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Investing the Concept of Courtyard for Sustainable Adaptable Multifamily Housing

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ABSTRACT

Housing is one of the most important basic needs for the community. Many countries suffer from housing problems and take a number of procedures to solve it. This paper approaches one of the strategies used in many countries to provide housing which is Affordable Housing, presents the relations between affordable and sustainable housing and proposes the adaptable multifamily courtyard house as an approach to achieve a sustainable affordable housing. Method: A three items framework for adaptability is introduced, an example of adaptable courtyard multifamily housing is prepared and a comparison is made between the courtyard and the non-courtyard housing. Results: Support the argument of the possibility of investing the concept of multifamily courtyard house to achieve a sustainable adaptable housing with private courtyards for each dwelling which will lead, supposedly, to sustainable affordable housing. Conclusions: This study gives indicators for architects on designing a sustainable affordable multifamily housing.

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1. Introduction

Affordable Housing is one of the concepts that are used around the world to solve the housing problems and to ensure that housing is available to all of the people including the low-income people. The emergence of affordable housing belongs to the twentieth century and after the World War II and the main objective was to provide low-cost housing for low-income people.

Affordable housing can be defined as the house which provides safety, acceptability, within the applicable standards of housing and is designed, built to be available, accessible and convenient for all people including low-income people. In general it does not require the tenant or owner to spend more than 30% of their income on housing (Sidawi B. , 2008, p. 68), (Qeensland government - Department of housing, 2004, p. 2).

1.1 The Importance of Affordable Housing

The importance of affordable housing is divided into several types of positive impacts, they are: economic impacts, educational impacts, healthy impacts and social impacts. Economic impacts include the costs and benefits can that may be measured by observing the production, business and the movement of funds that result from the housing projects. The social Impacts include the positive impacts of affordable housing on education, social life, health and other aspects that can't be easily measured in terms economic profit (Lubell, Crain, & Cohen, 2007, p. 2).

1.2 Strategies for Achieving Affordable Housing

There are six strategies for achieving the affordable housing, they are:

- Using standards and determinants in designing and building housing units (Qeensland government - Department of housing, 2004, p. 3).
- Increasing the density (Poulsen & Silverman, 2005, pp. 5-10).
- Flexibility (Rao, 2010, pp. 36-40).
- Standardization (Prince Abdullah Institute for Research, pp. 22-24).
- Eco-Affordable housing – reducing running cost (Lindburg, Howe, Bowyer, & Fernholz, 2007, pp. 2-4).
- Adaptability (Russel& Moffat, 2001. P2).

2. The Multifamily Housing

The emergence of multifamily housing belongs to the ancient time from the Roman till the multifamily housing projects in Europe after the Industrial Revolution and the World War II.

The tendency towards the multifamily housing in Iraq during the last decades of twentieth century was for different reasons and the most important reasons of them are:

- The increasing needs for dwelling units.
- The great increase in the urban residential land value as a result of the spread use of the single family house pattern in the urban area, which led to increase value of the residential land, especially near the centers of cities, services and transportations. This led to the trends of the efficient use of land to the optimum extent to provide housing for largest possible number of people and also to provide the best services to the highest residential density by using the multifamily housing.
- Reduce the cost of services: Multifamily housing reduces the cost of services such as water supply, electricity, phone and sewage by reducing the length of these supplying networks if designed properly.
- Multifamily housing reduces the continuous horizontal expansion of the city which result from single family housing pattern. The result of reducing the horizontal expansion of the city will lead to reduce cost of infrastructure, transportation and services.
- Multifamily housing facilitates the possibility of building the largest number of dwelling units and in short time.
- Multifamily housing has more economic efficiency compared to single family housing, which helps to provide adequate housing for largest number of people.

But there are some criticisms that were directed to the multifamily housing compared to single family housing, and the most important of these criticisms is that the dwelling units don't have the ability to accommodate the changing requirements of occupants during the family lifecycle. In addition to this, there are other criticisms like the problem of providing the privacy and the pattern of possession of the dwelling units (Mohammed, 1989, pp. 36-40).

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3. The Concept of Adaptability

The research presents adaptability as a strategy towards an affordable housing, and as an attempt to solve one of the most important multifamily housing problems. Previous studies defined adaptability as the building ability to be adapted to accommodate changing in requirements through simple changes. Adaptability indicates the extent to which the building can be adapted to the changes during the period of building's life which is inevitable due to the changes in the requirements of families over time. The change of the building is inevitable due to the changing in the requirements of families over time or due to the different requirements of families from each other. Therefore, the most adaptable building is considered as the most efficient building and remain for a longer period because it can respond to the changes in requirements (Russel & Moffat, 2001. pp.2-4).

3.1 Adaptability Benefits

This paper introduces adaptability due to its significance for housing and sustainability as for the following issues:

- Adaptability advantages for housing: Adaptability gives the house its ability to accommodate different requirements of different families which can achieve the concept of Universal Design; or to cope with changing requirements of the occupants during the family lifecycle. As a result the family doesn't have to change its residence which associated with many negative impacts to the family. This paper proposes the adaptability in this point as a strategy to solve one of the most important problems in the multifamily housing.
- The economic advantages of adaptability: There are several economic advantages from adaptability as it extends the service life of housing or extends its ability to achieve different functions. Adaptability provides the possibility of modifying the current house to achieve a different function or add another function to it according to the occupants' requirements (Hashemain, 2005, p. 9), (Gu, Xue, & Nee, 2009, pp. 1368-1369).
- The environmental advantages of adaptability: Adaptability provides an adaptable house which provides many functions and have the ability to be adapted. As a result it has a longer life which participates in reducing the natural material consumption and the energy consumption. It improves the operational efficiency and contributes in the protection of the

environment by reducing the demolition and construction of building and as a result reduces the damage to the environment (Moshaver, 2009, pp. 4-6).

3.2 Adaptability Design Properties

There are six design properties related to the adaptable housing, they are:

3.2.1 Structure Concentration and Structure Modularity

Structure Concentration is a design variable which describes the structural system of buildings. It plays an important role in facilitating buildings adaptability as concentration means that the supporting points of the structure must be concentrated and reduced as much as possible to increase building adaptability.

The structural modularity indicates the extent of the similarity or repetition among the structural units in relation to its dimensions and sizes (Al-Nijaidi R. H., 1985, pp. 50-54).

3.2.2 Zoning the Areas of Special Provisions

Zoning is one of design variables of the building plan, which describes the building's parts according to specific criteria. Zoning in previous studies related with two properties: activities' requirements in the different parts of the building and properties of building's elements itself.

For most studies, the idea of zoning in housing depends on the zoning of kitchens and bathrooms which must be clearly separated from other areas in the house because of the activities' characteristics that are carried out in them, as well as the properties of the services' requirements that are required in those zones (Lynch, 1956, p. 22).

3.2.3 Independency of Building's Elements

The independence of the building's elements is one of the variables that is associated with the building's adaptability. The buildings are compound of a variety of interrelated elements and these elements are often of different materials and are therefore of different life period. These elements that are independent from each other can be changed or modified without affecting the other elements in the building (Al-Nijaidi, 1985, p. 54).

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3.2.4 Other Features

Other features related with the housing adaptability are: overcapacity, additive forms and growth forms, which are proposed by Kevin Lynch (Lynch, 1956).

4. The Courtyard House

This paper proposes the courtyard house as a strategy to achieve the sustainable house and aims to use the courtyard pattern in the adaptable multifamily housing to offer a sustainable affordable housing.

4.1 Sustainability in the Courtyard House Pattern

The severe environmental condition in the hot arid regions has clear effects in the design of houses which is associated to the use of courtyard in house design. The courtyard provides the required optimum environmental conditions and at the same time provides the required privacy in Islamic and Arabic cities.

The courtyard house provides the required exposure to the sun which must be exactly determined. The courtyard house provides also the required natural ventilation between the inside and outside. It is associated with the required humidity which provide more comfort for the occupants.

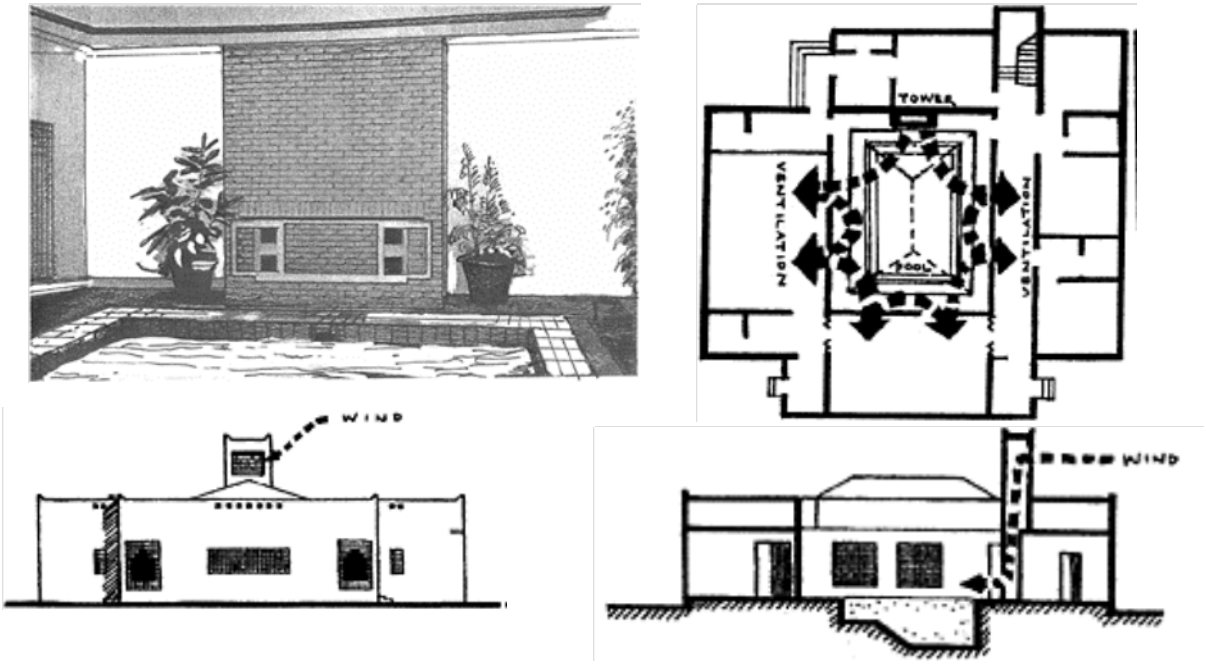

Figure 1: Courtyard house with wind tower.

The courtyard house is also associated with the use of wind tower which take the cold air from the outside to the inside. In 1989, Givoni made an experiment to prove the efficiency of courtyard and wind tower to provide comfort conditions in the house depending on a natural tactics. Givoni designed a wind-tower in a courtyard house in Saudi Arabia (Figure.1), and he proved that it is possible to cool down the house by 9.9 C^o between the outside and the internal rooms, and 6.7 C^o between the outside in the internal courtyard. He also discovered that it is possible to improve the courtyard and wind tower efficiency when he used a sprinkling water and a fan in the wind tower. He found that the difference between the outside and the internal rooms could reach to 11.1 C^o cooler and between the outside and the internal courtyard could reach to 13.5 C^o cooler (Edwards, Sibley, Hakmi, & Land, 2005, pp. 221-241)

All of these make the courtyard house consumes less energy and natural resources; and fewer producers of bad effects on the environment and achieve one of the most important points in Sustainable Architecture.

5. Adaptable Multifamily Courtyard House

This paper aims to show the possibility of making adaptable multifamily courtyard houses. An example of adaptable multifamily housing has been proposed and a comparison is carried out with a normal adaptable multifamily housing according to their adaptability to prove the possibility of making adaptable multifamily courtyard house.

5.1 Two Types of Adaptable Housing

This paper introduces two types of adaptable multifamily housing. One of them adopts the concept of courtyard while the other does not.

5.1.1 Non-Courtyard Housing

The example in (Figure 2) shows a model of multifamily non-courtyard housing. The building is a residential building in the (NIS) employing the characteristics of adaptable design.

The building was designed to ensure the provision of many possibilities in the organization of residential units within the building as the design provides adaptability in the apartments to expand,

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minimize or modify the apartment according to the family's requirements (Jovanović, 2007, pp. 33-47).

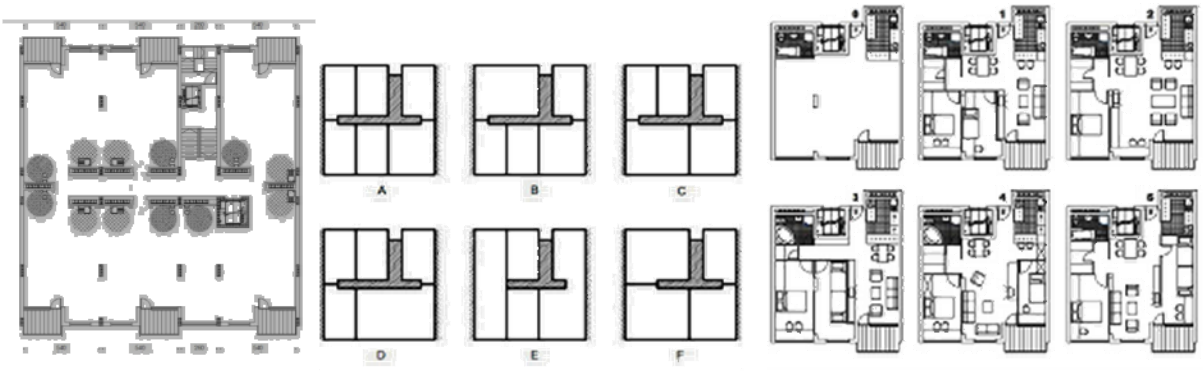

Figure 2: The plans and drawings of the non–courtyard multifamily housing.

5.1.2 Courtyard Housing

The second example is a multifamily housing building adopts the concept of courtyard. The building provides private court for each apartment in the building. The design provides many possibilities to make changes in the dwelling units' arrangement within the building. It also provides the possibilities to expand, minimize or modify the apartments of the building according to the family's requirement (Figure 3). (Al Hafith, 2010).

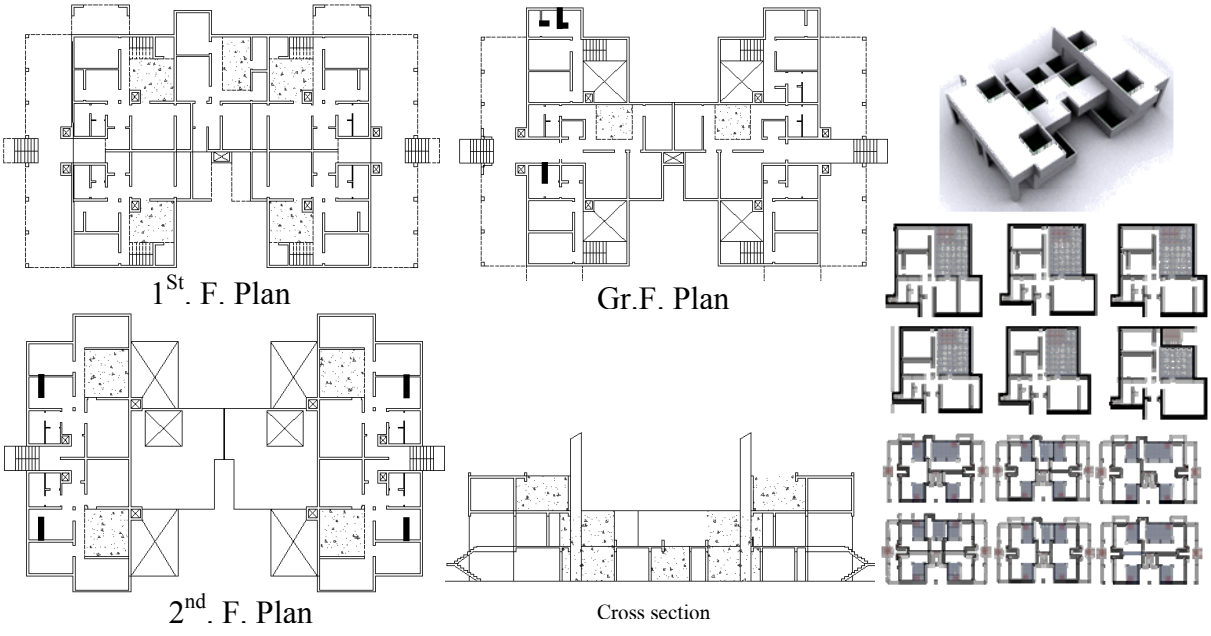

Figure 3: The plans and drawings of the courtyard multifamily housing.

6. Measurement of Properties Related Adaptable Design

This paper measures three of the design characteristics that affect the building adaptability which represent the dependent variable.

6.1 Structure Modularity

Structure Modularity can be measured by dividing the number of types of compound structure units to the total number of compound structure units of the building. The minimum amount of the ratio means that the building is more adaptable (compound unit consist of columns, beams and ground slab which based on them).

$$E1 = x1/y1 \quad (1),$$

Where (E1) is the ratio of types of compound structure units to the total number of compound units, (x1) refers to the number of types of compound structure units and (y1) refers to the total number of compound structure units.

The smallest amount of this ratio means that the building has more structure modularity and as a result it has more adaptability (Al-Nijaidi R. H., 1985, pp. 82-83).

6.2 Structure Concentration

Two indicators are adopted to measure the structure concentration which affects the building's adaptability.

Indicator 1, measures the structure concentration by dividing the number of supporting units to the total area of the building, the minimum ratio means that the building is more adaptable.

Indicator 2, measures the structure concentration by dividing the area of supporting units to the total area of the building, the minimum ratio means that the building is more adaptable

$$E2 = x1/y1 \quad (2),$$

$$E3 = x1/y1 \quad (3),$$

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Where (E2) is the ratio of number of supporting units to the total area of the building, (E3) is the ratio of area of supporting units to the total area of the building, (x1) refers to the number of supporting units in the structure, (x2) refers to the area of supporting units in the structure and (y1) refers to the area of the building. The smallest amount of these ratios means that the building has more structure modularity and as a result it has more adaptability (Al-Nijaidi R. H., 1985, pp. 83-85).

6.3 Zoning Areas of Special Provision

Proximity is used to measure the zoning of areas of special provision; proximity refers to the distance between any two rooms and can determine the extent of areas of special provision. The zoning is determined by the ratio of the distance between the rooms of special provision and all other rooms in the building by using the formulas below:

$$Xx = (x1+x2+x3+xi)/i \quad (4),$$

$$Yy= (y1+y2+y3+yi)/i2 \quad (5),$$

$$R= Xx/Yy \quad (6),$$

Where (R) is the ratio of the distance between the rooms of special provision and all other rooms in the building, (x) is the average distance between each special room and all other special rooms in the building, (y) is the average distance between each room and all the other rooms in the building, (Xx) is the average of the average distances between each special room and all other special rooms in the building, (Yy) is the average of the average distances between each room and all the other rooms in the building, (i) is the number of the rooms of special provision and (i2) is the number of common rooms. The smallest amount of this (R) ratio means that the building has more structure modularity and as a result it has more adaptability (Al-Nijaidi R. H., 1985, pp. 89-92).

7. Comparing the Two Types

A comparison between the two cases is made to support the argument of the possibility of making adaptable courtyard multifamily housing implying a single private courtyard for each dwelling unit in the building. The research measures the examples' adaptability by measuring three variables of adaptability. They are structure concentration, structure modularity and zoning of

special provision. The first two variables will be calculated for the whole building, while the third variable will be calculated for the apartment within the building.

7.1 Structure Concentration

(Table 1) clarifies the measurement of structure concentration in the two examples using equation (2), (3):

Table 1: Structure Concentration Measurements.

	courtyard example		Non- courtyard example	
Indicator 1	Area	Column N.	Area	Column N.
	743	36	400	30
Indicator 1 Result	0.048		0.075	
Indicator 2	Area	Supporting point area	Area	Supporting point area
	743	3.42	400	3.95
Indicator 2 Result	0.0046		0.0098	

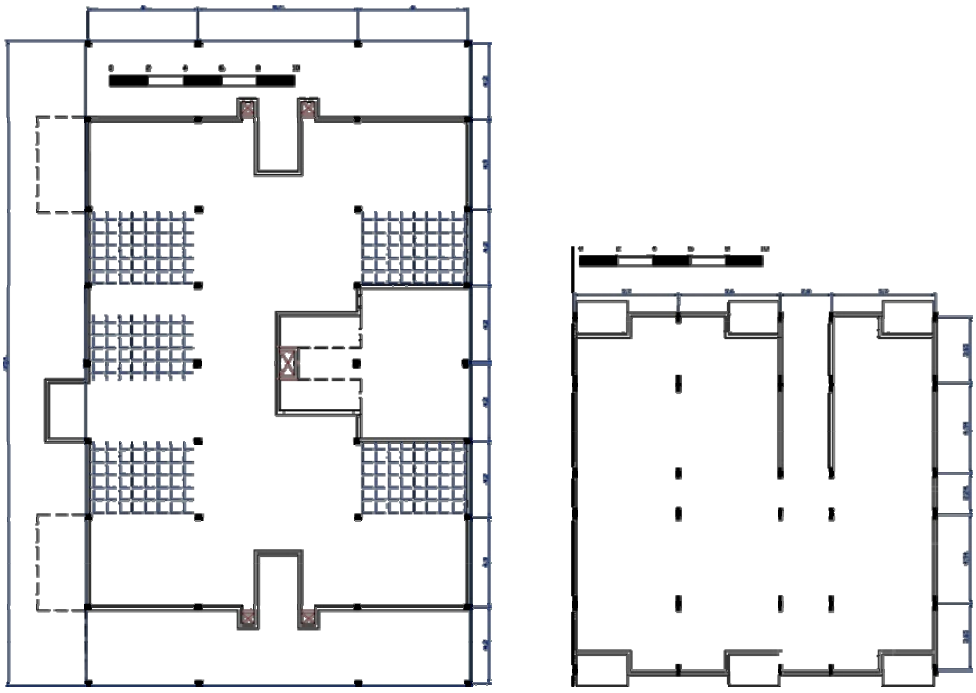

Figure 4: Structure in the two types of housing buildings.

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7.2 Structure Modularity

Structure concentration and modularity have been clarified in (Figure 4) for the two examples. Modularity has been measured depending on equation (3) and the results are as the following:

The courtyard house: 4 \ 24 = 0166

The non-courtyard housing: 6 \ 20 = 0.3

It can be seen that the courtyard house has the largest and the biggest concentration in the building and the biggest amount of modularity, which means that the case of courtyard housing is more adaptable than the other.

7.3 Zoning Areas of Special Provision

Zoning has been measured using equations (4), (5) and (6). Figure 5 and Table 2 clarify the measurement of zoning in the two examples.

Table 2: The distances between rooms in each apartment.

Courtyard Dwelling units								Non - Courtyard Dwelling units							
7	6	5	4	3	2	1		7	6	5	4	3	2	1	
	0		0				1	2.75					2.94	0	1
5.62		7.59		3.2	0		2	4.29					0	2.94	2
3.9		9.42		0	3.2		3		5.88	4.27	1.03	0			3
	1.07					0	4		5.9	4.29	0	1.03			4
7.33		0		7.59	5.74		5		2.43	0	4.29	4.27			5
			1.07			0	6		0	2.43	5.9	5.88			6

Av.Dis.of common rooms		Av.Dis.of special rooms		Av.Dis.of common rooms		Av.Dis.of special rooms	
5.47	2	0	1	4.07	3	2.845	1
5.506	3	0.535	4	3.74	4	3.615	2
6.886	4	0.535	6	4.263	5	3.52	7
5.616	7			4.736	6		

0.356	Av. Av. Dis. of special rooms	3.326	Av. Av. Dis.of special rooms
5.869	Av. Av. Dis. of common rooms	4.202	Av. Av. Dis. of common rooms
0.06	The Zoning amount	0.791	The Zoning amount

Figure 5: Common rooms & special rooms.

It can be seen that the zoning of areas of special provisions in the courtyard housing is greater than the one in the non-courtyard housing. This means that the courtyard building is more adaptable.

8. Conclusions & Recommendations

8.1 Conclusions

- Adaptability is a significant strategy for achieving affordable housing in terms of reducing the cost of housing in the long and short terms as it offers the possibility of constructing small units compatible with the requirements of the beginning families to grow and evolve with changing requirements without the stress of moving into new houses.
- This paper supports the argument that (Adaptability) represents a convenient solution for one of the most important problem in the multifamily housing which relates with ability of dwelling units to accommodate with changing requirement of the occupants.
- Adaptability plays an important role for the issue of sustainability in terms of reducing the consumption of natural resources and wastes of buildings and destruction.
- Courtyard house with wind tower play an important role for the issue of sustainability in terms of reducing the consumption of energy, operating costs as well as the courtyard association in satisfying the social requirement in terms of providing the required privacy.
- The paper shows possibility of employing the concept of courtyard in designing

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adaptable multifamily housing to achieve a sustainable affordable multifamily housing.

8.2 Recommendations

- Courtyard housing must be adopted in the hot arid area to achieve sustainable affordable housing.
- Adaptability must be adopted in a multifamily housing to achieve sustainable affordable housing and to solve one of the multifamily housing problems.
- To achieve adaptability, the designer has to use the Beams & Column Structural System with minimum supporting units and minimum structural area which will ensure the provision of the biggest possible free area for occupants to arrange or modify it according to their requirements.
- To achieve adaptability, the designer has to design the building plan and structural system in a way that makes the whole building composes of several similar units. This will facilitate the modification, addition or subtraction in the dwelling units and in its building as a whole.
- To achieve adaptability, the designer has to design the building and dwelling units plan putting the areas of special provision in a dependent zone, leaving the biggest possible free area in the dwelling units for occupants to arrange or modifying it according to their requirements.
- The paper recommends studying design characteristics that are related with adaptability and clarifying the exact influence and relative importance of each of them for adaptability.

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