**An-Najah National University**
**Faculty of Graduate Studies**

# Decision Making in the Selection of the Exterior Walls Techniques in Affordable Housing Buildings in Palestine

**By**
**Hanan Lutfe Abed-Allateef Muhsen**

**Supervisors**
**Dr. Riyad Abdel - Karim**
**Prof. Sameer A. Abu Eisheh**

**This Thesis is Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Engineering Management, Faculty of Graduate Studies, An-Najah National University, Nablus, Palestine**
**2012**

# Decision Making in the Selection of the Exterior Walls Techniques in Affordable Housing Building in Palestine

**By**
**Hanan Lutfe Abed-Allateef Muhsen**

**This thesis was defended successfully on 5/2/2012 and approved by:**

| **Defense Committee Members** | **Signature** |
|---|---|
| **1. Dr. Riyad Abdel-Karim / Supervisor** | **..……** |
| **2. Prof. Sameer Abu Eisheh / Co-Supervisor** | **……..** |
| **3. Dr. Jamal Zalatimo / External Examiner** | **…..……** |
| **4. Dr. Hasan Al- Qadi/ Internal Examiner** | **…….……** |

# DEDICATION

**To my Mom and Dad**

**To my sister and my brothers**

**To my husband, my daughter, and my son**

**With my love**

# ACKNOWLEDGMENTS

After sincerely thanking of Allah for all blessing, I would like to thank all those who helped me with their valuable support during the entire thesis process.

I would like to express my deep gratitude, appreciation and thankfulness to my supervisors Dr. Riyad Abdel-Karim and Prof. Sameer Abu Eisheh for their endless support and assistance, generous encouragement and supervision during all phases of this study, as well as in all the time of research and writing up this thesis.

I am deeply and forever indebted to my parents for their love, support and encouragement throughout my entire life. I am also very grateful to my sister Eng. Eman Muhsen. For sure, without their help, I could not have completed this thesis.

I also would like to thank my brothers Eng. Abd-Allateef, Ahmad, and Mohammad who did all their best in helping me to finish this thesis.

I would like to express my warmest love and forever appreciation to my husband Eng. Nasim Tanbour, my daughter Fadwa, and my son Feras for their continuous support to complete my thesis and making this study possible.

My profound appreciation to my friends and my colleagues especially Eng. Shifaa Kino, Eng. Reema Bedair, Eng. Sajeda Janem for their help and tips that helped me a lot in staying at the right track.

Finally, I would like to thank everybody who was important to the successful realization of thesis, as well as expressing my apology that I could not mention them personally, one by one.

**Hanan Muhsen .Tanbour**

**الإقرار**

إنا الموقعة أدناه مقدم الرسالة التي تحمل عنوان

# Decision Making in the Selection of the Exterior Walls Techniques in Affordable Housing Buildings in Palestine

# آلية اتخاذ القرار في اختيار نظام إنشاء الجدران الخارجية في مباني السكن الميسر في فلسطين

اقر بان ما اشتملت عليه هذه الرسالة إنما هو نتاج جهدي الخاص ، باستثناء مـــا تمـــت الإشارة إليه حيثما ورد، وان هذه الرسالة ككل من أو جزء منها لم يقدم من قبل لنيل أية درجة أو بحث علمي أو بحثي لدى أية مؤسسة تعليمية أو بحثية أخرى .

**Declaration**

The work provided in this thesis, unless otherwise referenced, is the researcher's own work, and has not been submitted elsewhere for any other degree or qualification.

**Student's name:** **اسم الطالبة:**

**Signature:** **التوقيع:**

**Date:** **التاريخ:**

# Table of Content

# List of Table

# List of Figures

# List of Appendices

**Decision Making in the Selection of the Exterior Walls Techniques in Affordable Housing Buildings in Palestine**

**By**
**Hanan Lutfe Abed-Allateef Muhsen**
**Supervisors**
**Dr. Riyad Abdel - Karim**
**Prof. Sameer A. Abu Eisheh**

## Abstract

Housing is considered the most important challenge facing the Palestinian National Authority, where the housing problem in Palestine is increasing day after day in light of the steady rise in population and returnees in the face of limited land and high prices of them, rising construction costs and relatively low income level.

Success in providing affordable housing depends on several factors including the reduction of construction costs, which in turn depends on the construction techniques.

Construction technique is a key tool to reduce the cost of the buildings but the reduction in cost should not be on the account of the efficiency of construction, durability, and resistance to natural and geological factors, and other than that the idea of getting the house of a low-cost, regardless of the expected age and quality of construction is a short sighted idea and a cheap solution in the present but a complex problem in the future. Therefore, there is a great need for a decision making process to select the optimum technique during the preliminary engineering study to reach to cut down the construction cost with the higher efficiency of the housing unit.

The aim of this study, is to improve the level of housing projects in Palestine through the selection of the proper construction techniques in terms of cost and quality in order to obtain affordable quality housing, by making

(1) Review of construction techniques currently used in Palestine. (2) Determining the Criteria that influence the decision making for selecting an optimum technique and its importance to the decision-maker. (3) Providing a mechanism to evaluate the construction techniques and to be judged on by referring it to the decision criteria.

Both qualitative and quantitative research methodology were utilized in this study. Eighty one questionnaires were distributed to selected local building contractors registered and classified at the Palestinian Contractors Union as first category, and fifty six responses were received. The response rate was sixty nine percent.

The result of the study revealed that the construction technique currently used in Palestinian housing projects are achieving the efficiency and quality of construction required, but are not satisfactory in terms of achieving cheaper housing construction or in cutting down the production cost. Therefore, some adjustments have been made to the technique in order to exit the technique that achieves cost reduction while maintaining the efficiency required.

# Chapter One

# Introduction

# Chapter One
# Introduction

## 1.1 Overview

Housing is a major concern of every country, society, and household. For the country it has a political and economical effect, and plays a significant role in developing the economy and creating new jobs. For families, it offers a shelter as well as it fulfills a social function within the society. It is also the most important and most valuable of the assets of the family in her life. Thus this sector is vital for the development of any country.

The Palestinian National Authority is initiating a new endeavor to stimulate economic development and improve the housing stock through infrastructure development within the housing sector. There is high demand for housing in the Palestinian Territories (approximately 400,000 to 450,000 housing units in the next 10 years) and limited supply (about 16,000 units per year) according to the Ministry of Public Works and Housing. Purchasing housing is increasingly unaffordable due to high prices and low - per capita income.

The Palestinian Reform and Development Plan published in December 2007 stated that it aims to achieve an “affordable housing” program that aims to generate jobs, meet the growth in demand for housing units and increase access to affordable quality housing for low and middle income families. This program was envisaged to be implemented through

public-private partnership. The scheme called for the Palestinian National Authority to provide the necessary infrastructure, through donors or its own funds, to support a major private-sector led program of housing construction. There are a number of large private sector affordable housing projects in the development phase.

## 1.2 The Problem of the Research

An analytical study prepared by the Palestine Investment Fund (PIF, 2010) about the housing and real estate market in Palestine indicates an increase in the demand for housing units caused by an increase in the natural population growth in the Palestinian territory, reaching up to 3.3% annually, and due to the fact that the Palestinian society is a youthful society. Sixty-five percent of the total population is under 25 years of age which leads to an increase in housing demand.

The study affirms that the current housing supply offered by the housing sector, which is 50% less than demand, does not meet the size of demand. The study also noted that 70% of the population wishes to own adequate housing, but according to the current market terms, most of the available housing exceeds the financial means of Palestinian households. Three quarters of Palestinian households can't afford purchasing even the lowest priced housing.

The study results affirm that there are many and varied obstacles facing the development of the housing sector in Palestine. These obstacles

include the lack of basic infrastructure necessary for the development of large scale housing projects, the inability of local developers to secure sufficient capital to finance large scale developments, the small size of land allowed for the establishment of housing projects and their high prices, and rising construction costs and relatively low income level (PIF, 2010).

Other related publications are published in the Conference of the Palestinian Reality and Adequate Housing, Dec 2010. The conference has identified the most relevant issues in the housing sector, and confirmed that the housing development is of central concern to the Palestinian National Authority (Fayyad, 2010).

To achieve such development, the sector needs the reduction of the construction costs which in turn depends on the construction techniques. However, cutting down the construction costs should not be on the account of the quality of the unit and the project as a whole.

**1.3 Significance of the Research**

This research derives its importance from the importance of the subject of study; the concept of decision making is of the most important management concepts that are well received and widespread in the recent years. This research looks in particular to study the decision making in the selection of the proper construction techniques in order to obtain affordable quality housing. Such a study will provide a mechanism to evaluate the construction techniques and development of the housing sector.

## 1.4 Objectives of the Research

This research aims mainly to work to improve the level of housing projects in Palestine through the selection of the proper construction techniques in terms of cost of construction, strength and durability, aesthetics, etc.

This will be achieved through:

- Review of construction techniques currently used in Palestine and knowledge the pros and cons of each.
- Develop a mechanism to evaluate these techniques and be judged by reference to identified decision criteria.

## 1.5 Methodology

For the purposes of this research the following data collection methods have been used:

- Desk research/ Internet research: which is based on library books, journals databases and web based resources largely designed to review existing literature and publications on the concept of decision making in the selection, and to review all housing sector studies and reports recently completed in Palestine.
- The questionnaire approach has been chosen in this research in order to achieve research quantitative and qualitative purposes. The questionnaire evaluates construction techniques through answering what, why, and how questions. Then a mathematical model was

formulated in order to measure the relation between questionnaire outputs.

- The case study approach has been chosen in this research in order to achieve research quantitative purposes; a housing unit has been taken as a case study in order to estimate the actual cost per meter square for each technique.

- In addition the qualitative approach has been used by executing some direct interviews. Field visits to concerned parties to conduct recorded interviews with officials to get the data concerning construction techniques and unstructured interviews with contractors who are responsible for conducting construction projects.

**1.6 Research Output**

This research is conducted on the construction techniques in order to evaluate them and make decision in the selection of the proper construction techniques in order to obtain affordable quality housing. The output of this research can be summarized in the following:

- Clarifying the current situation of housing sector and construction sector in research environment.

- Developing a mechanism to evaluate the construction techniques used in research environment and be judged by reference to identified decision criteria.

- Guidelines to help build homes at a lower cost with higher quality and energy efficiency.

- Contributing to the process of choosing housing projects to be funded and implemented. This can be the basis of development required in this sector.

## 1.7 Thesis Outline

The thesis will be formed from six chapters. **The introductory chapter**, which outlines the nature of the study, and presents an overview about the reality of housing in Palestine and the need for development. **Chapter 2** will review the related literature of the building and construction industry, construction techniques and related topics. **Chapter 3** will present an overview about the decision making process. **Chapter 4** will outline the methodology followed in the study. **Chapter 5** will discuss data gathering and analysis issues. Finally, **Chapter 6** will present the study's summary, conclusions and recommendations.

# Chapter Two

# Building and Construction Sector

# Chapter Two
# Building and Construction Sector

## 2.1 Introduction

Building and construction constitutes the backbone of the various development policies which have either a negative or positive impact on the different development sectors. At the Arab level, the building and construction industry has achieved high development rates. Yet, in spite of such development, the economic and technical importance of this industry has not received the due attention due to the absence of any link within the Arab market, and the lack of integration and unity in the industry per se, being scattered in small country-based frameworks. Therefore; it can't properly contribute to development unless it becomes an integrated system.

In this chapter, the status of the building and construction industry in the Arab Region, building and construction sector in Palestine, building materials industry in Palestine, and finally the construction techniques in Palestine will be explain.

## 2.2 Status of the Building and Construction Industry in the Arab Region.

The building and construction sector is vital to the economy, as it is diversified and covers several fields that are interrelated with the various sectors of economy. Building materials constitute the major elements in the buildings costs, ranging between 64% and 67% of the basic cost of any

building. Thus the increase in its cost consequently leads to the increase in the cost of buildings (League of Arab States, 2005).

### 2.2.1 Building Raw Materials and Industry

Raw materials for building industry are abundant in the Arab world in varying quantities, types and levels of quality, to satisfy all the buildings needs. These resources are usually found very close to urban areas, to infrastructures and utilities; thus facilitating the utilization of and reducing the cost of processing such materials.

Manufactured building materials may be divided into two categories: local and imported. Most Arab countries encourage the local building materials industries to reduce the cost of building and limit dependence on imported materials.

In spite of the widely spread use of manufactured building materials in the Arab world, yet some do not cover the needs of the building and construction industry in the region, such as metal products, and glass.

### 2.2.2 Building and Constructions Techniques

Building and construction technologies represent the effective solution to meet the ever increasing demand on quality, together with finalizing major projects on time, increasing the productivity of these materials, and maintaining high levels of vocational safety at the construction sites. Compared to other economic sectors, the building and construction sector is characterized by the huge number of workers (being a

labor intensive industry). The decision to use advanced building and construction technologies is affected by feasibility studies, which are manifested in the comparisons in the cost of employing highly skilled labor, modern technologies and equipment that require more or less intensive capital; particularly at the early stages of application of these technologies and the specific requirements of the project.

This is perhaps why some companies prefer capital intensive investment in advanced building technologies while reducing the dependence on labor, while other companies prefer dependence on the available labor and reducing investment in modern technologies. But with the high need to expedite the carrying out of projects, especially those of the infrastructure, and with the increasing demand on quality requirements, there is larger tendency towards resorting to technologies that fulfill these objectives. Partnerships between major Arab and foreign companies in the carrying out of giant projects (such as tunnels and sewage plants) represent another additional and effective means of transferring modern building and construction technologies to the Arab world (League of Arab States, 2005).

## 2.3 Building and Construction Sector in Palestine

### 2.3.1 Palestine at a Glance

**Geography**: The location of Palestine is at the eastern coast of the Mediterranean Sea. Palestine is located to the south of Lebanon and to the west of Jordan. Palestine is component from two geographically separated

entities, West Bank and Gaza Strip. The West Bank has an area of 5860 km2. Distances are limited; less than 60 km at the widest point east to west and about 130 km where the distance north to south is the longest. Topographically the West Bank is defined as a mountainous area with a maximum elevation of 1022 above mean sea level. It also includes the lowest point in the World, the Dead Sea, at 408 m below sea level.

**Population**: Palestine has a large and rapidly growing population. By the end of 2010, about 4.1 million Palestinians were in the Palestinian Territory, of which 2.5 million were in the West Bank and 1.6 million in Gaza Strip. In the Palestinian Territory, two thirds of Palestinians live in the West Bank while one third in Gaza Strip. Of every 100 person in the Palestinian Territory, about 44 are refugees, of whom 18 live in the West Bank and 26 in the Gaza Strip (PCBS, 2010).

**Rule:** Administratively, the West Bank and Gaza Strip are divided into 11 and 5 governorates, respectively. After 1967, the West Bank and Gaza Strip came under the Civil Administration of the Israeli military. However, this situation changed as a result of the peace process that started in 1990 between the Palestinians and the Israelis and the Oslo Interim Agreement that was signed in 1993.

The Oslo Agreement divided the West Bank and the Gaza Strip into three areas: A, B and C. Area A corresponds to all major population centers, where the PNA has full responsibility for both civilian and security matters, including land administration and planning.

Area B encompasses most rural centers, in which the PNA is responsible for civilian affairs, again including land administration and planning, with security under joint PNA and Israeli military responsibility, although in reality today security for all the parts is controlled exclusively by the Israeli military. The territorial space of Areas A and B is not contiguous, and consists of some 227 separate geographical areas under partial or full Palestinian control. Area C, which covers the entire remaining area, is the only contiguous area of the West Bank, and includes most of the West Bank's key infrastructure, including the main road network. Area C is under full control of the Israeli military for both security and civilian affairs related to territory, which includes land administration and planning. It is sparsely populated and underutilized (except by Israeli settlements and reserves), and holds the majority of the land (World Bank, 2008).

**The economic aspect**: The Palestinian economy in the West Bank and Gaza Strip still suffers from the cruel policies and practices of the Israeli occupation. This has been attained through the policy of closure, which broadly consists of comprehensive restrictions on the movement of people and goods within the West Bank, highly constricted movement of goods across the border with Israel, almost total isolation of the Palestinian economy from the outside world, both at the Arab and international levels, except, however, for some extremely limited transactions. Hence, the one and only one option left for the Palestinian economy was to be directly dependent on the Israeli economy.

The Palestinian Central Bureau of Statistics (PCBS, 2010) indicates the following:

- The Gross Domestic Product recorded an increase by about 9% during the three quarters of 2010 compared with the same period of 2009. The growth was concentrated in economic activities with largest share to the Gross Domestic Product mainly agriculture and fishing, construction, wholesale and retail trade, transport, storage and communications, services, and public Administration. The construction activity recorded the highest growth rate during that period by about 36%.

- An Increase in the number of workers during the first three quarters of 2010 compared with the same period of 2009 due to the increase in the number of workers in the construction, industry, and services sectors in the Palestinian Territory.

- Regarding trade movement in Palestine (the total exports and imports), there was an increase during 2010 in revenues of the Value Added Tax related to trade exchange with Israel. In 2010, exports increased by 8% compared with 2009, while imports increased by 6% compared with 2009.

**Climate:** The climate of the Palestinian Territories is influenced by the Mediterranean climate where long, hot, dry summer and short, cool, rainy winter climate conditions prevail. Climatic variations occur in the different topographical regions. Though relatively small in area, the West

Bank enjoys diverse topography, soil structure and climate conditions (Hadid, 2002). The West Bank is relatively arid, with about 50% of the land having a rainfall less than 500 mm/year, including hyper-arid area with a rainfall less than 100 mm/year. However, the remaining land has a rainfall range of 500-800 mm/year and 100-400 mm/year in Gaza.

### 2.3.2 Building Laws in Palestine

After Oslo agreement, Palestinian National Authority has modified building laws and by-laws, the previous laws that were acting are the Jordanian in the West bank and the Egyptian in Gaza Strip, and not to forget the Israeli laws and by-laws that were affecting whole planning process for community and urban developments. The modification made after Oslo agreement were to organize the building process and didn't make any dramatic change especially in the building codes issues. These are temporary laws and by-laws.

Laws and by-laws are key words in studying the modern architecture after the second half of the 20th century. Classifications of buildings according to the function, the building materials, the set back line, height of the building, number of floors and built up area were determined in the laws according to the classifications of the land. In some West Bank areas the outside shape of buildings must be from stone with its natural color and not more than 20% of the facades can be from different materials (concrete). Some exceptions can be made after having special approval from local or regional authorities, (according to article 9). This has affected

the building materials and details in most of the rural and urban developments except in the refugee camps. In Gaza Strip areas concrete replaced the stones since it is not a local material, plaster and paint are the finishing materials if not stone (Hadid, 2002).

### 2.3.3 Building and Construction Industry in Palestine

The building and construction industry is one of the leading economic sectors in the West Bank and Gaza, not only for its substantial contribution in the Palestinian Gross Domestic Product and in employment, but also for its strong interrelations with other economic activities. The construction of buildings, in particular, comprises a significant part of construction activities as a whole. Residential buildings make up the bulk of investments.

A survey by the Palestinian Central Bureau of Statistics indicated that the value of constructing new buildings and additions in the Palestinian Territory rose by 23.2% in 2010. The results of the survey indicated that the value of constructing new buildings and additions in the Palestinian Territory in 2010 was US$657 million, with $299 million spent on new constructions and $358 million spent on additions of vertical or horizontal construction. Unfinished construction accounted for $374 million and finished construction for $283 million(Wafa,2011).

The above results also indicated that the cost of current maintenance on existing buildings increased by 17.7% in 2010 as compared to 2009,

while the cost of capital additions repairs and improvements on buildings increased by 43.6% for the same period.

There have been serious attempts comes in response to the problem of ever growing demand and insufficient supply of housing units in the Palestinian real estate sector. Therefore, housing has been considered the most important challenge facing the Palestinian National Authority. Where the housing problem in Palestine is increasing day after day, Palestinian National Authority is trying to find solutions to this problem through the establishment of urban communities, but the availability of housing in it is inadequate in terms of quantity.

## 2.4 Building Materials Industry in Palestine

The building material is any material used for a construction purpose. Building materials can be generally categorized into two sources, natural and synthetic. Natural building materials are those that are unprocessed or minimally processed by industry, such as lumber or glass. Synthetic materials are made in industrial settings after much human manipulations, such as plastics and petroleum based paints. Both have their use. In general stone are used as basic structural components in these buildings, while mud is used to fill the space in between, acting as a type of concrete and insulation (Wikipedia, 2010).

Building materials industry in Palestinian Territories still doesn't cover all the requirements of local market and imports make up the

balance. All materials used in construction industries are purchased from Israel or other countries except those related aggregate and stone. The stone cutting industry in the West Bank is the largest construction industry and has a great influence in gross domestic product. Concrete blocks used in construction of the walls and ceiling slabs of the buildings are locally produced from local materials.

There is a lack in cement industry which forms a major part in building construction, as a result of the present difficult situation of preventing the supply of basic construction materials such as cement, steel, and other materials and not allowing their entry to the Palestinian areas through control of the border checkpoints by Israel (ECB Studies, 2002, B).

### 2.4.1 The Main Building Materials Used in Palestine

In general, the main materials used in construction in Palestine are concrete, stone, hollow concrete blocks, steel, aluminum, wood and other complementary materials. These kinds of building materials can be used individually or together with each other to form the structure of buildings (ECB Studies, 2002, A). The first use for steel was in roofs, using the solid concrete slab and steel (I Beam section) changed the roofing systems, which have been used and turned the roofs into flat roofs, with the possibility to have cantilevers, balconies and decorative elements. Besides the changing in the roofs' systems, by the second half of the 20th century steel started to be used as structural element for walls and different steel sections and bars were found as building materials. This changed the

techniques of construction building system from a bearing wall system into a skeleton system (the columns). The cement displaced the lime, and with steel it started to be not only the binding material, but also a structural element especially with steel.

With cement and steel the techniques of building walls had been changed and the stone was not any more structural element as in the traditional architecture. Even though stone is still used in most of the buildings in the West Bank Areas and some of the building in Gaza Strip area, it is only a cover material for the facades (see Figure 2.1).

**Figure (2.1): Building with stone. Source: (The researcher, 2010)**

Hollow blocks made from cement and aggregates were used as main building material especially in refugee camps (for economical reasons), and plastered from both sides in West Bank and Gaza Strip areas. In concrete hollow block walls painting for both sides of the walls (see Figure 2.2) is always found in Gaza Strip area, Jordan valley and refuge camps.

**Figure (2.2): Concrete hollow block building. Source: (The researcher, 2010)**

In exceptional cases no colors of external walls, leaving natural color of the plaster (concrete color) as the final layer. Light colors are most colors used in paint such as white color is the traditional color for external and internal, it came from the color of lime, new colors are taking place last years but still in the range of light color with different reflection effects.

In Palestinian architecture there is no calculation or scientific methods that recommended the light color but it is known spontaneously that light colors do reflect light around and can help in reducing heat gain in summer (Hadid, 2002). Most of the buildings in the West Bank Areas consist of exterior walls constructed from stone, concrete, hollow concrete blocks and plaster, and interior walls are constructed of concrete blocks (see Figure 2.3).

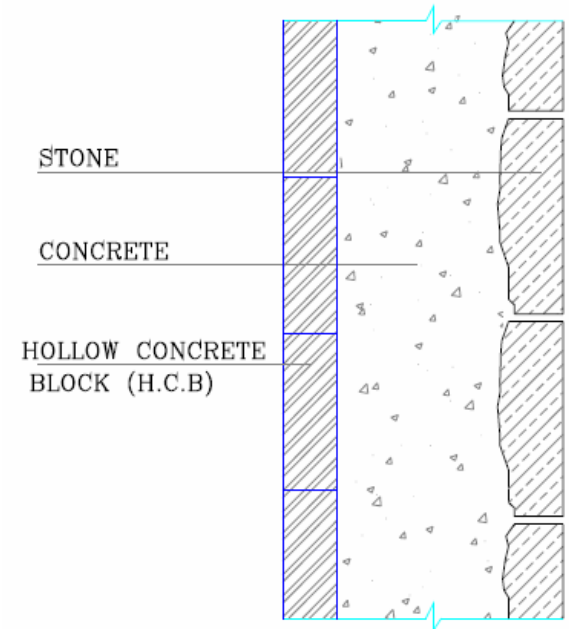



**Figure (2.3): An example of the traditional construction materials used for the exterior walls in WB. Source: (ECB Studies, 2002, B)**.

### 2.4.1.1 Stone

Building stone is obtained by taking rock from the earth and reducing it to the required shapes and sizes for the construction of residential houses and public buildings (see Figures 2.4).

**Figures (2.4): Stone for building. Source: (The researcher, 2010)**

The vast majority of these quarries are concentrated in the Hebron area, which is also known for using the most modern and sophisticated

machinery for extracting stone and for producing stone that has minimal defects, a good color and a uniform texture (ECB Studies, 2002, B). Table 2.1 shows the specifications and uses of major stone types in Palestinian lands.

**Table (2.1): Classifications of Major Types of Stones Used in West Bank and Gaza**

| Stone Type | Source | Classifications | Specifications | Uses |
|---|---|---|---|---|
| Injasah | Hebron-Bini Na'em | It is classified into four major categories: Asfar, Sid, Ardi, Sous | The "Ardi " type is the best one. White color, veined, different colors, hard, minimal absorption water | "Chiseled" for building, polished stone, paving sidewalks, decorative public places |
| Jarra'ah | Nablus | Band60, and Band 40 | Usually gray, minimal absorption water, veined, hard, uniform color | building, paving, decorative public places |
| Aseerah | Nablus-Aseerah | Band60, and Band 40 | White, minimal absorption water, hard, uniform color | Building (all sides), paving, decoration |
| Al Shyoukh | Hebron-Al Shyoukh | Asfar, Sid, Ardi | White color, absorbs water, hard, not uniform color | building, paving, decorating public places, renovating ancient places |
| Tafouh | Hebron-Tafouh | Bind Asfar, Ardi | Beige color, soft stone, absorbs water, not uniform color | Paving, polished stone, decoration |
| Samouh | Hebron-Samouh | Asfar, Ardi | Different colors, hard, minimal absorption water | Building, paving, decoration |
| Qabatya | Jenin-Qabatya | Bind Awal (cover), Bind Ardi | Different colors (almost beige), absorbs water, color is changeable with time, hard stone | Building, paving |
| Yatta | Hebron-Yatta | Bind Asfar, Ardai | White color, hard, almost uniform color, absorbs water | Building,Paving, polished, decoration |

**Source: The Union of Stone and Marble in Palestine**

Table 2.2 shows the properties of major types of stones used in West Bank and Gaza

**Table (2.2): Properties of Major types of Stones Used in West Bank and Gaza**

| Stone Type | Density Kg/m³ | Thermal Conductivity (W/m.c°) |
|---|---|---|
| Injasah | 2200 | 1.53 |
| Qabatya | 2580 | 2.23 |
| Aseerah and Jameen | 2650 | 2.60 |
| Samouh | 2500 | 2.20 |
| Tafouh | 2000 | 1.40 |

**Source: The Union of Stone and Marble in Palestine**

### 2.4.1.2 Cement

The cement industry is considered in all universe countries as one of the strategic industries, the cement represents a great importance in the projects of the construction, reconstruction and development on both levels as the specific levels and the general ones. This industry in Palestine has a special importance in this time in particular where the Palestinian society passes in construction stage and increasing population which increases the demand on cement.

The Palestinian market gets all its needs from cement by means of the import where the imported quantity spreads according to the source as follows: Israel 80% ، Jordan a 9% ، Europe a 6% ، Egypt 5% (ECB Studies, 2002, B).

### 2.4.1.3 Concrete

Concrete is widely used in all types of construction. Communities around the world rely on concrete as a safe, strong and simple building material. It is used in all types of construction; from residential houses to multi-storey office buildings and shopping complexes. Concrete is made by

mixing: Cement, water, coarse and fine aggregates, admixtures (if required) (see figure 2.5).

The aim is to mix these materials in measured amounts to make concrete easy to: transport, place, compact, finish and which will set, and harden, to give a strong and durable product.

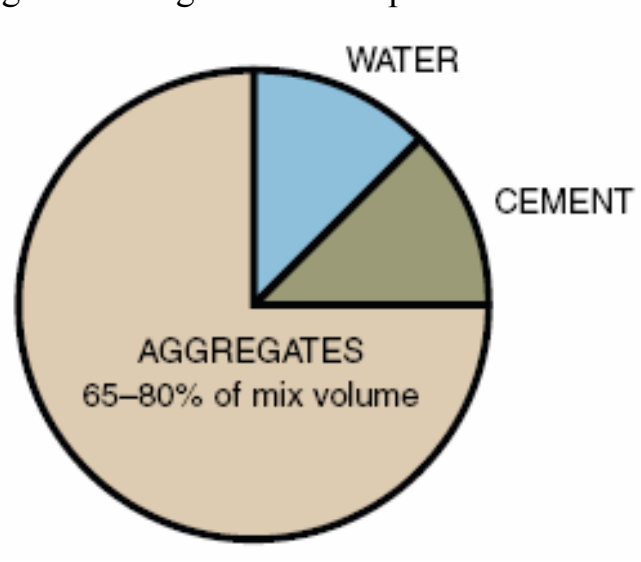



**Figure (2.5): Concrete components.**
**Source: (Aashiq, 2010).**

The amount of each material (i.e. cement, water and aggregates) affects the properties of hardened concrete (Aashiq, 2010). The use of concrete will lower insurance costs by virtue of its high resistance to fire. Concrete floors and walls reduce the transfer of noise, yielding a quieter environment and happier occupants.

## The Forms of Concrete

Concrete is produced in different forms, each with unique applications and properties. Ready mixed concrete, Pre-cast concrete, Concrete Blocks are some of these forms.

**1- Ready mixed concrete**

Ready mixed concrete, by far the most common form of concrete, accounts for nearly three-fourths of all concrete. Ready mixed refers to concrete that is batched for delivery from a central plant instead of being mixed on the job site. Each batch of ready mixed concrete is tailor-made according to the specifics of the contractor (ECB Studies, 2002, B).

**2- Precast concrete**

According to Svetlana Brzev and Teresa Guevara (1999) the concept of precast (also known as "prefabricated") construction includes those buildings where the majority of structural components are standardized and produced in plants in a location away from the building, and then transported to the site for assembly. These components are manufactured by industrial methods based on mass production in order to build a large number of buildings in a short time at low cost (Brzev and Guevara, 1999).

ECB Studies 2002 indicated that these products benefit from tight quality control achievable at a production plant. Pre-cast products range from concrete bricks and paving stones to bridge girders, structural components, and panels for cladding.

There are two types of pre-cast products: Standard products such as beams, decks. The other type of product is a specialty product, designed especially for the building, bridge, or structure where it will be used (see figure 2.6).

**Figure (2.6): Precast concrete wall panels**.
**Source: (Whited, Christopher, 2011)**

## Precast concrete advantages:

Precast concrete allows for ease in customization as well as reliability and consistency of manufacturing techniques and this definitely distinguishes them from other building systems and more traditional methods. In addition it is characterized by: fire and hurricane resistant, high quality, durable, energy efficient, cost effective, low maintenance. The New Encyclopaedia Britannica (1989) indicated that the main features of this construction process are as follows:

- The division and specialization of the human workforce
- The use of tools, machinery, and other equipment, usually automated, in the production of standard, interchangeable parts and products.

In the Palestinian territories there is no production plant for precast concrete wall panels. This technique began to be used in the Palestinian territories by The United Group for Construction and Building Technology which import light-weight concrete insulated wall panels from Jordan (Jayyousi, 2011). These wall panels can be used as external walls and internal walls (See Figure 2.7).

**Figure (2.7): External walls and internal walls from concrete wall panels.**
**Source: (Jayyousi, 2011).**

This technique began to be used in Palestine; table (2.3) shows the projects used the concrete wall panels in Palestine. This technique helps in developing the methods of construction to cut down the production cost in other countries but in research environment the infrastructure of this technique is not ready and need skilled workers for installation, changing the culture of people to adopt this new technique also needed. These panels hinder the architectural freedom and versatility.

**Table (2.3): Projects used the concrete wall panels in Palestine**

| Name | Project Description | Quantity SQM | Address |
|---|---|---|---|
| Unipal Distribution Center | Distribution Center/ Used as External walls for steel structure building | 4,000 | Ramallah |
| Palestine Academy for Security Science | Police Academy/ Used as Internal and External walls behind natural stones | 20,000 | Jericho |
| Al- Ghadeer Housing Project | Residential Building/ Used as Fence, Internal walls and External walls behind natural stones | 90,000 | Ramallah |
| Al- Rayhan Center | Commercial Building/ Used as Internal walls | 3,000 | Ramallah |
| Qreetemco. | Residential Building/ Internal walls | 200 | Ramallah |
| Bank of Palestine | Bank/Internal walls | 100 | Nablus |

**Source: (Jayyousi, 2011).**

## Concrete blocks

Concrete masonry has become a standard building material. This type of building material is widely used in both the residential and commercial construction industries (see Figure 2.8). Concrete blocks create structures that are economical, energy efficient, and fire-resistant.

**Figure (2.8): Concrete blocks wall**

In addition, concrete masonry allows architectural freedom and versatility. Concrete masonry homes are traditionally popular in Gaza strip and refuge camps (ECB Studies, 2002, B).

The standard concrete block is a rectangular unit made mainly of portland cement, gravel, sand, and water. The concrete mixture may also contain ingredients such as air-entraining agents, coloring pigments, and water repellent. Concrete block is a masonry unit, usually with single or multiple hollows, made of following ingredient: water, portland cement, blended cements and various types of aggregates such as sand, gravel, and crushed stone. Aggregates are generally designated as fine or coarse. There are three types of concrete blocks: (1) Hollow load bearing (2) Hollow non-load –bearing (3) Solid load bearing. The term "concrete block" was formerly limited to hollow masonry units made with aggregates such as sand, gravel, crushed stone, but the term today covers all types of concrete block, including solid units, made with any of the various kinds of aggregates. The weight and texture of concrete block depends largely on the type of aggregate used in its manufacturing. Blocks made with sand and gravel and crushed stone weighs from 18-22 kg .These blocks are strong and durable, with a low absorption rate. Table (2.4) shows Thermal Resistances Values of Various Dimensions of Concrete Blocks with Different Densities (ECB Studies, 2002, B).

**Table (2.4): Thermal Resistances Values of Various Dimensions of Concrete Blocks with Different Densities**

| Unit Dimension of the Block (cm). (Width X Length X Thickness) | Weight (Kg) | Density ($Kg/m^3$) | Thermal Conductivity ($W/m.c^o$) | Thermal Resistance ($m^2.c^o)/W$ |
|---|---|---|---|---|
| H.C.B 40X20X20 | 18 | 1125 | 0.52 | 0.38 |
| H.C.B 40X20X20 | 21 | 1350 | 0.62 | 0.32 |
| H.C.B 40X20X20 | 14 | 875 | 0.46 | 0.43 |
| H.C.B 40X20X15 | 16 | 667 | 0.45 | 0.33 |
| H.C.B 40X20X10 | 11 | 1375 | 0.63 | 0.15 |
| H.C.B 40X20X7 | 8 | 1428 | 0.70 | 0.10 |
| H.C.B 40X20X7 | 9 | 1607 | 0.74 | 0.09 |

**Source: (Palestine Standard Institution (PSI), 2002)**

## 2.5 Construction Techniques in Palestine

Building techniques in West Bank and Gaza strip are influenced by the materials available domestically as well as techniques in neighboring countries. The following construction techniques will be evaluated in this research:

### 2.5.1 External reinforced concrete walls with natural stone cladding

This system is used in many areas in Palestine, because of its capacity to resist seismic forces in addition to the carrying of the vertical forces. Natural stone units are built in courses after the casting of the reinforced concrete walls.

**Figure (2.9): External reinforced concrete walls with natural stone cladding.**

Steel mesh is placed on the face of the reinforced concrete wall before placing and building the stone units. Steel ties are usually used to tie stone units with the steel network (see figure 2.9). Backing concrete is cast between the reinforced concrete wall and the stone courses (Abdel-Karim, 2000).

### 2.5.2 External reinforced concrete walls with cast stone cladding

This system is very similar to the previous system. But cast stone units are built in courses after the casting of the reinforced concrete walls instead of natural stone units. Cast stone is very similar to natural stone in terms of external appearance (see Figure 2.10), and no less quality (**see Appendix L**, Cast stone specifications).

Hawash's Sons Cast stone company indicated that the cast stone manufacturing using treated concrete which takes the features of natural

stone and details in terms of color, shape and properties. In addition there are other features of cast stone: (1) Homogeneity of color where the color of the unification of up 90% - 100%. (2) The price of cast stone less than natural stone by 50-70%. (3) Production of stone in different colors, (On request). (4) Consistency with the building in term of expansion and contraction of more than natural stone. (5) Lightness in total weight relative to the natural stone (Hawash's Sons Cast stone company, 2011).


**Figure (2.10): Building with cast stone**

### 2.5.3 Slab-beam-column system with exterior masonry walls of stone backed by concrete.

This system was used extensively in Palestine where dimensioned stone was built in regular courses, and then wood forming was placed behind it at a certain distance, after which concrete was poured between the wood forming and the dimensioned stone courses (see figure 2.11).

In this system no more than three stone courses are allowed to be built before the pouring of concrete behind them takes place. The backing concrete should be workable so that it will be placed between the stone and the form without producing cavities or honeycombs in the wall (Abdel-Karim, 2000).

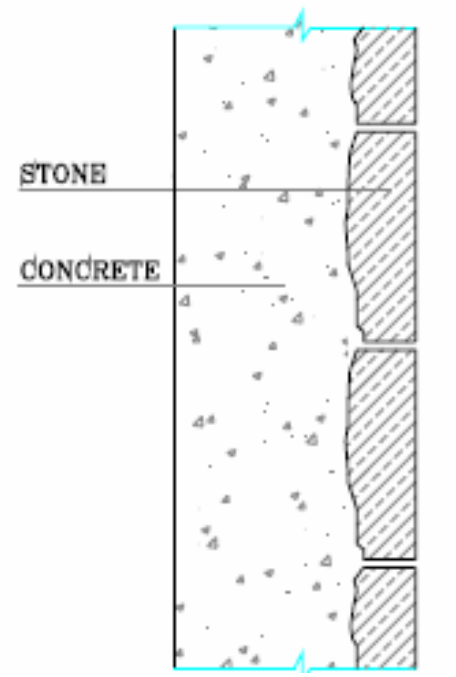



**Figure (2.11): Exterior masonry wall of stone backed by concrete**
**Source: (ECB Studies, 2002, B).**

### 2.5.4 Slab-beam-column system with exterior walls built from concrete, stone and concrete block.

This system is widely used in many areas in Palestine, because of its simplicity in construction and its thermal insulation properties. In this system the stone courses are built by placing the stone units in their places and by laying the cement mortar on the sides of the stone units, having into consideration the maintaining of the uniformity of the thickness of the

joints between the stones. Concrete block wall is built behind the stone wall keeping a sufficient distance between the two walls for concrete to be poured in this space. No more than three courses of stone are built before concrete is poured, to make sure that stone units will not be pushed out by the lateral pressure resulting from the pouring of concrete(see Figure 2.12).

**Figure (2.12): Exterior walls built from concrete, stone and concrete block.**
**Source: (Abdel-Karim, 2000).**

The reason for building the concrete block wall behind the stone masonry wall is to use it as a substitute for the wood form that is used behind the concrete backing and to reduce the amount of the backing concrete in addition to the increase of the thermal insulation capacity of the wall (Abdel-Karim, 2000).

### 2.5.5 Slab-beam-column system with exterior walls built from concrete, stone and concrete block and insulating material between them.

This system is similar to the previous system in terms of wall components, but to increase the insulation capacity of the wall an insulating material like polystyrene is added (see Figure 2.13). This system is widely used in Palestine although it is not simple in construction.

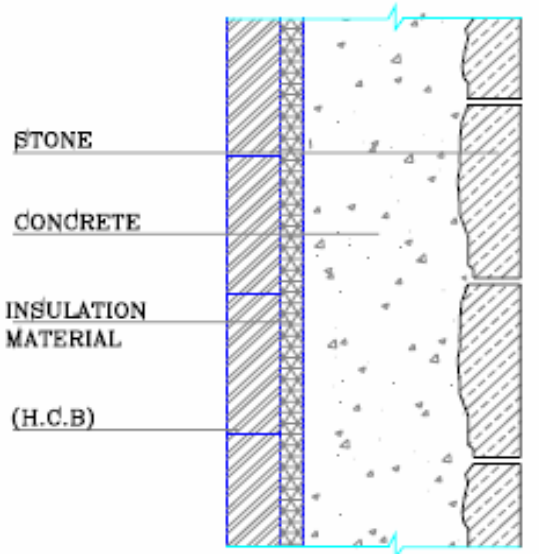



**Figure (2.13): Exterior wall built from stone, concrete, concrete block and insulating material between them.**

**Source: (ECB Studies, 2002, B).**

There are two methods for its construction:

**First,** after stone building with concrete backing, a concrete block wall of 7-10cm thickness is built behind the stone wall leaving a space to place insulating material between the two walls (see Figure 2.14), but "the division of the wall into two parts will certainly weaken the strength of the wall" (Baba', 2004).

**Figure (2.14): Insulating material between the two walls**

**Second,** the stone courses are built by placing the stone units in their places and by laying the cement mortar on the sides of the stone units, having into consideration the maintaining of the uniformity of the thickness of the joints between the stones. Concrete blocks wall is built behind the stone wall keeping a sufficient distance between the two walls to place insulating material like polystyrene plates and concrete be poured besides the polystyrene plates," but this leads to broken parts of the plates or leakage of concrete between the different plates, and this reduce its insulation capacity" (Baba', 2004).

There is other technique, in which a concrete block wall of 7-10cm thickness is built behind the stone wall with 5cm cavity in between; (as shown in figure 2.15).

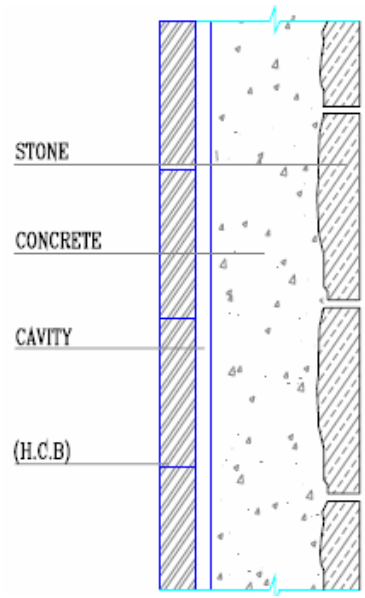



**Figure (2.15): Exterior wall built from stone wall, concrete block wall with 5cm cavity in between.**

**Source: (ECB Studies, 2002, B)**

### 2.5.6 Slab-beam-column system with exterior masonry walls built from light weight units with stone cladding.

In this system a lightweight block are used instead of concrete blocks (see Figure2.16). Lightweight blocks have high thermal resistance in comparison with concrete blocks. Despite the advantage that this system has in thermal insulation, it has a disadvantage in the tendency of the lightweight blocks in absorbing water.

Lightweight blocks are built using special mortar different from that used in building concrete blocks. After lightweight blocks are built, the outside face is sprayed by a light cement mortar of a thickness no more than 1cm to prevent the lightweight blocks from absorbing the water available in the backing concrete mix.

**Figure (2.16): Exterior wall in which stone units are built backed with lightweight blocks.**

**Source: (Abdel-Karim, 2000).**

The tendency of the lightweight blocks in absorbing water causes cracks in the interior plaster and makes the process of tiling the inside face of the with cermic tiles difficult, because of the need for spraying the lightweight blocks with cement mortar before the tiling process (Abdel-Karim, 2000).

Lightweight blocks are not widely used in Palestine because it has high cost in comparison with concrete blocks and it considers Israeli product and Engineers Association boycott Israeli products.

### 2.5.7 Slab-beam-column system with concrete blocks exterior walls.

This type of buildings is widely spread in West Bank villages and Gaza Strip territories and to a small scale in West Bank cities. It is

commonly used in the construction of residential and public buildings. Reinforced concrete skeleton is constructed and then walls are built of concrete blocks between the columns as shown in Figure 2.17.

**Figure (2.17): Exterior walls built from concrete blocks.**

**Source: (The researcher, 2011)**

**For insulation**, there are different techniques used:

- Adding a wall of 7cm thick hollow concrete blocks with 5cm cavity in between; as shown in Figure 2. 18.

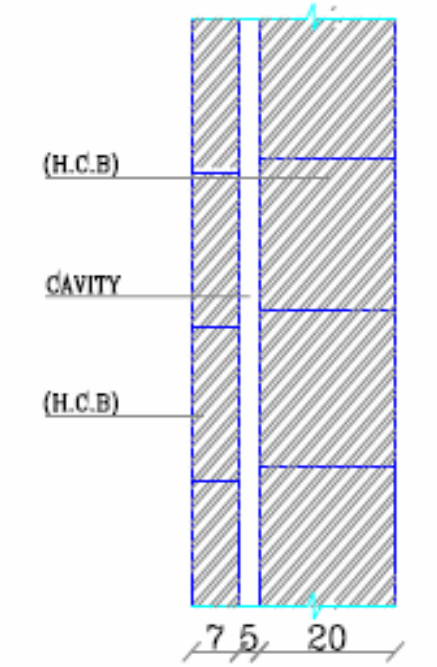



**Figure (2.18): Exterior wall built from two walls of concrete blocks with 5cm cavity in between.**

**Source: (ECB Studies, 2002, B)**

- Adding a wall of 7cm thick hollow concrete blocks with insulation materil in between, as shown in Figure 2. 19.

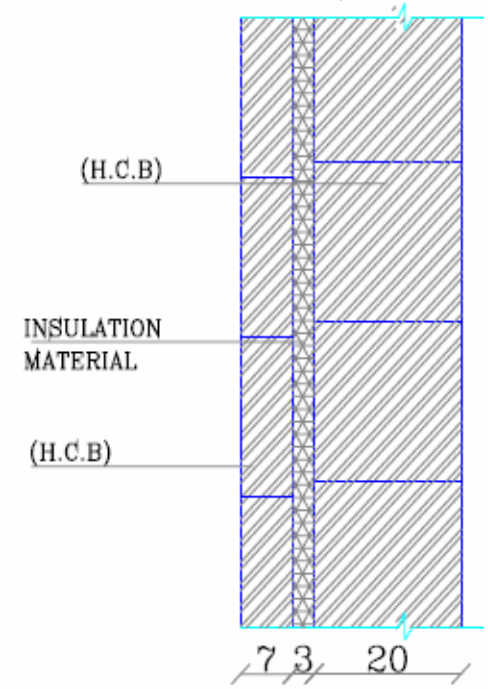



**Figure (2.19): Exterior wall built from two walls of concrete blocks with polystyrene plats layer in between.**

**Source: (ECB Studies, 2002, B)**

# Chapter Three

# Decision Making Mechanism

# Chapter Three
# Decision Making Mechanism

## 3.1 Introduction

All human beings are faced with certain situations in their everyday life, where they need to take important decisions. However, decisions that are made without any planning have a risk of leading to failure. To avoid such problems, it is necessary to take decisions in an organized way.

## 3.2 Decision making definition

A good place to start is with some standard definitions of decision making. Harris (2009) defined decision making as" the study of identifying and choosing alternatives based on the values and preferences of the decision maker". Making a decision implies that there are alternative choices to be considered, and in such a case we want not only to identify as many of these alternatives as possible but to choose the one that (1) has the highest probability of success or effectiveness and (2) best fits with our goals, desires, lifestyle, values, and so on.

Decision making can be regarded as" the mental processes (cognitive process) resulting in the selection of a course of action among several alternative scenarios. Every decision making process produces a final choice. The output can be an action or an opinion of choice" (Wikipedia, 2011).

## 3.3 Kinds of decisions

According to Harris (2009), there are several basic kinds of decisions. Those are:

1. Decisions “whether”. This is the yes/no, either/or decision that must be made before we proceed with the selection of an alternative. Decisions whether are made by weighing reasons pro and con. It is important to be aware of having made a decision whether, since too often we assume that decision making begins with the identification of alternatives, assuming that the decision to choose one has already been made.

2. Decisions “which”. These decisions involve a choice of one or more alternatives from among a set of possibilities, the choice being based on how well each alternative measures up to a set of predefined criteria.

3. Contingent decisions. These are decisions that have been made but put on hold until some condition is met.

Since this research aims at developing local criteria for evaluating construction techniques currently used in Palestine and selecting the optimum technique, the kind of decision is "decisions which". This decision has a scheme like this: ***decision which ... select criteria ... identify alternatives ... match criteria to alternatives ... make choice.***

## 3.4 Decision making techniques

There are several basic decision techniques available. In this research the concentrate is on analytical methods:

- Decision Making Model In Five Steps - This is a step by step methodology that guides one through the decision making process. Using the simple logical procedures, it will empower the decisions.
- Decision Matrix - A decision matrix helps to make a decision between different alternatives. one can use factors that are important. Each of these factors can be weighted, reflecting your feelings of their relative importance. This is an important tool that clears the fog from your decision making.
- SWOT Analysis ( strengths, weaknesses, opportunities and threats). This is a specialized decision making technique that is used primarily for business situations. Prospective on the decision making process is achieved by diagramming the strengths, weaknesses, opportunities and threats of the situation (Kartha, 2010).

In this research, decision matrix technique will be used to make a decision between different construction techniques.

### 3.5 Decision making process

The decision making process which is followed in this research is the process of generating decision criteria, and identify the alternatives to select from. In this process the following table will used to:

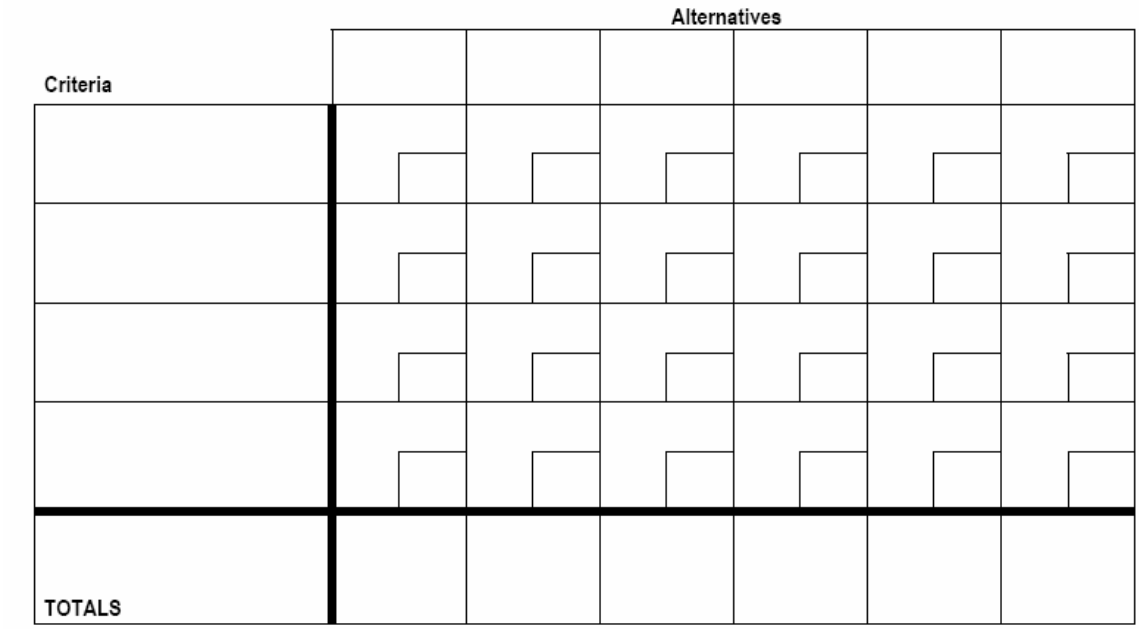
1. Identify a decision the researcher wish to make and the alternatives considering.

2. Identify the criteria that consider important.

3. Assign each criterion an importance score.

4. Determine the extent to which each alternative possesses criterion.

5. Multiply the criterion scores by the alternative scores to determine which alternative has the highest total points.




"Just making the decision and implementing it is not the end of the decision making process, it is very important to monitor your decision regularly. At this stage, you have to keep a close eye on the progress of the solution taken and also whether it has led to the results you expected" (Kartha, 2010).

# Chapter Four

# Methodology

# Chapter Four
# Methodology

## 4.1 Introduction

Housing is considered the most important challenge facing the Palestinian National Authority, where the housing problem in Palestine is increasing day after day in light of the steady rise in population and expected considerable number of returnees in the face of limited land and high prices of them, and rising construction costs and relatively low income level.

Success in providing affordable housing depends on several factors including the reduction of construction costs, which in turn depends on the construction techniques.

“The reduction in cost should not be on the account of the efficiency of construction, durability, and resistance to natural and geological factors, and other than that the idea of getting the house of a low-cost, regardless of the expected age and quality of construction is a short-sighted idea and a cheap solution in the present but a complex problem in the future” (Ismail, 2000).

This thesis aims at developing local criteria for evaluating construction techniques currently used in Palestine and selecting the optimum technique. According to An-Najah University’s Team of Consultants, (2009) “An optimization must be reached between safety,

serviceability, and economy to reach the minimum cost with the higher efficiency of the housing unit".

## 4.2 Research Background

### 4.2.1 Research Hypotheses

1. The production cost of housing units in Palestinian territory is considered relatively high in comparison with the affordability of the household to pay for buying a housing unit.

2. The construction techniques currently used in Palestinian housing projects are not satisfactory in terms of achieving cheaper housing construction or to cut down the production cost.

### 4.2.2 Research Question

What is the optimum construction technique that can be used in the research environment – Palestine- with regarding to its special conditions?

### 4.2.3 Research Objectives

This thesis aims mainly to work to improve the level of housing projects in Palestine through the selection of the proper construction techniques in terms of cost of construction, strength and durability, aesthetics, etc. This will be achieved through:

- Review of construction techniques currently used in Palestine
- Develop a mechanism to evaluate these techniques

## 4.3 Research Methodological Approach

The research approach selection should be in accordance with the important decisions needed to be made. The research approach will not influence the research design, but it will give the researcher the opportunity to consider how each of the various approaches may contribute to the research design. It may also limit the study, allowing satisfaction of the articulated objectives and design to an approach which best satisfies the research's requirements (Creswell, 2003).

The research approach embraces the quantitative versus the qualitative. (Jackson, 1994) takes issue with this perception and contends that a researcher should not limit himself to a particular approach but, instead, should use a variety of approaches, if and when required by the study. This section will highlight some issues regarding the quantitative and qualitative research, their features, and the reason behind the selection of two approaches in this research.

### 4.3.1 The Qualitative versus the Quantitative Approach

#### 4.3.1.1 Quantitative Research

Quantitative research, according to Cornford and Smithson (1996), is research that "relies on developing metrics (numbers) that can be used to describe the phenomena (objects and relationships) under study". Quantitative research is a deductive process (i.e. logic based on rules, models, and laws), as indicated by Trochim (2002), which consists of

measuring and analyzing the relationships between variables. Quantitative research tells us how often or how many people act in a certain way, but it doesn't answer the question "why" (Denzin and Lincol, 2003). Different kinds of methods can be used for quantitative research such as field and laboratory experiments to investigate a research problem (Straub et al, 2004). Analysis of data collected in quantitative research is typically performed using statistical techniques to produce results which can then be used to prove or disprove the hypothesis underpinning the research (Easterby-Smith et al, 2002).

#### 4.3.1.2 Qualitative Research

Researchers in the field of social sciences realized the limitations of quantitative research for understanding situations which involve the complex interaction of human behaviors, interpersonal relationships, cultural transitions, economics and politics. Consequently, qualitative research has become increasingly favored, especially in the social sciences (Denzin and Lincoln, 2003). Qualitative research is "any kind of research that produces findings not arrived at by means of statistical procedures or other means of quantification" (Strauss and Corbin, 1990). The purpose of qualitative research is "to understand human experience to reveal both the process by which people construct meaning about their worlds and to report what those meanings are" (Hull, 1997). Table 4.1 provides a summary of the key typical differences between qualitative and quantitative research.

**Table (4.1): Comparison between qualitative and quantitative research**

| Qualitative | Quantitative |
|---|---|
| What is X | How many X |
| Inductive Process | Deductive Process |
| Sample is selective (non-random) | Sampling is random |
| Researcher looks for patterns and Concepts | Hypotheses and concepts are chosen before the research begins |
| Theories are developed or compares patterns with other theories | An instrument is used to measure the variables in the study |

**Source: Miles and Huberman (1994).**

## 4.4 Type of Sampling

There are two types of sampling; the purposive and random sampling. In the purposive sampling target people have some appropriate characteristics needed to get the required information and data (Zikmund, 2000). Also under this category of sampling, there are two kinds of purposive sampling; the judgment sampling and the quota sampling. Judgment sampling is used when a limited number or category of people have the information and data needed for research and study (Sekaran, 2003). Therefore, judgment sampling is selected to this study. In this research, the type of sampling is purposive, which according to Zikmund (2000) is a sampling technique in which selection of the sample is based upon some appropriate characteristic of the sample members, since the target group is specific (building contractor), as it is only these people who can provide the desired information.

In this research, a questionnaire was prepared to determine the criteria that influence the decisions for selecting the proper construction technique and to determine their overall importance in the decision making

process, and to evaluate the construction techniques by reference to these criteria. To achieve this, (81) questionnaires were distributed to selected local building contractors registered and classified at the Palestinian Contractors Union as first category. According to PCU (2011) "Classification of contractors is the most significant of the services provided by the Palestinian Contractors Union.

Contractors, classified according to their specialties, are divided into 5 categories (Roads, Buildings, Electro Mechanic, Water and Sewage, Public Works and Maintenance); each of which shall be subcategorized into several specialties and every category may have a grade from 1-5 (1 is highest)" (PCU, 2011). The building contractors have been chosen to form a representative research sample because the contractor plays a major role in conducting construction projects, by overseeing and managing construction projects.

According to the Palestinian Contractors Union the total registered and classified building contractors at the Palestinian Contractors Union are 419 companies in January 2011. Building contractors are classified into five classes, based on their capital, experience, achievements, and their technical staff. Table 4.2 shows the number of building contractors in each class.

**Table (4.2): Classes of building contractors companies in WB according to the Palestinian Contractors Union**

| class | First | Second | Third | Fourth | Fifth |
|---|---|---|---|---|---|
| **No. of contractor** | 81 | 94 | 89 | 76 | 79 |

According to the Palestinian Contractors Union, the first class that has been chosen as a representative research sample constitutes around 19 per cent of total building contractors companies in 2011. Table 4.3 shows Geographical distribution of the surveyed companies, and Figure 4.1 shows the percentage of those companies.

**Table (4.3): Geographical distribution of the surveyed companies**

| Governorate | No. of companies | Governorate | No. of companies |
|---|---|---|---|
| Nablus | 24 | Jerico | 2 |
| Ramallah | 22 | Beth lahemof | 8 |
| Tulkarem | 3 | Salfit | 1 |
| Jerusalem | 3 | Qalqilia | 2 |
| Hebron | 10 | Jenin | 6 |
| **Total: 81 questionnaires were distributed** | | | |

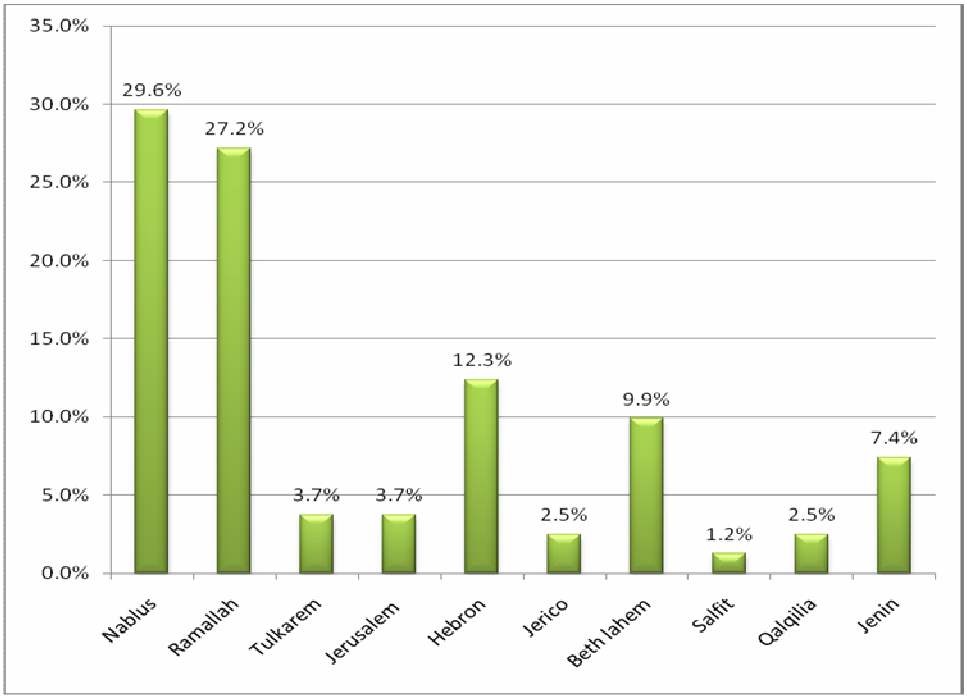



**Figure (4.1): Percentage of companies interviewed**

## 4.5 Data Collection Methods

After deciding research objectives, the researcher started by review of construction techniques currently used in research environment and

collecting related topics in a chapter two which form the main base for the research. Therefore the following represents the methodology by which the above aim can be achieved in order to select the proper construction techniques in Palestine.

### 4.5.1 Questionnaire design

The questionnaire was developed in a way in order to achieve research purposes, see Appendix A.

Pilot test have been conducted and the feedbacks taken into consideration before sending the final questionnaire. Furthermore some external experts have been asked to review the questionnaire and their feedback also was considered and accepted. Face to face, the email and the fax have been used in order to attempt to reach the entire research sample.

In this questionnaire, the construction techniques have been evaluated based on the weighted evaluation method by using a 10-point scale in making judgment in a decision criterion that influence the decisions for ranking and evaluating construction techniques. These criteria were obtained from the literature review, documentation of previously implemented construction projects, a survey and informal interviews with the people who are responsible for conducting construction projects. There are other criteria that can be included. However, the following Table (Table 4.4) shows the decision criteria.

**Table (4.4): Decision criterion that influence the decisions for ranking and evaluating construction techniques**

| | |
|---|---|
| 1- Strength and durability | 2- Cost of construction |
| 3- Safety during construction | 4- Aesthetically |
| 5- Environmental factor resistance | 6- Construction speed |
| 7- Cost of future maintenance | 8- Thermal insulation |
| 9- Fire resistance | 10- Need for specialized skills |

Also in this questionnaire a value method is used to estimate the relative weights for these decision criteria in order to determine their overall importance in the decision making process.

### 4.5.2 Case study

A housing unit has been taken as a case study in order to estimate the actual cost for each technique. Some external experts (Four contractors) have been asked to price the same BOQ for each technique and the average has been taken in order to assess the techniques and compare them in terms of the cost of construction.

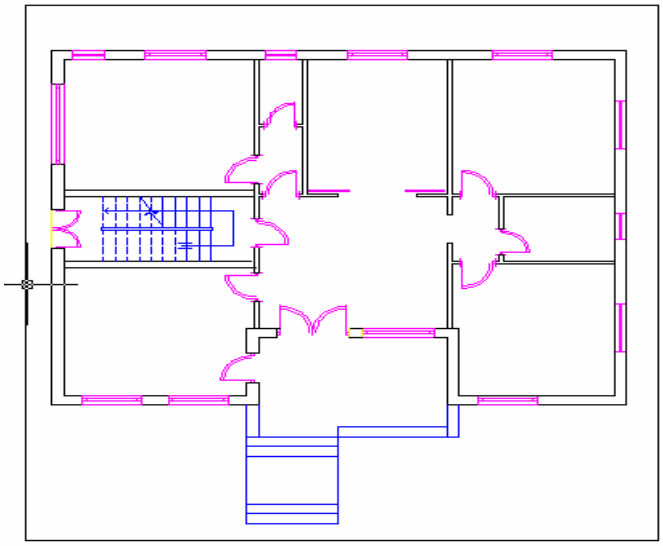


**Figure (4.2): Housing unit plan that has been taken as a case study.**

# Chapter Five

# Data Gathering and Analysis

# Chapter Five
# Data Gathering and Analysis

## 5.1 Introduction

The data have been collected using a questionnaire distributed to the contracting companies in West Bank of Palestine. Some of the data came from the Palestinian Contractors Union, Palestinian Housing Council, Engineers Association, Ministry of Public Works and Housing, and also from Palestinian Central Bureau of Statistics. In addition to direct interviews which have been conducted with some contractors and consulting engineers within research activities.

Selecting the proper construction technique depends upon evaluating the current techniques that can be used in the construction projects. In order to do that the researcher conducted a questionnaire. The building contractors have been chosen as a representative research sample because the contractor plays a major role in conducting construction projects. The respondents were asked to answer the questionnaire questions. Those were 56 completed responses which constitute the basis for deriving the results of this chapter.

This chapter presents a discussion of the study's results as related to the statement of the problem, purpose of the research, and the research questions, followed by results analysis, findings and conclusions.

## 5.2 Data analysis

As noted earlier, the questionnaire was distributed to a number of local contracting companies in the West Bank which represent the main enterprises whose classification is the first class in building specialty.

The researcher chose this sample of population in order to achieve the research objectives which were generally the large companies and could not be clearly noticed in small and micro firms.

The researcher had made efforts to have at least 81 responses to be completed, which had been calculated as an appropriate sample which are currently working and satisfying research requirements (81 is the number of local building contractors registered and classified at the Palestinian Contractors Union as first class). A period of seven weeks (24/1/2011-15/3/2011) elapsed for the completion of the questionnaire and their return back to the researcher. At the end of the seven weeks period, 63 questionnaires were returned; seven were rejected and excluded from the study because they were not complete. Therefore, only 56 collected filled questionnaires had been approved, the response rate was 69 per cent.

In this questionnaire, the construction techniques have been evaluated based on the weighted evaluation method by using a 10-point scale in making judgment in a decision criterion that influence the decisions for ranking and evaluating construction techniques. This chapter presents a discussion of the questionnaire's results. These results included:

- Evaluation of the decision criteria that influence the decisions for ranking and evaluating construction techniques.
- Evaluation of the construction techniques.
- Selection of the construction technique for executing an affordable housing project.
- Determine which of the surveyed techniques is actually used by the research sample companies in executing housing projects.

The study evaluated the following construction techniques in the West Bank of Palestine, all of which were derived from the literature review and observation during field visits within research activities, and included in Chapter Two. These techniques included:

1- External reinforced concrete walls with natural stone cladding.

2- External reinforced concrete walls with cast stone cladding.

3- Slab-beam-column system with 20cm concrete block exterior walls.

4- Slab-beam-column system with exterior walls built from two layers of 20 and 7 cm concrete blocks and insulating material between them.

5- Slab-beam-column system with exterior masonry walls of stone backed by concrete.

6- Slab-beam-column system with exterior walls built from concrete, stone and concrete block.

7- Slab-beam-column system with exterior walls built from concrete, stone, concrete block and insulating material between them.

8- Slab-beam-column system with exterior masonry walls built from light weight units “ytong” with stone cladding.

9- Slab-beam-column system using precast concrete facade panels for exterior walls.

### 5.2.1 Evaluation the decision criteria that influence the decisions for ranking and evaluating construction techniques

As noted earlier, in the questionnaire, the construction techniques have been evaluated based on the weighted evaluation method by using a 10-point scale in making judgment in a decision criterion that influence the decisions for ranking and evaluating construction techniques. These criteria were obtained from the literature review, documentation of previously implemented construction projects, a survey and informal interviews with the people who are responsible for conducting construction projects. There are other criteria that can be included. However, the first objective of the questionnaire was to determine the criteria that influence the decisions for selecting the proper construction technique and to determine their overall importance in the decision making process as the following example. (10 means very important).

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Strength and durability** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 3 | 2 | 1 | 0 | 0 | 0 | 1 | 2 | 6 | 46 | 56 |
| | X*Y | 3 | 4 | 3 | 0 | 0 | 0 | 7 | 16 | 54 | 460 | 543 |
| | Weighted average score = Σ (X*Y) / Σ (X) | | | | | | | | 543/55= **9. 87** | | | |

Table 5.1 shows the results obtained from evaluation of the decision criteria.

**Table (5.1): Evaluation of the decision criteria**

**Evaluation of the factors that are used in evaluating construction techniques**

| | **Decision Criterion** | **Percentage** | | | **Decision Criterion** | **Percentage** |
|---|---|---|---|---|---|---|
| **1** | Strength and durability (9.87)* | **15%**** | | **6** | Construction speed (7.22) | **10%** |
| **2** | Cost of construction (9.58) | **15%** | | **7** | Cost of future maintenance (6.76) | **10%** |
| **3** | Safety during construction (9.07) | **15%** | | **8** | Thermal insulation (5.25) | **5%** |
| **4** | Aesthetically (7. 75) | **10%** | | **9** | Fire resistance (4.35) | **5%** |
| **5** | Environmental factor resistance (7. 51) | **10%** | | **10** | Need for specialized skills (3.80) | **5%** |
| **The sum of total scores =71.16**<br>**The sum of total percentage =100%** | | | | | | |

***The number between ( ) is the weighted average score for a decision criterion.**

**** The weighted average score was converted to a percentage and rounded to the nearest five. For more details about evaluation of the decision criterion, see Appendix B**

### 5.2.2 Evaluation of the construction techniques

The second objective of the questionnaire was to evaluate the construction techniques. The construction techniques have been evaluated based on the weighted evaluation method by using a 10-point scale in

making judgment in a decision criterion as the following example (10: mean very positive).

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Strength and durability E.F(15)⋆** | Scores( X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 0 | 0 | 0 | 1 | 0 | 5 | 10 | 15 | 25 | 56 |
| | X*Y | 0 | 0 | 0 | 0 | 5 | 0 | 35 | 80 | 135 | 250 | 505 |
| | weighted average score = Σ (X*Y) / Σ (X) 505/55=9.18 | | | | | (weighted average score*E.F)/10 (9.18*15)/10 =13.77 | | | | Score⋆⋆ **13.8** | | |

**⋆E.F is the evaluation factor for a decision criterion which was taken from table 5.1**

The construction techniques have been evaluated; results came as below:

### 5.2.2.1 Evaluation technique: External reinforced concrete walls with natural stone cladding.

**Table (5.2): Evaluation technique: External reinforced concrete walls with natural stone cladding**

| | | | | | | |
|---|---|---|---|---|---|---|
| **1** | Strength and durability (15)⋆ | **13.8** | | **6** | Construction speed (10) | **5.8** |
| **2** | Cost of construction (15) | **8.9** | | **7** | Cost of future maintenance (10) | **7.5** |
| **3** | Safety during construction (15) | **9.5** | | **8** | Thermal insulation (5) | **3.3** |
| **4** | Aesthetically (10) | **8.3** | | **9** | Fire resistance (5) | **4.0** |
| **5** | Environmental factor resistance (10) | **7.9** | | **10** | Need for specialized skills (5) | **3.3** |
| **The sum of total points =72.3** | | | | | | |

***The number between ( ) is the evaluation factor for a decision criterion**

For more details about evaluation this technique, **see Appendix C**

### 5.2.2.2 Evaluation technique: External reinforced concrete walls with cast stone cladding.

**Table (5.3): Evaluation technique: External reinforced concrete walls with cast stone cladding.**

| | | | | | | |
|---|---|---|---|---|---|---|
| **1** | Strength and durability (15) | **11.5** | | **6** | Construction speed (10) | **5.8** |
| **2** | Cost of construction (15) | **9.1** | | **7** | Cost of future maintenance (10) | **6.2** |
| **3** | Safety during construction (15) | **9.4** | | **8** | Thermal insulation (5) | **3.0** |
| **4** | Aesthetically (10) | **7.0** | | **9** | Fire resistance (5) | **3.5** |
| **5** | Environmental factor resistance (10) | **6.3** | | **10** | Need for specialized skills (5) | **3.3** |
| **The sum of total points =65.1** | | | | | | |

***For more details about evaluation this technique, see Appendix D**

### 5.2.2.3 Evaluation technique: Slab-beam-column system with 20cm concrete block exterior walls.

**Table (5.4): Evaluation technique: Slab-beam-column system with 20cm concrete blocks exterior walls**

| | | | | | | |
|---|---|---|---|---|---|---|
| **1** | Strength and durability (15) | **6.3** | | **6** | Construction speed (10) | **9.1** |
| **2** | Cost of construction (15) | **10.8** | | **7** | Cost of future maintenance (10) | **5.2** |
| **3** | Safety during construction (15) | **11.9** | | **8** | Thermal insulation (5) | **2.0** |
| **4** | Aesthetically (10) | **4.2** | | **9** | Fire resistance (5) | **2.2** |
| **5** | Environmental factor resistance (10) | **3.9** | | **10** | Need for specialized skills (5) | **4.0** |
| **The sum of total points = 59.6** | | | | | | |

***For more details about evaluation this technique, see Appendix E**

**5.2.2.4 Evaluation technique: Slab-beam-column system with exterior walls built from two layers of 20 and 7cm concrete blocks and insulating material between them.**

**Table (5.5): Evaluation technique: Slab-beam-column system with exterior walls built from two layers of 20 and 7cm concrete block and insulating material between them**

| | | | | | | |
|---|---|---|---|---|---|---|
| **1** | Strength and durability (15) | **7.4** | | **6** | Construction speed (10) | **7.3** |
| **2** | Cost of construction (15) | **10.1** | | **7** | Cost of future maintenance (10) | **5.8** |
| **3** | Safety during construction (15) | **11.5** | | **8** | Thermal insulation (5) | **3.9** |
| **4** | Aesthetically (10) | **4.3** | | **9** | Fire resistance (5) | **3.0** |
| **5** | Environmental factor resistance (10) | **5.9** | | **10** | Need for specialized skills (5) | **3.7** |
| **The sum of total points = 62.9** | | | | | | |

***For more details about evaluation this technique, see Appendix F**

**5.2.2.5 Evaluation technique: Slab-beam-column system with exterior masonry walls of stone backed by concrete.**

**Table (5.6): Evaluation technique: Slab-beam-column system with exterior masonry walls of stone backed by concrete**

| | | | | | | |
|---|---|---|---|---|---|---|
| **1** | Strength and durability (15) | **12.0** | | **6** | Construction speed (10) | **5.9** |
| **2** | Cost of construction (15) | **9.3** | | **7** | Cost of future maintenance (10) | **7.3** |
| **3** | Safety during construction (15) | **10.6** | | **8** | Thermal insulation (5) | **3.2** |
| **4** | Aesthetically (10) | **8.3** | | **9** | Fire resistance (5) | **3.7** |
| **5** | Environmental factor resistance (10) | **7.3** | | **10** | Need for specialized skills (5) | **3.1** |
| **The sum of total points = 70.7** | | | | | | |

***For more details about evaluation this technique, see Appendix G**

### 5.2.2.6 Evaluation technique: Slab-beam-column system with exterior walls built from concrete, stone and concrete block.

**Table (5.7): Evaluation technique: Slab-beam-column system with exterior walls built from concrete, stone and concrete block**

| | | | | | | |
|---|---|---|---|---|---|---|
| **1** | Strength and durability (20) | **11.3** | | **6** | Construction speed (10) | **6.3** |
| **2** | Cost of construction (15) | **9.2** | | **7** | Cost of future maintenance (5) | **7.3** |
| **3** | Safety during construction (15) | **10.4** | | **8** | Thermal insulation (5) | **3.6** |
| **4** | Aesthetically (10) | **8.2** | | **9** | Fire resistance (5) | **3.7** |
| **5** | Environmental factor resistance (10) | **7.5** | | **10** | Need for specialized skills (5) | **3.4** |
| **The sum of total points =70.9** | | | | | | |

***For more details about evaluation this technique, see Appendix H**

### 5.2.2.7 Evaluation technique: Slab-beam-column system with exterior walls built from concrete, stone, concrete block and insulating material between them.

**Table (5.8): Evaluation technique: Slab-beam-column system with exterior walls built from concrete, stone, concrete block and insulating material between them**

| | | | | | | |
|---|---|---|---|---|---|---|
| **1** | Strength and durability (15) | **11.3** | | **6** | Construction speed (10) | **5.7** |
| **2** | Cost of construction (15) | **9.3** | | **7** | Cost of future maintenance (10) | **7.4** |
| **3** | Safety during construction (15) | **10.5** | | **8** | Thermal insulation (5) | **4.3** |
| **4** | Aesthetically (10) | **8.4** | | **9** | Fire resistance (5) | **4.0** |
| **5** | Environmental factor resistance (10) | **8.2** | | **10** | Need for specialized skills (5) | **3.5** |
| **The sum of total points = 72.6** | | | | | | |

***For more details about evaluation this technique, see Appendix I**

### 5.2.2.8 Evaluation technique: Slab-beam-column system with exterior built from light masonry walls weight units “ytong” with stone cladding.

**Table (5.9): Evaluation technique: Slab-beam-column system with exterior masonry walls built from light weight units “ytong” with stone cladding**

| | | | | | | |
|---|---|---|---|---|---|---|
| **1** | Strength and durability (20) | **8.9** | | **6** | Construction speed (10) | **7.1** |
| **2** | Cost of construction (15) | **8.8** | | **7** | Cost of future maintenance (10) | **6.5** |
| **3** | Safety during construction (15) | **10.1** | | **8** | Thermal insulation (5) | **3.9** |
| **4** | Aesthetically (10) | **7.7** | | **9** | Fire resistance (5) | **3.7** |
| **5** | Environmental factor resistance (10) | **7.3** | | **10** | Need for specialized skills (5) | **3.1** |
| **The sum of total points = 67.1** | | | | | | |

***For more details about evaluation this technique, see Appendix J**

### 5.2.2.9 Evaluation technique: Slab-beam-column system using precast concrete facade panels for exterior walls.

**Table (5.10): Evaluation technique: Slab-beam-column system using precast concrete facade panels for exterior walls**

| | | | | | | |
|---|---|---|---|---|---|---|
| **1** | Strength and durability (20) | **11.3** | | **6** | Construction speed (10) | **8.4** |
| **2** | Cost of construction (15) | **8.9** | | **7** | Cost of future maintenance (5) | **6.2** |
| **3** | Safety during construction (15) | **8.7** | | **8** | Thermal insulation (5) | **3.0** |
| **4** | Aesthetically (10) | **5.7** | | **9** | Fire resistance (5) | **3.6** |
| **5** | Environmental factor resistance (10) | **6.7** | | **10** | Need for specialized skills (5) | **2.2** |
| **The sum of total points = 64.7** | | | | | | |

***For more details about evaluation this technique, see Appendix L**

### 5.2.3 Ranking the construction techniques

As noted earlier, the questionnaire was conducted to determine the criteria that influence the decisions for selecting the proper construction technique, to determine their overall importance in the decision making process, and to evaluate the construction techniques by reference to these criteria.

In the following table the construction techniques were ranked according to the evaluated of the research sample.

**Table (5.11): Ranking the construction techniques**

| | **Construction techniques** | **Score** |
|---|---|---|
| **1-** | Exterior walls built from concrete, stone, concrete block and insulating material between them. | **72.6** |
| **2-** | External reinforced concrete walls with natural stone cladding. | **72.3** |
| **3-** | Exterior walls built from concrete, stone, and concrete block | **70.9** |
| **4-** | Exterior masonry walls of stone backed by concrete. | **70.7** |
| **5-** | Exterior masonry walls built from light weight units with stone cladding. | **67.1** |
| **6-** | External reinforced concrete walls with cast stone cladding. | **65.1** |
| **7-** | Precast concrete facade panels for exterior walls | **64.7** |
| **8-** | Two layers of 20 and 7cm concrete block and insulating material between them. | **62.9** |
| **9-** | 20cm concrete block exterior walls. | **59.6** |

According to the results mentioned above, the following techniques have the highest total points:

- Exterior walls built from concrete, stone, concrete block and insulating material between them.

- External reinforced concrete walls with natural stone cladding.

### 5.2.4 Selection of the construction technique

The research sample was asked to determine which one of the previous nine techniques is the proper technique for executing an affordable housing project. The answers are shown in table 5.12.

**Table (5.12): Selection of the construction technique**

| | **Construction techniques** | **Repetition** | **Percent** |
|---|---|---|---|
| **1-** | Exterior walls built from concrete, stone, concrete block and insulating material between them. | **31** | **55.4%** |
| **2-** | External reinforced concrete walls with natural stone cladding. | **11** | **19.6%** |
| **3-** | Exterior walls built from concrete, stone, and concrete block | **3** | **5.4%** |
| **4-** | Exterior masonry walls of stone backed by concrete. | **5** | **8.9%** |
| **5-** | Exterior masonry walls built from light weight units with stone cladding. | **1** | **1.7%** |
| **6-** | External reinforced concrete walls with cast stone cladding. | **0** | **0.0%** |
| **7-** | Precast concrete facade panels for exterior walls | **0** | **0.0%** |
| **8-** | Two layers of 20 and 7cm concrete block and insulating material between them. | **3** | **5.4%** |
| **9-** | 20cm concrete block exterior walls. | **2** | **3.6%** |
| Total Summation | | **56** | **100%** |

Based on the results mentioned above regarding the selection of the proper construction technique for executing an affordable housing project of the nine surveyed techniques, one can say that there is a matching between the selection and the evaluation of these techniques if one looks to the selection of the proper technique, where most of the research sample (55.4%) selected the technique: Exterior walls built from concrete, stone, concrete block and insulating material between them, which has the highest

total points (72.6**)** as the proper technique for executing an affordable housing project.

### 5.2.5 Construction techniques actually used in executed housing projects.

The third objective of the questionnaire was to determine which of the surveyed techniques is actually used by the research sample companies in executing their housing projects.

The questionnaire results showed that 25% of the surveyed companies had not executed any housing project, and 75% of the sample had executed housing projects by one of the surveyed techniques. The answers are shown in table5.13

**Table (5.13): Construction techniques that actually used in Projects**

| | **Construction techniques** | **Repetition** | **Percent** |
|---|---|---|---|
| **1-** | Exterior walls built from concrete, stone, concrete block and insulating material between them. | **20** | **47.6%** |
| **2-** | External reinforced concrete walls with natural stone cladding. | **5** | **11.9%** |
| **3-** | Exterior walls built from concrete, stone, and concrete block | **13** | **31.0%** |
| **4-** | Exterior masonry walls of stone backed by concrete. | **4** | **9.5%** |
| **5-** | Exterior masonry walls built from light weight units with stone cladding. | **0** | **0.0%** |
| **6-** | External reinforced concrete walls with cast stone cladding. | **0** | **0.0%** |
| **7-** | Precast concrete facade panels for exterior walls | **0** | **0.0%** |
| **8-** | Two layers of 20 and 7cm concrete block and insulating material between them. | **0** | **0.0%** |
| **9-** | 20cm concrete block exterior walls. | **0** | **0.0%** |
| Total Summation | | **42** | **100%** |

Based on these results, one can say that most of the surveyed companies (47.6%) actually used the technique: Exterior walls built from concrete, stone, concrete block and insulating material between them, which has highest total points (72.6**)** in executing housing projects.

## 5.3 Summary of Results

According to the questionnaire findings; with regard to **evaluation**, the following techniques have the highest total points:

- Exterior walls built from concrete, stone, concrete block and insulating material between them (72.6).
- External reinforced concrete walls with natural stone cladding (72.3).

With regard to **selection**, the research sample selected the technique (Exterior walls built from concrete, stone, concrete block and insulating material between them), as the proper technique for executing an affordable housing project.

With regard to **executed** housing projects, most of the research sample ( 47.6%) actually used the technique;

- Exterior walls built from concrete, stone, concrete block and insulating material between them, in executed their housing projects.

## 5.4 Case Study

Although most of the research sample actually used the technique that has highest total points (72.6) in executing their housing projects, the hypothesis of the research considered that construction currently used in Palestinian housing projects is not satisfactory in terms of achieving cheaper housing construction or to cut down the production cost.

A case study was used as a tool to check the hypothesis; hypothesis was tested by taking a housing unit as a case study in order to estimate the actual cost for each technique. The area of this housing unit is 187.5 m² (see Figure 4.2). Some external experts (Four contractors from Nablus, Ramallah, Hebron, and Tulkarem) have been asked to price the same BOQ for each technique (**see Appendix M**). The average has been taken in order to assess the techniques and compare them in terms of the cost of construction. The average actual cost is shown in table 5.14.

**Table (5.14): The average actual cost of construction for each technique**

| | Construction techniques | cost per m2 (JD) | Average cost (JD) |
|---|---|---|---|
| **1-** | External reinforced concrete walls with natural stone cladding. | **71,851** | **383.2** |
| **2-** | External reinforced concrete walls with cast stone cladding. | **67,268** | **358.7** |
| **3-** | Exterior walls built from concrete, stone, concrete block and insulating material between them. | **54,430** | **290.3** |
| **4-** | Exterior masonry walls built from light weight units with stone cladding. | **53,674** | **286.3** |
| **5-** | Exterior walls built from concrete, stone, and concrete block | **53,239** | **283.9** |
| **6-** | Exterior masonry walls of stone backed by concrete. | **47,097** | **251.2** |
| **7-** | Two layers of 20 and 7cm concrete block and insulating material between them. | **46,349** | **247.2** |
| 8- | 20cm concrete block exterior walls. | **44,010** | **234.7** |
| 9- | Precast concrete facade panels for exterior walls | **41,697** | **222.4** |

***For more details about BOQ for each technique, see Appendix M**

## 5.5 Discussion the Results

According to the contractors pricing, one can say that the bearing walls system (External reinforced concrete walls) with natural or cast stone cladding are considered as the most costly techniques.

According to the general manager of Bayt Al-Handasah Consultant Co, in an interview with the researcher ,indicated that the bearing walls system is considered time consuming in executing housing projects, as a result of the specialized skills they need because a steel ties are usually used to tie stone units with the steel network and thus cost more than the Slab-beam-column system(Eng.I'khlass,2011).

However, when the cast stone was used for walls cladding instead natural stone means the cutting down of the cost of stone used in building and thus a reduction in the production cost, since " cutting cost of any building material leads to cutting down of production cost" (An-Najah University's Team of Consultants, 2009).

With regard to slab-beam-column system the technique, Exterior walls built from concrete, stone, concrete block and insulating material between them, which has highest total points (72.6) and most of the research sample actually used in executed their housing projects considered this technique costly more than other techniques.

"This technique meets the demand of the Engineers Association with respect to insulation" (Eng.I'khlass,2011). Dr. Mutasim Baba' the chairman of the Building Engineering Department at An-Najah National University (2011), noted that this technique is considered the best among the surveyed techniques in terms of wall components (stone, concrete, concrete block and insulating material) (Dr. Mutasim, 2011).

And according to the general manager of Tubeileh Company for engineering and contracting in an interview with the researcher (Eng. Samih Tubaileh ,2011), added that this technique is considered relatively costly due to the use of natural stone that can't be dispensed with because it represents the culture and identity of the buildings in the West Bank, and the use of this technique in executing housing projects will not help in

obtaining economic housing that serves low-income families, who make up a broad class of Palestinian society.

“Building materials constitute the major elements in the buildings costs, ranging between 64% and 67% of the basic cost of any building. Thus the increase in its cost consequently leads to the increase in the cost of buildings” (League of Arab States, 2005)**.**

So, when the cast stone was used for walls instead the natural stone means the cutting down of the cost of stone used in building and thus a reduction in the production cost. " Cast stone is saving up to 50% of the cost of building stone" (Hawash’s Sons Cast stone company, 2007).

As a result, for the technique (Exterior walls built from concrete, cast stone, concrete block and insulating material). There are two ways for its construction. **First** after stone building with concrete backing, a concrete block wall of 7-10cm thickness is built behind the stone wall leaving a space to place insulating material like polystyrene between the two walls, but "the division of the wall into two parts will certainly weaken the strength of the wall" (Baba', 2004).

**Second** the stone courses are built by placing the stone units in their places and by laying the cement mortar on the sides of the stone units, having into consideration the maintaining of the uniformity of the thickness of the joints between the stones. Concrete blocks wall is built behind the stone wall keeping a sufficient distance between the two walls to place

insulating material like polystyrene plates and concrete be poured besides the polystyrene plates," but this lead to broken parts of the plates or leakage of concrete between the different plates, and this reduce its insulation capacity" (Baba', 2004). Therefore another way for insulation had been suggested by Baba' (2004), to be used in construction. In this suggested way (see Figure 5.2): (1) concrete blocks wall is built behind the stone wall keeping a sufficient distance between the two walls for concrete to be poured in this space, (2) a wood studs are fixed in a vertical and parallel with the wall, (3) a mineral fiber are fixed between the wood studs, (4) a metal net are fixed over a mineral fiber (5) finally the metal net are covered with cement plaster.

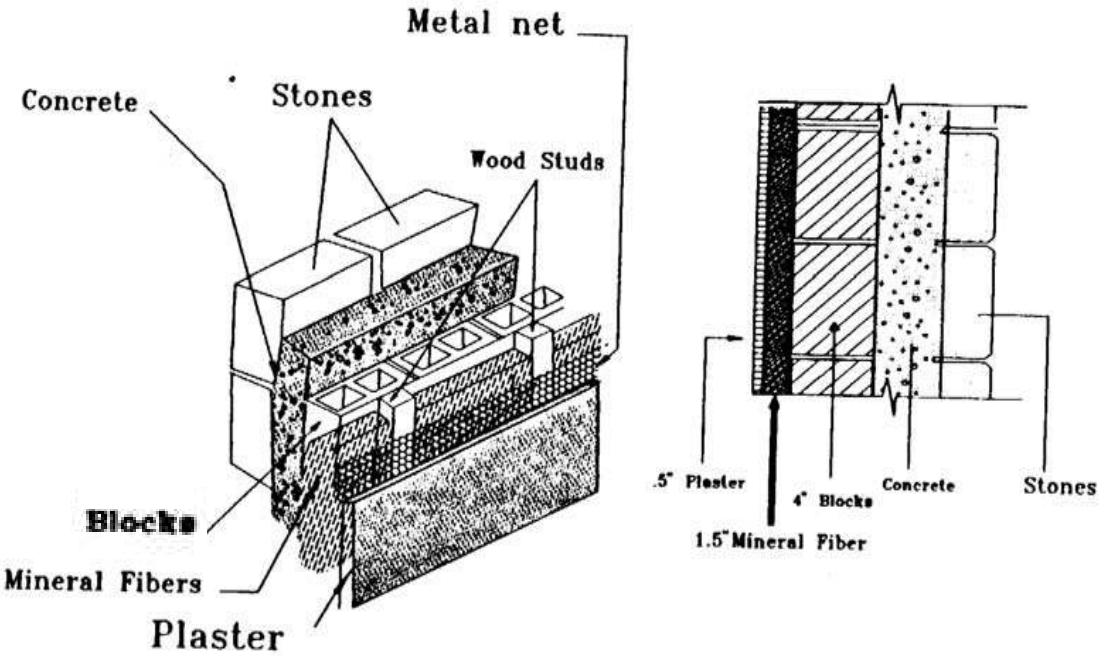



**Figure (5.1): Layers of the wall after the addition of insulation.**

**Source: (Baba', 2004).**

**Figure (5.2): Mineral fibers are fixed between the wood studs.**

**Source: (Baba', 2004).**

As a result, for the technique (Exterior walls built from concrete, cast stone, concrete block and insulating material):

- Will enable cheaper housing construction.
- Achieving an efficient technique (Affordable technique).
- Achieving a safe technique.
- Satisfy the need for insulation.
- Commensurate with the local architecture and consistent with the surrounding environment
- Achieving a clean technique since the cast stone is friendly to the environment, no dust or pollution of the environment in the process of making cast stone.

- Building the concrete blocks wall behind the stone masonry wall is to reduce the amount of the backing concrete in addition to the increase of the thermal insulation capacity of the wall.

# Chapter Six

# Conclusions and Recommendations

# Chapter Six
# Conclusions and Recommendations

## 6.1 Summary and Conclusions

Selection the optimum construction techniques in order to obtain affordable housing was introduced as a result of this thesis research. Because an optimization must be reached between safety, serviceability, and economy to reach the minimum cost with the higher efficiency of the housing unit, the researcher started the thesis by introducing research objectives which can be summarized by review of construction techniques currently used in research environment (West Bank), then Developed a mechanism to evaluate these techniques and be judged by reference to decision criteria.

Quantitative and qualitative researching approach has been used, and the data was collected using a questionnaire, 81 companies have been surveyed and the response rate was 69 per cent. Another data collection ways have been used also such as interviews, and personal observations.

As a result the technique: Exterior walls built from concrete, cast stone, concrete block and insulating material, will enable cheaper housing construction.

Other techniques such as precast concrete facade panels for exterior walls helps in developing the methods of construction to cut down the production cost in other countries but in research environment prefer dependence on the available labor to avoid the cost of employing highly

skilled labor and reducing investment in modern technologies, so the infrastructure of this technique is not ready. Changing the culture of people to adopt this new technique is also needed. There are building regulations that impact, for example the requirements on using stone in external walls.

The techniques that have been selected in this study (Exterior walls built from concrete, cast stone, concrete block and insulating material) have the highest score in the evaluation and meet the demand of the Engineers Association with respect to insulation and reduce the production cost by saving in building materials while maintaining the appearance of the stone that represents the culture and identity of the buildings in the West Bank.

## 6.2 Contribution to knowledge and practice

This research makes several contributions to the topic. In summary, the contribution can be summarized as bellow:

1. Clarifying the current situation of housing sector and construction sector in research environment.

2. Developing a mechanism to evaluate the construction techniques used in research environment and be judged by reference to decision criteria.

3. Guidelines to help build homes at a lower cost with higher quality and energy efficiency, and better safety.

4. Contributing in the process of choosing housing projects to be funded and implemented, this can be the basis of development required in this sector.

## 6.3 Recommendations

After the efforts which have been made in order to select the proper construction technique, and after presenting the above conclusions, some notes and recommendations can be summarized as bellow:

1. Since it is difficult to increase the affordability of a house hold to pay more than 40% of his monthly income, it is of great importance to reduce the production cost by saving in building materials, and by mass production.

2. Changing the culture of people to adopt new materials such as cast stone, helps in developing the methods of construction to cut down the production cost.

3. Encourage the establishment of factories for the production of cast stone to cover the needs of the building and construction industry in the region

4. Producing large number of similar housing units reduces the production cost of each unit. The use of moulds to reproduce certain elements in the housing unit such as columns, beams, and slab units cuts the cost of formwork and the workmanship.

5. Also having similar units makes it possible to have a production line to produce doors, windows, and other carpentry works leading to a cut down in the cost. The repetition in the implementation of similar works makes it easier and faster for the engineers and contractors to achieve

the housing units which mean a reduction in the cost.

6. More emphasize on adopting new construction techniques in the Palestinian Territories, since the development in the construction sector in Palestine in the last years and the return back of large number of engineers who had good experience in construction methods in the Gulf area, in addition to the potential of having a rapid increase in the construction works in the coming years makes it easier to adopt the new construction techniques in Palestinian Territories.

7. Support the construction industry sector and reduce the cost of raw materials for industry.

8. More focus should be given to construction technique choosing because of their major impact in cutting down the cost.

9. More focus should be given to formwork system choosing since selecting the formwork system is a critical decision that can affect cost, safety, quality, and speed of construction. Many factors must be considered for the proper selection of the formwork system**.**

## 6.4 Future works

- The construction technique that selected for higher efficiency and affordable housing construction should be approved and validated by implementing it in a real and actual case in research environment.

- The developed mechanism in this thesis can be of use to researchers for further studies to evaluate other construction techniques in or out Palestine.

- There are other items of the building have an impact in cutting down the cost and will enable for cheaper housing construction such as infra structure, flooring systems, interior walls, formwork system; the selection of a formwork system is a critical decision with very serious implications. Due consideration must be given to such factors as the system's productivity, safety, durability, and many other variables that may be specific to the site or job at hand. And because this thesis covered used exterior walls, therefore more studies and research shall be exerted in this regard.

- Building regulations that impact on the overall cost of construction can be amended (form a technical perspective) for example is requirements on using stone on external walls.

# References

Aashiq, Zohair: ***Concrete Basics***. **A Guide to Concrete Practice.** Sixth Edition. August. 2004.

Abdel –Karim, Riyad: **Construction Stone In Palestine**. An-Najah National University. Nablus. Palestine. 2000.

An-Najah University's Team of Consultants: **Consulting Service for the Study on Criteria for Selecting Private Sector Housing Projects for Public Funding in the West Bank**. (Unpublished Study). An-Najah National University. Nablus. Palestine. December, 2009.

Baba'**,** Mutasim: ***Building and Construction Research Center***, ***Workshop: Healthy Building in the Proper Insulation,*** **Methods of thermal insulation of existing buildings and under construction buildings.** Ramallah, Palestine. February12, 2004.

Britannica Macropaedia: ***The New Encyclopaedia Britannica***. **Definition of "Mass Production" in "Industrial Engineering and Production Management"**, 15th Edition, Vol. 21, p. 204,1989.

Brzev, Svetlana-Britishn Columbia Institute of Technology, Canada & Guevara, Teresa--Perez, Architect, Venezuela: P**recast Concrete Construction,** 1999, available at: *www.world-housing.net/uploads/**precast__concrete**.pdf*

Cornford, T. & Smithson, S: ***Project Research in Information Systems***, **A Students Guide. Basingstoke:** Macmilla. 1996.

Creswell. J. ***Research Design,*** **Qualitative,quantitative and Mixed method Approaches** [Book]. - calefornia : sage Publications, 2003.

Denzin, N.K, & Lincoln, Y.S: **Handbook of Qualitative Research**, (2nd Ed) pp.509-535. Thousand Oaks, CA: Sage, 2003.

Easterby-Smith, M. Thorpe, R & Lowe, A: **Management Research**, Second Edition. London: sage. 2002.

ECB Studies (A): ***Establishing, Adoption, and Implementation of Energy Codes for Building.*** **Construction Techniques Survey in Palestinian Territories,** August, 2002, available at: http://www.molg.gov.ps/ecb/studies/construction/construction.pdf

ECB Studies (B): ***Establishing, Adoption, and Implementation of Energy Codes for Building.*** **Construction Materials &Local Market Survey In Palestinian Territories,** August, 2002, available at: www.molg.gov.ps/ecb/studies/material/material.pdf.

Fayyad, Salam**:** ***Conference of the Palestinian Reality and Adequate Housing***, **Palestinian Real Estate first Forum**, Ramallah. Palestine. December 23, 2010.

Hadid, Mouhannad: ***Establishing, Adoption, and Implementation of Energy Codes for Building*****. Architectural Styles Survey in Palestinian Territories.** August, 2002.

Harris, Robert: **Introduction to Decision Making,** December 2, 2009, available at: http://www.virtualsalt.com/crebook5.htm.

Hawash's Sons Cast stone company, **Features of Cast Stone**. Tulkarem. Palestine. 2011, available at: http://www.hawash-stone.ps.

Hull, G. **Research with Words: Qualitative Inquiry. Focus on Basics**. Vol 1, Issue. A, February, 1997, available at: http//:www.gse.harvard.edu.

Ismail, Ghassan: **Towards a national policy for housing in Palestine** (Master's Thesis). An-Najah National Universit . Nublus. Palestine. 2000.

Jayyousi, Ahmad: ***United Group for Construction and Building Technology.*** **Light weight concrete insulated wall panel.** Ramallah, Palestine. September, 2011.

Jackson. P.Desk Research [Report]. - London : Kegan-Paul, 1994.

Kartha, Deepa: **Steps to Decision Making Process**, April, 2010, available at:http://www.buzzle.com/articles/6-steps-to-decision-makingprocess.html

League of Arab States (CAMRE), **Sustainable Building and Construction in the Arab Region,** June 2005.

Miles & Huberman. **Qualitative Data Analysis**, Sage Publications: London, 1994.

Palestine Investment Fund (PIF): **The National Affordable Housing Program,** Ramallah, Palestine. 2010, available at: http://www.pif.ps/index.php?lang=en&page=1245234139362

Palestinian Central Bureau of Statistics PCBS. **Press Release: Economic Forecasts for 2010,** available at:

http://www.pcbs.pna.org/Portals/_pcbs/PressRelease/Forecasts_E_2010.pdf

Palestinian Central Bureau of Statistics PCBS **Press Release: Existing Building Survey in Palestinian Territory 2010,** available at: http://www.pcbs.gov.ps/DesktopDefault.aspx?tabID=3549&lang=en

WAFA: Palestine News & Information Agency, ***PCBS*: Rise in Expenditures in 2010 on New Buildings in West Bank,** Ramallah, Palestine. June 9, 2011

Palestine Standards Institution (PSI): **Thermal Insulation for Building.** Ramallah, Palestine. 1999.

Palestinian Contractors Union (PCU), **classification of contractors**. 2011. available at: http://www.pcu.ps/e/index.php?action=s_categories

Sekaran, U. ***Research Methods for Business***: **A Skill-building Approach**. 4th edition. South Illinois University at Carbondale: John Wiley & Sons, Inc. 2003.

Straub, D. Gefen, D. & Boudreau, M-C. **The IS World Quantitative, Positivist Research Methods.** 2004, http://dstraub.cis.gsu.edu.

Strauss, A. & Corbin, J. **Basics of Qualitative Research: Grounded Theory Procedures and Techniques**, Sage, London, 1990.

Trochim, W.M. **Research Methods Knowledge Base**. 2002, Available at www.socialresearchmethods.net/kb/index.htm.

Whited , Christopher , ***Precast Solution***, **Precast Concrete Wall Panels,** April 26,2011.

Wikipedia, ***free encyclopedia,*** **Building material,** 2010, available at: http://en.wikipedia.org/wiki/Building_material

Wikipedia, ***free encyclopedia***, **Decision_making**. August, 2011, available at: http://en.wikipedia.org/wiki/Decision_making

World Bank (2008). **West Bank and Gaza. The Economic Effects of Restricted Access to Land in the West Bank**. Available at: http:// siteresources.worldbank.org/INTWESTBANKGAZA/Resources/ EconomicEffectsofRestrictedAccesstoLandintheWestBankOct.21.08.p

Zikmund, W.G. **Business research methods**. (6th Ed.). Orlando, FL: The Dryden Press. 2000.

## Interviews

I'khlass Al-Ratrout. **The general manager of Bayt Al-Handasah Consultant Co**. Nablus. Palestine. April 28, 2011.

Mutasim Baba'. **The chairman of the Building Engineering Department at An-Najah University**. Nablus. Palestine. December 13, 2010

Samih Tubaileh. **The general manager of Tubeileh Company for engineering and contracting.** Nablus. Palestine. March 24, 2011.

# Appendices

# Appendix A

# The questionnaire

**تحية طيبة و بعد:**

الباحثة تقوم بدراسة حول (**آلية اتخاذ القرار في اختيار نظام إنشاء الجدران الخارجية في مباني السكن الميسر في فلسطين**). و ذلك لإتمام رسالة الماجستير. إن تعاونك في تعبئة الاستمارة إسهام في تطوير البحث العلمي و هو محل التقدير و الامتنان و ان المعلومات التي سوف تقدمها لن تستخدم إلا لأغراض البحث العلمي.

**مع وافر الاحترام**

**الباحثة :حنان محسن**

**جامعة النجاح الوطنية /ماجستير ادارة هندسية**

**القسم الاول:**

طبيعة العمل: ☐ مهندس ☐ مقاول ☐ مهندس مقاول

المؤهل العلمي: _____

سنوات الخبرة: _____

المنطقة/المحافظة:_____

**القسم الثاني:**

يندرج تحت هذا القسم 9 أنظمة من أنظمة الإنشاء في فلسطين للمقارنة بينهم من عدة نواحي . يرجى **وضع تقييم** لكل تقنية في المربع اسفل كل بند من بنود المقارنة **بما يتفق مع رأيك** .علما ان **التقييم عبارة عن علامة من1 الى 10** تعطى لكل بند .**فالعلامة (1) تدل ان التقنية سلبية** جدا في هذه الناحية بينما **(10) تدل على ان التقنية ايجابية جدا .**

فمثلا سرعة التنفيذ شئ ايجابي فالتقنية التي تحقق اقصى سرعة في الانجاز تأخذ10و هكذا تتدرج العلامات من 10 الى 1 حيث 1 يعني ان التقنية بطيئة جدا مقارنة بغيرها. بينما مثلاكلفة الانشاء زيادتها شئ سلبي فالتقنية التي تحقق اقل كلفة تأخذ 10 و التي تكلفتها اعلى تاخذ علامة اقل و هكذا..

| | بنود المقارنة / تقنية بناء الجدران الخرجية | سرعة التنفيذ | كلفة الانشاء | القوة و المتانة | تكاليف الصيانة المستقبلية | الامان اثناء الانشاء | الحاجة لمهارات متخصصة | مقاومة المؤثرات الجوية | مقاومة الحريق | العزل الحراري | الناحية الجمالية |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | الجدران الخارجية من **الباطون المسلح و كسوته بالحجر الطبيعي** | | | | | | | | | | |
| 2 | الجدران الخارجية **من الباطون المسلح و كسوته بالحجرالصناعي** | | | | | | | | | | |
| 3 | الجدران الخارجية من **طوب 20سم** | | | | | | | | | | |
| 4 | الجدران الخارجية من **طبقتين طوب 20,7 سم و بينهما مادة عازلة** | | | | | | | | | | |
| 5 | الجدران الخارجية من **حجر و باطون بعمل طوبار خلف الحجر** | | | | | | | | | | |
| 6 | الجدران_الخارجية من **حجر وباطون و طوب** | | | | | | | | | | |
| 7 | الجدران الخارجية **حجر وباطون وطوب ومادة عازلة بينهما** | | | | | | | | | | |
| 8 | الواجهات الخارجية **من طوب خفيف اوالايتونج و كسوته بالحجر الطبيعي** | | | | | | | | | | |
| 9 | الواجهات الخارجية **ألواح باطون مسبق الصب**Precast Concrete_ | | | | | | | | | | |

**القسم الثالث:**

يرجى وضع تقييم لبنود المقارنة حسب اهمية تحققها في أي تقنية بنـــاء ستســـتخدم لانشـــاء مشروع اسكان، علما ان التقييم عبارة عن علامة من1 الى 10_ حيث رقم 10 يعني مهم جـــدا تحققها و رقم 9 اقل اهمية و هكذا ...مع العلم انه بالامكان ان يأخذ بندان نفس الترقيم.

| بنود المقارنة | سرعة التنفيذ | كلفة الإنشاء | القوة و المتانة | تكاليف الصيانة المستقبلية | الامان اثناء الانشاء | الحاجة لمهارات متخصصة | مقاومة المؤثرات الجوية | مقاومة الحريق | العزل الحراري | الناحية الجمالية |
|---|---|---|---|---|---|---|---|---|---|---|
| الترقيم حسب الاهمية | | | | | | | | | | |

**القسم الرابع:**

أي من التقنيات التالية تختار لإنشاء مشروع مباني السكن الميسر على شكل عمارات سكنية مع توضيح السبب

| | |
|---|---|
| 1 | الجدران الخارجية من **الباطون المسلح و كسوته بالحجر الطبيعي** |
| 2 | الجدران الخارجية **من الباطون المسلح و كسوته بالحجرالصناعي** |
| 3 | الجدران الخارجية من **طوب 20سم** |
| 4 | الجدران الخارجية من **طبقتين طوب 20 و7سم و بينهما مادة عازلة** |
| 5 | الجدران الخارجية من **حجر و باطون بعمل طوبار خلف الحجر** |
| 6 | الجدران الخارجية من **حجر وباطون و طوب** |
| 7 | الجدران الخارجية **حجر وباطون و طوب ومادة عازلة بينهما** |
| 8 | الواجهات الخارجية **من طوب خفيف او الايتونج و كسوته بالحجر الطبيعي** |
| 9 | الواجهات الخارجية **ألواح باطون مسبق الصب** |

رقم التقنية التي وقع عليها اختيارك باعتبارها الأنسب في تنفيذ مشروع مباني السكن الميسر على شكل عمارات سكنية حسب رأيك _____

سبب الاختيار _____

_____

- هل سبق و قمت بتصميم او تنفيذ **<u>مشروع اسكان على أرض الواقع</u>**

نعم لا

اذا كانت الاجابة بنعم فقم بكتابة رقم التقنية التي تم اعتمادها في تنفيذ مشروع الاسكان

_____

ذكر اسم الاسكان و موقعه _____

_____

ولكم جزيل الشكر/ م.حنان محسن

# Appendix B

## Evaluation of the decision criteria

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1- Construction speed.** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 2 | 3 | 1 | 4 | 7 | 3 | 5 | 8 | 12 | 11 | 56 |
| | X*Y | 2 | 6 | 3 | 16 | 35 | 18 | 35 | 64 | 108 | 110 | 397 |
| | weighted average score | 397/55=**7.22** | | | | | | | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2- Cost of construction** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 7 | 11 | 36 | 56 |
| | X*Y | 0 | 0 | 0 | 0 | 0 | 12 | 0 | 56 | 99 | 360 | 527 |
| | weighted average score | 527/55=**9.58** | | | | | | | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **3- Strength and durability** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 3 | 2 | 1 | 0 | 0 | 0 | 1 | 2 | 6 | 46 | 56 |
| | X*Y | 3 | 4 | 3 | 0 | 0 | 0 | 7 | 16 | 54 | 460 | 543 |
| | weighted average score | 543/55= **9. 87** | | | | | | | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **4- Cost of future maintenance** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 1 | 2 | 8 | 3 | 6 | 4 | 7 | 6 | 10 | 9 | 56 |
| | X*Y | 1 | 4 | 24 | 12 | 30 | 24 | 49 | 48 | 90 | 90 | 372 |
| | weighted average score | 372/55=**6.76** | | | | | | | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **5- Safety during construction** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 0 | 0 | 0 | 2 | 3 | 5 | 7 | 10 | 29 | 56 |
| | X*Y | 0 | 0 | 0 | 0 | 10 | 18 | 35 | 56 | 90 | 290 | 499 |
| | weighted average score | 499/55=**9.07** | | | | | | | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **6- Need for Specialized skills** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 6 | 8 | 12 | 10 | 12 | 5 | 3 | 0 | 0 | 0 | 56 |
| | X*Y | 6 | 16 | 36 | 40 | 60 | 30 | 21 | 0 | 0 | 0 | 209 |
| | weighted average score | 209/55=**3. 80** | | | | | | | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **7- Environment-al factor resistance** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 2 | 2 | 4 | 5 | 6 | 6 | 8 | 10 | 13 | 56 |
| | X*Y | 0 | 4 | 6 | 16 | 25 | 36 | 42 | 64 | 90 | 130 | 413 |
| | weighted average score | 413/55=**7. 51** | | | | | | | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **8- Fire resistance** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 1 | 8 | 13 | 10 | 10 | 8 | 4 | 1 | 1 | 0 | 56 |
| | X*Y | 1 | 16 | 39 | 40 | 50 | 48 | 28 | 8 | 9 | 0 | 239 |
| | weighted average score | 239/55=**4.35** | | | | | | | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **9- Thermal insulation** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 3 | 6 | 7 | 9 | 8 | 6 | 5 | 5 | 4 | 3 | 56 |
| | X*Y | 3 | 8 | 21 | 36 | 40 | 36 | 35 | 40 | 36 | 30 | 289 |
| | weighted average score | 289/55=**5.25** | | | | | | | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **10- Aesthetically** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 2 | 4 | 1 | 3 | 7 | 6 | 5 | 13 | 15 | 56 |
| | X*Y | 0 | 4 | 12 | 4 | 15 | 42 | 42 | 40 | 117 | 150 | 426 |
| | weighted average score | 426/55= **7.75** | | | | | | | | | | |

| **Evaluation of the decision criteria that are used in evaluating construction techniques** | | | | | | |
|---|---|---|---|---|---|---|
| | **criterion** | **score** | | | **criterion** | **Score** |
| ***1** | Strength and durability (9.87) | **15%** | | **6** | Construction speed (7.22) | **10%** |
| **2** | Cost of construction (9.58) | **15%** | | **7** | Cost of future maintenance (6.76) | **10%** |
| **3** | Safety during construction (9.07) | **15%** | | **8** | Thermal insulation (5.25) | **5%** |
| **4** | Aesthetically (7. 75) | **10%** | | **9** | Fire resistance (4.35) | **5%** |
| **5** | Air resistance effects (7. 51) | **10%** | | **10** | Need for specialized skills (3.80) | **5%** |
| **The sum of total scores =71.16**<br>**The sum of total percentage =100%** | | | | | | |

*The decision criteria have been arranged according to their evaluation factor -the number between ( ).

# Appendix C

## External reinforced concrete walls with natural stone

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1- Construction speed E.F(10)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 1 | 1 | 9 | 4 | 12 | 10 | 5 | 10 | 3 | 1 | 56 |
| | X*Y | 1 | 2 | 27 | 16 | 60 | 60 | 35 | 80 | 27 | 10 | 318 |
| | weighted average score 318/55=5.78 | | | (weighted average score*E.F)/10 | | | | | | | Score **5.8** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2- Cost of construction E.F(15)** | Scores( X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 1 | 5 | 5 | 4 | 8 | 10 | 6 | 12 | 4 | 1 | 56 |
| | X*Y | 1 | 10 | 15 | 16 | 40 | 60 | 42 | 96 | 36 | 10 | 326 |
| | weighted average score 326/55=5.92 | | | (weighted average score*E.F)/10 (5.92*15)/10 = 8.89 | | | | | | | Score **8.9** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **3- Strength and durability E.F(15)** | Scores( X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 0 | 0 | 0 | 1 | 0 | 5 | 10 | 15 | 25 | 56 |
| | X*Y | 0 | 0 | 0 | 0 | 5 | 0 | 35 | 80 | 135 | 250 | 505 |
| | weighted average score 505/55=9.18 | | | (weighted average score*E.F)/10 (9.18*15)/10 =13.77 | | | | | | | Score **13.8** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **4- Cost of future maintenance E.F(10)** | Scores( X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 1 | 2 | 6 | 2 | 3 | 1 | 5 | 10 | 15 | 11 | 56 |
| | X*Y | 1 | 4 | 18 | 8 | 15 | 6 | 35 | 80 | 135 | 110 | 412 |
| | weighted average score 412/55=7.49 | | | (weighted average score*E.F)/10 (7.49*10)/10 = 7. 49 | | | | | | | Score **7.5** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **5- Safety during construction E.F(15)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 1 | 1 | 4 | 9 | 7 | 6 | 8 | 12 | 5 | 3 | 56 |
| | X*Y | 1 | 2 | 12 | 36 | 35 | 36 | 56 | 96 | 45 | 30 | 349 |
| | weighted average score 349/55=6.35 | | | (weighted average score *E.F)/10 (6.35*15)/10 = 9.51 | | | | | | | Score **9.5** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **6- Need for Specialized Skills E.F(5)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 3 | 6 | 3 | 6 | 6 | 11 | 13 | 5 | 3 | 56 |
| | X*Y | 0 | 6 | 18 | 12 | 30 | 36 | 77 | 104 | 45 | 30 | 358 |
| | weighted average score 358/55=6.51 | | | (weighted average score*E.F)/10 (6.51*5)/10 = 3.25 | | | | | | | Score **3.3** | |

| 7- Air Resistance Effects E.F(10) | Scores( X) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 55 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Repetition (Y) | 0 | 1 | 1 | 1 | 4 | 7 | 5 | 13 | 15 | 9 | 56 |
| | X*Y | 0 | 2 | 3 | 4 | 20 | 42 | 35 | 104 | 135 | 90 | 435 |
| | weighted average score 435/55=7.91 | | | | (weighted average score*E.F)/10 (7.91*10)/10 =7.90 | | | | | | Score **7.9** | |

| 8- Fire Resistance E.F(5) | Scores( X) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 55 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Repetition (Y) | 0 | 0 | 2 | 3 | 2 | 7 | 5 | 13 | 12 | 12 | 56 |
| | X*Y | 0 | 0 | 6 | 12 | 10 | 42 | 35 | 104 | 108 | 120 | 437 |
| | weighted average score 437/55=7.95 | | | | (weighted average score*E.F)/10 (7.95*5)/10 =3.97 | | | | | | Score **4.0** | |

| 9- Thermal Insulation E.F(5) | Scores( X) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 55 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Repetition (Y) | 1 | 1 | 3 | 2 | 8 | 9 | 14 | 9 | 6 | 3 | 56 |
| | X*Y | 1 | 2 | 9 | 8 | 40 | 54 | 98 | 72 | 54 | 30 | 368 |
| | weighted average score 368/55=6.69 | | | | (weighted average score*E.F)/10 (6.69*5)/10 = 3.34 | | | | | | Score **3.3** | |

| 10- Aesthetically E.F(10) | Scores( X) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 55 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Repetition (Y) | 0 | 0 | 1 | 1 | 5 | 6 | 5 | 9 | 11 | 18 | 56 |
| | X*Y | 0 | 0 | 3 | 4 | 25 | 36 | 35 | 72 | 99 | 180 | 454 |
| | weighted average score 454/55=8.25 | | | | (weighted average score*E.F)/10 (8.25*10)/10 = 8.25 | | | | | | Score **8.3** | |

| **Evaluation technique: External reinforced concrete walls with natural stone cladding.** | | | | | | |
|---|---|---|---|---|---|---|
| | **criterion** | **score** | | | **criterion** | **Score** |
| **1** | Strength and durability (15) | **13.8** | | **6** | Construction speed (10) | **5.8** |
| **2** | Cost of construction (15) | **8.9** | | **7** | Cost of future maintenance (10) | **7.5** |
| **3** | Safety during construction (15) | **9.5** | | **8** | Thermal insulation (5) | **3.3** |
| **4** | Aesthetically (10) | **8.3** | | **9** | Fire resistance (5) | **4.0** |
| **5** | Air resistance effects (10) | **7.9** | | **10** | Need for specialized skills (5) | **3.3** |
| **The sum of total scores =72.3** | | | | | | |

# Appendix D

## External reinforced concrete walls with cast stone

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1- Construction speed E.F(10)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 3 | 4 | 8 | 8 | 15 | 7 | 9 | 2 | 0 | 56 |
| | X*Y | 0 | 6 | 12 | 32 | 40 | 90 | 49 | 72 | 18 | 0 | 319 |
| | weighted average score 319/55=5.8 | | | | (weighted average score*E.F)/10 (5.8*10)/10=5.8 | | | | | | Score **5.8** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2- Cost of construction E.F(15)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 5 | 6 | 2 | 5 | 7 | 2 | 8 | 9 | 6 | 6 | 56 |
| | X*Y | 5 | 12 | 6 | 20 | 35 | 12 | 56 | 72 | 54 | 60 | 332 |
| | weighted average score 332/55=6.03 | | | | (weighted average score*E.F)/10 (6.03*15)/10 =9.05 | | | | | | Score **9.1** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **3- Strength and durability E.F(15)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 1 | 0 | 3 | 3 | 5 | 12 | 12 | 16 | 4 | 56 |
| | X*Y | 0 | 2 | 0 | 12 | 15 | 30 | 84 | 96 | 144 | 40 | 423 |
| | weighted average score 423/55=7.69 | | | | (weighted average score*E.F)/10 (7.67*15)/10 = 11.53 | | | | | | Score **11.5** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **4- Cost of future maintenance E.F(10)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 1 | 1 | 4 | 3 | 12 | 10 | 11 | 10 | 4 | 0 | 56 |
| | X*Y | 1 | 2 | 12 | 12 | 60 | 60 | 77 | 80 | 36 | 0 | 340 |
| | weighted average score 340/55=6.18 | | | | (weighted average score*E.F)/10 (6.18*10)/10 = 6.18 | | | | | | Score **6.2** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **5- Safety during construction E.F(15)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 1 | 2 | 5 | 5 | 8 | 7 | 11 | 11 | 4 | 2 | 56 |
| | X*Y | 1 | 4 | 15 | 20 | 40 | 42 | 77 | 88 | 36 | 20 | 343 |
| | weighted average score 343/55=6.24 | | | | (weighted average score*E.F)/10 (6.24*15)/10 = 9.35 | | | | | | Score **9.4** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Need for Specialized Skills** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 1 | 3 | 3 | 4 | 4 | 6 | 14 | 15 | 4 | 2 | 56 |
| | X*Y | 1 | 6 | 9 | 16 | 20 | 36 | 98 | 120 | 36 | 20 | 362 |
| | weighted average score 362/55=6.58 | | | | (weighted average score*E.F)/10 (6.58*5)/10 = 3.29 | | | | | | Score **3.3** | |

| **7- Air Resistance Effects E.F(10)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Repetition (Y) | 0 | 1 | 3 | 8 | 12 | 7 | 6 | 13 | 4 | 2 | 56 |
| | X*Y | 0 | 2 | 9 | 32 | 60 | 42 | 42 | 104 | 36 | 20 | 347 |
| | weighted average score 347/55=6.31 | | | | (weighted average score*E.F)/10 (6.31*10)/10=6.31 | | | | | | Score **6.3** | |

| **8- Fire Resistance E.F(5)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Repetition (Y) | 0 | 0 | 3 | 5 | 6 | 5 | 12 | 13 | 8 | 4 | 56 |
| | X*Y | 0 | 0 | 9 | 20 | 30 | 30 | 84 | 104 | 72 | 40 | 389 |
| | weighted average score 389/55=7.07 | | | | (weighted average score*E.F)/10 (7.07*5)/10 = 3.53 | | | | | | Score **3.5** | |

| **9- Thermal Insulation E.F(5)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Repetition (Y) | 1 | 1 | 4 | 10 | 8 | 9 | 10 | 10 | 3 | 0 | 56 |
| | X*Y | 1 | 2 | 12 | 40 | 40 | 54 | 70 | 80 | 27 | 0 | 326 |
| | weighted average score 326/55=5.93 | | | | (weighted average score*E.F)/10 (5.93*5)/10 = 2.96 | | | | | | Score **3.0** | |

| **10- Aesthetically E.F(10)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Repetition (Y) | 0 | 2 | 1 | 3 | 6 | 6 | 16 | 14 | 4 | 4 | 56 |
| | X*Y | 0 | 4 | 3 | 12 | 30 | 36 | 112 | 112 | 36 | 40 | 385 |
| | weighted average score 385/55=7.0 | | | | (weighted average score*E.F)/10 (7.0*10)/10=7.0 | | | | | | Score **7.0** | |

**Evaluation technique: External reinforced concrete walls with cast stone cladding.**

| | **criterion** | **score** | | | **criterion** | **Score** |
|---|---|---|---|---|---|---|
| **1** | Strength and durability (15) | **11.5** | | **6** | Construction speed (10) | **5.8** |
| **2** | Cost of construction (15) | **9.1** | | **7** | Cost of future maintenance (10) | **6.2** |
| **3** | Safety during construction (15) | **9.4** | | **8** | Thermal insulation (5) | **3.0** |
| **4** | Aesthetically (10) | **7.0** | | **9** | Fire resistance (5) | **3.5** |
| **5** | Air resistance effects (10) | **6.3** | | **10** | Need for specialized skills (5) | **3.3** |
| **The sum of total scores =65.1** | | | | | | |

# Appendix E

## 20cm concrete blocks exterior walls.

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1- Construction speed E.F(10)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 0 | 0 | 1 | 0 | 3 | 4 | 8 | 13 | 27 | 56 |
| | X*Y | 0 | 0 | 0 | 4 | 0 | 18 | 28 | 64 | 117 | 270 | 501 |
| | weighted average score 501/55=9.10 | | | | (weighted average score*E.F)/10 (9.10*10)/10 =9.10 | | | | | | Score **9.1** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2- Cost of construction E.F(15)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 1 | 7 | 0 | 6 | 1 | 4 | 4 | 9 | 12 | 12 | 56 |
| | X*Y | 1 | 14 | 0 | 24 | 5 | 24 | 28 | 72 | 108 | 120 | 396 |
| | weighted average score 396/55=7.2 | | | | (weighted average score*E.F)/10 (7.2*15)/10 = 10.8 | | | | | | Score **10.8** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **3- Strength and durability E.F(15)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 4 | 9 | 8 | 12 | 8 | 8 | 6 | 1 | 0 | 0 | 56 |
| | X*Y | 4 | 18 | 24 | 48 | 40 | 48 | 42 | 8 | 0 | 0 | 232 |
| | weighted average score 232/55=4.21 | | | | (weighted average score*E.F)/10 (4.21*15)/10 =6.32 | | | | | | Score **6.3** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **4- Cost of future maintenance E.F(10)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 4 | 4 | 5 | 10 | 6 | 10 | 7 | 9 | 0 | 1 | 56 |
| | X*Y | 4 | 8 | 15 | 40 | 30 | 60 | 49 | 72 | 0 | 10 | 288 |
| | weighted average score 288/55=5.23 | | | | (weighted average score*E.F)/10 (5.23*10)/10 =5.23 | | | | | | Score **5.2** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **5- Safety during construction E.F(15)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 2 | 0 | 0 | 3 | 3 | 5 | 7 | 10 | 11 | 15 | 56 |
| | X*Y | 2 | 0 | 0 | 12 | 15 | 30 | 49 | 80 | 99 | 150 | 437 |
| | weighted average score 437/55=7.94 | | | | (weighted average score*E.F)/10 (7.94*15)/10 = 11.91 | | | | | | Score **11.9** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **6- Need for Specialized Skills E.F(5)** | Scores ( X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 0 | 0 | 0 | 4 | 10 | 11 | 10 | 10 | 11 | 56 |
| | X*Y | 0 | 0 | 0 | 0 | 20 | 60 | 77 | 80 | 90 | 110 | 437 |
| | weighted average score 437/55=7.94 | | | | (weighted average score*E.F)/10 (7.94*5)/10=3.97 | | | | | | Score **4.0** | |

| 7- Air Resistance Effects E.F(10) | Scores ( X) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 55 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Repetition (Y) | 8 | 7 | 15 | 10 | 3 | 6 | 3 | 3 | 0 | 1 | 56 |
| | X*Y | 8 | 14 | 45 | 40 | 15 | 36 | 21 | 24 | 0 | 10 | 213 |
| | weighted average score 213/55=3.87 | | | | | (weighted average score*E.F)/10 (3.87*10)/10 =3.87 | | | | | Score **3.9** | |

| 8- Fire Resistance E.F(5) | Scores ( X) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 55 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Repetition (Y) | 7 | 5 | 8 | 12 | 7 | 8 | 3 | 4 | 1 | 1 | 56 |
| | X*Y | 7 | 10 | 24 | 48 | 35 | 48 | 21 | 32 | 9 | 10 | 244 |
| | weighted average score 244/55=4.43 | | | | | (weighted average score*E.F)/10 (4.43*5)/10 =2.21 | | | | | Score **2.2** | |

| 9- Thermal Insulation E.F(5) | Scores ( X) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 55 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Repetition (Y) | 10 | 9 | 8 | 5 | 11 | 2 | 6 | 3 | 2 | 0 | 56 |
| | X*Y | 10 | 18 | 24 | 20 | 55 | 12 | 42 | 24 | 18 | 0 | 223 |
| | weighted average score 223/55=4.05 | | | | | (weighted average score*E.F)/10 (4.05*5)/10=2.02 | | | | | Score **2.0** | |

| 10- Aesthetically E.F(10) | Scores ( X) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 55 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Repetition (Y) | 10 | 9 | 6 | 7 | 9 | 2 | 9 | 1 | 1 | 2 | 56 |
| | X*Y | 10 | 18 | 18 | 28 | 45 | 12 | 63 | 8 | 9 | 20 | 231 |
| | weighted average score 231/55=4.20 | | | | | (weighted average score*E.F)/10 (4. 20*10)/10=4.20 | | | | | Score **4.2** | |

**Evaluation technique: Slab-beam-column system with 20cm concrete block exterior walls.**

| | criterion | score | | criterion | Score |
|---|---|---|---|---|---|
| **1** | Strength and durability (15) | **6.3** | **6** | Construction speed (10) | **9.1** |
| **2** | Cost of construction (15) | **10.8** | **7** | Cost of future maintenance (10) | **5.2** |
| **3** | Safety during construction (15) | **11.9** | **8** | Thermal insulation (5) | **2.0** |
| **4** | Aesthetically (10) | **4.2** | **9** | Fire resistance (5) | **2.2** |
| **5** | Air resistance effects (10) | **3.9** | **10** | Need for special-ized skills (5) | **4.0** |
| **The sum of total scores = 59.6** | | | | | |

# Appendix F

## Exterior walls from two layers of concrete block

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1-Construction speed E.F(10)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 0 | 1 | 5 | 5 | 6 | 11 | 17 | 7 | 4 | 56 |
| | X*Y | 0 | 0 | 3 | 20 | 25 | 36 | 77 | 136 | 63 | 40 | 400 |
| | weighted average score 400/55=7.27 | | | | (weighted average score*E.F)/10 (7.27*10)/10 =7.27 | | | | | | Score **7.3** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2- Cost of construction E.F(15)** | Scores ( X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 1 | 3 | 4 | 10 | 7 | 9 | 13 | 7 | 2 | 56 |
| | X*Y | 0 | 2 | 9 | 16 | 50 | 42 | 63 | 104 | 63 | 20 | 369 |
| | weighted average score 369/55=6.70 | | | | (weighted average score*E.F)/10 (6.70*15)/10 =10.06 | | | | | | Score **10.1** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **3- Strength and durability E.F(15)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 3 | 6 | 8 | 5 | 6 | 15 | 11 | 2 | 0 | 0 | 56 |
| | X*Y | 3 | 12 | 24 | 20 | 30 | 90 | 77 | 16 | 0 | 0 | 272 |
| | weighted average score 272/55=4.94 | | | | (weighted average score*E.F)/10 (4.94*15)/10 =7.41 | | | | | | Score **7.4** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **4- Cost of future maintenance E.F(10)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 2 | 3 | 4 | 7 | 5 | 13 | 10 | 9 | 3 | 0 | 56 |
| | X*Y | 2 | 6 | 12 | 28 | 25 | 78 | 70 | 72 | 27 | 0 | 320 |
| | weighted average score 320/55=5.81 | | | | (weighted average score*E.F)/10 (5.81*10)/10=5.81 | | | | | | Score **5.8** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **5- Safety during construction E.F(15)** | Scores(X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 1 | 2 | 2 | 6 | 5 | 4 | 14 | 14 | 8 | 56 |
| | X*Y | 0 | 2 | 6 | 8 | 30 | 30 | 28 | 112 | 126 | 80 | 422 |
| | weighted average score 422/55=7.67 | | | | (weighted average score*E.F)/10 (7.67*15)/10 = 11.5 | | | | | | Score **11.5** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **6- Need for Specialized Skills E.F(5)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 0 | 0 | 3 | 5 | 9 | 11 | 16 | 10 | 2 | 56 |
| | X*Y | 0 | 0 | 0 | 12 | 25 | 54 | 77 | 128 | 90 | 20 | 406 |
| | weighted average score 406/55=7.38 | | | | (weighted average score*E.F)/10 (7.38*5)/10 = 3.69 | | | | | | Score **3.7** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **7- Air Resistance Effects E.F(10)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 3 | 9 | 6 | 9 | 4 | 9 | 11 | 3 | 2 | 56 |
| | X*Y | 0 | 6 | 27 | 24 | 45 | 24 | 63 | 88 | 27 | 20 | 324 |
| | weighted average score 324/55=5.89 | | | | (weighted average score*E.F)/10 (5.89*10)/10 = 5.89 | | | | | | Score **5.9** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **8- Fire Resistance E.F(5)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 1 | 5 | 11 | 6 | 8 | 11 | 13 | 0 | 1 | 56 |
| | X*Y | 0 | 2 | 15 | 44 | 30 | 48 | 77 | 104 | 0 | 10 | 330 |
| | weighted average score 330/55=6.0 | | | | (weighted average score*E.F)/10 (6.0*5)/10 =3.0 | | | | | | Score **3.0** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **9-Thermal Insulation E.F(5)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 0 | 0 | 2 | 3 | 10 | 11 | 10 | 10 | 10 | 56 |
| | X*Y | 0 | 0 | 6 | 20 | 45 | 24 | 42 | 120 | 81 | 60 | 430 |
| | weighted average score 430/55=7.81 | | | | (weighted average score*E.F)/10 (7.81*5)/10 = 3.90 | | | | | | Score **3.9** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **10- Aesthetically E.F(10)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 8 | 6 | 7 | 8 | 12 | 3 | 10 | 1 | 1 | 0 | 56 |
| | X*Y | 8 | 12 | 21 | 32 | 60 | 18 | 70 | 8 | 9 | 0 | 238 |
| | weighted average score 238/55=4.32 | | | | (weighted average score*E.F)/10 (4. 32*10)/10 = 4.32 | | | | | | Score **4.3** | |

**Evaluation technique: Slab-beam-column system with exterior walls of two layers of 10cm concrete block and insulating material between them.**

| | criterion | score | | criterion | Score |
|---|---|---|---|---|---|
| **1** | Strength and durability (15) | **7.4** | **6** | Construction speed (10) | **7.3** |
| **2** | Cost of construction (15) | **10.1** | **7** | Cost of future maintenance (10) | **5.8** |
| **3** | Safety during construction (15) | **11.5** | **8** | Thermal insulation (5) | **3.9** |
| **4** | Aesthetically (10) | **4.3** | **9** | Fire resistance (5) | **3.0** |
| **5** | Air resistance effects (10) | **5.9** | **10** | Need for specialized skills (5) | **3.7** |
| **The sum of total scores = 62.9** | | | | | |

# Appendix G

## Exterior masonry walls of stone backed by concrete.

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1-Construction speed E.F(10)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 1 | 1 | 4 | 5 | 10 | 13 | 16 | 4 | 2 | 0 | 56 |
| | X*Y | 1 | 2 | 12 | 20 | 50 | 78 | 112 | 32 | 18 | 0 | 325 |
| | weighted average score 325/55=5.90 | | | | (weighted average score*E.F)/10 (5.90*10)/10 =5.9 | | | | | | Score **5.9** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2- Cost of construction E.F(15)** | Scores( X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 0 | 5 | 5 | 6 | 18 | 10 | 9 | 3 | 0 | 56 |
| | X*Y | 0 | 0 | 15 | 20 | 30 | 108 | 70 | 72 | 27 | 0 | 342 |
| | weighted average score 342/55=6.22 | | | | (weighted average score*E.F)/10 (6.22*15)/10 =9.32 | | | | | | Score **9.3** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **3- Strength and durability E.F(15)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 0 | 0 | 1 | 1 | 6 | 13 | 17 | 12 | 6 | 56 |
| | X*Y | 0 | 0 | 0 | 4 | 5 | 36 | 91 | 136 | 108 | 60 | 440 |
| | weighted average score 440/55=8.0 | | | | (weighted average score*E.F)/10 (8.0*15)/10=12 | | | | | | Score **12** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **4- Cost of future maintenance E.F(10)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 0 | 2 | 3 | 4 | 10 | 9 | 15 | 11 | 2 | 56 |
| | X*Y | 0 | 0 | 6 | 12 | 20 | 60 | 63 | 120 | 99 | 20 | 400 |
| | weighted average score 400/55=7.27 | | | | (weighted average score*E.F)/10 (7.27*10)/10 = 7.27 | | | | | | Score **7.3** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **5- Safety during construction E.F(15)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 0 | 1 | 5 | 5 | 7 | 14 | 15 | 9 | 0 | 56 |
| | X*Y | 0 | 0 | 3 | 20 | 25 | 42 | 98 | 120 | 81 | 0 | 389 |
| | weighted average score 389/55=7.07 | | | | (weighted average score*E.F)/10 (7.07*15)/10=10.6 | | | | | | Score **10.6** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **6- Need for Specialized Skills E.F(5)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 0 | 2 | 5 | 12 | 12 | 16 | 8 | 1 | 0 | 56 |
| | X*Y | 0 | 0 | 6 | 20 | 60 | 72 | 112 | 64 | 9 | 0 | 373 |
| | weighted average score 343/55=6.23 | | | | (weighted average score*E.F)/10 (6.23*5)/10 = 3.11 | | | | | | Score **3.1** | |

| 7- Air Resistance Effects E.F(10) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 0 | 0 | 3 | 5 | 12 | 12 | 13 | 8 | 3 | 56 |
| | X*Y | 0 | 0 | 0 | 12 | 25 | 72 | 84 | 104 | 72 | 30 | 399 |
| | weighted average score 399/55=7.25 | | | | | (weighted average score*E.F)/10 (7.25*10)/10 =7.25 | | | | | Score **7.3** | |

| 8- Fire Resistance E.F(5) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 0 | 0 | 2 | 4 | 10 | 15 | 13 | 10 | 2 | 56 |
| | X*Y | 0 | 0 | 0 | 8 | 20 | 60 | 105 | 104 | 90 | 20 | 407 |
| | weighted average score 407/55=7.40 | | | | | (weighted average score*E.F)/10 (7.40*5)/10 = 3.7 | | | | | Score **3.7** | |

| 9-Thermal Insulation E.F(5) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 2 | 4 | 1 | 5 | 16 | 15 | 8 | 3 | 2 | 56 |
| | X*Y | 0 | 4 | 12 | 4 | 25 | 96 | 105 | 64 | 27 | 20 | 357 |
| | weighted average score 357/55=6.49 | | | | | (weighted average score*E.F)/10 (6.49*5)/10 = 3.24 | | | | | Score **3.2** | |

| 10- esthetically E.F(10) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 0 | 1 | 0 | 3 | 3 | 9 | 14 | 14 | 12 | 56 |
| | X*Y | 0 | 0 | 3 | 0 | 15 | 18 | 63 | 112 | 126 | 120 | 457 |
| | weighted average score 457/55=8.30 | | | | | (weighted average score*E.F)/10 (8. 30*10)/10 = 8.3 | | | | | Score **8.3** | |

**Evaluation technique: Slab-beam-column system with exterior masonry walls of stone backed by concrete.**

| | criterion | score | | | criterion | Score |
|---|---|---|---|---|---|---|
| **1** | Strength and durability (15) | **12.0** | | **6** | Construction speed (10) | **5.9** |
| **2** | Cost of construction (15) | **9.3** | | **7** | Cost of future maintenance (10) | **7.3** |
| **3** | Safety during construction (15) | **10.6** | | **8** | Thermal insulation (5) | **3.2** |
| **4** | Aesthetically (10) | **8.3** | | **9** | Fire resistance (5) | **3.7** |
| **5** | Air resistance effects (10) | **7.3** | | **10** | Need for specialized skills (5) | **3.1** |
| **The sum of total scores = 70.7** | | | | | | |

# Appendix H

## Exterior walls built from stone and concrete block.

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1-Construction speed E.F(10)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 1 | 3 | 1 | 5 | 9 | 6 | 16 | 13 | 2 | 0 | 56 |
| | X*Y | 1 | 6 | 3 | 20 | 45 | 36 | 112 | 104 | 18 | 0 | 345 |
| | weighted average score 345/55=6.27 | | | | | (weighted average score*E.F)/10 (6.27*10)/10 =6.27 | | | | | Score **6.3** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2- Cost of construction E.F(15)** | Scores( X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 1 | 1 | 6 | 13 | 13 | 9 | 12 | 1 | 0 | 56 |
| | X*Y | 0 | 2 | 3 | 24 | 65 | 78 | 63 | 96 | 9 | 0 | 340 |
| | weighted average score 340/55=6.18 | | | | | (weighted average score*E.F)/10 (6.18*15)/10 = 9.27 | | | | | Score **9.2** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **3- Strength and durability E.F(15)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 0 | 0 | 2 | 2 | 8 | 18 | 16 | 6 | 4 | 56 |
| | X*Y | 0 | 0 | 0 | 8 | 10 | 48 | 126 | 128 | 54 | 40 | 414 |
| | weighted average score 414/55=7.52 | | | | | (weighted average score*E.F)/10 (7.52*15)/10 = 11.29 | | | | | Score **11.3** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **4- Cost of future maintenance E.F(10)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 1 | 2 | 2 | 4 | 11 | 5 | 18 | 11 | 2 | 56 |
| | X*Y | 0 | 2 | 6 | 8 | 20 | 66 | 35 | 144 | 99 | 20 | 400 |
| | weighted average score 400/55=7.27 | | | | | (weighted average score*E.F)/10 (7.27*10)/10 = 7.27 | | | | | Score **7.3** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **5- Safety during construction E.F(15)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 1 | 0 | 0 | 2 | 8 | 11 | 11 | 17 | 5 | 1 | 56 |
| | X*Y | 1 | 0 | 0 | 8 | 40 | 66 | 77 | 136 | 45 | 10 | 383 |
| | weighted average score 383/55=6.96 | | | | | (weighted average score*E.F)/10 (6.96*15)/10 =10.44 | | | | | Score **10.4** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **6- Need for Specialized Skills E.F(5)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 0 | 1 | 3 | 12 | 4 | 17 | 13 | 4 | 2 | 56 |
| | X*Y | 0 | 0 | 3 | 12 | 60 | 24 | 119 | 104 | 36 | 20 | 378 |
| | weighted average score 378/55=6.87 | | | | | (weighted average score*E.F)/10 (6.87*5)/10 = 3.43 | | | | | Score **3.4** | |

| **7- Air Resistance Effects E.F(10)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Repetition (Y) | 0 | 1 | 0 | 0 | 2 | 14 | 11 | 15 | 11 | 2 | 56 |
| | X*Y | 0 | 2 | 0 | 0 | 10 | 84 | 77 | 120 | 99 | 20 | 412 |
| | weighted average score 412/55=7.49 | | | | (weighted average score*E.F)/10 (7.49*10)/10 =7.49 | | | | | | Score **7.5** | |

| **8- Fire Resistance E.F(5)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Repetition (Y) | 0 | 0 | 0 | 2 | 4 | 14 | 11 | 13 | 10 | 2 | 56 |
| | X*Y | 0 | 0 | 0 | 8 | 20 | 84 | 77 | 104 | 90 | 20 | 403 |
| | weighted average score 403/55=7.32 | | | | (weighted average score*E.F)/10 (7.32*5)/10 = 3.66 | | | | | | Score **3.7** | |

| **9-Thermal Insulation E.F(5)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Repetition (Y) | 0 | 0 | 1 | 3 | 5 | 9 | 11 | 16 | 10 | 1 | 56 |
| | X*Y | 0 | 0 | 3 | 12 | 25 | 54 | 77 | 128 | 90 | 10 | 399 |
| | weighted average score 399/55=7.25 | | | | (weighted average score*E.F)/10 (7.25*5)/10 = 3.62 | | | | | | Score **3.6** | |

| **10- Aesthetically E.F(10)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Repetition (Y) | 0 | 0 | 0 | 1 | 4 | 6 | 6 | 14 | 13 | 12 | 56 |
| | X*Y | 0 | 0 | 0 | 4 | 20 | 36 | 42 | 112 | 117 | 120 | 451 |
| | weighted average score 451/55=8.20 | | | | (weighted average score*E.F)/10 (8. 20*10)/10 = 8.2 | | | | | | Score **8.2** | |

| **Evaluation technique: Slab-beam-column system with exterior walls built from concrete, stone and concrete block.** | | | | | | |
|---|---|---|---|---|---|---|
| | **criterion** | **score** | | | **criterion** | **Score** |
| **1** | Strength and durability (20) | **11.3** | | **6** | Construction speed (10) | **6.3** |
| **2** | Cost of construction (15) | **9.2** | | **7** | Cost of future maintenance (5) | **7.3** |
| **3** | Safety during construction (15) | **10.4** | | **8** | Thermal insulation (5) | **3.6** |
| **4** | Aesthetically (10) | **8.2** | | **9** | Fire resistance (5) | **3.7** |
| **5** | Air resistance effects (10) | **7.5** | | **10** | Need for specialized skills (5) | **3.4** |
| **The sum of total scores =70.9** | | | | | | |

# Appendix I

## Slab-beam-column system with exterior walls from stone, concrete block and insulating material

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1-Construction speed E.F(10)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 3 | 3 | 3 | 8 | 8 | 7 | 12 | 8 | 4 | 0 | 56 |
| | X*Y | 3 | 6 | 9 | 32 | 40 | 42 | 84 | 64 | 36 | 0 | 316 |
| | weighted average score 316/55=5.74 | | | | (weighted average score*E.F)/10 (5.74*10)/10 =5.74 | | | | | | Score **5.7** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2- Cost of construction E.F(15)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 1 | 5 | 2 | 7 | 7 | 7 | 8 | 9 | 8 | 2 | 56 |
| | X*Y | 1 | 10 | 6 | 28 | 35 | 42 | 56 | 72 | 72 | 20 | 342 |
| | weighted average score 342/55=6.22 | | | | (weighted average score*E.F)/10 (6.22*15)/10 = 9.32 | | | | | | Score **9.3** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **3- Strength and durability E.F(15)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 0 | 1 | 1 | 4 | 5 | 17 | 16 | 9 | 3 | 56 |
| | X*Y | 0 | 0 | 3 | 4 | 20 | 30 | 119 | 128 | 81 | 30 | 415 |
| | weighted average score 415/55=7.54 | | | | (weighted average score*E.F)/10 (7.54*15)/10 =11.31 | | | | | | Score **11.3** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **4- Cost of future maintenance E.F(10)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 1 | 4 | 2 | 3 | 5 | 10 | 12 | 16 | 3 | 56 |
| | X*Y | 0 | 2 | 12 | 8 | 15 | 30 | 70 | 96 | 144 | 30 | 407 |
| | weighted average score 407/55=7. 40 | | | | (weighted average score*E.F)/10 (7. 40*10)/10 =7.4 | | | | | | Score **7.4** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **5- Safety during construction E.F(15)** | Scores( X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 0 | 0 | 3 | 9 | 9 | 12 | 18 | 4 | 1 | 56 |
| | X*Y | 0 | 0 | 0 | 12 | 45 | 54 | 84 | 144 | 36 | 10 | 385 |
| | weighted average score 385/55=7.00 | | | | (weighted average score*E.F)/10 (7.00*15)/10 = 10.5 | | | | | | Score **10.5** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **6- Need for Specialized Skills** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 0 | 4 | 3 | 8 | 3 | 13 | 15 | 7 | 3 | 56 |
| | X*Y | 0 | 0 | 12 | 12 | 40 | 18 | 91 | 120 | 63 | 30 | 386 |
| | weighted average score 386/55=7.02 | | | | (weighted average score*E.F)/10 (7.02*5)/10 = 3.5 | | | | | | Score **3.5** | |

| 7- Air Resistance Effects E.F(10) | Scores (X) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 55 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Repetition (Y) | 1 | 0 | 1 | 0 | 0 | 3 | 12 | 13 | 17 | 9 | 56 |
| | X*Y | 1 | 0 | 3 | 0 | 0 | 18 | 84 | 104 | 153 | 90 | 453 |
| | weighted average score 453/55=8.24 | | | | | (weighted average score*E.F)/10 (8.24*10)/10 =8.23 | | | | | Score **8.2** | |

| 8- Fire Resistance E.F(5) | Scores (X) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 55 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Repetition (Y) | 0 | 0 | 0 | 1 | 1 | 7 | 11 | 22 | 8 | 6 | 56 |
| | X*Y | 0 | 0 | 0 | 4 | 5 | 42 | 77 | 176 | 72 | 60 | 436 |
| | weighted average score 436/55=7.93 | | | | | (weighted average score*E.F)/10 (7.93*5)/10 =3.96 | | | | | Score **4.0** | |

| 9-Thermal Insulation E.F(5) | Scores (X) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 55 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Repetition (Y) | 0 | 1 | 0 | 0 | 1 | 6 | 1 | 16 | 15 | 16 | 56 |
| | X*Y | 0 | 2 | 0 | 0 | 5 | 36 | 7 | 128 | 135 | 160 | 473 |
| | weighted average score 473/55=8.60 | | | | | (weighted average score*E.F)/10 (8.60*5)/10 = 4.3 | | | | | Score **4.3** | |

| 10- esthetically E.F(10) | Scores (X) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 55 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Repetition (Y) | 0 | 0 | 0 | 2 | 3 | 4 | 6 | 13 | 14 | 14 | 56 |
| | X*Y | 0 | 0 | 0 | 8 | 15 | 24 | 42 | 104 | 126 | 140 | 459 |
| | weighted average score 459/55=8.35 | | | | | (weighted average score*E.F)/10 (8. 35*10)/10 =8.35 | | | | | Score **8.4** | |

**Evaluation technique: Slab-beam-column system with exterior walls built from concrete, stone and concrete block and insulating material between them.**

| | criterion | score | | criterion | Score |
|---|---|---|---|---|---|
| **1** | Strength and durability (15) | **11.3** | **6** | Construction speed (10) | **5.7** |
| **2** | Cost of construction (15) | **9.3** | **7** | Cost of future maintenance (10) | **7.4** |
| **3** | Safety during construction (15) | **10.5** | **8** | Thermal insulation (5) | **4.3** |
| **4** | Aesthetically (10) | **8.4** | **9** | Fire resistance (5) | **4.0** |
| **5** | Air resistance effects (10) | **8.2** | **10** | Need for specialized skills (5) | **3.5** |
| **The sum of total scores = 72.6** | | | | | |

# Appendix J

## Exterior masonry walls from light weight units with stone

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1-Construction speed E.F(10)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 0 | 4 | 1 | 4 | 10 | 12 | 15 | 9 | 1 | 56 |
| | X*Y | 0 | 0 | 12 | 4 | 20 | 60 | 84 | 120 | 81 | 10 | 391 |
| | weighted average score 391/55=7.11 | | | | (weighted average score*E.F)/10 (7.11*10)/10 = 7.11 | | | | | | Score **7.1** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2- Cost of construction E.F(15)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 7 | 5 | 5 | 10 | 5 | 5 | 12 | 7 | 0 | 56 |
| | X*Y | 0 | 14 | 15 | 20 | 50 | 30 | 35 | 96 | 63 | 0 | 323 |
| | weighted average score 323/55=5.87 | | | | (weighted average score*E.F)/10 (5.87*15)/10 =8.8 | | | | | | Score **8.8** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **3- Strength and durability E.F(15)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 1 | 3 | 11 | 10 | 10 | 8 | 10 | 3 | 0 | 56 |
| | X*Y | 0 | 2 | 9 | 44 | 50 | 60 | 56 | 80 | 27 | 0 | 328 |
| | weighted average score 328/55=5.96 | | | | (weighted average score*E.F)/10 (5.96*15)/10 =8.94 | | | | | | Score **8.9** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **4- Cost of future maintenance E.F(10)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 0 | 5 | 5 | 8 | 8 | 14 | 10 | 5 | 1 | 56 |
| | X*Y | 0 | 0 | 15 | 20 | 40 | 48 | 98 | 80 | 45 | 10 | 356 |
| | weighted average score 356/55=6. 47 | | | | (weighted average score*E.F)/10 (6.47*10)/10= 6.47 | | | | | | Score **6.5** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **5- Safety during construction E.F(15)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 2 | 2 | 2 | 3 | 16 | 11 | 15 | 5 | 0 | 56 |
| | X*Y | 0 | 4 | 6 | 8 | 15 | 96 | 77 | 120 | 45 | 0 | 371 |
| | weighted average score 371/55=6.74 | | | | (weighted average score*E.F)/10 (6.74*15)/10 =10.11 | | | | | | Score **10.1** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **6- Need for Specialized Skills E.F(5)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 4 | 5 | 4 | 4 | 11 | 12 | 13 | 2 | 1 | 56 |
| | X*Y | 0 | 8 | 15 | 16 | 20 | 66 | 84 | 104 | 18 | 10 | 341 |
| | weighted average score 341/55=6.20 | | | | (weighted average score*E.F)/10 (6.20*5)/10 =3.1 | | | | | | Score **3.1** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **7- Air Resistance Effects E.F(10)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 0 | 0 | 6 | 3 | 10 | 10 | 15 | 6 | 6 | 56 |
| | X*Y | 0 | 0 | 0 | 24 | 15 | 60 | 70 | 120 | 54 | 60 | 403 |
| | weighted average score 407/55=7.32 | | | | (weighted average score*E.F)/10 (7.32*10)/10 =7.32 | | | | | | Score **7.3** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **8- Fire Resistance E.F(5)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 0 | 2 | 5 | 2 | 8 | 10 | 15 | 10 | 4 | 56 |
| | X*Y | 0 | 0 | 6 | 20 | 10 | 48 | 70 | 120 | 90 | 40 | 404 |
| | weighted average score 404/55=7.34 | | | | (weighted average score*E.F)/10 (7.34*5)/10 = 3.67 | | | | | | Score **3.7** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **9- Thermal Insulation E.F(5)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 0 | 0 | 4 | 0 | 10 | 11 | 10 | 10 | 11 | 56 |
| | X*Y | 0 | 0 | 0 | 16 | 0 | 60 | 77 | 80 | 90 | 110 | 433 |
| | weighted average score 433/55=7.87 | | | | (weighted average score*E.F)/10 (7.87*5)/10 = 3.93 | | | | | | Score **3.9** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **10- Aesthetically E.F(10)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 0 | 1 | 3 | 5 | 6 | 10 | 11 | 12 | 8 | 56 |
| | X*Y | 0 | 0 | 3 | 12 | 25 | 36 | 70 | 88 | 108 | 80 | 422 |
| | weighted average score 422/55=7.67 | | | | (weighted average score*E.F)/10 (7. 67*10)/10 = 7.67 | | | | | | Score **7.7** | |

**Evaluation technique: Slab-beam-column system with exterior masonry walls built from light weight units "ytong" with stone cladding.**

| | **criterion** | **score** | | | **criterion** | **Score** |
|---|---|---|---|---|---|---|
| **1** | Strength and durability (20) | **8.9** | | **6** | Construction speed (10) | **7.1** |
| **2** | Cost of construction (15) | **8.8** | | **7** | Cost of future maintenance (10) | **6.5** |
| **3** | Safety during construction (15) | **10.1** | | **8** | Thermal insulation (5) | **3.9** |
| **4** | Aesthetically (10) | **7.7** | | **9** | Fire resistance (5) | **3.7** |
| **5** | Air resistance effects (10) | **7.3** | | **10** | Need for specialized skills (5) | **3.1** |
| **The sum of total scores = 67.1** | | | | | | |

# Appendix K

## Precast concrete facade panels for exterior walls.

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1-Construction speed E.F(10)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 2 | 1 | 1 | 3 | 1 | 7 | 12 | 5 | 24 | 56 |
| | X*Y | 0 | 4 | 3 | 4 | 15 | 6 | 49 | 96 | 45 | 240 | 462 |
| | weighted average score 462/55=8.4 | | | | (weighted average score*E.F)/10 (8.4*10) /10 =8.4 | | | | | | Score **8.4** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2- Cost of construction E.F(15)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 8 | 5 | 3 | 3 | 5 | 3 | 10 | 6 | 4 | 9 | 56 |
| | X*Y | 8 | 10 | 9 | 12 | 25 | 18 | 70 | 48 | 36 | 90 | 326 |
| | weighted average score 326/55=5.92 | | | | (weighted average score*E.F)/10 (5.93*15)/10 =8.89 | | | | | | Score **8.9** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **3-Strength and durability E.F(15)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 1 | 0 | 2 | 5 | 7 | 11 | 18 | 4 | 8 | 56 |
| | X*Y | 0 | 2 | 0 | 8 | 25 | 42 | 77 | 144 | 36 | 80 | 414 |
| | weighted average score 414/55=7.52 | | | | (weighted average score*E.F)/10 (7.52*15)/10 = 11.29 | | | | | | Score **11.3** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **4- Cost of future maintenance E.F(10)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 3 | 8 | 7 | 4 | 8 | 9 | 7 | 6 | 4 | 56 |
| | X*Y | 0 | 6 | 24 | 28 | 20 | 48 | 63 | 56 | 54 | 40 | 339 |
| | weighted average score 339/55=6.16 | | | | (weighted average score*E.F)/10 (6.16*10)/10 =6.16 | | | | | | Score **6.2** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **5- Safety during construction E.F(15)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 2 | 8 | 2 | 4 | 9 | 7 | 9 | 8 | 5 | 2 | 56 |
| | X*Y | 2 | 16 | 6 | 16 | 45 | 42 | 63 | 64 | 45 | 20 | 319 |
| | weighted average score 319/55=5.80 | | | | (weighted average score*E.F)/10 (5.80*15)/10 = 8.7 | | | | | | Score **8.7** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **6-Need for Specialized Skills E.F(5)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 7 | 5 | 8 | 12 | 7 | 9 | 3 | 4 | 1 | 0 | 56 |
| | X*Y | 7 | 10 | 24 | 48 | 35 | 54 | 21 | 32 | 9 | 0 | 240 |
| | weighted average score 240/55=4.36 | | | | (weighted average score*E.F)/10 (4.36*5)/10 = 2.18 | | | | | | Score **2.2** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **7- Air Resistance Effects E.F(10)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 0 | 3 | 3 | 9 | 13 | 12 | 6 | 10 | 0 | 56 |
| | X*Y | 0 | 0 | 9 | 12 | 45 | 78 | 84 | 48 | 90 | 0 | 366 |
| | weighted average score 366/55=6.65 | | | | (weighted average score*E.F)/10 (6.65*10)/10 =6.65 | | | | | | Score **6.7** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **8- Fire Resistance E.F(5)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 1 | 2 | 4 | 4 | 10 | 9 | 10 | 12 | 4 | 56 |
| | X*Y | 0 | 2 | 6 | 16 | 20 | 60 | 63 | 80 | 108 | 40 | 395 |
| | weighted average score 395/55=7.18 | | | | (weighted average score*E.F)/10 (7.18*5)/10 =3.59 | | | | | | Score **3.6** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **9- Thermal Insulation E.F(5)** | Scores (X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 0 | 4 | 6 | 4 | 5 | 10 | 12 | 12 | 3 | 0 | 56 |
| | X*Y | 0 | 8 | 18 | 16 | 25 | 60 | 84 | 96 | 27 | 0 | 334 |
| | weighted average score 334/55=6.07 | | | | (weighted average score*E.F)/10 (6.07*5)/10 = 3.03 | | | | | | Score **3.0** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **10- esthetically E.F(10)** | Scores( X) | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | 55 |
| | Repetition (Y) | 2 | 6 | 3 | 8 | 6 | 8 | 9 | 11 | 0 | 3 | 56 |
| | X*Y | 2 | 12 | 9 | 32 | 30 | 48 | 63 | 88 | 0 | 30 | 314 |
| | weighted average score 314/55=5.70 | | | | (weighted average score*E.F)/10 (5. 70*10)/10 =5.70 | | | | | | Score **5.7** | |

| **Evaluation technique: Slab-beam-column system using precast concrete facade panels for exterior walls.** | | | | | | |
|---|---|---|---|---|---|---|
| | **criterion** | **score** | | | **criterion** | **Score** |
| **1** | Strength and durability (20) | **11.3** | | **6** | Construction speed (10) | **8.4** |
| **2** | Cost of construction (15) | **8.9** | | **7** | Cost of future maintenance (5) | **6.2** |
| **3** | Safety during construction (15) | **8.7** | | **8** | Thermal insulation (5) | **3.0** |
| **4** | Aesthetically (10) | **5.7** | | **9** | Fire resistance (5) | **3.6** |
| **5** | Air resistance effects (10) | **6.7** | | **10** | Need for specialized skills (5) | **2.2** |
| **The sum of total scores = 64.7** | | | | | | |

# Appendix L

## Cast Stone Specifications[1]

## فحص الامتصاص

**Date:**

**N:**

| |
|---|
| طالب الفحص: |
| المشروع: |
| المالك: |
| نوع العينة: حجر صناعي |
| تاريخ الاستلام: 21.6.2009 |
| تاريخ الفحص: 9.7.2009 |
| مصدر العينة: |
| مرجعية الفحص: ASTM-C97 |

| رقم العينة | SDS* | الوزن جاف | وزن الماء الممتص (غم) | نسبة الامتصاص (%) |
|---|---|---|---|---|
| 1-طبزة | 11956 | 11596 | 360 | 3.10 |
| 2-طبزة | 11486 | 11132 | 354 | 3.18 |
| 1-مفجر | 10640 | 10272 | 368 | 3.58 |
| 2-مفجر | 10908 | 10486 | 422 | 4.02 |
| **المعدل** | | | | **3.47** |

**[1] Construction and Transportation Research Center (CTRC), Laboratory of building materials, An-Najah National University (2011).**

***SDS: Saturated Dry Surface**

**فحص الكثافة**

**Date:**

**N:**

| |
|---|
| طالب الفحص: |
| المشروع: |
| المالك: |
| نوع العينة: حجر صناعي |
| تاريخ الاستلام: 21.6.2009 |
| تاريخ الفحص: 9.7.2009 |
| مصدر العينة: |
| مرجعية الفحص: ASTM-C97 |

| رقم العينة | الطول | العرض | السماكة | الوزن | الكثافة |
|---|---|---|---|---|---|
| 1-طبزة | 200.1 | 102.3 | 50.4 | 2381.7 | 2.308 |
| 2-طبزة | 200.7 | 100.6 | 50.2 | 2331.7 | 2.301 |
| 1-مفجر | 202.6 | 101.7 | 47.8 | 2254.7 | 2.288 |
| 2-مفجر | 201.7 | 100.8 | 40.3 | 1873.7 | 2.284 |
| | | **المعدل** | | | **2.295** |

# فحص الوزن النوعي

**Date:**

**N:**

| |
|---|
| طالب الفحص: |
| المشروع: |
| المالك: |
| نوع العينة: حجر صناعي |
| تاريخ الاستلام: 21.6.2009 |
| تاريخ الفحص: 9.7.2009 |
| مصدر العينة: |
| مرجعية الفحص: ASTM-C97 |

| رقم العينة | الوزن جاف | *SDS | وزن الماء | الوزن النوعي |
|---|---|---|---|---|
| 1-طبزة | 3292.4 | 3315.2 | 1866.9 | 2.273 |
| 2-طبزة | 1840.0 | 1856.1 | 1038.9 | 2.252 |
| 1-مفجر | 3069.1 | 3096.1 | 1742.0 | 2.267 |
| 2-مفجر | 3769.7 | 3811.0 | 2138.9 | 2.254 |
| **المعدل** | | | | **2.262** |

***SDS: Saturated Dry Surface**

## فحص قوة الضغط- حجر

**Date:**

**N:**

| |
|---|
| طالب الفحص: |
| المشروع: |
| المالك: |
| نوع العينة: حجر صناعي |
| تاريخ الاستلام: 21.6.2009 |
| تاريخ الفحص: 9.7.2009 |
| مصدر العينة: |
| مرجعية الفحص: ASTM-C97 |

| رقم العينة | الطول | العرض | السماكة | القوة (كيلو نيوتن) | القوة (كغم/سم$^3$) |
|---|---|---|---|---|---|
| 1-طبزة | 50.8 | 51.3 | 51.2 | 102 | 398 |
| 2-طبزة | 50.9 | 48.8 | 51.6 | 92 | 395 |
| 1-مفجر | 46.5 | 46.5 | 51.4 | 102 | 481 |
| 2-مفجر | 46.4 | 51.9 | 51.1 | 114 | 483 |
| **المعدل** | | | | | **439.25** |

# فحص التمزق

**Date:**

**N:**

| | |
|---|---|
| طالب الفحص: | |
| المشروع: | |
| المالك: | |
| نوع العينة: حجر صناعي | |
| تاريخ الاستلام: 21.6.2009 | |
| تاريخ الفحص: 9.7.2009 | |
| مصدر العينة: | |
| مرجعية الفحص: | ASTM-C97 |

| رقم العينة | الطول | العرض | السماكة | المسافة بين نقاط الارتكاز | معايير التمزق MP |
|---|---|---|---|---|---|
| 1-طبزة | 200.1 | 102.3 | 50.4 | 170 | 6.9 |
| 2-طبزة | 200.7 | 100.6 | 50.2 | 170 | 7.1 |
| 1-مفجر | 202.6 | 101.7 | 47.8 | 170 | 8.1 |
| 2-مفجر | 201.7 | 100.8 | 40.3 | 170 | 8.2 |
| **المعدل** | | | | | **7.58** |

# Appendix M

## One of the BOQ as an example

| 1- واجهات باطون مسلح و تكسيته بالحجر الطبيعي Bearing wall system<br>External reinforce concrete walls with natural stone cladding | | | | | | | |
|---|---|---|---|---|---|---|---|
| رقم البند | بيان العمل | الوحدة | الكمية | السعر | | المجموع | |
| | | | | فلس | دينار | فلس | دينار |
| **1** | **الحفريات** | | | | | | |
| 1.1 | حفريات الموقع | م$^3$ | **50** | | 5 | | 250 |
| 1.2 | حفريات قواعد الأعمدة "أساسات مستمرة" | م$^3$ | **105** | | 10 | | 1050 |
| **2** | **الباطون** | | | | | | |
| 2.1 | باطون B200 "باطون نظافة قواعد الأعمدة" | م$^3$ | **17** | | 70 | | 1190 |
| 2.2 | باطون B250 باطون المدة الأرضية وباطون الدرج وواجهاته "السعر يشمل أعمال الطوبار والحديد" | م$^3$ | **26** | | 150 | | 3900 |
| 2.3 | باطون B300 باطون قواعد الأعمدة، جسور أرضية وأسقف "السعر يشمل أعمال الطوبار والحديد" | م$^3$ | **135.5** | | 160 | | 21680 |
| 2.4 | باطون مدة الميلان B200 | **م$^2$** | **190** | | 10 | | 1900 |
| 2.5 | باطون B250 باطون الواجهات الخارجية "السعر يشمل أعمال الطوبار والحديد | م$^3$ | **55** | | 150 | | 8250 |
| **3** | **الطوب** | | | | | | |
| 3.1 | (14*40*20) طوب الربس | **عدد** | **960** | | 0.5 | | 480 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 3.2 | طوب10"القسامات الداخلية" | م$^2$ | **83** | | 10 | | 830 |
| 3.3 | طوب20"القسامات الداخلية" | م$^2$ | **30** | | 15 | | 450 |
| **4** | أعمال الحجر "السعر يشمل تلبيس الواجهات الخارجية بحجر طبيعي وكل ما يلزم" | م$^2$ | **275** | | 45 | | 12375 |
| **5** | **أعمال القصارة** | | | | | | |
| 5.1 | قصارة السقف | م$^2$ | **190** | | 4 | | 760 |
| 5.2 | قصارة الواجهات | م$^2$ | **540** | | 5 | | 2700 |
| 5.3 | تكحيل واجهات الحجر الطبيعي | م$^2$ | **275** | | 3 | | 825 |
| **6** | **أعمال البلاط** | | | | | | |
| 6.1 | بلاط الأرضية | م$^2$ | **120** | | 16 | | 1920 |
| 6.2 | بلاط أرضية الحمامات والمطابخ | م$^2$ | **25** | | 16 | | 400 |
| 6.3 | بلاط جدران الحمامات والمطابخ | م$^2$ | **100** | | 18 | | 1800 |
| 6.4 | بلاط الدرج الداخلي والخارجي | م$^2$ | **30** | | 35 | | 1050 |
| **7** | **الشبابيك والأبواب** | | | | | | |
| 7.1 | شبابيك ألمنيوم | م$^2$ | **24** | | 100 | | 2400 |
| 7.2 | أبواب حديد | م$^2$ | **10** | | 100 | | 1000 |
| 7.3 | أبواب خشب | م$^2$ | **14** | | 80 | | 1120 |
| **8** | **أعمال البراطيش** | | | | | | |
| 8.1 | براطيش شبابيك وطفطاف | م$^2$ | **60** | | 30 | | 1800 |
| **9** | **أعمال الحراسة** | | | | | | |
| 9.1 | حراسة شبابيك | م$^2$ | **24** | | 35 | | 840 |
| | **المجموع** | | | | | | **68970** |

| 2- واجهات باطون مسلح و تكسيته بالحجر الصناعي Bearing wall system<br>External reinforced concrete walls with cast stone cladding | | | | | | | |
|---|---|---|---|---|---|---|---|
| رقم البند | بيان العمل | الوحدة | الكمية | السعر | | المجموع | |
| | | | | فلس | دينار | فلس | دينار |
| 1 | الحفريات | | | | | | 1300 |
| 2 | الباطون | | | | | | 36920 |
| 3 | الطوب | | | | | | 1760 |
| 4 | أعمال الحجر<br>"السعر يشمل تلبيس الواجهات الخارجية بحجر صناعي وكل ما يلزم " | $م^2$ | 275 | | 35 | | 9625 |
| 5 | أعمال القصارة | | | | | | 4285 |
| 6 | أعمال (البلاط، الشبابيك والأبواب،البراطيش،الحراسة) | | | | | | 12330 |
| المجموع | | | | | | | 66220 |

**3- واجهات خارجية طوب 20سم** **Slab-beam-column system**
**20 cm concrete block exterior walls**

| رقم البند | بيان العمل | الوحدة | الكمية | السعر | | المجموع | |
|---|---|---|---|---|---|---|---|
| | | | | فلس | دينار | فلس | دينار |
| **1** | **الحفريات** | | | | | | |
| 1.1 | حفريات الموقع | $م^3$ | **50** | | 5 | | 250 |
| 1.2 | حفريات قواعد الأعمدة "قواعد مفردة" | $م^3$ | **31** | | 10 | | 310 |
| **2** | **الباطون** | | | | | | |
| 2.1 | باطونB200 "باطون نظافة قواعد الأعمدة" | $م^3$ | **5.5** | | 70 | | 385 |
| 2.2 | باطون B250 باطون المدة الأرضية وباطون الدرج "السعر يشمل أعمال الطوبار والحديد" | $م^3$ | **22.5** | | 150 | | 3375 |
| 2.3 | باطون B300 باطون قواعد، جسور أرضية وأسقف "السعر يشمل أعمال الطوبار والحديد" | $م^3$ | **76** | | 160 | | 12160 |
| 2.4 | باطون مدة الميلان B200 | **$م^2$** | **190** | | 10 | | 1900 |
| **3** | **الطوب** | | | | | | |
| 3.1 | طوب الربس (14*40*20) | **عدد** | **960** | | 0.5 | | 480 |
| 3.2 | طوب 20 | **$م^2$** | **305** | | 15 | | 4575 |
| 3.3 | طوب 10 | **$م^2$** | **83** | | 10 | | 830 |
| **4** | **أعمال القصارة** | | | | | | |
| 4.1 | قصارة السقف | **$م^2$** | **190** | | 4 | | 760 |
| 4.2 | قصارة الواجهات | **$م^2$** | **780** | | 5 | | 3900 |
| **5** | **أعمال(البلاط،الشبابيك والأبواب،البراطيش،الحراسة)** | | | | | | 12330 |
| | **المجموع** | | | | | | **41255** |

| 4- واجهات حجر و باطون بعمل طوبارخلف الحجر Slab-beam-column system<br>Exterior masonry walls of stone backed by concrete | | | | | | | |
|---|---|---|---|---|---|---|---|
| رقم البند | بيان العمل | الوحدة | الكمية | السعر | | المجموع | |
| | | | | فلس | دينار | فلس | دينار |
| 1 | **الحفريات** | | | | | | 560 |
| 2 | **الباطون** | | | | | | 17820 |
| 3 | **الطوب** | | | | | | |
| 3.1 | طوب الربس (14*40*20) | **عدد** | **960** | | 0.5 | | 480 |
| 3.2 | طوب 20 | **م²** | **305** | | 15 | | 4575 |
| 3.3 | طوب 10 | **م²** | **83** | | 10 | | 830 |
| 4 | **أعمال الحجر**<br>"السعر يشمل الباطون خلف الحجر والحجرمع عمل طوبار خلفه" | **م²** | **275** | | 35 | | 9625 |
| 5 | **أعمال القصارة** | | | | | | |
| 5.1 | قصارة السقف | **م²** | **190** | | 4 | | 760 |
| 5.2 | قصارة الواجهات | **م²** | **540** | | 5 | | 2700 |
| 5.3 | تكحيل واجهات الحجر | **م²** | **275** | | 3 | | 825 |
| 6 | **أعمال(البلاط،الشبابيك والأبواب،البراطيش،الحراسة)** | | | | | | 12330 |
| **المجموع** | | | | | | | **41255** |

**5- واجهات حجر و باطون و طوب** **Slab-beam-column system**

**Exterior walls built from concrete, stone, and concrete block**

| رقم البند | بيان العمل | الوحدة | الكمية | السعر | | المجموع | |
|---|---|---|---|---|---|---|---|
| | | | | فلس | دينار | فلس | دينار |
| **1** | **الحفريات** | | | | | | 560 |
| **2** | **الباطون** | | | | | | 17820 |
| **3** | **الطوب** (طوب الربس, طوب 20, طوب 10) | | | | | | 1760 |
| **4** | **أعمال الحجر** "السعر يشمل الطوب والحجروباطون بينهما " | م$^2$ | **275** | | 60 | | 16500 |
| **5** | **أعمال القصارة**( قصارة سقف وواجهات , تكحيل حجر) | | | | | | 4285 |
| **6** | **أعمال(البلاط،الشبابيك والأبواب،البراطيش،الحراسة)** | | | | | | 12330 |
| | **المجموع** | | | | | | **53255** |

**6- واجهات حجر وطوب و مادة عازلة Slab-beam-column system**

**Exterior walls built from concrete, stone, concrete block and insulating material**

| رقم البند | بيان العمل | الوحدة | الكمية | السعر | | المجموع | |
|---|---|---|---|---|---|---|---|
| | | | | فلس | دينار | فلس | دينار |
| **1** | **الحفريات** | | | | | | 560 |
| **2** | **الباطون** | | | | | | 17820 |
| **3** | **الطوب** (طوب الربس, طوب 20, طوب 10) | | | | | | 1760 |
| **4** | **أعمال الحجر** "السعر يشمل الطوب وباطون خلف الحجر ومادةعازلة بينهما" | $م^2$ | **275** | | 65 | | 17875 |
| **5** | **أعمال القصارة**( قصارة سقف وواجهات , تكحيل حجر) | | | | | | 4285 |
| **6** | **أعمال(البلاط،الشبابيك والأبواب،البراطيش،الحراسة)** | | | | | | 12330 |
| **54630** | **المجموع** | | | | | | |

| 7–طبقتين طوب 20 و 7 سم و بينهما مادة عازلة Slab-beam-column system<br>Two layers of 20 and 7 cm concrete block and Insulating material | | | | | | | |
|---|---|---|---|---|---|---|---|
| رقم البند | بيان العمل | الوحدة | الكمية | السعر | | المجموع | |
| | | | | فلس | دينار | فلس | دينار |
| **1** | **الحفريات** | | | | | | 560 |
| **2** | **الباطون** | | | | | | 17820 |
| **3** | **الطوب** | | | | | | |
| 3.1 | طوب (14*40*20)<br>الربس | **عدد** | **960** | | 0.5 | | 480 |
| 3.2 | طوب 7,20 سم طبقتين للواجهات الخارجية مع وضع مادة عازلة بينهما | $م^2$ | **305** | | 25 | | 7625 |
| 3.3 | طوب 10 للقسامات الداخلية | $م^2$ | **83** | | 10 | | 830 |
| **4** | **أعمال القصارة** | | | | | | |
| 4.1 | قصارة السقف | $م^2$ | **190** | | 4 | | 760 |
| 4.2 | قصارة الواجهات | $م^2$ | **780** | | 5 | | 3900 |
| **5** | **أعمال(البلاط،الشبابيك والأبواب،البراطيش،الحراسة)** | | | | | | 12330 |
| | **المجموع** | | | | | | **44305** |

**8-واجهات طوب ايتونج و كسوته بالحجر Sab-beam-column system**

**Exterior masonary walls built from light weight units with stone cladding**

| رقم البند | بيان العمل | الوحدة | الكمية | السعر | | المجموع | |
|---|---|---|---|---|---|---|---|
| | | | | فلس | دينار | فلس | دينار |
| **1** | **الحفريات** | | | | | | 560 |
| **2** | **الباطون** | | | | | | 17820 |
| **3** | **الطوب** | | | | | | |
| 3.1 | طوب الربس (14*40*20) | **عدد** | **960** | | 0.5 | | 480 |
| 3.2 | طوب الايتونج سماكة 20سم | $م^2$ | **30** | | 20 | | 600 |
| 3.3 | طوب 10 قسامات داخلية | $م^2$ | **83** | | 10 | | 830 |
| **4** | **أعمال الحجر** " السعر يشمل تكسية الواجهات الخارجية بالحجر ووضع شبكة حديد بين الحجر وطوب الايتونج " | $م^2$ | **275** | | 65 | | 17875 |
| **5** | **أعمال القصارة**( قصارة سقف وواجهات , تكحيل حجر) | | | | | | 4285 |
| **6** | **أعمال(البلاط،الشبابيك والأبواب،البراطيش،الحراسة)** | | | | | | 12330 |
| **المجموع** | | | | | | | **54780** |

جامعة النجاح الوطنية
كلية الدراسات العليا

# آلية اتخاذ القرار في اختيار نظام إنشاء الجدران الخارجية في مباني السكن الميسر في فلسطين

إعداد
حنان لطفي عبد اللطيف محسن

إشراف
د. رياض عبد الكريم
أ. د. سمير أبو عيشة

قدمت هذه الأطروحة استكمالاً لمتطلبات الحصول على درجة الماجستير في الإدارة الهندسية بكلية الدراسات العليا في جامعة النجاح الوطنية في نابلس، فلسطين
2012م

# آلية اتخاذ القرار في اختيار نظام إنشاء الجدران الخارجية في مباني السكن الميسر في فلسطين

**إعداد**

**حنان لطفي عبد اللطيف محسن**

**إشراف**

**د. رياض عبد الكريم**

**أ. د. سمير أبو عيشة**

## الملخص

يعتبر الإسكان من أهم التحديات التي تواجه السلطة الوطنية الفلسطينية، حيث تزداد مشكلة الإسكان في فلسطين يومًا بعد يوم في ظل التزايد المطرد للسكان والعائدين وفي ظل محدودية الأراضي وارتفاع أثمانها، ويرى بعض الخبراء أن المسكن الفلسطيني يواجه مشكلات ترجع إلى ارتفاع تكاليف أسعار البناء، و انخفاض مستوى الدخل نسبياً.

إن النجاح في توفير السكن الاقتصادي معتمد على أمور عدة من بينها تقليل كلفة الإنشاء للوحدة السكنية والتي بدورها تعتمد على آلية التنفيذ الإنشائي للوحدة. لذا فالاختيار الأمثل لنظام الإنشاء له أهمية كبيرة في خفض تكلفة المساكن، إلاّ أن خفض الكلفة يجب ألا يكون على حساب كفاءة البناء، وبخلاف ذلك فإن فكرة الحصول على بيت رخيص التكاليف بغض النظر عن جودة البناء تعتبر فكرة تفتقر إلى بعد النظر وتشكل حلا رخيصا آنيا ومشكلة معقدة مستقبلاً، لذلك هناك حاجة ملحة لعملية اتخاذ القرار لاختيار النظام الإنشائي الأمثل.

تهدف هذه الدراسة بشكل أساسي إلى العمل على تحسين وضع قطاع الإسكان في فلسطين وتسهيل إمكانية الحصول على إسكان اقتصادي وذلك من خلال (1) استعراض الأنظمة الإنشائية المستخدمة في الضفة الغربية من فلسطين (2) تحديد معايير القرار التي تؤثر في عملية تقييم تلك الأنظمة وإعطاء وزن لكل معيار من مئة (3) وضع علامة لكل نظام من هذه الأنظمة في كل معيار من معايير القرار وجمع تلك العلامات لمعرفة النظام الذي أخذ أعلى مجموع في تلك المعايير واختياره.

تم استخدام كلا المنهجيتين البحثيتين –الكمي والنوعي– لإتمام هذا العمل البحثي، حيث تم تصميم استبانة وتوزيعها على أفراد العينة البحثية والتي هي 81 شركة مقاولات مصنفة في اتحاد المقاولين الفلسطينيين تخصص أبنية فئة أولى، و قد أعيدت 56 استبانة مكتملة أي ما نسبته (69%) من العينة المستهدفة لتمثل مادة البحث والدراسة. أيضاً قد تم تطبيق جميع الأنظمة الإنشائية التي تم تقييمها على إحدى الوحدات السكنية كحالة دراسية وعمل جداول لحساب الكميات و تسعيرها من اجل المقارنة فيما بينهم من الناحية الاقتصادية.

وبعد تحليل المعلومات الواردة، أظهرت النتائج أن النظام الإنشائي المستخدم في تنفيذ المشاريع السكنية يحقق كفاءة وجودة البناء المطلوبة حيث انه حصل على أعلى تقييم وأيضاً تم اختياره من قبل غالبية أفراد العينة على أنه النظام الأنسب لمشاريع الإسكان ولكنه لا يساهم في الحصول على السكن الاقتصادي إذ انه مرتفع التكلفة.

لذلك فقد قامت الباحثة ببعض التعديلات على هذا النظام من أجل الخروج بنظام يحقق خفض الكلفة مع الإبقاء على الكفاءة المطلوبة.