“OVIDIUS” UNIVERSITY OF CONSTANTA

DOCTORAL SCHOOL OF APPLIED SCIENCES

DOCTORAL DOMAIN: CIVIL ENGINEERING AND INSTALLATION

Contributions on optimizing the management of civil buildings by applying modern materials and technologies

PhD thesis summary

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Abstract

This thesis discusses the relationship between effective management through the use of modern technology to improve performance factors in civil projects, in general, and housing projects, in particular. The importance of this research comes through increasing the efficiency in the performance of projects through reducing costs and time completion and improving quality through modern technology. This research simulates global trends of improving the building quality and reducing the harmful effects on the environment as well as reducing costs through finding affordable housing. The research dealt with a study of the most prominent international research in this field of knowledge and what it contains of research and studies that discuss the most prominent global problems related to the problems of the building sector, especially residential complexes that suffer from many problems, including increased cost, pollution resulting from implementation and operation stages, and an increase in the completion time for these projects. The research limitations include focusing on residential projects, the importance of this topic, because this topic is important to many who are interested in solving housing problems. In this research, the descriptive methodology was adopted through collecting information and identifying the main problems and then analyzing performance through mathematical methods and then discussing the results and presenting proposed solutions. As a start to solve the problem, the research dealt with planning for managing housing projects through determining the percentage of deficit and demand for the housing sector and studying economic, social and environmental impacts. The main pillar in finding solutions is to study the impact of the main project constraints and try to improve them (time, cost and quality), which is the most prominent thing covered in this study, as well as the potential risks that are linked to the project constraints and the possibility of reducing those risks. The contribution of modern technological alternatives to achieving feasibility requirements for any project was discussed by reducing costs, completion time and improving quality standards. And the most important research themes focused on studying the recent trends in construction, which aims to increase the efficiency of the building. The study of energy efficiency in buildings contributes to achieving the economic, environmental and social goals of any housing project. To highlights on the main axis of the research, the case study related to an important and strategic residential project in Iraq, which is the largest residential project in the Middle East and which contains the largest factory in the world for the production of prefabricated structural elements, which is one of the most important modern trends in construction. The case study included analyzing performance in the project in terms of costs, completion time, accidents, labor, energy consumption, and all environmental and social impacts and comparing them to traditional projects that do not use modern methods as the analysis of the results between that the modern method in construction has a higher feasibility than traditional methods . On the other hand, the research discussed other technological instruments related to controlling and controlling the project, such as software and drones used to increase control in modern projects. The result of the conclusions of this research was that the use of modern technology in construction helps to significantly improve performance in housing projects and this is done through contributors according to the size of each project to achieve feasibility requirements, as

well as this research needs to continue research and studies in this field through a case study for other regions of the world, the focus is more on all areas of research in a broader and deeper way**.**

Keywords: project management, performance, cost, implementation time, new technology, residential projects

Contents

Chapter 1 Introduction, necessity and opportunity of the subject of the doctoral thesis

1.1 Introduction

Naturally, the construction sector is one of the main sectors of the civil engineering sector, which is one of the most important challenges facing the governments and interested investors in this sector and all scientific and research institutions to minimize the growing housing crisis with increasing population growth . In EU the rate of people living in a crowded area is more than 17% and people spent 26.3% of budget to rent residential areas. In USA 30% of expenditures go to rent residential unit according to HUD. The reliance on the traditional style of building residential complexes with traditional building blocks, which require a lot of time, cost and manpower, makes them unrealistic and does not take into consideration the tremendous developments in the field of construction. In this context the need for orientation towards modern methods and patterns of construction may lead to optimum management of these projects and achieve the requirements of economic feasibility, social and environmental benefits achieved in addition to the integration of services and other facilities such as electricity, water networks, sewage networks, gas systems and the Internet as well as other recreational services like as stadium, green zones, hypermarkets and others. Also, the approach of this subject in the PhD research program (which is a very current topic for the entire international community) aims to increase the efficiency of construction work in terms of quality and social conditions resulting from the need to build in the emergency system, to secure housing in special cases of natural disasters and not only - by addressing modern technologies and materials in construction with appropriate management in implementing construction projects, especially residential complexes.

1.2 Research objectives

The search program has a priority objective to define and improve performance factors in housing projects as well as find realistic and logical solutions for the housing sector through a realistic field study and compare them with studies and scientific research that focus on this field through studying economic feasibility and achieving social and technical requirements and improving the environmental reality, as well as finding the integration among principles control elements (time, cost, quality). With the increasing demand for growth on the acquisition of affordable housing, the solutions associated with exploiting modern technology to find alternatives that reduce the housing crisis and reduce financial burdens on people, taking into account several key factors:

- They conform to the quality standards
- Be compatible with environmental standards
- To achieve satisfaction with the target group
- To be within an integrated strategy
- Be compatible with legal housing regulations

1.3 Research importance

The importance of the research program is to define and apply the basic factors upon which effective management depends in the housing policy for the elements of interdependence of the matrix of modern materials, modern technologies (effective management - especially construction techniques to reduce pollution and increase building efficiency, to reduce the costs of a particular consumption - very important parameters in the current stage of progress of civilization and environmental safety.

Another important element comes through the importance of linking between project management improving and modern technology through performance factors in construction projects constraints (time, cost, quality) in all stages of project life cycle.

Thesis contains 7 chapters, and develops and details this concept in its own vision, the case study analyzed in the paper being a housing complex in Baghdad, and it contains:

Chapter 1: presents - the motivation of approaching the topic, the importance and topicality of the topic, the international concerns in the field of research of the research activity, the objectives proposed for solving in the research

Chapter 2: The stage of national and international knowledge of construction technology, important problems, specifications and categories of residential unit, global new trends in construction, durability, and efficiency in residential complexes

Chapter 3: Current researches - description of the research framework used in the program, research limits, research variances, planning of housing sector and analysis of main potential risks in this field, also this chapter focuses on new technology and materials that support this research.

Chapter 4: Case study - focuses on a case study in Iraqi capital (Baghdad) and takes in consideration new technology to build the largest city in Baghdad.

Chapter 5: Research results – discuss analytical results by using a quantitative analysis and compare the performance factors (economical, society, technical and environmental objectives) in both styles traditional and modern style.

Chapter 6: Capitalizing the research results – discuss the contributors in field of housing to contribute crisis by dividing residential complexes on categories, also the modern solution in parallel of global trends to improve building technology and focus on important suggested solution.

Chapter 7: conclusions - It represents conclusions arising from the conducted research, the research team's contributions, the originality of the paper, the value of the results obtained, their applicability - capitalization of results, and proposals for new research trends.

Chapter 2 The stage of international knowledge of construction technology

2.1 important problems in housing sector

Through the study framework and through the determinants of the study, the study focuses on residential buildings in particular. The housing sector faces many problems, and most of the solutions were focused on an aspect of the problem without taking into consideration the integration of the elements of solutions related to the economic, technical, social and environmental aspects.

No.	Issue	Impact
1	Economic issues	High cost of execution
		High cost of operation
		High cost of maintenance
2	Technics issues	Absence in insulation
		Low quality of finishing
		High implementation schedule
		Huge structure elements
		Complexity in operation and maintenance
3	Environment issues	High consumption in raw materials
		High emissions due to raw materials transport emissions
		High emissions in construction fabrication
		High consumption in electricity energy leads to high emissions in energy plants
		High consumption of materials leads to increasing in waste materials in site
4	Society issues	High cost of traditional residential units
		Absence of affordable residential unit
		Shortage in residential units
		High schedule time lead to impact on marketing value

Table (1) Impact of traditional pattern on feasibility of residential projects

2.2 New trends in civil buildings projects

The recent trends in construction address the impacts resulting from the use of traditional methods in construction and reduce the amount of economic and environmental damage. Modern trends study the stages that building materials must go through and then improve building efficiency during these stages.

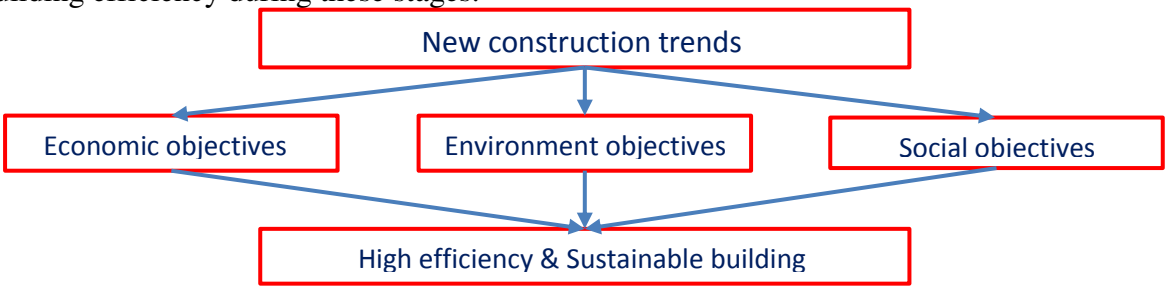

Figure (1) New trends objectives for new buildings

Chapter 3 Current researches

3.1 Research limits

This study focuses on performance factors and efficiency elements for construction projects by achieving feasibility requirements as well as achieving balance in the elements of project control which are time, cost and quality. This study does not discuss all types of civil buildings, but rather discusses the mechanisms of solutions for residential buildings and does not refer to industrial and commercial buildings. The sample for the case study was taken from one of the large and modern residential projects in Iraq due to the presence of the elements of integration for residential projects and the presence of modern technologies used in construction.

3.2 Research variables

By studying the performance factors in the projects, the variables of the constraints elements in the project show us (time, cost, and quality). Therefore, it is difficult to achieve a positive agreement between all the elements at the same time, as it is known that increasing the quality leads to increasing the cost and increasing the time leads to Increasing costs, and therefore these variables must be dealt with on a realistic basis that cannot be overlooked, and the most prominent challenge in this study is to improve those elements together as much as possible to obtain realistic and acceptable results at the same time to achieve integration of performance. The effect associated with the research variables is as shown in the table below

3.3 Research methodology

In this study, the descriptive methodology was adopted by defining the aim of the study, which is performance factors in construction projects after collecting complete information about the case through the current studies approved in this field and the available database on the situation to be studied, and by identifying the problem and using data and determining the factors affecting In it the question about the problem is determined and the transition to the stage of brainstorming to find solutions in light of the available data on this case, and then hypotheses and proposals for solutions through studying the traditional pattern and comparing it with the modern pattern in the case study and the comparison among the advantages and disadvantages of the project. The results obtained from this study are analyzed by scientific methods through the modern style compared to the traditional pattern and then finding solutions and proposals to improve the coefficients of the performance of residential projects and come up with conclusions and recommendations on these results.

3.4 constraints in construction projects

The study of project performance problems should be based on achieving the performance framework for all areas of project management knowledge.

There are many factors that affect the efficiency of performance in projects, some of which are related to planning and preliminary studies for the project, including what is related to the stages of implementation of the project until the end of the project life cycle, and all of these factors are related to the formation of the three constraints of project management (time, cost and scope). As shown in figure below:

3.5 Risk management of civil buildings projects

The risks are usually associated with the main constraints of the project, especially those relating to time, cost, and scope management. By identifying the risks involved in the project, appropriate measures can be identified to address these potential risks. Main factors of potential risk in construction are:

a) Time
b) Cost
c) Scope
d) Quality
e) Security
f) Organization and regulation

3.6 Contribution of new technology on feasibility study in construction projects

The economic feasibility study is the most important and the decisive factor in studying each project. Every investment institution has its main goal in achieving the economic feasibility of establishing these projects and reaching the percentage of profits planned for the establishment of this project.

Revenues after the operation phase of the building can be achieved through a careful study of the economic feasibility by which the building life of the building is measured, as well as the recovery period in which the value of the expenditures will be equal to the value of the revenues through the operation and exploitation of the project. The technology used in the design and implementation of the building determines the amount of economic viability of the project through the following:

- Economic alternatives to materials used in the project industry, which can contribute to reducing the total cost of the project
- The contribution of modern technology and materials to the early completion of the project and thus reaching the recovery value of the project as quickly as possible and thus increasing the profit period up to the end of the project life cycle
- The contribution of modern materials to increasing the operational life of the building

- Increasing the marketing value of the project through the modern construction style and the appropriate cost that contributes to increasing the sales speed of these units.

Environment contribution

All environmental problems related to environmental issues must be addressed through deep planning of the preliminary study stage of the project and the technical designs stage after defining the environmental plan inputs. Building patterns must achieve this plan for the protection and improvement of the environment through all stages of the life cycle of origin. The table below shows the steps necessary to achieve environmental improvement

No.	Stage	Requirements
1	Execution	High quality foundation
		High cladding insulation
		High partition insulation
		High roof insulation
		Low quantity of structure materials
		High acoustic insulation
		Smart lighting
		High glass insulation
2	Operation and maintenance	Low energy consumption
		Low water consumption
		High personal health
		Low building emissions
3	Demolition and recycling	Low waste materials
		Ability of recycling
		Low emissions of waste materials

Table (2) Requirements to reduce emissions and pollution on life cycle of building

Technical contribution

Technical determinants must take into account the achievement of technical requirements in the design and implementation stages through design and implementation. The technical specifications that represent suitable alternatives for construction works should be used for high performance factor technically.

Building codes can revolutionize the sustainable construction industry. The technology used in building depends on the following main elements:

(1) Improve the properties of building materials
(2) Intelligent monitoring and control
(3) Smart mechanisms

The most important factors that help improve the performance of residential buildings are:

1) Selection of high-insulation materials for ceilings, walls and windows

- ✓ Roof insulation
- ✓ Walls insulation
- ✓ Windows and doors insulation

According to scientific studies, the building energy loss is as follows:

- ★ Walls and ceilings 65%
- ★ Windows and doors 35%

2) Use lightweight materials to reduce dead loads
3) Use of high resistance structural sections

3.7 Problems of traditional materials

Many problems maybe occur when using traditional materials in construction especially in residential complexes like increasing in implementation time and increasing in budget of the projects. Almost issues that related to using traditional materials are environment problems. In figure below the most important issues in the housing sector due to the use of traditional techniques in construction:

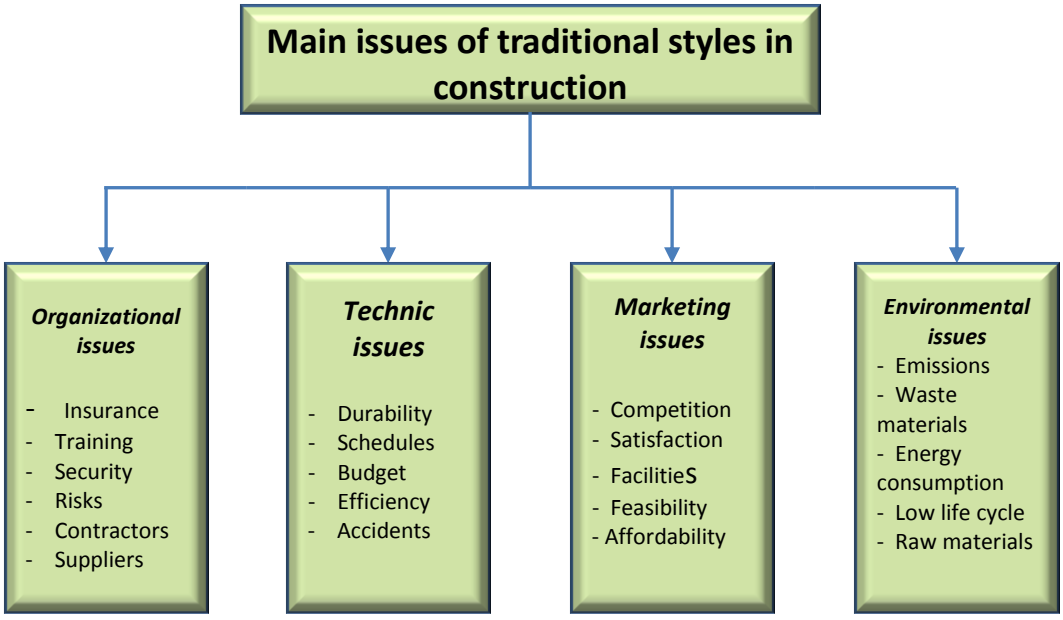

Figure (2) Main issues of traditional style in construction

3.8 Modern technologies and new materials in construction projects

There are two tracks of modern technology used in construction and they must go together with a parallel path, as one of them completes the other to reach a modern and integrated management of the construction sector, and the first track is modern technology that is

dependent on machinery and modern equipment that contributes significantly to improving performance in projects, while the second track is Find alternatives to traditional building materials with others that are more efficient in many ways (thermal and acoustic insulation, energy efficiency, durability and environmental improvement).

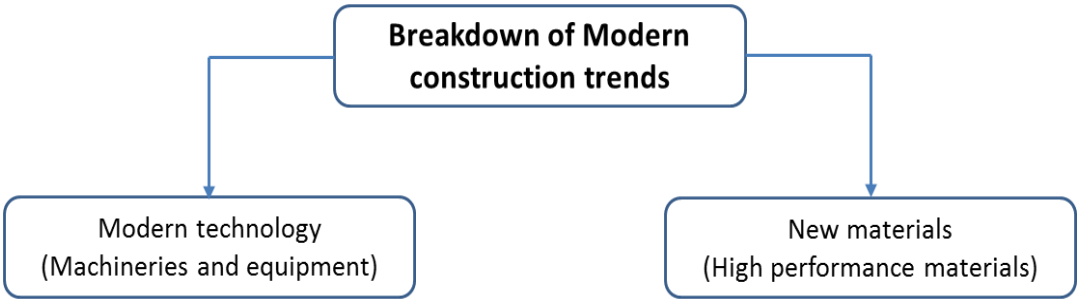

Figure (3) Breakdown of modern construction trends

3.9 Measures to improve energy efficiency of buildings

To improve energy efficiency within the building, it is important to take integrated measures to ensure the conservation of energy gained and reduce energy consumption. The procedures should be in accordance with the environmental regulations adopted for the buildings. The measures taken to improve the efficiency of the building can be included in the term "green buildings", which are environmentally friendly through the efficiency of insulation and energy consumptionThe most important measures to be followed in the improvement of energy are:

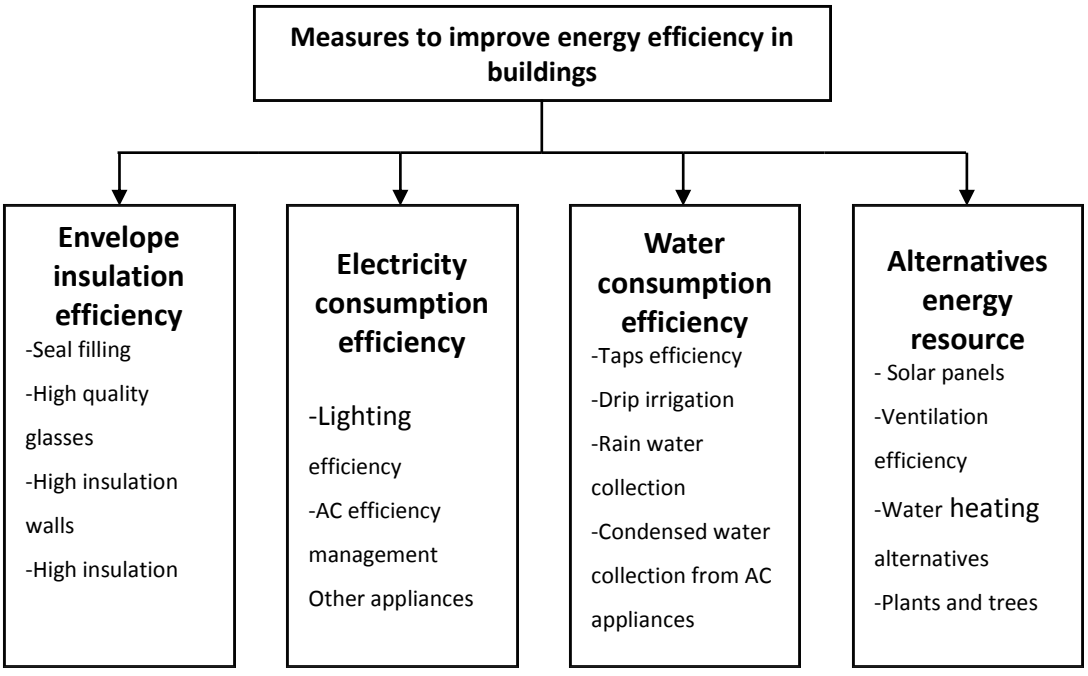

Figure (4) Measures to improve energy efficiency in buildings

Chapter 4 Case study

1.1 Introduction

The circumstances experienced by Iraq from internal wars and conflicts over the years have led to many problems and deficits in the housing sector, especially the period between 2014 and 2016 that witnessed major military operations in several Iraqi cities, which led to the demolition of many housing units in those cities, the housing crisis in Iraq has been further exacerbated, bringing the deficit in housing units in Iraq to more than 3,000,000 housing units. The population growth rate in Iraq, according to the latest statistic, is 2.6 %; therefor it is too important to find a new solution to decrease the shortage rate in housing sector. Figures in below show the scale of the destruction in Iraqi cities due to the military actions

The population growth in Iraq ranged 2.5-3.4, where the highest population growth was 3.4 in period 1947 -1957, and according to the latest statistics, the population growth in Iraq is 2.8.

The shortage in housing units ranged between 450,000 housing units in 1970 and more than 4,120,000 housing units in 2016, which is a large percentage and a dangerous indicator of the worsening of the housing crisis in Iraq, figure in below show the shortage in housing unit in period 1970 – 2016. Housing units began to increase significantly, especially in the period 2014 - 2016, because of military operations in Iraq during that period led to the destruction of many cities.

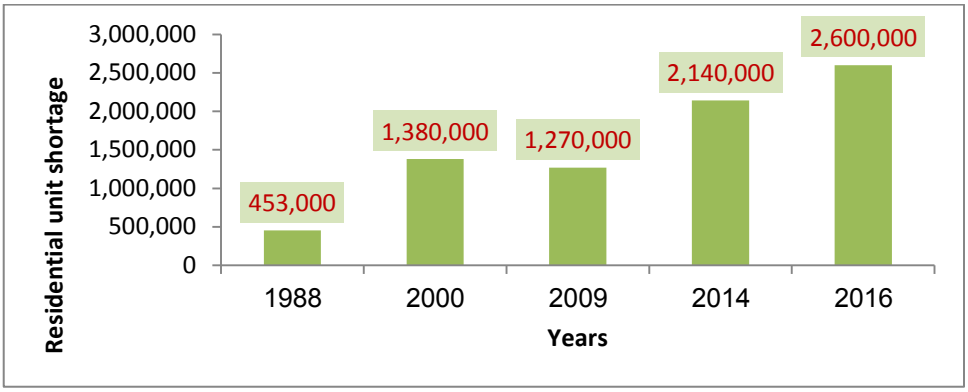

Figure (5) Shortage of residential units in Iraq

4.2 Bismayah new city project

This case study focuses on one of the housing projects in the Iraqi capital, Baghdad, and this project is one of the main strategic projects that the Iraqi government is implementing with the investment system within the housing initiative plan that consists of three phases.

Figure (6) Hybrid image of Bismayah new city project (Source: hanwha.com)

The Iraqi government, represented by the National Investment Commission, chose the South Korean Hanwha Company to implement this project under the supervision of the Iraqi Ministry of Housing and Construction.

Project Name	Bismayah New City Project
Client	Iraqi National Investment Commission INC
Main Contractor	Hanwha Engineering & Construction
Location	10 km south east of Baghdad
Total Area	18,300,000 m²
Residential Unit No.	103,416
People Capacity	600,000 people
Funding	Iraqi Government
Implementation period	7 years (2 years design, 5 years execution)
Total Budget	7,750,000,000 USD
Total Manpower	26,000 people

Table (3) General information about Bismayah new city project

4.3 Factories and new technologies in Bismayah new city project

The pre-cast plants complex was established near the project site with a total area of 657,000 m² to be a biggest precast plant in the world. The complex includes many plants:

- ★ Sandwich wall plant (to produce 1,210,000 m² or 800m³/day)
- ★ Battery wall plant (to produce 855,250 m² or 622m³/day)
- ★ Hollow core slab plant
- ★ Autoclaved aerated concrete plant (capacity = 1063 m³)

4.4 Analysis of performance according to project constraints

4.4.1 Economic effects

No.	Expenditures type	Traditional (USD)	Prefabrication (USD)
1	Direct expenditure	5672295.58	3496124
2	Indirect expenditure (9%) (fees, insurances, taxes)	510506.6	314651.2
3	Contingency budget (5%)	283614.8	174806.2
4	Management budget (5%)	283614.8	174806.2
	Total budget	***6750032***	***4160388***

Table (4) Expenditure comparison between traditional& modern construction style

Comparing the results in using the modern style in construction represents 61% of the cost of traditional construction, means that we can to reduce the project budget by rate of **39%**.

4.4.2 Implementation time

$$\textbf{Time saving ratio} = \frac{(Traditional\ implementation\ time - Prefabricated\ implementation\ time)}{Traditional\ unit\ consumption} * 100\%$$

$$\textbf{Time saving ratio} = \frac{(366-192)}{366} * 100\% = 47.5\%$$

4.4.3 Low electrical energy consumption

One of the most important reasons and reasons that led to the choice of pre-fabricated building style is to reduce the consumption of large consumption of electricity, especially as the bulk of the consumption of electrical energy goes to the cooling devices, which work continuously most of the year.

According to official statistics issued by the Iraqi Ministry of Electricity, which represents the rate of consumption of electricity throughout the year and compared with the actual figures achieved in the city of Bismayah new note that there is a significant reduction in the consumption of electricity at least 36% of total consumption.

The percentage of savings in energy increases if the consumption is calculated in the summer period, which need to consume more in the air conditioners and may reach more than **54%** of the total consumption.

$$\textbf{Power saving ratio} = \frac{(Traditional\ unit\ consumption - prefabricated\ unit\ consumption)}{Traditional\ unit\ consumption} * 100\%$$

$$\textbf{Power saving ratio} = \frac{(4681.5-2989.5)}{4681.5} * 100\% = 36\%$$

4.4.4 Durability

The using of advanced plants in the production of prefabricated concrete contributes to improving the properties of concrete through the following things:

1. Improve the resistance of concrete, especially the property of future compression through the central control on the proportions of mixing concrete components.
2. Improve and accelerate the curing time of the concrete through the use of concrete treatment methods by using steam curing.
3. Increase the durability of concrete by using additives like plasticizers and others.
4. Improve the accuracy of the dimensions of the concrete members
5. To improve the electrical and sanitary installations through the sleeves that installed in the walls accurately and symmetrically in all directions.

4.4.5 Reducing of labors

Below comparison between two patterns

No.	Manpower	Traditional pattern working days	Prefabrication pattern working days	Saving ratio
1	Carpenter	330	0	100%
2	Smith	330	0	100%
3	Mason	260	0	100%
4	Skilled worker	379	164	57%
5	Unskilled worker	394	192	51%
6	Electricity technician	75	40	47%
7	Sanitary technician	75	40	47%
8	communication technician	75	45	40%
9	Firefighting technician	75	45	40%
10	Interior plastering technician	90	25	72%
11	Dyer	37	30	19%
12	Welder	268	174	35%
13	Tiles technician	260	100	61%
14	Cladding technician	18	0	100%
15	Waterproof technician	22	2	91%
16	Exterior plastering technician	30	0	100%

Table (5) Manpower comparison between traditional and prefabricated construction style

Chapter 5 - Research results

1.1 Evaluation of objectives (Modern vs. Traditional)

1. Economic objectives

Main goals	Objective sequence	Detailed objective	Main goals weight	Detailed objective weight	Construction style factor		Weighting Matrix	
					Modern	Traditional	Modern	Traditional
Economic objectives	1.1	Implementation cost	4	1	2	1	2.0	1.00
	1.2	Operation cost		0.75	2	1	1.5	0.75
	1.3	Maintenance cost		0.25	2	1	0.5	0.25
	1.4	Implementation time		1	2	1	2	1
	1.5	Energy consumption		0.75	1	0	0.75	0
	1.6	Raw materials consumption		0.25	1	0	0.25	0
					∑ =		**7.00**	**3.00**

Table (6) Result evaluation by using Goal Achievement Matrix (Economic objectives)

2. Environmental objectives

Main goals	Objective sequence	Detailed objective	Main goals weight	Detailed objective weight	Construction style factor		Weighting Matrix	
					Modern	Traditional	Modern	Traditional
Environment objectives	2.1	Electrical energy consumption	2	0.75	1	0	0.75	0
	2.2	Water consumption		0.25	1	0	0.25	0
	2.3	Carbon Emissions		0.5	1	0	0.5	0
	2.4	Public health		0.25	2	1	0.5	0.25
					∑ =		**2.25**	**0.25**

Table (7) Result evaluation by using Goal Achievement Matrix (Environmental objectives)

3. Social objectives

Main goals	Objective sequence	Detailed objective	Main goals weight	Detailed objective weight	Construction style factor		Weighting Matrix	
					Modern	Traditional	Modern	Traditional
Social objectives	3.1	Housing problems solving	2	1	2	1	2	1
	3.2	New jobs		0.5	1	3	0.5	1.5
	3.3	Housing welfare		0.25	2	1	0.5	0.25
	3.4	Utilities Integration		0.25	1	1	0.25	0.25
					∑ =		**3.25**	**3.00**

Table (8) Result evaluation by using Goal Achievement Matrix (social objectives)

4. Technical objectives

Main goals	Objective sequence	Detailed objective	Main goals weight	Detailed objective weight	Construction style factor		Weighting Matrix	
					Modern	Traditional	Modern	Traditional
Technical objectives	4.1	Durability	2	0.75	2	1	1.5	0.75
	4.2	Acoustic insulation		0.25	2	1	0.5	0.25
	4.3	Thermal insulation		0.25	2	0	0.5	0
	4.4	Finishing work accuracy		0.25	2	1	0.5	0.25
	4.5	Accidents reducing		0.25	2	1	0.5	0.25
	4.6	Architectural design flexibility		0.25	1	3	0.25	0.75
					∑ =		**3.75**	**2.25**

Table (9) Result evaluation by using Goal Achievement Matrix (technical objectives)

In order to obtain the final results to evaluate the research results, the results must be combined to achieve the final values of the study, and through the table listed below, the final result is determined to evaluate all results as a final outcome:

No.	Matrix objectives items	Modern style score	Traditional style score
1	Economic objectives	7.00	3.00
2	Environmental objectives	2.25	0.25
3	Social objectives	3.25	3.00
4	Technical objectives	3.75	2.25
Total score		**16.25**	**8.50**

Table (10) Final results of matrix objectives evaluation

Chapter 6 - Capitalizing the research results

The choice of proposed solutions to use building patterns requires consideration of the main determinants that help improve project performance. One of the most important of these is improving quality and reducing costs and delivery time. The integration of objectives may not be achieved through the main project determinants, but it is important to have a convergence of results as much as possible to improve performance and increase efficiency to the maximum possible extent.In addition to the geographical and social nature having an effect on the choice of alternatives, societies differ in their social nature in addition to the environment and climate, making the alternatives different according to the geographical distribution.

6.1 Modern Solution of residential projects by using categories of residential capacity

In order to put the appropriate technology for housing projects, this depends on the cost of the project and the number of housing units, as it is not correct that there is one technology for all types of projects. The proposed projects should be divided into several categories, including:

1) ***Projects with a capacity from 1 - 100 housing units***

The use of the insulated concrete frame system is one of the modern systems that have features that make it one of the modern methods of building, especially for separate building units. This style is characterized by automatic features:

- ✓ Light weight
- ✓ Ease of transport and use
- ✓ Does not lead to work accidents
- ✓ No polluting emissions
- ✓ Affordable building
- ✓ Fast installation
- ✓ Against mold
- ✓ High thermal insulation
- ✓ High sound insulation

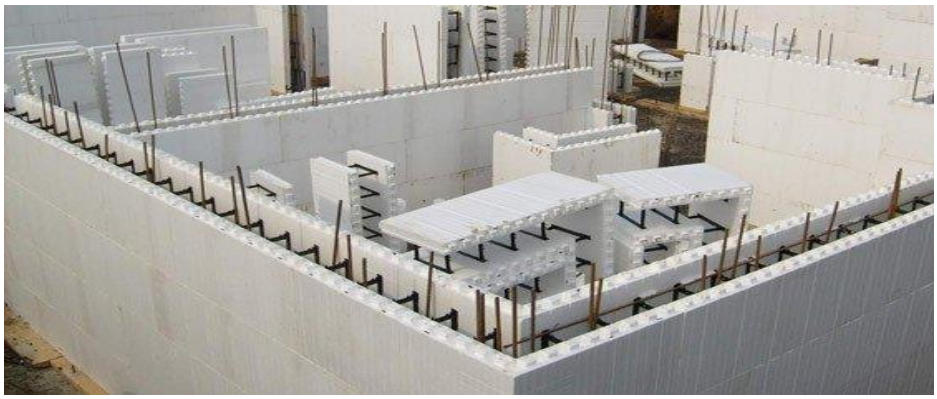

Figure (7) Insulated Concrete Formwork ICF (source: pmrpressrelease.com)

2) *Projects with a capacity of 100 - 1000 housing units*

Medium-sized projects, which consist of 100-1000 housing units, can be implemented by investors or banks, and this research suggests using the technique of using three-dimensional construction technology. This pattern is used for separate units consisting of one or two floors.

The cost of 3D printing machines is very expensive and therefore cannot be used for small projects because they are not feasible. This technology has several advantages that make it suitable for these residential projects, which will revolutionize the future in the construction industry

Figure (8) 3D printing technology (source: constructionreviewonline.com)

This technology has many advantages that make it one of the most appropriate solutions for medium-capacity projects, and the most important of these advantages:

- ✓ Very high accuracy in execution
- ✓ Very short time to implement
- ✓ Very high quality
- ✓ Affordable cost
- ✓ High durability

3) *Projects with a capacity >1000 housing units*

For large projects that can be from the responsibility of government, banks, or investors, or through a government coalition with investors or with banks, it is possible in this case to use pre-fabricated building technology, which is the most efficient method currently, and because the cost of establishing their own factories and warehouses requires high cost with the condition that large spaces are available for the structural elements stores after manufacture, this technique cannot be applied to medium or small projects as it is not economically feasible.

The choice of this method came after studying the case study in Bismayah project and then analyzing the results that showed many advantages:

- ✓ The possibility of using each factory in more than one residential project to reduce the cost of the project

- ✓ Low cost saves more than 30% of construction cost
- ✓ Very high quality
- ✓ Environment friendly by reducing construction waste
- ✓ Significant energy savings of up to 50% of traditional methods
- ✓ Great design life of up to 60 years
- ✓ Labor saving of more than 40%
- ✓ Accidents less than 50% less than traditional methods
- ✓ Savings on maintenance and operating amounts of up to 50%

6.2 Suggested modern technologies for projects performance monitoring

Project monitoring is a necessary matter, and modern technology has helped many projects to develop monitoring and control systems and improve performance, and one of the most important of these technologies

1) The drone

One of the best modern technologies that are not manufactured for the construction sector, but many projects have benefited from them in monitoring works very effectively and have led to improved performance processes in projects, especially large projects through monitoring the movement of manpower and mechanisms, in addition to improving performance in the field of safety and security to reduce accidents and thefts, in addition to space works for large areas and taking aerial photographs, and for this reason, this technology is very important in improving monitoring despite its high cost. However, it is feasible for important and strategic projects.

2) Construction Management Software

The recent trends in construction focus a lot on monitoring techniques for projects through on-site monitoring and office monitoring, and the most important techniques used in monitoring and control work in modern projects are project management software which have a major role in controlling project performance and one of the most important features that make these technologies very important in improving performance are:

- ✓ Schedule monitoring
- ✓ Monitoring costs
- ✓ Monitoring of contracts
- ✓ Monitor payments and salaries
- ✓ Modify updates to project activities
- ✓ Monitor warehouse expenses

Chapter 7 Conclusions

The research program highlighted the following aspects:

Research has shown that traditional construction methods may not be possible through economic, social, marketing and technical accounts. By studying the performance factors of residential projects, the traditional construction method has many drawbacks, including the long implementation period as well as the high economic cost in addition to other environmental and financing issues related, especially in investment projects in the field of construction and housing.

Through the analytical study of project performance with regard to cost, it is clear that traditional projects are more expensive when compared to the modern pattern, as the use of a pre-fabricated building system has resulted in the provision of large sums, at an estimated rate of 39% of the total cost of the traditional patterns,

The second determinant of performance in projects, which is also linked to the cost factor in an indirect way, the use of new materials and modern technology greatly helps in reducing completion time. The analytical study showed that the use of modern construction techniques can reduce the time required to complete by 45-50% from the time needed to complete traditional projects.

From studying the effect of quality on improving the efficiency of buildings, the research showed that the modern method of construction has reduced the consumption of electrical energy to more than 50%, especially in hot areas, in addition to increasing sound insulation and reducing noise through methods of thermal insulation of external walls and roofs in addition to using Heat insulating glass. In addition to the insulation properties, the durability of the building is much higher through the implementation of the pre-fabricated building method, as the design life of the pre-built buildings is greater than 50 years.

Reducing pollution resulting from electricity consumption can be reduced to a large percentage through improving the energy efficiency of the building through several measures, including the efficiency of electrical and sanitary appliances and facilities, in addition to the use of renewable energy such as solar panels to generate electricity at the roofs of buildings or heating water, and thus additional energy can be provided an estimated 12-15% of the total energy needed to operate the building.

In addition to reducing pollution by reducing the consumption of electrical energy, it is possible to reduce pollution resulting from construction waste through the use of pre-fabrication of construction units as this method can provide more than 12% of raw materials, in addition to providing an amount of 5-10 % of materials by reducing the thefts that take place in traditional projects.

Likewise, modern patterns help to reduce labor and thus improve performance in the field of human resources management, as the number of workers can be reduced by a rate ranging 20-60% from the total workforce according to each category of work.

The research results highlighted the following aspects that represent the elements of originality of the research, namely:

- The obtained results must be according to technical, economic, environmental and social goals that will be achieved, and achieve the principle of sustainability in buildings in light of recent trends in construction. Changing the pattern of solutions should be applicable in the near future, provided that there are future proposals that can be modified and improved, as they cannot be among the feasible solutions.

- Planning to improve performance in buildings, especially residential, must be done in the light of there being a division according to the size of the project and social and environmental conditions, provided that the necessary requirements are achieved for each category of projects:
- Another aspect of the research results refers to the fact that for small projects that are implemented by contractors or that are done with individual efforts by people to create units for a separate residential option, the building style option should be adopted using the insulated concrete framework ICF .
- The research results also highlighted the fact that as for the medium projects, which are between 100-1000 housing units, the appropriate method of implementation is to use the three-dimensional printing method to obtain an environmentally friendly housing unit in a very short time while achieving the principle of affordable housing with a very high quality .
- As for large housing projects, which consist of more than 1000 housing units, the study recommends the use of pre-fabricated building technology to obtain high quality with a short implementation time and low cost
- Increasing the efficiency of buildings through thermal insulation of all areas of heat transfer, especially roofs and walls, which accounts for 45-55% of heat exchange areas in buildings, as well as the use of multi-layer glass, which increases the energy efficiency in the building by 15-20%
- Adoption of lightweight concrete (Autoclaved Aerated Concrete) in all types of internal partitions and surface insulating tool to increase thermal and acoustic insulation.
- Using the roof of buildings, especially large projects in generating alternative energy through the use of photovoltaic solar panels to increase energy efficiency inside the building and use it for heating and lighting purposes in addition to increasing the building's insulation, as well as using PV panels or thermal panels to heat water to provide 10-12% of the building's energy.
- The use of PHC piles in large projects to save costs and increase the durability of more than 80 N/mm² as they are better than raft foundations or ordinary piles .

Because of importance of the research topic, there is a need for more research and studies related to managing housing projects and raising the efficiency of performance through the use of modern materials and instruments.

All these conclusions represent elements of originality of the work. The research results were capitalized and disseminated at international conferences in which I participated. I have published 3 articles and an article under publishing in ISI or BDI listed publications.

1 ”Use of modern technology to develop investment housing projects in Iraq ” International conference WATER 2018 – ed EX PONTO 2018; ISBN 978-606-598-663-3;

2 "Contributions of Prefabricated construction to improve project risk management” Proceedings of the 4th World Congress on Civil, Structural, and Environmental Engineering (CSEE’19) Rome, Italy – April 7-9, 2019 Paper No. ICSECT XXX (The number assigned by the Open Conf. System);

3 ”Improve of projects performance factors by using integrated cities and modern technology. Case study: Bismayah new city project” 2019 International Journal of Management and Applied Science (IJMAS) ISSN(p):2394-7926 ISSN(e): 2394-7926 http://www.ijmas.iraj.in/;

4 "Efficient planning and management of determinants in Iraqi residential projects" International Journal of Engineering and Applied Sciences (IJEAS ISSN: 2394-3661, Volume-7, Issue-4, April 2020).