# Towards energy security in Gaza Strip

*Exploring passive design strategies in residential buildings*

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# Abstract

Energy crises in the Gaza Strip push interested and concerned parties to start investigating new energy alternatives for energy security. Energy security includes the conservation and reliability of energy supplies to satisfy demands at all times and at good prices, while also avoiding and environmental impact. In light of the political context in the Gaza Strip and in relation to many conditions of energy and electricity supply problems, sustainable energy can play a key role in guaranteeing energy security for the Gaza Strip in the long-term. The availability, affordability and sustainability of an energy supply are interlinked facets of an overall energy security.

The high energy consumption in the buildings sector and the acute shortage of energy sources in the Gaza Strip implies an obstacle to achieving a reasonably comfortable life. Residential buildings in the Gaza Strip come in at the top of buildings that consume the largest share of energy which is estimated at about 70% of the total amount of energy consumed according to the 2009 estimations of the Gaza Electricity Distribution Company. In comparison, in Sweden the building and residential sector consumes around 40% of Sweden's total energy consumption (Swedish Energy Agency, 2013). This consumption of energy is increasing over time as a result of the continued increase in population and housing stock, consequently increasing the use of energy for lighting, electrical appliances, heating, cooling, etc. As a matter of fact, most residential buildings in the Gaza Strip are constructed using concrete hollow blocks in walls and reinforced concrete skeleton structures. This has resulted in buildings that lack acceptable thermal comfort conditions, making such structures too hot in the summer and too cold in the winter.

Moreover the Gaza Strip has a real problem with electricity. The electricity schedule is for 8 by 8 hours. By reducing the residential consumption of energy, we can increase the period for using electricity during the day.

This study aimed to enhance an understanding of energy use in the Gaza Strip towards strategies for energy security with a focus on passive strategies in residential buildings to reduce energy demand through extensive literature study that can be incorporated in residential buildings to make them energy efficient. The study also aimed at identifying changes in the design process that can affect energy efficiency in residential buildings. It has analyzed the design features of typical residential buildings in the Gaza Strip through a case study conducted in the Gaza Strip. It also distinguishes the different roles of owners, residents, architects, government and Israeli occupation that can act as a barrier in achieving energy efficiency in residential buildings.

The results from this study indicate passive design methods suits the Gaza Strip can reduce the cooling and heating load of the case study building and hence reduce the total energy use of the building. In the end the study concludes that the process of designing energy efficient residential buildings is not a one-man's show. Owners, architects, government and the political situation are the other actors who can bring a change in the design practice.

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# Chapter 1: Energy Demand in Building in the Gaza Strip

## 1.1 Energy Shortage

There is a significant shortage in electricity supply to the Gaza Strip. According to the Gaza Electricity Distribution Company-2012, statistics show that the Gaza Strip needs 359 MW of electricity. The available quantity is 222 MW, coming from the Israeli Electricity Company 120 MW (54%), the Gaza Power Plant up to 80 MW (36%), and an Egyptian source of 22 MW (10%). Therefore, the Gaza Strip shortage of electricity is about 38%, assuming that all current sources work up to standard. The matter that has deteriorated the issue of electric energy in the Gaza Strip is the destruction of the Gaza Power Plant in 2006. This should motivate efforts towards looking for acceptable alternatives that can contribute to solving this shortage. Figure 1.1 shows the shortage of electricity is 60% with consideration taken of the absence of any power supply from the Gaza power plant. As depicted in Figure 1.2, electricity demand increases by about 7.5% MW annually, as a result of the natural population growth and the expansion in different sectors requiring electricity supplies (Abu-Jasser, 2012). However, according to the Gaza Electricity Distribution Company 2007 statistics, it is likely to conclude that about 70% of the total electricity consumption in the Gaza Strip comes from the domestic sector (Muhaisen, 2007).

## 1.2 Energy Resources

The Gaza Strip is a high-density populated area with very limited resources, depending on energy suppliers. It suffers from a serious energy problem. This problem has increased over time due to the rapid population growth and unstable political situation that has negatively affected development in the Gaza Strip. Currently, the Gaza Strip depends mainly on fossil fuels to produce electricity from a local generating plant. This is in addition to electricity imported from Israeli and Egyptian electricity companies.

There are no developed domestic resources for commercial energy. Gaza is almost entirely dependent on imported energy supplies, specifically oil products and electricity. Because of logistical and political factors nearly all of these supplies at present come from Israel.

Israeli policies and actions affect the ability of the Palestinian Territory to operate and develop its energy systems independently. Israel aims to keep Palestinians dependent on Israel.

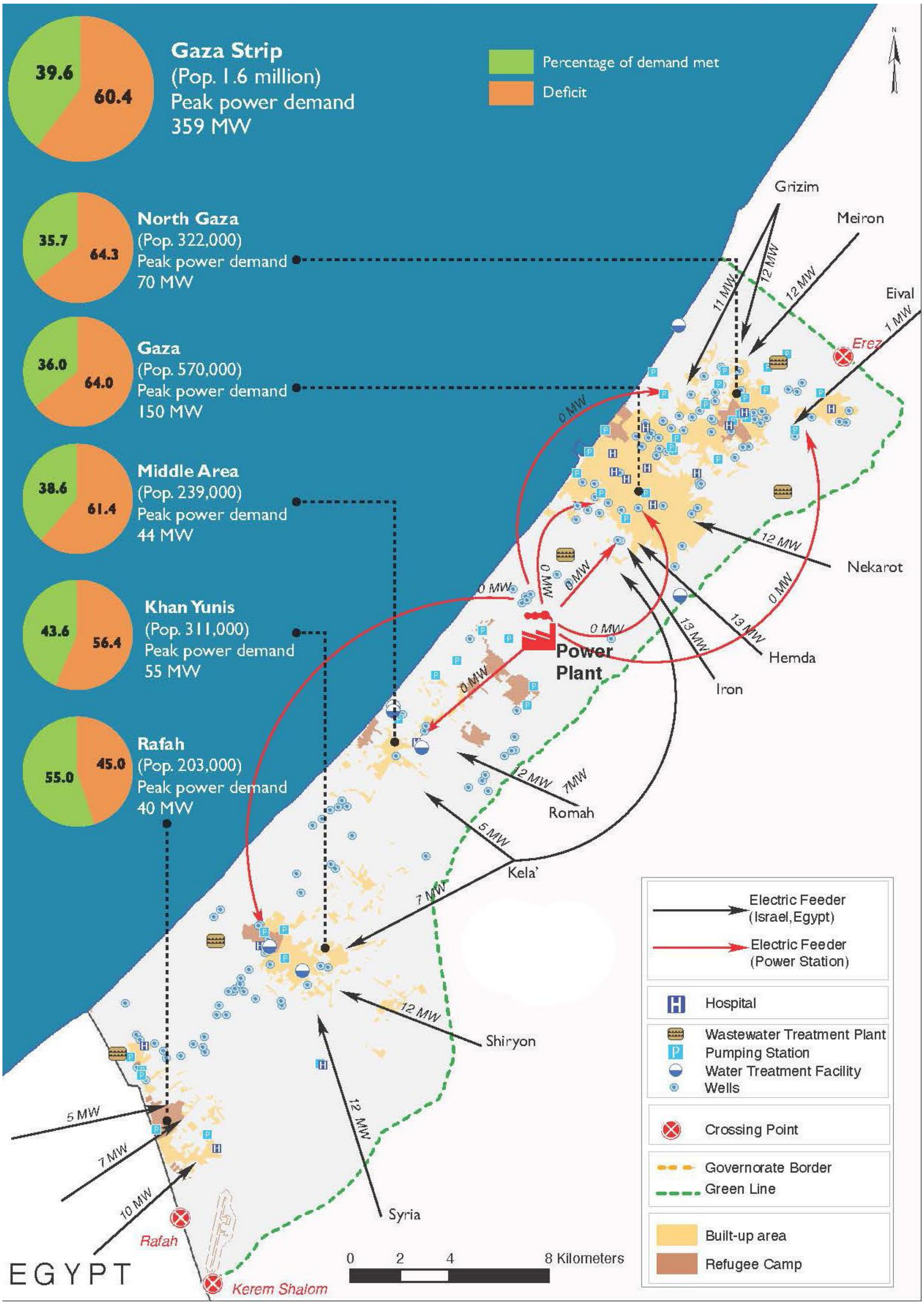



Figure 1.1: Power Defect (Given zero supply from Gaza power plant)
Source: UNITED NATIONS, 2012

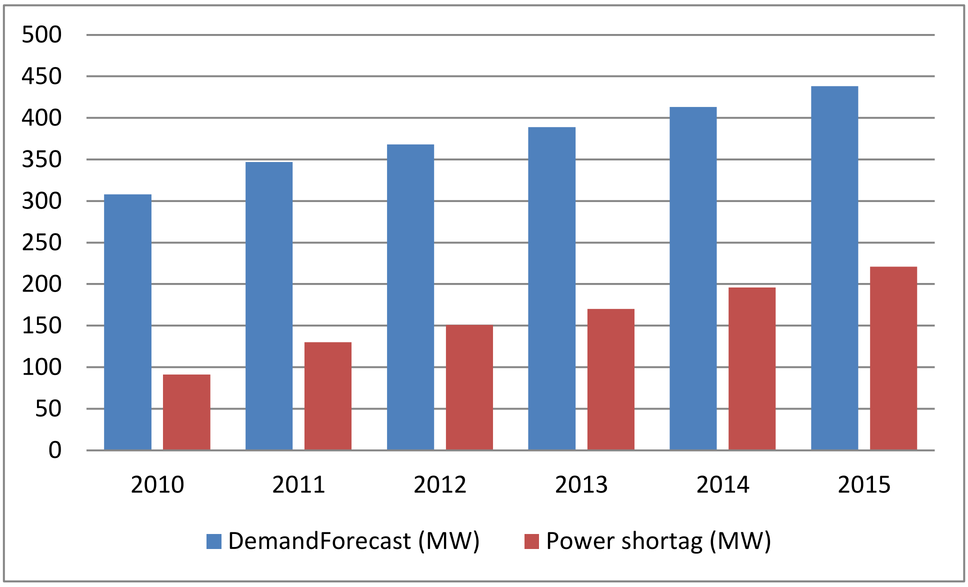



Figure 1.2: Demand and shortage between 2010 and 2015 in Gaza Strip
Source: Abu-Jasser,2012

As for natural gas, two natural gas fields were discovered in the territorial water of the Gaza Strip in 2000 in commercial quantities. One of these fields is entirely within the regional boarders of the Gaza Strip, while 67% of the second field is located within them. Tests made on this discovered gas proved it to be of high quality. However, harvesting this energy source has not been invested in yet due to the unstable political situation, though it still represents a promising potential for the future. As for oil, petroleum products (gas, kerosene, gasoline, diesel, oil and liquefied petroleum gas (LPG)) are imported directly from Israel to the Gaza Strip.

In general the Gaza Strip depends on imported energy from other countries like Israel and Egypt. This imported energy is not enough and irregular as a supply due to political reasons.

## 1.3 Residential Building and Energy Use

The residential sector in Palestine is the primary sector that uses the imported energy as shown in figure (1.3). In 2005 the percentage of energy imports for the residential sector was 64% in the whole of Palestine, while the transportation sector and telecommunications sector came in second with 19%, with the industrial sector at 8% coming in third.

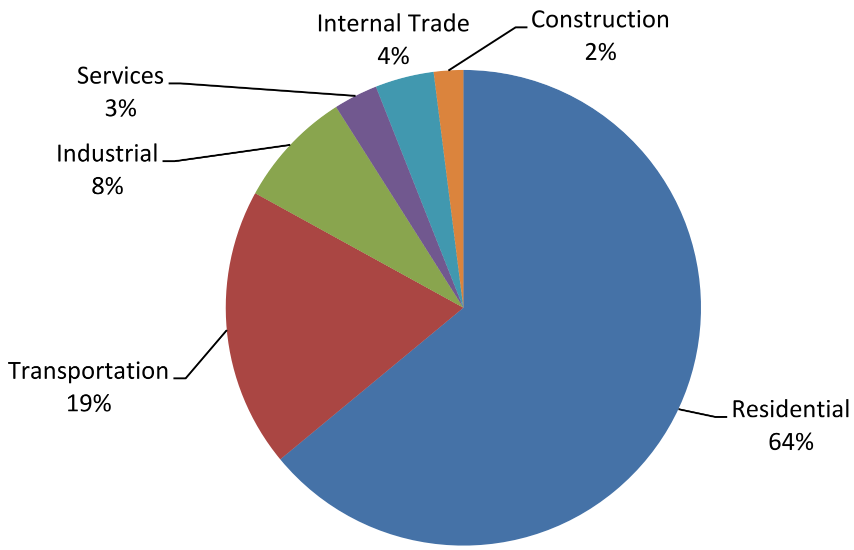



Figure. (1.3) The Percentage Imports of Energy's Derivatives by Sectors in 2005
Source: Palestinian Central Bureau of Statistics

### 1.3.1 Types of Energy Consumption in Residential Buildings

In residential buildings there are many forms of energy consumption such as hot water, space heating and cooling, lighting, cooking, refrigerators, and TVs.

#### *1.3.1.1 Hot water*

There is no quantitative information about the consumption of hot water in residential buildings. In general, electricity, petroleum products, firewood and solar energy are the available sources used for hot water production.

Table (1.1) Percentage of households using different types of fuel to produce hot water,
Source: Palestinian Central Bureau of Statistics, household energy survey 2005 for Palestine

| Index | % |
|---|---|
| The percentage of households using LPG | % 35.0 |
| The percentage of households using solar energy | % 27.8 |
| The percentage of households using electricity | % 25.2 |
| The percentage of households using firewood | % 9.8 |
| The percentage of households using kerosene | % 1.0 |

### *1.3.1.2 Space Heating and Cooling*

Heating and cooling are forms of energy consumption in residential buildings that use different means to achieve their purpose, for example, central air conditioning, fans, and heaters, which rely on different types of fuel such as electricity, gas, kerosene, and firewood. From the following Table 1.3, we can observe the different types of heating facilities used in residential buildings. We can also note that many families used more than one heating facility.

Table (1.2) Percentage of households using heating facilities in Palestinian Territories
Source: Palestinian Central Bureau of Statistics, household energy survey 2005 for Palestine

| Index | % |
|---|---|
| Percentage of households using Electrical Heater | **39.4%** |
| Percentage of households using Gas Heater | **34.7%** |
| Percentage of households using Kerosene Heater | **11.2%** |
| Percentage of households using Wood heater | **35.4%** |
| Percentage of households using Central Heater | **1.6%** |
| Percentage of households using other | **9.4%** |
| Percentage of households not using any heat | **13.3%** |

### *1.3.1.3 Lighting*

Lighting is one of the most important forms of energy consumption in all sectors, especially domestic housing, hospitals, hotels and other public buildings based on the facility of using electricity as a main source of fuel as indicated in the following Table 1.3, which shows the percentage distribution of households in the Palestinian Territories by the main fuel used for lighting by region. It can be said that the reasons for the high reliance on electricity as a main source for lighting has been due to:

- Poor natural lighting in homes and public buildings
- Poor distribution of electric light bulbs when building plans were designed, as well as in the execution phase
- The use of non-efficient lighting systems creating a large consumption and waste of energy

Table (1.3) Percentage distribution of households by the main fuel used for lighting by region
Source: Palestinian Central Bureau of Statistics, household energy survey 2005 for Palestine

| Region | Kerosene | LP | Electricity | Other | None |
|---|---|---|---|---|---|
| **Palestine (in total)** | 0.5 | 0.0 | 99.1 | 0. | 0.3 |
| **West Bank** | 0.4 | 0.1 | 99.1 | 0. | 0.4 |
| **Northern West Bank** | 0.4 | 0.1 | 99.5 | 0. | 0.0 |
| **Middle West Bank** | 0.5 | 0.0 | 98.8 | 0. | 0.6 |
| **Southern West Bank** | 0.1 | 0.1 | 98.9 | 0. | 0.7 |
| **Gaza Strip** | 0.7 | 0.0 | 99.1 | 0. | 0.0 |

### *1.3.1.4 Cooking*

The main fuel adopted in the process of cooking is Liquefied Petroleum Gas (LPG) with different consumption sectors.

Table (1.4) Percentage distribution of households by the main fuel used for cooking by region
Source: PCB, household energy survey 2005 for Palestine

| Region | Electricity | None | Wood | Kerosene | LPG |
|---|---|---|---|---|---|
| **Palestine (in total)** | **0.0** | **0.0** | **2.0** | **0.3** | **97.7** |
| **West Bank** | **0.0** | **0.1** | **2.4** | **0.4** | **97.1** |
| North of West Bank | 0.1 | 0.0 | 0.6 | 0.0 | 99.3 |
| Middle of West | 0.0 | 0.0 | 0.4 | 0.6 | 99.0 |
| South of West Bank | 0.0 | 0.3 | 7.5 | 0.6 | 91.6 |
| **Gaza Strip** | **0.0** | **0.0** | **1.0** | **0.1** | **98.9** |

## 1.4 Study Objectives

The objective of the study is to enhance an understanding of energy use in the Gaza Strip work towards strategies for energy security with a focus on passive strategies in residential buildings to reduce energy demand. The study's secondary aims include:

1. Analyzing the criteria for energy efficiency, resulting in a series of feasible passive design solutions that can make a contribution in the field of architecture, towards the knowledge of developing and designing passive residential buildings.
2. Identifying changes in the design process that can affect energy efficiency in residential buildings.

## 1.5 Previous studies.

Studies done until now have focused on energy security in order to change the energy supply, lower the energy demand, thus proposing different strategies. They all start from the statement that the increasing demand and the simultaneous supply shortages create great insecurity for the population of the Gaza Strip

1- *Guidelines for Energy Efficient Building Design, Ministry of Local Government, 2004*
2- *Capacity Building for the Adoption and Application of Energy Codes for Buildings (Regional Project for Lebanon and Palestinian Territories), 2004*
3- *S4G Solar For Gaza, 2009*
4- *The Energy Problem in the Gaza Strip and its Potential Solution, 2007*
5- *Planning for Solar Energy as an Energy Option for Palestine, 2009*
6- *Energy trends in the Palestinian Territories of the West Bank and Gaza Strip, 2012*
7- *Effect of Building Form on the Thermal Performance of Residential Complexes in the Mediterranean Climate of the Gaza Strip, 2012*
8- *Integration of Photovoltaic into Gaza Strip Residential Buildings, 2013*

**Previous studies point at the possibility to**

- Increase energy security by the application of passive design strategies
- and/or increase energy supply by use of renewable energy technologies

Passive strategies are interesting because they allow for the decrease in energy demand while enhancing the interior comfort and quality of life for inhabitants.

Adopting passive strategies shall be one of the measures used in this paper to reduce the total energy consumption in residential sectors. The amount of purchased energy will be decreased accordingly. The investment costs associated with implementing these strategies and their payback periods are usually low.

Some renewables are already in use. Mainly solar energy is currently used in the residential sector in Solar Water Heaters (SWH). According to Muhaisen (2007) about 70% of residential buildings in the Gaza Strip are integrated with solar water heating systems.

Photovoltaic cells are also starting to be used in the Gaza Strip in some public buildings to cover some needs under the supervision of NGOs, but implementing photovoltaic cells is still not a realistic choice due to:

1- High cost, installation and maintenance for cells
2- Advanced technical requirements in manufacturing, installation and maintenance
3- Neighboring countries are yet to possess such technology, except for Israel
4- Israeli occupation affects life in the Gaza Strip, keeping people non-independent and away from any technology which facilitates independence.

In order to implement passive design strategies it is important to give a description of the climate and the specific built environment that we find in the Gaza Strip. This will be done in the next chapter.

### 1.6 Conclusion

This chapter has discussed the energy consumption in the Gaza Strip and its importance in contemporary life. It has presented in a summarized manner the energy sources of the Gaza Strip. The energy demanded of buildings for heat in the winter, cooling in the summer, water heating, lighting, electronic entertainment, computing, refrigeration, and cooking require significant energy use, about 64% for residential energy use per year. Energy consumption in buildings has overall been increasing over time.

Energy crises in the Gaza Strip push us to start investigating new energy alternatives for energy security. Energy security includes the saving of sufficient and reliable energy supplies to satisfy demand at all times and at good prices, while also avoiding environmental impacts. In light of the political context of the Gaza Strip and in relation to many conditions of energy and electric supply problems, sustainable energy can play a key role in guaranteeing energy security in the long-term. The availability, affordability and sustainability of an energy supply are interlinked facets of an overall energy security.

# **Chapter 2: Background and context** (Built Environment)

## 2.1 Background

Human coexistence with environment for a long time is a proof of human ability to adapt this environment in order to serve interests and improve life conditions. Thus, humans along the history have strived to protect themselves from the outdoor climatic conditions by finding adequate shelter. This traditional shelter provided security and comfort, and was ideal in integrating the building with its context and occupants. It is a result of long experiences and numerous observations of builders in response to the impact of climate. The main lesson that could be learnt from the traditional architecture is any design solutions should be intended to provide comfort to the users with a minimal negative environmental impact. This includes saving energy and protecting eco system.

So this study discusses the different possible means and principles that help improving the idea for low energy buildings. This has been done with reference to the Gaza Strip, which suffers from a severe shortage in energy supply. Thus, several passive design strategies have been presented. The ultimate aim of this trend is to improve human comfort inside the building and to contribute to reduce the negative effects associated with the use of fossil fuels on the environment. This is expected to reduce the reliance on electricity and rationalize of energy consumption.

## 2.2 Study place

The Gaza Strip is located at the south-west area of Palestine. It is a narrow strip that stretches along the south-east corner of the Mediterranean Sea, 40 km long and between 6 and 12 km wide. It locates on Longitude 34° 26' east and Latitude 31° 10' north. The Gaza Strip total area is estimated at 365 km2. Its height above sea level may reach 50 m in some areas.

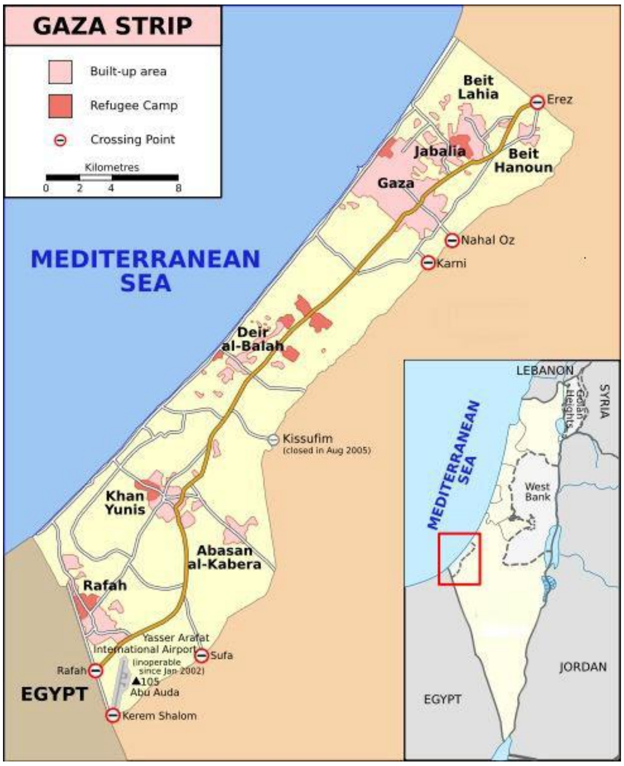



Figure 2.1: Gaza Strip Map (Wikipedia)

## 2.3 Climate Conditions

The Gaza Strip is considered a transition zone between the coastal area wetlands and the dry desert region (Negev desert in the south-east and Sinai desert in the south-west). According to Palestinian Energy Authority (PEA, 2010), winter in the Gaza Strip area is rainy and mild while summer is hot and dry and extends over longer period of the year. The average daily mean temperature ranges from $34^0$C in summer (May-August), to $17^0$C in winter (November-February). In 2012 the daily maximum temperature reach in some days to $39^0$C on summer and minimum temperature reach to $7^0$C in winter. Table 2.1

| Month | Jan | Feb | Mar | Apr | May | Jun | July | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Av.High $C^0$** | 17 | 17 | 20 | 26 | 29 | 31 | 33 | 33 | 31 | 28 | 24 | 19 |
| **Av.Low $C^0$** | 7 | 7 | 9 | 13 | 15 | 18 | 20 | 21 | 19 | 17 | 12 | 8 |

Table 2.1: The annual average temperatures in Gaza Strip
Source: Wikipedia

The Gaza Strip has a relatively high solar radiation. It has approximately 2861, sunshine -hour. The daily average solar radiation on a horizontal surface is about 222 W/m2 (7014 MJ/m2/yr). This varies during the day and throughout the year. Figure 2.2

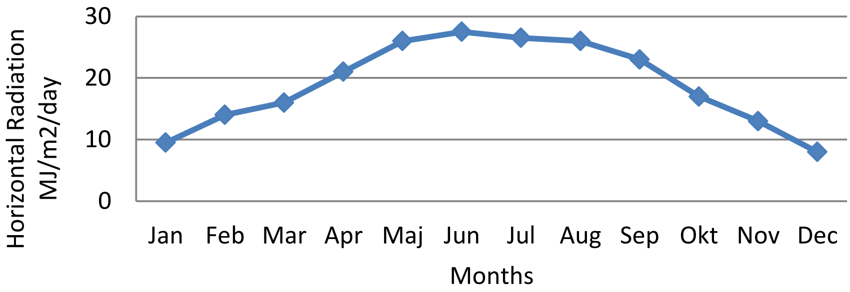



Figure 2.2: The annual variation in solar radiation (MJ/m2/day) in Gaza Strip
Source: (Palestinian Energy Authority (PEA), 2010)

Prevailing winds in the Gaza Strip are northwesterly in the summer, and wind speed up to 3.9 m/s during the afternoon, differs from the prevailing wind direction and speed during the winter, as it turns to the southwesterly wind and increase speed to up to 4.2 m/s speed, and sometimes blowing winds of up sometimes to 18 m/s. Figure: 2.3

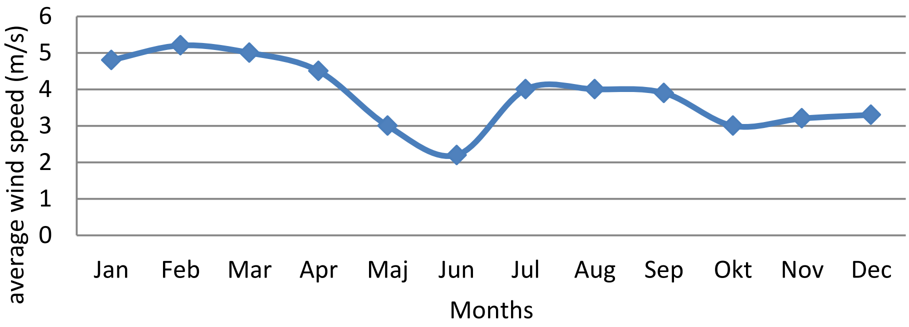



Figure2.3: The annual average wind speed (m/s) in Gaza Strip
Source: (Ministry of Local Government, 2004)

Relative humidity fluctuates between 65% and 85% in summer, and between 60% and 80% in winter. Figure (3.4) shows the annual average Relative Humidity in the Gaza Strip (Ministry of Local Government, 2004).Figure 2.4

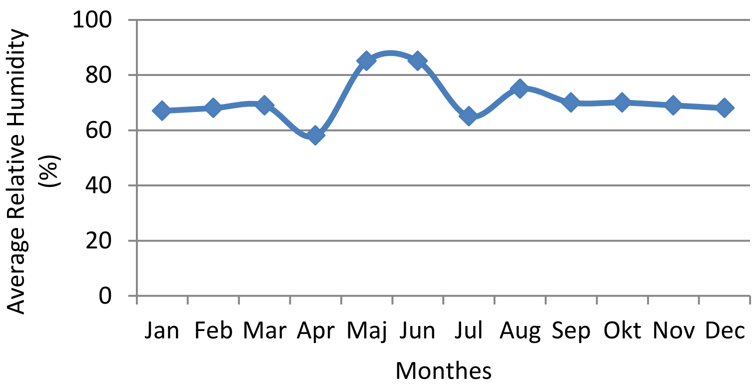



Figure2.4: The annual average Relative Humidity in Gaza Strip
Source: Ministry of Local Government, 2004

## 2.4 Type of Building

The most common Buildings in the Gaza Strip are multi-story residential buildings. This type is common as a response to the extended family culture; each father try to keep his sons lived in the same home so they believe that the multi-story building is the way to keep the family together. These buildings are often built with contemporary materials and construction methods, mainly the structural system (reinforced concrete foundations, columns, and ceilings). The walls are made of concrete hollow blocks, while the windows are single-glazed with aluminum frame. This building with concrete as a main construction material with no treatment or thermal insulation gives a hot indoor climate in summer and a cold indoor climate in winter.

## 2.5 Building Law and Cods in the Gaza Strip

After Oslo agreement, Palestinian National Authority has modified building laws and by-laws, the previous laws that were acting are the Jordanian in the West bank and the Egyptian in the Gaza Strip, and not to forget the Israeli laws and by-laws that were affecting whole planning process for community and urban developments. The modifications made after Oslo agreement were to organize the building process and didn't make any dramatic change especially in the building codes issues. These are temporary laws and by-laws, laws are temporary because peace agreement does not totally applied so Palestine still not stabile and not recognized as a country and does not impose its control over all the Palestinian territories, temporary Laws and by-laws are key words in studying the modern architecture after the second half of the 20th century. Classifications of buildings according to the function, the building materials, the set back line, height of the building, number of floors and built up area were determined in the laws according to the classifications of the land. Refugee camps where are the most dense areas in the Gaza Strip are not covered by any building law or cods.

## 2.6 Building practice in the Gaza Strip

*1 <u>Self-Build Buildings</u>*

In this dense urban area, residential buildings in the Gaza Strip are filled with a wide variety of housing and building qualities, ranging from extremely solid concrete frame constructions with all services, to squalid windowless shacks made of concrete blocks. Those buildings and the people who live in them are not all the same. Some occupants will be able to mobilize enough funds to improve their housing up to comfort houses, while others will continue living in the most basic shelters, unable to afford any improvements at all. The main concern of so many people was to build a shelter in a very economical way regarding the form or shape.

People in the Gaza Strip build individual homes for all sorts of reasons, but mainly because they want to create something tailored to their family's unique requirements. Houses which are functionally efficient and providing for basic human needs of shelter and comfort using basic elements such as floor, walls, roof and hearth.

### *2 Uncertainty of Planning*

Single and extended family houses scattered throughout the Gaza Strip and align outer perimeter of the Gaza City. With slab of living spaces, raised on pilotis, and a flat roof, they look like local variations of the modernistic villa. It was indeed the influence of early modernism that first arrived in the region via occupied Palestinian territories, reaching its zenith in the 1930s that filtered through to the Gaza Strip via Palestinians construction workers, to almost become the new vernacular (Weizman and Dietrich, 2000).

The lack of urban, regional planning, building laws and management of constructed properties in the Gaza Strip is a critical issue. Building licenses are granted liberally, existing land use regulations are often ignored, and the Gaza Strip lacks experience with planning in general. At the same time the population is increasing while the available land is decreasing. In order to meet the needs of its population, the Gaza strip needs urban and regional planning to use its remaining land most effectively. Forms and spatial relationships are dictated by lifestyle and the needs of the occupants (Figure: 3.5) rather than the willful composition of a designer if there is any! The architect until late 1980s was not the only designer and building process could pass even without the architect’s signature.

### *3 Housing Units Ownership*

In 2011, 93.6% of households listed in housing units owned by one family member, while 3.7% were living in rented houses in the Gaza Strip. In Palestine 53.7% live in apartments in multi-story buildings, 43.3% live in homes and 2% live in villas. (PCBS, 2012)

Figure 2.5: A typical self-built house in the Gaza Strip where form is dictated by needs of occupants.
Source: Al Qudwa, 2013

Figure 2.6: Repetitive use of building products and components in the Gaza Strip.
Source: Al Qudwa, 2013.

# Chapter 3: Exploring passive design strategies

## 3.1 Introduction

Passive design is a key element and the main factor of sustainable buildings. It aims to improve thermal comfort of people and reduce the rate of consuming energy. It means making use of natural sources of energy, heating, lighting and ventilation without polluting the environment. Thus, this chapter explains the issue of passive design considering its definition, design aspects, and role in the provision of thermal comfort inside buildings and saving energy consumption.

Out of the numerous passive design features that were discussed in the theoretical framework, only those features have been chosen that can meet the purpose of this study and can be applied in the context of the Gaza Strip

## 3.2 Definition of Passive Design

Passive design is defined as: "an approach to building design that uses the building architecture to minimize energy consumption and to improve thermal comfort" ((Mikler et al., 2008). The building form and thermal performance of its elements (including architectural and structural ones) should be carefully considered and optimized for interaction with the local microclimate. The ultimate aim of passive design is to fully eliminate requirements for active mechanical systems (and associated fossil fuel-based energy consumption), and to maintain residents' comfort at all times.

Building shape, orientation and composition can improve residents' comfort by harnessing on site renewable energy sources and reducing reliance on other forms of energy. Through properly applied passive design principles, we can greatly reduce building energy requirements before we even consider mechanical systems.

Designs that do not consider passive solar technical behavior mostly rely on extensive and costly mechanical (HVAC) systems to maintain adequate indoor conditions. Furthermore, even the most efficient technologies will use more energy than it is necessary with a poorly designed building.

According to (Mikler et al., 2008), to successfully implement the passive design approach, one must first accomplish the following:

1. Understand and define acceptable thermal comfort.

2. Understand and analyze the local climate, preferably with site-specific data.
3. Understand and establish clear, realistic and measurable energy consumption targets.

## 3.3 Passive Design Basic Principles in Buildings

It is evident from the above section that passive design in buildings is a vital strategy. Thus, it is now important to focus on the basic principles that can bring about energy efficiency in residential buildings of the Gaza strip- through this design strategy. An extensive literature review consisting of different journals, books, researches and related websites was undertaken to establish the basic passive design principles for low energy residential buildings that have been arrived from the literature review and based on the context of the Gaza strip are discussed below:

## 3.4 Planning Aspects

### 3.4.1 Site Analysis :

Building site analysis done to define the following:

**1- Wind Breaks:**

Wind breaks are barriers used to reduce and redirect undesired wind in both hot and cold climates. They usually consist of trees and shrubs, but may also be fences. The reduction in wind speed behind a wind break modifies the environmental conditions or microclimate in the sheltered areas. Moreover wind breaks are not desirable in arid climates as they impede desirable breezes. Instead, it is desirable to have air movement. However, dense housing developments and increasing of built structures in the Gaza strip do not leave a scope for choosing a portion of the site without windbreaks. Generally, plots are not surrounded by open spaces or green spaces in the Gaza Strip.

**2- Shade from existing buildings:**

Building should be placed in such a way that it gets shading from existing landmasses. The building can be sited to the east of such feature to reduce solar gain during afternoons when the sun is low. Improper planning of the site can result in ‘heat island effect’. Such effects can be alleviated by reducing the total paved area on the site and shading the paved surfaces.

As already mentioned above, surrounding buildings in the Gaza strip are at very close proximity to plots. Hence, buildings constructed get shade form existing landmasses in almost all cases. Buildings, however, do not get shade from surrounding trees due to the absence of green spaces. The above mentioned criteria do not directly generate reductions in energy use. Instead, they provide air movement for ventilation if wind breaks are absent and help to keep buildings cool through the shade provided by surrounding buildings.

### 3.4.2 Building Form:

Climatic region has an effect on the shape of buildings and spaces between them. Forms with large surfaces rather than compact buildings as large surfaces favor ventilation and heat emission at night-time. The building forms should thus be open, outward oriented and built on stilts. Building form largely depends on whether the building is planned to be air-conditioned or if it is intended to rely on natural ventilation. In hot dry areas, compact configuration is used to reduce the rate of heat gain through external walls. Studies proved that, the rectangular shape is the best shape of buildings in hot and relatively hot areas, as it provides energy and reduces heat gains. It might not be possible to design open, outward buildings in constricted areas as the Gaza strip and where maximum utilization of land for profitability is the main objective. Most residential buildings in the Gaza strip are compact. The compactness of residential buildings is attributed to the fact that land is exploited to its utmost capacity, without leaving any open space.

### 3.4.3 Building Orientation:

Many site considerations can affect passive design, including building orientation on the site, shadows from other buildings, wind patterns, noise and urban character. All of these aspects need to be considered to optimize heating or cooling, and day lighting. However, it is important in this regard to consider the local architectural context. According to (Ministry of Local Government, 2004), there are some factors that affect the orientation of a building:

1. Thermal effects such as: the sun and the wind.
2. Visual effects (natural lighting through the light).
3. Sound effects and inconvenience.

4. The degree of privacy that has a very important role to direct building, and its external appearance and design.

### 3.4.4 Rooms arrangement and Orientation:

Arrangement of rooms depends on their function and according to the time of the day, they are in use. Building can be made more energy efficient if it is planned according to solar orientation and prevailing wind direction. However, they did specify how much energy saving is possible through such planning. Overheating due to solar radiation is the real problem in the Gaza strip for most of the year, especially during the day.

Cross-ventilation can be used to enable faster cooling and better ventilation. Building layout which provides good potential for cross-ventilation is more appropriate for developing countries in hot-humid regions where the vast majority of people cannot afford to buy air conditioners.

The usual trend for orientation of rooms in residential buildings of the Gaza strip is to give maximum priority to master bedroom followed by other bedrooms. Living spaces are used most frequently; dining spaces are rarely given importance. Living spaces are centrally located and perform more as circulation space.

### 3.4.5 Landscaping and Vegetation:

Landscaping and vegetation, economically speaking, could save up to 25% of a household's energy consumption for heating and cooling systems. In fact, trees are very effective means of shading in summer. In addition, it could reduce air temperatures when water evaporates from vegetation and cools the surrounding air (Heinberg, 2009).

Even though appropriate tree plantation can bring significant amount of energy savings, this design principle can only be applicable in buildings of the Gaza Strip if adequate space is left open either as a setback area or as designated green space.  Due to dense construction in the Gaza Strip there are no enough areas to plant big trees that can provide shade.

## 3.5 Design of Building Envelope

Building envelope is the part that separates between the internal and the external environments of a building. It serves as the outer shell to protect the indoor environment and facilitate its climatic control. Building envelope design is an important area of architectural and engineering practice that is based on buildings physics. The physical components of building envelope include the r oof, walls, and doors and windows. The dimensions, materials, and details of connection are the main factors which determine the effectiveness and durability of the building envelope.

### 3.5.1 Thermal insulation:

Thermal insulation in buildings is an important factor to achieve thermal comfort for its resident. Insulation reduces unwanted heat loss or gain, and decreases the energy demands of heating and cooling systems. Insulation doesn't only refer to the mere use of insulation materials employed to slow heat loss, such as cellulose, glass wool, and polystyrene, but also refers to the correct design of their interaction with the thermal environment.

Thermal design of building envelope includes designing all external structural elements that are in contact with the external environment. One aspect of this design is to implement thermal insulation in order to reduce heating and cooling loads, while providing healthy and comfortable indoor environment. Thermal insulation targets the external elements, such as roofs, external walls and windows, where thermal properties of these elements should be carefully selected.

#### 1- Objectives of Thermal Insulation

Thermal insulation is primarily used to limit heat gain or loss from buildings surfaces, which operate at temperatures above or below ambient temperatures. Thermal insulation may be used to satisfy one or more of the following design objectives (National Mechanical Insulation Committee -NMIC, 2012):

- **Energy conservation:** To reduce unwanted heat losses, or heat gains through roofs, walls, doors, windows and floors.

- **Comfortable climate:** To create a comfortable and refreshing climate, and increasing the level of comfort for buildings residents, throughout the year. This, consequently, reduces energy required for heating or cooling.
- **Condensation control**: minimizing condensation and the potential for mold growth by keeping surface temperature above the dew point of surrounding air.
- **Fire safety:** protecting critical building elements and slowing the spread of fire in buildings
- **Freeze protection:** minimizing energy required for heat tracing systems and/or extending the time to freezing in the event of system failure
- **Personnel protection**: controlling surface temperatures to avoid contact burns (hot or cold)
- **Process control:** minimizing temperature change in processes where close control is needed
- **Noise control:** reducing/controlling noise in mechanical systems.

## 2- Thermal Properties of Building Materials

The quantity of transmitted heat through a building envelope is mainly related to the thermal characteristics of materials that make up these elements. This is in addition to their thickness and exposure to the affecting atmosphere factors. This could be judged depending on the amount of heat loss or gain, and the resulting level of thermal comfort. Therefore, thermal properties of the external elements of any building should be selected to offer acceptable level of thermal insulation in order to achieve thermal comfort. So, the following sections discuss some of these thermal properties as follows:

### A. Thermal Transmittance (U-Value)

Thermal transmittance (U-Value), also known as the U-Factor or coefficient of heat transmission, is a measure of the rate of non-solar heat loss or gain through a material or assembly. U-Values measure how well a material allows heat to pass through. The lower the U-Value is, the greater a product's resistance the heat flows.

### B. Thermal Lag

Thermal lag of a building is the time taken for heat energy to pass through a building element from one side to the other one. Thermal lag is always measured in hours. For most low-rise buildings in temperate climates, massive external walls could achieve a time lag of (10-12) hours, and could be effectively used without the need for external insulation (Baggs, & Mortensen, 2006).

Table 3.1: Time lag figures for some building materials.
Source: (Baggs, & Mortensen, 2006)

| Material (thickness in mm) | Time lag (hours) |
|---|---|
| **Concrete (250)** | 6.9 |
| **Double Brick (220)** | 6.2 |
| **Adobe (250)** | 9.2 |
| **Rammed Earth (250)** | 10.3 |
| **Compressed Earth Blocks (250)** | 10.5 |

### C. Thermal Decrement

Thermal decrement represents the ratio of peak amplitude temperature fluctuation on one side of a material, compared to the other side of a one. The larger the decrement factor, the better the stabilization of internal temperatures.

### D. Solar Absorption

Solar absorption refers, to the portion of incident solar radiation that is absorbed by the surface of a building, and not reflected away or transmitted through. This affects thermal calculations through indirect solar gains, and the sol-air temperature. For windows, this value becomes the shading co-efficient, a value between (0 and 1) which represents the relative quantity of a solar radiation passing through the material. This value is available from glass suppliers.

## 3- Building Insulation Materials

Walls, roofs, floors, chimneys and windows are all considered escape routes of heating or cooling. Well-determined levels of insulation are a cost-effective way of reducing heating or cooling energy consumption. Therefore, the additional cost of insulation could be recovered through the reduced cost of heating and cooling systems in buildings. There are numerous alternatives when it comes to choosing insulation materials. They differ in thermal efficiency and in offering certain important properties, like resistance to fire and avoidance of ozone depleting chemicals. Some other, also, lose much of their insulating efficiency if affected by moisture.

### 3.5.2 External Wall:

As the main goal in building design of hot climates is reduction of direct heat gain by radiation through openings and reduction of internal surface temperature, the building should be designed with protected openings and walls. External walls of a building are considered among the most complex components of the building envelope. External walls are the first defense line against external thermal conditions.

In general, the methods of insulating external walls in buildings may be summarized as follows:

**1- Internal insulation of walls:**

This is done by using composed boards of polystyrene, which are fixed on gypsum or wood boards. Boards must be installed on walls using cement mortar or glue. This way leads to save in the costs of internal finishes, and ensures the complete insulation of walls and columns Figure:3.1

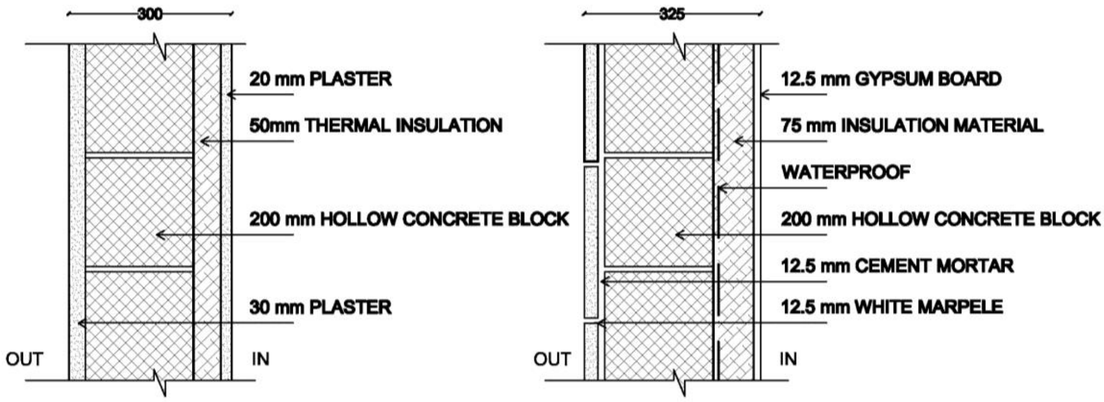



Figure 3.1: Two different ways to insulate external walls from inside
Adapted by author

**2- External insulation of walls:**

This consists of thermal insulation installed on the outside surface with a layer of mortar applied to it using a reinforce fiber net. After that, it can be finished using any desired type of finishing. This kind of insulation is characterized with the achievement of full insulation for the external walls, including columns and roof slabs, and prevents heat leakage. Also, it is lighter than the way of insulating walls at the middle, and could be used for old and new buildings.

According Solar for Gaza study to Fitting 50mm expanded polystyrene insulation to the outside of concrete block walls can reduce heat fluctuations by 63% in arid climates. This can lead to a 10-14% reduce on in energy requirements with 8-10% in air conditioning use. Covering the exterior surface of the walls in smooth stucco painted white can mean 70-80% of incident solar radiation is reflected, compared with about 50% for most commonly used finishes, such as lime stone or textured stucco. Figure: 3.2

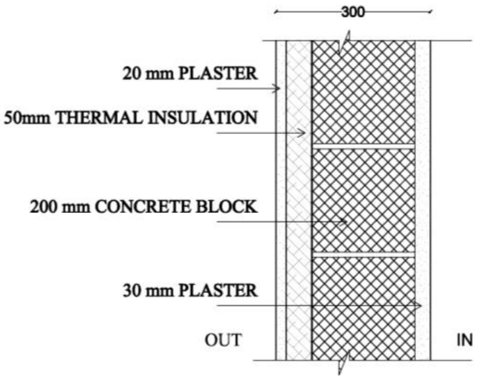



Figure 3.2: External insulation fitted to wall blocks

Adapted by author

**3- Core insulation of walls:**

Insulation boards are usually placed between the two layers of the external wall. Alternatively, air cavity could be left between these two layers to act as an insulator. Core insulation is easy to install and had high efficiency in resisting high temperature up to 300% compared to the normal wall. Figure: 3.3.

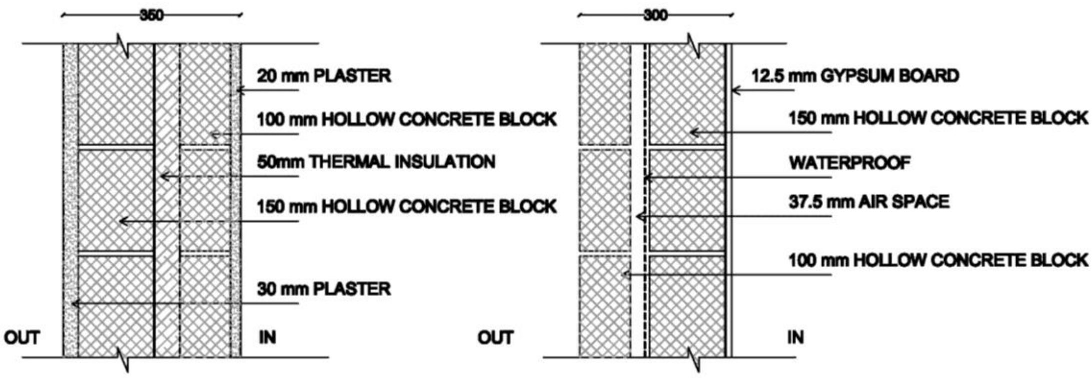



Figure 3.3: Two different ways to insulate the external walls from the middle

Adapted by author

**4- External wall for existing residential buildings in the Gaza strip**

Most commonly, walls in the Gaza Strip are made of hollow concrete blocks and thin layers of cement plastering applied to the internal and external walls. A typical section of external walls shows 200 mm hollow concrete blocks, with 10-15 mm of internal plaster and 20-30 mm of external plaster. Thermal properties of this element are as follows: U-value: 2.3 W/m2K. With fitting polystyrene layer 50 mm to external wall (East, South, West) that reduce U-value to 0.58 W/m2K.

### 3.5.3 Building Material:

Construction materials used in building envelope, such as external walls and openings, have an important role in determining the rate of heat gain and loss. Consequently, those materials should be chosen carefully in the design stage taking into consideration their thickness, colors and thermal properties. For example, to reduce thermal transfer through the external walls of a building, a material with high thermal resistance and larger thickness should be used.

This study focuses only on the energy used by a building during the operation stage. It will not consider the energy used in manufacturing the building materials and transporting the building materials from the production plant to the site. Neither will it consider the energy used in on-site construction activities and the energy used in the demolition of the building and the recycling of their parts.

### 3.5.4 Roof:

The roof is an important element of design when it comes to conserving energy because this part of the building receives most of the solar radiation and its shading is not easy.

Residential buildings in the Gaza Strip have typical roof section shows three parts: 8 cm layer of reinforce concrete, 17cm layer of hollow concrete blocks, and 1cm layer of plastering. Thermal properties of this element are as follows: U-value: 2.6 W/m2K, decrement factor: 0.4, time lag: 6.8 hrs. Figure 3.4

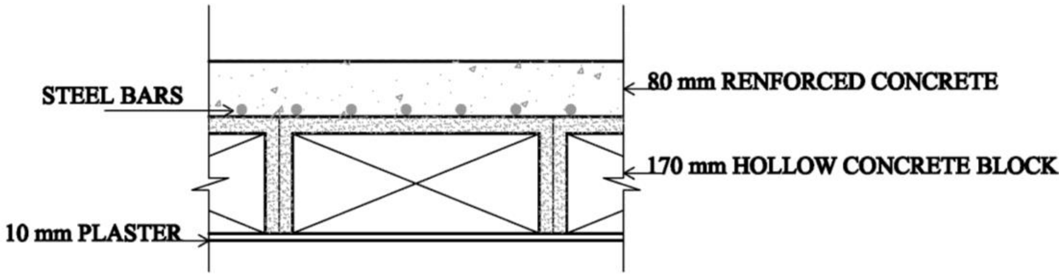



Figure 3.4: Typical concrete slab
Adapted by author

**1- *Roof shading*.**

Shading the roof is a very important method of reducing heat gain. Roofs can be shaded by providing roof cover of concrete or plants or canvas or earthen pots etc. Shading provided by external means should not interfere with night-time cooling. A cover over the roof, made of concrete or galvanized iron sheets, provides protection from direct radiation. Disadvantage of this system is that it does not permit escaping of heat to the sky at night-time.

**2- *Roof insulation*.**

An insulated roof section recommended by the proposed Palestinian Code of Energy Efficient Buildings is a 250 mm ribbed concrete roof covered with 50 mm of thermal insulation, 50 mm of foam concrete, 20 mm of moisture insulation, 25 mm of sand, and 10 of tiles, respectively from bottom to top. Thermal properties of this insulated roof are: U-value: 0.73 W/m2K, decrement factor: 0.1, time lag: 11hrs. This means that the insulated roof has lower U-Value (0.73 compared to 2.6 W/m2K), and higher thermal lag (11 compared to 6.8 hrs.). Figure 3.5

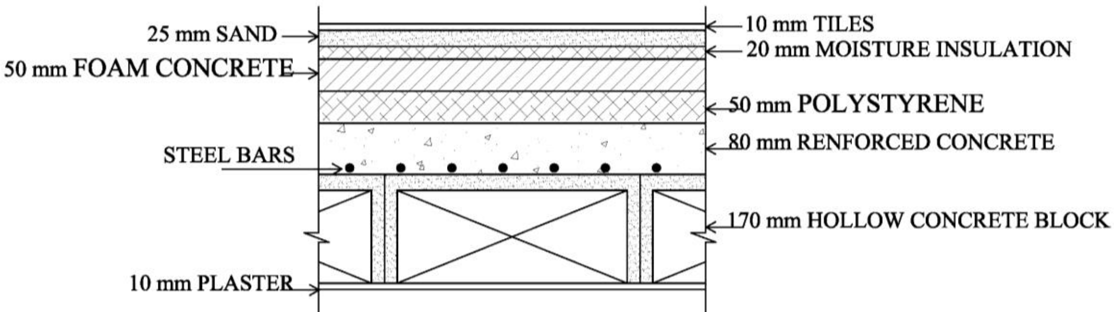



Figure 3.5: Roof insulation
Adapted by author

### 3.5.5 Windows :

**1- Size:**

Openings are important design elements for admitting daylight, air flow, providing cross ventilation and views. Windows should be large and fully openable, with inlets of a similar size on opposite walls for proper cross-ventilation. However, windows in residential buildings of the Gaza Strip are not fully openabe and they do not function effectively in admitting airflow, ventilation and indoor air quality can be improved by increasing the window to wall ratios, but it would also increase solar heat gain. There has always been a conflict with daylight provision and exclusion of solar penetration in designing windows. The design and location of windows for buildings in the Gaza Strip the orientation of windows should aim at excluding solar penetration. Windows should be avoided on western walls as it is almost impossible to shade it in all seasons.

**2- Orientation**:

Openings should be placed according to the prevailing breeze so that air can flow through the internal space. However, this is difficult to achieve in multi-unit residential building. Avoiding east or west facing rooms for the purpose of thermal comfort and energy use. However, there are situations in the Gaza Strip, where the orientation of building due to the site orientation is such that the west facade of a building is the front facing. The solution might lie in having well designed verandahs and roof overhangs. The surface that has the verandahs can have glass openings which are 2.1 meters in height, which serve both as window and door.

**3- Shading device:**

In warm, sunny climates excess solar gain, may result in high cooling energy consumption. In cold and temperate climates, winter sun entering south-facing windows could positively contribute to the passive solar heating. Depending on the amount and location of openings, reductions in annual cooling energy consumption of (5%) to (15%) have been reported (Prowler, 2008). In this context, shading devices offer the opportunity to control solar radiation admittance into the space. There are several types of shading devices, as follows (Ministry of Local Government, 2004):

1- Horizontal devices: on the southern elevations.
2- Vertical devices: on the eastern and western elevations. However, they should be

inclined to the north side of a building to reduce radiation form the south.

3- Combined devices: on the southeast and southwest elevations. It is recommended to use these types of elevations in hot climatic areas, or areas located at low latitudes.

Table 3.2: Horizontal device
Source: (Ministry of Local Government, 2004)

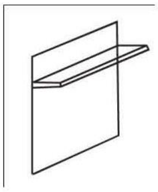
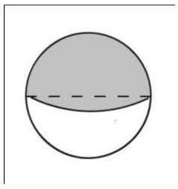
| Shading Device | Side View | Shading Mask | Comments |
|---|---|---|---|
|  |  |  | **Straight overhangs** are most effective on southern exposure. |

Table 3.3: Vertical device
Source: (Ministry of Local Government, 2004)

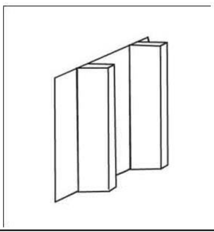
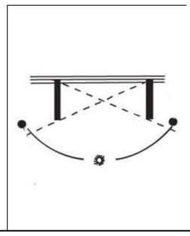
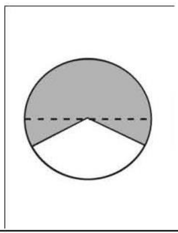
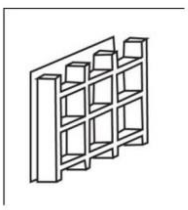
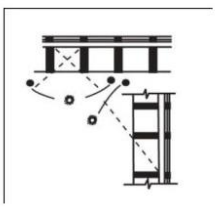
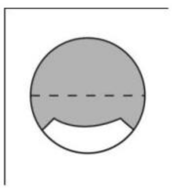
| Shading Device | Plan View | Shading Mask | Comments |
|---|---|---|---|
|  |  |  | **Vertical fins** are most effective on the near-east, near-west and north exposures. |

Table 3.4: Combined devices
Source: (Ministry of Local Government, 2004)

| Shading Device | Plan & Side View | Shading Mask | Comments |
|---|---|---|---|
|  |  |  | **Compound types** are combinations of horizontal and vertical types. Most effective in hot climates on east and west exposures. |

Some recommendations of using shading devices are:

- Shading devices should be located in a way that prevents the reflected solar radiation from entering to the space.
- Shading devices should be made from materials with low heat capacity (materials that don't save heat).

- To leave a small gap between the device and the building elevation to allow for hot air movement.
- To use suitable colors with high reflectivity without compromising the aesthetic quality of the building

Glazing materials in residential buildings of the Gaza Strip are clear and tinted without any solar transmittance properties. Special glasses such as heat reflecting and heat absorbing will not be considered for the context of the Gaza Strip because they are not locally available. Heat absorbing and heat reflecting glasses could be used for air-conditioned buildings. However, it would increase construction costs as the glasses would need to be imported. In residential buildings of the Gaza Strip, drapes and curtain is used for interior shading.

### 4- **Natural ventilation:**

Ventilation refers to the movement of air within a building and between a building and the outdoors. The control of ventilation is one of the most important concerns of building designs, and aims to make air moves in a way that satisfies the residents (Roaf et al., 2007). In general, maximizing natural ventilation potential through windows, the building should be oriented according to the prevailing wind direction. Also, the use of some architectural elements is useful, such as courtyards and wind catchers. Ventilation has three useful functions in buildings, as it is used to:

- Satisfy the fresh air needs of the residents.
- Increase the rate of evaporative and sensible heat loss from the body.
- Cool a building internal space by the exchange of warm indoor air by cooler outdoor air.

As a matter of fact, air moves easily down a pressure gradient. Positive pressure exists on the windward side of a building where air is pushed with some force against a building. Negative pressure occurs on the leeward side of a building, in the wind shadow, and drags air from the structure. In fact, the design challenge is to create or enhance that pressure gradient. This could be done in two ways (Roaf et al., 2007):

- Using pressure differences caused by wind. Using wind pressure to ventilate is usually common, particularly in hot climates. There are many challenges in designing properly for ventilation, including the variability of the wind; its speed and direction. Figure 3.6

- Using pressure differences caused by temperature variations within the space. It is known that warm air is less dense than cold air. Thus, pressure variation causes warm air to rise and cold air to replace it. This is called the (Stack Effect), and could be used as a ventilation driving force.

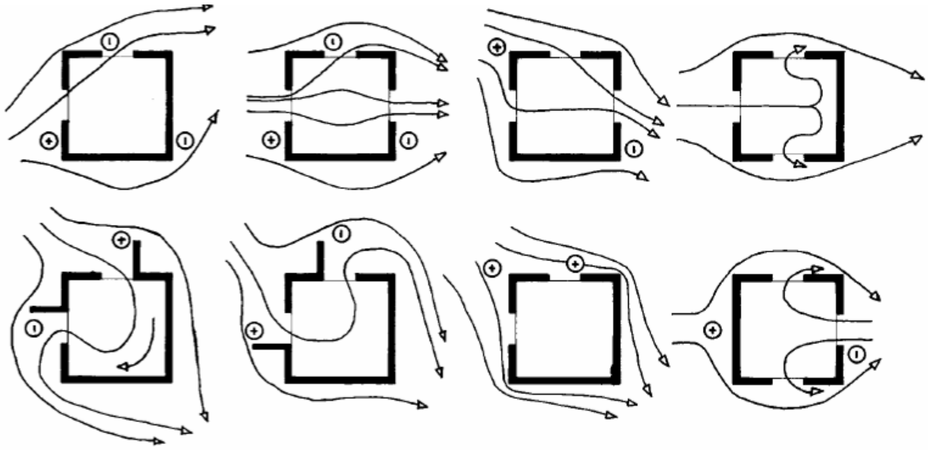
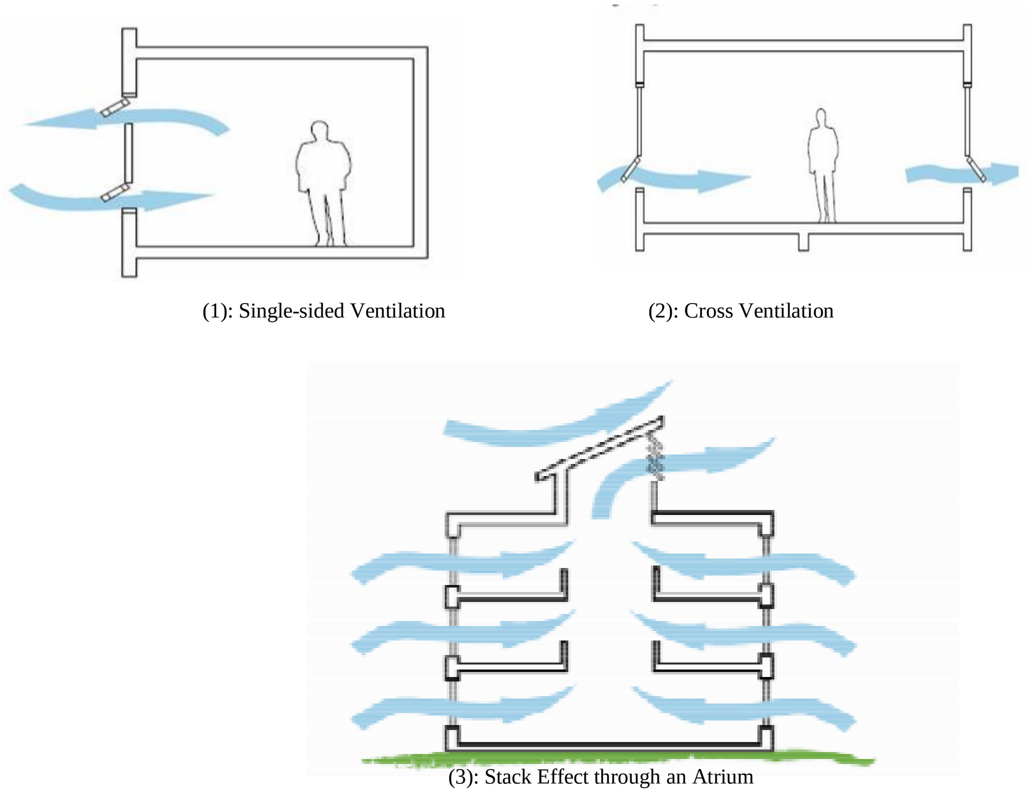


Figure 3.6: Positive and Negative Wind Pressures around Different Building Configurations
Source: Roaf *et al.*, 2007

The above-mentioned ventilation driving forces result in several methods for natural ventilation (Mikler et al., 2008). The first method is the single-sided ventilation, which is the simplest form of using operable windows. Air here enters and leaves through windows located on the same side of the occupied space.

More effective is the cross-ventilation strategy, where operable windows on adjacent or opposing walls draw air across the occupied space. This requires the provision of at least two exposed walls to allow for cross-ventilation. In larger buildings with significant core spaces, such as atria, both stacks and wind effect through the central space and opposite windows may be necessary to provide adequate ventilation. Figure 3.7



(1): Single-sided Ventilation

(2): Cross Ventilation

(3): Stack Effect through an Atrium

Figure 3.7: Several Methods of Natural Ventilation.
Source: (Mikler et al., 2008)

In the Gaza strip to explore air change in still outdoor conditions in rooms with a single window. The design aspects of windows as a function of indoor airflow pattern generated by ceiling fans. It has already been mentioned that not all rooms in multi-unit residential buildings of the Gaza Strip have two exposed surfaces to ensure cross-ventilation. Furthermore, rooms that have single walls exposed to outdoors, have windbreaks because of the close proximity of the surrounding buildings.

5- **Daylight**:

Day lighting is the controlled admission of natural light into a space through windows, to reduce or eliminate artificial lighting. Day lighting helps create a visually stimulating and productive environment for building residents, while reducing as much as one third of total building energy costs. The art and science of proper day lighting design is not so much how to provide enough daylight to an occupied space, but how to do so without any undesirable side effects. This means the careful balancing of heat gain and loss, glare control, and variations in day light availability. In addition, window size and spacing, glass selection, the reflectance of internal finishes, and the location of any internal partitions must all be evaluated. Some building elements that can effectively contribute to the day lighting strategy are: atrium space, light shelves, skylights and light tubes, and clerestories.

Day lighting reduces energy requirements for electrical lighting. Indirectly, it could, also reduce energy requirements for space heating. Thus, detailed building modeling and analyses is required to achieve an effective day lighting design.

### 3.6 Passive Cooling

Passive cooling is usually used to maximize the ability of a building envelope to minimize heat gain from the external environment, and generate cooling potential wherever possible. Two methods are commonly used to generate a passive cooling potential: natural ventilation and evaporative cooling. Natural ventilation has been discussed in the previous Section in this chapter.

As for evaporative cooling, it is based on the fact that when water evaporates, it consumes an amount of sensible heat from its surrounding objects. Some design solutions for evaporative cooling include the use of pools, ponds and water features, immediately outside windows or in courtyards to pre-cool air before entering the space. Such phenomenon is used to cool buildings in two different ways (Lechner N. 2001):

- Direct evaporative cooling: by spraying water into the air. This lowers the temperature but raises the humidity. In this context, the use of evaporative coolers is common, which are simple, inexpensive and use little energy.

- Indirect evaporative cooling: by using heat exchanger to prevent air to get in direct contact with water vapor. This offer the advantage of cooling without increasing the indoor humidity (Figure 3.8).

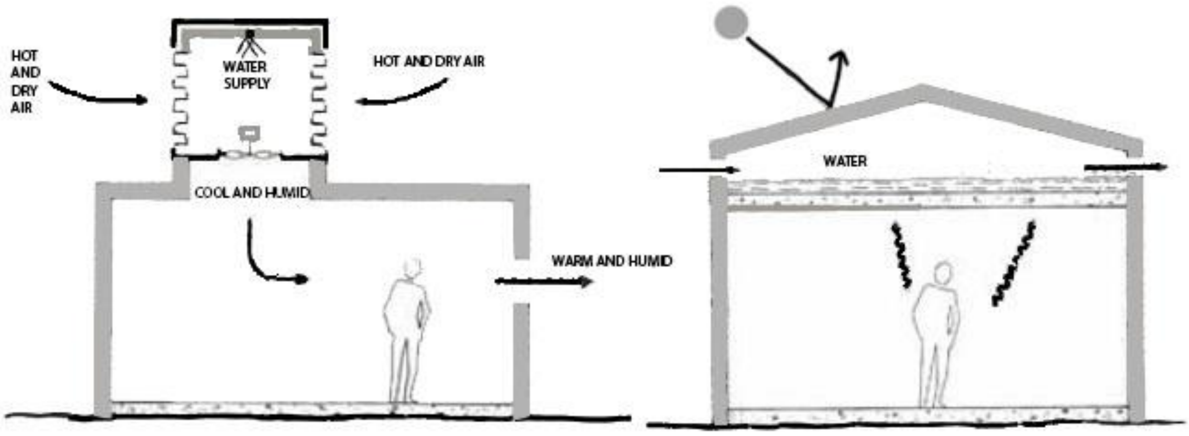



Figure 3.8: Direct Evaporative Cooling with the Usage of Evaporative Coolers (Left), and Indirect Evaporative Cooling (Right). Source: (Lechner N. 2001)

## 3.7 Passive Heating

Passive heating encourages the usage of architectural elements to take advantage of the natural sun heat in order to reduce the cost of building heating. Passive heating aims to minimize heat loss from a building and to generate a heating potential through maximizing heat gains.

Several passive heating systems could be used. Two of these systems can be implement in the Gaza Strip:

1- *Trombe Wall Systems:*

Trombe wall system (Figure 3.9) is a sun-facing massive wall separated from the outdoors by glazing, and an air space, which absorbs solar energy and releases it selectively towards the internal side at night. Modern variations include insulating glass to retain more of the stored solar heat, and include high and low, sometimes operable, vents to allow convective heat transfer to the indoors.

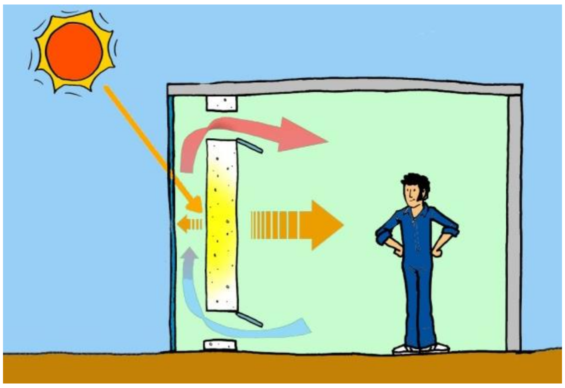


Figure 3.9: Typical Trombe Wall
Adopted by author

2- Solar Chimney:

Solar chimney system is similar to the Trombe Wall system. However, solar chimneys could be used for both passive cooling and heating, where the entire height of a building can be utilized to promote the stack effect, as shown in Figure (3.10).

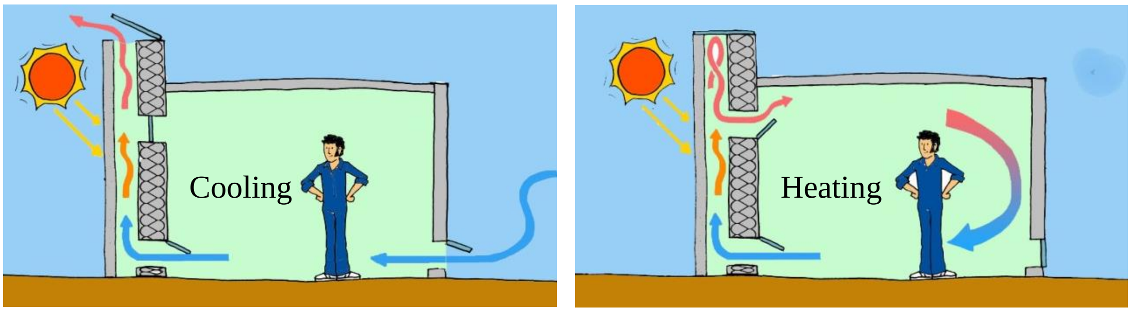



Figure3.10: Solar Chimney System
Adopted by Author

## 3.8 Conclusion

This chapter presented a wide range of ideas and solutions to achieve a low energy design of buildings. This has been done with considering the passive design concepts and techniques, and their potential on site planning level and building design level. The principles of passive design and its relationship with human thermal comfort have been highlighted.

It has been concluded that passive design is one of the most important aspects that should be considered in designing low energy buildings. It is advantage of incorporating no mechanical components makes it a desired option to reduce buildings reliance on energy. However, good understanding of the human thermal comfort requirements should be ensured in order to offer effective passive design solutions and systems like passive cooling and passive heating. Designers should also integrate passive design techniques in accordance with the requirements of building codes, aesthetic qualities, and building function, the following table 3.5 shows the most important passive methods.

Table 3.5 Passive design methods.
Adopted by Author

| Methods | Function: a brief description | Heating / cooling | Use new construction/ renovation |
|---|---|---|---|
| **Solar shading (Landscape and Existing building)** | Reduce the heat gained by direct solar radiation | Cooling | Depends on site location and conditions/ New construction |
| **Thermal insulation (Roof and External walls)** | Insulation reduces unwanted heat loss or gain, and decreases the energy demands of heating and cooling systems | Both (heating and cooling) | some insulation methods can used in new construction and other for renovation |
| **Roof Shading** | Roofs can be shaded by providing roof cover of concrete or plants or canvas or earthen pots etc. | Cooling | new construction/ renovation |
| **Shading Device** | shading devices offer the opportunity to control solar radiation admittance into the space | Cooling | new construction/ renovation |
| **Natural Ventilation** | Aims to make air moves in a way that satisfies the residents | Cooling | new construction/ renovation |
| **Evaporative Cooling** | used to maximize the ability of a building envelope to minimize heat gain from the external environment, and generate cooling potential wherever possible | Cooling | new construction/ renovation |
| **Trombe Wall Systems** | A sun-facing massive wall separated from the outdoors by glazing, and an air space, which absorbs solar energy and releases it selectively towards the internal side at night | Cooling | new construction/ renovation |
| **Solar Chimney** | Similar to the Trombe Wall. However, solar chimneys could be used for both passive cooling and heating | Heating & Cooling | new construction/ renovation |

# Chapter 4: RESULTS: Typical Flat in the Gaza Strip- Application of for passive design Strategies and better comfort.

## 4.1 Selection of case study

In this research, the residential flat that houses upper middle income groups is the primary case and the household surveyed is the embedded unit of analysis. The selection of the case study building was based on the following criteria:

- It is representative of typical residential building design in the Gaza Strip.
- The architectural drawings of the apartments were available
- It was accessible
- The households were cooperative.

## 4.2 Overview of the case study

The building located in Khan-younis refugees' camp residential area (Figure: 4.1), in the west of Khan-younis city which located in south of the Gaza Strip. The case study building (figure 4.2) is a typical residential building with one flat on each floor. This type of residential building is popular in the Gaza Strip because of the increasing pressure on land and the dynamic changes in the urban lifestyle. Due to scarcity and the price of land, old single-family houses are demolished and in its place residential buildings are built by the same family to cover the need for family. The building was built in 2000, there are 8 persons live in this flat, surround by roads from north and west but from south and east surround by residential building. Due to scarcity of land there is less than one meter between the building and other building from east and south. Finally the area for the study case flat is 144 m² with 4 bedrooms, living area, kitchen, WC and bathroom, energy bill in this flat its high comparing with other flats in the same conditions due to using of air conditioners and heating facilities.


Figure 4.1: Site Location.
Source: Google Earth

Figure 4.2: The Case Study Building.

## 4.3 Design features of the case study building

### 4.3.1 Planning Aspects:

#### *4.3.1.1 Site Analysis*

As buildings in the Gaza Strip are densely packed, it is usually only the front that gets road side exposure. However, this building is sited on a corner plot and thus, it has two road facing exposures .Two roads, 10 meters wide on the northeast side and 8 meters from southwest (Figures. 4.3). Two residential buildings surround the building, one on the southwest and the other on the southeast. The distance between the case study building and the neighbor is 1 meter on the southwest and on the southeast is 0.2 meter (Figures. 4.4,4.5,4.6). The proximity of the surrounding buildings has both positive and negative effects. Negative, because they create windbreaks by impeding desirable breezes, block daylight from penetrating and disturb privacy; positive, because the surrounding buildings provide shade.

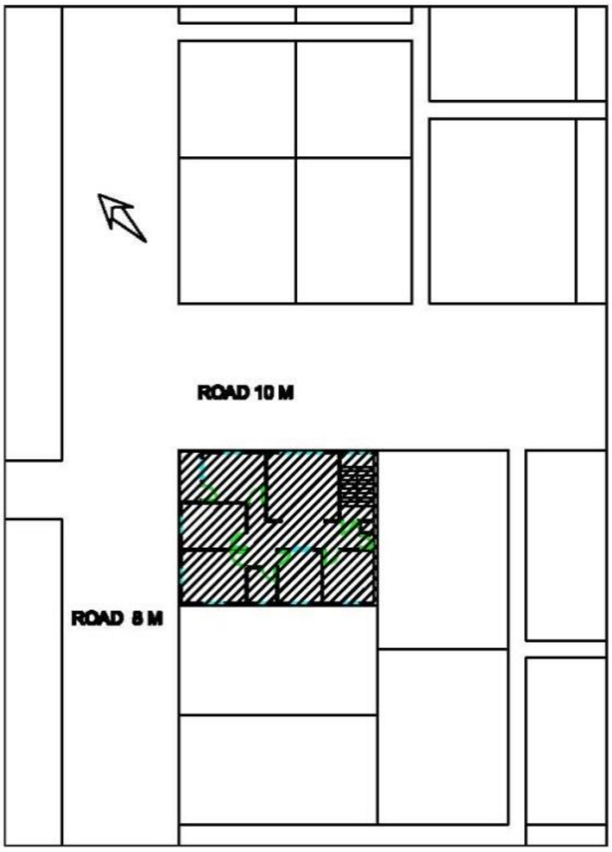



Figure 4.3: Site plan of the case study building

Figure 4.4: Two roads on the northeast and southwest side of the case study building

Figure: 4.5: The case study building and the building next to it on the northeast side

Figure 4.6: Case study building and the building next to it on the southwest side

*Building form:*

The building has a compact shape, unlike the form suitable for hot climates. Spread-out forms is suitable for hot climates. The compact shape recommended only if buildings are to be dependent on air conditioners. A discussion with the owner and architects of the building revealed the reality concerning the building form. The compactness of the form was not intended to support air conditioning. In fact, it had nothing to do with air conditioning. The compactness of the form was a result of maximum utilization of floor area.

### 4.3.1.2 Building orientation

The long axis of the building runs northwest- southeast, i.e. the facades on the southwest and northeast are bigger than the northwest and south elevations (Figure: 4.7). The orientation of the case study building is not like the best orientation for buildings in hot climates that is the longer axis of the building to lie along east-west direction to avoid solar heat gain. Protection from solar heat gain on the west and east were not the guiding factors while orienting_the building. The outline of the building follows the layout of the site. It is all about using every square cm. The orientation for wind flow is a problem only on the southeast side and in future southwest side because of the phenomenon of windbreak. The surrounding buildings on east and south are so close that they block the airflow.

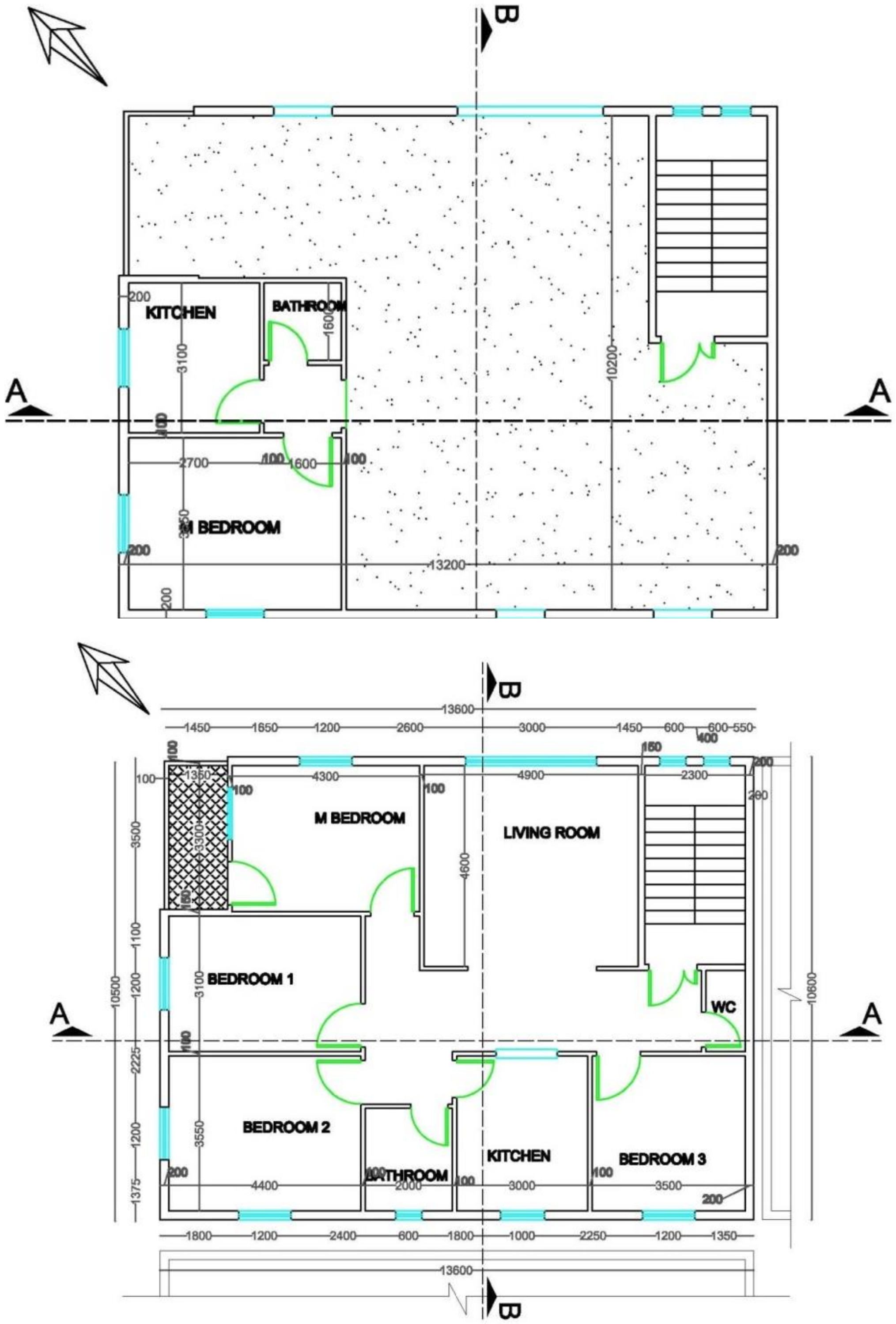



Figure 4.7: First Floor plan (bottom) and Roof plan (Top) showing the longer axis oriented towards the northwest-southeast direction

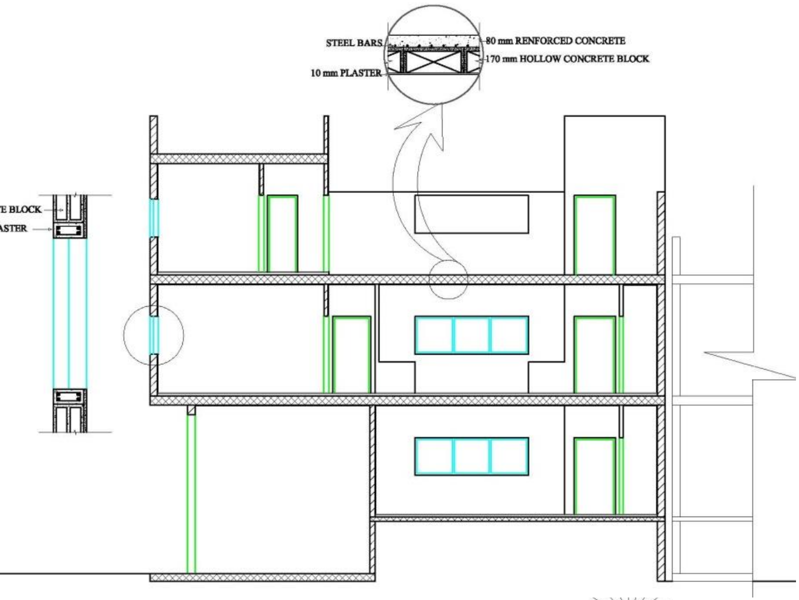



Figure 4.8: Section A-A

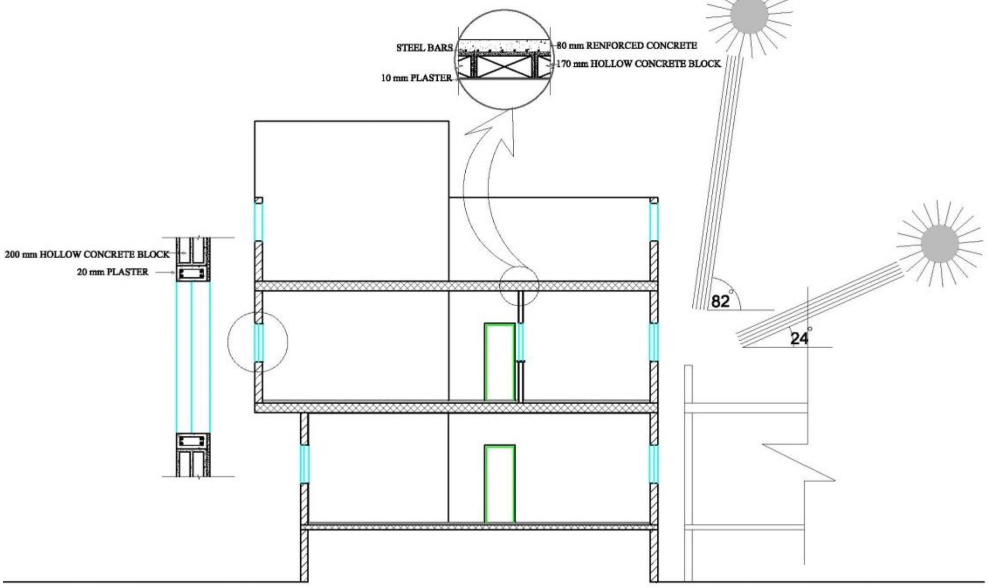



Figure 4.9: Section B-B

#### *4.3.1.3* *Rooms arrangement*

The arrangement of rooms depends on their function and according to the time of the day they are in use. The household of the flat was interviewed about their occupancy pattern and the functions they perform in different rooms. There are 8 residents in the flat, 2 of those residents stay at home throughout the day, the living room and bedrooms are the most using spaces and the location of television in living room and one other bedroom. Observation and interview demonstrate that living space is the most frequently used room in the flat and it is used as a dining space also (Figure 4.10). The reason why the living space is the most used space is because the family members catch up with each other and have meals together in the living space and the television is located in the living room. Watching television is the most common way of spending free time. Public spaces are so limited and have shrunk so much that people rely on watching television for relaxation and to pass time after they get home from jobs and schools. Bedrooms were the second most used rooms

Figure 4.10: living space.

Besides arranging rooms according to their function and time of the day they are in use, detaching main rooms from rooms with internal heat load such as kitchens. The kitchen in the case study building is located beside a bedroom on one side and toilet on the other side. The internal heat gain from the kitchen is likely to get transmitted to the bedroom and raise the temperature of the bedroom. In addition, condensing units of split air conditioners in certain rooms of the flat are fixed on the exterior walls that contain the conditioners. These condensing units not only raise the temperatures inside the rooms by transmitting heat, but also spoil the aesthetic quality of the building's external facade.

#### *4.3.1.4 Rooms orientation*

The master bedroom, the bedroom beside the living room and the living room are located on the northeast and therefore heat up in the morning. The household of the flat has put up curtains in two layers in 2 bedrooms for protection from solar heat gain (figure 4.11) and the master bed have balcony in northwest side so it has its own shade. The flat have air conditioners in the master bedroom and other bedroom located in southwest and the family think about paying one more air conditioner for the third bedroom located in southwest (figure 4.12)

Figure 4.11: Two layers of curtain and A.C in bedrooms (located on southwest)

Figure 4.12: A.C in master bedroom and other bedroom (located on southwest)

#### *4.3.1.5 <u>Landscape</u>*

Proper plantation of trees to save energy and provide many other benefits. Due to dense construction in the Gaza Strip there are no enough areas to plant big trees that can provide shade .The setback space between the building and the boundary wall of blocks, however, is not adequate to grow big trees.

### 4.3.2 Building Envelope

#### *4.3.2.1 <u>External wall and building material</u>*

All external walls are of 200 mm hollow concrete block without external finishing as show in figure 4.13.

Figure 4.13: External wall without any finishing.
Adopted by Author

It was explained in the section on external walls in the literature review that fitting 50mm expanded thermal insulation to the outside of concrete block walls on southwest side and southeast but in northeast due to the closed building the 50 mm polystyrene insulation fitting to the inside covered by gypsum board (figure: 4.14), previous studies proved that can reduce heat fluctuations by 63%. This can lead to a 10-14% reduce on in energy requirements with 8-10% in air conditioning use. Covering the exterior surface of the walls in smooth stucco painted white can mean 70-80% of incident solar radiation is reflected, compared with about 50% for most commonly used finishes.

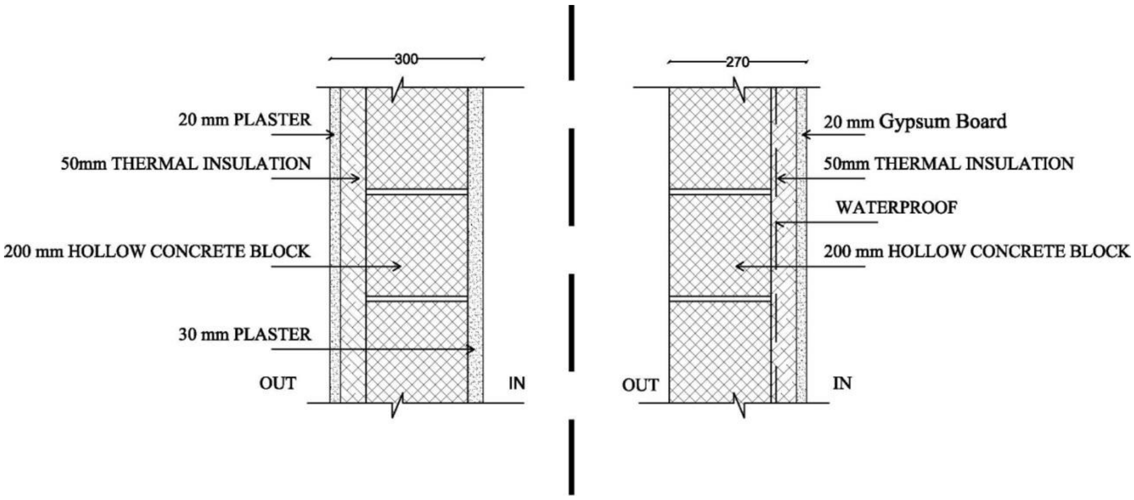



Figure 4.14: External wall external and internal insulation.

Adopted by Author

#### 4.3.2.2 *Thermal Insulation*

In general, residential buildings in the Gaza strip do not have thermal insulations. In the case study building, neither walls and windows nor roofs, have any type of insulation. Now some architect and owner start using thermal insulation method like double wall with 50mm air cavity and external polystyrene insulation material as shown in figure 4.15 and 4.16

Figure 4.15: Double wall with 50mm air cavity (under construction building)

Figure 4.16: Polystyrene material for external insulation.

#### 4.3.2.3 *Roof*

Roof section in this building shows three parts: 8 cm layer of reinforce concrete, 17cm layer of hollow concrete blocks, and 1 cm layer of plaster figure 4.17. Roof is used by the residents for hanging laundry and as a community space.

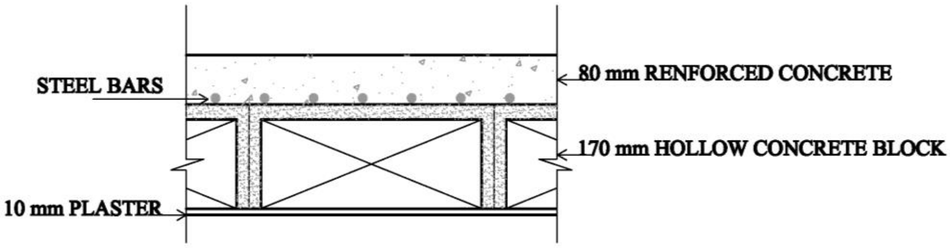



Figure (4.17): Existing roof
Adopted by Author

The option of using a 250 mm concrete roof covered with 50 mm of thermal insulation (polystyrene), 50 mm of foam concrete, 20 mm of moisture insulation, 25 mm of sand, and 10 of tiles, respectively from bottom to top, can be used to protect roof from solar radiation and reduce energy used to cool the spaces. (Figure: 4.18)

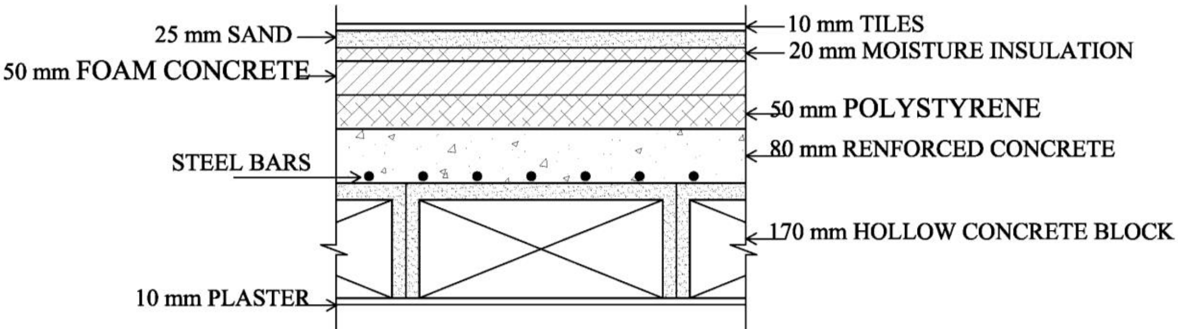



Figure (4.18): Roof insulation
Adopted by Author

### 4.3.2.4 Windows

- *Size & Location*

The windows are sliding with aluminum frame and have 5 mm thickness tinted glass. The opening of these sliding windows is limited to 50% of the window size and so is not good for providing airflow in particular. The windows have sliding insect nets. These insect nets also provide hindrance to airflow.

The window to wall area ratio in the flat was calculated by dividing the window area by wall area. The results are presented in table 6.1. Analysis of the results for the flat shows that the living room space have window to wall area ratios (WWR) of 0.21. The values are below the recommended value for sustainable windows design. Sustainable windows design recommends that the optimum window to wall ratio should be equal to 0.24.Even though the value of WWR in all bedrooms is below the recommended value.

Table 4.1: Window to wall area ratio of rooms (WWR).
Calculated by Author

| Room | Window orientation | Window size ($m^2$) | Wall area ($m^2$) | Window to wall area ration (WWR) |
|---|---|---|---|---|
| **Living Room** | Northeast | 3.1 | 14 | 0.22 |
| **M Bedroom** | Northeast | 1.2 | 12.3 | 0.1 |
| **M Bedroom** | Northwest | 1.2 | 10 | 0.12 |
| **Bedroom 1** | Northwest | 1.2 | 9.4 | 0.13 |
| **Bedroom 2** | Northwest | 1.2 | 10.1 | 0.12 |
| **Bedroom 2** | Southwest | 1.2 | 12.5 | 0.1 |
| **Bedroom 3** | Southwest | 1.2 | 10 | 0.12 |
| **Kitchen** | Southwest | 1.0 | 8.5 | 0.12 |

The general conclusion that can be drawn regarding the size of the windows is that in all rooms of this case study building, the rooms on the all directions have small windows corresponding lower than recommended values for WWR.

- *Natural lighting and ventilation*

The windows on the all directions of flats are not effective in allowing day light and airflow because of their sizes as discussed above and because of the close proximity of the buildings that surround this case study building on the southwest and there is no windows in the southeast. As a result, the lights in study case need to be kept on throughout the day.

For proper cross ventilation windows should located diagonally opposite to each other. However, the master bedroom and bedroom 2 of all rooms in this flat have provision for cross-ventilation through two pairs of windows located on side walls. But, as the location of the outlet is very close to the inlet, most of the space inside the room is unaffected by the air current.

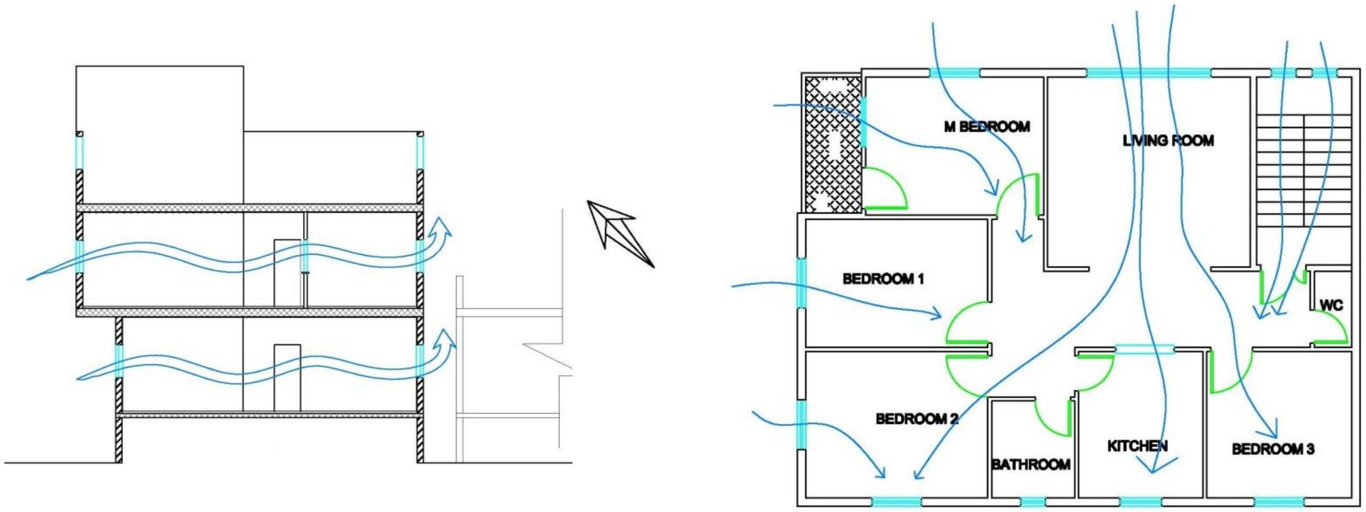



Figure (4.19): Plan and section show natural ventilation
Adopted by Author

- *Shading devices*

Shading devices are needed in the Gaza Strip to ensure protection the rain and solar heat gain; the shading devices of windows in the case building were analyzed using one of the methods explained in literature review that method is compound shading devise (figure 6.20) which preferred to use in southeast and southwest façade since it protects the façade from horizontal and vertical solar radiation. The analysis of shading devices for windows demonstrate that shading devices are absent in the case study building.

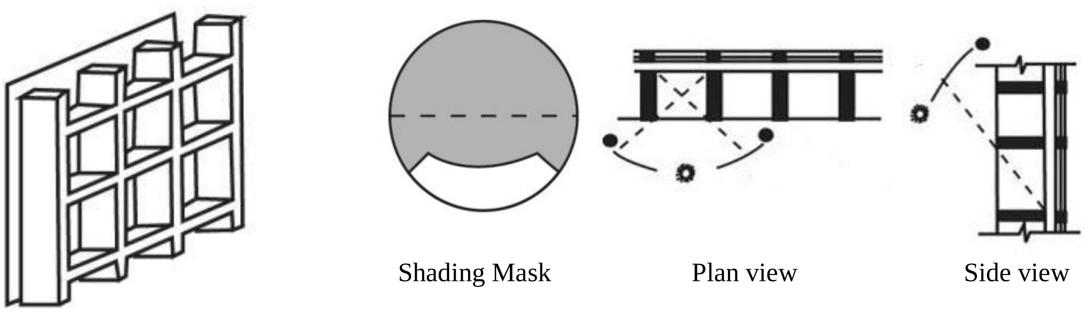



Figure 4.20: Compound shading device.
Source: Ministry of Local Government Palestine

# Chapter 5: Recommendations and Conclusions

## 5.1 Energy Surety in Gaza Strip

Energy crises in the Gaza Strip push us to start investigating new energy alternative for energy security. Energy security includes the saving of enough and reliable energy supplies to satisfy demand at all times and at good prices, while also avoiding environmental impacts. In light of the political context in the Gaza Strip and in relation to many conditions of energy and electricity supply problems, sustainable energy can play a key role in guaranteeing energy security in the long-term. Availability, reasonably price and sustainability of energy supply are interlinked facets of overall energy security.

## 5.2 Passive design features

The literature review in this study contains a list of basic principles in passive building design. Out of the numerous passive design features that were discussed in the theoretical framework, only those features have been chosen that can meet the purpose of this study and can be applied in the context of the Gaza Strip. The features that have been selected pertain only to the building envelope, reduce heat gain by the buildings, and they mainly reduce the energy use for cooling. It needs to be strictly emphasized that the chosen features reduce only the cooling energy; the features do not influence the energy used for electrical appliances. It must also be stressed that as this study focuses on possible energy savings by adopting low energy design features, only those low energy design features have been selected that quantify the energy savings. It can be recalled that the use of external thermal insulation for external wall in south and west façades reduced cooling energy and is adaptive for the context of the Gaza Strip. Use of thermal insulation for the roof reduced cooling energy and can also be applied for the Gaza Strip's context. Appropriate shading devices on all southeast and southwest also indicated energy savings and are suited for residential buildings in the Gaza Strip.

The research front has thus been summarized to formulate the adoption of the following low energy features in the Gaza Strip:

1- Cooling load can be reduced by using external insulation from 50 mm polystyrene for external walls 200 mm hollow concrete block in south and west façades instead of 200 mm hollow concrete block external walls as is the general practice.
2- Using a 250 mm reinforcement concrete roof slab covered with 50 mm of thermal insulation, 50 mm of foam concrete, 20 mm of moisture insulation, 25 mm of sand, and 10 of tiles, respectively from bottom to top, can be used to protect roof from solar radiation and reduce energy used to cool the spaces.

3- Using of compound shading device in south and west help with saving energy used for cooling.

## 5.3 Barriers in adopting passive strategies in residential buildings.

### *5.3.1 Barriers related to designing passive buildings.*

Passive building features have been identified in this study through literature review. The study also shows the proficiency of these passive design features. Despite the effectiveness of these features, there are barriers that may impede the construction of passive buildings. Based on the experience of the construction sector and on the way architects, work and how the families behave, the roles of these actors involved in the process of designing passive building are explained below to identify the barriers.

#### *5.3.1.1 Role of owners*

Owners are unaware of the role they can play in mitigating the energy crisis of the Gaza strip. They need to be explained about the necessity of passive design strategies. Owners interested in maximum profits through lower construction costs and maximum utilization of land. The different passive buildings features can only be implemented if the owners are prepared to pay the extra costs and compromise with reduced floor area. Owner should know that there are many economic benefits for implementation of passive buildings features that reduce the energy use and energy bill as well that is besides improving interior comfort and better indoor air quality. Barriers in the form of behavioral characteristics of residents, their lifestyle and split incentives can also obstruct the energy efficiency of residential buildings and are discussed as follows:

- Behavioral characteristics of residents

Even if a building is designed with energy efficient features, behavioral characteristics of individuals are in fact a great obstruction to achieving energy saving in residential buildings. However, it should also be noted that their results are from a different cultural setting. Small, but easy practices such as switching off the lights when leaving a room are often ignored. Using higher set point temperatures for air conditioners instead of lower temperatures like 24°C, can also achieve energy efficiency.

- Lifestyle of residents

The lifestyle of the higher income groups contradicts with the notion of energy efficiency. In such cases, a well-designed passive building can fall short of its endeavor. For example, using air conditioners in each and every room, latest and biggest appliances irrespective of their energy use and plenty of trendy lights such as spotlights, chandeliers in an interior decorated house is a matter of status symbol for the upper income groups.

#### *5.3.1.2 Role of architects*

We as architects in the Gaza Strip are not fully aware of the energy situation of the country. We have little knowledge about the possibilities, techniques and potentials of energy efficiency design solutions. Architects need more information and technical skills to design low energy buildings. Even if the architects are well-informed about passive design features, they might still not be able to use all the passive design features, because the architect is not the only actor in the design process who can bring changes. We are appointed or hired as consultants by the owners and under constant pressure from the owners to maximize space utilization with minimum construction costs. Unless the owners are very keen in including passive design features, architects cannot take the entire responsibility of designing passive residential buildings.

#### *5.3.1.3 Role of Israel occupation*

Israel is imposing a siege on the Gaza Strip since 2007, and due to this siege, construction sector has been one of the most affected sector. Considering that the construction in the Gaza Strip is very typical and traditional. Now the most used materials are the traditional building materials, and these materials are not allowed in the Gaza Strip most of the time.

Some projects before 2007 were designed some special purpose materials, like insulation materials, those materials were allowed or not allowed in the Gaza Strip after a long series of procedures and security considerations by Israel and this depends on the nature of the projects. Having a strategy for passive design in the Gaza Strip will require special arrangements with Israel.

### *5.3.2 Recommendations for overcoming barriers.*

Different roles of architects and owners that act as barriers in achieving energy efficiency in residential buildings have been discussed above. These barriers can be overcome by the following changes in design practice.

Architects need to learn about the importance and problems of achieving energy efficiency in residential buildings and the opportunities of addressing them. The architects can learn about these issues at the university or through journals. The Institute of Engineers and the regulations in the Gaza Strip Building Construction can help the architects and owners to learn about the issues related to energy efficient residential buildings and then based on that knowledge, they can act differently.

The architects first need to brief the owners on the urgency of energy efficiency in residential buildings. Owners need to be explained that the energy efficient design features (wall thermal insulation on facades, use of appropriate shading devices and use of thermal insulation on roof) reduce the cooling energy. Only if the owners are convinced and agree to compromise with floor area and construction costs, the passive design features can be adopted. Owners should be made to understand that though passive design features may appear costly at the initial stage, they can bring back returns and are profitable in the end. Owners should take more responsibility and should not be concerned with maximum utilization of land and profitability.

Collaboration between architect and the owner can help in achieving the overall target of designing passive residential buildings. Once the building has reached a stage where architects hired by the owners, all the actors involved need to sit together. The architect can then explain the passive strategies used and can also recommend the owners to use low energy lights and less trendy lights for the interiors.

In addition to overcoming the barriers in energy efficiency, building codes need to be developed by the Gaza Strip Municipalities to promote and influence energy efficiency in buildings. The Gaza Strip Municipalities can formulate building regulations for low energy residential buildings. These regulations or building codes would help the owners and the architects to overcome the barriers and implement the energy efficient design features in the residential buildings of the Gaza Strip. The focus of the codes should be to incorporate low energy design features right from the design stage.

## 5.4 Conclusion

Considering the significant amount of energy used by the residential buildings in general and the prevailing energy crisis in the Gaza Strip, it is important to overcome the barriers and adopt the reasonably simple passive design features highlighted in this study that reduce the total energy use of the case study flat by a factor of one third and also provide comfort to the households. In addition to the benefits of energy savings from the use of this passive design features, improving the energy efficiency of the residential buildings in the Gaza Strip can also result in *reduced energy costs to users, improved supply of electric energy as a result of the decreased use of energy by the residential building sector, reduced dependency on energy suppliers as Israel and Egypt and finally it can also play a role in lowering greenhouse gas emissions.*

Once the design features are identified and the energy savings are demonstrated, the next emerging questions are: ‘Who is going to bring a change in the design practice? Who is responsible for the design of low energy residential buildings?’ As evident from the section on barriers in adopting passive strategies in residential buildings, the process of designing passive residential buildings is not a ‘one-man’s show’. It is just not the architect who is responsible for designing passive residential buildings and changing the design practice.

Owners are the other actors who can bring a change in the design practice. All the actors are closely intertwined. The architect, with increased knowledge and awareness can be the initiator of designing low energy buildings and the change in design practice. The architect should influence the owners.

At the end you conclude that it should be of importance to “convince people in Gaza” about the possibilities given by passive strategies to

- Reduce their energy demand
- Reduce their energy bills
- Reduce dependence on suppliers (Israel and Egypt)
- Improve interior climate
- Better indoor air quality
- Lower carbon emission

Passive strategies for the outdoor environment should be studied for establishing new codes and norms for planning.

The role of the architect becomes important in this context. The work of convincement of people in Gaza could be done also by architects through information, demonstration projects of implementation of passive strategies, and proposing good and affordable solutions. The architects should also contribute to the establishment of new building codes adapted to the specific situation in Gaza Strip.

Finally: what is good for energy security in conditions of war is also good for the future and for a more sustainable living in Gaza.

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