



## Flexibility Criteria in Multifamily Housing Design for Residential Apartments in the Erbil City of Iraq

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### Abstract

Since dwelling is almost constant in human life, it is the architects' responsibility to design the housing that accommodates changes over time. Flexibility is not an easy theme, so architects need to follow steps for applying flexibility in housing, especially in multifamily housing design. Through analyzing previous literature related to flexibility, this paper tries to collect and connect flexibility ideas, themes, and factors for achieving flexibility in multifamily housing design. By reaching 12 factors for designing flexibility criteria and formulating these factors as an evaluation form for flexibility level of multifamily housing then testing these factors on five cases in Erbil city, for determining the most influential factor among these factors. Quantitative questionnaires were distributed among 30 experts, to obtain a criteria list in sequence according to the experts' opinion from the most to least influential. Results showed that not all the criteria have the same weight in the design of the five case studies, as some criteria were completely neglected. The final results of flexibility level showed a difference among the complexes as the highest is obtained by Shahan city and the lowest level is Atlantic city.

**Disciplinary:** Architecture (Housing & Building).

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## 1 Introduction

In the field of architecture, the basic concept of flexible design was defined near the end of the twentieth century by researchers in housing support systems (Habraken, 1981), the open

building movement (Kendall and Teicher, 2000), and adaptive architecture (Brand, 1994). Various researchers have defined flexibility in different ways. Flexibility is a widely used term that refers to the adaptability of buildings' features to the needs of its users. In technical terms, buildings are constructed to last and fulfill the needs of the user; they are expected to have longevity. A building's longevity is its ability to sustain structural integrity over a long period as well as maintaining desirability in terms of its functionality and style (Macozoma, 2002). Flexibility is defined as the existence of a balance between durability and adaptability in the design of a building (Ibd). A building or building system can accommodate changes (Keymer, 2000).

The idea of housing capable of responding to change has been the subject of numerous initiatives, architectural competitions, and projects throughout the twentieth century (Schnider and Till, 2007). Most research focused on some specific points, not most points, and did not include the detailed elaboration of dimensional, organizational, and comprehensive criterion parameters of applicable flexibility. In this paper, many were analyzed to extract the common features of flexible design. As a result, this paper is an attempt to analyze available scholarly studies and developments of the idea of flexibility towards flexible housing design criteria and identifying their most significant key indicators. This paper will try to focus on internal flexibility evaluation in multi-family housing as it's a complex and demanding procedure, which cannot be implemented without using the results of certain long-term research. Since previous studies of flexible housing evaluation, are quite meager, so this work is mainly based on extracting applicable points, the information taken from prior literature, books, global and local researches.

This work contains flexibility (studies and definitions), flexibility in multifamily housing, and extracted flexibility criteria in housing design. In addition, for the process of evaluating the level of flexibility, this study formulates an evaluation form, and applies on several cases in Erbil city trying to exploring whether the multi-residential housing complexes in Erbil city are flexible or not? And to what extent they are. The results show: none of the five cases are highly flexible according to the research scale, but the results range from medium to low level.

## 2 Literature Review

Rabeneck (1973) proposed flexibility against "Tight-fit functionalism" indicating freedom of interior spaces. Sheppard (1974) criticized the unsuccessful attempts in flexibility for they may lead to what they call the "fallacy of freedom through control". Rabeneck et al. (1974) give another meaning "Non-random freedom." Flexible housing should be capable of offering "choice" and "personalization" (Town, 1973), leading to variety and durability. Hertzberger (1991), the pioneer of polyvalency idea/concept, stated in flexible design "there is no single solution that is preferable to all others. Multi solutions have no single solutions, thus multi-functionality. Also, he stated about polyvalency: "a building can be used in different ways without adjustment to the way it is built." (Hertzberger, 1991). Groák (1992) referred flexibility as "capability of different physical arrangements", meant adjustability in design. Geraedts (2008) stated multi-functionality as the possibility of using or deploying space, construction or installation components for several

functions. Maccreanor (1998) said “Flexibility does not imply the necessity of endless change and breakdown of accepted formula” that indicates not completely change. Forty (2000) stated “The incorporation of ‘flexibility’ into the design allowed architects the illusion of projecting their control over the building into the future, beyond the period of their actual responsibility for it.” The confusion in meaning of Flexibility” is based on two contradictory roles: “it has served to extend functionalism and so make it viable” and “it has been employed to resist functionalism.” (Forty, 2000), and this indicates the meaning of Freedom with control. Schneider and Till (2007) discussed flexibility in the context of housing and referred to (Dividing up) the potential to divide a larger unit. (Schneider & Till, 2007), that led to Divisibility also discussed the physical components of the building regarding flexibility: Flexibility in the context of housing is “achieved by altering the physical fabric of building” (Schneider & Till, 2007), means they referred to Alter-ability as a part of flexible design. Schneider et al. (2007) referred Connect ability as “... Refers back to the traditional system of ‘Enfilade’, whereby a series of adjacent rooms can be connected through sliding wall panels or doors.” Eriberger (1960) defined flexibility as the capacity of buildings for fixed elements (the ability of change), which are Experimental Housing in Sweden, for example, has been adaptable according to the demands of the users. Schneider & Till (2007) focused on Adaptability and flexibility and adaptability as a part of flexibility. James (2006) stated: “Allowing for increases in volume or capacity (the latter can be achieved by inserting an additional floor in a building, which does not increase its volume).” James (2006) referred to Expandability. Sebastian and Peter (2001) referred to Durability as “Selecting materials, assemblies, and systems that require less maintenance, repair, and replacement”. Geraedts (2008) asked “... is the possibility of splitting up, rearranging or simply combining different spatial units?” meaning partitioning ability. Schmidt (2010) refers to flexibility as a change of size, performance, and function - indicating Scalability, Refit-ability, and Convertibility.

### 3 Method

This study includes three phases. One: Relevant literature was analyzed related to the concept of flexibility in architectural design, trying to collect and connect every idea and theme related to flexibility, due to the absence of what is called a list of concrete and definite criteria that collect all (flexibility characteristic). This study listed all flexibility factors under the name of flexibility criteria in the design of multifamily housing. Two: formulating an evaluation model for testing the level of flexibility of the flat plan based on previous criteria. Three: Consisting of a quantitative questionnaire that supports the previous evaluation form, distributed among 30 experts for determining the most influential factor on the level of flexibility. Finally: applying this procedure to the chosen cases in Erbil city, getting the results.

#### 3.1 Case Studies

This paper studied five housing projects in Erbil city. The first one was Zhyan City, located in the East of Erbil on Koya Road. The second project was Kurdistan City, located in the North East of Erbil. Shahan city was the third project located in North East of Erbil, on Erbil Kasnazan Road next

to the Blue pool. The fourth one was Shari Mamostayan, located in the north of Erbil on 150 meter street. Atlantic City was the fifth project, located in the East of Erbil on Koya Road.

### 3.2 Research Scale

To determine the limits of the scale, (the scale of flexibility level) the following will be done:

- The weight of each factor (criteria) is fixed, for all cases, they were obtained from the questionnaire and the total weights will be (8.58).

- The lowest flexibility level: any case gaining a value of 1 for all criteria. The highest flexibility level: any case gaining the value of 3 for all criteria, with the medium of 2.

The lowest flexibility level is  $1 * 8.58 = 8.58$

The highest flexibility level is  $3 * 8.58 = 25.74$

The medium flexibility level is  $2 * 8.58 = 17.16$

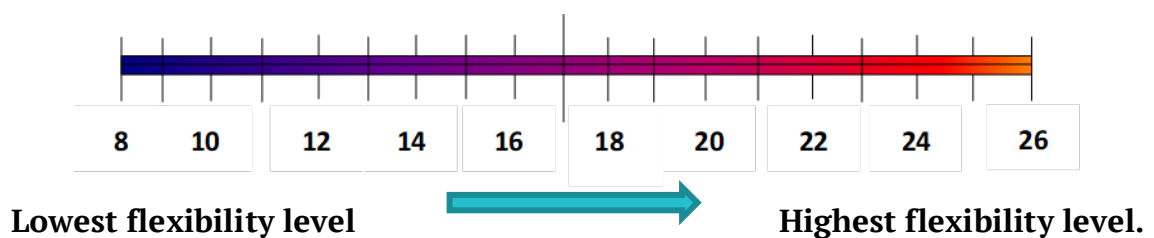


Figure 1: Research scale (Flexibility levels from lowest to highest).

## 4 Flexibility in Housing Design

Flexibility is an important concept in the context of housing because of the users' needs and demands for change and modification. The first query; why flexible housing refers to the capability of offering every user an adequate and efficient basic quality at the base building level, and through infill or built-in level, the ability to respond to individual wishes and demands over time and during the life cycle of the family. Schneider and Till (2007) define "flexible housing" as "housing that is designed for 'choice' at the design stage, both in terms of social use and construction, or designed for 'change' over its lifetime" (Ibd). Therefore, flexible housing seems to be appropriate for users with diverse lifestyles. In that respect, the ability to respond to the wishes and demands of the users, starting from the very beginning of the occupation, and lasting over time, can be regarded as the main scope of flexibility. This paper discusses the following criteria that determine the level of flexibility in multifamily housing.

### 4.1 Criteria of Flexibility in Multifamily Housing

The criteria extracted from literature analysis and their sequence and weights were determined according to the questionnaire results. According to the research equation as mentioned below, for determining the level of application of each factor, this research adopted some important points on the level of application of each factor as follow:

Adopting Likert 3-point scale as (1=low, 2=medium, 3=high), the level of application of each factor considered as high if (factor#1: Building structure: Disposition of columns are around the plan (krstic, 2001), factor#2: space organization: Possibility of increasing number of rooms with

Possibility of switching between day and night zones (kovacevic, 2009), factor#3: geometry of the plan: pure, clear, regular shapes of the plan (Omer, 2012), factor#4: position of services: Grouped with central position along one wall (stojijkovic, 2004), factor#5: initial flexibility: Existence of multi type of flat plans in the building as well as participation of user participated in design (Schneider and till, 2007), factor#6: number of facade plane: Three façade planes gives the highest possibility of relations (Jovanovic, 2007), factor#7: flexible furniture-sliding moving folding walls and partitions: Existence of more than one type (Schneider and till, 2006), factor#8 :slack space: Existence of more than one type of slack space (Schneider and till, 2007), factor#9: dwelling joining: possible if the size of the unit is small, existence of a wall between them, service position (ferencak,1966), factor#10: number and disposition of entrance: Two entrances (Jovanovic, 2007), factor#11: dwelling dividing: possible when the size of unit is big, place for extra entrance, service position (ferencak,1966), factor#12: shared switched room: if a room exists (Schneider, 2007).

The level of application of each factor considered as a low level if (structure: Columns are inside the plan, space organization: There is no possibility of switching between zones and increasing number of rooms, the geometry of plan: Dispersed, irregular shape of the plan(contains many breaks), the position of services: Dispersed, initial flexibility: One type of flat plan exists in the building and without users participation in design, number of facade planes: One side façade gives the lowest possibility of relations, flexible furniture and sliding moving folding walls and partitions: Not exist, slack spaces: Not exist dwelling joining: Not possible without these conditions, number and disposition of entrance: One entrance with peripheral location, dwelling dividing: Not possible without these conditions and finally shared switched room: Not exist).

The level of application of each factor is considered as a medium level if (structure: both, space organization: either an increasing number of rooms or switching between day and night zones geometry of plan: In-between position of services: Grouped with peripheral position initial flexibility: not exist Number of facade plane: Two façade plane gives a range of relations flexible furniture and sliding moving folding walls and partitions: Existence on one type slack spaces: Existence of one type number and disposition of entrance: One entrance with central location ).

This study uses the sum of a simple weighted model to find Flexibility level,

$$V = Fw * Fl \tag{1},$$

$$Flex\ l = \sum_{i=1}^{12} Vi \tag{2},$$

where  $V$  refers to Factor's value,

$Fw$  refers to Factor's weight,

$Fl$  refers to the application level of the Factor,

$Flex\ l$  refers to Flexibility level.

## 5 Result and Discussion

### 5.1 Questionnaire Result

The results were as follows: According to expert's responses The results show that the building structure factor attained the highest percentage within the group, which is 93.3% In terms of impact and importance in achieving flexibility, and the shared switched room factor got 50.6% which is the lowest percentage in terms of impact and importance in achieving flexibility and got the last position on the list of factors within the set of criteria.

This study will adopt these results as a weight for each factor so the weight of the building structure will be 0.93 and the weight of the shared switched room will be 0.51 that for the rest of the factors will be dependent. In addition, the factor building structure SD result is 0.47, which is the lowest among the SD results of the rest of the factors. This is strong evidence that the building structure factor is the most important and influential part of the flexible design of multifamily housing. It is at the top of the criteria list. While the result of SD of the dwelling dividing factor: is 1.32 which is the highest meaning a conflict in opinions among the experts on this factor in terms of achieving flexibility in the design of multifamily housing. For the rest of the factors (criteria), according to the mean and percentage in terms of the most influential factor among the group of factors in the criteria list sequence as in Table 1.

**Table 1:** Factors weight (from questionnaire).

Flexibility criteria in the design of multifamily housing		mean	Percentage %	Factors weight	SD	variance
#1	Building structure	4.67	93.4	0.93	0.479	0.23
#2	Space organization	4.3	86	0.86	0.915	0.838
#3	Geometry of plan	4.1	82	0.82	1.094	1.197
#4	Position of services	3.9	78	0.78	0.923	0.852
#5	Initial flexibility	3.83	76.6	0.77	0.986	0.971
#6	Number of façade plane	3.67	73.4	0.73	0.994	0.989
#7	Flexible furniture and sliding-moving- folding walls-partitions	3.67	73.4	0.73	1.028	1.057
#8	Slack space	3.4	68	0.68	0.894	0.8
#9	Dwelling joining	3.03	60.6	0.61	1.129	1.275
#10	Number and disposition of the entrance	2.9	58	0.58	0.995	0.99
#11	Dwelling dividing	2.9	58	0.58	1.322	1.748
#12	Shared (switched) room	2.53	50.6	0.51	1.074	1.154
Total				8.58		

- For the two factors (initial flexibility and flexible furniture and partitions) according to the opinion of the experts, they were ranked fifth and seventh respectively, with rates of %77 and %73, however, they were not applied in all projects.
- The factor (Shared switched room) came at the end of the list of criteria according to the opinions of experts, in terms of importance and impact, with a percentage %51, and also it was not applied in four projects, only in one project out of five.

- The factor (position of services) was ranked fourth in terms of importance and impact of the list of criteria according to the opinions of experts, with a percentage of %78 and also it was not applied in four projects, only in one project out of five.
- The factors (space organization and geometry of plan) were ranked second and third with percentages of %86 and %82 respectively, while their application was not as their importance.
- The most applied criteria in the five projects through the results of the form analysis are: (dwelling joining) which was ranked first as it was applied in four out of five projects with a high level. The second place was for the criteria (number of façade plane) that was applied in two projects with high-level and in three projects with medium-level out of five projects. The third criteria are (building structure), which was applied in two projects at the high level and two projects at the medium level.
- In the five projects, 12 criteria were analyzed, the high level was repeated only 14 times out of 60 with a rate of 23.3%. While the low level was repeated 31 times with a rate of 51.7%, this indicates that the flexibility criteria are not applied to a large extent, Also, the medium level was repeated 15 times out of 60 with a rate of 25%.

## 5.2 Flexibility Level Results

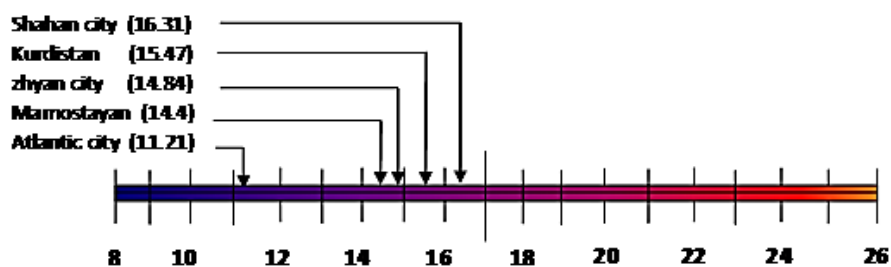
Shahan City Project obtained the highest level of flexibility according to the evaluation model of the research with a score of 16.31 within the research scale which is between 8.58- 25.74. Five of the criteria were with a high level, and they are (geometry of the plan, the position of the services, and many facade planes, dwelling joining, and shared switched room). Three of them were among the most important factors. according to the opinion of the experts in the questionnaire. And two of the criteria were within a medium level, (slack spaces, building structure). Although the Shahan City project had the highest level of flexibility among the five projects, five of the criteria were not applied, but four of them were within the least important factors according to experts' opinion. The Atlantic City project obtained the lowest level of flexibility 11.21 among the five projects, according to the evaluation model of the research, within the research scale which is between 8.58-25.74. One of the criteria was with a high level (dwelling joining) while it was the least important and impact according to the questionnaire result, also in this project 9 of the flexibility criteria were not included, including the five most important (building structure, space organization, geometry of the plan, position of services, initial flexibility) And two criteria were with medium level, they are (number of façade plane, slack spaces).

Kurdistan city project obtained 15.47 and it came second in terms of the level of flexibility among the five projects, as were 4 criteria with the high level they are (building structure, space organization, slack spaces, dwelling joining), two of them were within the most important in the questionnaire result in terms of importance and impact, Although in this project seven of the criteria were not included, but it obtained the second level of flexibility within the five projects, most of not included criteria in this project was the least important and impact. The level of flexibility of the project Zhyan city is 14.84 and comes close to Kurdistan city flexibility level, the

difference is that Zhyan city comes after Kurdistan city is that: in Zhyan city two criteria were with high level and four criteria with a medium level which they are among the most important and impact of the criteria. The third level of flexibility is the Mamostayan city projects - one criterion with high level and six criteria with the medium level (dwelling joining, building structure, space organization, the geometry of the plan, number of façade plane, slack spaces, number and disposition of entrance) respectively. Although one criterion with a high level but does not affect the level of flexibility of this project as it is the least important criteria.

**Table 2:** level of application of the criteria (analyzing plans).

Flexibility criteria in the design of multifamily housing	weight	Zhyan city	value	Kurdistan city	value	Shahan city	value	Mamostayan city	value	Atlantic city	value
#1 Building structure	0.93	3	2.79	3	2.79	2	1.86	2	1.86	1	0.93
#2 Space organization	0.86	2	1.72	3	2.58	1	0.86	2	1.72	1	0.86
#3 Geometry of the plan	0.82	2	1.64	1	0.82	3	2.46	2	1.64	1	0.82
#4 Position of services	0.78	1	0.78	1	0.78	3	1.56	1	0.78	1	0.78
#5 Initial flexibility	0.77	1	0.77	1	0.77	1	0.77	1	0.77	1	0.77
#6 Number of façade plane	0.73	3	2.19	2	1.46	3	2.19	2	1.46	2	1.46
#7 Flexible furniture, sliding moving folding walls and partitions	0.73	1	0.73	1	0.73	1	0.73	1	0.73	1	0.73
#8 Slack spaces	0.68	2	1.36	3	2.04	2	1.36	2	1.36	2	1.36
#9 Dwelling joining	0.61	1	0.61	3	1.83	3	1.83	3	1.83	3	1.83
#10 Number and disposition of entrance	0.58	2	1.16	1	0.58	1	0.58	2	1.16	1	0.58
#11 Dwelling dividing	0.58	1	0.58	1	0.58	1	0.58	1	0.58	1	0.58
#12 Shared switched room	0.51	1	0.51	1	0.51	3	1.53	1	0.51	1	0.51
<b>Flexibility level using the research model</b>		14.84		15.47		16.31		14.4		11.21	



**Figure 2:** Flexibility levels of case studies on the research scale

## 6 Conclusion

From the result, none of the factors were obtained at a high level in all cases. This indicates that not all criteria were applied well, as there are factors completely neglected while they are important according to the experts' opinion. About some factors, the experts' opinion and the level of the application were corresponding to each other, also some factors not applied at all in the five cases. The result indicates that the designer does not take to account a big range of flexibility



criteria at the design stage. The first most influential factor was (building structure) according to the expert's opinion in terms of importance and impact, also its application was appropriate to its importance.

The factors (space organization and geometry of plan) were ranked second and third, while their application was not as their importance.

In general, the factors that came within the first, second, third, and fourth place according to the questionnaire result, their application in the design of the projects was not as their importance. This study finds that the number of applications of the criteria were not important as the level of their application, related to the flexibility level.

The Atlantic City project obtained the lowest level of flexibility because; most of the flexibility criteria were not applied, especially the most important. However, Shahan city obtained the highest level of flexibility among the five cases because the most important criteria with a high application level are applied.

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