An-Najah National University
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Towards Sustainable Construction Systems Of External Walls Of Buildings In The West Bank Of Palestine

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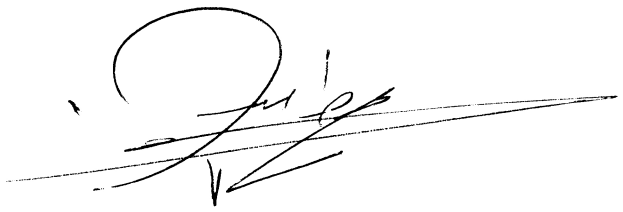

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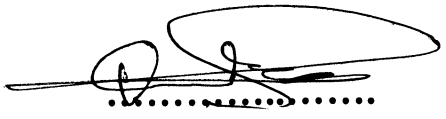
2. Dr. Jamal Amro / External examiner	
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DEDICATION

To my beloved country: Palestine,

To the spirits of all Palestinian martyrs,

To my dearest parents for their continuous encouragement,

To my beloved wife and son; "Rose and Odai", whom I see the life through their eyes.

ACKNOWLEDGMENT

I would like to thank everyone who supported me, those who helped me with their wise guidance, my supervisor Dr. Mohammad Yousof and my friend Arch. Asad Arandi.

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Finally I would like to expand my thanks and gratitude to my wife Rose who supported me and ensured a suitable environment for the completion of this thesis.

الإقرار

أنا الموقع اسمي أدناه مقدم الرسالة التي تحمل العنوان:

Towards Sustainable Construction Systems Of External Walls Of Buildings In The West Bank Of Palestine

نحو أنظمة إنشاء مستدامة لجدران المباني الخارجية في الضفة الغربية من فلسطين

اقر بأن ما اشتملت عليه هذه الرسالة إنما هو نتاج جهدي الخاص، باستثناء مـــا تمـــت الإشارة إليه حيثما ورد، وان هذه الرسالة ككل، أو أي جزء منها لم يقدم من قبل لنيل أية درجة علمية 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 of qualification.

Student's name: **اسم الطالب:**

Signature: **التوقيع:**

Date: **التاريخ:**

Table of Contents

List of Tables

List of Figures

List of Charts

Towards Sustainable Construction Systems of External Walls of Buildings in The West Bank of Palestine

by
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Supervisor
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Abstract

Sustainable construction is one of the important aspects of sustainable development which meets a growing concern in most of the world communities. As a very large sector in the West Bank, construction has a significant *impact* on the *environment*, during the construction phase and the running of the structures and buildings. In the last decades, as in most of the world countries, the interior environment of buildings became uncomfortable in the West Bank, which require an extensive use of heating and cooling that raised the running costs of the buildings and the consumption of energy, and consequently negatively affected the environment in the West Bank.

This study focuses on the methods that lead to obtain *sustainable construction* of external walls of buildings as a very important component of the building envelope. Such a study will help in improving the construction sector and make it less harmful to the environment; it will also help in improving the *external wall systems* and make them more efficient and *sustainable*.

The study reached the intended aims through studying and analyzing the relevant literature, performing a *pioneer study* and comparing findings.

It produced a number of findings , for example, the use of *thermal insulation* in the external walls of buildings would decrease the need for *heating and cooling* by 14-20% when using *air gap technique*, and by 22-56% when using *insulation material technique*. It also found that *construction materials* in the West Bank needed to be improved regarding their properties, management, disposal, *recycling* and *reuse*, in order to become more sustainable.

The study concluded that; conventional ways of practicing construction in the West Bank do not take into consideration construction sustainability and without including construction actions into *sustainable approach*, *environmental problems* in the West Bank will be uncontrolled and running costs of building will be higher. The study presented a number of recommendations for all parties involved in the construction process, these recommendations are intended to improve and develop the construction in general and the construction of external walls in particular, in the West Bank.

Chapter One

Introduction

Chapter One
Introduction

This chapter is going to provide a clear introduction to the subject. It will give a brief background; define the problem, focus and objectives. It will show the value of the study, clarify the followed methodology, and review the relevant literature.

1.1 Background

'If all the people consumed natural resources at the same rate as the average US and UK citizen, we would require at least two extra planets like Earth.'[1]

This statement is by a spoken man for World Wildlife Fund (WWF), a leading environmental organization around the world, supports the fact that the extensive use of earth resources is going to lead natural resources into depletion.

That was one of a number of reasons for societies to increase their interest in ecological and environmental issues, and to search ways that could decrease the impact of industry and machines, as well as to stop resources depletion, in order to insure a healthy world for present and future generations. As a result, various sectors join a race of contribution to decrease that impact.

The construction industry in the West Bank of Palestine is one of these sectors, it is one of the most important and essential activities in

[1] Mark Townsend and Jason Burke, 2002, p1

Palestinian economy and development. On the other hand, it is a contributing activity in environmental pollution, due to the great dependence on conventional machines, material industry and transportation, in addition to the large quantity of wastes produced from the construction of building, structures and infrastructures. This leads to the question:

What can be done to minimize the negative impact of construction, in the West Bank?

Most of the countries around the world, trying to follow a sustainable construction approach, as a part of overall sustainable development; consequently, the construction industry in Palestine must follow the international trend to make the construction in the West Bank more sustainable.

Sustainability, which is a wide comprehensive concept, involves social, environmental, and economical aspects, as main pillars according to Halliday[1].

It can be defined as "*The long-term maintenance of valued environmental resources in an evolving human context*" [2]

Sustainable construction aims to maintain a balance between nature and the built environment, and it is an exigent need to make our

[1] Sandy Halliday, 2008, p7
[2] Yale Center for Environmental Law and Policy ,2005, p11.

construction practice sustainable to save our environment and maintain a good quality of life.

Studying the construction in the West Bank; including construction materials, techniques and systems using a sustainable approach would provide a concrete ground that might be the base of implementing sustainable construction in the West Bank.

This study will be helpful for all parties involved in the construction sector from the local governments which draw the legislations and laws to contractors, materials manufacturers and suppliers, engineers, architects, and owners of projects, in order to take their responsibilities towards their societies and environment and make their projects more sustainable.

1.2 Problem Statement

Construction is considered to be one of the most human actions that consumes resources and affects the environment, not only through the construction process but also during the lifetime of structures and buildings. The currently adopted construction systems in the West Bank have proved that they can provide people and community with a suitable shelter and structure, but in the last decades the thermal discomfort inside buildings pushed to an extensive use of air conditioning to maintain a convenient temperature, by using fans or air conditioning systems in summer and heaters in winter, a procedure that raises the running costs and the consumption of fossil fuel. Besides, the conventional construction actions became more harmful to the environment.

1.3 Research Focus

Obtaining a sustainable construction, does not mean to find new systems, so if some improvements and developments as well as sustainable practice are applied to these systems, that will make them more sustainable. This research is going to study the architectural construction systems including; foundation systems, floor systems and roof systems in the West Bank, with a focus on the exterior walls of buildings as they are the wider connections between inside and outside of the building, based on sustainability criteria.

1.4 Aims and Objectives

The main goal of this study is to investigate and evaluate the construction systems of external walls of buildings in terms of sustainability, and a number of secondary targets such as:

1- Raising the awareness regarding the sustainable construction and sustainable materials.

2- Exploring and highlighting the new building materials and technologies used in the West Bank and helping in developing sustainable systems.

3- Determining the advantages of the new materials and systems.

4- Providing suggestions for improvements and developments of wall construction systems.

1.5 Research Significance

One of the most active actions that societies do is building and constructing its physical environment. The concept of sustainability spread widely to cover every part of these actions. Studying the construction activities in terms of; construction materials, techniques and systems in general and that of the external walls of buildings in particular- using sustainability approach would add a value to construction in a variety of ways;

1- It is important and urgent to decrease the depletion materials and the increasing impacts of construction processes on the environment.

2- It will raise the awareness regarding sustainable construction and sustainable materials by exploring the benefits of implementing sustainable construction and using sustainable materials.

3- It will help in highlighting the new materials and techniques regarding sustainability and help in developing sustainable systems, by studying and analyzing them using sustainability approach.

4- It will determine the advantages of the new sustainable materials and systems by showing the benefit of using them and how they contribute to improve our quality of life.

5- It will provide suggestions for improvements and developments of wall construction systems, based on the literature review analysis of study cases and empirical data.

1.6 Approach and Methods

1.6.1 Methodology

This study is going to follow the Deductive Approach methodology:

- A study and analysis of the existing construction systems in West Bank, with a focus on the external walls of buildings, in terms of sustainability, will be performed.
- A comparison between these systems, the applied construction technology and the materials used will be performed. This will show how applying sustainable construction could make a difference.
- Obtaining conclusions and providing recommendations

The study will depend on a computer simulation experiment using TRANSYS program. The resulted data will be studied, analyzed and compared.

1.6.2 Data Resources

The study is going to rely on the following resources:

- Library resources, including; Books and magazines specialized in architectural construction technology and materials. Books and

magazines specialized in sustainable architecture, green buildings, and sustainable materials.

- Data from the construction materials companies, including its specifications and details.
- Data and observations from fieldwork.
- Personal interviews.

1.7 Literature Review

The concern about sustainability in general and sustainable construction in particular has notably increased around the world lately.

A study carried out by Malik M.A Khalfan 2002, on *sustainable development and sustainable construction* showed that the main aim of sustainable development was to ensure a better quality of life for human beings, at the present and in the future. His study defined the sustainable construction as" *the creation and responsible management of a healthy built environment based on resource efficient and ecological principles*"

He mentioned some ways that must be followed to achieve sustainable construction.[1]

Khalfan's study discussed general aspects of sustainable development and sustainable construction. He did not elaborate on some important issues that need to be addressed such as materials; their selection

[1] Malik M.A Khalfan, 2002, p1-26

consideration, resources, manufacturing, management and what materials are recommended for sustainable construction.

Another wide study carried out by the United Nations and titled "*Agenda 21 for sustainable construction in the developing world"* realized that there is a need for a different approach to be followed in developed countries. Some of the main objectives of that study were identifying, the key issues, needs and challenges facing sustainable construction in the developing world, as well as the major barriers to practicing sustainable construction.

The study showed that the construction industry is probably more important in developing countries than it is in developed countries, due to the very little regard for environmental considerations.

It concluded that there is no clear understanding yet of the tremendous innovation in building materials, service systems and construction processes that will be required.[1]

Agenda 21, indeed, is a wide valuable study that could be considered as a starting point for any sustainable construction study in the developing world. This study did not take into consideration the specialty of the case of Palestine. Which is not only a developing country, but also an occupied one.

[1] Chrisna de plessis(Editor), 2001 p 59-73 .

A related research also carried out by "the Ministry of Local Government" and titled "*code of energy-saving buildings*". The main goal for this code was to put new construction regulations that help in limiting the energy waste for conditioning and heating needs. The code discussed the primary concepts in thermal design.[1]

Moreover the code is considered an essential reference that helps in finding buildings that conserve energy, but this is just one of a number of aspects of sustainable construction. This code did not discuss other aspects of sustainable construction such as sustainable construction materials and practicing of sustainable construction, the code lacks examples that show the effect of applying this code on energy consumption and cost.

Another study also by the ministry of local government titled (*Establishing, adopting and implementing of energy cods for building)* discussed the construction materials at local market in the Palestinian territories and aimed to review the available construction materials used in Palestinian territories and introduced thermal specifications and energy efficient materials. The study concludes that insulation and solar energy are cost effective elements in housing and should be encouraged.

Furthermore, it suggests that it is necessary to study the wastes of wood, paper or plastic, aluminum foils and use them in cavity walls as boards or fibers.[2]

[1] Ministry of Local Government, 2004, p 31-120
[2] Ibid,, 2002, p 1-36

Reservation due to the fact that, this study discussed the construction materials used in the West Bank and their thermal properties, which are one of the aspects of materials sustainability, more aspects needed to be considered regarding construction materials such as recycling, waste management, reuse and durability.

Another study for the same researcher also discusses the construction techniques in the Palestinian territories, and aims to review the traditional and contemporary building techniques used, and to introduce thermal specifications and energy efficiency of these techniques, so as to be considered as a base for alternative solutions of developing the building construction with, in order to establish Energy Building Codes.

The study concludes that some techniques of construction are used for water insulation, and not for thermal, because of little engineering experience about thermal behavior of building elements, when adding thermal insulation materials to the compositions.[1]

One of the reservations on this study is, due to the fact that this study introduced the construction techniques and highlighted the use of insulation materials without providing an example that shows the effect of the use of these insulation materials on thermal comfort and energy consumption for heating and cooling purposes.

[1] Ministry of Local Government, 2002, p 7-21.

This study is intended to examine the effect of using insulation materials in the external walls of buildings and provide a clearer picture and a better understanding.

1.8 Structure of Research

This study includes the following chapters:

Chapter 1: Introduction

This chapter gives background information on the impact of construction on the built environment and how implementing sustainable construction could help in solving related ecological problems caused by buildings in the West Bank. Research objectives are identified, as well as the importance of this study is clarified.

Chapter 2: Sustainability And Sustainable Construction

This chapter clarifies the reasons that lead to the concept of sustainability such as; the increasing population, the depletion of natural resources, the effect of energy consumption on global warming, pollution and ozone depletion, in addition to impacts of the built environment.

It provides the reader with a clear understanding of how sustainability helps in solving construction problems by implementing sustainable development on all fields of life and shows the concept of sustainable development. It also provides a good understanding of sustainable construction; clarifies the importance of practicing sustainable

construction and states its principles. Also discusses the governmental responsibilities.

Construction materials are also discussed, the need, resources, use and recycling of materials are clarified, in addition to the impacts of those materials. Moreover, this chapter identifies the green or sustainable materials, clarifies their selection considerations, and puts forward some recommendations.

Chapter 3: Traditional Construction in The West Bank

This chapter discusses the traditional construction and building materials in the West Bank, and analyses the types of traditional construction systems.

Chapter 4: Contemporary Construction in The West Bank

This chapter discusses the contemporary construction systems in the west bank; foundation systems, floor systems, and roof systems. It also analyses these systems and provides suggestions to make them more sustainable. It explores the basic construction materials in the West Bank; concrete, insulation materials, steel and natural building stone. It also gives an idea about how sustainable those materials are.

Chapter 5: Wall Construction in The West Bank

This chapter examines the wall construction systems in the West Bank focusing on the external walls; there types, orders and materials,

including concrete external walls, hollow concrete block external walls, stone external walls, metal panels curtain walls, glass and aluminum curtain walls and windows. It also provides a simulation thermal analysis for the different types of external walls in order to find out an appropriate sustainable type.

Chapter 6: Conclusions and Recommendations

This chapter provides conclusions regarding sustainable construction, sustainable materials and systems. It puts forward recommendations for sustainability of construction in general and the wall construction in particular in the West Bank.

Charter Two

Sustainability and Sustainable Construction

Charter Two
Sustainability and Sustainable Construction

2.1 The Need for Sustainability

The importance of sustainability raises a number of questions such as: why do we bother ourselves in such concepts, do we really need them, or is it just a science fashion?

There are a number of factors that affect human prosperity and quality of life such as: population, natural resources and energy.

2.1.1 The Increasing Population

Murray and Lopez, 1996 urged that the increase of human population especially in urban areas, accompanied with pollution of water, food, soil, and air due to chemical and pathogenic organisms causes diseases prevalence that lead to human deaths.[1]

According to the World Bank, the current world population increases at a rate of 1.15% per year, with an average annual population change estimated currently at over 77 million. In Palestine according to the same source, the population growth in 2009 was around 2.7% per year. The total population of the Palestinian territories mid 2009 was about 3.9 million.[2]

[1] Pimented David and others, 1999, http://www.oilcrash.com/articles/limit.htm, p 1-15
[2] Palestinian central bureau of statistics, http://www.pcbs.gov.ps/Portals/_pcbs/PressRelease/PalEconomic_2010_E.pdf , 2011, p 1-3

2.1.2 Depletion of Natural Resources

That earth resources are limited and divided among the increasing number of people. How long will some resources be available?

The world watch institute, 1992 and WRI, 1994-1998 announced that "*the quality and quantity of arable land, water, energy and biological resources determine the current and future status of the support services for human life, measurable shortage of fertile land, water and fossil energy now existing in many regions around the world.*"

According to Dudeen, 1997, "*Palestine is an area with very limited natural resources. The geographic, political and socioeconomic uniqueness of this area imposes additional pressure of their resources*"[1]

2.1.3 Energy Consumption

Energy can be produced from several resources, and most of our technology depends on it to run, the problem of most of energy resources is the negative impact on natural environment.

The extensive use of energy affects the environment and causes number of impacts such as:

- *Global warming* - *Pollution* -*Ozone depletion*
- *Depletion of Resources* - *Deforestation* - *Soil degradation*

[1] Basim Dudeen, 2008, P16

- *Waste*.[1]

Note: see appendix (1) for more elaboration.

2.1.4 Impacts of The Built Environment

Rodman and Lenssen,1996, argued that the construction of built environment, have a great impact on earth resources, they gave an example that one-sixth of world's fresh water withdrawal caused by building actions, one-quarter of its wood harvest, and two-fifth of its materials and energy flows.

Williams believes that "At *the point where the use exceeded the supply, the standards of living are reduced and the quality of life goes down as well*".[2]

In the West Bank constructing the physical environment is one of the most active actions, due to the occupation, which intended to destroy Palestinian buildings, structures and infra-structure. That's put extra pressure on the natural resources and consumes much more energy.

2.1.5 Sustainable Development (SD)

" *what sustainability means is adopting the way we all live and work towards"... , meeting the needs while minimizing the impacts of*

[1] Paola Sassi, 2006, p5
[2] Daniel E. Williams,2007, p

consumption providing for people of today and not endangering the generation of tomorrow…"[1]

All sustainability definitions stated that the needs of present living people must be attained without preventing the coming generations to obtain their needs.

According to Julien, 2010, environment, society and economy are the pillars of sustainable development; the economy depends on the other two pillars, environment and society. He believes in the hierarchy of theses pillars, and finds that the following model is the most appropriate and realistic one, see figure (1)[2]

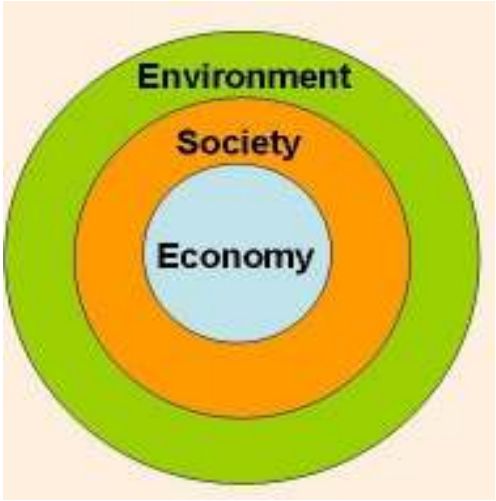


Figure (1:) Realistic sustainability model according to Julien Roberg's Blog
Source: Julie Roberg, November 2010,

- **The Reality of Sustainable Development in The West Bank**

National Palestinian authority did some initiatives to establish the roots of sustainable development. These steps are still not enough.

[1] The chartered Institute of building, 2003, p 1-11
[2] Julie Roberg, 2010, http://julienroberge.wordpress.com/tag/three-pillars-of-sustainability , p1

The Palestinian National Authority (PNA) since its establishment has given a great interest to sustainable development as it is one of the pillars of the future state of Palestine. The statement by State of Palestine at the world summit on sustainable development, in Johannesburg-South Africa, in September 2002, shows that the (PNA) creates the needed laws and legislations which ensure organized and managed resources of water, environment, education, health, industry, trade, tourism, and other fields.

It also developed a strategic development plans for land use framework in the West Bank and started to apply these plans in fields of environment, health, agriculture, tourism, and water. The statement reviews the actions and projects made to achieve (SD) in various fields of health, education, environment and society.

2.2 Sustainable Construction (SC)

Looking on the meaning of sustainable construction, one can finds that it focuses on two sides; human and the environment. Agenda 21 for sustainable construction in developing countries defines sustainable construction as *"one of the integral processes of sustainable development and is seen as a holistic process aiming to restore and maintain harmony between the natural and the built environment, and create settlements that affirm human dignity and encourage economic equity".*[1]

More explanation on the definition of (SC) introduced by Kent design guide conceive the sustainable construction as "*a set of construction*

[1] *Anil Laul, Ambrose Adebayo*, *Liliana Miranda & Arch. Liliana Marulanda,* 2001, p1-7 .

processes that help communities improve the infrastructure they use and live in while simultaneously protecting the environment". Such ways of construction protect the environment, raise public awareness, and achieve a long term economic profitability[1].

2.2.1 Practicing Sustainable Construction

There is noticeable impact of construction processes; reducing such impact on the environment and natural resources requires a conscious environmental practice of construction. This can prevent from disturbing the site, reducing the quantity of waste, reducing the use of natural resources during constructions processes, and minimize the affecting indoor air quality.

Approaching constructions from a sustainable perspective needs some actions to be taken before the construction process begins. Actions in the design stage, specifications and bidding documents stage should be considered. [2]

These actions include addressing sustainability and environment requirements.[3]

The Kent design guide agrees with Heiber point view when noted that applying sustainable construction to a project must include actions that guarantee environmental reservation, such as avoiding environmentally

[1] The Kent design guide, 2006, http://www.s-p-i-n.co.uk/assets/sustainableconstructiontechnicalappendixkentguide.pdf
[2] Heiber 1996, p15
[3] Myers Michael , 1996, p V.1- V.13

harmful materials, rational use and procurement of materials, using recycled materials and materials from local resources, design for energy efficiency, using advanced construction methods.[1]

Table (1) shows the benefits of applying sustainable construction issues in environmental, social, and economic aspects.

Table (1): Sustainability benefits

	Sustainability Benefits			
Sustainable Construction Issue	Definition	Environmental	Social	Economic
Recycled/Reclaimed Materials	Using construction material with recycled content or materials reclaimed from previous uses	Reduction in depletion and degradation of resource base	Reduced impacts on road traffic and congestion	• Transport costs reduced e.g. fuel • Virgin material costs reduced e.g. aggregates levy
Material Avoidance	Environmental and health concerns associated with construction material and methods	CO_2 emissions reduced from production of energy intensive materials	Reduced impacts on human health from manufacture e.g. PVC	Energy costs from intensive manufacture e.g. expanded polystyrene, VOC paints
Local Sourcing	Obtaining construction material from local outlets or from the existing site	Resource extraction footprint radius is reduced	Supporting local economy	Vibrant local economy

Source: The Kent design guide, Making it happened –sustainable construction, sustainable construction technical appendix

Heiber believes that the team including the owner, the architect, the engineers and the contractor, should work together to come out with guidelines, plans, goals and practice of construction. This will guarantee that the contractor is well aware of and understands environmental and sustainability responsibilities before the work begins. [1]

2.2.2 Principles of Sustainable Construction

Heiber, 1996, suggests some practices that help achieving sustainable construction such as:

- Establishing and enforcing environmental guidelines for the construction process and incorporate them into the construction drawing

[1] The kent design guide, 2006, p 1.

and specification, following that with monitoring the commitment of the contractor to these guidelines.

- Incorporating environmental responsibilities in the construction contract and monitoring the contractor commitment to these responsibilities.
- The design team can help the contractor understand environmentally preferred practice.1

The Sustainable Construction Team DTI, 2004[2] also defines and suggests key themes to be taken in the construction industry, under the title "building a better quality of life", these themes are:

- Design for minimum waste.
- Lean construction and minimize waste.
- Minimize energy in construction and use.
- Avoid polluting the environment.
- Preserve and enhance biodiversity.
- Respect local environment.
- Monitor and report, in other words, use benchmarks.

The themes above reflect responsibility, effectiveness, and efficiency.[3]

[1] Public technology Inc., 2004, p 6-28
[2] Cours Construction Center, 2003, p 7.
[3] Sustainable construction team, 2004, p3

Most of these elements and principles are suitable to be followed in the West Bank which in no doubt will help achieving sustainable construction.

2.2.3 Governmental Responsibilities

Governments are supposed to play a major role to make sustainable construction a reality, what does that require?

Adopting sustainable policies by local governments requires some issues to be addressed. Such as educating parties involved in green or sustainable construction projects, ensuring that ordinances, procurement practices, building codes and permitting processes are in place, and taking some factors, such as accessing to environmentally sound materials, and infrastructure for recycling construction and demolition into consideration.[1]

Mayers, 1996, suggests some options that might be taken by the local governments such as:

- Educating people public and professionals involved in green building construction about green practice.
- Reviewing jurisdiction codes and ordinances to remove green practice parries.
- Establishing a commission to develop specifications that are accurate and improve green and sustainable efforts using environmental procedures.

[1] Michael Mayers, 1996. Chapter 20

- Establishing a commission to promote construction and demolition waste recycling.
- Directing the contractors to local and regional vendors of environmental products and material recycling.[1]

What Mayer suggests will cast shadows on the need to put forward governmental guidelines by the PNA as a part of sustainable construction.

2.2.4 Agenda 21 for Sustainable Construction in Developing Countries

The United Nations offered a special agenda for the construction sector, as a part of Agenda 21 for sustainable development mainly for taking into consideration the developing countries.

The agenda focus was on sustainability involvement on the built environment, including construction process as the main action of creating the physical environment and human settlements, from the extraction of raw materials, passing processes of manufacturing to recycle and reuse of materials.

The agenda suggests a strategy for actions that could help in implementing sustainable construction in developing countries.

The strategy contains "supportive actions by all role-players", besides developing new knowledge and technologies.[1]

[1] Anilaul, Kirtee Shah, Ahmad Sassan, Ambrose Adebayo, 2001, p 59-73

2.2.5 Sustainable Construction Materials

For constructing and running a building, Paola Sassi[1], 2006 consider three substantial elements; materials, energy and water. He believes that the sustainable approach in construction requires thinking of these three elements in terms of environmental and social impacts, besides the continuous depletion of these elements.

Table (2) shows the existing reserves of raw materials.

Table (2): The existing reserves of raw materials

Raw material		*Statistical reserve (years)*
Mineral		
1.	Aggregate (sand, gravel)	Very large
2.	Arsenic	21
3.	Bauxite	220
4.	Boric salts	295
5.	Cadmium	27
6.	Chrome	105
7.	Clay, for fired products	Very large
8.	Copper	36
9.	Earth, stamped	Very large
10.	Gold	22
11.	Gypsum	Very large
12.	Iron	119
13.	Lead	20
14.	Lime	Very large
15.	Mineral salts	Very large
16.	Nickel	55
17.	Perlite	Very large
18.	Quartz	Very large
19.	Silica	Very large
20.	Stone	Very large
21.	Sulphur	24
22.	Tin	28
23.	Titanium	70
24.	Zinc	21
Fossil		
25.	Carbon	390
26.	Natural gas	60
27.	Oil	40

(Source: Crawson 1992; World Resource Institute, 1992)

[1] Paola Sassi, 2006, p144-148

The use of raw materials should be reduced; especially that of non-renewable resources, another important thing is reducing the loss of materials during the life cycle of buildings, from production to the demolishing. Recycling must be developed. Recycling process can be categorized into three forms or levels:

1- Re-use. 2- Recycle. 3- Energy recovery.

Recycling of some materials can be through melting or crashing the component, and then a new manufacturing process begins.

The most suitable materials for recycling are metals, other materials become less valuable when recycled. Energy recovery could be by burning the product to produce energy.[1]

Now it is important to answer the question: What are sustainable (Green) materials?

"*Green building materials are composed of renewable, rather than non-renewable resources, green materials is environmentally responsible because impacts are considered over the life of the product.*"[2]

The use of green or sustainable materials and products can decrease the depletion of non-renewable resources besides reducing environmental impacts, which is caused by extraction, manufacturing, transforming, and installation of those materials

[1] Bjorn Berge, 2000, p 4-15.
[2] Calrecycle website.

Some materials could be a sustainable alternative for building materials; table (3) shows the recommended materials and the environmental reasons.

Table (3): Recommended materials for sustainable construction

INSULATION	
INSULATION / First Preferance	**Environmental Reasons**
Mineral wool/Stone Wool (e.g. Rock Wool)	Free of Blowing agent.
Recycled Cellulose insulation (e.g. VITAL 040)	recycled material, very low embodeid energy
wood fiber board with rendring or overcladding	Renewable Material
(external wall insulation)	
Cork (flat roof insulation "warm deck")	Renewable Material
cellulose fiber (flat roof insulation "cold deck")	recycled material, very low embodeid energy
silicone (sealants)	
INSULATION / second Preferance	
expanded polystrene	consumes less energy than extruded polystrene to be made, but more than mineral wool. Uses pentane as blowing agent which has no effect on ozone or global warming .
polysulphide (sealants)	
Foam polyethelene tape (joint fillers)	Durable
water baced acrylicc (sealants)	
BUILDING MATERIALS	
BUILDING FABRIC First preferance	
Reclaimed brick(external cladding)	ultra low embodied energy, diverting waste - brick crushing for hardcore is very energy intensive. durable
Recycled aggregate (hardcore/aggrigates)	Recycled material.
EPDM sheet"synthetic rubber" (Flat roof member) e.g. firestone	Durable

reclaimed doors/windows	Ultra low embodied energy, diverting waste and reuses as high grade product
28 mm double glazing with low emissivity coatings and argon filled cavity.	
Coated Aluminum(Gutters).	Durable.
polyethylene/vitrified clay pipes(Drainage)	Durable.
BUILDING FABRIC second preferance	
high dencity polyethylene piping	Low embodied energy, durable.
asphalt/Bitumen Felt(Flat roof member)	Low recycling rate and high raw material coast.
28mm double glazing with low emissive coatings	Double glazing with low emition has the performance of of triple glazed
Polyester(Gutters)	lower energy than aluminium but less durable
BUILDING FINISHES First preferance	
Natural paints (paintwork)	Nutural pigments, renewable
High solids alkyde exterior woodwork (paintwork)	Low solvent content
Mineral paint external walls	Low solvent content
Powder coating - external steelwork	very Low solvent content, Durable
Unsealed cork tiles	Renewable, natural
BUILDING FINISHES Second preferance	
water based acrylic - interior walls & woodwork	Low solvent content
Ceramic tiles	
High solids alkyde(paintwork)	
Land scaping First preferance	
Reclaimed paving material	ultra low embodied energy diverts waste and avoids extraction and manufacture
concrete slaps made with recycled aggregate	Recycled, low embodied energy

Source: Lembeth Housing, – performance Strategy and Regeneration- Environmental Development Team

2.3 Conclusion

The concept of sustainability is still promising in the West Bank and there is a need to move forward towards it. Sustainable construction is a part of the proposed strategic plan. That's extremely important to be considered.

Materials have different behaviors, understanding the material properties will help to select the appropriate sustainable ones. There is a need to examine how the old traditional builders used these materials and what type of technologies they employed and to what extent their buildings are sustainable.

Charter Three

Traditional Construction in the West Bank

Charter Three
Traditional Construction in the West Bank

Construction occupies a very important position in community development. It reflects the way of building, new materials and new technologies. The use of building materials in general have a great dependent on the country resources; countries that have abundance of some kinds of building materials, use them extensively in building construction.

3.1 Traditional Construction Systems

"Architecture and building construction are not necessary the same thing. An understanding of the methods for assembling various materials, elements and components is necessary during both the design and the construction of the building"[1]

Ching, (1943) categorizes the elements that formulate the structure of any building into the following systems: Foundation systems, Floor systems, Wall systems, Roof systems.

A system according to Ching is "*an assembly of interrelated parts forming a more complex and unified whole and serving a common purpose*."[2]

He also believes that a building is the physical embodiment of a number of systems and sub systems that are related, and integrated with

[1] Francis D.K Ching 1943, p1.03
[2] Ibid, p 1.03

each other and with the three dimensional form and special organization of the building as a whole. [1]

Building processes are connected directly to the prevailing habits and traditions in Palestine; the action of building depends on community participation and the concept of "help" which distinguishes the Palestinian society in all matters.

Building process could be categorized into several stages according to its sequence.

3.1.1 Foundation Systems

Foundations are that part of the building which supports the building, the process of defining and building the foundation is divided into stages as follows.

1- Setting up a wooden frame around the building site with a distant of about 50-100 cm far from the expected walls, with a 100-150 cm height.

2- Marking the foundation place and excavating.

3- Building the foundation using lime soil mixed with water in addition to stone in a specified way to make courses.[1] See figure (2).

[1] - Omar Hamdan, 1996, p 599-648

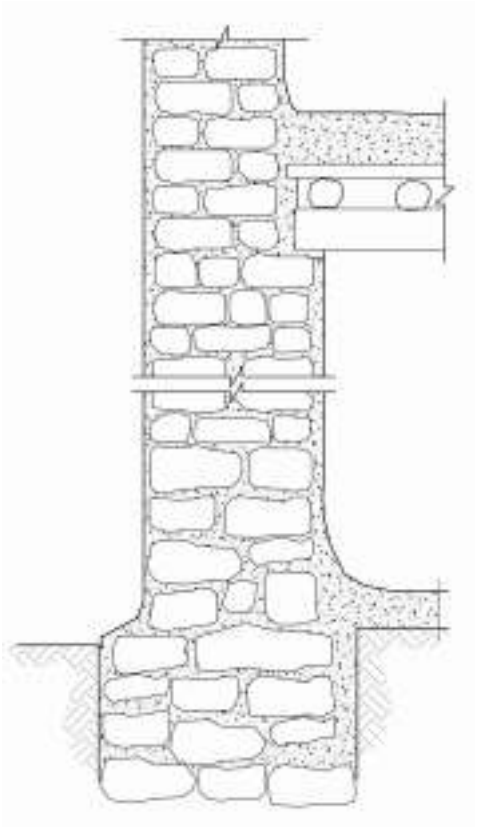


Figure (2): A section showing the foundation of walls at the lower part.
Source: (after) Traditional domestic architecture of the Arab Region, by Friedrich Ragette, 2003

3.1.2 Wall Systems

A study[1] carried out by the ministry of local government shows that traditional elevations built from stone can be divided into two types:

- **Two linked facing**

This type of walls usually associated with continuous foundation system, foundation for such walls built to be thicker than wall thickness.

This type of walls does not maintain the same thickness as it gets thinner as we go higher. This type of walls perform very well in resisting

[1] Ministry of local government, August 2002, p 7-21.

thermal transitions, due to its bright colors which reflect the sun heat and the big thickness of the wall which contain rubble and earth.

For arcades, stone columns were used in traditional architecture.

The study justifies that the disappearing of this technique was because of its high cost, the availability of new materials and techniques and the lack of trained workers.

Furthermore, the new reinforced concrete material provided us with strong walls in a thinner thickness.[1] See figure (3).

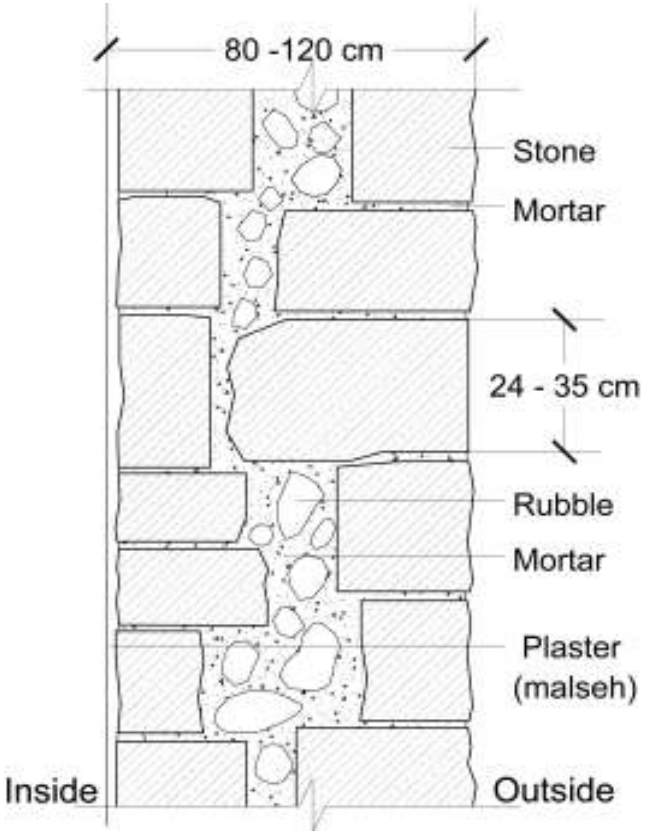


Figure (3): Section in a two facing stone wall.
Source: (after) Ministry of Local Government,

[1] Concrete walls will be discussed in chapter five.

- **One facing**

The study[2] shows that another type of stone walls was founded even it was rare, this type was used in mountain rural areas and built with bigger rough stones, and it was associated with continuous foundations. This type of walls performs very well in resisting thermal transitions[1]. see figure (4).

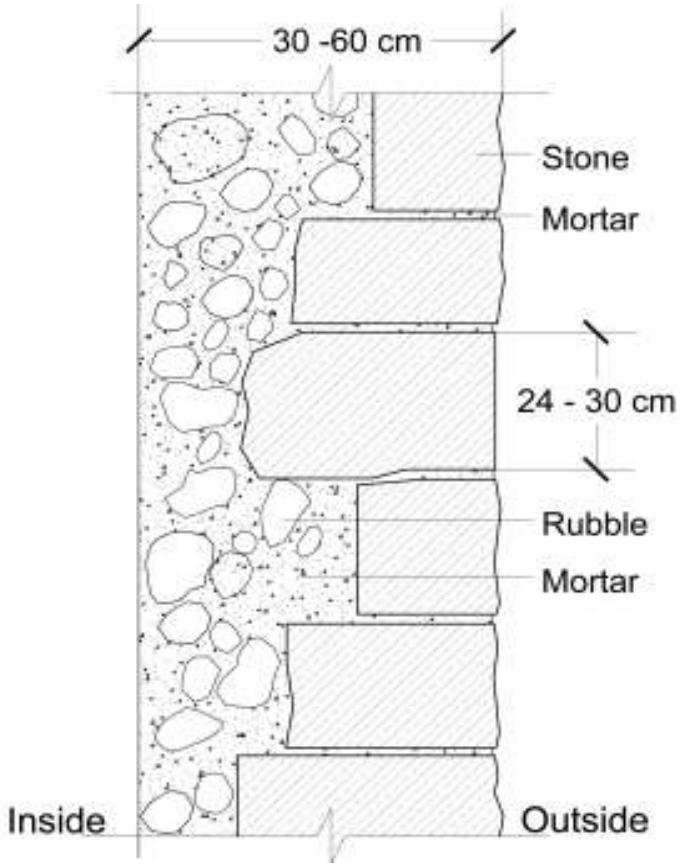


Figure (4): Section in a one facing stone wall
Source: (after) Ministry of Local Government, 2002

3.1.3 Roof Systems

Traditional roofing systems differ from place to another according to the type, size and use of the building and can be categorized into three groups: Flat roofs, vaults and domes.

[1] Ministry of local government, August 2002, p 7-21.

- **Flat roofs**

Flat roofs existed in many forms according to their building materials which varied from mud to stone tiles.

- **Mud roofing**

Mud roofs are used usually in rural mountainous areas for various building types, especially for residential buildings and agricultural storages.

Mud roofs usually depend on frame structure; frame structure appeared in the 17th century and last as a roofing construction system up to 1940s. Mud roofing mainly consisted of the following materials:

1- Wood trunks.

2- Earth mortar.

3- Dried hay and plant roots.

4- Stones and pebbles.

5- Ashes and lime.

Mud roofs unlike the other roofing systems in terms of thickness, they are 10-15 cm thicker and lighter, excluding the frame thickness which varies according to the span of the roof see figure(5).

Mud roofs perform positively in resisting thermal transitions.

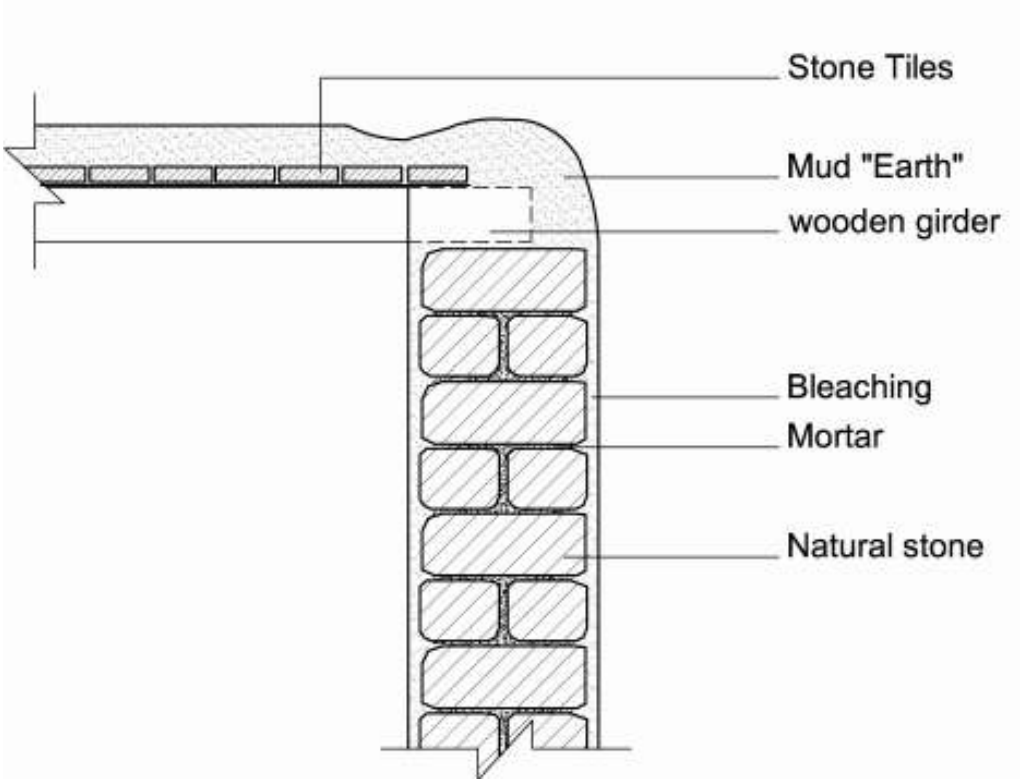


Figure (5): A section shows flat mud" earth" roofing system
Source: (after) Ministry of Local Government, 2002

- **Stone tiles.**

Stone tiles are used for all types of buildings, especially when the roof was used as a terrace. This roofing system consisted of lime stone fixed with mortar on a concrete slab reinforced with steel I beams, stone roofs showed a good resistance to most weather conditions. Special care and regular maintenance should be applied to this type of roofing, to prevent from the growth of some vegetation between the stone tiles and in the joints. See figure (6)

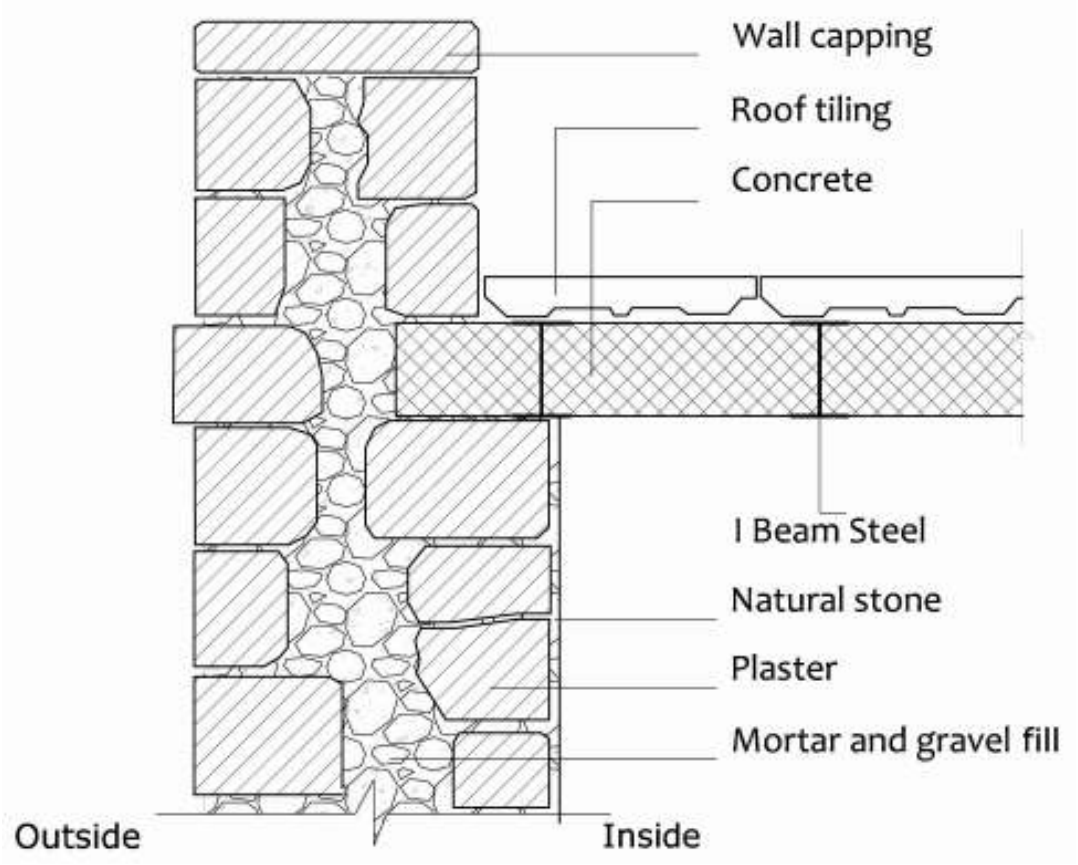


Figure (6): A section shows the stone tile roofing system.
Source :(after) Ministry of Local Government, 2002.

- **Pitched Roofs**

Pitched roofs can be found in both urban and rural areas, they resists all weather conditions, but they show a negative thermal performance, because they absorbs the heat and radiate it through the roof to the inside, red tiles pitched roofs have existed in Palestine since the 19th century during the mandate period after the use of (I) beam and concrete slab, and they are still used till these days.[1] See figure (7)

[1] Ministry of local government, August 2002, p 7-21.

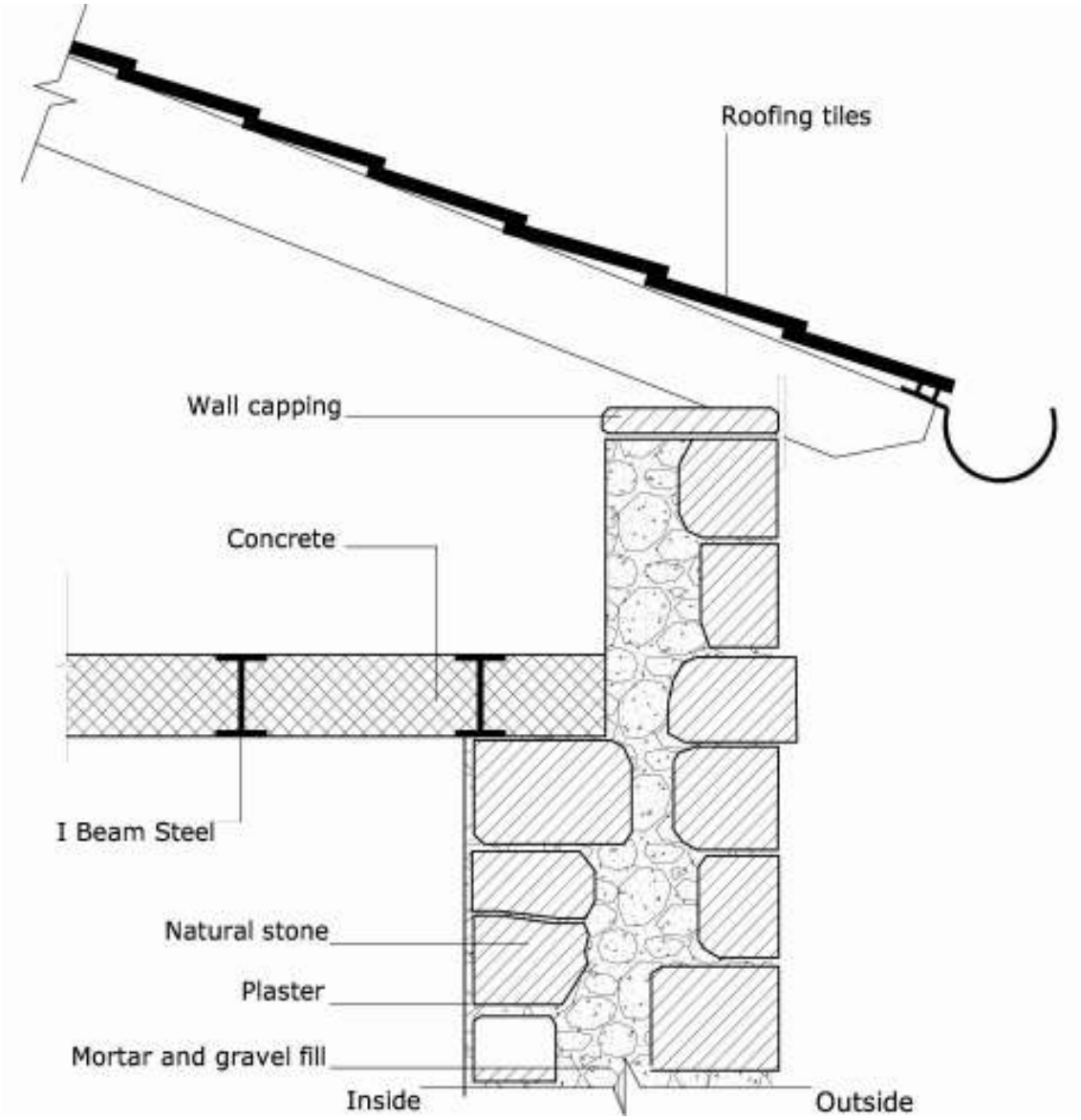


Figure (7): A section shows the pitched roof roofing system.

Source: (after) Ministry of Local Government, 2002

- **Vaults**

Vaults are one of the oldest construction techniques in the West Bank for building roofs since they depend on their shape to transmit loads from the roof through walls to the foundations then to the earth.

Vaults are existed in Palestine in two shapes; barrel vaults and cross vaults.

- **Barrel vaults**

Barrel vaults are usually built using framework either stacked wood, or earth fill using branches or leaves that form the shape of the barrel vault. After constructing the vault that earth fills removed, Palestinians used two types of barrel vaults; pointed and semicircular, barrel vaults perform positively in resisting all thermal transitions.

Building materials for barrel vaults consisted of earth, stones, pebble, lime and branches of trees see figure (8) [1].

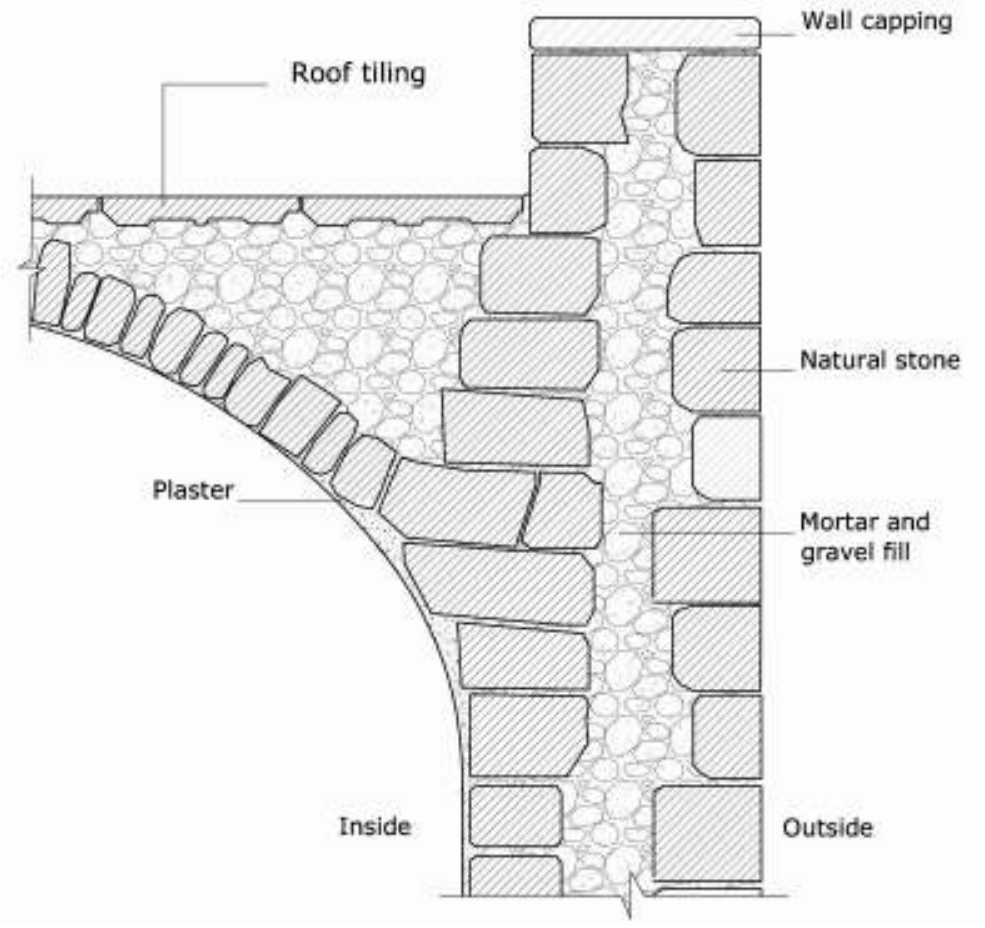


Figure (8): A section shows the barrel vault roofing system
Source: (after) Ministry of Local Government, 2002

[1] Ministry of local government**,** August 2002, p 7-21.

Barrel vaults are usually used for large scale buildings, the way of building barrel vaults depends on the special stone pieces called “Reash” and the mortar.

Barrel vaults mostly used to cover building of rectangular shape plans; the direction of the vault goes with the long sides.

- **Cross Vaults**

Cross vaults played a major role in roofing all types of buildings, residential, commercial and public.

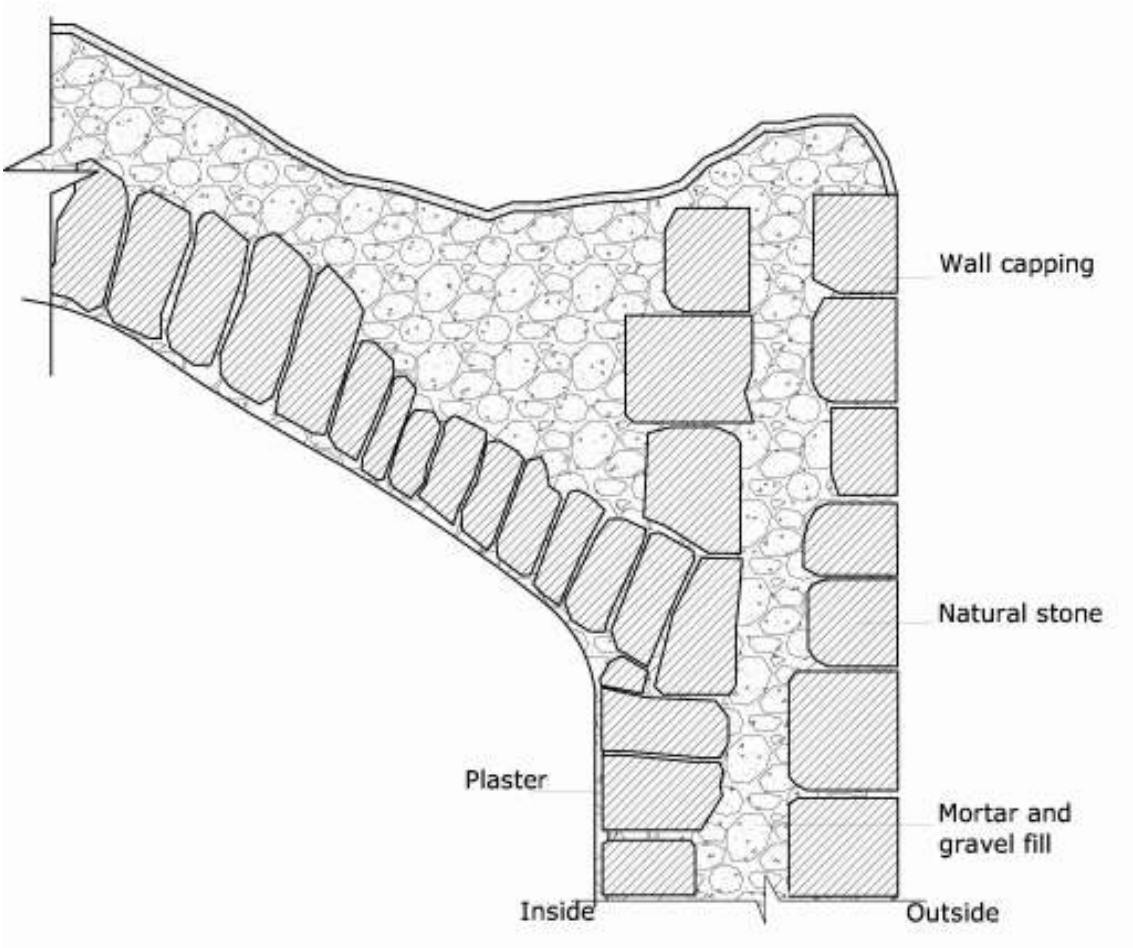


Figure (9): A section shows the cross vault roofing system.

Source: (after) Ministry of Local Government, 2002

The roof of cross vaults has a distinguished appearance from the inside of the building, where the vault embodied and shows the roof structure see figures (9, 10, and 11).

This type of roofing performs effectively in resisting thermal transitions and maintaining a suitable environment inside the building during summer and winter. Building materials for cross vaults are the same of other traditional buildings such as lime, hay, ash, earth, branches of trees and light mortar for roof plaster.

Figure (10): Demolished small structures in Nablus were the cross vault roofing system is clear

Photo by: the author, 2011

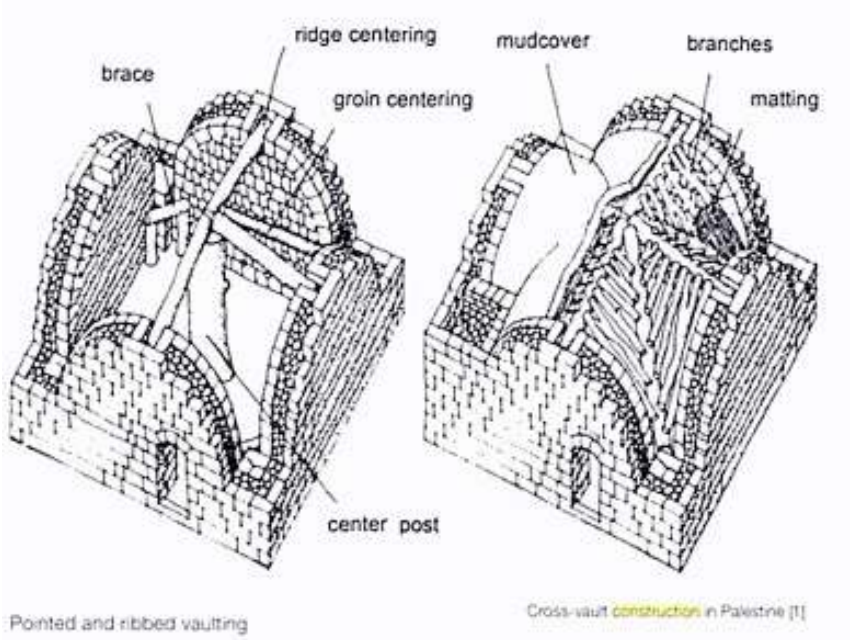


Figure (11): Cross vault construction in Palestine (pointed and ribbed vaulting).
Source: Traditional domestic architecture of the Arab Region, by Friedrich Ragette, 2003.

- **Domes**

Domes are usually used in public buildings rather than houses, domes also were a distinguishing element for mosques, tombs, schools and houses of rich families, the technique of building domes considered one of the oldest roofing techniques widely used by Byzantine in the 5th century.

The building materials for domes were; stone, lime rubbles and mortar. Building a dome was usually required a framework mainly made of wood, another way was by filling the building with earth or branches and leaves of trees which were made in a form of the dome, and after building the dome that will be removed.

Dome roofing performs positively in resisting thermal transitions, and provides a suitable environment inside the building both in summer and winter.

In some cases to transform from square shape to a circular shape a shift built to make an eight sides shape which considered a distinguished architectural element that could be designed in different forms. In addition to its architectural value, it has a structural function, it transmit loads from the dome to the walls.[1] See figure (12)

Figure (12): The use of domes in traditional buildings
Source: (after) Ministry of Local Government, 2002

3.2 Traditional Building Materials in the West Bank

Building materials have affected the form and ways of building since ancient times. It played a major role in shaping buildings and resisting the environmental factors. Building materials can be categorized into two categories; raw building materials and industrialized building materials.

[1] Ministry of local government, 2002, p 7-21.

Stone, one of the basic building materials in traditional construction was extensively used in mountainous areas due to its availability, while clay brick - which is produced using clay and straw fibers in addition to gravels and water - was used in plain areas. Wood also used for building roofs.

Table (4) contains a list of elementary building materials for traditional Palestinian architecture and the employment of these materials:[1]

[1] Omar Hamdan, 1996, p 599-648.

Table (4): Traditional construction materials

Material	Employment and Function
Lime	Lime is used with clay to stratify stones; it is usually mixed with soil in various proportions, and it is also used in bleaching processes especially interior works.
Soil	Soil used in foundations, walls, stone stratifying processes and roof building in a specified proportions 10-50%, the soil of igneous rocks also could be used.
Saltpeter	A kind of sedimentary rocks in a shape of amorphous salt peter that have a transparent color and sometimes include colors, it is used after grinding in bleaching mix to insure its consistency and durability.
Stones	Stone material considered one of the fundamental materials in building processes in Palestine. Where the most of traditional buildings consists of stone, building stone varies in their hardness and colors, the process of stone industry can be divided into two stages; extracting the stone, and shaping the stone
Brick	Brick material is mostly made from red soil, which consists of soil mixed with mineral salts in specified ratios, this type of brick varies in shape and form, but the most used size was (20X20X40) which used extensively for building courses.
Pottery	Pottery is used mainly for household utensils, as well as in building the "keezan" the upper part of the building at the end of the elevations which is used for air conditioning and cooling.
Woods and twigs	Woods has been used extensively in building works, especially for building roofs and for doors and windows thresholds, in addition to furniture as well as wood formwork.
Hey and straw	Hey and straw formed by chopping stiff wheat or barley where it become soft, hey and straw usually used in clay mix in a specified ratios for beaching works whether interior or exterior.
Water	Water used in all various mixing processes to form the needed interaction which lead to make the coherence of materials.
Olive oil	Olive oil used in lime mixes in addition to water for roofs building and bleaching processes, people in that time thought that oil provide more stability and durability to the building.1

Source: Omar Hamdan, 1996

[1] Omar Hamdan, 1996, p 599-648

To summarize, traditional building technologies and materials were sustainable and have been developed on the basics of construction and aesthetic sustainability, they were locally available, environmentally friendly and of a very little embodied energy.

By the time, the interest in traditional buildings became less due to the people trend towards modernity and the use of new materials, the main reason for their ignorance of them is due to the raising costs of adopting the traditional methods as well as the scarcity of traditional workmen and the skillful building craftsmen. This made people look for alternatives, towards contemporary building construction.

3.3 Conclusion

Traditional structures vary in shape and building techniques: they almost share similar sustainable properties such as the use of local material, being environmentally friendly, maintain a suitable environment inside the building.

Moreover ancient people were very intelligent in developing their techniques which established to fit the sustainable requirements. Nowadays, those become less efficient due to raising cost of implementation, absence of skilled workers and the emergence of contemporary building materials and techniques.

Charter Four

Contemporary Construction in the West Bank

Charter Four
Contemporary Construction in the West Bank

Building construction in the West Bank is one of the most active sectors. The importance of this sector reflects the ability of the Palestinians to build their physical environment.

Construction techniques in the West Bank developed to go with global development in the construction field. This field is one of the economic activities with largest share to gross domestic product in the West Bank. This sector continues increasing its activities as indicated by the Palestinian Central Bureau of Statistics in its report about the economic growth in year 2010. Statistics showed that the construction activity record was the highest, with a growth of about 36%, these statistics also showed an increase of the total number of workers in the construction sector by 22% compared with the same period in 2009[1], where the number of employees reaches 5200, while the number of enterprises was 508 in 2009.[2] Considering that these numbers reflect only the formal contracting companies, and projects.

In 2007 a value of 489.9 million US$ was the cost of constructing new buildings and additions to old ones, with an increasing by 60.7% in comparison to 2006, and the maintenance of the existing buildings reached a value of 105.2 million US$, a value of 95.9 million US$ was the cost of improvements and repair for the existing buildings in 2007, with a decrease of 30.8% in comparison with 2006.

[1] Palestinian Central Bureau of Statistics, 2010, p 19
[2] Palestinian Central Bureau of Statistics, 1996-2009, p5

All these values indicate the capacity of the construction sector to create job opportunities, and contribution to gross domestic product.[1] The above values also indicate that the construction sector in the West Bank is an active sector, and reflect the continuous development in the physical man made environment in the West Bank, which turns positively in the Palestinian society and economy.

According to Roy Chudley and Roger Greeno, 2005, the aspect of construction of buildings can be categorized into two categories: Conventional or traditional methods and Modern or industrialized methods, and there is always a kind of mixing or overlapping between traditional and modern methods in the same building[2]. Baola Sassi, 2006 on the other hand, considers three elements needed to construct and run a building; materials, energy and water[3]

This chapter is going to invistigate the construction systems, techniques, and materials in the West Bank.

4.1 Construction Systems in the West Bank

Any building consists of a number of interrelated systems; these systems are assembled of interdependent parts that form a more complex and unified entirety. Ching 1943 believes that any building can be "*understood as a physical embodiment of a number of systems that must necessarily be related, coordinated and integrated with each other as well*

[1] Palestinian central bureau of statistics, 2007, p 19,
[2] Roy Chudley and Roger Greeno, , 2005, p3.
[3] Paola Sassi, 2006, p 144-148

as with three dimensional forms and spatial organization of the building as a whole"[1].

Any building consists of the following structural systems:

- Foundation systems.
- Floor systems.
- Roof systems.
- Wall systems. (Will be discussed in the next chapter).

Construction Systems in the West Bank do not differ from construction systems used elsewhere in the world, the selection of these systems depends on the building type and site properties. Those systems contribute in forming any type of building, and can be divided into: foundation systems, floor systems, roof systems, and wall systems. The need for studying these systems comes from the fact that, they have direct contact with the external walls of buildings, and many of the problems that happened to the building, resulted from the wrong implementation of these systems.

4.1.1 Foundation Systems

Foundation of buildings varies according to a number of factors such as; the size and type of the building, and the number of floors and service load in addition to the strength of earth on the construction site.

[1] Cing, 2008 , p2.2

Foundation is the lowest part of the building, in most cases it is constructed under the surface of the ground. The main function of foundation is to support, anchor and transmit loads of the structure above to the earth.

These foundations can be classified into two categories: Shallow foundations and deep foundations.[1]

- **Sallow foundation**

This type of foundation used when stable soil or adequate capacity occurs near the surface of the ground.

Shallow foundations may have the form of spread foundation which have many forms such as; strip footings and isolated footings which considered the most common foundation system in The West Bank.

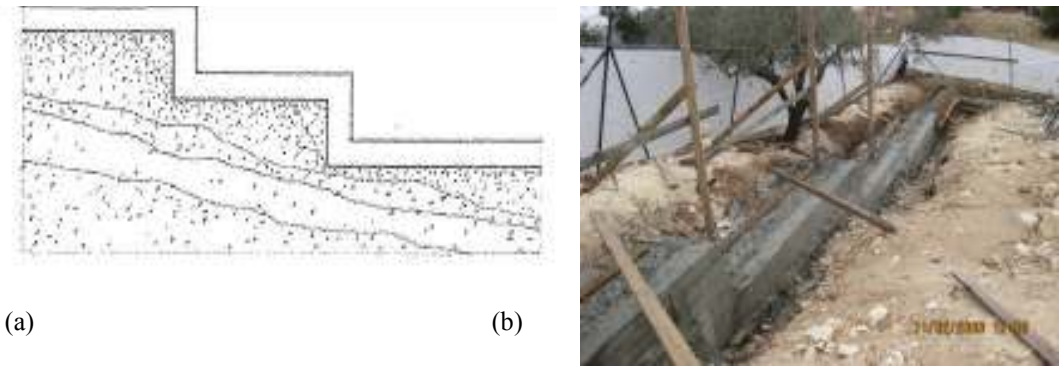
1- Spread foundation.

The following types of footings are other forms of spread foundation:

- **Stepped footings**

Stepped footings are those kinds of strip footings that change levels in stages to accommodate a sloping grade and maintain the required depth. See figure (13).

[1] Edward Allen and Joseph Iano 2009, p38



(a) (b)

Figure (13): (a) A section in a Stepped footing, (b) Photo of a stepped footing in the West bank

Source: (a) Ching, 2008, (b) photo by Faculty of engineering, An-Najah University,2009

- **Cantilever or strap footing**

A column footing connected to another footing usually by a tie beam to make a balance for asymmetrically imposed load see figure (14).

- **Cantilever and combined footing**

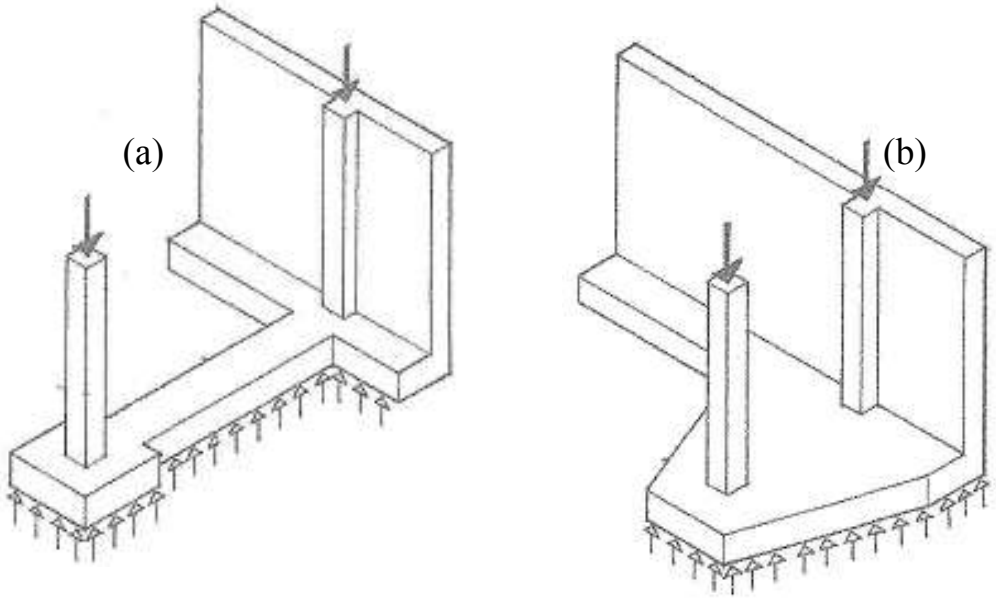


Figure (14): (a) A Cantilever footing, (b) A cantilever and combined footing

Source: Ching, 2008.

This kind of footings is used when the foundation abuts a property line, to prevent rotation and guarantee uniform soil pressure. See figure (14) (a).

- Combined footing for a perimeter or a column extended to support an interior column load. See figure (14) (b).

- Mat or raft foundation

A heavy link reinforce concrete slab that form a single monolithic footing for a number of columns or the whole building. It is usually used when the bearing capacity of soil in low relative to the building loads interior columns. See figure (15)

(a) (b)

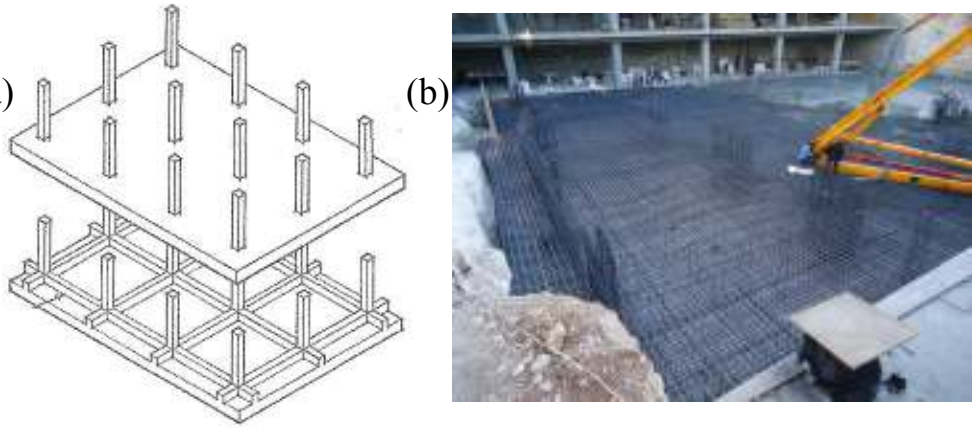


Figure (15): (a) Mat or Raft Foundation, (b) The foundation of Nablus tower in a form of mat

Source: (a) Ching, 2008, (b) Photo by the author, 2010.

2- Foundation walls

Foundation walls are used for superstructures; they support the structure above and enclose a basement below grade. Not only do foundation walls transmit loads to the earth but also resist active earth pressure and anchor the structure against wind loads and seismic forces, foundation walls used extensively in mountainous areas in the west bank. See figure (16).

(a) (b)

Figure (16): (a) A section in a Foundation Wall, (b) Photo of a foundation wall in a project in the West Bank

Source: (a) Ching, 2008, (b) photo by faculty of engineering, An-Nahaj national university, 2010.

3- Concrete slab on grade

A form of shallow foundations used near or at the grade level and function as a floor and a foundation system, this kind of foundation require a compacted dense uniformly soil. See figure (17).

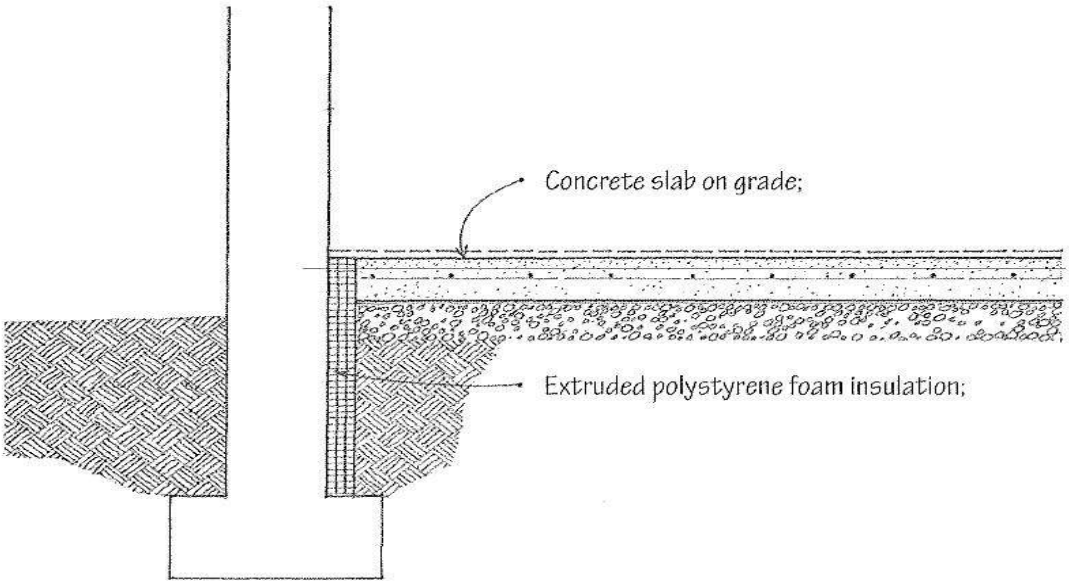


Figure (17): Concrete slab on grade

Source: Ching, 2008.

- **Deep foundations**

The most common type of deep foundations is pile foundation and caisson foundation.

- **Pile foundations.**

A foundation system of end- bearing of friction piles, pile caps and beams working together to transfer building loads down to a suitable bearing stratum, this type of foundation is usually used in flat sites in the West Bank. See figure(18) right.

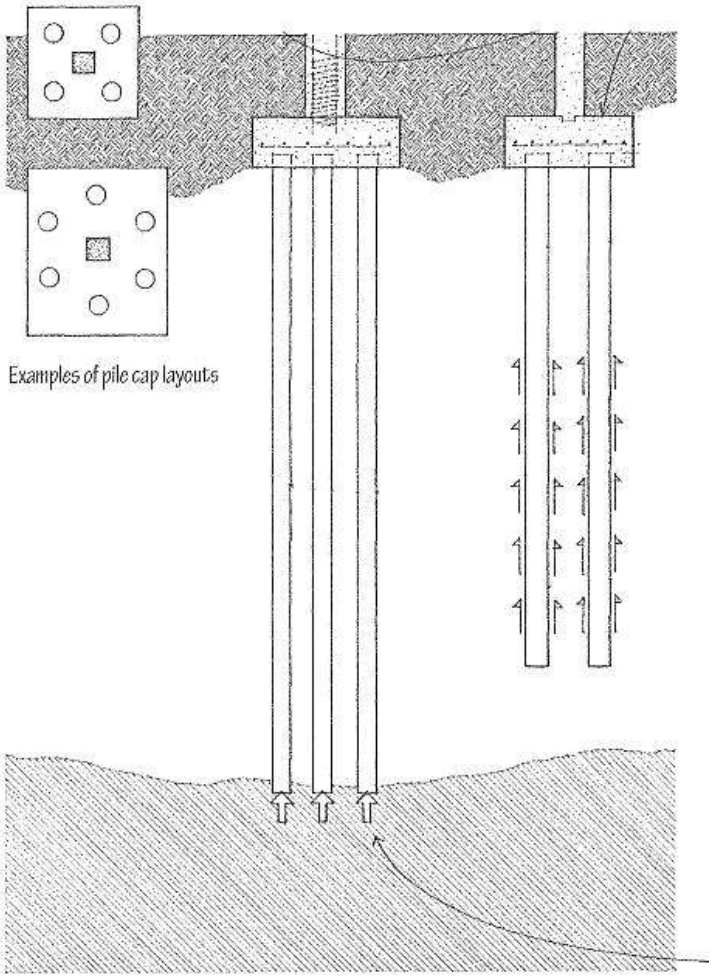


Figure (18): To the right end bearing piles, to the right friction piles
Source: Ching, 2008.

- **Caisson foundations**

A plain of reinforced concrete piles usually cast in place, and formed by a large auger, or excavated by hand, to shape a shaft down to a suitable bearing stratum then filled with concrete. See figure (18) left.

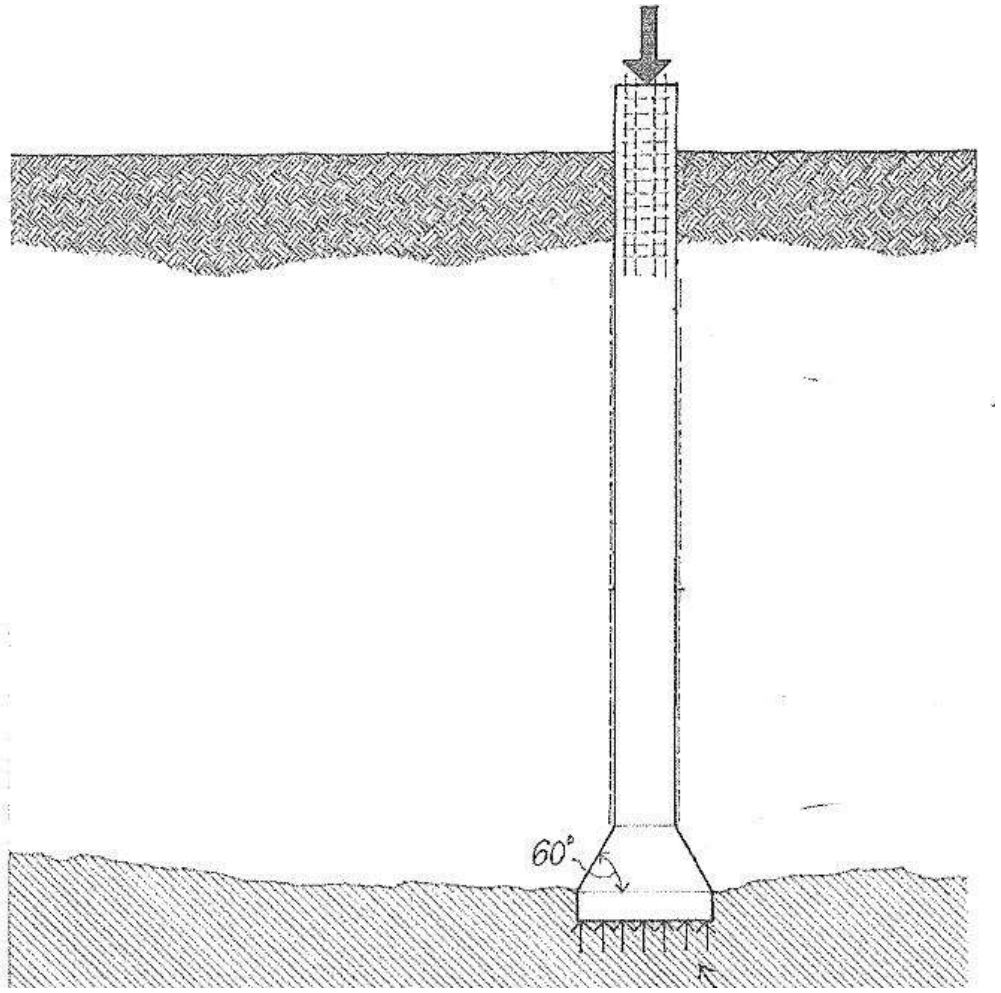


Figure (19): Caisson raft foundation

Source: Ching, 2008

- **Floating foundations**

Floating foundations are suitable for sites with yielding soil, the footing placed deep in a form of mat, where the weight of excavated soil is equal, or greater than the weight of the construction. See figure (20).

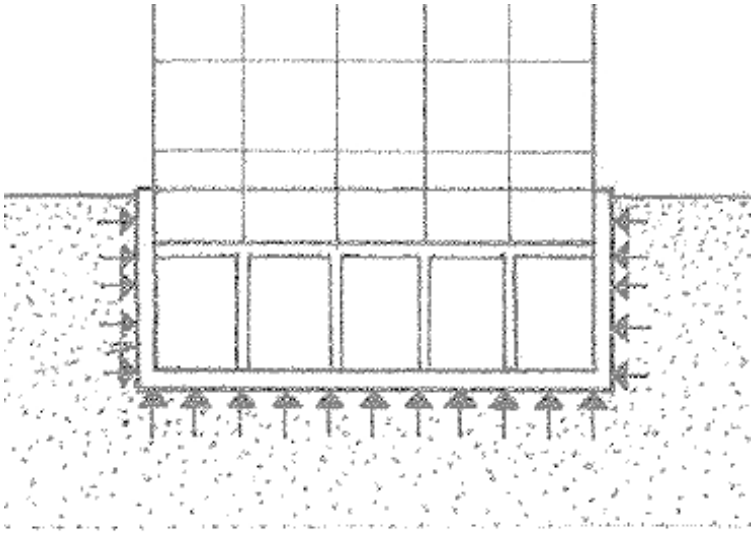


Figure (20): Floating foundation

Source: Ching, 2002

To sum up foundations is one of the most important elements that support the structure; the wrong selection of the foundation type subjects the whole structure to extreme danger, which might cause a lot of problems such as, cracks or failure. These problems could affect the interior appearance of the building and required more costs for maintenance. Consequently such problems make the structure unsustainable. The wrong building practice during the establishment of foundation systems could also be harmful to the environment and devastating to natural habitats.

- **Sustainable foundation systems**

Analyzing foundation systems in the West Bank using sustainability approach can give a clear understanding of what these systems need to become more sustainable.

Constructing foundations and footings include two stages; excavating the foundation place and constructing the foundation system.

The first stage include fossil fuel consumption through using heavy machines for excavating and removing of earth, the efficient and managed use of these machines can reduce the fuel consumption.

The result from excavation can be reused as back fill for the same project or moved to a nearby suitable place; during this stage protecting the existing natural habitats as much as possible enhance the relationship between the building and the nature, protect habitats and maintain biodiversity.[1]

The second stage which includes constructing the foundation system differs according to the type of foundation but in all cases maintaining harmony between the nature and built environment through reducing waste and minimizing affecting air quality must be taken into consideration.

As foundation is an underground member of the building all needed procedures to insure their durability must be considered, including using suitable admixtures for concrete mix to increase its strength and resistibility for various conditions under the ground and the use of suitable insulation and coating materials to prevent from underground conditions.

4.1.2 Floor Systems

Floor systems can be defined as "*The horizontal plans that must support both live and dead loads, floor systems must transfer their loads horizontally across space to beams and columns or to load bearing walls*."[2]

[1] Edward Allen and Joseph Iano 2009, p38
[2] Francis D.K. Ching 2008, p 3.02

Floor systems in The West Bank can be founded in many forms such as: concrete floors, steel floors and wooden floors.

- **Concrete floors**

Concrete floors are the most common type in the West Bank and have many forms such as:

- Ground floor slabs

Slab of ground floor is constructed on a 15-20 thick layer of compacted base course, and made of reinforce concrete of 10 cm thick most of the time, except in cases that it exposed to very heavy loads, see figure (21)

In some cases insulation materials used, by adding plastic sheets over the compacted layer. See figure (22)

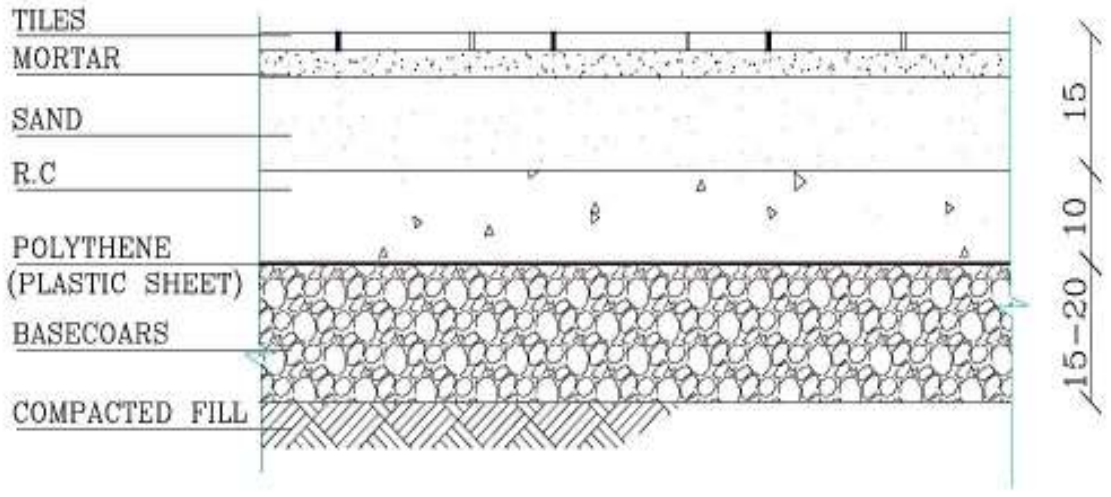


Figure (21): Section in a concrete ground floor slab

Source: Ministry of Local Government, 2002

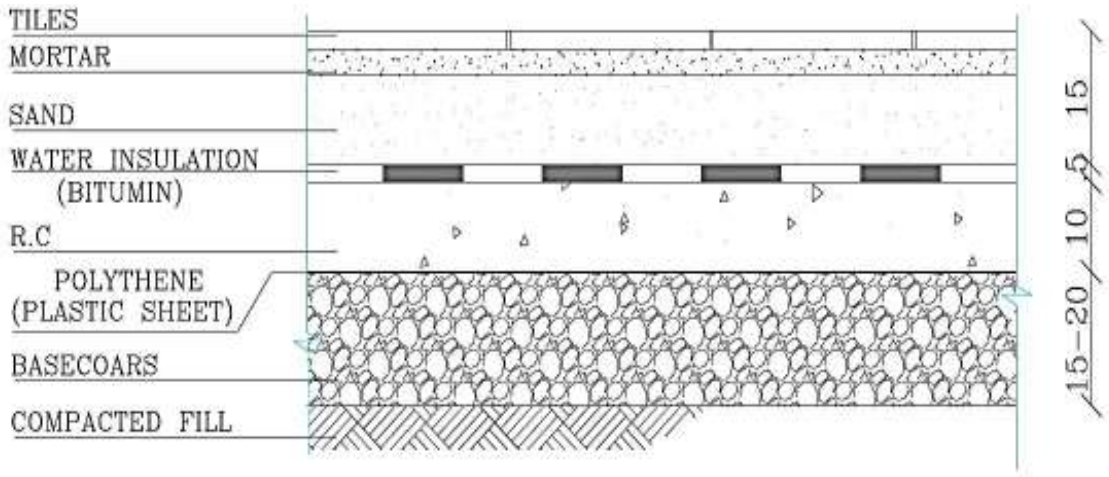


Figure (22): Section in an insulated concrete ground floor slab

Source: Ministry of Local Government, 2002

In some cases avoiding the use of insulation materials leads to a number of problems such as the rabid devastation of tiling due to water leakage.

- **Solid reinforced concrete slab**

This slab is constructed using a 15-20 cm reinforced concrete thick see fig (23).

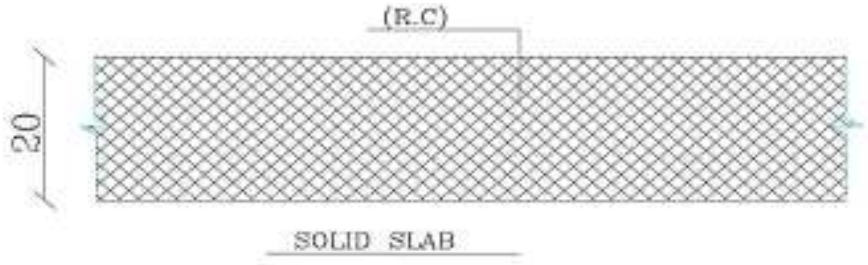


Figure (23): Section in a solid concrete slab

Source: Ministry of Local Government, 2002

- **Hollow concrete block slab (Ripped slab)**

25-30 cm thick, where 17-24 cm thick hollow concrete block used see figure (24), in some cases instead of concrete blocks Etong blocks used.

When the slab becomes a roof, a layer of insulation material and falling screed should be added, see fig (25).[1]

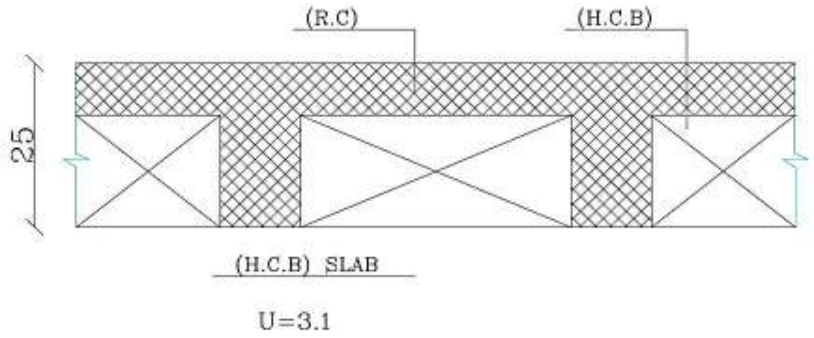


Figure (24): Section in a ribbed concrete slab

Source: Ministry of Local Government, 2002

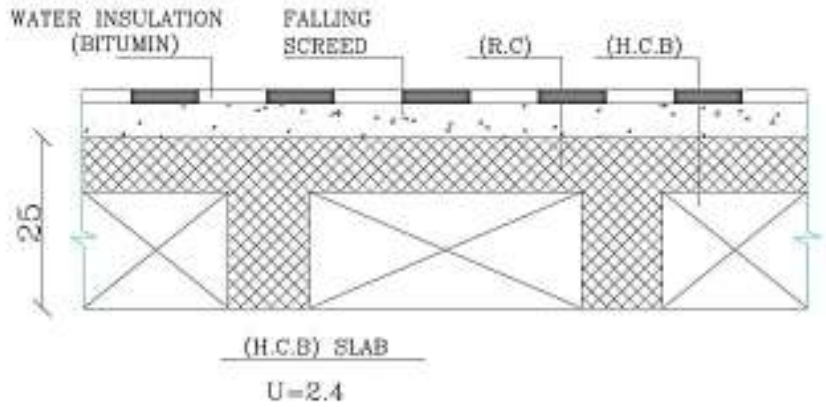


Figure (25) Section in an insulated ribbed concrete slab

Source: Ministry of Local Government, 2002

- **Two- way waffle slab**

Two way waffle slab is a concrete slab that is reinforced in two directions by ribs, this kind of slabs suitable for heavy loads and long spans. See figure (26) (AlBireh transit station)

[1] Ministry of Local Government, August 2002, p 29-33.

Figure (26): Waffle slab at Al Bireh.

Photo By: the author, 2011.

- **Steel floors**

In some cases steel floors are used for small mezzanines in commercial buildings in the West Bank where "I" beams steel framing is used, see figure (27).

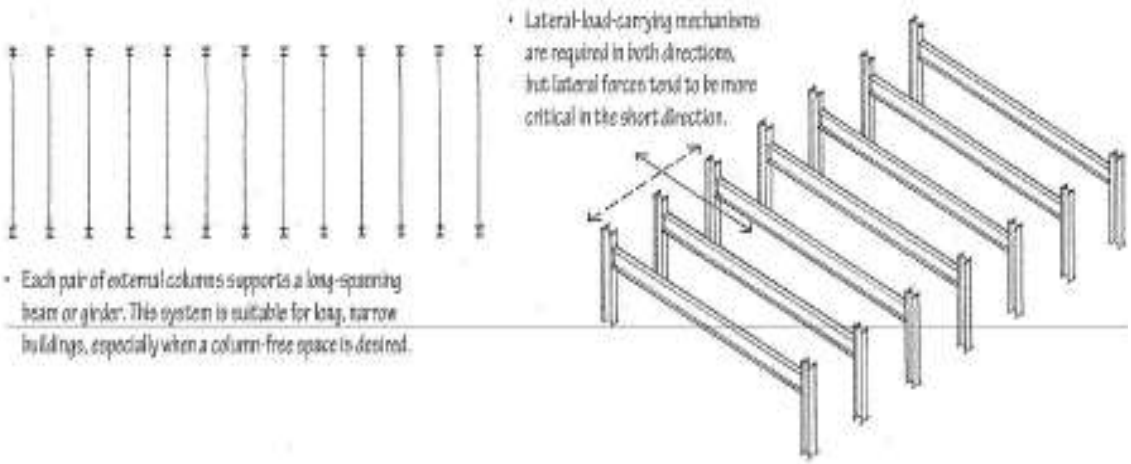


Figure (27): Steel framing

Source: Ching, 2008

- **WOODEN FLOORS**

Also wooden floor is used for mezzanine, where rectangular section joints used and covered with sheeting or subfloor tiles, see figure (28)

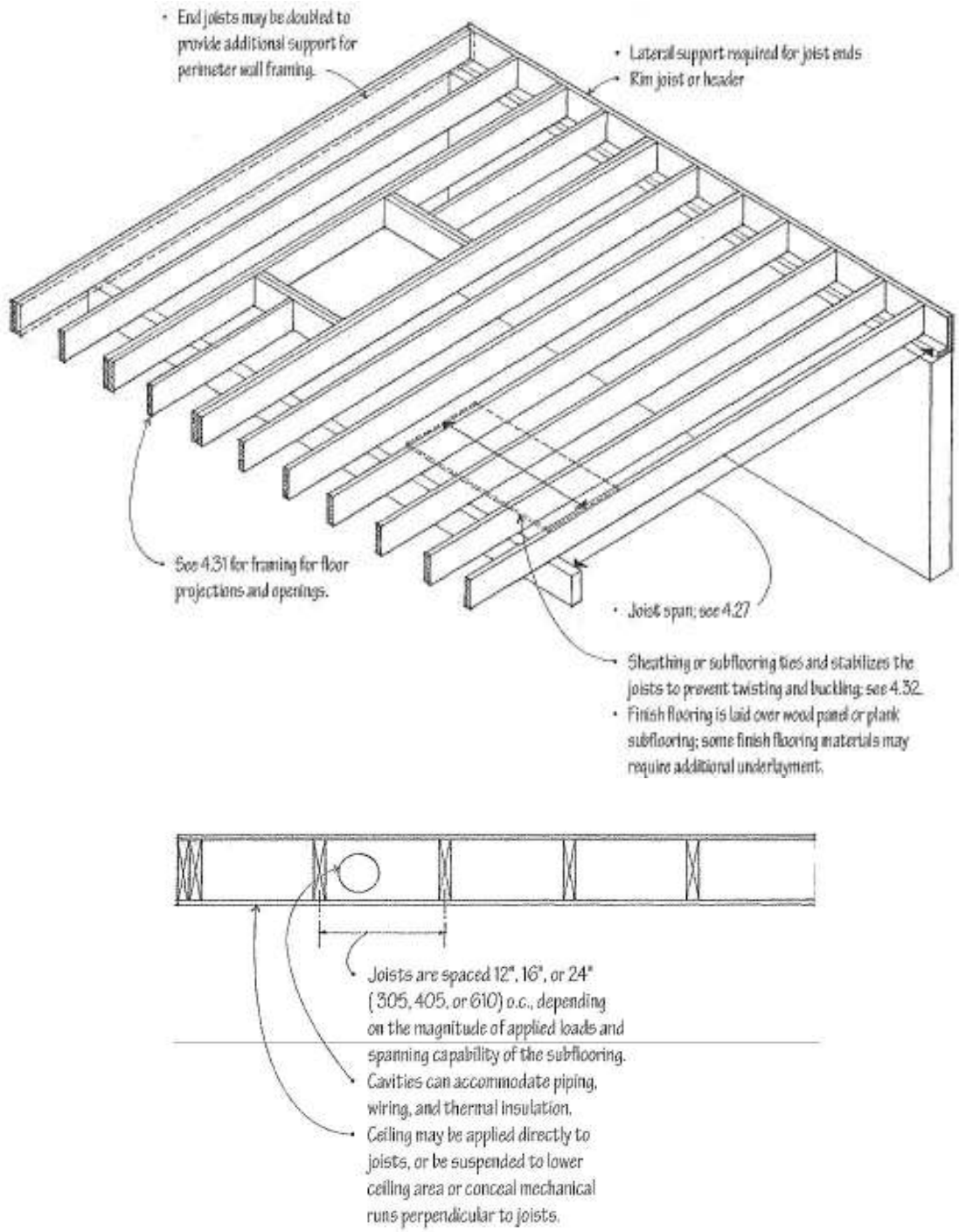


Figure (28): Wood joists framing

Source: Ching, 2008

In conclusion, floors are the most components of buildings that are exposed to loads and activities; they always need care and maintenance to be more sustainable. Undermining minor problems that occurred to floors will make them worst. As a result this requires changing the tiles or the wooden boards, i.e. additional costs and use of materials.

- **Sustainable floor systems**

Obtaining sustainable flooring systems includes also maintaining harmony between nature and the built environment and considering the whole life cost, health and safety. It also includes reducing the loss of materials during the construction of floors and slabs.

When using concrete floors special care needs to be given to insulation, especially for ground floors. Insulating ground floors prevent from the ground circumstances and the leakage of water which devastate the concrete.

Proper thermal insulation also needs to be applied to maintain a suitable temperature inside the building and stop thermal transmittance from and to the ground.

Maintenance should be regularly applied to concrete floors, slabs and tiles, to extend its lifetime and consolidate durability and that could be by replacing corrupted tiles.

When using wooden floors, it is important to consider that wood is the only major structural material that is renewable, so it is needed to make

sure that trees are growing in a sustainable manner and being harvested under managed conditions. Wood has the lower embodied energy compered to concrete and steel, in the other hand it must be kept dry and away from fire to live indefinitely [1]

When using steel and wooden floors, it is necessary to reduce the use of materials through reducing the loss[2], using recycled materials and considering management and maintenance.

In most cases there is no need to use thermal insulators for wooden and steel floors since it is used as sub floors inside the whole building other than wood itself is a good thermal insulator.

4.1.3 Roofing Systems

The most common type of roofing in the West Bank is concrete flat roofs, as in figure (29)

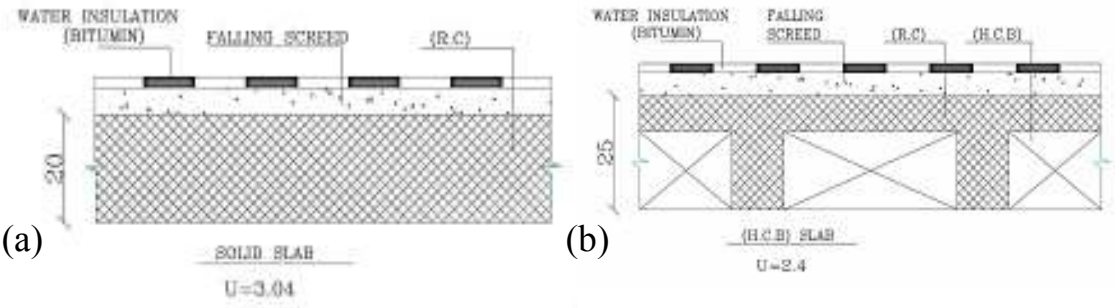


Figure (29): (a) A section in a solid concrete slab, (b) A section in a ribbed concrete slab.

Source: Ministry of Local Government, 2002.

Other types of roofing also used in the West Bank such as:

[1] Edward Allen and Joseph Iano 2009, p90

[2] In some cases untrained workers case loss of materials through misunderstanding, or wrong calculations.

- **Pitched roofing (Marseille tiles)**

This type of roofing is founded in most areas in the West Bank; pitched roofing shows a good resistance to external weather conditions. This type of roofing needs continuous maintenance to be more durable.

(a) **(b)**

Figure (30): Pitched roofs villas at Nablus

Source: http://www.paldf.net/forum/showthread.php?t=464656

In the contrary regarding thermal resistance, it shows a negative impact because it absorbs heat and radiates it to the inside[1]. See figure (30)

- **Steel roofing**

Steel roofs used to cover spaces of long spans such as courtyards, halls and industrial structures, steel roofing could be found as space frame systems, truss systems and steel rigid frames, see the following figures.

[1] Ministry of Local Government, august 2002, p35

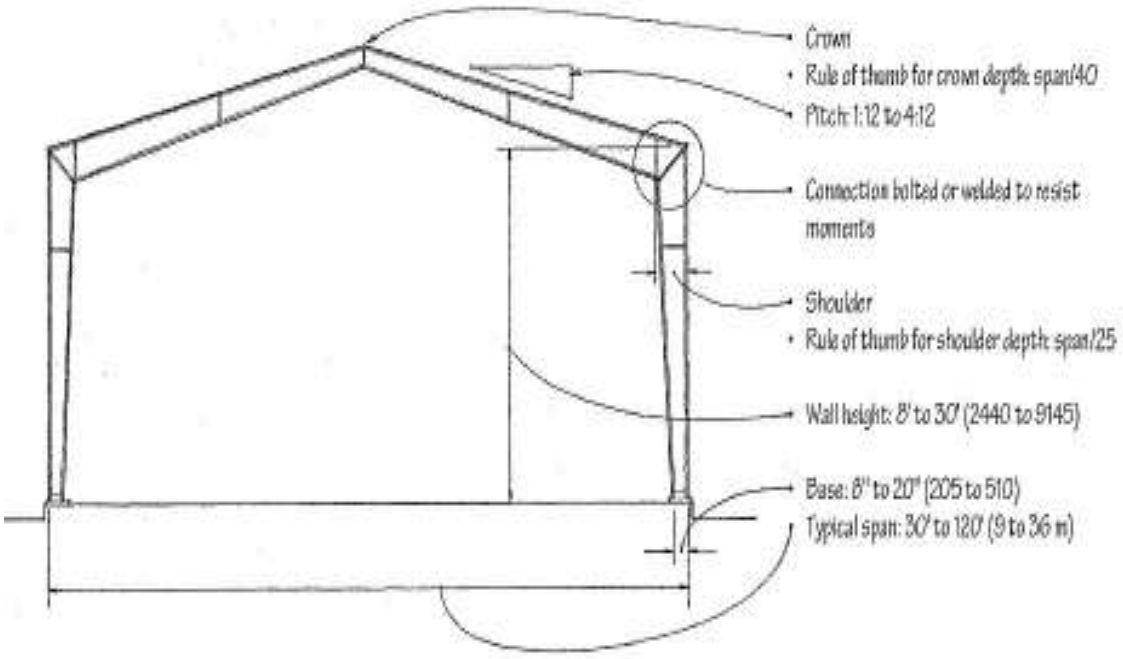


Figure (31): Rigid steel frame (elevation view)

Source: ching, 2008

Figure (32): Sport Hall at An-Najah National University.

Photo by: the author, 2011.

Figure (33): Sport hall at An-Najah National University. (A view showing the roof)
Photo by: the author, 2011.

Figures (31, 32 and 33) shows the use of rigged steel framing to cover the sport hall, this type of roofs needs to be braced together to ensure stability, moreover concrete walls and floors can be combined.

Figures (34, 35) shows different types of space frame roofing systems, these systems in most cases, used to cover a court yard.

Figure (34): School of Fine Arts at An-Najah National University (A view showing the court yard roof)
Photo by: the author, 2011.

Figure (35): Space frame dome at Nablus commercial center. (A view showing the court yard roof)

Photo by: the author, 2011.

To summarize, most of roofing systems in the west bank suffer from water leakage, and causes rabid loss of interior temperature. They require more costs for maintenance and for heating and cooling, and as a result that raises the consumption of energy and pollutes the environment.

- **Sustainability considerations**

Roofs of buildings are one of the building components that need to be treated carefully, since it covers and save inside spaces. Obtaining sustainable roofing systems requires thinking of these systems in terms of sustainability; these systems must follow sustainability criteria regarding materials, construction techniques, durability, health and safety. For all types of roofs insulation against water leakage and condensation must be applied, since water can destroy and corrupt construction materials such as wood steel and concrete.

Thermal insulation is highly recommended to stop thermal transmittance through roofs, for steel and bitched roofs maintenance must be applied regularly to extend their life time.

Roofs can be used for rain water collection to be used for domestic use or irrigation. Light- colored covering can reflect about half of solar radiations that hit its surface and that would reduce the heat gain and improve occupant comfort and consequently reducing cooling loads in hot conditions.[1]

4.2 Contemporary Building Materials

Building materials and construction techniques developed from those which were used in vernacular architecture, to the most modern materials used around the world.

While Palestinian import new materials to be used for building some modern building designs , the use of local building materials such as stone , marble , granite and others considered dominant.

In this section the contemporary building materials in the West Bank are going to be discussed, the focus will be on basic materials such as:

1- Cement.

2- Concrete.

3- Insulation materials.

[1] Edward Allen and Joseph Iano 2009, p90

4- Steel.

5- Building stone.

4.2.1 Cement (Portland)

Cement which is the main ingredient of concrete contains; silicon aluminum and iron, combined together Portland cement. Manufacturing of cement consist of several stages starts with obtaining the raw material which is a combination of limestone, chunk, shale sand, clay and iron ore, these materials crashed two times and reduced to ¾ inch (19 mm) .

Portland cement which is the most used type in the West Bank produced in two methods dry and wet, where the water added in a specified ratio to the mixture, and then the mixture of row materials fed to a cylindrical rotated kiln, this kiln exposed to heat till the raw material in the kiln reach a temperature (1430c-1630c), at 1480c the reaction needed to fuse the mixture to create cement clinker- grayish- black pellets happened, then the clinker cooled and grind to a powder that passes a No. 200 mesh (75 micron) sieve, this fine gray powder is Portland cement.

- **Cement industry**

Cement industry is considered one of the most important industries all over the world, and it has a special importance for Palestinian, since the Palestinians pass through a construction and reconstruction stage of building the independent state of Palestine. In 2005 world demand on

cement reaches 2283 million tons, the expected demand for 2010 were estimated at 2836 million tons.[1]

In 1997 the gross demand on cement in Palestinian areas was between 1600000 to 1700000, the demand were expanded to reach 3 million tons in 2003[2]

Palestinian market import 100% of cement to meet the needs, 80% of the cement imported from Israel, 9% imported from Jordan, 6% from Europe and 5% from Egypt.[3]

4.2.2 Concrete

Concrete which is one of the most important building materials is formed by mixing a paste of Portland cement, water with course aggregates a chemical reaction called hydration happens and makes the paste hardens and become strong and durable.

Concrete is the most preferred building material because of its distinguished characteristics; it is plastic and malleable when mixed, strong tough and durable when hardened.

The ratios of concrete components that give the desired workability when Mixed strength and durability when hardened are:

- 10-15% cement.

[1] http://www.philippelasserre.netcontenuDownloadGlobal_Cement_industry.pdf
[2] http://www.mapsofworld.com/palestine/economy-and-business/cement-industry.html
[3] Ministry of local government, August 2002, p 21-27.

- 60-75% aggregate.
- 15-20% water.
- 5-8% Air. (When there is a need for air entrained).

The quality of the mixed past gives the concrete its character, and the ratio of water to cement determine the strength of the paste (weight of mixed water / weight of mixed cement) lowering this ratio produce more strong and quality concrete.

Concrete can be classified into two types according to its density:

- Insulating light weight concrete.
- Normal weight concrete.
- Heavy Wight concrete.

- **Concrete curing**

Concrete needs to be cured as soon as its external surface hardened, curing insures that the hydration of the cement continues and that would give the concrete more strength, curing the concrete include deluge the surface of concrete with water , sometimes using wet fabric such as a cotton mat to cover the surface of concrete is preferable.

The concrete become stronger if it is kept moist for more than seven days.

- **Concrete production**

The properties of concrete make it easy to produce different forms. In the West Bank concrete come in the following forms:

1- Ready mix concrete: prepared and batched at local plant, and delivered to customers by mixers.

2- Precast concrete: this form of concrete is cast in a factory and delivered ready to be used to customers, precast concrete could be; brick, paving stone, girders and cladding panels.

3- Concrete masonry: such as blocks of 20×20×40cm, 10×20×40cm, 15×20×40cm block.

4- Cement-based materials: such as mortar, grout and terrazzo.

- **Mixing and preparing concrete**

Concrete mixed in different size mixers according to the quantity needed, small stationary quantities mixed by small mixers that use volume batching, or stationary batching plant and transit mixers, large quantities mixed by central batching plants.

- **Placing concrete**

Concrete must be handled with careful, especially during placing and finishing, depositing concrete must insure that concrete can be spreaded, struck off, consolidated, and bull floated. Concrete must be deposited from a near place continuously.

- **Concrete admixtures**

Admixtures are those chemical materials that added to the concrete mix during or before mixing, those admixtures used for several reasons such as; reducing the construction cost of concrete, modify the properties and to overcome emergency cases. Admixtures in most cases come in a liquid form. Several factors control the effectiveness of the admixtures including the amount of cement, water, mixing time, temperature of concrete and air.

- Classes of chemical admixtures

Chemical admixtures can be classified into five classed according to their function.

1- Air- entrained:

Air entrained used to place air bubbles with microscopic size in the concrete.

2- Water reducing:

Help in reducing water content in concrete mixture 6-10 percent which provides a lower water to cement ratio without increasing the cement ratio.

3- Retarding:

Retarding admixtures slow the sitting rate of concrete and used in hot weathers to reduce the hydration rate to make the concrete more workable.

4- Accelerating admixtures:

These admixtures used to accelerate the strength development to early time.

5- (plasticizers)(super plasticizers):

Also known as high-range water reducers (HRWR), help in reducing the water content in concrete, super plasticizers affect the concrete for 30-60 minutes.

6- Corrosion inhabitation:

Corrosion inhabitations used to slow the corrosion of reinforcing steel in concrete.

7- Shrinkage reducing:

Shrinkage reducing admixtures Used to reduce drying shrinkage which minimize cracking.[1]

- **Types of concrete**

- Light weight aggregate concrete

Aggregate in this type of concrete could be light expanded pumice vermiculite aggregate, this type of concrete used to produce blocks, slabs or floor beam units.

[1] Ministry of Local Government, August 2002, p 21-42

- Pre-cast concrete (artificial stone)

Artificial stone is precast reinforced concrete material with a decorated face.

Precast concrete can be categorized into two categories:

1- Facing for exterior or interior walls of buildings.

2- Items for masonry work such as stair treads, beams, and decks.

- Autoclaved cellular concrete (ACC)

A precast concrete with a lightweight, this type of concrete made inside kilns called autoclaves which provide a high pressure, all the material used in this type of concrete are fine materials . (ACC) is light due to the microscopic cells that are generated during the manufacturing process.

- Concrete Blocks

Concrete block consider one of the most used building materials in Palestine, because of it is relatively cheap, energy efficient and fire resistant. Concrete block come in standard dimensions 20×20×40, 20×10×40, 20×15×40, and 20×7×40. The materials used in making concrete block are; Portland cement, gravels, sand, and water.

Concrete block most of the time come in hollow shape, common types of concrete blocks are:

1- Hollow load bearing.

2- Hollow non-load bearing.

3- Solid load bearing.

Table (5) shows the thermal resistance values of various dimensions of concrete blocks.

Table (5): Thermal resistances values of various dimensions of concrete blocks.

Unit Dimensions of the Block (cm) (Width X Length X Thickness)	Weight Kg	Density Kg/m^3	Thermal Conductivity $(W/m.c^0)$	Thermal Resistance $(m^2. c^0)/W$
H.C.B 40X20 X 20	18	1125	0.52	0.38
H.C.B 40 X 20 X20	21	1350	0.62	0.32
H.C.B 40 X 20X20	14	875	0.46	0.43
H.C.B 40X20 X 15	16	667	0.45	0.33
H.C.B 40 X 20X10	11	1375	0.63	0.15
H.C.B 40 X 20 X 7	8	1428	0.70	0.10
H.C.B 40 X 20X7	9	1607	0.74	0.09

Source: Palestine Standards Institution (PSI)

Source: Ministry of Local Government, 2002

The weight of concrete blocks depend on the materials used in making these blocks, blocks which made of sand, gravel and crushed stone weight 18-22 kg, those which made of light weight aggregate weight 11-16 kg.

- Calcium silicate bricks – Y Tong

Y-Tong bricks consider cheaper than normal concrete blocks and provide better thermal resistance, it also come in different sizes and facing textures, and can be used as bearing walls.[1]

[1] Ministry of local government, August 2002, p 21-42.

In conclusion, concrete products in the West Bank always has a distinct problems, one of those is moisture. Such problem occurred when the used concrete mixture treated wrongly, during placing concrete or after that when not enough curing occurred. However, in some conditions, chemical admixture must be used; the ignorance of using the required admixture causes future problems and makes the concrete material unsustainable.

- **Sustainability of concrete**

Concrete is consider the main construction material all around the world, concrete used for all construction activities, from building the foundation to wall plaster, so it is important to answer the question if concrete is sustainable or not?

A research carried out by Leslie Struble and Jonathan Godfrey 2004, from the University of Illinois at Urbana- Champaign, USA to determine whether concrete is a sustainable material or not, their study, analyzed and compared the environmental impact of producing concrete and steel, utilization of resource, embodied energy and the generation of waste were the critical elements that had been analyzed.

Concrete consisted of manufactured byproduct or material extracted by mining so it was necessary to consider the impact of each separate consistent.

Except Portland cement which has a high embodied energy, all other consistent has low or modest embodied energy. In general concrete

manufacturing in all of its processes, (moving, mixing and handling) required modest amount of energy and produces small amount of waste. Concrete is neither a good insulator nor a good heat conductor, but it store energy and release it later.

When dead concrete structures demolished and the demolish process needs modest amount of energy, demolishing produce dust and fragments of concrete which used as landfill. The results of computation of environmental impact including estimating energy consumption, solid waste, air pollution, water pollution, global warming, resource use for manufacturing concrete and steel shows that "the energy to produce the reinforce concrete beam was estimated

To be 109 MJ and the energy to produce the steel I beam with the same strength was estimated to be 237 MJ" which is about half the energy to produce similar steel I beam.

The result also shows that the resource use of concrete was about double that for steel, both produce high levels of carbon dioxide. Water pollution index for concrete was about half of that for steel, air pollution values were similar also.

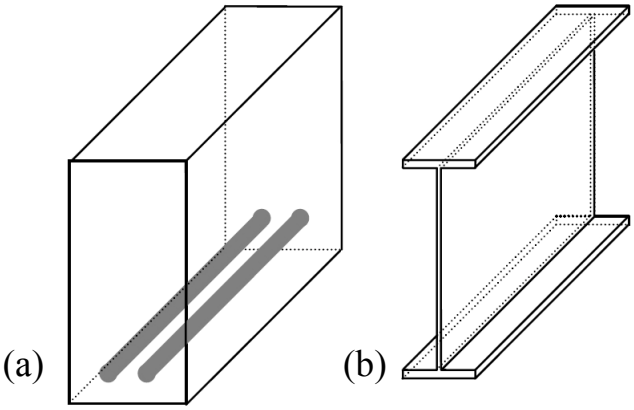


Figure (36):Schematic of structure (a) reinforced concrete beam and (b) steel I beam

Source: Leslie Struble and Jonathan Godfrey, 2004

The energy consumption for concrete was about two third that for steel.

In general computation shows that concrete impact was smaller than that of steel.[1]

- **Improving concrete properties**

Improving the properties of concrete making it more sustainable, chemical admixtures have proven that it could improve the properties of concrete, in developing world the use of these admixtures puts extra financial costs, since they are imported from abroad. In their seek to find some local alternatives for these admixtures, Ryad Abd-alkareem together with Osama Abaza and Narmeen al-Barq carried out a research to find out the effect of adding Zebar[2] as an admixture on the durability and permeability of concrete.

[1] Leslie Struble and Jonathan Godfrey, 2004, p 2- 13

[2] Zebar is a liquid material that composed of water and organic materials such as sugar and inorganic material such as iron, potassium, phosphorus and ash and produced from olive.

Palestine is an olive producing area and Zebar is byproduct of oil production, Zebar as a result is a polluting material and if it shows a positive effect when used as an admixture to concrete that will protect the environment from a harmful material and improve the properties of concrete to become more sustainable.

The result shows that when Zebar percentage was of 30-35 % of mixing water the strength of concrete increased up to 24%, regarding permeability air content for the mix increased up to 5% when Zebar added.

The final results of the can be listed as:

1- Zebar can be converted from a harmful material to an effective important material to the concrete industry.

2- Minimizing the pollution caused by discarding Zebar.[1]

4.2.3 Insulation Materials

Saving energy, protecting structure against temperature variations, increasing confortable by providing suitable air temperature and relative humidity, and controlling condensation in constructions, are good reasons for using thermal insulation.

- **Types and use of insulation materials**

Insulation materials produced in different types and shapes and used to insulate most of the external building members, such as walls roofs and floors, the most common insulation materials used in Palestine are:

[1] Ryad Abd-Alkareem, Osama Abaza and Nirmeen Albrq, 2001, paper

- Polyurethane and polystyrene foams

Figure (37): Extruded polystyrene
Source: http://www.izocam.com

There are two ways to make this kind of insulation materials the first way is through a reaction between isocyanides and carboxylic compounds in addition to a compound that produce carbon dioxide to make urethane foam. The second way is by making a reaction between diisocyanate with a compound that contains active hydrogen[1].

Polystyrene a derivative of petroleum can be produced by the extrusion method, as boards which have a closed-cell structure that resist water and humidity. Polystyrene suitable for flat roofs inverted roof gardens, parking decks, exterior walls, below grade exterior walls, on grade floors of buildings, cold store insulation. Polystyrene also produced as exterior coating boards, this kind of polystyrene have a high working temperature of +70□ C and a minimum working temperature of -180□ C and produced with dimensions 60×125 cm and 3,4, 5,6,8 cm thickness it is also resistant to compression and high resistant to thermal transitions.[2]

[1] Ministry of local government, August 2002, p 21-42.
[2] Izocam, http://www.izocam.com.tr/izocam/Urunler/Ekstrude-Polistren-%28XPS%29/Foam board.aspx

Polyurethane and polystyrene used in roofs and exterior walls to resist thermal transition, and produced in a form of boards with standard dimensions 0.914 to 1.219m width and 1.219 to 3.658 m length.

Polystyrene is a polymerized styrene with compounds added; these compounds produce carbon dioxide which makes polystyrene foam. Polystyrene produced in a form of rigid boards with widths (0.406, 0.610, 1.219) m and thickness (12.7, 19.05, 25.4, 38.1, 50.8, 76.2, 101.6)mm Polystyrene produced in three types:

1- Extruded polystyrene.

2- Low and medium density expanded polystyrene.

3- High density expanded polystyrene.

- Rock wool panels (RWP)

Rock wool produced in a form of panel which contain bonded fibers

Thermosetting binder, rock wool panels produced in two forms rigid and semi rigid with various densities and thickness.

High density panels recommended to be used in roofs and floors, in addition to their function as insulator, (RWP) produced with facing materials.[1]

[1] Ministry of local government, August 2002, p 21-42..

Rock wool utilized for thermal and fire safety, do not cause corrosion or rust, dimensionally stable, do not affected by sunrays, and it is a good fire resistant. Rock wool imported to Palestine usually from turkey[1] see figure (43).

Figure (38): Rockwool panels

Source: http://www.ebonite.ae/trading/rockwool_panels.aspx.

- The use of semi rigid panels includes: External walls, prefabricated buildings and solar heating systems.
- The use of rigid panels includes: Roofs, floors and partitions, duct internal lining.[2]

In summary, People in the West Bank avoid using thermal insulation due to a number of factors; such as the relatively high initial cost and the low awareness of their benefits, in addition to the fact that most buildings

[1] -Izocam, http://www.izocam.com.tr/izocam/Urunler/Ekstrude-Polistren-%28XPS%29/Foamboard.aspx

[2] - Ministry of local government, August 2002, p 21-42.

are built for trading purposes. The benefits of using thermal insulation materials in the exterior walls of building will be reached in the running cost and the whole life of buildings.

- **Sustainability of insulation materials**

The use of insulation materials consolidates construction sustainability. As mentioned before it saves energy, protects the structure, provides comfort, and control condensation. Preferable insulation materials are those of low embodied energy such as cellulose fiber which used for flat roof insulation or renewable insulation materials such as wood fiber boards and cork, and free of blowing agent such as mineral wool/stone wool.

A second preference such as expanded polystyrene which has lower embodied energy than extruded polystyrene, also foam polyethylene tape which is a durable insulation material.

4.2.4 Steel

Steel is among the basic construction materials in Palestine, the properties of steel make it a unique material that helps in forcing the structure and strengthen its members.

Steel can be categorized into two categories: steel reinforcement and steel structure.

- **Steel reinforcement**

This type of steel produced in a form of bars, that are used to reinforce concrete structures, steel imported to Palestine from Jordan as steel alloys, this alloys produced as bars in the steel factory at Jericho, the resulted steel bars reaches 4200 kg/cm², in various diameters such as 6,8, 10,12, 14,16,18,20,25,32.[1]

- **Steel structure**

Steel structures are mostly found in the West Bank in small and medium size buildings such as factories, industrial workshops and sport halls.

The component of these structures varies depending on the architectural design and could be one of the following:

- Hot rolled sections "I, H, L" shapes.
- Tubular sections of circular, square and rectangle shape (this type of components is not available any more in Palestinian areas due to Israeli prohibition)2.
- Fabricated sections made by welding.
- Stainless steel components.

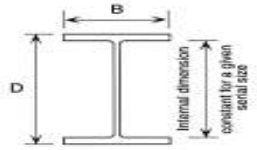
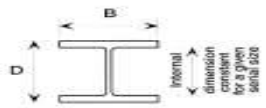
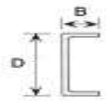
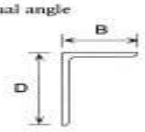
[1] Department of engineering works – An Najah national university, personal interview with civil engineer Hatem Alwahsh.
[2] Israeli occupation prohibited importing this type of steel structural component, as it can be used for making bombs and rockets.

- Modular units made from light steel components.

In general it can be noticed that I sections are used for beams, H-sections for columns, tubular sections for bracing, fabricated sections for primary beams and transfer beams that support columns and light steel used for infill walls.

Table (6) shows the standard hot rolled sections (UB, UC, C and L), table (7) shows the structural hollow sections (note, external dimensions are constant for a given serial size in all hollow sections).[1]

Table (6): rolled steel sections.

Universal beam (UB) 	**Universal Beams** Nominal dimensions (mm) D: 203, 254, 305, 356, 406, 457, 533, 610 B: 102 and 133; 102 and 146; 102 and 165; 127 and 171; 140 and 178; 152 and 191; 210; 229 and 305 Deeper and shallower UB sections are available but are not liste
Universal column (UC) 	**Universal Columns** D: 152, 203, 254, 305, 356 B: 152, 203, 254, 305, 368 and 406
Channel (PFC) 	**Parallel Flange Channel** D: 100, 125, 150, 180, 200, 230, 260, 300, 380, 430 B: 50; 65; 75 and 90; 75 and 90; 75 and 90; 75 and 90; 75 and 90; 90 and 100; 100; 100
Equal angle 	**Rolled Steel Angles** External dimension of equal angle: 25, 30, 40, 45, 50 60, 70, 80, 90, 100 120, 150, 200, 250
Unequal angle 	**Rolled Steel Angles** External dimension of unequal angle Various sizes from: 40 × 25 to 200 × 150 Including common sizes of: 75 × 50, 100 × 75, 150 × 75, 200 × 100

Source: Peter Trebilcock and Mark Lawson, Architectural design in steel, The steel construction institute, 2004.

[1] Peter Trebilcock and Mark Lawson, 2004 , p 8-90

Table (7): Tubular steel sections

	**Square Hollow Section (SHS)** External dimension of square section (mm): 40, 50, 60, 70, 80, 90 100, 120, 140, 150, 160 200, 250, 300, 350, 400
	**Rectangular Hollow Section (RHS)** External dimension of rectangular section: Depth (mm) × width (mm). Various sizes from: 50 × 25 to 500 × 300 Including common sizes of: 100 × 50, 150 × 100, 200 × 100, 250 × 100 250 × 150, 300 × 200, 400 × 200, 450 × 250
	**Circular Hollow Section (CHS)** Size of CHSs Various sizes from: 21.3 mm diameter to 508 mm diameter Including common sizes of: 114.3, 168.3, 193.7, 219.1, 244.5, 273, 323.9, 355.6, 406.4, 457

Source: Peter Trebilcock and Mark Lawson, Architectural design in steel, the steel construction institute, 2004.

- **Structural and steel framing**

Steel is used to form skeleton frames for small and large size structures, steel prepared according to design specifications, then moved to the site shaped drilled and ready, steel structure , may be left exposed but it needs coating to resist corrosion and it's better to be covered with fire resistant material.

The major use of steel products in the West Bank concentrated on steel reinforcement. In some cases, steel bars become exposed to rust, due to the wrong storage of steel bars. These rusted pars when used in concrete reinforcement affect the strength of reinforced concrete. The use of steel structure in the west bank is limited due to a number of factors such as the

absence of steel manufactures, and the high costs of importing steel members, in addition to the inexperienced architects and engineers to use steel structures.

- **Sustainability of steel**

Efficiency, durability, recyclability and reuse, make steel construction environmentally friendly, as it uses less resources, less energy, needs less transport and produce less emissions and less waste

The embodied energy for the production of all steel components for a multi-story steel building compared to a 50-years life cycle is less than 2% of the total energy usage[1].

Regarding operational energy, prober use of steel systems in external walls makes them very efficient. Steel structures are light, so less weight to be transported, very small amount of waste needed to be moved to recycling or deposit. On the other hand there is more volume to transport to site when there is a high degree of prefabrication since the specialized fabricators are mostly far from construction sites.[2]

Since steel construction has a high degree of recycled content, the need for virgin sources is relatively small, and compared to other building systems steel construction has low levels of emissions.

[1] dilstam, T., Livscykelanalys av bostadshus I lattbyggnad, 2005, http://www.sbi.nu/uploaded/dokument/files/SBI-Sustainability_of_steel_framed_buildings.pdf
[2] Personal communication: international Iron and Steel Institute, sited on the previous reference.

Steel can be fully recycled many times without affecting its quality; 94-97% of built-in steel products can be recovered.

Waste of steel construction is very limited due to a high degree of recyclability and reusability.[1]

4.2.5 Building Stone

Natural building stone is one of the most distinguishing building materials to Palestinian construction. Not only because the availability in local market, but also to due to its preferred characteristics such as durability and hardness.

Building stone can be found in Nablus, Jenin, Qabatia, and Jammaen, with various colors such as white, pink and yellow. The craft of quarrying and processing of natural stone started as a small- scale enterprise which depend on intensive labor till 1973 when machines such as mechanical jack hammer, air compressor breakers, loaders, and lorries where introduced, this improvements was a result of the continuous demand on natural stone in the Palestinian market.

The next stage after quarrying natural stone is the process of shaping and trimming, which used to be a difficult process before the use of electrical saws in the early 1970s.[2]

[1] International Iron and Steel Institute, (2005).
[2] Background papers for a conference held on November 24-27, 1995 in Amman-Jordan, the urban and rural reconstruction of Palestine, issues, options, policies and strategies, p 551- 554

The industry of stone is the main extraction industry in the West Bank, together with stone saw industry are one of the Palestinian industries that fill the demand of the construction market from one side and traditional Palestinian experts from another side.

Markets for natural stone in Palestine divided into the following sides:

1- Local markets which accommodate 93.4%.

2- Israeli markets which accomodate6.6 from stone sales.

3- Jordanian and Arab markets which reaches a value of 10% before the use of Jordanian alternative stone lately.[1]

- **Types of stone**

The type of rock decides the properties of the building stone, rock can be categorized into three categories:

1- Igneous rocks: rocks that resulted from lava, an example of this kind of rocks; granite and basalt stone.

2- Sedimentary rocks: rocks that resulted from precipitation of lime atone and sand stone after exposed to high pressure levels such as lime stone and sand stone.

[1] Ryad awad, 2000, p8-15

3- Metamorphic rocks: sedimentary or igneous rocks which transformed to a new kind of rocks after exposed to high levels of pressure, such as; marble which is present in different colors.[1]

- **Physical properties of stone**

The physical properties of stone make it suitable for building. These properties are:

1- Durability: stone durability depends on the combination of its particle; those of small particles are more durable than those of big ones.

2- Absorption: the ratio of stone absorption of water that the dry stone can absorb if immerse in water for 24 hours to the weight of dry stone.

3- Bulk specific gravity: the ratio of stone mass to an equivalent mass of water in a specified temperature and measured in kg/m³, bulk specific gravity can give indication about the stone absorption.

4- Expansion and shrinkage**:** building stones affected by temperature; it expand by the rise of temperature and shrink by low temperatures and the change in size could be 0.02%-0.45%.

5- Fire resistance**:** stone is a relatively fire resistant material, but it is affected by high temperatures, lime stone can bear 600□ c.

[1] Background papers for a conference held on November 24-27, 1995 in Amman-Jordan, the urban and rural reconstruction of Palestine, issues, options, policies and strategies, p 551- 554

6- Frost resistance: stones of small bores absorb less water, so it's resistance to frost is higher than those of large bores. [1]

- **Mechanical properties of stone**

Stone shows a good mechanical behavior which makes it durable and preferable, for example; stone can bear high compressive strength up to 1000 kg/cm², also stone can resist the tensile strength by about 1/7 – 1/11 of its ability to resist compressive strengths, stone in general can resist abrasion, which caused by the weather circumstances.

- **Preparing the building stone**

Stone passes through a number of stages to be ready for use, these stages include:

1- Cutting the stone from rocks**:** the first step in cutting the stone is finding the suitable rocks, and there is three ways to cut the stone:

- Manual machines: by using the heat of fire which fragment the rocks, or by using wedging.
- Mechanical machines: machines which use steam, compressed air of electricity used to make vertical holes 4-5 cm deep and 5-7 cm diameter around the piece of stone.
- Exploding materials such as TNT used to defragment the rock into different sizes.

[1] - Ryad awad, 2000, p8-15

2- Cutting stone by the saw**:** stone saw used to shape the stone in to the needed sizes and shapes.

3- Shaping and finishing the stone: finishing the stone include giving it the needed facing texture by curving it using manual machines, and there are various types of curved stone such as:

- Tobzeh:

Tobzeh facing stone gives the stone a natural appearance using the chisel and the hammer, the four sides of the stone must be straight and perpendicular in all sides, the protrusion must not exceed 90mm from the edges level and must not be less than 30 mm in second degree building.

- Msamsam:

In this type the stone being curved using the chisel and the hammer where equal and parallel lines horizontally, vertically or in 45□ angle made, making sure that the depth of these cure does not exceed 5 mm.

- Mnaqqar (Pitted):

In this type a uniform pitted face made using the tapered thorn, making sure that the depth of these cure does not exceed 5 mm.

- Matabeh:

After cutting the stone by the electrical saw the face treated using a hammer called Matabeh till the glossiness of the face completely removed, and there are three different sizes of the hammer 10, 12, 14.

- Mulattash or mufajjar:

In this type the face is treated using the tapered thorn to make short lines, which can be distributed uniformly or randomly.

- Mamsouh :

In this type the stone face treated by the electrical saw to get totally level face. [1] different types of stone finishing are shown in figure (39).

Figure (39): Stone finishing types.
Source: the author, 2011.

- **Properties of building stone from the first class**

Building stone varies in quality; those from the first class must have these characteristics, according to architect Abu So'ud 1989,:

1- Must be from hard limestone, pure white that does not change color with time, and have a density of at least (2.530 g/cm^3), and rate of absorption that does not exceed 1%. Free of cracks and grouts. Have the

[1] Ryad Awad, 2000, p8-33

same height in courses and the depth of stone piece must be 10 cm unless the design needs less.

2- It must be free of rock layer that is in touch with soil and free of stone holes, yellow red or brown spots and other impurities.

3- The stone piece must have a 90□ angles and free from deviation in the stone face, in case of Tobzah the relief must be at least 5 cm from the elevation line, the stone piece must be at least 55-60 cm in length except in special cases such as the close piece. See figure (40).

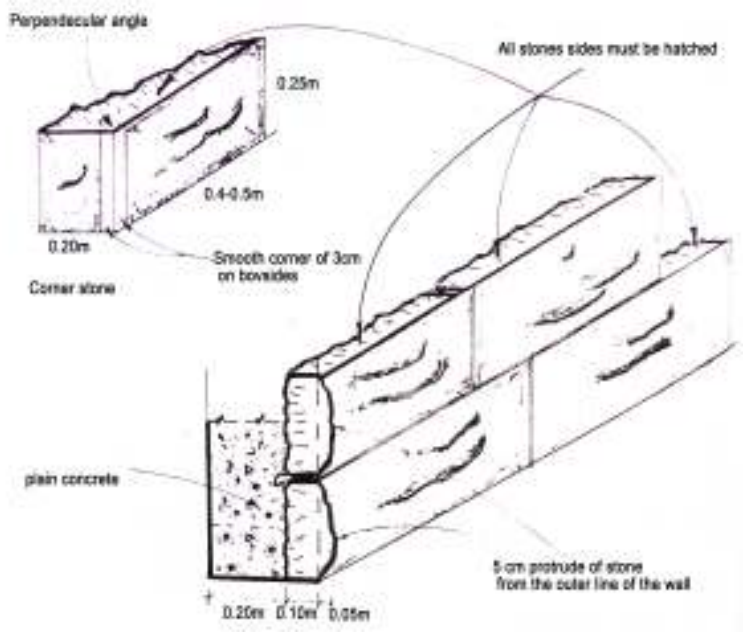


Figure (40): Courses of tobzah stone
Source: (after) Sa'ed Abu So'oud 1989.

The recess in Tobzah stones must be at least double of the relief to maintain the center of gravity inside the wall. All smooth sides and the back of the stone must be rough and hatched.[1]

[1] Sa'ed Abu so'oud, 1989, p 79-82

- **Sustainability of stone**

Most of the time Architects use stone types based on aesthetic prepuces, however the medium-to-long term durability of the stone needs to be taken into consideration.

In order to deserve the relatively high price of stone as a building material the performance of stone may include the following criteria

1- Service life requirements “life of the stone not less than 60 years”.

2- Aesthetic requirements “no obvious change of color during the first 10 years of use”.

3- Maintenance frequency requirements “scaffoldings not to be erected for maintenance in 10 years intervals maximum.”

4- Maintenance expenditure requirements “no excessive maintenance requirements during the first 25 years.”

- **Environmental Impacts of stone**

Stone industry affecting the environment significantly on the following areas:

- Extracting and processing natural stone leads to water pollution and waste generation, so procedures need to be taken to manage the waste through isolating it from natural water resources, and dispose it as land fill.

- Air pollution : extracting, processing and transporting stone leads to air pollution through the burning of fossil fuel, it also generate dust from processing, stone companies must take suitable procedures to control the dust and rely more on manual shaping and finishing of stone.

- **Social Impacts of stone**

When used stone showed positive social impacts, however during extracting and processing stage there were some problems that affect the nearby communities such as dust and noise.

- **Embodied energy**

BRE'S "Green guide to housing specifications" in their wide-ranging approach to energy consumption and production of waste showed that stone "marked down" in terms of water extraction, waste disposal, and mineral extraction and recycled input.[1]

- **Points to be taken into consideration concerning sustainably produced natural stone:**

1- Relationship with local environs:

Stone production companies needs to maintain a good relationship with clients, employees, financers, stockholders; through engaging them in a dialog with their representatives.

[1] Tim Yates and Kathryn Bourke,BRE, 2005, p 49-53.

2- Child labor:

Companies should not use Childs as employee below the age of 14.

3- Environmental policy:

Companies must minimize the environmental impact of their activities; for example they can design measures to monitor and limit noise pollution and land scape destruction.

4- Water:

Companies must insure that water used during extraction and processing of natural stone does not affect ground and surface water levels negatively, they need to think about recycling waste water.

5- Pollution:

Measures need to be taken to minimize the emission to water and air, and air must be recycled. [1]

4.3 Conclusion

There is a new trend in the West Bank to use modern new materials, in walls such as metal, glass, etc. the problem come from undermining their physical and sustainable qualities and confine them to aesthetics or decoration appearance.

[1] India committee of the Netherlands, 2007, www.**indian**et.nl/pdf/**naturalstone**.pdf p 1-7

In conclusion, people moved towards contemporary building methods and materials because it has some advantages such as, it is cheaper, easy to be implemented and as esthetical development, but still have disadvantages such as, the big thermal loss, heat absorbtion and the need for continuous maintenance. Sustainable construction approach tended to reduce the disadvantages.

Charter Five

Walls Construction in the West Bank

Charter Five
Walls Construction in the West Bank

"*Walls are the vertical constructions of the building that enclose, separate and protect its interior spaces*." [1]

Walls in general can be divided into two divisions:

1- Internal walls.

2- External walls.

The focus in this chapter will be on external walls of buildings - because it has a direct contact with the environment- their types, techniques, materials and systems.

- **Intrnal Walls**

Walls are used inside the building to divide the space; these interior walls could be constructed using wide range of materials such as:

Concrete walls usually constructed 15-20 cm thick, hollow cement block 10-15 cm thick, etong block 10-15 cm thick and Gypsum boards 5-15 cm thick walls.

5.1 External Walls

External walls (envelope) are those vertical construction members that separate the interior space from the exterior environment and have openings such as doors and windows.

[1] Ching, 2008, p 5.02

External walls in the West Bank of Palestine varies in types, systems and materials, most of the time the economic factor decide what kind of external walls would be used.

There are many types of external walls used in the West Bank most of them use the locally available materials such as stone, concrete and hollow concrete block.

According to a survey carried out by the Ministry of Local Government, external wall types are as follows:

5.1.1 Concrete External Walls

Concrete used in external wall could be: ready mixed concrete and considered the most common type, precast concrete such as concrete walls include constructing the reinforced concrete columns then casting the concrete wall with a 20-25 cm thick see figure (41)

Figure (41): A photo shows a concrete wall.

Photo by: Faculty of engineering, at An-Nahaj national university,2009

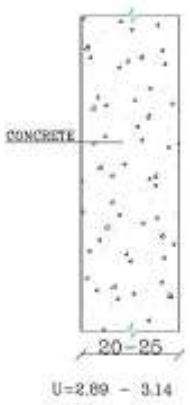


Figure (42): Section in a concrete wall

Source Ministry of Local Government, 2002

Concrete external walls need to be insulated since the concrete absorbs water, there are three main ways used in the West Bank to insulate concrete walls see figure (43).[1]

[1]- Ministry of local government, 2002, , p 38-42

U: coefficient of heat transmission, a measure of the rate of non-solar heat loss or gain through a material or assemble.

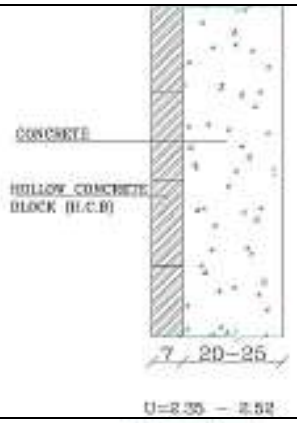
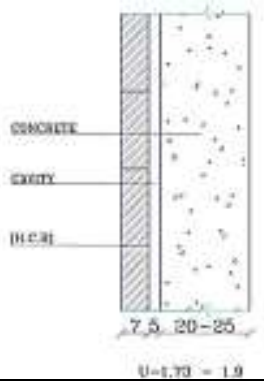
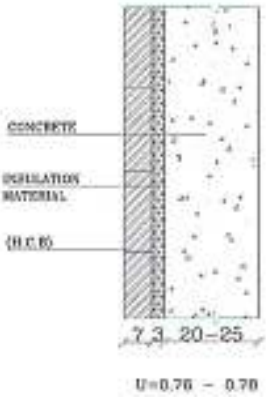
Description	Detail
1. A layer of hollow concrete block added to the inner side of the wall to increase its insulation properties	
2. A layer of hollow concrete block and a cavity added to the inner side of the wall to increase its insulation properties.	
3. A layer of hollow concrete block and a layer of insulation material used in the inner side of the wall to increase its insulation properties.[1]	

Figure (43): Concrete wall types

Source: Ministry of Local Government, 2002

Adding thermal insulation material to the concrete wall will result in a clear decrease in the u value, and maintain a good temperature inside the building. [2] For more data see appendix (2)

[1] Ministry of local government, August 2002, p 38-42.
[2] Ministry of local government, 2004, p 188-199

5.1.2 External Hollow Concrete Block Walls

Concrete block is one of the fundamental building units in the West Bank, this material come in a form of hollow block with multiple hollows, and there are three types of concrete block used in The West Bank which are:

1- Hollow load bearing.

2- Hollow non load bearing.

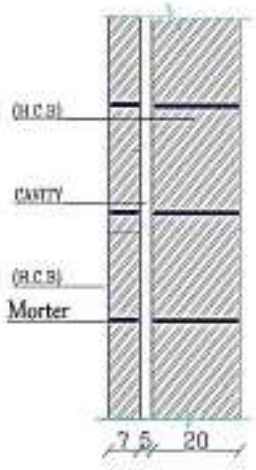
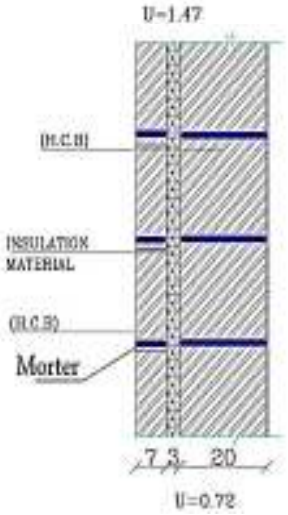
3- Solid load bearing.

Hollow concrete block walls built using 20 cm thick blocks see figure (44)

Figure (44): Section in a hollow concrete block wall
Source: Ministry of Local Government, 2002.

Two ways used to insulate Hollow concrete block external walls in the West Bank see figure (45) [1]

[1] - Ministry of local government, August 2002, p 38-42.

Description	Detail
1. Another wall of 7-10 cm thick of hollow concrete block built from the inner side of the wall and a cavity of 5 cm left between the walls.	
2. A 3 cm layer of insulation material (polystyrene or polyurethane) added to the inner side of the wall then another hollow concrete block wall of 7-10 cm thick built.	

Note. U: The thermal transmittance of the composition

Figure(45): Hollow concrete block types

Source: Ministry of Local Government, 2002

The u values for the different hollow block walls, decreases when a cavity added to the hollow concrete block wall, but it will be smaller when an insulation material used in the external hollow concrete block wall for more elaboration see appendix (2)

Some points needs to be taken into consideration when building a hollow concrete external wall:

1- It is not recommended to sprinkle the concrete blocks with water before building them, it is better to modify the consistency of the mortar mixture to suit the absorption of concrete blocks.

2- Walls built by concrete block must be straight and plummet.

3- After building the hollow concrete block walls it must be cured for at least one day.

When using cavity walls from hollow concrete blocks these notes must be taken into consideration:

1- Cavity must be kept clean from mortar and block fractions.

2- Steel ties must be used and fixed in the mortar at a depth of not less than 50 mm and in a regular distances vertically and horizontally, and taking all necessary precautions to prevent from leakage of moisture from outside to the inside through these ties.

3- Isolation materials in multiple layers must be fixed in the wall from the ground to a level not less than 150mm to prevent from moisture leakage.

4- Suitable drainage under the level of isolation layers must be fixed to get rid of gathered water in the cavity between the two layers of the wall.

5- The cavity must be continuous as much as possible in all parts of the wall.[1]

1 (Jordanian ministry of local works), 1985 p 608-617

To sum up, people in rural areas in the West Bank uses hollow concrete block for building extensively due to its very low cost compared to other materials such as concrete and stone. Using hollow concrete block for exterior walls is not always a wise selection since its permeability for moisture is very high and need to be isolated using water or moisture insulation in addition to one of the thermal insulation techniques.

5.1.3 External Stone Walls

Natural stone is one of the most popular building materials in the West Bank. Stone earns its popularity due to its availability in the local market and its preferred characteristics which have been discussed earlier.

External stone walls can be found here in Palestine in different types and systems where stone can be built either with the wall or cladded to the wall see figure (46). [1]

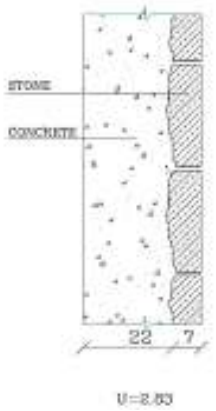


Figure (46): Section in a stone concrete wall
Source: Ministry of Local Government, 2002

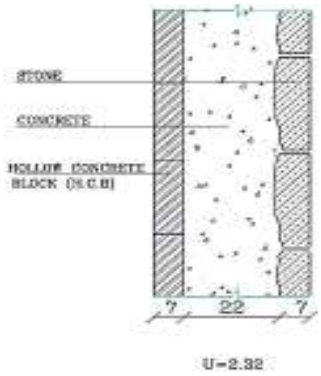
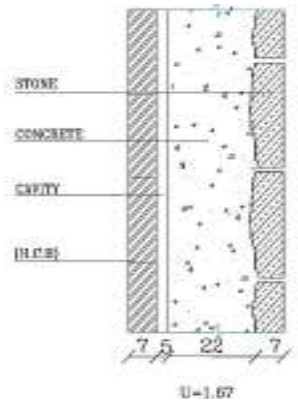
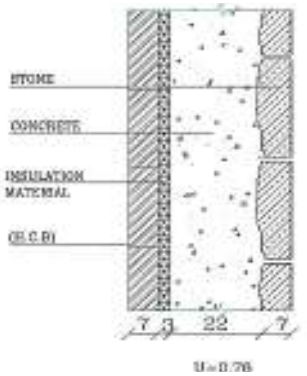
Figure (47) shows one type of external -stone walls in which a layer of 7 cm thick stone built then casting a 22-23 layer thick of concrete behind the stone layer [1]

(a)

(b)

Figure (47): Stone elevations.

Photo by: the author, 209

Description	Detail
1. Another wall of 7-10 cm thick of hollow concrete block built from the inner side of the wall to improve its isolation properties.	
2. A wall of 7-10 cm thick of hollow concrete block built from the inner side of the wall and a cavity of at least 5 cm left between the two walls properties.	
3. A 3 cm layer of insulation material added to the inner side of the wall then another hollow concrete block wall of 7-10 cm thick built.	

Figure(48): Stone wall types

Source: Ministry of Local Government,2002

Figure (48) shows that the u value[1] decreases by 0.51 when adding another layer of hollow concrete block, while decreases by 1.16when using a cavity and hollow concrete block in the stone wall.[2]

It can be concluded that the most affective factor in decreasing the u value of thermal is adding the thermal insulation layer to the wall where the value decreases by 2.7 for more elaboration see appendix(2) .

- **Insulating the stone wall**

It can be noted that even those people in the West Bank who use thermal insulation do not install it properly, especially in corners, connections and columns.

Thermal insulation must be fixed continuously to prevent from any thermal bridges that could be produced if any of the wall members left un-insulated, the following figures show the correct way of insulating critical areas such as the wall corners, areas where the wall intersects with the ceiling and areas where the wall intersects with the floor. In figure (50) drawing (B) shows how could thermal bridges formed in the corner of the wall and the intersection area between the wall and the ceiling and causes a big thermal loss which leads to a decrease in the temperature of that area and produce a condensation surface. Drawing (A) in the same figure shows a suitable way to prevent from forming such thermal bridges.

[1] coefficient of heat transmission, a measure of the rate of non-solar heat loss or gain through a material or assemble

[2] Ministry of local government, Guidelines for energy efficient building design, 2004, p45- 47

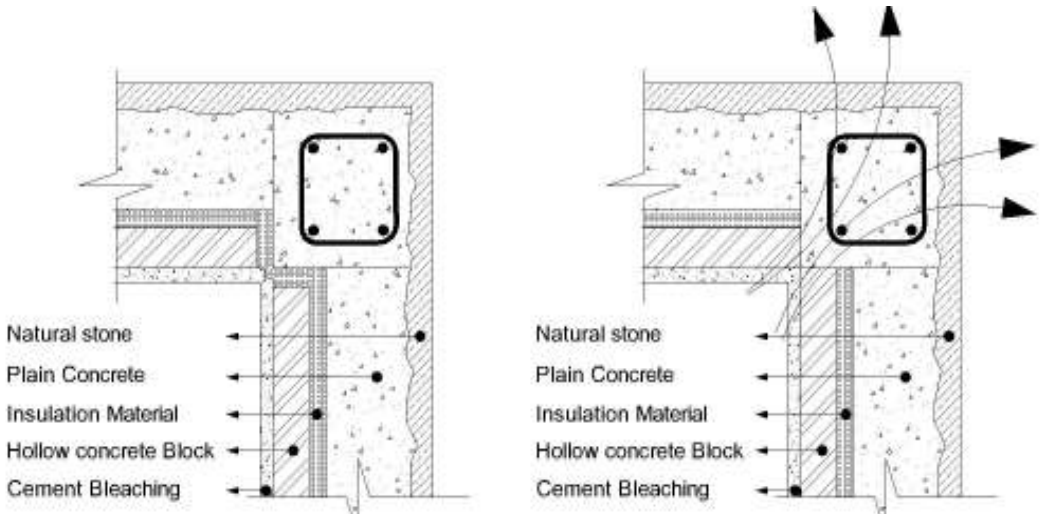


Figure (49): Stone wall insulation technique (corners)

Source: (after) Ministry of Local Government, energy efficient building code, 2004.

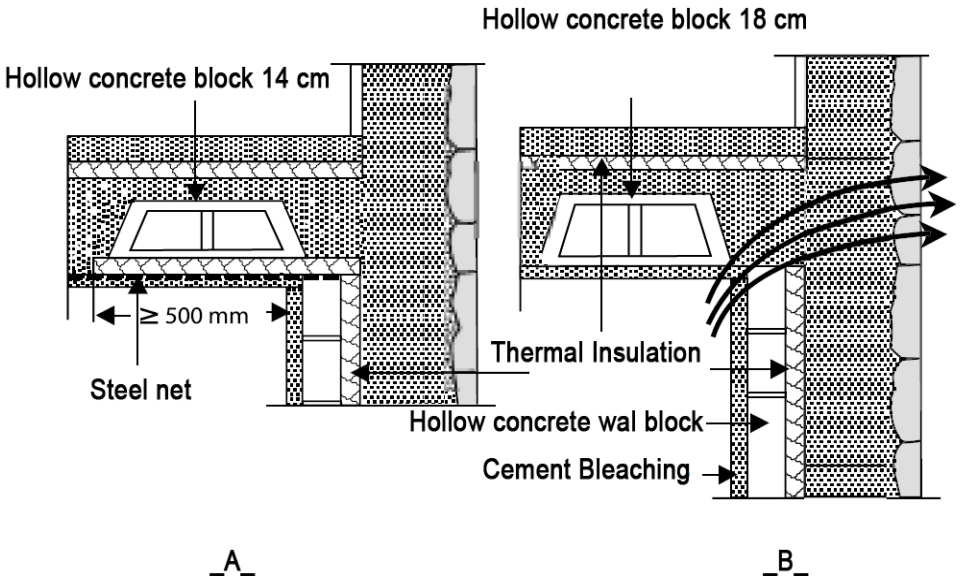


Figure (50): Stone wall insulation technique (roof)

Source: (after) Ministry of Local Government, energy efficient building code, 2004.

Also where the walls and the floors intersect the thermal insulation must be continuous and extended horizontally at not less than 500 mm length, as shown in the right drawing of figure (51).[1]

Another side must be taken into consideration regarding the wall openings which is air infiltration control. While moving air currents

[1] Ministry of local government, energy efficient building code, 2004, p 44-47

transport water, vapor, conditioned air, pollutants and sound, so there is need to stop the flow of this air through the exterior wall by using air barriers.

While the moving of air through the exterior wall has negative impacts, it is needed through carefully designed ventilation system, when the exterior wall has no operable windows, to insure the change of air in all spaces. The united state department of energy found that up to 40 percent of energy lost due to air movement.

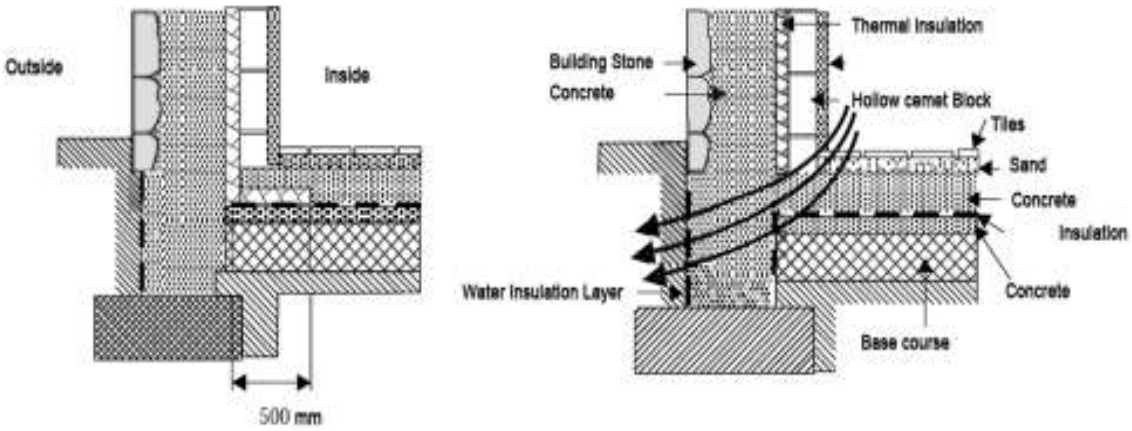


Figure (51): Stone wall insulation technique (floor)
Source: Ministry of Local Government, energy efficient building code, 2004.
Redrawn by: the author

Air barrier systems used to stop or reduce the leakage of air through the exterior walls.[1] To prevent from air leakage in air conditioned spaces, the following points must be considered:

1- Guarantee that no air leakage will pass through the external envelope of the building by sealing all cracks and joints in walls ceilings and floors.

[1] Linda Brock, 2005, p 48-50.

2- Using suitable insulating materials for sealing cracks and joints such as putty and tapes that prevent from air and water leakage. Recommended putty such as silicon, polyurethane, polysulfide, and tapes such as rubber from Butyl and Neoprene types.

3- Special care must be given to external openings for rolling shutters cases, and taking proper procedures to prevent from air and thermal leakage, see figures (52, 53).[1]

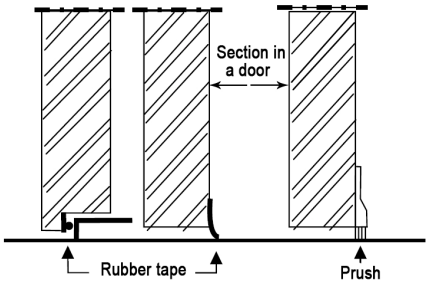


Figure (52): Door air barrier types

Source: Ministry of Local Government, energy efficient building code, 2004.

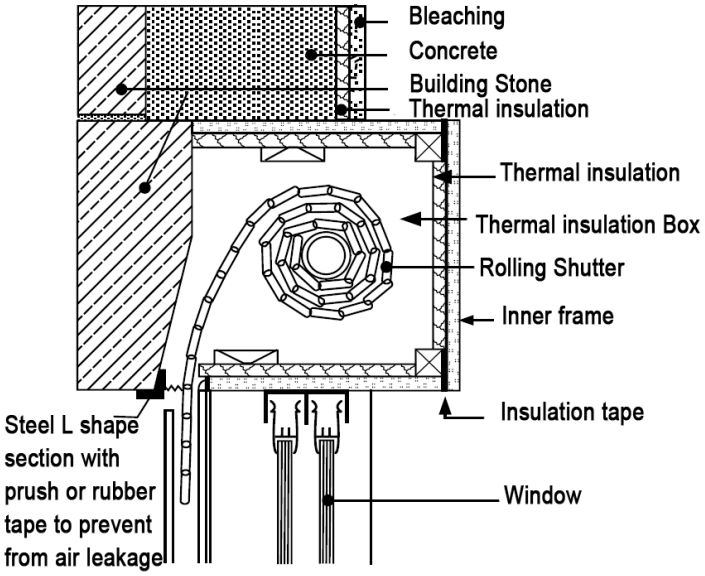


Figure (53): Rolling shutter box insulation

Source: Ministry of Local Government, energy efficient building code, 2004.

[1] Ministry of local government, energy efficient building code, 2004, p 94-95

5.1.4 Susatainability Considerations.

The construction process of external walls and the resulted external wall systems must in all stages imply and apply the criteria of sustainability.

Again the process must maintain and restore harmony between nature and the built environment and reduce the quantity of waste of all wall construction materials including concrete, hollow concrete block, stone, insulation materials, and reduce the use of nonrenewable natural resources.

The whole life cost of the project and the running costs must be given the priority and highly consideration instead of initial cost mainly when choosing the wall system, material and techniques that achieve sustainability.

Resourcing, manufacturing, transporting, maintenance and disposal of external wall construction materials must also be considered when selecting materials for wall construction.

Achieving maximum sustainability for external walls also include using suitable systems that support and maintain a convenient environment and temperature inside the building and reduce the costs of heating and cooling which consumes energy and increases the impacts on the environment.

In rare occasions stone aggregate in concrete or stone masonry has been found that it could be a source of radon gas emission.

The thermal mass of concrete and stone masonry could be a useful effect that reduce heating and cooling loads and conserve energy. The use of stone and concrete masonry could reduce the use of paint finishes, which is a source of volatile organic compounds.

5.2 Metal Panel Curtain Walls

A wide variety of metal materials are suitable for curtain walls, such as terracotta, titanium, aluminum and stainless steel. The properties of metal make it easy to be fabricated in a form of panels, which can be integrated with insulation, shingles or laminated to sheathing to be attached directly to a light-gauge frame. This kind of curtain walls is not new to the world, (Alucobond) for example used in Europe before 1970s, but it is newly introduced to the West Bank.

5.2.1 Types And Finishes

Composite metal panels can be produced with various thicknesses; in general composite metal panels consist of aluminum or other metal material as a skin with a stiff layer of honeycomb of plastic, aluminum or paper. This composite provide improved thermal properties to the structure, one of the most popular types of Aluminum composite panels is Alucobond which founded in Europe during the late 1970s, .

- Aluminum: is one of the corrosion resistant metals, it can be fabricated with different finishes and a wide range of colors, but it must be protected with clear anodizing.

- Stainless steel: is one of the durable materials and can be fabricated in a number of finishes such as matt, smooth, brushed and embossed.

Stainless steel considered costly in its initial, but the life cycle cost is less than other less durable materials. For protection of stainless steel superficial zinc coating is used.[1]

- Weathering steel: used for cladding when fabricated in plate form, but it needs careful detailing in order to keep it dry.

- Titanium: considered costly, it gains its popularity when Frank Gehry used it in Guggenheim museum in Bilbao; Spain. Titanium has a low coefficient of thermal expansion, more flexible and less weight than steel.

5.2.2 Metal Selection Consideration

Some notes need to be taken into consideration when regarding the specification of the metal panels:

- Some metals need to be installed in the same direction of fabrication, with the rolling direction indicated.

[1] Linda Brock, 2005, P48-50

- Flatness: the finish of the surface, the size of the profile (or backing) of the panel, the thickness of the material all of these are factors that affect the flatness of the panels.

- Durability should be considered when selecting metal materials for panels.[1]

5.2.3 Insulation Techniques

Metal curtain walls could be composite or plate, the following figures show how some kinds of metal composite panels could be installed if they are oriented horizontally or vertically.

Horizontally oriented panels need to be supported from below by a distribution Cleat, which guarantee that panels are not going to move vertically, since in most cased composite panels designed to be installed vertically. To insure that no air or water leakage is going to happen, factory applied sealant used in the joints as shown. Vertically oriented panels also supported by distribution cleat to guarantee that panels are not going to move vertically or horizontally.

[1] Linda Brock, 2005, P48-50

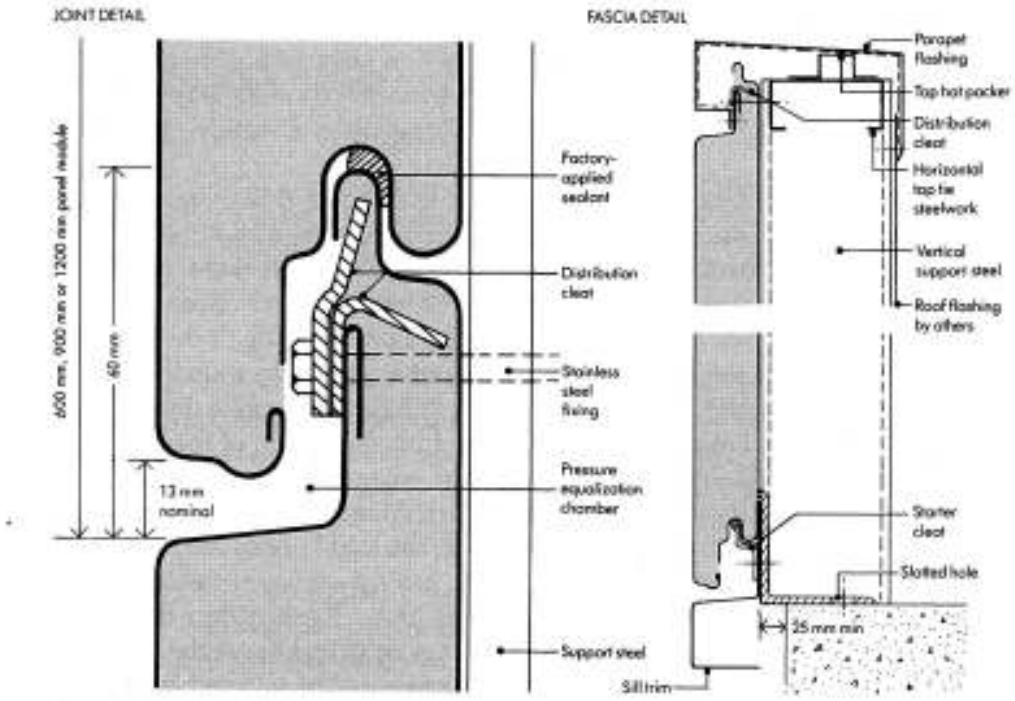


Figure (54): vertically oriented panels.

Source: Linda Brock, Designing the exterior wall, an architectural guide to the vertical envelope, 2005.

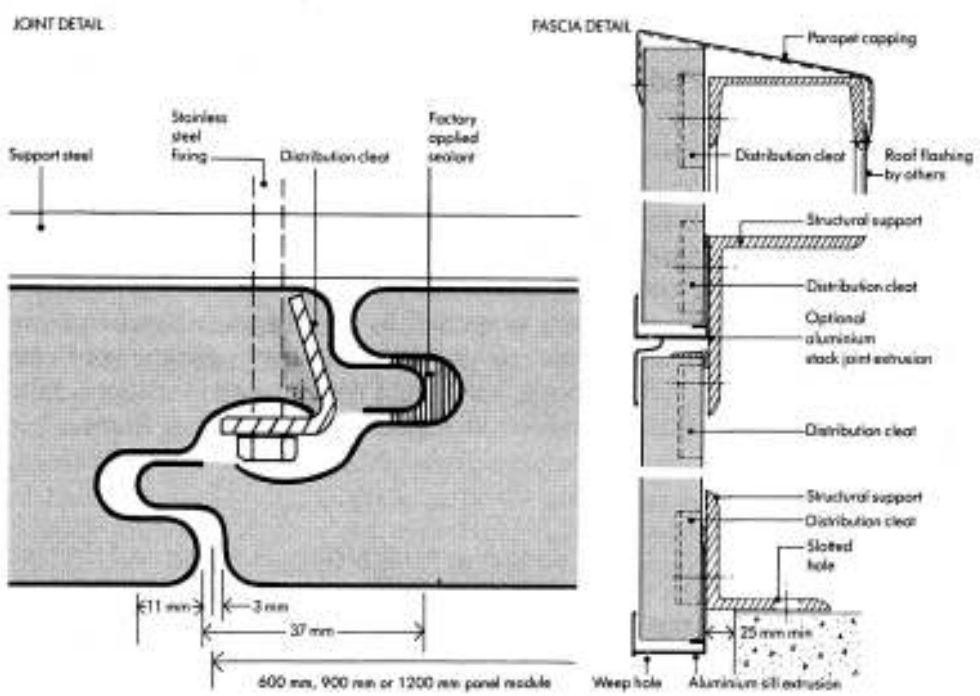
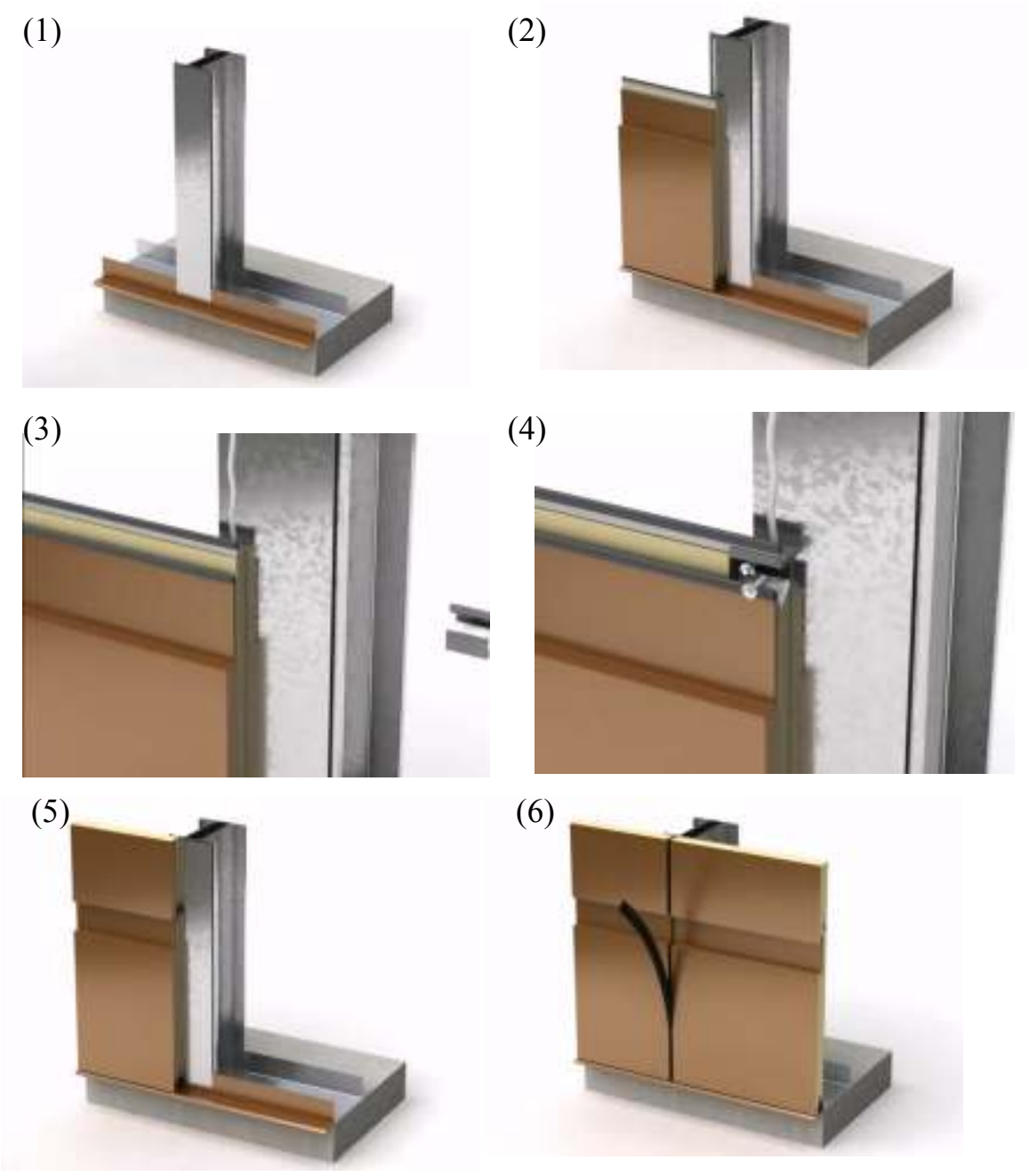


Figure (55): Horizontally oriented panels

Source: Linda Brock, Designing the exterior wall, an architectural guide to the vertical envelope, 2005

Factory applied sealants are also used to prevent from water and air leakage, parapet flashing in the free sides of the wall also needed to prevent from air and water for both horizontally and vertically oriented panels.

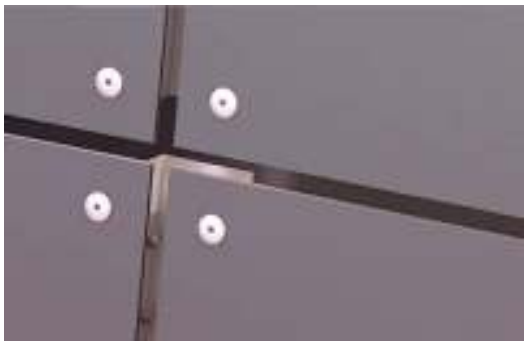
The following figures show that composite panels and metal plates can be installed in different ways.



Figure(56): Composite panels installation

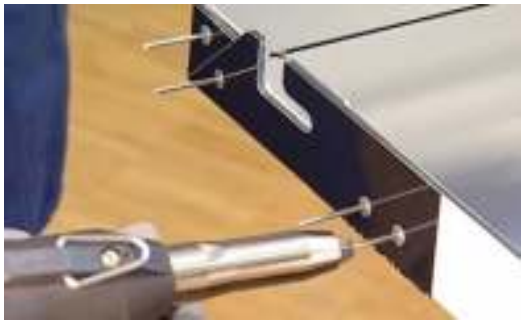
Source: http://www.youtube.com/watch?v=fAljg7sB950

(1) (2)

(1) (2)


(1) (2)




(3)

Figure(57): Composite panels installation

Source: http://www.youtube.com/watch?v=fAljg7sB950

Metal curtain walls are found in The West Bank in some small or medium projects such as commercial centers or some times for specific

shops or exhibitions elevations the following pictures shows some of metal curtain walls cladding.

Figure (58): The use of Alucobond in wall cladding in Ramallah, 2011.

Photo by: the author

Figure (59): The use of Alucobond for wall cladding in Jawwal Exhibition in Nablus.

Photo by: the author, 2011.

Figure (60): The use of metal plates for wall cladding in Sbaitany Exhibition in Nablus.

Photo by: the author, 2011.

Figure (61): The use of metal plates for wall cladding in Sbaitany exhibition in Nablus-cladding face.

Photo by: the author, 2011

5.2.4 Sustainability Consideration for Metal Panels

In addition to the general demands of sustainability regarding external wall constructions such as reducing the quantity of waste and taking the whole life cost into consideration, making metal panels curtain walls more sustainable required thinking of these curtain walls as a vital part of the wall that could improve its properties such as durability and thermal insulation. One of the distinguishing characteristics that the metal panel curtain walls have is the ability to be reused and recycled.

Local architects need to stop using these metal panel curtain walls as a decoration cladding only and try to develop the use of them to become an effective part that make these walls more sustainable.

Manufacturing of these metal panels needs to be taken into consideration since it becomes a favorite material in designing main facades of some commercial buildings.

5.3 Glass and Aluminum Curtain Walls

Glass needs another material to be fixed the material must be stiff enough to bear wind loads and keep glass safe. Aluminum is one of these materials.

5.3.1 GLASS

Glass main integrant is sand (silicon dioxide), lime, soda ash, alumina, potassium oxide and coloring materials, all of these components mixed and heated to form glass.

Glass is not strong in tension (fragile) due to microscopic imperfection; glass manufactured in different thicknesses ranges from 2.5 mm (single strength), 3mm (double strength), up to 25.4 mm. the need for different glass thicknesses came from the need for stronger glass for windows of large areas, and that exposed to heavy wing loads.

In tall buildings thicker glass is used, taking into consideration the supporting frame, and how glass is supported. ASTME 1300[1] established a way to evaluate the stability and probability in the glass structure, and that could provide us with the needed thickness of the glass for a window of a given dimensions, conditions, supporting and wind pressure.

5.3.2 Types of Glass

Different conditions required variety of glass types that suit these conditions. The following are the different types of glass:

1- Heat treated glass

Heat treated process applied to annealed glass and induces compressive stress in the edges and surfaces of the glass and tensile in the core. This treatment makes the glass not only more strong in bending, But also stronger in resisting thermal stresses.

Heat treated glass used for windows that is expected to face heavy wind pressure, or very cold or hot conditions.

[1] ASTME 1300: Standard practice for determining load resistance of glass in buildings.

Heat treatment also can provide us with the following types of glass:

- **Tempered glass**

Tempered glass is distinguished by its high residual stresses which make it very strong in bending. It is used for safety glass because when breaks it turned to small square edged grains, tempered glass cannot be cut after treated.

- **Heat strengthened glass**

Heat strengthened glass can replace tempered glass in many cases, it is cheaper than temper glass, stronger in bending than annealed and more resistant to heat stresses, when breaks it makes sharp hurting edges.

- **Laminated glass**

Laminated glass is a sandwich glass that consisted of two sheets of glass and a layer of polyvinyl butyral, the composition but under heat and pressure and bonded together, when breaks the shards of glass are hold with the interlayer.

Laminated glass is suitable for sky lights and overhead glassing.

- **Chemically strengthen glass**

When annealed glass immersed in a molten salt bath, smaller sodium ions replaced with large potassium ions, after butting it in under compression the resulted glass is stronger and tougher than tempered glass, when breaks chemically strengthened glass produces large shards with

hurting edges. It can be cut after treatment, this kind of glass suitable for thin, small and irregular shapes.

2- Fire rated glass

Fire rated glass is used for windows and doors that supposed to parry the passage of smoke even when exposed to heat and flames it could resist up to 20 minutes.

3- Fritted glass

Ceramic-based paints contains pigmented glass particles called firt imprinted on glass surface, and exposed to fire in a tempering furnace, that transform the firt into a hard ceramic coating.

4- Spandrel glass

Spandrel glass is a special opaque glass used to cover spandrel areas (floor edges) in glass curtain walls, a uniform coating of firt used to create special effects of spandrel glass.

5- Tinted glass

One of glass types that reduces glare and heat gain, in general clear glasses have a value between 80-90% of visible light transmittance, the remaining 10-20% is reflected or absorbed by the glass, tinted glass produced by adding chemical elements to the molten glass with blue, green and gold colors, and reduce the visible light transmittance to a range between 10-75%.

6- Reflective coated glass

Reflective coated glass is made by adding a thin layer of durable film of metal or metal oxide on the surface of the glass; it also called (solar control glass).

7- Insulating glass

Insulating glass is made by adding sheets of glass and air space in between (double glass), adding more sheets with air space in between increase the insulating properties (triple glass).

To improve thermal performance experts recommended using stainless steel instead of aluminum, for more improved thermal performance air is replaced by a dense gazes with lower thermal conductivity in the space between glass sheets in double or triple glasses.

8- Low emissivity coated glass

Low emissivity coated glass can be used to improve the thermal performance of glass; it is colorless and transparent and selectively reflects solar radiations of different wave lengths.

9- Self-cleaning glass

Titanium oxide used as coating to glass on the external surface, this coating enables sun lights to convert organic dirt to carbon dioxide and water.

10- Plastic glassing sheets

Plastic glassing sheets used instead of glass for some applications, acrylic and polycarbonate are examples of this kind of plastic sheets and both are more expensive than glass.

11- Glass that changes its properties

It is also called chromogenic glass, thermo chromic glass convert to darker color when wormed. Photochromic glass also converts to a darker color when exposed to bright light.

12- Aerogel- filled glassing

A silicon based foam that have 99.8 percent of air called aerogel, this gel used to fill the space between sheets in double glass, it has a milky color and an opaque appearance depends on its thickness, it is good for insulating. [1]

Most of the glass types we discussed above are imported to Palestinian market, to be used for windows in different sizes a, skylights and curtain walls.

5.3.3 Fixing the Glass

Windows larger than 0.6 m² needs special care in fixing (Glazing), because of the load stresses caused by the wind, irregularities in the frame may cause distortion to the glass which may lead to the fracture of the

[1] Edward Allen and Joseph Iano, 2009 , p710-724

glass. Thermal expansion may also cause stresses and lead to the fracture of glass.

Glazing and fixing aims to; support the weight of the glass and prevent from undesired stresses caused by heavy wind loads, keep the glass isolated from structural deflections, allow for expansions of both the glass and the frame, and avoid the contact between the glass and the frame.

Supporting the glass requires a synthetic rubber called setting blocks.

A suitable amount of bite (grip depth of the edge of the glass) must be applied to prevent from pup out of the glass under heavy wind loads and allow for deflection of glass, all of that provided by the mullions that support the frame and must be stiffed enough to transform the loads of the glass to the frame.

Sealant material required to seal the void between the glass and millions.

These materials must be resilient with sufficient elasticity and dimensions to allow thermal movement.

In general sealant glazing materials can be categorized into two categories:

1- Wet glazing component (mastic component).

2- Dry glazing component (rubber or elastomeric gaskets).

Wet sealants is considered more effective in resisting the leakage of air and water under the condition of good workmanship, in most cases wet and dry sealant components are used together.

Weep holes made in the horizontal mullions to drain water out of the frame to the exterior.

Figure (62): The use of rubber for sealant in glass curtain walls.

Source: Edward Allen and Joseph Iano, fundamentals of building construction, material and methods, 2009.

(a)  (b) 

Figure (63): The use of glass curtain walls – Ramallah.
Photo by: the author, 2011.

(a)  (b) 

Figure (64): Glass curtain wall Bank of Jordan building – Ramallah.

Photo by: the author, 2011.

Figure (65): The use of glass curtain – Nablus.

Photo by: the author, 2011.

(a)  (b) 

Figure (66): The use of glass curtain wall – Ramallah.

Photo by: the author, 2011

5.3.4 Advanced Glazing Systems

Architects continue unleash their imagination in designing glass curtain walls, and that promote developers to provide new details for glazing.

1- Butt-joint glazing

In this type of glazing, the glass only supported horizontally from above and below, vertical jointing for glass sheets made from colorless silicon sealant, this type of glassing provide continuous panoramic view.

2- Structural glazing

Glass in this type fixed outside the mullions, for sealant two types of sealants could be used; structural silicon sealant or, acrylic foam. Structural glazing type provide continuous glass appearance, silicon sealant made in the factory and imported to the site with small aluminum channel fixed, acrylic foam structural glazing type is more quickly applied and produce less waste.

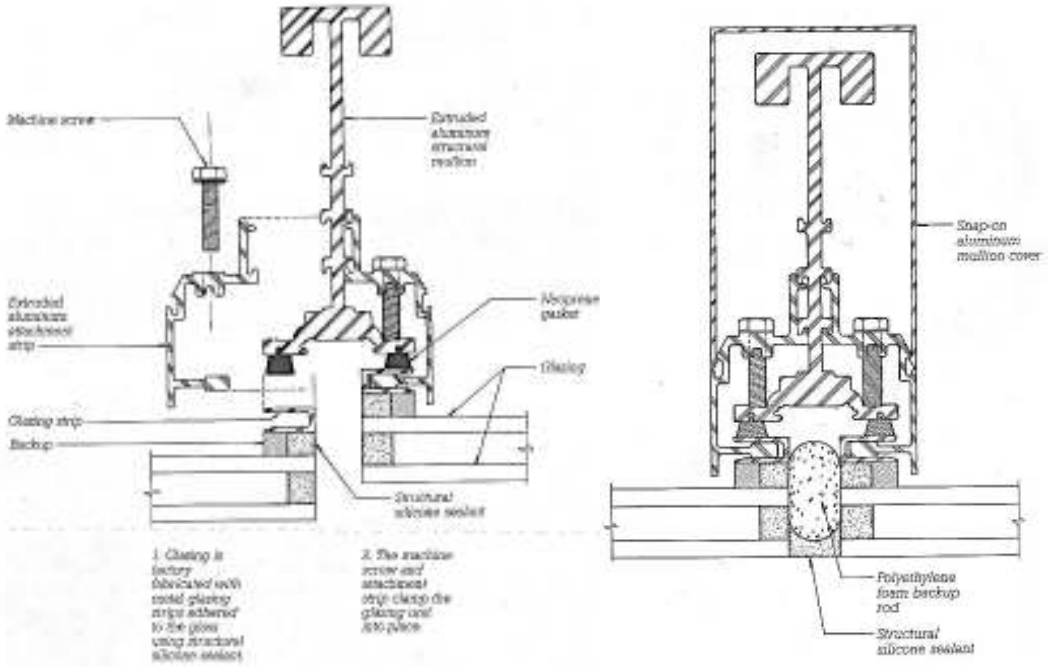


Figure (67): Structural glazing installation details.

Source: - Edward Allen and Joseph Iano, fundamentals of building construction, material and methods,2009

(a)  (b) 

Figure (68): Samples of glass aluminum curtain walls, presented at Buildex exhibition, which held between 18t-20 October 2011 in Ramallah, product of NAPCO.

Photo by: the author, 2011.

(a)  (b) 

Figure (69): Samples of glass aluminum curtain walls, presented at buildex exhibition, which held between 18t-20 October 2011 in Ramallah

Photo by: the author, 2011.

3- Pended glazing systems

This type of glazing used mainly for high glass curtain walls and that requires multiple sheets to be fixed together horizontally and vertically, metal fittings are used in the corner of and edges of the glass sheets to fix them together.

Figure (70): Bended glazing curtain walls

Source: - Edward Allen and Joseph Iano, fundamentals of building construction, material and methods,2009

5.3.5 Glass And Energy

"*Glass is a two-way pipeline for the flow of both conducted and radiated heat*" [1]

Glass transmits heat rapidly from outside to the inside or vice versa even when doubled or tripled, glass trap and collect heat inside the building.

In residential buildings the heat loss or gain through the glass should be minimized to the possible degree, through double glazing, with low conductivity gas fill and low-e coatings.

Tinted glass as well as reflected glass can control the entry of solar radiation into the building.

5.4 Windows

Doors and windows are those components of the wall that control the relationship between outside and inside of the building, it does not allow air and water as well as other undesirable things to pass to the inside of the building, windows and doors considered the most expensive and complex part of the wall.

5.4.1 Types of Windows

Windows that used in residential buildings and commercial buildings could be from the following types;

[1] Edward Allen and Joseph Lano ,2009, p 736

1- **Fixed windows**: one of the least expensive windows, better in resisting the leakage of air and water.

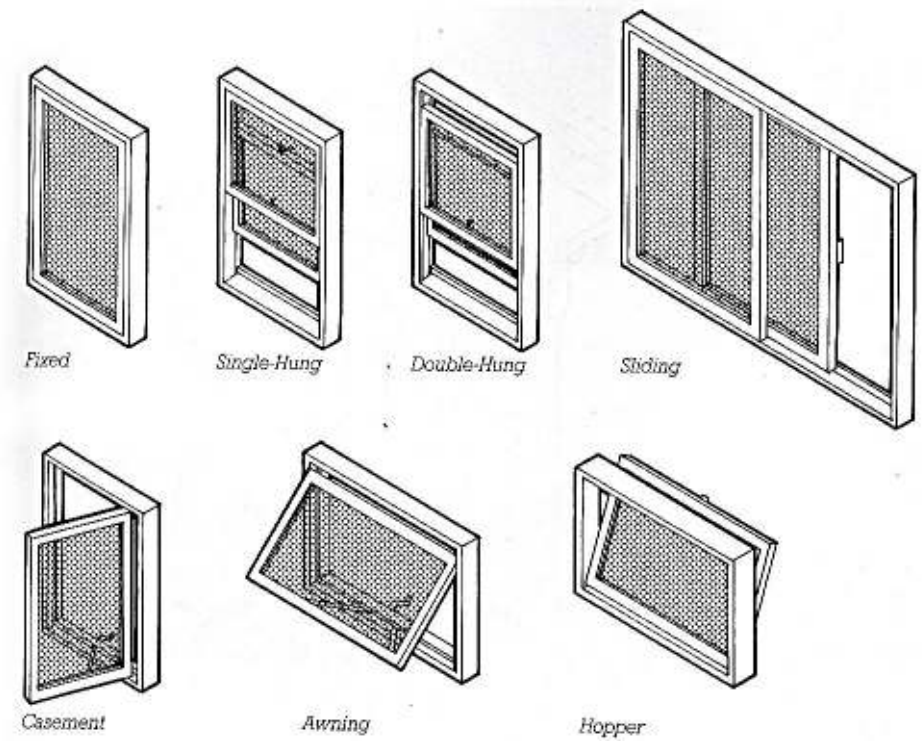
2- **Single and double hang windows**: in this kind of windows, one or two sashes are moving.

3- **Sliding windows:** in this kind of windows there are tracks in the frame that hold the sliding sashes which moves in opposite directions.

4- **Projected windows:** in this type of windows, sashes rotate outward or inward, and being supported from two corners, projected windows could be:

- Casement windows - Hopper windows - Awning windows

- Inswinging windows - Pivot windows.



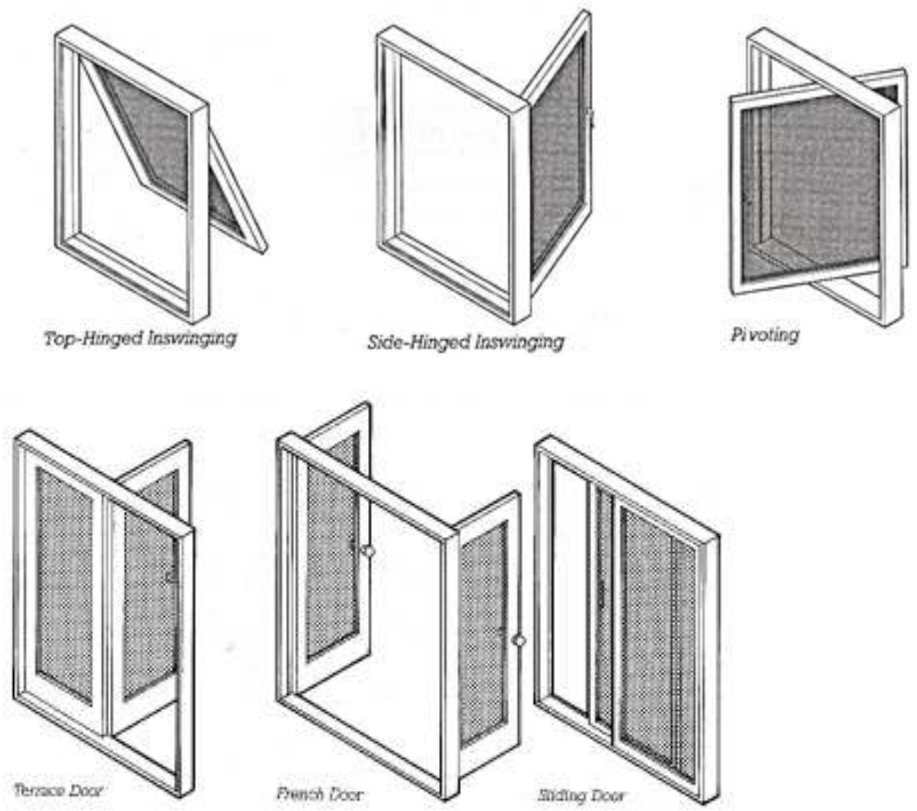


Figure (71): Basic window types

Source: - Edward Allen and Joseph Iano, fundamentals of building construction, material and methods, 2009

5.4.2 Window Frames.

Window frames could be made from wide variety of materials, such as wood, aluminum, plastic and steel.

1- **Wooden frames**: wood used to be the traditional material for window frames all over the world, one of the most desirable properties that characterized the wood is its good resistance to thermal transmittance, and its slight change in size in high and low temperatures. Wood needs repainting every few years, recently new composite wood products introduced and become usable for window frames.[1]

[1] Edward Allen and Joseph Iano, 2009 , p710-724

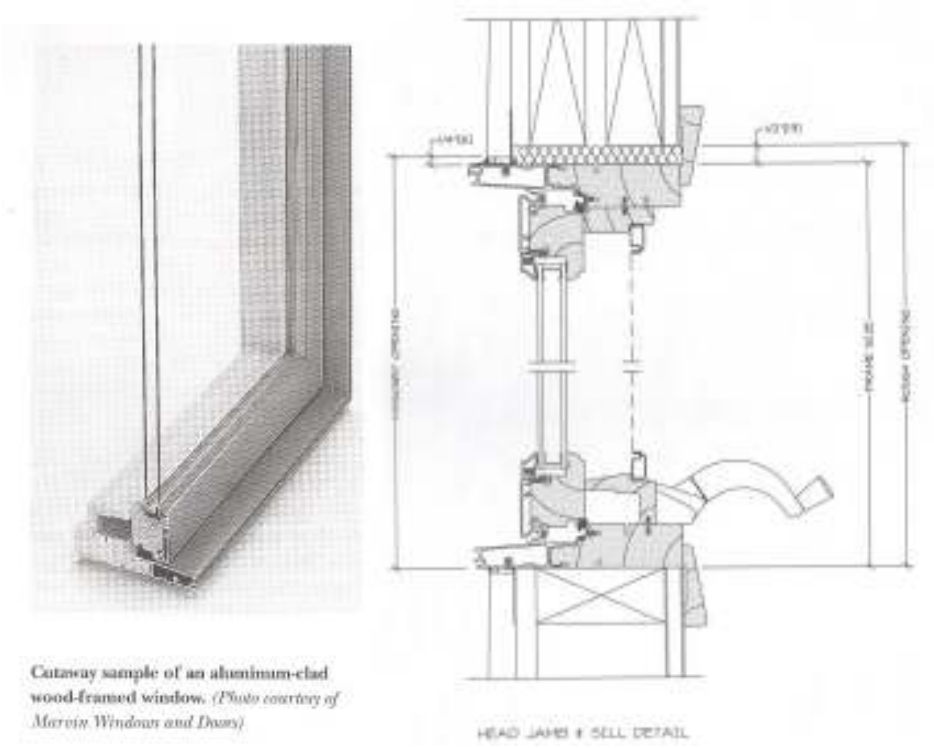


Figure (72): Cutaway sample of an aluminum-clad wood-frame window.

Source: Edward Allen and Joseph Iano, fundamentals of building construction, material and methods, 2009

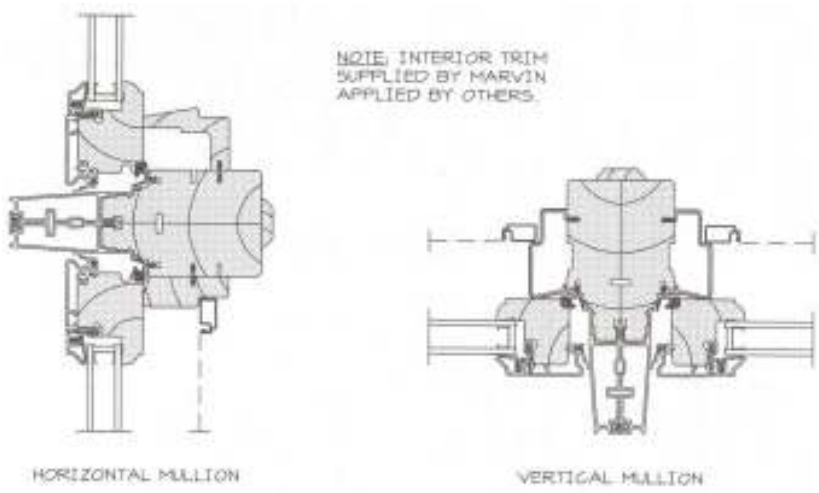


Figure (73): Mullion details of an aluminum-clad wood-frame window.

Source: - Edward Allen and Joseph Iano, fundamentals of building construction, material and methods, 2009

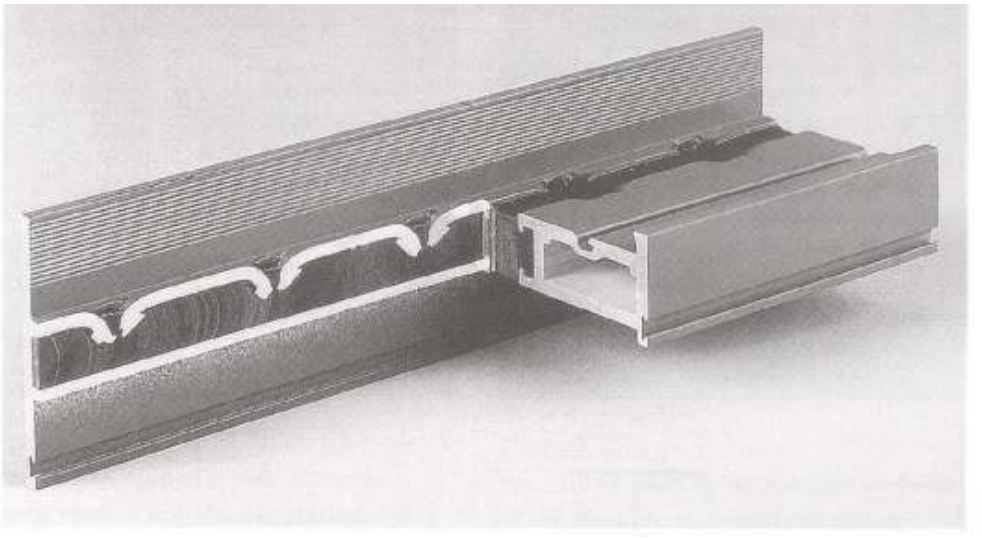


Figure (74): A cutaway demonstration sample of cast and debrided plastic thermal break into an aluminum window frame.

Source: Edward Allen and Joseph Iano, fundamentals of building construction, material and methods, 2009

2- **Aluminum frames:** aluminum is a strong material, it can be easily shaped and joined, aluminum is a bad thermal insulator it conducts heat and cold very rapidly, unless it contains a thermal break made of plastic or synthetic rubber. One of the disadvantages of using aluminum frames without thermal break is the form of condensation or frost in very cold weathers. Aluminum frames are considered more expensive than wooden frames, but more durable.

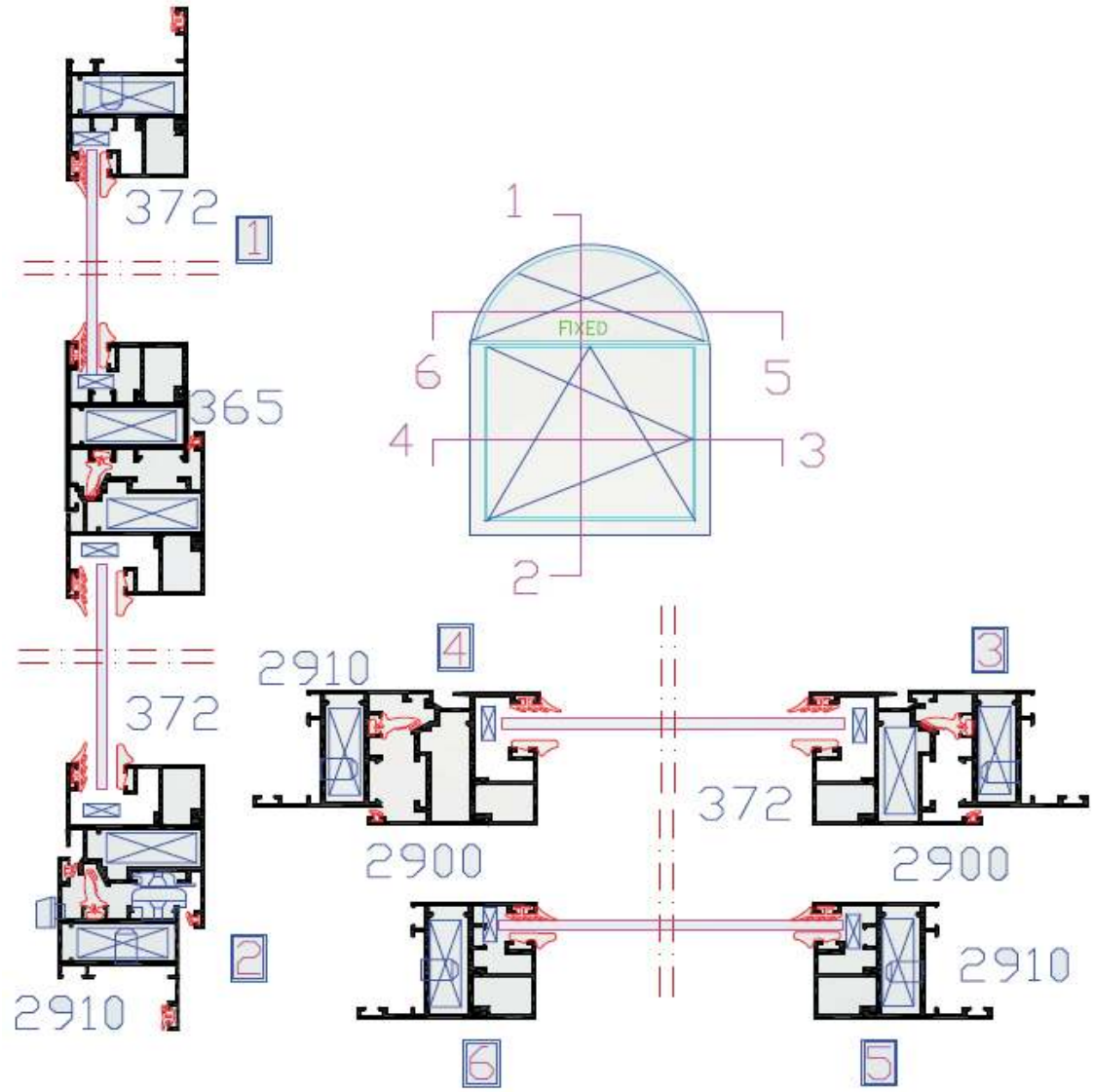
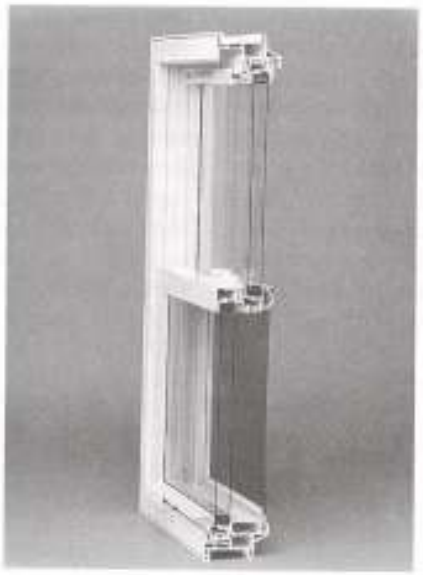


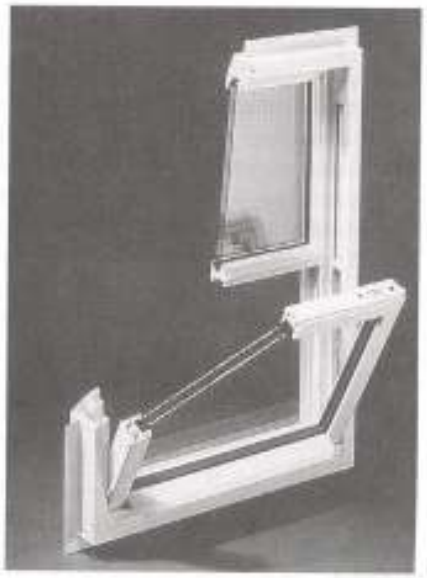
Figure (75): Aluminum window frame without thermal break,

Source: - NAPCO catalog, 2011.

Figure (76) Samples of Aluminum window frame with thermal break, presented at Buildex exhibition, which held between 18t-20 October 2011 in Ramallah, product by NAPCO. Photo by: the author, 2011.



Cutaway sample of a plastic double-hung window with double glazing and an external half-screen. *(Courtesy of Vinyl Building Products, Inc.)*



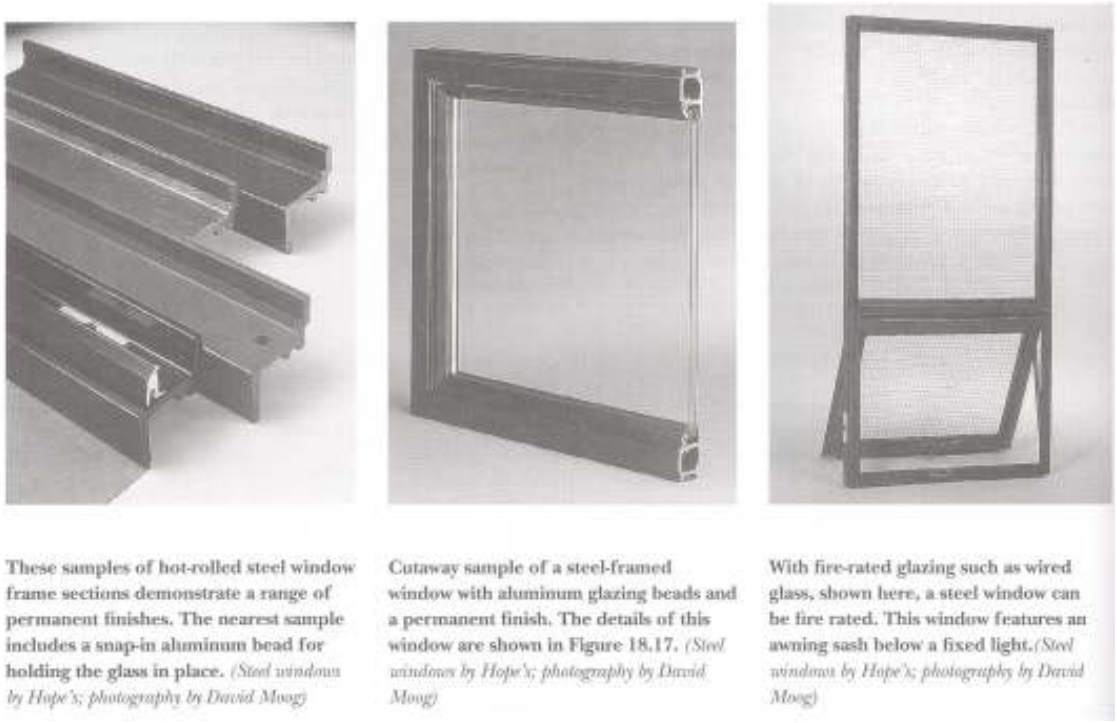
For ease of washing the exterior surfaces of the glass, the sashes of this plastic window can be unlocked from the frame and tilted inward. *(Courtesy of Vinyl*

Figure (77): Plastic windows

Source: - Edward Allen and Joseph Iano, fundamentals of building construction, material and methods,2009.

3-Plastic frames: this type of frames made from plastic (polyvinyl chloride (PVC, vinyl)) and glass-fiber forced plastic (GFRP) (fiber glass windows. These types are new in windows market, it is a very good thermal insulator and for more effective insulating properties foam insulation can be injected into the frame, it is durable, but not strong as aluminum and woo. This type of windows is not desired in Palestinian market due to its poor fire resistance.

4- **Steel frames:** Steel is a strong material, so window frames made of steel could be made slender than wooden or aluminum frames, steel needs to be coated to give a good appearance and to be protected from the weather, it is less conductor than aluminum.



These samples of hot-rolled steel window frame sections demonstrate a range of permanent finishes. The nearest sample includes a snap-in aluminum bead for holding the glass in place. *(Steel windows by Hope's; photography by David Moog)*

Cutaway sample of a steel-framed window with aluminum glazing beads and a permanent finish. The details of this window are shown in Figure 18.17. *(Steel windows by Hope's; photography by David Moog)*

With fire-rated glazing such as wired glass, shown here, a steel window can be fire rated. This window features an awning sash below a fixed light. *(Steel windows by Hope's; photography by David Moog)*

Figure (78): Steel windows.

Source: Edward Allen and Joseph Iano, fundamentals of building construction, material and methods, 2009.

5.4.3 Installing Windows

One of the most common problems of windows are air and water leakage, so when installing windows special care must be taken to insure that no leakage will occur. Masonry opining edges should be cleaned and flushed, after that it must be covered by a layer of asphalt saturated felt.

Another material also can be used and give more pleasant effects which is adhesive-backed window flashing, such as rubberized asphalt, metal flashing which is corrosion resistant also can be used.

Anchoring and fixing windows can be done by several ways, such as nailing and powder driven fasteners.[1]

[1] Edward Allen and Joseph Iano, 2009 , p710-724

5.4.4 Susatainability Considerations for Metal Panel Curtain Walls

Openings in walls considered one of the most critical parts regarding sustainability. A special care must be given when treating these parts, and when selecting materials for curtain walls and windows, the selection of glass type for these parts must support and achieve sustainability criteria regarding maintaining a suitable environment and temperature inside the building, such as double glass with low conductivity gas fill and low e coating and tinted glass and reflected glass.

Manufacturing of glass also needs to be taken into consideration, since there is no any glass factory in the West Bank, importing the glass puts extra financial loads on any project cost.

Regarding window frames and curtain wall frames and structures, the insulation matter also must be considered, through the use of low thermal conductivity materials and the use of aluminum or other metal frames with thermal brakes see table(8).

Table (8): U- value for different materials used for windows.

	Overall U-Factor[a]		
Window Frame	**Single-Glazed**	**Double-Glazed, Clear**	**Double-Glazed, Low-e, Argon Gas**
Aluminum, without thermal break	1.2 *6.8*	0.76 *4.3*	0.60 *3.4*
Thermal break aluminum	1.0 *5.7*	0.63 *3.6*	0.48 *2.7*
Steel	0.92 *5.2*	0.55 *3.1*	0.41 *32.3*
Wood, clad wood, vinyl	0.84 *4.8*	0.49 *2.8*	0.35 *2.0*
GFRP	0.65 *3.7*	0.44 *2.5*	0.27 *1.5*

[a]U-factor: Btu/ft^2-hr-°F followed by W/m^2-°K.

Source: Edward Allen and Joseph Iano, fundamentals of building construction, material and methods, 2009.

5.5 Pioneer Study Of Contemporary External Wall Construction Systems.

In order to provide a better understanding of external wall construction systems regarding sustainability and thermal insulation properties, a computer simulation experiment was carried out to compute the monthly heating and cooling loads for a typical plan of a residential apartment with an area of 131.4 m², using TRANSYS program[1]. See figure (79) for the apartment plan.

A different system has been used for the exterior walls of this apartment every time.

The general parameters for the test were as follows:

- Humidity 50%.
- Air speed 0.5 m/s.
- Air change 2 units/hour.
- Efficiency of heating and cooling 95%.
- Cooling starts when the temperature inside the apartment roses more than 26□.

[1] TRNSYS (pronounced 'tran-sis') is an extremely flexible graphically based software environment used to simulate the behavior of transient systems. While the vast majority of simulations are focused on assessing the performance of thermal and electrical energy systems, TRNSYS can equally well be used to model other dynamic systems such as traffic flow, or biological processes.

- Heating starts when the temperature inside the apartment decreases under 18□.

- Occupant density 0.1 person/m2

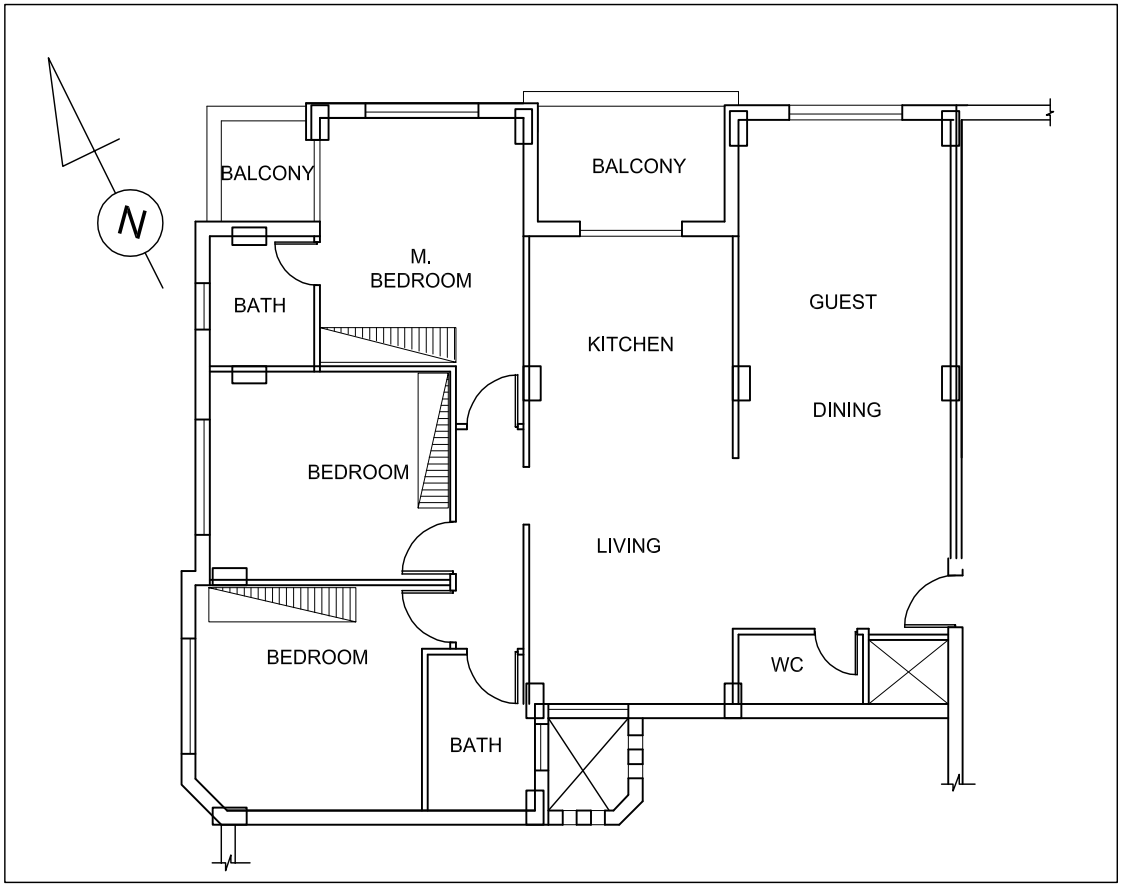
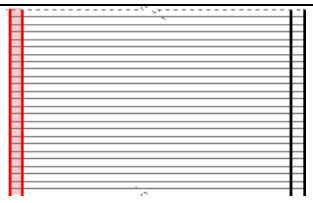
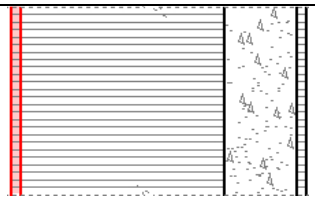
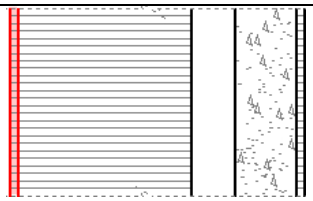
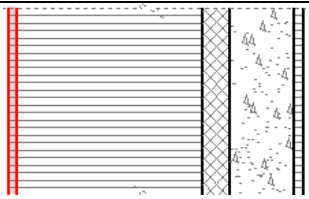
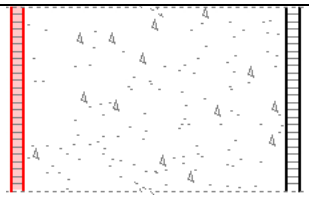
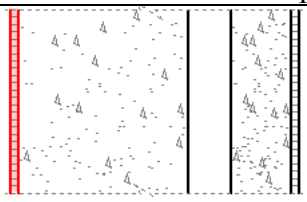
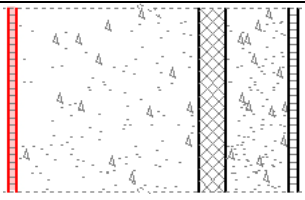


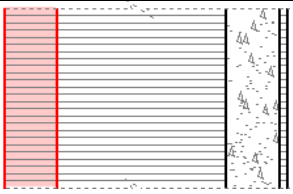
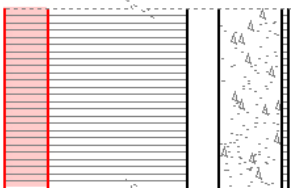
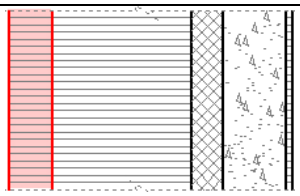
Figure (79): Typical apartment plan.

Source: Mass engineering office- Rammallah , 2011.

Table (10) shows the heating and cooling loads for the apartment which contains two thermal zones one for the living room, guest room, dining and kitchen and one for the rest of the apartment.

Table(9): Wall types, sections and materials

Wall Material	Type
Concrete	Type1  plaster, concrete, plaster
	Type2  plaster, concrete, hollow concrete block, plaster
	Type3  plaster, concrete, air gap, hollow concrete block, plaster
	Type4  plaster, concrete, polyurethane, hollow concrete block, plaster
Block	Type1  plaster, hollow concrete Block, plaster
	Type2  plaster, hollow con. Block, air gap, hollow concrete block
	Type3  plaster, hollow con. Block, polyurethane, hollow concrete Block, plaster

Stone	Type1  Natural Stone, concrete, hollow concrete block , plaster
	Type2  Natural Stone, concrete, air gap, hollow concrete block, plaster
	Type3  Natural Stone, concrete, polyurethane, hollow concrete block, plaster

Source: the author,2011.

Table(10): Heating and cooling loads for different wall types

Material	type	Total Heating PER M²(KWH)			Total Cooling PER M²(KWH)			Total H&C PER M² (KWH)		
		single G	*double G*	*argon F.D.G*	*single G*	*double G*	*argon F.D.G*	*single G*	*double G*	*argon F.D.G*
concrete	Type1	**158.7**	**150**	**149.3**	**13.76**	**12.06**	**12.42**	**172.46**	**162.06**	**161.72**
	Type2	**135.9**	**122.5**	**121.6**	**10.6**	**8.082**	**8.585**	**146.5**	**130.582**	**130.185**
	Type3	**113.8**	**101.2**	**100.2**	**9.212**	**7.146**	**7.724**	**123.012**	**108.346**	**107.924**
	Type4	**64.86**	**47.12**	**46.18**	**10.14**	**7.54**	**8.269**	**75**	**54.66**	**54.449**
block	Type1	**131.6**	**120.6**	**119.6**	**12.62**	**10.47**	**11.04**	**144.22**	**131.07**	**130.64**
	Type2	**104.8**	**87.48**	**86.59**	**9.994**	**7.219**	**7.727**	**114.794**	**94.699**	**94.317**
	Type3	**65.99**	**44.87**	**43.74**	**10.89**	**7.507**	**8.439**	**76.88**	**52.377**	**52.179**
Stone	Type1	**124.4**	**109.8**	**108.8**	**10.19**	**7.551**	**8.101**	**134.59**	**117.351**	**116.901**
	Type2	**105.8**	**88.05**	**86.91**	**9.771**	**6.864**	**7.492**	**115.571**	**94.914**	**94.402**
	Type3	**66.29**	**45.07**	**43.93**	**10.91**	**7.471**	**8.399**	**77.2**	**52.541**	**52.329**

Sorce: TRANSYS calculations, by the auther.

A simple comparison between the heating and cooling loads for the various types of the same wall will provide us with a better understanding of the effect of using different types of insulation.

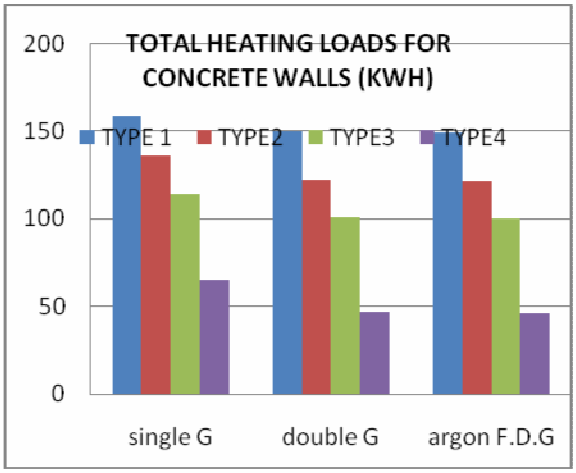


Chart (1): Source: the author

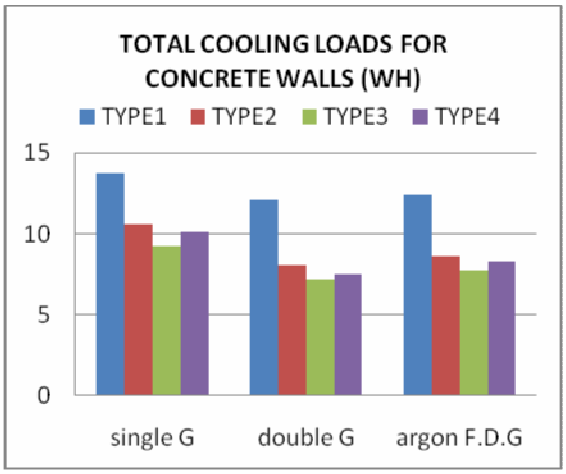


Chart (2)Source: the author

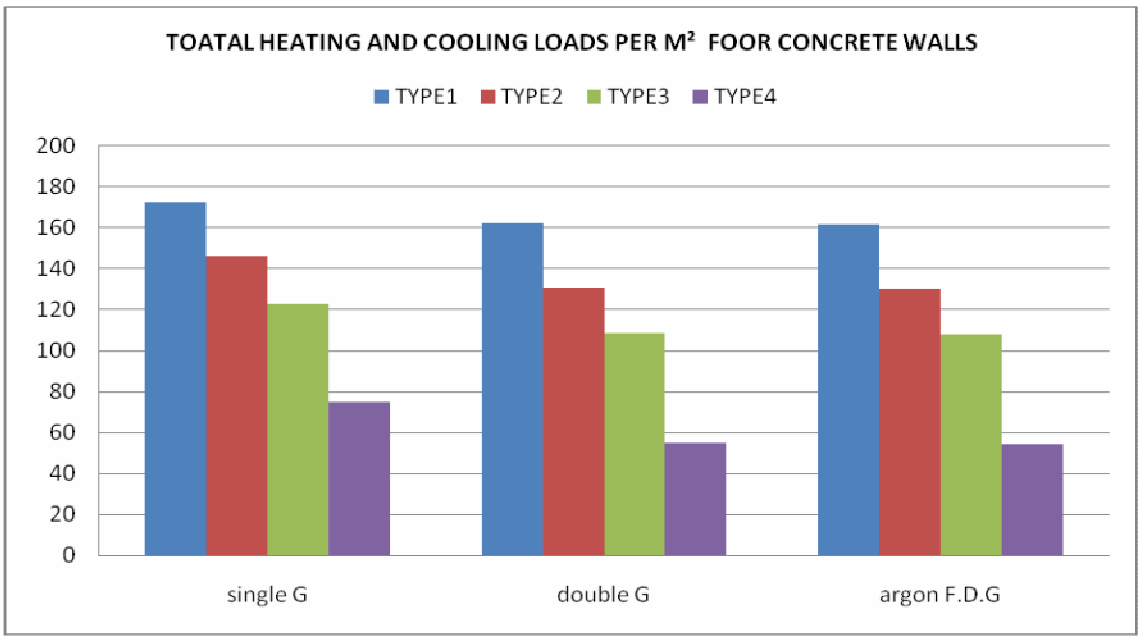


Chart (3): Source: the author

5.5.1 Comparing Concrete Wall Types

1- Heating

Chart (1) shows that (type one) concrete wall without insulation has the highest heating loads value while (type four) concrete wall insulated with polyurethane has the lowest, where the heating loads value dropped by 59%.

The heating loads value could be decreased by 27% when using double glass and 29% when using argon filled double glass instead of single glass windows.

2- Cooling

Chart (2) also shows that (type one) has the higher cooling loads value while (type three) has the lowest, where the cooling loads dropped by 32%.

The coaling loads value could be decreased by 19% when using double glass and 18% when using argon filled double glass.

3- Heating and cooling

Chart (3) shows that (type one) has the highest heating and cooling loads value while (type four) has the lowest, where the total heating and cooling loads per m^2 dropped by around 54%.

Heating and cooling loads value could be decreased by 27% when using double or argon filled double glass.

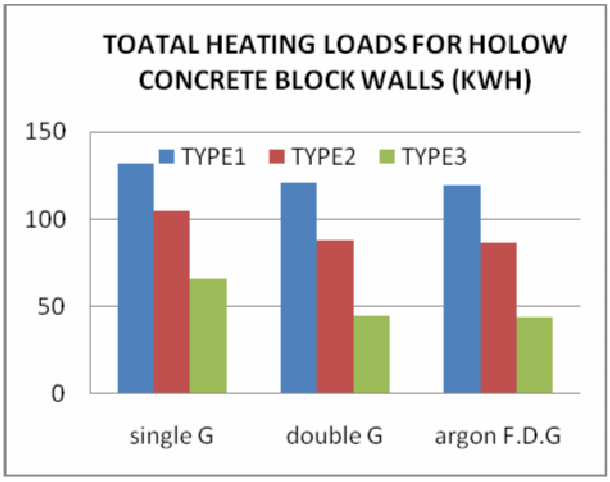


Chart (4): Source: the author

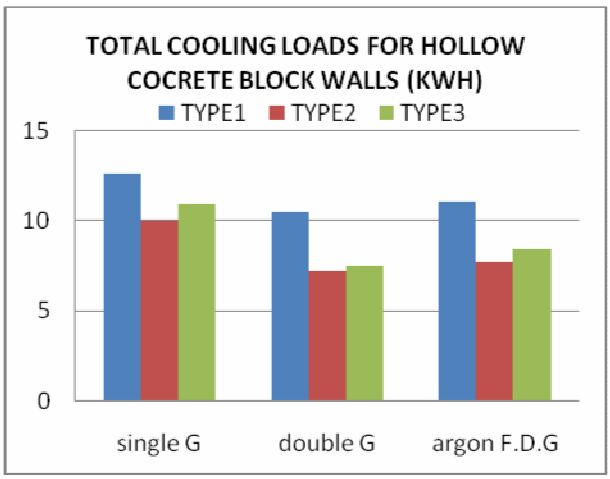


Chart (5): Source: the author

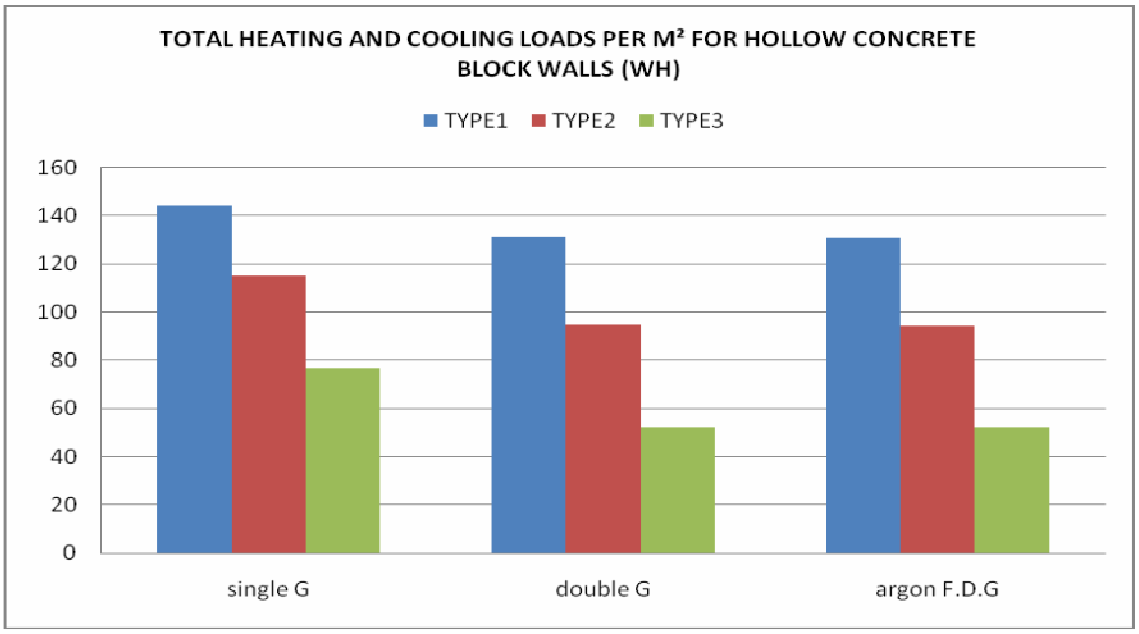


Chart (6): Source: the author

5.5.2 Comparing Hollow Concrete Block Wall Types

1- Heating

Chart (4) shows that (type one) hollow concrete block without insulation has the highest heating loads value while (type three) hollow concrete block wall insulated with polyurethane has the lowest, where the heating loads value dropped by 50%.

The heating loads value could be decreased by 32% when using double glass and 33% when using argon filled double glass instead of single glass windows.

2- Cooling

Chart (5) also shows that (type one) has the higher cooling loads value while (type two) hollow concrete block wall insulated with air gap has the lowest, where the cooling loads dropped by 21%.

The coaling loads value could be decreased by 27% when using double glass and 22% when using argon filled double glass.

3- Heating and cooling

Chart (6) shows that (type one) has the highest heating and cooling loads value while (type three) has the lowest, where the total heating and cooling loads per m^2 dropped by around 46%.

Heating and cooling loads value could be decreased by 31% when using double or argon filled double glass.

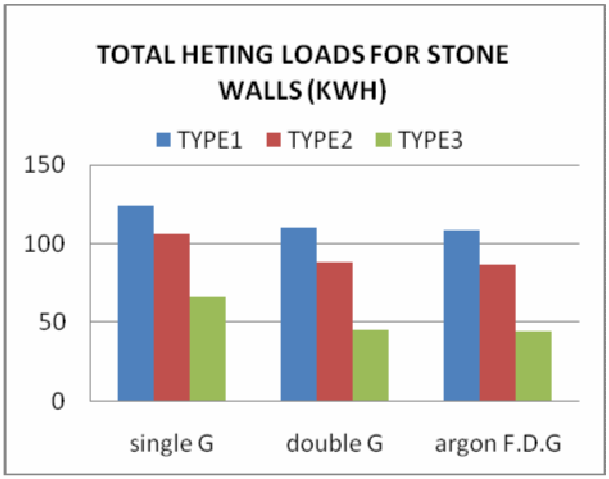


Chart (7): Source: the author

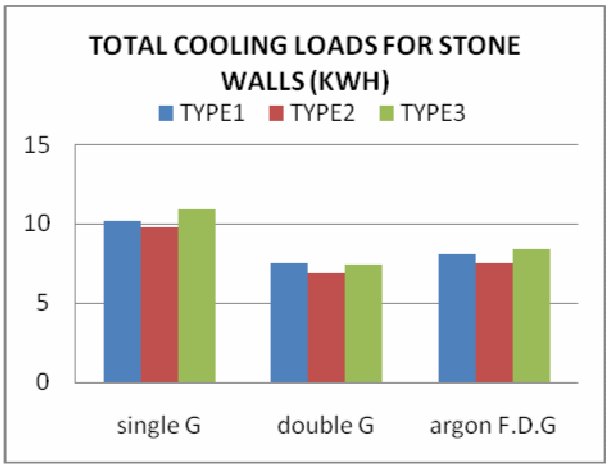


Chart (8): Source: the author

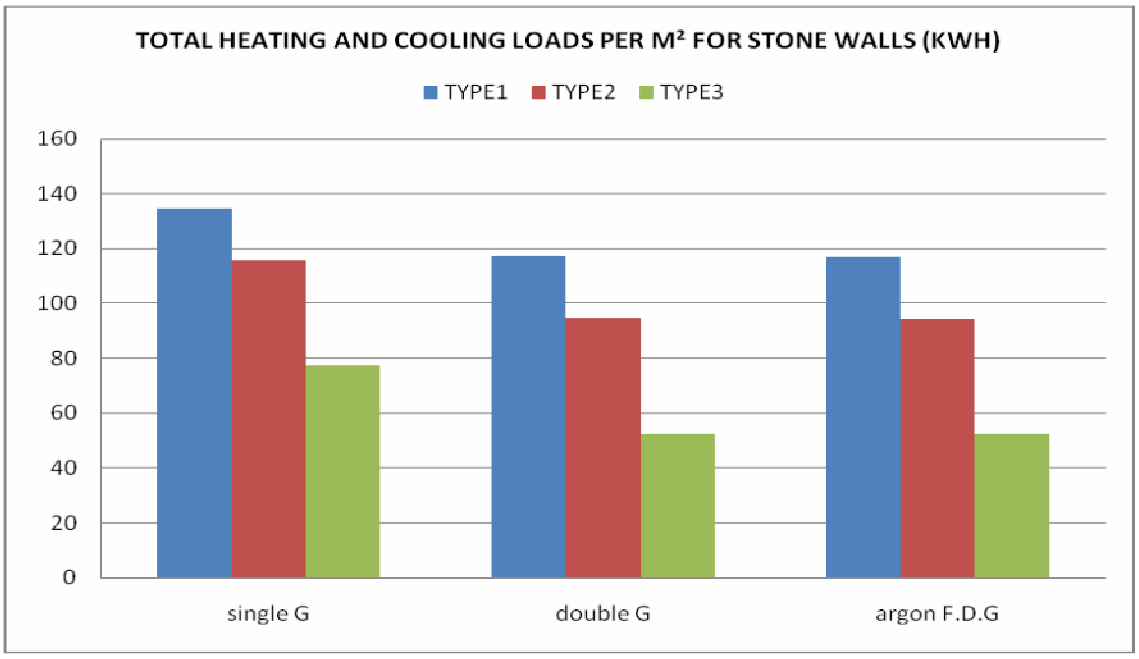


Chart (9): Source: the author

5.5.3 Comparing Stone Wall Types

1- Heating

Chart (7) shows that (type one) stone wall without insulation has the highest heating loads value while (type three) stone wall with polyurethane insulation material has the lowest, where the heating loads value dropped by 46%.

The heating loads value could be decreased by 32% when using double glass and 33% when using argon filled double glass instead of single glass windows.

2- Cooling

Chart (8) shows that (type three) has the highest cooling loads value while (type two) has the lowest, where the cooling loads raised by 7%, when using single glass.

When using double glass (type one) has the highest cooling value while (type two) has the lowest, where it dropped by 9% and when using argon filled double glass it dropped by 8%.

The coaling loads value could be decreased by 25% when using double glass and 19% when using argon filled double glass.

3- Heating and cooling

Chart (9) shows that (type one) has the highest heating and cooling loads value while (type three) has the lowest, where the total heating and cooling loads per m² dropped by around 42%.

Heating and cooling loads value could be decreased by 31% when using double or argon filled double glass.

5.5.4 Key Findings and Conclusions

The following key findings are concluded from the study:

1- The use of air gab as an insulation technique for different walls would decrease the total heating and cooling loads by 14-20%, when using single glass with aluminum frame windows, and 19-33% when using double glass with aluminum frame windows or argon filled double glass with aluminum frame windows, compared to walls with no insulation.

2- The use of insulation material for different walls would decrease the total heating and cooling loads by 42-56% when using single glass with aluminum frame windows, 35-60% when using double glass with aluminum frame windows and 55-66% when using argon filled double glass with aluminum frame windows, compared to walls with no insulation.

3- The difference in total heating and cooling loads between argon filled double glass and normal double glass is very slight about 0.3%

To summarize, People in the West Bank use several construction techniques and building materials, In order to ensure a safe and comfort shelter. In most cases these are employed not in a proper way, without considering their physical and sustainable qualities. To improve comfort satisfaction and minimize the cost of functioning interior spaces, there is a need to employ the sustainable construction approach to external walls and other elements of the building.

Chapter Six

Conclusions and Recommendations

Chapter Six
Conclusions and Recommendations

This chapter is going to provide the key conclusions, regarding, construction process, construction materials, and construction of external walls of building. Recommendations for all parties involved in the construction process also will be provided.

6.1 Conclusions

Having discussed different ways and construction techniques and building materials, in order to achieve sustainable construction, the following conclusions can be drawn:

- **Construction process**

Construction processes is one of the most human actions that consume resources, and affect the environment. Without including these processes into a sustainable approach; the world environmental problems including the West Bank will be uncontrolled, construction materials will be scarce and the quality of life will decrease.

Together the client the contractor, the engineers and the government must assume their responsibilities towards their society, environment and the future generations.

- **Construction materials**

Studying the basic construction materials in the West Bank in depth can provide a number of conclusions:

firstly highlighting the basic construction materials in the west bank and analyzing them using a sustainable approach, will help in finding ways that consolidate its recycling, reuse, and durability, besides minimizing its waste and lowering its emissions and embodied energy.

Secondly the conventional ways of practicing construction of various components and systems of buildings, in the West Bank need to be developed regarding materials durability, resourcing, recycling, reuse and maintenance, besides developing the construction techniques.

Finally without using the proper and sustainable insulation materials for every type of systems and component of buildings, these systems will be exposed to rapid devastation of materials and the increase of energy consumption for heating and cooling purposes.

- **Construction of external walls of buildings**

Developing walls systems and techniques to become more sustainable required applying sustainability criteria, standards and recommendations, on both the construction process of these walls, Consequently the systems and types, to become more thermally efficient, durable and environmentally friendly. Improving walls thermal properties by using the suitable insulation materials could decrease the need for heating and cooling by more than a half and that would conserve energy, lowering the running cost and keep the environment clean.

Moreover the use of sustainable materials and systems could help in solving environmental problems which caused by the wrong practice of construction in the last decades.

Such results will, in no doubt, achieve better quality of life, enhanced biodiversity, preserved natural resources, protected environment, and reduced running costs.

6.2 Recommendations

The following are key recommendations that will help in making construction process in general, and the construction of external walls in particular more sustainable. Such recommendations can be classified into four categories recommendations for public, local governments, research institutes, and contractors and engineering offices:

6.2.1 On The Level Of The Bublic

- **Raising awareness regarding sustainability and sustainable construction**

One of the most effective actions that help in implementing sustainability and sustainable development is introducing the concept of sustainability to people in all age levels and showing the benefits of sustainability and that could be by using media workshops and school curriculum.

6.2.2 On The Level Of Contractors, Manufacturers And Engineering Offices

- **Encouraging the use of sustainable materials**

Materials that support sustainability must be encouraged to be used for building maintenance and alterations, the use of raw materials should be reduced, loss of materials should also be reduced, recycling and maintenance of materials should be encouraged.

- **Adopting responsible practice of sustainable construction**

Governments should introduce support and facilities for contracting and engineering companies and offices that consider sustainability in their construction practice. This would encourage other contractors and offices to follow a sustainable construction practice to obtain facilities and certificates of qualities.

- **Encouraging the use of insulation materials**

Insulation materials for external walls, roofs and floors must encouraged to be used; the correct use of these materials consolidates sustainability in all levels. All types of external walls must be carefully insulated; insulation would help in reducing conditioning costs and burning of fossil fuel, and it would make these walls more durable.

- **Encouraging the use of steel construction**

Since steel construction consider environmentally friendly, as it can be reused recycled, and it is durable, efficient and produce less waste, steel construction is encouraged to be used for sustainable projects.

- **Developing the use of metal panel curtain walls**

Metal panel curtain walls could improve the thermal characteristics of external walls, so it must be used as a vital integrated part of external walls and not just for decoration purposes.

- **Encouraging the use of insulated aluminum frames with thermal break**

Aluminum frames that contain thermal break are highly recommended for sustainable projects, it could help in reducing heat loss and gain, and it could control and prevent from condensation.

6.2.3 On the Level of Research Institutes

- **Learning from old traditional buildings and materials**

Since traditional buildings and materials have proven to be a very good example of sustainable buildings, learning from these building materials and techniques could be through more researches on these buildings. Such researches could study the traditional construction techniques, and determine the ability to improve them and produce better modern construction techniques.

- **Supporting more research that consolidate sustainability of basic construction materials**

More researches that consolidate sustainability of basic construction materials must be carried out. A good example of these researches was carried out and proven that the use of "zebar" of an amount not less than 30% of mixing water will increase the strength of concrete up to 30-35%, and permeability by 5%, consequently this would increase its sustainability.

- **Supporting natural building stone industry**

Natural building stone have proven that it is a very good and sustainable material; it is strong, hard, durable and plentiful. Researches must be carried out on the building stone regarding its manufacturing and finishing ways. Such researches could improve the manufacturing ways and help in lowering the costs and burning of fossil fuel for manufacturing process.

6.2.4 On The Level Of Local Government

- **Adopting sustainable policies by local government**

Stringent and appropriate policies that support sustainable construction should be developed and adopted by local governments, and that required educating all parties involved about green project. Contractors, engineers, owners, and local government employees must be educated about the sustainable projects, and the benefits that could be gained from these projects for the environment and the owner.

- **Adopting Agenda 21 for sustainable construction in the developing countries**

This is a leading Agenda focuses on sustainability involvement on the built environment, including construction processes as the main action of creating the physical environment and human settlements; the author recommended to take into account this Agenda by the local governments.

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Appendixes

Appendix 1

Definitions

- *Global warming*: when the greenhouse gases in the atmosphere, reaches a very high levels, it raise the earth radiations to a very high temperature, casing a rising in sea level, expansion of deserts, and changes in rainfall.

- *Pollution:* when the exhausts of burning fossil fuel spread in the atmosphere, or when chemical and toxic materials reaches the land and water they become polluted.

- *Ozone depletion:* when chlorofluorocarbons and other substances spread in the atmosphere the case a depletion and damage to the ozone shell or layer, the ozone layer prevent from the ultraviolet radiations passage to the earth atmosphere, this ultraviolet radiations are harmful for human health

- *Resources:* some resources especially non-renewable such as natural gas and petrol are at risk and going to an end, the extensive use of renewable resources such as timber, put them also in the at risk list resources.

- *Deforestation:* when converting forests and natural habitats to agricultural or destructive use.

- *Soil degradation:* when construction, urbanization, war , mining, and deforestation invade the land, they ulter the soil structure and cause degradation.

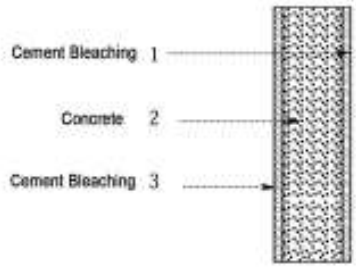
- *Waste:* wastes polluting land earth and water, and produce toxic materials.[1]

If we look at the map below we can see the world energy consumption per capita in 2008, it is obvious that the United States of America, and Saudi Arabia and some parts of developed nations in Europe, consumes the highest rates, over 6 tons of oil per capita, while the developing nations consumes the less.[2]

[1] Paola Sassi, 2006, p5
[2] Solocomhouse, 2010 , www.solocomhouse.com/worldenergy.html ; p1

Appendix 2

Thickness d (m)	Thermal Conductivity k (W/m.K)	Thermal Capacity C (J/kg.K)	Density ρ (kg/m³)	Layer	Section
0.03	1.20	1000	2000	1	
0.20	1.75	1000	2300	2	
0.02	1.20	1000	2000	3	

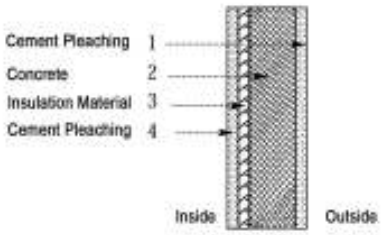


2.81	Protected Area	Thermal Transition (U) W/m.K
2.98	Average exposed area	
3.27	Totally exposed area	
6.81	Time lags (Φ) hour	
0.35	decrease factor (μ)	

Section in a non-isolated concrete wall

Non- insulated concrete wall.
Source: Ministry of local government, Guidelines for energy efficient building design,2004.

Thickness d (m)						Ther. Conductivity (W/m.K)	Thermal Capacity C (J/kg.K)	ρ Density (kg/m³)	Layer	Section
	0.02	0.02	0.02	0.02	0.02	1.20	1000	2000	1	
	0.20	0.20	0.20	0.20	0.20	1.75	1000	2300	2	
	0.05	0.04	0.03	0.02	0.01	0.04	1000	140	3	
	0.03	0.03	0.03	0.03	0.03	1.20	1000	2000	4	



	0.62	0.74	0.90	1.17	1.65	Protected Area
	0.63	0.75	0.92	1.20	1.71	Average exposed area
	0.64	0.77	0.95	1.24	1.80	totally exposed area
	11.73	11.40	11.00	10.41	9.30	Time lags (Φ) Hour
	0.07	0.09	0.11	0.16	0.24	Decrease Factor (μ)

Thermal transmittance (U) W/m.K

Isolated Concrete Wall

Insulated concrete wall.
Source: Ministry of local government, Guidelines for energy efficient building design, 2004.

Thickness d (m)						Ther. Conductivity (W/m.K)	Thermal Capacity C (J/kg.K)	ρ Density (kg/m³)	Layer	Section
	0.02	0.02	0.02	0.02	0.02	1.20	1000	2000	1	Cement Bleaching 1
	0.20	0.20	0.20	0.20	0.20	0.90	1000	1400	2	Hollow concrete block 2
	0.05	0.04	0.03	0.02	0.01	0.04	1000	140	3	Thermal insulation 3
	0.03	0.03	0.03	0.03	0.03	1.20	1000	2000	4	Cement Bleaching 4
										Inside Outside
	0.58	0.68	0.82	1.04	1.40	Protected Area		Thermal transmittance (U) W/m.K		Hollow concrete Block wall isolated from the inside
	0.59	0.69	0.84	1.06	1.44	Average exposed area				
	0.60	0.71	0.86	1.09	1.51	totally exposed area				
	11.90	11.58	11.14	10.55	9.50	Time lags (Φ) hour				
	0.07	0.08	0.10	0.14	0.20	Decrease Factor (μ)				

Hollow concrete block insulated from the inside
Source: Ministry of local government, Guidelines for energy efficient building design, 2004

Thickness d (m)	Thermal Conductivity k (W/m.K)	Thermal Capacity C (J/kg.K)	Density ρ (kg/m³)	Layer	Section
0.03	1.20	1000	2000	1	Cement Bleaching 1
0.10	0.90	1000	1400	2	Hollow concrete block 2
0.05	0.00	0.00	0.00	3	Cavity 3
0.10	0.90	1000	1400	4	Hollow concrete block 4
0.02	1.02	1000	2000	5	Cement Bleaching 5
1.53	Protected Area		Thermal Transition (U) W/m.K		Cavity concrete block wall
1.58	Avarage exposed area				
1.66	Totally exposed area				
10.06	Time lags (Φ) hour				
0.13	decrease factor (μ)				

Cavity concrete block wall
Source: Ministry of local government, Guidelines for energy efficient building design,2004.

Thickness d (m)	Thermal Conductivity k (W/m.K)	Thermal Capacity C (J/kg.K)	Density ρ (kg/m³)	Layer	Section
0.07	1.70	1000	2250	1	
0.20	1.75	1000	2300	2	
0.03	1.20	1000	2000	3	

Natural Building Stone 1
Plain Concrete 2
Cement Bleaching 3

2.63	Protected Area	Thermal Transition (U) W/m.K
2.77	Avarage exposed area	
3.03	Totally exposed area	
7.97	Time lags (Φ) hour	
0.26	decrease factor (μ)	

Section in a non-isolated stone wall

non-insulated stone wall
Source: Ministry of local government, Guidelines for energy efficient building design, 2004.

Thickness d (m)						Ther. Conductivity (W/m.K)	Thermal Capacity C (J/kg.K)	ρ Density (kg/m³)	Layer	Section
0.07	0.07	0.07	0.07	0.07	0.07	1.70	1000	2250	1	
0.20	0.20	0.20	0.20	0.20	0.20	1.75	1000	2300	2	
0.04	0.03	0.03	0.02	0.01		0.04	1000	140	3	
0.03	0.03	0.03	0.03	0.03	0.03	1.20	1000	2000	4	

Natural building stone 1
concrete 2
insolation material 3
Natural building stone 4

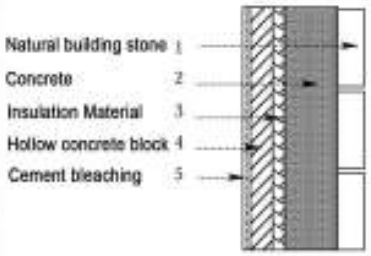
0.61	0.72	0.88	1.14	1.59	Protected Area	Thermal transmittance (U) W/m.K
0.62	0.74	0.90	1.16	1.64	Average exposed area	
0.63	0.75	0.93	1.20	1.72	totally exposed area	
12.93	12.60	12.20	11.61	10.49	Time lags (Φ) horr	
0.05	0.06	0.08	0.11	0.17	Decrease Factor (μ)	

Section in an insulated stone wall

Insulated stone wall
Source: Ministry of local government, Guidelines for energy efficient building design, 2004.

Thickness d (m)						Ther. Cconductity (W/m.K)	Thermal Capacity C (J/kg.K)	ρ Density (kg/m³)	Layer
0.07	0.07	0.07	0.07	0.07	0.07	1.70	1000	2250	1
0.20	0.20	0.20	0.20	0.20	0.20	1.75	1000	2300	2
0.05	0.04	0.03	0.05	0.04	0.03	0.04	1000	140	3
0.10	0.10	0.10	0.07	0.07	0.07	0.90	1000	1400	4
0.03	0.03	0.03	0.03	0.03	0.03	1.20	1000	2000	5
0.57	0.67	0.81	0.59	0.69	0.83	Protected Area		Thermal transmittance (U) W/m.K	
0.58	0.68	0.82	0.59	0.70	0.84	Average exposed area			
0.59	0.69	0.84	0.60	0.71	0.86	totally exposed area			
14.63	14.40	14.15	14.05	13.81	13.54	Time lags (Φ) horr			
0.02	0.02	0.02	0.02	0.02	0.03	Decrease Factor (μ)			

Section

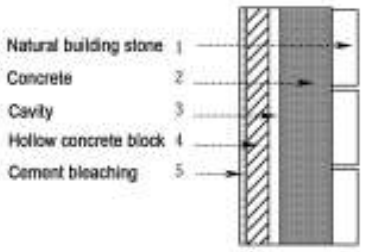


Section in an insulated wall with hollow concrete block

stone wall insulated with hollow concrete block
Source: Ministry of local government, Guidelines for energy efficient building design, 2004.

Thickness d (m)						Ther. Cconductity (W/m.K)	Thermal Capacity C (J/kg.K)	ρ Density (kg/m³)	Layer
				0.07	0.07	1.70	1000	2250	1
				0.20	0.20	1.75	1000	2300	2
				0.05	0.05	0.28	1000	1.25	3
				0.10	0.07	0.90	1000	1400	4
				0.03	0.03	1.20	1000	2000	5
				1.49	1.57	Protected Area		Thermal transmittance (U) W/m.K	
				1.53	1.62	Average exposed area			
				1.61	1.70	totally exposed area			
				12.92	12.16	Time lags (Φ) horr			
				0.07	0.09	Decrease Factor (μ)			

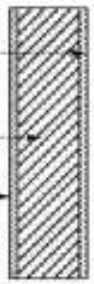
Section



Section in a cavity stone wall

cavity stone wall
Source: Ministry of local government, Guidelines for energy efficient building design, 2004.

Thickness d (m)	Thermal Conductivity k (W/m.K)	Thermal Capacity C (J/kg.K)	Density ρ (kg/m³)	Layer	Section
0.03	1.20	1000	2000	1	Cement Bleaching 1
0.20	0.90	1000	1400	2	Hollow concrete block 2
0.02	1.20	1000	2000	3	Cement Bleaching 3
2.16	Protected Area		Thermal Transition (U) W/m.K		
2.25	Avarage exposed area				
2.42	Totally exposed area				
7.36	Time lags (Φ) hour				
0.29	decrease factor (μ)				



Hollow concrete block non- isolated walle

Hollow concrete block non-insulated wall
Source: Ministry of local government, Guidelines for energy efficient building design, 2004.

جامعة النجاح الوطنية
كلية الدراسات العليا

نحو أنظمة إنشاء مستدامة لجدران المباني الخارجية في الضفة الغربية من فلسطين

إعداد
وسيم رضا احمد سلامة

إشراف
د. محمد عطا يوسف

قدمت هذه الأطروحة استكمالا لمتطلبات الحصول على درجة الماجستير في الهندسة المعمارية بكلية الدراسات العليا في جامعة النجاح الوطنية في نابلس، فلسطين.

2012م

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الملخص

يعتبر الإنشاء المستدام احد أكثر المظاهر التي لاقت اهتماما واسعا في مختلف بلدان العالم، وحيث أن هذا القطاع هو من اكبر القطاعات التي تساهم في بناء المجتمعات على الإطلاق، فان له تأثيراً لا يمكن إهماله على البيئة والمجتمع، ولا يقتصر هذا التأثير على البيئة خلال مرحلة الإنشاء والبناء فقط وإنما يتعداها لما بعد ذلك، وخاصة خلال تشغيل هذه المباني والمنشآت.

وفي العقود الأخيرة أصبح السكان يشعرون بعدم الارتياح داخل مبانيهم ومنشآتهم ويعود ذلك إلى عده عوامل منها ارتفاع درجة حرارة الأرض بما يعرف بظاهرة الاحتباس الحراري، واستخدام المواد الحديثة في عملية الإنشاء، مما اضطرهم إلى استخدام أنظمة التبريد والتدفئة، والتي بدورها زادت من كلفة تشغيل المباني والمنشآت وزادت من استهلاك الطاقة أيضاً.

هذه الدراسة تبحث في كيفية الحصول على أنظمة جدران خارجية مستدامة للمباني، كون الجدران الخارجية احد أهم المكونات لغلاف المبنى وهي على اتصال مباشر مع البيئة. مثل هذه الدراسة سيكون لها اثر ايجابي في العمل على تقليل الآثار السلبية لقطاع الإنشاءات بشكل عام في الضفة الغربية على البيئة، كما أنها ستساعد على تحسين أنظمة الجدران الخارجية وجعلها أكثر فعالية واستدامة مما سيخفف العبء على البيئة.

وقد وصلت هذه الدراسة إلى أهدافها من خلال دراسة وتحليل المواد والمعلومات التي تتعلق باستدامة الإنشاء، وكذلك من خلال إجراء تجربة رائدة حول نظم الإنشاء والمواد التي تشكل الجدران الخارجية للمبنى ومقارنة نتائجها.

وقد خرجت الدراسة بعدد من النتائج والتوصيات التي يجب الاهتمام بها والعمل على تعزيزها بأقرب وقت ممكن ومن هذه النقاط: الحاجة الماسة لتطبيق معايير ومقاييس الاستدامة على قطاع الإنشاءات في الضفة الغربية، وإعادة التفكير بمواد الإنشاء الأساسية كالخرسانة والمواد العازلة والحجر والحديد والألمنيوم من حيث استدامتها، وذلك من اجل رفع كفاءتها وتحسين خصائصها إدارتها التخلص من مخلفاتها، إعادة استخدامها وإعادة تصنيعها، كما وجدت الدراسة أيضا أن استخدام تقنيات العزل في الجدران الخارجية خصوصا وفي باقي العناصر الإنشائية عموما تعمل على تحسن الأجواء داخل المباني وعلى تقليل الحاجة إلى استخدام التدفئة والتبريد بما مقداره 14- 20% في حالة استخدام تقنية فراغ الهواء داخل الجدران الخارجية للمبنى، وما مقداره 22- 56% في عند استخدام مواد العزل الحراري وهذا المقدار الذي يشكل الربع في ادني حالاته، وأكثر من النصف في أفضل حالاته جدير بان يؤخذ بعين الاعتبار عند اختيار نظام ونوع الجدار الخارجي للمبنى أو المنشأ. وان كانت هذه التقنيات مرتفعة التكلفة عند شرائها وتركيبها، فإنها ستعمل على تخفيض النفقات التشغيلية للمبنى بشكل كبير على المدى الطويل لعمر المبنى.

ومن اجل الوصول إلى أنظمة إنشاء مستدامة وأنظمة جدران خارجية للمباني مستدامة أيضا وضعت الدراسة عدد من التوصيات التي تعمل على تحقيق مبادئ الاستدامة في الإنشاء.