": it is defined as the ability of change in the function. As Schneider and till calls it "more architect-determined", it needs an architectural control over the space in order to change the function in the building (Schneider & Till, 2007, p. 18). Brubaker (1998) explains convertibility as:

> Convertibility designates the ease of adapting space for new uses (Brubaker, 1998, p.32).

"Versatile space": a space with ability of having multi functionality in use. Multi-functional spaces such as cafeteria, stadiums and auditoriums are a good example of versatile space. Torin (2002) explains versatile spaces as a space which can allow variety of functions take place in it but in order to a required function to work properly it is needed to put extra effort (Torin, 2002, p.15).

"Malleable space": Rydeen (2004) explains malleable space as the ability to change "at once and at will". He believe offering classes with different sizes in a learning environment helps to achieve malleable space (Rydeen, 2004).

Bakkaloglu (2006) stated that "the ability of the rearranging furniture in space" also can improve the functional flexibility of the space.

"The ability of the rearranging furniture in space" means the ability to change in the organization and arrangement of furniture in order to change a function in a space.

Two of the significant examples of functional flexibility are Maison Domino and Maison Citrohan designed by Le Corbusier. He proposed a structural system called as "Maison Dom-ino" as a skeleton of the building consist of permanent components

such as columns, slabs and access unit with no internal structural elements that limits the user to give function to the building (Albostan, 2009) (Figure 39).

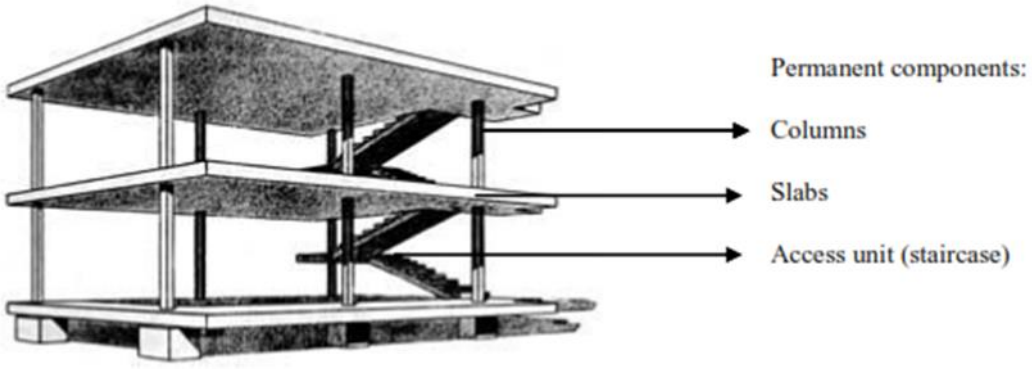


Figure 39: Maison Dom-ino by Lecorbusier in 1919 (Albostan, 2009).

Maison Citrohan, another design of Le Corbusier which was based on Maison Dom-ino system, designed in five different versions from 1919 to 1927, with the help of having free plan with no load bearing elements inside gave the possibility of versatility, convertibility and rearranging furniture organization (Risselada, 1991) (Figure 40).

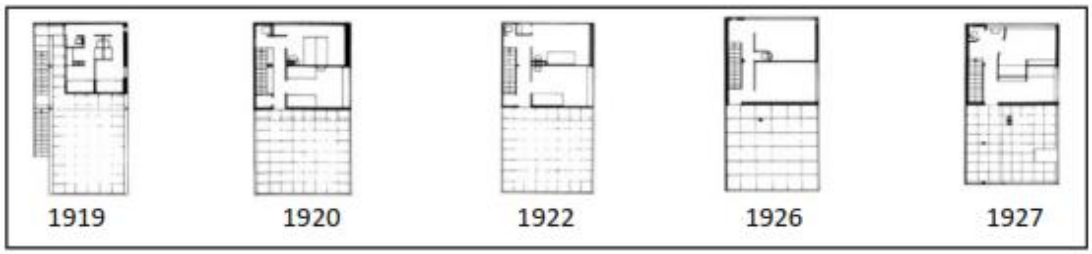


Figure 40: Five version of ground floor of Citrohan Houses (Risselada, 1991, p.95).

Therefore it can be said that in order to a building to have functional flexibility existence of some or even all of the “expansible space”, “convertible space”, “versatile space”, “malleable space” and “the ability of the rearranging furniture in space” is necessary (Figure 41).

Functional flexibility	expansible space	"Which can allow for ordered growth." (providing a free plan)
	convertible space	"Convertibility designates the ease of adapting space for new uses […]."
	versatile space	A space with ability of having multi functionality in use.
	malleable space	ability to change "at once and at will"
	the ability of the rearranging furniture in space	ability to change in the organization and arrangement of furniture in order to change a function in a space

Figure 41: Important factors in achieving functional flexibility (Risselada,1991,p.95).

Structural flexibility:

In general it refers to the ability of the building to be extended in horizontal and vertical directions without making any major change to the rest of the building. Structural flexibility can achieve with three techniques, "extendibility", "base structures" and "polyvalent organization" (Gilani, 2012, p.25).

- Extendibility

Bakkaloglu (2006) cited in Attarzadeh jozdani (2009) explains extendibility in structural flexibility, as ability to apply "standard modularization" in addition to the ability of extension vertically and horizontally. He defines standard modularization as "open-ended unobstructed structural design which allows for vertical or horizontal additions or modifications through the free placement of services. Another method of application of structural flexibility is through prior grouping and placement of service in specific zones and freeing of the rest of space for end-users spatial definition" (Bakkaloglu, 2006).

Extendibility can be classified according to direction, scale and form. Expansion in vertical or horizontal direction or both refers to direction expansion. Scale expansion occurs according to the building's scale and form expansion refers to the way expansion occurs. Radial, linear and clustered expansions are forms of expansion (Gulaydin, 2004, p.28).

Friedman explains extendibility in structure by stating that:

> Design that considers expansion beyond the dwelling or growth into a space within the perimeter of the original volume is another form of flexibility and also adaptability (Friedman, 2002, p.17).

Schneider and Till (2007) classified structural flexibility into two as "Base structure" and "Polyvalent organization" in their books Flexible housing.

- Base structure

Base structure got influenced by theory of "support" and "infill" system introduced by Habreken in 1972. He defined the support as a fix elements which architect and builders can decide about it and infill which industrial designers and users can make decision about it and it refers to movable and attached elements (Tatsumi et al, 1987). Fix elements such as load bearing walls, columns and stair cases and infill are those which are flexible, such as kitchen elements, furniture, doors, partitions and dividing walls, sleeping units and heating elements (Habreken, 2002) (Figure 42).

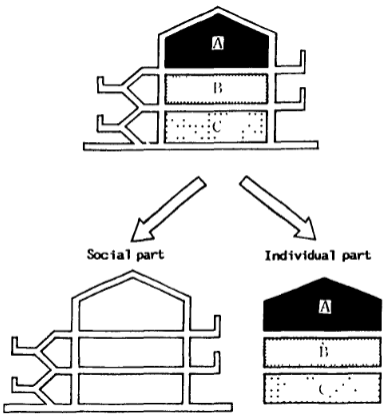


Figure 42: Social part (support) and Individual part (infill concept) (Tatsumi et al, 1987).

- Polyvalent organization

Polyvalent organization unlike base structure, is consist of fixed size modules with ability to join or divide for different proposes and functions. Albostan (2009) mentions about polyvalent organization as:

> "In this approach, the sizes of the modules are standard and fixed in form, but it is possible to join two or more modules together or to divide a module into smaller modules" (Albostan, 2009, p.30) (Figure 43).

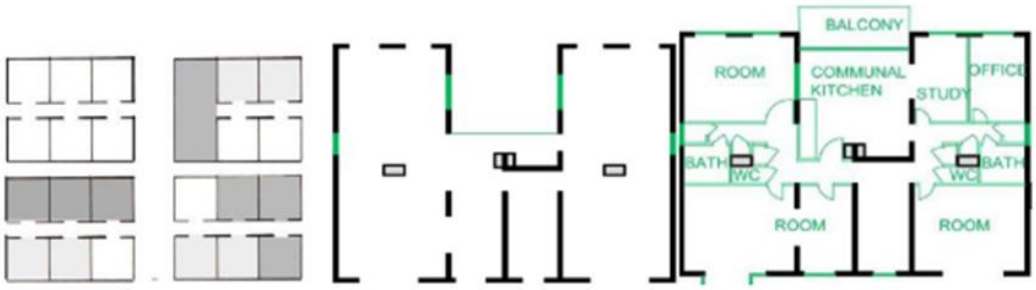


Figure 43: Polyvalent Organizations: Rooms without Labels. Woningbouw multi-storey apartment (1984) (Albostan,2009).

3.3.2.2 Type 2: Soft and Hard

Tatjana Schneider and Jeremy Till (2007) in their book "Flexible housing" mentioned two methods of having flexibility in a building. One is through "Use" and the second method is through "technology", and in order to evaluate the application of these two

methods, they introduced the terms “Soft” and “hard” (Schneider, Till, 2007) (Figure 44).

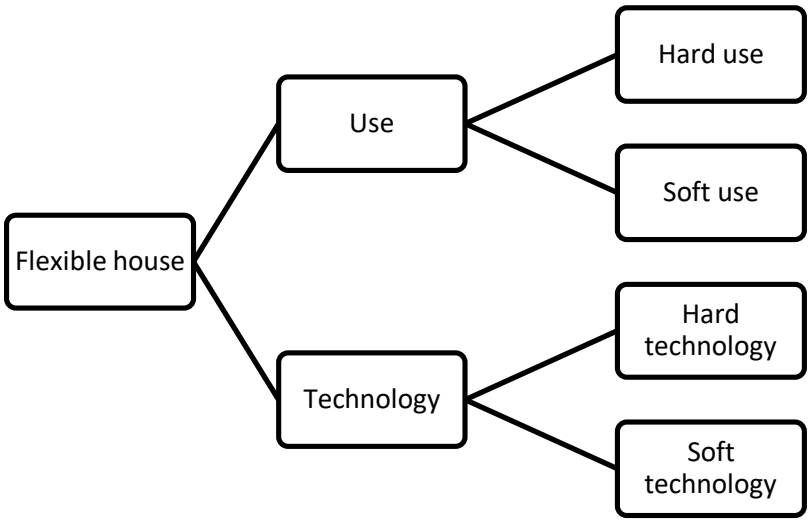


Figure 44: Methods of achieving Flexibility according Schneider and Till (Drown by the author).

Schneider and till (2005) in their article “Flexible housing: the means to the end” explained “hard” and “soft” terminologies as:

> 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 (Schnider, Till, 2005, p.289).

Use

Flexibility in term of use can be achieve by providing undefined spaces, or exactly defined spaces by the architect or designer to set of activities . Use can be subdivide to two as “soft use” and “hard use”, where soft use allows the user to take the decision about the space mainly and the designer works in the background and on the other hand hard use refers to limiting the users by giving certain and defined spaces by the designer to use. In hard use spaces should have to be able to be multifunctional in order to be flexible and designers and architects are in the foreground.

Soft use: Origin of soft use comes from its vernacular back ground. In the past dwellers used to respond to the changes in their family size and structure such as care for young children, birth and death, by the help of having multi-functional and multi-proposal spaces. Gathering in one big room for some activities or simply dividing the space by curtain or other temporary partitions (Oliver, 2003).

Amount of respond and the method of respond to such needs were often depended on the culture and climate, and it would have varied in different situations. Although the architects' involvement may remove such impacts but nevertheless existence of the soft use of the space remains still (Schnider & Till, 2005, p.290).

Soft use have been practiced in many projects especially during the modernism period, due to shortage of housing between 1920 and 1930. One of the good examples of such attempt is the Britz Project in 1925, designed by Bruno Taut and Martin Wagner. In this design three undefined similar sized rooms (zimmer) provided to the dwellers to use it according to their needs. Bathroom and kitchen by being in the separate zone helped the dwellers to give function to the rooms exactly the way it was needed (Scheerbart & Taut, 1972)

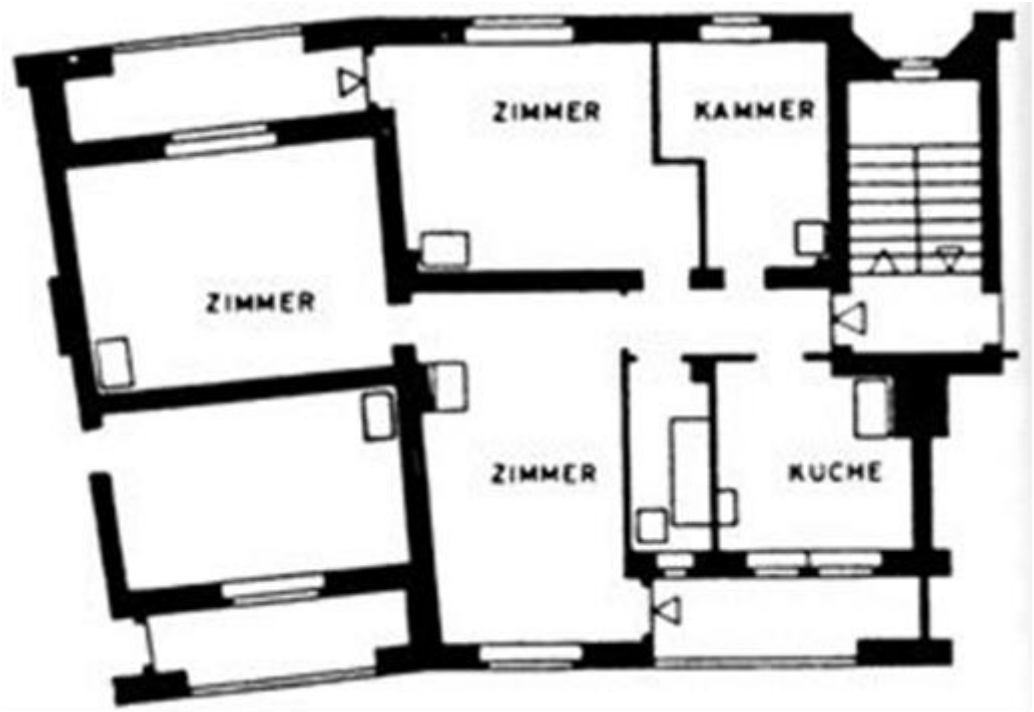


Figure 45: Typical plan of "horseshoe" block, Britz Housing (1925) (Schneider&Till,2005).

Schneider and Till (2005) explain the solution to have soft use in design by stating that:

> If one approach to soft use depends on the designer providing a physically fixed, but socially flexible, layout, a more common solution is to provide raw space that can then be divided according to the needs of the occupants (Shneider and Till, 2005, p.290).

They improved the solution they stated by adding the point that, simply providing a free space by the architects, is not enough in order to have soft use. But also designers have to carefully provide the suitable staircases and services position.

Hard use: In hard use unlike the soft use, spaces are largely defined by the architecture. The desire of architecture in taking the control of the space in hard use is widely visible. In hard use design architects by offering different functional alternative spaces with the help of flexible elements, define the space function (Schneider and Till, 2005). The Maison Loucheur designed by Le Corbusier in 1928 with the inspiration of

twentieth century architecture movement is one of the dissent examples of applying hard use in space. Le Corbusier in his design by providing sliding walls and partitions, moveable furniture and flexible elements offered various functional spaces to the dwellers (Broadhurst, 2009).

Hard use in spaces has its own disadvantages. Lawn Road apartments (1934) designed by Wells Coates, is an example of failure in applying hard use in design of the building. Dwellers after a while finds the folding, sliding and defined functional alternatives of the house determined by the architecture, not useful for their tasks or too intolerable to deal with it in every day uses (Carr, 2004).

It is important to mention application of hard use in design is not a failure and it depends on the user mainly and expectation from the house. Schneider and till (2005) regarding minimal spaces with hard use stated that:

> The minimal space standards and discipline associated with hard use may thus have a future relevance for two groups of people, one of which has no other choice but accept small, the other which sees small as a beautiful life style accessory (Schneider and Till, 2005, p.293).

Technology

Technology is another method of achieving flexibility in the building. Although technology and use are two different method, but they may affect one another indirectly. For instance long span structure (technology) because of the elimination of having loadbearing internal walls/partitions, offers a free plan which allows to have soft use in the space. Technological approach deals with structural and servicing strategies mostly and as well as "Use" approach, it is divided into 'hard' and 'soft' (Schneider, Till, 2005).

Hard technology: Hard technology refers to those elements, which designed specifically to reach flexibility in the building. It is important to mention about open building movement by John Habreken which had its affect in this approach. John Habreken (1972) believed mass housings are kind of consumer units, in which dwellers had no control of their spaces.

> [mass housing] reduces the dwelling to a consumer article and the dweller to consumer (Habreken, 1972, p.11).

Habreken believed that the participation of dwellers in building the dwelling is important. This participation improves the ability of the dwellers in order to take the control of their dwelling (Habreken, 1972). Habreken's theory of "support" and "infill", where support refers to the base structure and long lasting elements of the building and infill refers to internal settings, mainly determined by the users with short time life. Amount of involvement of user and professional in support and infill can vary but it is important to note that professional should give up the fully control of infill.

There are few examples of open building which have been constructed. In these buildings, the main focus was on the technical and constructional (support) aspects of the building and the individual (infill) aspects of the building was not considered mainly. Therefore in 1970's, interests on open building diminished due to lack of enough information about suitable infill system for the provided support system, and that decrease the flexibleness of the building instead of increasing it (Rabeneck, Sheppard & Town, 1973).

One of such buildings can be the housing project known as “PSSHAK house at Adelaide Road” designed in 1997 by Nabil Hamdi and Nick Wilkinson in UK. This building has hardly changed over the years although it was designed to be able to change (open building). The reason was instruction and methods of applying infill kits were not provided to the dwellers, therefore dwellers were not able to update or change the infill kits by the time new needs occurred (Hmadi, 1984).

This does not mean that the open buildings are not addressing flexible housing and they cannot be flexible in the usage stage. However, over use of technology in open building by professionals may give reversed result. As Schneider and Till (2005) explains about open building as:

> There is a danger [In] open building projects of getting obsessed by the techniques, and in this the technology becomes an end in itself rather than a background means to an end (Schneider, Till, 2005, p. 294).

Soft technology: Develop of soft technology after analyzing the disadvantages of hard technology helped flexible houses to move from being completely determinism of hard technology in foreground to supporting background of soft technology. Schneider and Till defined soft technology in this way:

> Soft technology is the stuff that enables flexible housing to unfold in a manner not completely controlled by the foreground of construction techniques (Schneider and Till, 2005).

Soft technology is less determinist compare to the hard technology therefore it gives ability to dwellers to participate in their dwelling and take control over it. It also improves the main principal of flexible hosing which is ability to accept change over the time. Genter Straase (1972) in Munich, Germany is one of the examples of soft technology, in which by providing prefabricated frame, users can fill it according to their needs and desire (Figure 46). This approach allowed the hard technology to take

its' roll in the back ground and in addition, allow soft technology in the foreground. This method and other similar methods, express the soft technology in the structural system gives the opportunity to the dwellers to adjust the building and change in future.

Figure 46: Genter Strasse Building, Munich in 1972 (Schneider&Till,2005).

Another example of soft technology achieved in Brandhofchen designed by Rudiger Kramm in Frankfurt (1995). In this building loadbearing elements are consist of columns and beams, and there are no internal loadbearing elements to limit the interior space. In that case, internal walls can be easily removed, spaces and rooms can merge or divide easily according to users need (Figure 47).

Figure 47: Brandhofchen houses, designed by Rudiger Kramm (1995) (Schneider&Till,2005).

In following table different classification of flexibility based on types and process will be shown. This table concludes the studies which have been done about flexibility approaches on buildings by some reliable scholars.

Table 6: Different classification of flexibility according to different scholars

<table>
<tr><td rowspan="3">Process flexibility</td><td colspan="3">Design/Initial flexibility</td></tr>
<tr><td colspan="3">Production/Construction flexibility</td></tr>
<tr><td colspan="3">Usage flexibility:</td></tr>
<tr><td rowspan="10">Types flexibility</td><td rowspan="7">Type one</td><td rowspan="5">Functional flexibility</td><td>Expansible space</td></tr>
<tr><td>Convertible space</td></tr>
<tr><td>Versatile space</td></tr>
<tr><td>Malleable space</td></tr>
<tr><td>Ability of rearranging furniture in space</td></tr>
<tr><td rowspan="3">Structural flexibility</td><td>Extendibility</td></tr>
<tr><td>Base structure</td></tr>
<tr><td>Polyvalent organization</td></tr>
<tr><td rowspan="4">Type two</td><td rowspan="2">Use (user base)</td><td>Hard use</td></tr>
<tr><td>Soft use</td></tr>
<tr><td rowspan="2">Technology (architecture base)</td><td>Hard technology</td></tr>
<tr><td>Soft technology</td></tr>
</table>

Chapter 4

ACHIEVING FLEXIBILITY IN BUILDING LAYERS

In this chapter, based on the analyses and information's gathered from different scholars in previous chapters a new framework will be develop. This framework in addition of bolding the importance of having flexibility in buildings focuses on the methods of applying flexibility in building layers; building layers which have been classified according to their life span and functions by Brand (1994).this frame work will give the flexibility alternatives to building layers and illustrates the methods of developing flexibility in each layer.

In following paragraphs, firstly flexibility in building layers will be analyze according to "Hard" and "Soft" terms which has been introduced by Schneider and Till (2005). Secondly the methods of developing flexibility in each layer will take place and accordingly it will be supported with existing examples.

Flexibility in the buildings can be achieved in two ways according to Schneider and Till (2005), where one is through determined design, in which architects are in the foreground (hard) and the other one, through the undetermined design, where users are set free to accommodate change according to their wish and architects are in the background (soft).

Building layers as they were explained in previous chapters, can be classified to six layers according to their life span and function as site, skin, structure, service, space

plan and stuff (Brand, 1994). These layers although are separated from each other but are have great relation with each other and any attempts to make change in one layer may result a need to make change in other layers as well. Flexibility in building layers in addition to reduce the negative impacts such as demolition or making major changes, eases the process of changing the elements of the layers by the time it is needed.

In this study these layers are divided into two groups of hard and soft, based on the definitions as Schneider and Till proposed. Hard layers (architectural base) are those in which making any change in them will need a professional participants. Site, skin, structure and service layers are those which are hard and needs professionals in order to make change in them. Soft (user base) refers to space plan and stuff layers which building users can make change in them by depending on the set of alternatives which architects and designers provided.

4.1 Flexibility in Site Layer

Flexibility in site allows for different alternatives for expanding the buildings and units. As it was explained one of the methods of achieving flexibility is through ability of extension and expanding. The expanding can be in vertical or/and horizontal direction. Site as the base for the building should have the capacity in itself to allow such activities by the building.

Hard site: Hard site can be explain as the ability of the site to accept determined future changes by the architects/designers or even the dwellers. Buildings because of their defined lot size, do not have the ability to expand horizontally or vertically by the wish of the dwellers and architects, except the time architects have actually consider the necessary additional sizes in order to have space for future changes. For instant “The

extendible houses", designed by J.H. van den Broek and J.B. Bakema in Netherlands (1963) with the ability of future expansion, is designed in a way that it can expand in both vertical and horizontal direction. The house consist of a core unit (services, living room and dining room), a front garden, back garden and three bedrooms in second floor. Smallest parts of the core unit has the ability to be pushed towards front garden and back garden and in second floor towards up. Considering the site in the design allowed Broek and Bakema to give a future function of expanding. In addition to the expansion of units, in front garden, portion of site left untouched, to build a multi-function room which can be used as guest room, shop or garage on request of the dwellers. In vertical direction also by providing basic structure to add another room up wards, another room also could be added to the existing house in future (Bakema, 1981) (Figure 48).

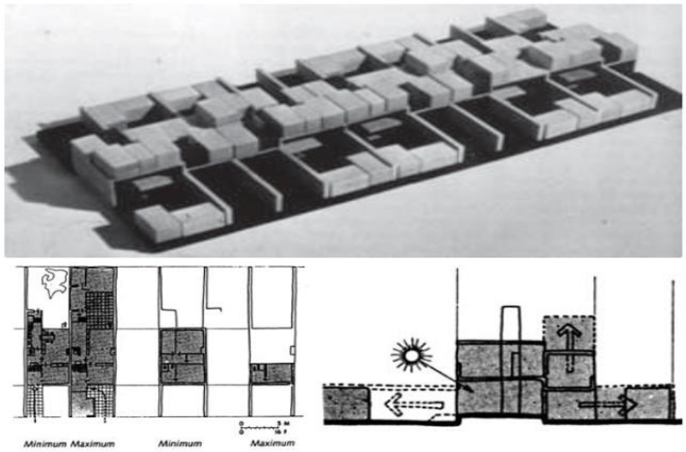


Figure 48: The extendible houses, designed by J.H. van den Broek and J.B. Bakema in Netherlands (1963) (Bakema, 1981).

Another consideration in site layer, which a building has been built to accept unexpected future changes such as adding units to building or extend the existing one. In this approach to site, although the position and the way these changes can be make is not determined, but designers while building the main building, consider such

unexpected changes and provide a space for such activities. In other word dwellers are free to make future changes according to their needs and are not limited to certain alternatives determined by the architects. For an example laneway houses can be considered as the houses which are benefiting from this approach (Figure 49). Laneway houses as it was explained in chapter two are called houses which have been built in the back yard of the family houses, with different propose of use.

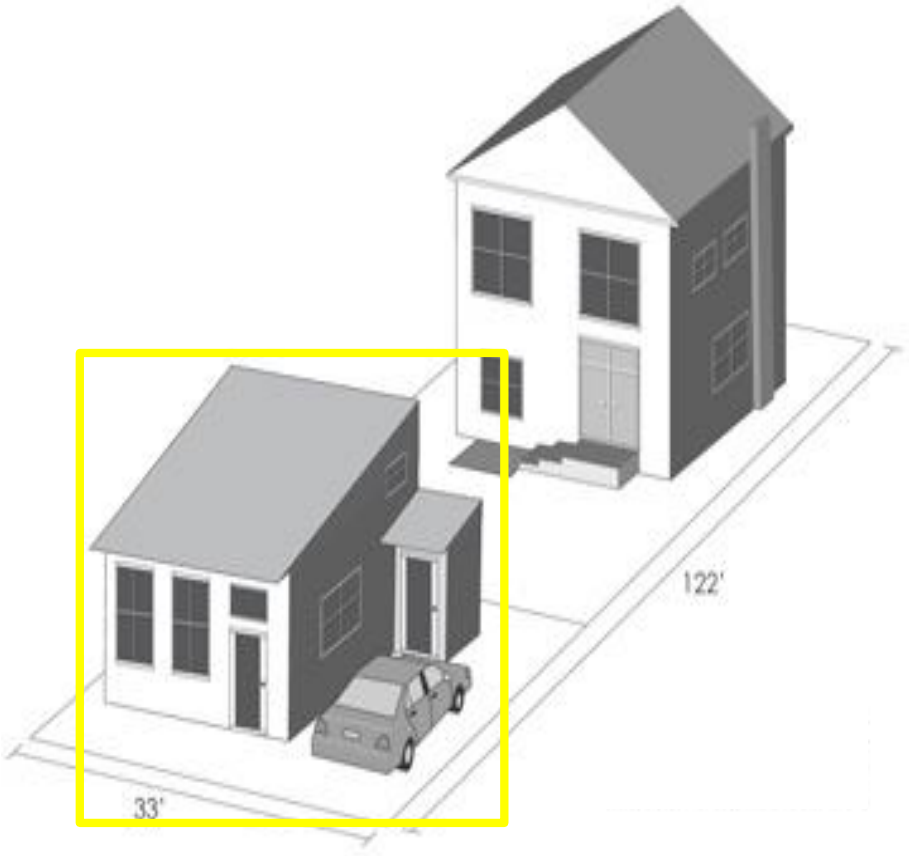


Figure 49: Laneway house prototype by Laneway Live design company (URL:16).

4.2 Flexibility in Skin Layer

As it was explained skin is the surface which consists of façade, roofs and exterior finish that covers the structure of a building. Skin of a building is one of the layers which needs to be changed in approximately 20 years according to Brand (1994).

Façade of the building can limit the ability of the change in the building components and structure. Design of the façade should also be flexible in a way that any change in the building, do not affect the façade negatively and exactly the opposite, any change in the façade should not have negative impact in the building core unit.

Hard skin: Bernard Leupen, René Heijne and Jasper van Zwol (2005) mentioned in their books "Time-based Architecture" about importance of façade in the flexible houses as:

> The façade design figures prominently in designing flexible buildings. It makes special demands on the design's presentation during the design process, as the building can assume different appearances over time. Avoid anonymity; design a building with a façade that gives the building a clear identity (Leupen, Heijne & Zwol, 2005, p. 66).

Hard flexible skin refers to covering elements which has been defined by the architects to change and adjust according to dwellers needs and wants. Double façades are a proper example of hard skin. For instant "Twin houses in Amsterdam" can be a perfect example of hard skin (Figure 50). Façades of these houses are designed in a way that, by the evening time, they become transparent in order to get the sun light and during they time, position of hatches changes the sun direction reflected inside.

Figure 50: Twin houses façades during a day and night, Amsterdam (Time-based Architecture) (Leupen, Heijne & Zwol, 2005).

Skin layer of a building is one of the key components of the building which allows the expansion in interior layout. One of the examples of such buildings can be the “Next 21” project designed by Osaka Gas and SHU-KO-SHA architecture in 1993 (Figure 51). This project was designed in order to be able to adapt to individual residents needs and lifestyle. The building was divided into two types of long-life (containing the base structure which are hard to replace) and short-life parts which can be change and modify according to the dwellers wish. Not using a load bearing elements in the façade gave the opportunity to the users to even adjust the façade of their dwellings. In this case some users preferred to use the balconies as the close space and part of the internal space and some also left it untouched.

Figure 51: “Next 21” project designed by Osaka Gas and SHU-KO-SHA architecture in 1993 (URL:17).

4.3 Flexibility in Structure Layer

Structure layer consist of foundation and skeleton of the buildings. It defines the space of the dwellings. Functional flexibility of a building strongly relies on flexibility of structural elements. As it was explained in previous chapter, the main classification of flexibility in structure is consist of three types “base structure”, “polyvalent organization” and “extendibility”.

Hard structure: Polyvalent organization can be classified as a hard structure in which the fixed size modules have the ability to easily join and detach as the architect defines it. Although this ability to change is improving the flexibility in use, but it is very determined in structure.

Base structure can be explain as a structure which provides variety of choices to its user, without determining any specific layouts. This structure, is similar to what Habreken (1972) introduced as “infill” and “support”. Support is defined by the architect and plays an important role in the back ground and infill refers to set of activities and arrangements which the dweller can easily apply to the support. As a good example of such approach can be the The Siedlung Hegianwandweg apartments designed by EM2N Architekten in Switzerland. Structure of this apartments by using the base structure approach offeres a undetermined interior spaces which can accommodate different set of plan layouts according to different user groups (Figure 52).

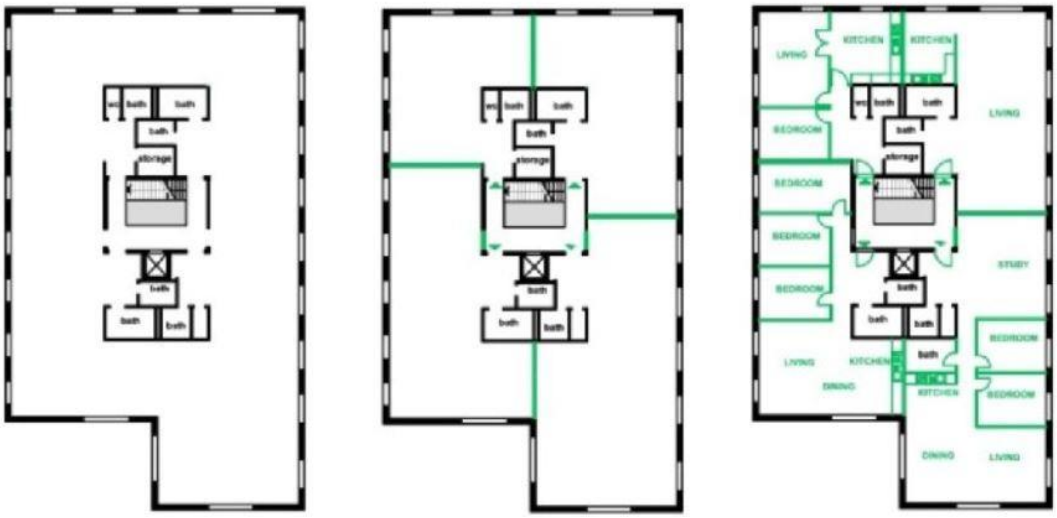


Figure 52: Plan layout of The Siedlung Hegianwandweg apartments by EM2N Architekten, Switzerland (Schneider & Till, 2007, p. 125).

Ability to expand vertically and horizontaly can be called as direction expansion. A building can expand according to its form and scale, such as radial, linear and clustered expansions. All these methods of expanding can be group as extendible flexibility in structure (Gulaydin, 2004, p.28).

4.4 Flexibility in Service layer

According to DGBC (2013) in order to achieve a flexible house the position of service space is very important. Correct position of the service space allows the rest of the building to function in variety of forms according to users' future needs. Service area covers the access units and the wet spaces such as kitchen and bathroom. Regarding the importance of service area position in flexible housing design, Schneider and till has been quoted in Albostan (2009) as :

1) The strategic placing of service cores to allow kitchen and bathrooms to be placed within specific zones but not to be permanently fixed.

2) The ability to access services so that they can be updated at a later date.

3) The distribution of services across the floor plate so that they can be accessed for in any plan arrangement" (Till & Schneider, 2005, p. 294).

Service units can be placed in the middle of the building or areas in the façade or both (Figure 53). These can be either internal or external according to Schneider and Till (2003).

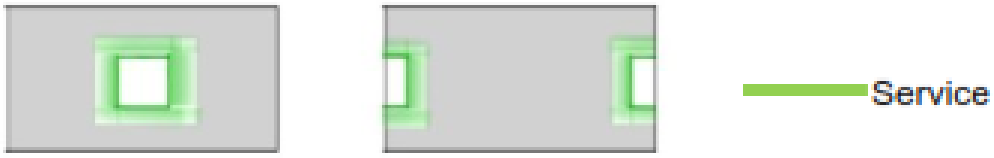


Figure 53:Service unit different arrangement. (Albostan, 2009)

On the other hand access units are divided into two as vertical access and horizontal access and vertical access unit is a service unit with staircases to access the house and different spaces, and it can be in the middle of the house or in sides (Figure 53).

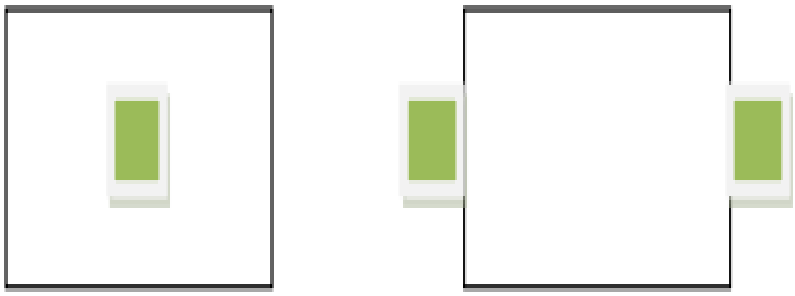


Figure 54: Vertical access units. (Albostan 2009)

Horizontal access unit, is to determine and connect the vertical access unit to the housing units. Horizontal access also can be placed within the building or as an attachment to the building façade like open galleries (Figure 54) (Shneider,F. , 2003)

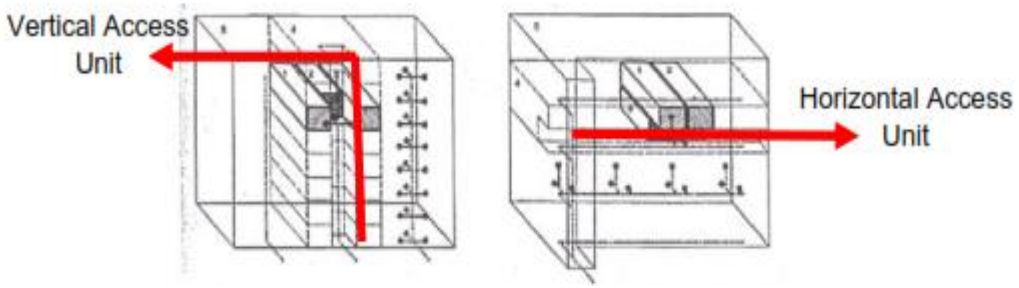


Figure 55: Vertical and horizontal access in the building (Shneider,F. , 2003).

Hard service: Use of hard service allows the building to be change according to users' needs and wish. The placement of service by the architecture in the plan is very important in order to not limit the users by defined arrangement or alternatives. Core services and services in the sides are good examples of such hard services.

4.5 Flexibility in Space Plan Layer

This layer deals with the spatial organization of the building. The organization of spaces and relation between the spaces occurs in this layer. Elements which have been used in the spatial organization of a building in order to divide or/and connect such as partitions and separators are very important. The life span of this layer is 3-30 years.

Soft space plan: soft space plan refers to the offered spaces by the designers which has the ability to accept different interior layouts and functions asked by the users. Row spaces, multi-function rooms and slack spaces are a good example of such.

Using unit types to divide the spaces by the architecture for different uses and functions allow the user to match the space according to his/her changing needs. Schneider and till mention about these units as "slack spaces" in which the designer intentionally provides space for different activities without labeling them therefore users give the function to them (Schneider and Till, P. 136) (Figure 56). Similar to slack spaces, there are multi-functional spaces in which the space does accommodate more than one function in itself. Multi-functional spaces were and still are very popular in small spaces and in traditional houses. A spaces for dining, resting, gathering and even sleeping by the time it is needed.

In addition to slack spaces there are spaces which are undetermined by the architecture in the use and it allows the user to take over the control of their space and change the

spatial organization of the spaces according to their needs. Schneider and Till (2005) mentioned about such spaces as “raw space”, which can be applied to “base structure” and “polyvalent organization”. In this approach the space is free from load bearing elements to accommodate future changes by the dwellers in time. Use of partitions and temporary separators are a common technique to achieve such plans.

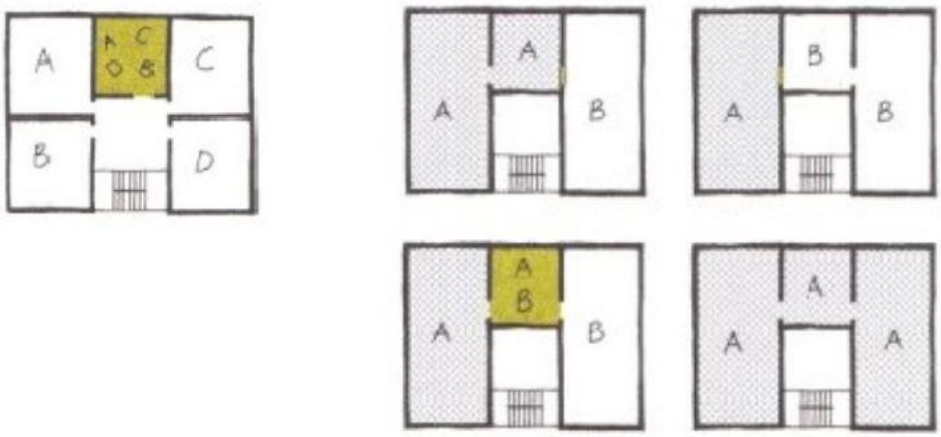


Figure 56: Unlabeled spaces to change according to users needs (Schneider&Till,2005).

4.6 Flexibility in Stuff Layer

Use of furniture to define different functions and activities occurs in this layer. Partition and dividing elements to separate functional spaces with each other and change interior setting of the house achieves by the use of furniture.

Soft stuff: Furniture with the ability to move, fold and change according to required needs and tasks of the users can be classified as the soft stuff. Shroders house is a perfect example of using soft stuff in the building. Foldable, movable furniture, flexible partitions, dividers and movable walls are the example of soft furniture used in that house (Figure 57). In addition to these furnitures flexible units are also can be soft stuff. These units which can have different function during the day and night are the perfect solution for limited spaces and multi-functional spaces.

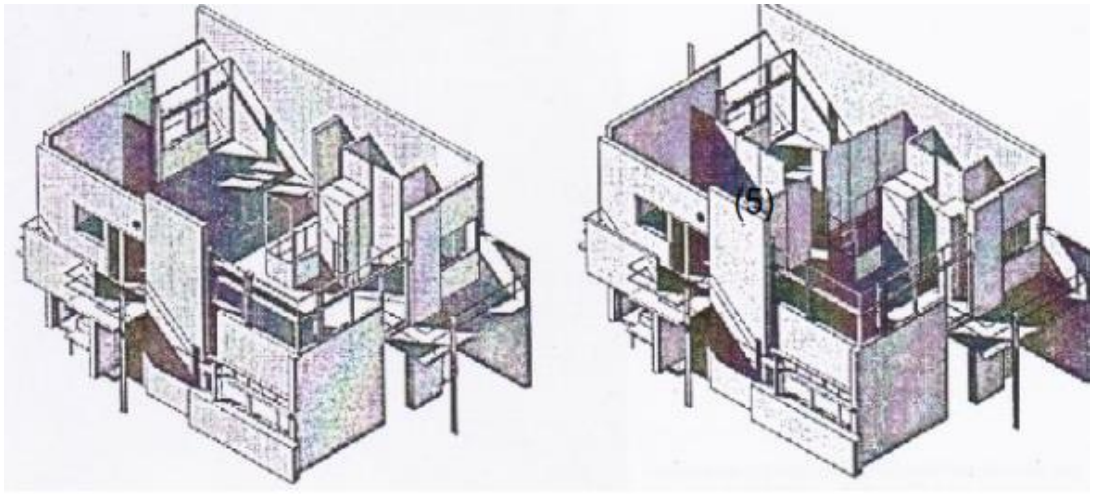
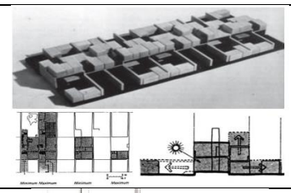
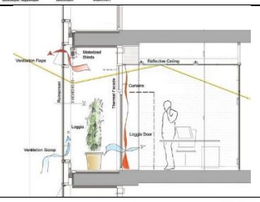
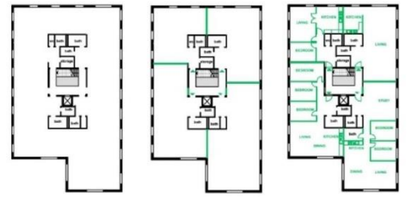
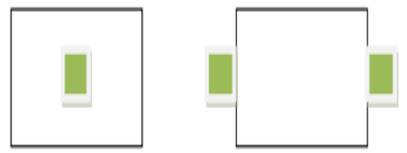
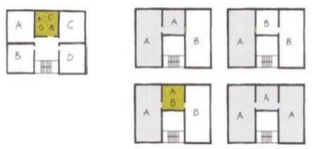
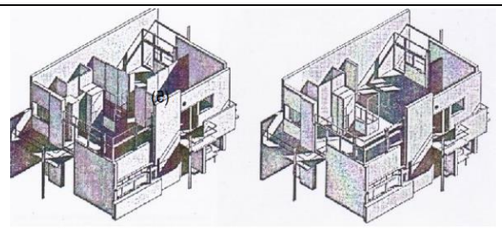


Figure 57:Schroder house designed by Gerrit Rietveld (Leupen, 2003).

The table below explains the achieved framework of this study, in which firstly building elements have been classified as building layers (Brand's classification), secondly each layer's specification has been provided. Followingly these layers have been seprated to two groups of "hard" and "soft". Hard refers to architectural base layers in which, making change in them will need professional participation. Soft subgroup also refers to user base layers in which users can easily make changes in them with the help of the base for these changes provided by architects and designers. Lastly the methods of achieving flexibility in these layers based on the comprehensive studies of reliable scholars with examples have been given.

Table 7: Achive framework of flexibility in this study

BUILDING LAYERS	DESCRIPTION	Hard (architecture base) and Soft (user base) flexibility method		LIFE SPAN	TYPES OF FLEXIBILITY		SCHEMAS
Site	Determined lot	**Architecture base**	**Hard site:** In which the designer considers the future changes in the building and its effect on site	Eternal	Horizontal addition		
Skin	Exterior finish, roofs and façade		**Hard Skin:** Architect defines set of alternatives either for daily use or long term use.	20 years	Double skin		
					Allowance for expansion		
Structure	Skeleton of the building, load-bearing columns and walls		**Hard structure:** Architect provides alternatives to user for future changes.	30 – 300 years	Base structure		
					Polyvalent organization		
					Extendibility		
Service	wet spaces and accesses		**Hard Service:** Architect places the service in a way that, it allows space plan free of any interruption for different layout organization.	7 – 15 years	Wet spaces	Core servicing	
						Side servicing	
					Accesses	Vertical access	
						Horizontal access	
Space plan	Interior layout of the building, vertical and horizontal dividing elements	**User base**	**Soft space plan:** Offered space by the architect should be able to accept different interior layout asked by the users.	3 – 30 years	Slack spaces		
					Row spaces		
					Multi-function rooms		
Stuff	Furniture such as sofa, bed, desk, table, lighting elements and etc.		**Soft stuff:** Partition and dividers along with the furniture should have flexibility in order to respond to different users and tasks.	Depends on the user	Temporary walls: sliding, moving, folding walls		
					Foldable furniture		
					Flexible units		

Chapter 5

CONCLUSION

Residential buildings are very important due to their significant role in human life. Motivational house, which is at the top of the list showing the houses in relation to performance levels, should have the ability to response all human needs. Capability of residential interior spaces to respond the requirements of users are tightly related to housing several different scenarios of the residents in long term of use. Therefore it is important for a house to have the ability to respond to these changing needs.

In recent years due to environmental changes, population growth, and economic impacts on people, lifestyle has been changed. Many people prefer to live in location-efficient areas rather than living in suburbs that are usually far from the place which they work or study. The problem with these location-efficient areas is most of the houses are smaller in size in comparison to suburb dwellings. This Lifestyle changes does not mean that the expectation of the users has been decreased whereas it is the same and even increased. Because of their limited internal spaces small houses have to be designed in a more comprehensive manner in order to respond all needs of the users.

It is needed to understand building layers and components in order to achieve flexible design. Building layers which have been discoursed in the previous chapters provides the basis for analyzing buildings. On the other hand flexibility in design has been

developed as a solution to respond to human changing needs especially in small houses. Therefore in this study based on information achieved regarding to building layers and different classification of flexibility, the framework has been formed to analyze existing buildings and helps designers, builders and dwellers to achieve flexible buildings that respond to the rapidly changing needs of daily life.

Applicable framework has been designed based on classifications of Schenider and Till which introduces soft and hard terminologies. These terminologies has been used in each layer to determine the possibility of applying flexibility in layers. Hard and soft terminologies has been studied on sets of elements which are consisting the building layers such as: site location, skin layer design, structural elements, service areas and access units, internal organization and plan layout, and furniture. Thus concluded framework can be applied to the buildings to understand the level of flexibility and limitation which has been done by the preliminary steps of the building design by the architects, which illustrated that having flexible indoor spaces needs to be considered from the beginning of the design process to achieve the maximum possibility of functional scenarios that result as flexible space.

The result of this thesis is grouping the building layers into two general categories. The division between “affective roles depending on the life span” and difficulties of the “changes based on the knowledge of the responsible actors”. This separation does not eliminating the other group. In reality in each section one group will have the authority of decision making in order to put on the flexibility convention on the building layers. According to the results which has been extracted from the literature, a house in order to have flexibility should be able to accept adaptable, convertible and modifiable design in all building layers. The contribution to site, skin, structure, and

service layers needs professional involvement. Therefore architects should play the important role in the foreground by providing sets of alternative for future changes by users. On the other hand in space plan and stuff layers, users should be in the foreground and able to apply changes based on provided alternatives by architects at the background.

Although building layers are having different set of functions and specifications at the end they should complete each other. In another words, each layer provides a ground base for its lower layer in order to accept flexibility and change. Ability to make change in stuff layer needs a base that can accept these changes in space plan layer. In order to accept changes in space plan layer it needs a free space with no limiting elements such as load bearing walls and columns, therefore position of the structure and service should provide opportunities to the necessary requirements. Although it is difficult to change the structure of a building the skin layer should be designed in a way that contributes the expected modification. At the end all these changes can take place if only the site of the building gives chance to those modifications. Size, form and location of the site are very important and should be analyzed in a very careful manner for the extension of lifetime of a building.

This research might be the base for the future researches that will focus more on layers specifically in order to illustrate the factors which helps the selected layers to be designed as open to future life scenarios of users'. The result of more detailed analyses will help to have checklist which should be considered by the designers for providing more flexible indoor spaces that can respond to the task and future needs of the users.

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