MOHAMMED ALI SALEH ALI

SHADING AND AIR FLOW ANALYSIS ON SELECTED RESIDENTIAL BUILDINGS IN AL - BAYDA CITY, LIBYA

NEU 2019

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A THESIS SUBMITTED TO THE GRADUATE SCHOOL OF APPLIED SCIENCES OF NEAR EAST UNIVERSITY

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In Partial Fulfillment of the Requirements for the Degree of Master of Science in Architecture

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that as required by these rules and conduct. I have fully cited and referenced all material and results that are not original to this work.

Name, Last name:

Signature:

Date:

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Finally, I wish to thank my parents and family for loving me, and for supporting me every step in my life.

To my parents…

ABSTRACT

An enormous quantity of residential properties were recently constructed in Libya offers a poor quality interior. A lot of energy is required to provide a comfortable interior with air conditioning systems. Furthermore, the use of high energy in buildings has made an important contribution to climate change and air pollution. It is crucial for energy efficiency to reduce energy consumption. Thermal comfort in residential buildings can be provided by applying the architectural principles of climatic design.

In order to reduce the energy consumption, some domestic buildings in Al Bayda Libya are studied. The study provides detailed survey of these buildings. The building plans are analyzed according to their shading and air movement opportunities

In this research, an analytical study was conducted on the climate factors that affect the energy consumption in the residential buildings in the city of Al-Bayda Libya. Nine buildings were randomly selected. The impact of solar energy, orientation and wind factors that affect the climatic comfort on the selected residential buildings are considered as the main indicators for improving energy consumption. These topics are studied comprehensively on the selected samples and outcomes of the analysis are evaluated. At the end, simple constructional applications which can prevent high energy use are recommended for future architectural designs. By this way, extensive use of air conditioners and thus air pollution which has become one of the major problems in the cities of Libya can be reduced to a certain extend.

Keywords: Air conditioners; energy consumption; orientation; climate design; shadow analysis

ÖZET

Libya'da yakın zamanda inşa edilen çok sayıda konut tipi binada, konforsuz bir iç ortam sunulmakta ve bununla beraber iklimlendirme için de çok miktarda enerji gerektiren klimalar kullanılmaktadır. Doğal olarak, binalarda kullanılan yoğun enerji hem hava kirliliğine hem de iklim değişikliğine yol açmaktadır. Bu çalışmada, iklim faktörlerini dikkate alarak yapılan mimari tasarımların önemine ve buna bağlı olarak, enerji tüketiminin azaltılmasıyla, konut binalarında ısıl konfor sağlanabileceğinin önemine vurgu yapılmıştır.

Tezde, Libya'daki konutlarda enerji tüketiminin azaltılması amacıyla incelemeler yapılmıştır. Alan çalışması olarak, Al Bayda Libya kentinde bir dizi bina seçilerek, oluşturulan kriterler çerçevesinde analiz ve değerlendirmeler yapılmıştır.

Çalışma kapsamında, Al-Bayda, Libya kentinde dokuz adet tek katlı bina rastgele kent dokusu içerisinden seçilmiştir. Bu binalar, doğal konfor ortamının oluşmasında önemli rol oynayan, güneş enerjisi, yönlenme, ve iç – dış hava akımlarının etkenleri esasında incelenmiştir. İnceleme sonunda enerji korunumunu sağlayacak basit ve çevreye uygun mimari çözümlemelere dayalı öneriler yapılmıştır. Böylelikle, Al-Bayda kenti özelinde ve Libya genelinde klimalar dolayısıyla yoğun enerji tüketimi sorununa ve dolaylı olarak hava kirliliğine belirli oranda çözüm getirilmesi hedeflenmiştir.

Anahtar Kelimeler: Klimalar; enerji tüketimi; yönlenme; iklim tasarımı; gölge analizi

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CHAPTER 1
INTRODUCTION

1.1 Background About Research

In order to achieve the equation of energy-saving housing, have to reconcile with the environment, which is one of the most important sources concern for the modern man and the source of danger that threatens mankind in the continuing terrible increase, and so we cannot Ignore them and the need to avoid collisions with them because they are the strategic choice to preserve the future of humanity. In our approach to the environment and its preservation of pollutants, do not only provide energy consumption, but create a healthy climate free of pollution, both outside and inside the building because pollution inside the house is more dangerous than external pollution. Human beings live in temporal intervals inside buildings rather than outside and windows are closed most of the time. Frequent use of air conditioning as a contributes to reduce the entry of the sun and air flow inside the building, which contributes to the spread some diseases.

The return to nature and the environment balance and stability and the presence of long-lived buildings that contribute to the preservation of the heritage and identity of the architecture belonging to the place and reduce the cloned buildings of one model has not changed for years, is the model that was adopted in the convenience and security and beauty on the mechanization and that function has been depleted our economy and waste our energy and return to laziness and help spread diseases.

This call for reconciliation with the environment does not mean that we return to the old thought and adopt it as it is because it was found in a time other than our time and with a simple technique and limited use materials, the scientific, technological and industrial revolution contributes to the expansion of our horizons and provides us with the facilities that enable us to take all that is good in the old thought and employ it in line with our time in order to create an architecture with a temporal, local, authentic and rooted identity, Historical.

1.2 Statement of the Problem

A large number of recently built residential buildings in Libya provide an environment of a poor quality that requires a great deal of energy to provide a comfortable internal environment. Unpredictable power consumption in Libya has led to the need for a pause to correct the way energy is treated, which can lead to many problems. In addition, increase in population correspondingly increases energy consumption. Therefore, energy is the problem of the future, making it the top scientific and applied research in various parts of the world.

So, the need arises to try to find out ways of creating a comfortable natural environment with passive systems. As known, passive systems are a kind of architectural layout focusing on energy efficiency, which aims to create a climatically comfortable environment for people without the use of any mechanical and electrical system.

1.3 Aim of the Thesis

The aim of this thesis is to analyze single – storey houses in residential areas of Al-Bayda - Libya, in terms of orientation, shadow areas, natural ventilation and site plan decisions which are important criteria of passive system design and also, to put forward positive and negative design decisions on selected examples.

Thus, within the framework of the analysis criteria discussed, it is aimed to make suggestions for future architectural layouts, in order to increase energy efficiency.

1.4 Methodology

The study was carried out in three main phases. The theoretical framework for this study was defined in the first stage. Furthermore, the analysis methodology and the issues investigated in the case study were identified. The first phase included extensive book reviews, journal papers, investigations and documents to identify the energy efficiency of the principles of a residential building to be utilized.

The second phase includes a field consists of the field visit and is working on an interview and examination of nine buildings. A case study of the building collects quantitative and qualitative data. During this phase, all information will be analyzed to meet the architecture described in the conceptual framework.

In the third stage, analyze and produce results (as regards integration in the thesis structure) and discuss the objectives and recommendations, Table 1.1. A framework developed for shading and air movement analysis of the buildings. The framework was divided into three basic parts. In the first part, general information about building location, plans, sections, elevations, sizes, materials etc. are mentioned. In the second part, shading analysis (by using Autodesk Revit) and airflow analysis of buildings are done on a theoretical basis. In this part, user's responds to solar and ventilation effects is also reflected. By this way, the compatibility relation between analysis and user's responds could also be seen.
The third part of the framwork used for the evaluation of the shading and air movement facilities of the building.

Table 1.1: Framework for shading and air movement analysis

	PLAN	SECTION	PHOTO	FINDINGS
GENERAL INFORMATION				
SHADE ANALYSIS OF BUILDING	USER`S RESPONDS ON SOLAR EFFECTS	AIR FLOW ANALYSIS	USER`S RESPONDS ON VENTILATION EFFECTS	
SHADOW AND MOVEMENT ANALYSIS OF BUILDING				
EVALUATION				

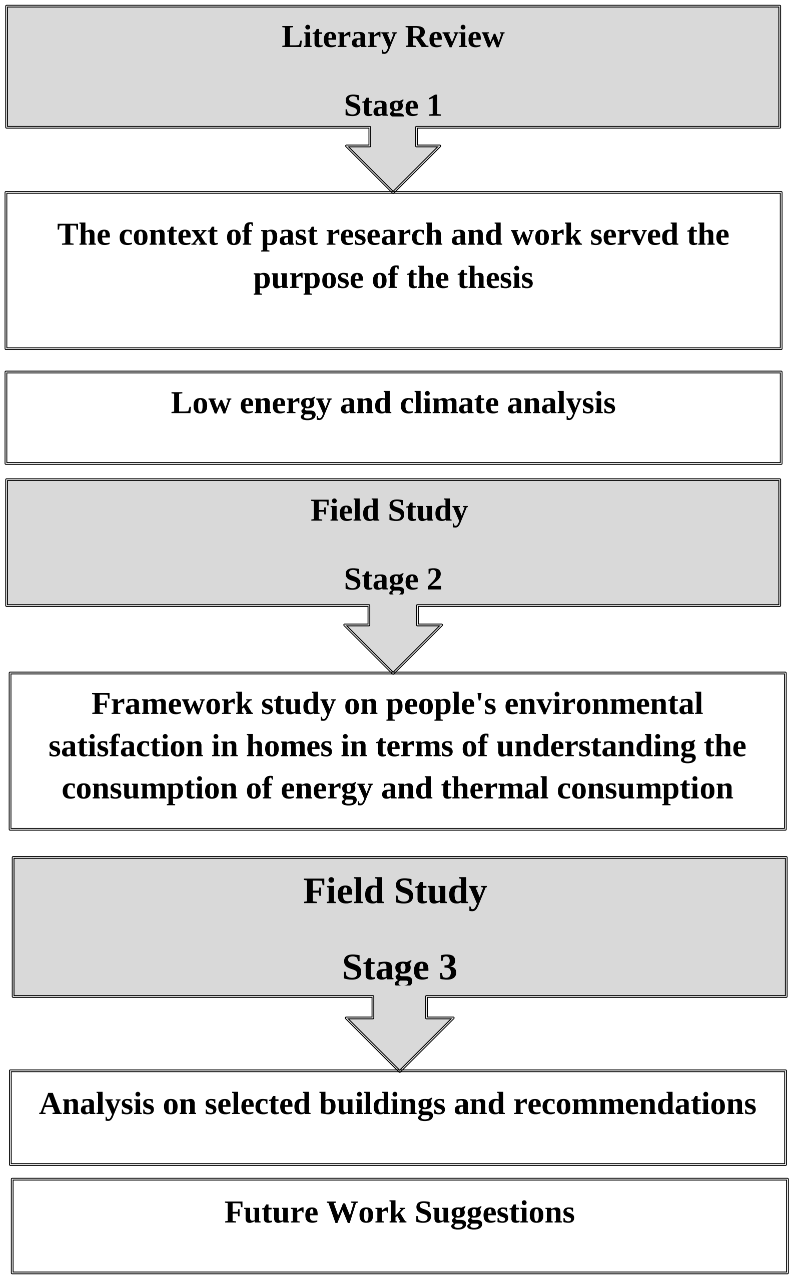


Figure 1.1: The plan shows the study's methodology

CHAPTER 2

THEORETICAL FRAMEWORK

In this chapter, the importance of passive design strategies is emphasized. As it is known; orientation of buildings, solar control, choice and use of materials, use of water elements and form of building, air-movement control and daylight control are the main factors which are considered in passive design strategies. The strategies are interpreted in several ways. Some of them are mentioned in Table 2.1.

Table 2. 1: The topics of the passive design strategies are presented by some researchers (Altan et al, 2016; California sustainability alliance, 2016; **Passive** design, 2019; Whang, 2014)

PASSIVE DESIGN STRATEGIES			
Hasim Altan et al	**Passive design handbook**	**Passive solar design strategies**	**Passive Design Toolkit**
• Orientation	• Climactic considerations	• Use of mechanical Systems	• Passive Solar Power
• Building Shape (Massing)	• Passive cooling and ventilation	• South-Facing glass	• Orientation.
• Choice of Materials	• Passive Heating	• Thermal mass	• Interior Layout
• Landscaping (Heat Island Effect)	• Lighting controls and dayligting	• Orientation	• Insulation
• Water bodies and vegetation (Micro-climate)	• Passive water strategies	• Site planning for solar access	• Windows (glazing)
• Daylighting		• Space Planning	• Lighting
• Space Conditioning			• Ventilation
• Passive Cooling			• Thermal mass
• Preventive Techniques			
• Natural Ventilation			
• Radiative			
• Evaporative			
• Earth Coupling			
• Passive Heating			

Ramos, at all. (2014), mentions that “orientation” is one of the most important factors to be addressed in passive design. This is because orientation influences; air movements in and around buildings, solar radiation loads, topography, nearby buildings, etc. In this context, the chapter is structured on importance of orientation, solar shading and air movements. Daylight effect is not included in the chapter as it is not considered in the analysis of selected buildings.

2.1 Passive Design Strategies in General

Some passive construction components have intrinsic synergies and can be joined together to improve comfort and power efficiency in distinct ways.

The incorrect combination of components or the use of certain in-isolation components can have negative effects on thermal comfort and energy efficiency. In order for large south-west windows for passive solar heat to achieve the desired overall building efficiency gains, for example, they must be used in conjunction with high-performance windows or external shading, in order to protect the interior from excessive solar thermal gain during the summer. Figure 2.1 below demonstrates an illustration of how multiple passive components can be combined in a typical Vancouver construction in order to ensure continuous heat comfort. The baseline complies with ASHRAE 90.1 minimum criteria. As each extra component is integrated, the annual energy consumption is further decreased so that the effectiveness is ultimately high (Robertson, 2009).

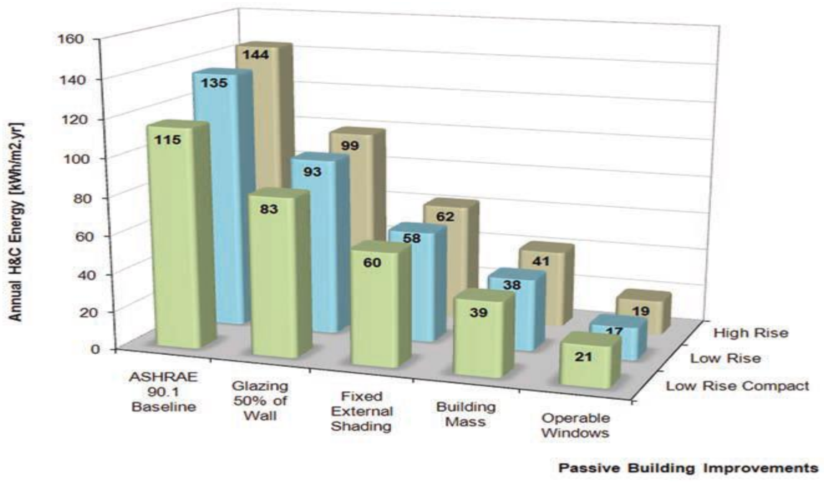


Figure 2.1: Effect of Passive Design on Energy Intensity (Robertson, 2009)

2.1.1 Orientation

In the passive house, the first basic principle is the orientation towards the equator in the north hemisphere (and the northern façade to the west in the southern hemisphere).

The longer dimensions of the home faces are more probable to achieve the highest solar radiation by facing the long east-west axis of the construction. Therefore, in this portion of the construction there should be places that are most frequently used, like kitchens and living rooms.

It is also beneficial for cooling summer situations since the East-West facades are minimized in the morning and evening (Esru, 2019). See Figure 2.2.

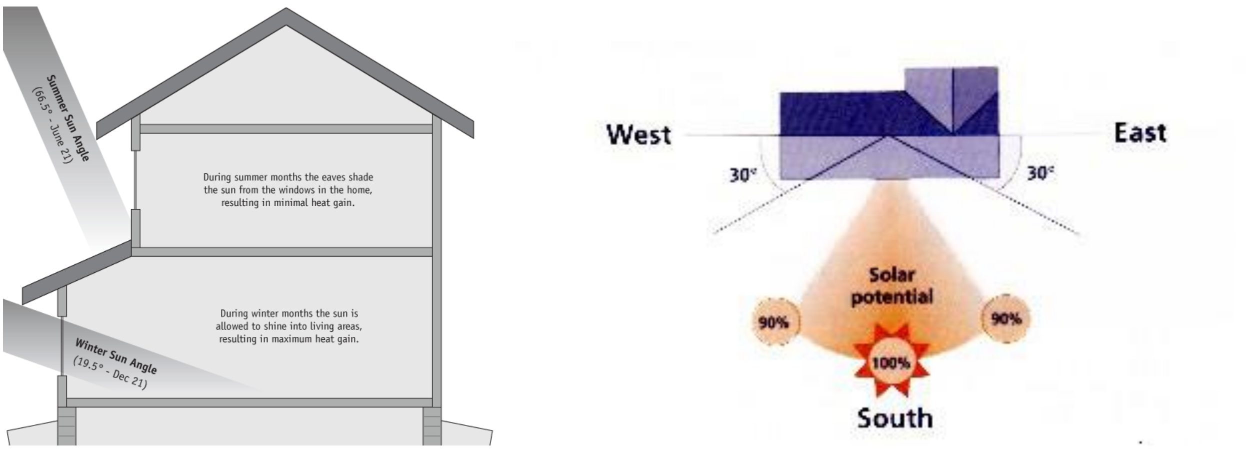


Figure 2.2: Orientation and solar gain (Esru, 2019)

Orientation is also important in terms of air movement for indoor and outdoor spaces. Spaces should be prevented from undesirable winds during winter, while benefited from desirable winds in summer.

At the same time, orientation is important for natural daylighting. When making lighting choices, it is essential to take into account the fact that proper design and orientation of the construction can decrease the artificial lighting requirement and thus enhance occupant convenience. The structure must react to the sun's route, which provides adequate natural light through windows.

The windows to the South offer plenty of light and energy benefits, while the windows to the North offer a diffuse light with minimal solar gain.

In order to balance the interior lighting needs, a good passive structure should place windows in various directions. The right approach allows for varying light levels and light quality in accordance with the lighting needs of every room; direct lighting in kitchens, offices and workshops as well as reflecting or diffusing light in each living room or bedroom (Wimmers, 2009)

- Use various screen orientation for balanced rates of lighting
- Choose room-based lighting systems, see Figure 2.3.

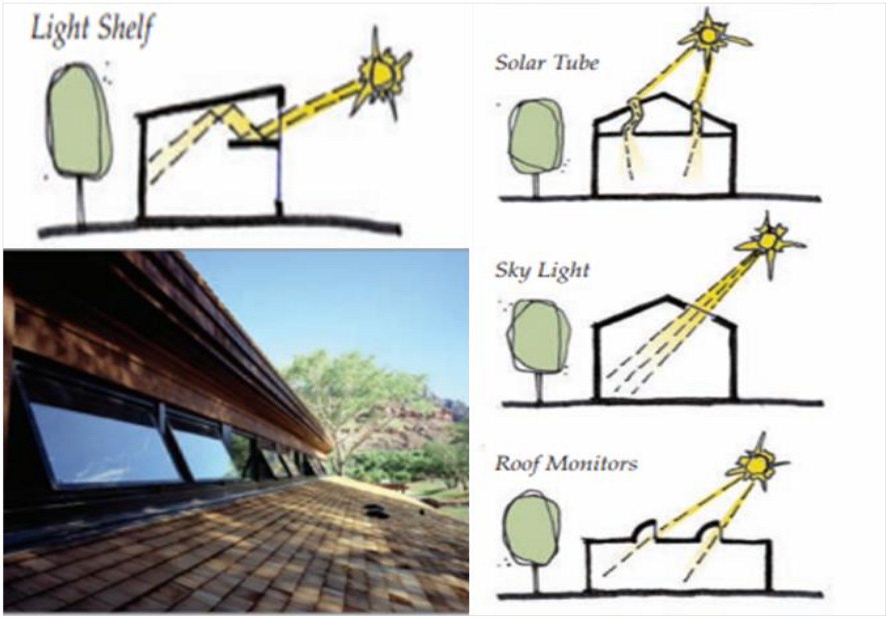
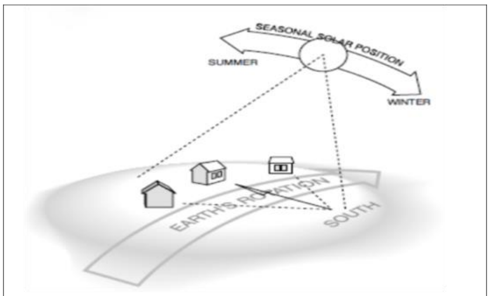


Figure 2.3: Types of daylighting (Wimmers, 2009)

As mentioned before, construction orientation is an important factor in design, particularly as far as wind and solar radiation are concerned (Al-Tamimi et al. 2011). The orientation has an effect on some of the variables, such as daylight, ventilation and air conditioning that contribute directly to total energy consumption, and thus achieve an optimized orientation plays a key role in reducing energy conservation.

The sun is rising in the east and setting in the west. The side of the building used to achieve solar efficiency must face to the south in order to maximize the potential energy of the sun. If the building's axis is located east – west with its longest size faced to the South, the building will absorb the heat energy of the sun more effectively. Passive solar structures with a lengthy side to the south of the building are typically rectangular. The distance from the input thermal source (south) to the absorption location (typically a northern wall) must be kept to a minimum. It is rectangular in form (Green Passive Solar Magazine, 2019).

<u>South facing windows and orientation:</u> As the difference from the real south increases, the structure's general solar potential reduces. In other words, the more southern degrees vary, the less solar gain the building has. Consequently, the construction may require big quantities of additional energy in winter. As the glass of the building faces further southwest, more energy may be necessary for summer refrigeration Figure 2.4 (Green Passive Solar Magazine, 2019). See Figure 2.4.



If the building in the middle were longer, stretching toward the two houses located on either side of it, more of its mass would be ideally situated to absorb and radiate heat in the winter

Figure 2.4: Orientation to the south (Green Passive Solar Magazine, 2019)

In the summer the sun penetrates only marginally into the interfaces and openings, while in the winter solar energy can be accessed when the sun's way is less so (Rosenlund, 2000)

There are several methods which tries to find out the optimum orientation of buildings depending on their climatic zones and local climatic data such as (Varoglu et al., 2017);

- “Sun method” which consider mainly solar radiation from windows
- “Rogers et al, method” that considers cooling loads
- “Shewiv method” which focuses on desired shading periods

- “Etzion method” that considers better design for shading
- “Ok method” which interpreted mathematical formulas to find out the shading areas of shaded parts.

Already there are many methods to find out ideal orientation, but this is not the main aim of this thesis, as effect of sun and wind will be studied on the existing buildings.

2.1.2 Solar shading

Solar shading is important for cooling structures and also preventing excess heat gains. Solar shading must be designed very carefully so that it will protect building in summer but allow sunlight in winter (Kamal, 2012).

2.1.2.1 Shading by overhangs

Overhangs and shading in a passive house are significant equipment because they contribute to decreasing overheating over the summertime. Consequently, it is extremely essential to size the equipment correctly. To prevent overheating and keep house cool in summer months, the southern façade through which the Sun mainly flows must be properly shaded or fitted with size hangings. The device should be carefully designed to ensure that the size and inclination (if needed) satisfy the need for sunlight during winter and to shade the building in summer. The shade type and degree is always related to the sun and the building's geometry. Simple overhangs are, for example, very effective when sunshine is high in the sky to shade the building in the south façade during the summer (Gheorghe et al. 2013).

However, for the south-west façade, this sort of shading device is not effective to prevent the morning and the evening, if the sun's in the sky. The highest sun angles occur during the solstice in the summer on the 21st of June, but the high temperature and humidity most often occur in August.

Well-designed sun control and shading equipment can dramatically reduce building heat gain and cooling requirements as a part of a building or separately from a building façade and enhance the natural lighting quality of indoor buildings. Depending on the solar orientation of an individual construction facade, efficient shading systems can be developed. For instance, easy, fixed overhangs are very useful in summer when sun angles are high when shading south-facing windows (Kamal 2012). See Figure 2.5.

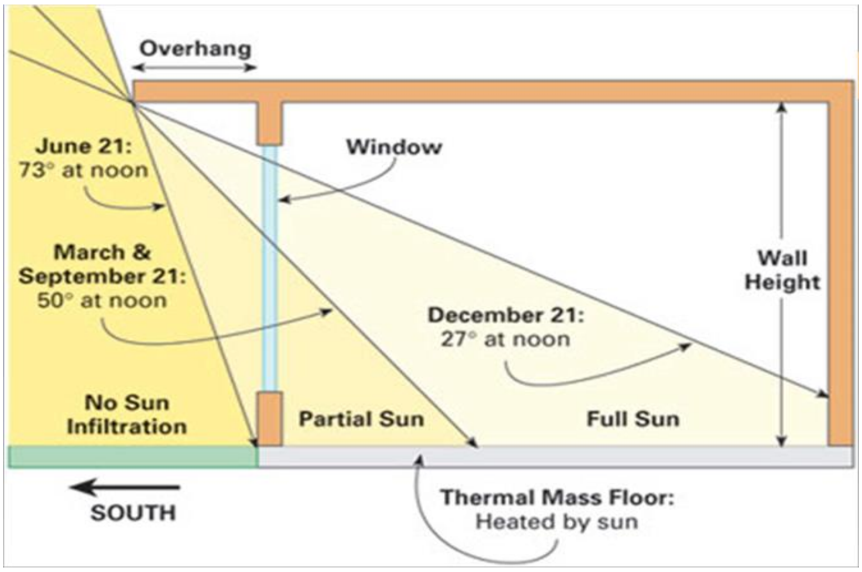


Figure 2.5: Overhangs function in summer and winter (Improving the Thermal Performance of the Building Envelope, 2016)

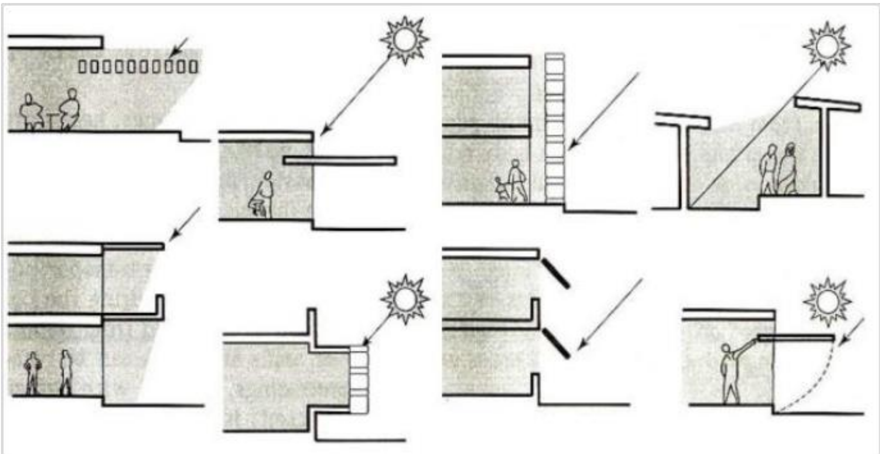


Figure 2.6: Different types of shading devices (Kamal, 2012)

However, the same horizontal device does not work if the low morning sun is blocked from entering windows to the west during peak summer heat gain times (Figure2.6).

2.1.1.2 Shading of the roof

Roof shading is a key way of decreasing heat gain. The roof can be shaded with a cement or plants roof, canvas or pots of earth etc. External shading should not interfere with cooling at night. A cement or galvanized sheet over the ceiling offers protection against direct radiation. This system's disadvantage is that it does not allow the heat to escape to the sky in the evening (Kamal, 2012). See Figure 2.7.

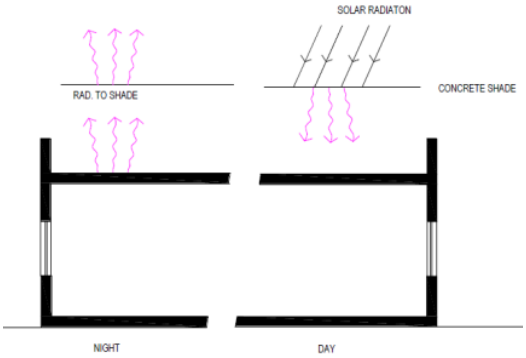


Figure 2.7: Roof shading by solid cover (Kamal, 2012)

A cloak and gravel of leafy crops are a better alternative. It reduces the roof temperature to a point below the daily air temperature. In the evening the temperature is even smaller than in the sky Figure 2.8.

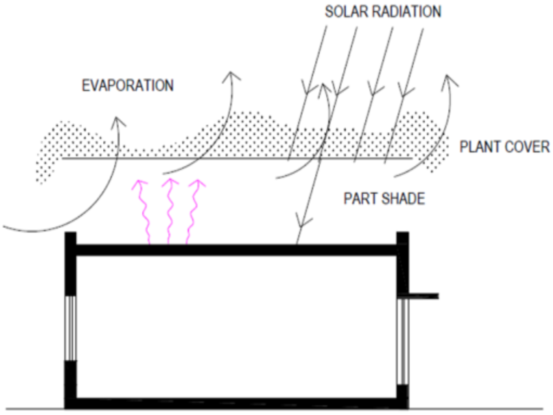


Figure 2.8: Roof shading by plant cover (Kamal, 2012)

2.1.1.3 Shading by trees and vegetation

Proper land-use can be one of the key variables in building energy conservation. In specific vegetation and trees shade and decrease of heat gain is very efficiently. Trees can beneficially be used for shading roof, walls and windows. The process by which a plant actively releases water vapor from the trees can reduce surrounding air temperatures as much as 5 ° C by the shading and evapotranspiration. Different plant kinds (beams, shrubs, vines) can be chosen for the required degree of shading for different window and conditions based on their growing habit (tall, small, dense, light permeable). For the summer shading (Kamal, 2012), we should look at the following points.

1. Summer shade is provided by deciduous trees and breezes but winter access is possible. On the south and south west side of the building are the best places for feeding trees. In winter the sunlight can reach indoors if these trees drop their leaves.
2. Trees with high foliage obstruct the rays of the sun and cast a thick shadow. The roof, walls and windows can be shaded with high branching canopy trees. On the south and the west, evergreen trees provide optimal safeguards against the environment of summer sun and cold winter winds.
3. For east and west walls and windows in the summer, the vertical shading is best suited in order to safeguard against intense sunlight at small angles, for instance screening by thick tree trunks, feeding wines with frame support and bushes combined with trees. See Figure 2.9.
4. Wall-sticking crops like English Ivy or wall support crops such as jasmine may provide shade and insulation for the walls.
5. Horizontal shading is best for windows facing south. For instance caduceus plants such as decorative grape or wisteria can be cultivated on a pergola for summer shading (which loses foliage in the winter).

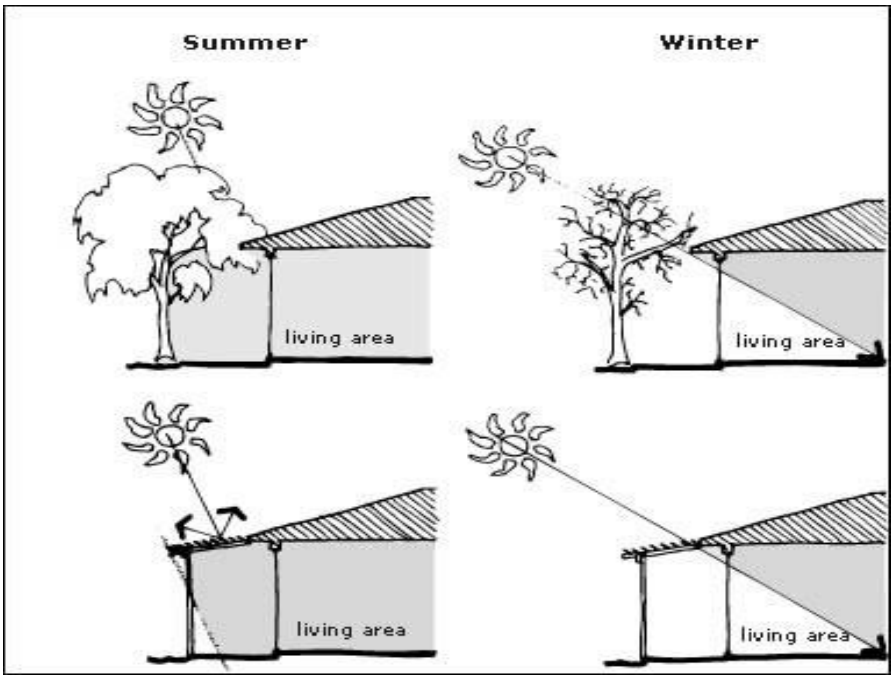


Figure 2.9: Deciduous trees which provide shade in summer and allow sun rays during winter (Esru, 2019)

2.1.3 Building form

The shape is an important factor in construction because of its considerable effect on energy efficiency and construction expenses. In the conceptual phase of building design, building shape is one of the key factors. Building shapes can influence construction performance in many ways: power efficiency, price and esthetic aspects, because the exterior envelopes can be oriented to the outdoor setting. However, too often construction choices are based solely on esthetic aspects, which are obviously detrimental to limit the potential for improved results. Formal optimisation can contribute to overcoming this disadvantage by explore additional design options for particular requirements such as environmental and financial results at the conceptual design level (Wang et al., 2006).

A number of prior research have been carried out on the optimisation of construction form. The grammar of design and genetic algorithm of Rosenman and Gero have merged to develop two-dimensional buildings. The entire construction scheme is built by applying sequentially the design grammatics to the construction, including space units, of hierarchical components (Caldas, 2002). In Hemsath et al., journal article The impact of energy use, the enhanced volume-to-surface ratios indicates that thermal transfer across the building envelope is increasing. Analysis of sensitivity Assessments of the base building architecture The equilibrium between shape, quantity, light and shell is crucial for the design of an energy-free structure (Hemsath et al., 2015).

Brown et al., book authors of “Sun, Wind, and Light”, recommend east-west rectangular construction. Shortened east and west façade will thake less sun’s energy as the sun angle is very low during morning and afternoon times. It is difficult to control low sun angle on west during summer time. On the other hand, south side is widened to allow low winter angles, while prevent high summer angles easily with the help of overhangs (Dekay and Brown, 2013).

Philip Steadman discusses the use of the low-energy surface area and that the walls with the greatest solar radiation are on the west side in his Energy, environment, and Building book (Steadman, 1975). He discusses the optimal form of buildings by Victor Olgyay, which are calculated by low heat in the winter and heat gain during the summer months, and rectangular shapes extending to the east and to the west become effective forms. See Figure 2.10.

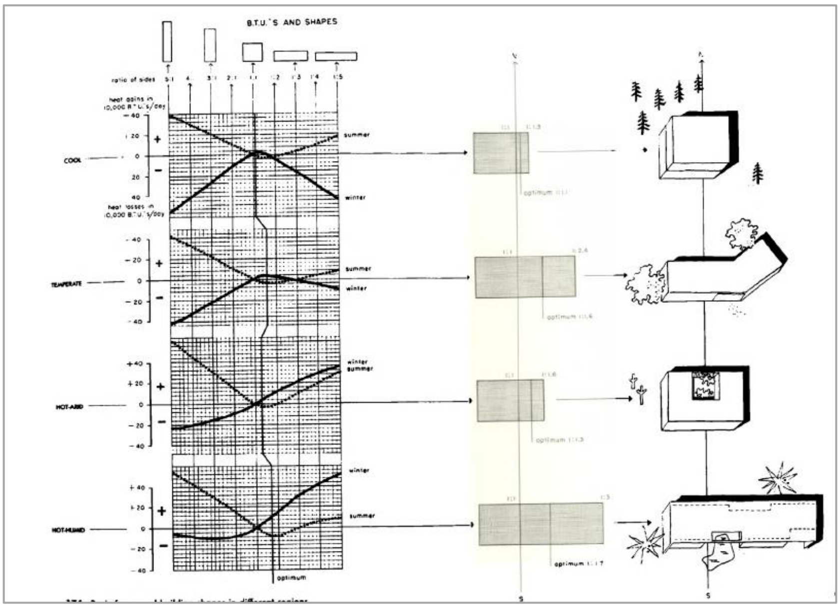


Figure 2.10: Basic forms and shapes from Victor Olgyay in several regions (Olgyay, 2015)

It can be said, the shape and structure of the building are of great importance in determining the amount of shadows. Shows, Figure 2.11 the difference in the amount of shade between buildings with a flat surface.

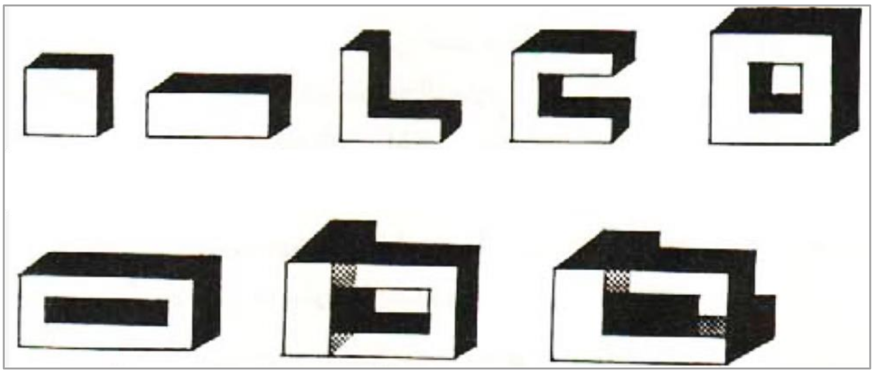


Figure 2.11: Effect of the shape of the building on the amount of fallen shadows (Olgyay, 2015)

2.2. Climatic Elements

In order to guarantee a better organization and judicious use of space, users convenience and operational functionality of the entire setting is needed. Satisfaction of physiological, protection and social needs, must be considered in architectural designs together with climate parameters (Agboola, 2011).

2.2.1 Solar radiation

The sun is crossing the seasonal paths from east to west in the southern hemisphere. As known, higher angle in summer and lower angle in winter is observed. These solar angles influence the level of solar radiation obtained on the horizontal and vertical surfaces directly. The lower angles tend to concentrate on vertical surfaces and the radiation is concentrated on horizontal surfaces at higher solar angles (Bahrami 2008). See Figure 2.12.

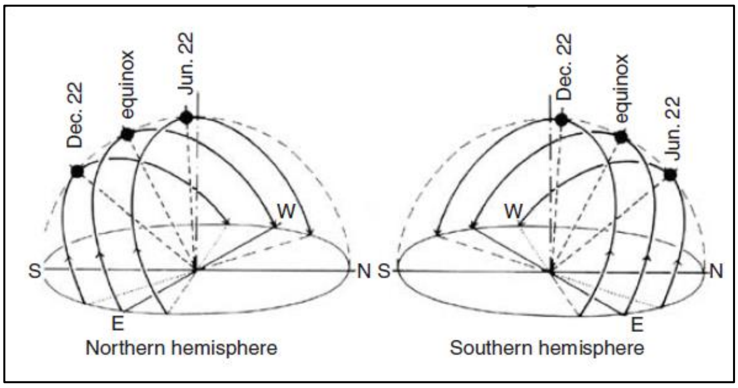


Figure 2.12: Lococentric view of the sky hemisphere, with sun-paths for the main dates (Szokolay, 2012)

In order to measure the sun's angle through the sky, incident and azimuth angles must be read. The solar altitude is the angle between the sun's rays and horizontal plane. At zenith, which is an overhead point, it has a peak value of 90°. Azimuth, measured in a clockwise direction along the horizon (Math, 2019).

Azimuth begins at 0 degrees from north precisely, increasing in the clockwise direction. The following instance shows the sun angles to North (Northern Hemisphere) 56 degrees latitude. The altitude as seen from the figure above is symbolical of β from the horizon, while α from the South Pole and horizontally is symbolic of the azimuth. Even in a latitude of 65, during the winter and the summer solstice, the Sun rises more south eastwards and west eastwards (Mulyansaka, 2013). See Figure 2.13.

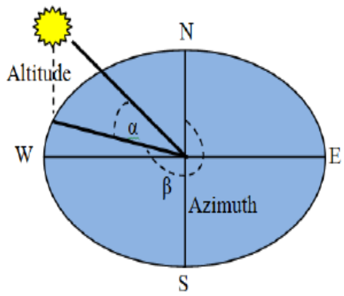


Figure 2.13: Azimuth and Altitude (Mirdanies, 2015)

2.2.1.1 Sun path and shading devices

Bioclimatic chart, Psychometric chart and Mahoney's table suggest the shading of windows almost throughout the year through. March till October. Sun path diagram of Lucknow is used to create a shading mask with the help of shading protractor for the months in which shading of windows is required. Figure 2.14 From this shading mask we get a horizontal shading angle and vertical shading angle. Figure 2.14 North have only morning and evening sun that can be shaded by approximately 400mm vertical fins. Maximum sun is in south direction, shading mask is created so that it shades the summer sun and allows the winter sun to come in. For that purpose overhang with small fins would work. Designing of shading devices for east and west direction is the most difficult task, the sun rays are almost vertical and the intensity of radiation is also high. Therefore, vertical fins designed for that direction are almost parallel to windows. (Bano and Tahseen, 2017). See Figure 2.14.

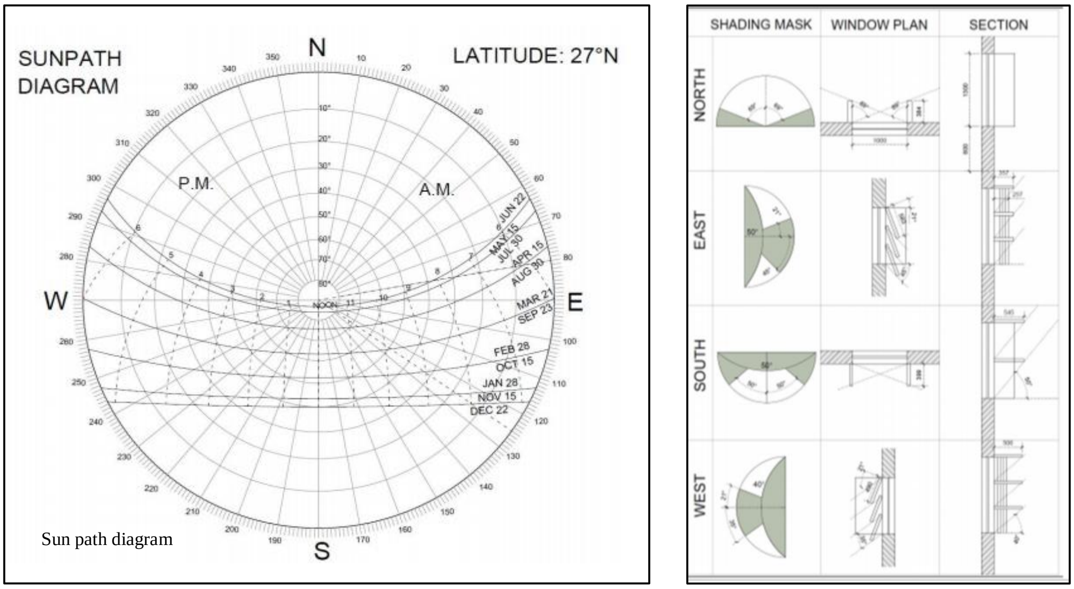


Figure 2.14: Shading devices in North, East, South and west direction of openings in building in Lucknow (Bano, Tahseen, 2017)

Shading equipment can considerably decrease building solar thermal gains while preserving daylight, view and natural ventilation possibilities. Conversely, carefully designed shading device can allow direct solar radiation at certain times of the year, when such energy is wanted, especially at mountain highlands, to passively heat buildings. (Priatman and Loekita, 2015). Shading equipments have principal objectives as:

- Physical function: Reduces sunlight, reduces radiation effect on building, provides rain protection for openings
- Aesthetic function: To express architectural aesthetic by façade appearance.

2.2.1.2 Types of shading devices

Internal shading devices: They limit the glare caused by sunlight. Normally the occupants can adjust and the direct light easily. Illumination level can be regulated in the space. (Improving the Thermal Performance of the Building Envelope, 2016). See Figure 2.15.

Figure 2. 15: Internal shading devices (Improving the Thermal Performance of the Building Envelope, 2016)

External sun shading devices: Thermal efficiency, in terms of heat gain by radiation can be controlled effectively by horizontal and vertical shading devices. Horizontal shading devices are better on south facades for the hot summer to shade a window, but for a winter time they must let the sun shine through a window to warm a building. Vertical shading devices on the other hand are mainly helpful to enhance the isolation value of glass in winter months for east and west exposures (Improving the Thermal Performance of the Building Envelope, 2016). See Figure 2.16

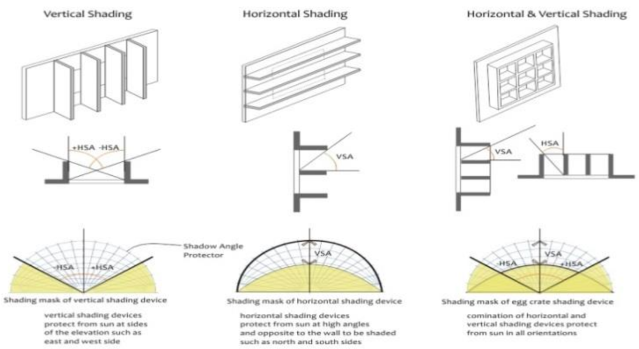


Figure 2.16: Horizontal and vertical shadow devices (Nzeb, 2019)

2.2.1.3 Shadow angles

Shadow angles describe the position of sun in relation to shadow angles on the face of the construction. On the vertical surface, the vertical shadow angle is described as the corner of the dropping radiation between the surface and the vertical perpendicular on the ground.

When an edge of the shade is located at the view (see Figure 2.17), the horizontal shade angle differs from the azimuth from the position of the sun and the viewing orientation (Szokolay, 2012).

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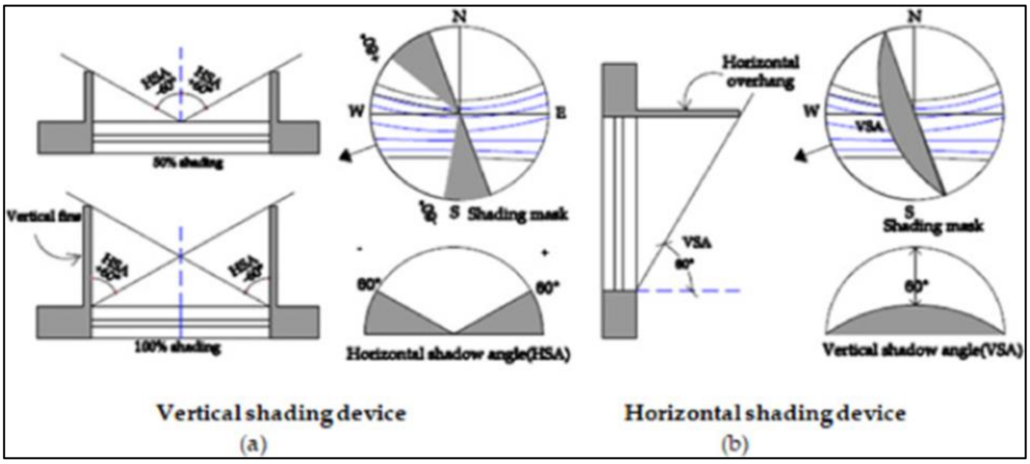


Figure 2. 17: Vertical shadow devices and horizontal shading devices (Subhashini and Thirumaran, 2018)

With the passing of time, specialists have noticed that shades can affect heating loads as the used solar gains are reduced during the winter. Many studies have shown that the most energy-efficient shading approaches are used in heating-dominated climates. In these buildings use of shading systems create shaded areas with high percentages (Priatman and Loekita, 2015).

2.2.2 Temperature

Temperature (T) is an indication of the heat being in the substance. The Celsius size is based on water: its point of freezing and its point of boiling (at standard atmospheric pressure) (100 C^o). With "absolute zero," the kelvin scale starts without total heat. S^o 0 drafts C = 273.15 drafts K. Thus, 50C ^{o} − 10 C^o = 40 K and likewise 50 C^o O–25 C^o is 30 K, but 15 C^o as a scale point, the grade of notation of difference of density is 288.15 K (Szokolay, 2012). Temperature range is 30 K, but the grade of scale is 15 C^o. (Kelvin).

Annual temperature values of the places are important in finding out the overheated periods, so that shading time for the building walls and windows can be decided. On macro scale temperature is affected according to the zone of the location due to changing altitude and latitude.

<u>Altitude:</u> Altitude is called the measured height above the sea level. A dense mass of air at low altitude has capability of absorbing sufficient heat from the sun. However, the temperature also reduces gradually as the altitude rises. Thus, a very thin body of air at elevated altitude cannot absorb sufficient heat from the sun, so it is cool at high altitudes. When the height goes up to 160 meters to 165 meters (Simplified 2019) the temperature falls by 10 degrees Celsius.

<u>Latitude:</u> The further away from the equator, colder is felt, because the places near the equator receive direct sun rays while away from the equator receive slanted sun rays. So, high concentration of heat is absorbed by the atmosphere near the equator and less heat is absorbed as away from the equator (Coura, 2019).

2.2.3 Winds

The reasons for wind development are very manifold and complex phenomenon. However, the main reason is the unequal distribution of solar radiation worldwide. It results from different surface heating and temperatures. This causes differences in air pressure and as a result, air moves from high pressure side to lower pressure side (Fmlink, 2019).

The wind is retarded and the turbulent flow near the earth forms a limit layer. The wind is slowed down as it is closer to ground. It can range between approximately 270 m and over 500 m across the city (Szokolay, 2012). See Figure 2.18.

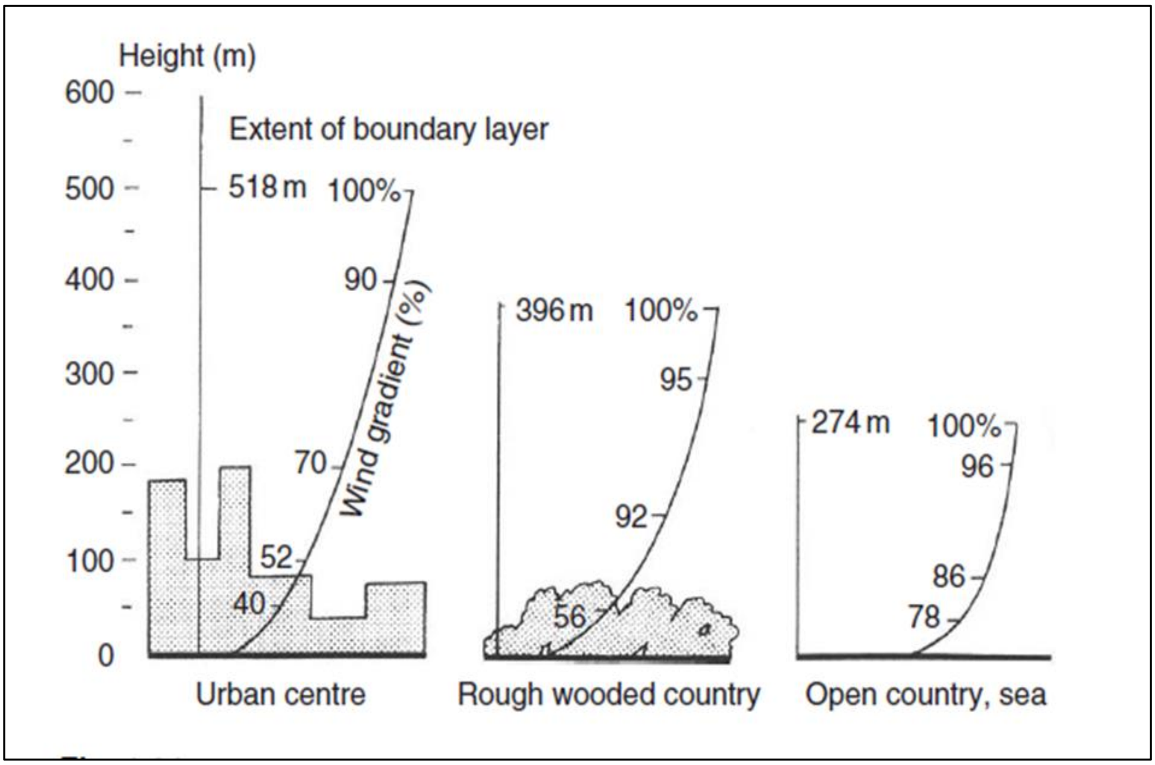


Figure 2.18: Wind speed profiles: depth of the boundary layer (Olgyay, 2015)

The strategic orientation, configuration and building envelopes and energy use affect wind speed and direction. Wind disturbs the silent air membrane around and isolates a building and increases heating and refreshing loads. In order to cool the surface below ambient air temperatures, wind can also evaporate moisture on the wet building rooves. The northern and western sides of the building face high winds in the northern hemisphere. In order to minimize air flow from doors and windows, the buildings must have the most vulnerable areas, such as entrances and glazed areas, away of prevalent winds. The entrance must be properly protected against wind when it is built to the North or the West. If not, high winds and low temperatures can cause discomfort during the winter months, leading to high energy consumption. Although high winds often cause increased energy consumption, they can actually reduce consumption at certain locations if winds use and apply natural cooling properties throughout the building (Pinteric, 2017).

2.2.3.1 Windbreaks

Air pressure differences cannot change large amounts of air during their motion. But speeds can be controlled to some degree in the living spaces closer to the ground. The frictional drag of vegetation and obstruction caused by trees can be used for this purpose. In addition to its esthetic and shading properties, vegetation can well be used to deviate airflow. Trees are capable of reducing wind speeds. This mechanical effect brings significant temperature and humidity changes to the air (Olgyay, 2015).

The type of windbreak used has a definite effect on the resultant airflow pattern and on the area of protection. Solid wind barriers, or walls, cause eddies which reduce wind effectiveness. In the study done by Olgyay, the heating load of the houses which is unprotected at wind speed 20 mph is about 2.4 times, when compared with protected one under the same temperature conditions. This indicates that high dense evergreen belts are quite effective at higher wind speeds.

Wind speed can be controlled by landscape elements. Windbreaks can be effective in controlling wind and its impacts on buildings. These shelter belts may occur from rows of trees and shrubs that are planted to reduce wind speed or redirect wind movement. In a cold climate, a properly located and effective windbreak can decrease air infiltration and heat loss by reducing wind velocity near the building. Plant species selected for a windbreak should be able to withstand the desiccating effects of winter winds. Evergreen species should constitute a significant portion of the windbreak composition because they retain wind-blocking mass in winter when it is most needed. An evergreen properly selected and placed can divert cold winds from the building and reduce heating costs (Seckin, 2018). See Figure 2.19. Building itself also may act as wind break. There is high air pressure zone on the windward side of building, as low air pressure zone is observed on the leeward side. See Figure 2.20.

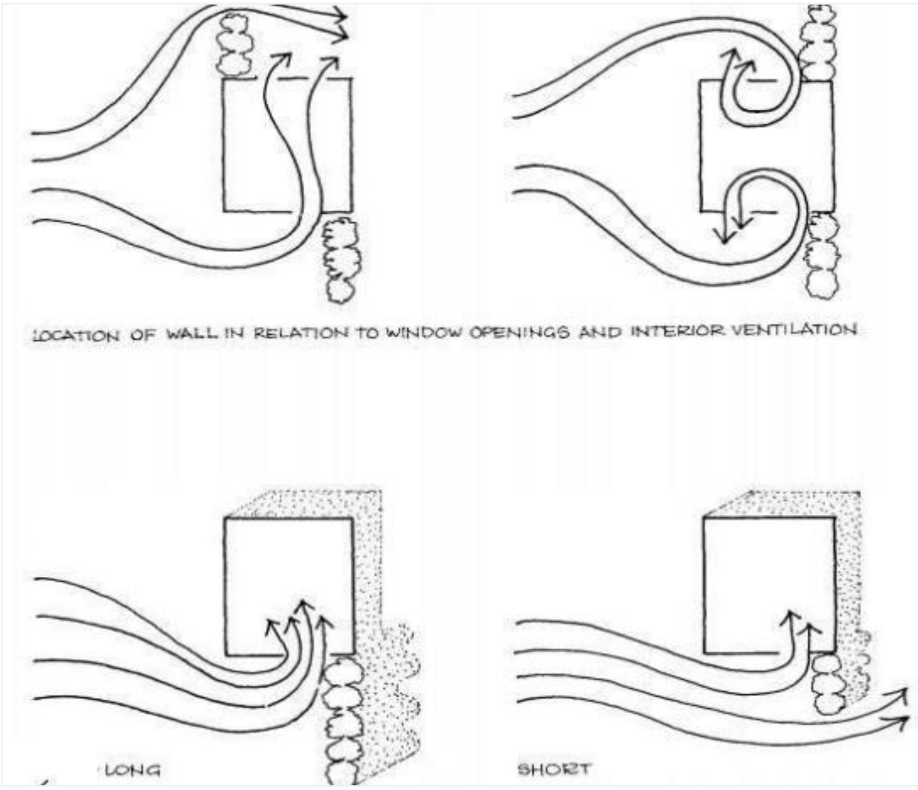


Figure 2.19: wind control by trees (Chawla, 2017)

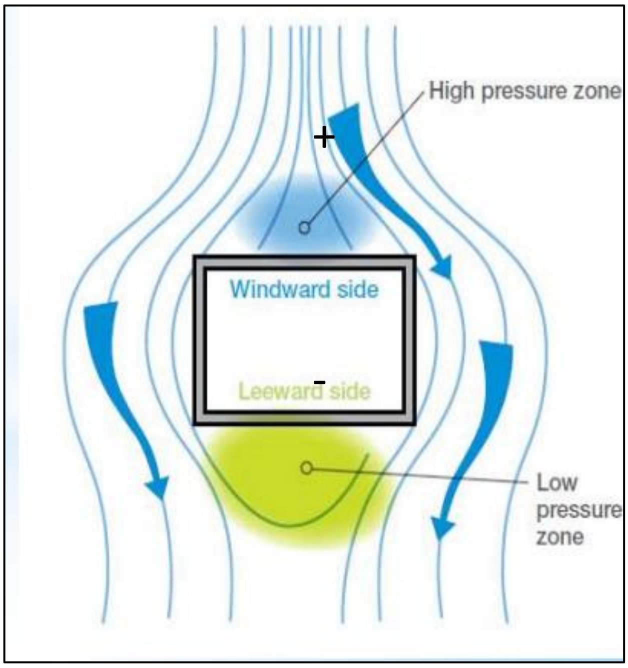


Figure 2.20: Wind-induced natural ventilation (Kumar, 2017)

2.2.3.2 Ventilation

Use of natural ventilation in the arrangement of living spaces is a very important tool as it reduces energy demand for cooling. Natural ventilation can be obtained in several ways. If space has window opening on one side, this is known as single – sided ventilation. If space has opening on different walls, then we can obtain cross ventilation which is more efficient than one-sided ventilation. It is used to generate airflow routes from inlets to outlets that go through the occupied construction stage. Cross ventilation up to a maximum depth of five times the height of the space is efficient. They can be moved by a wind effect or by a stack effect, as in the case of wall openings or atrium ventilation, where the resulting flux is vertical (Kumar, 2017).

The excellent distribution of openings must also be planned. Openings on the opposite walls are more efficient than on neighboring walls for cross ventilation. In regards to the occupied level of the room the vertical position of the inlet should also be. Low inlets for cooling are generally suggested and elevated inlets for ventilation stacks are suggested. With the use of trickle ventilation, minimal flow rate should be guaranteed at the minimum window zone of approximately 5 percent of the floor area (Smith, 2001). The window area should in any event be sufficient to satisfy the necessary ventilation rate, which depends on the construction. See Figure 2.21.

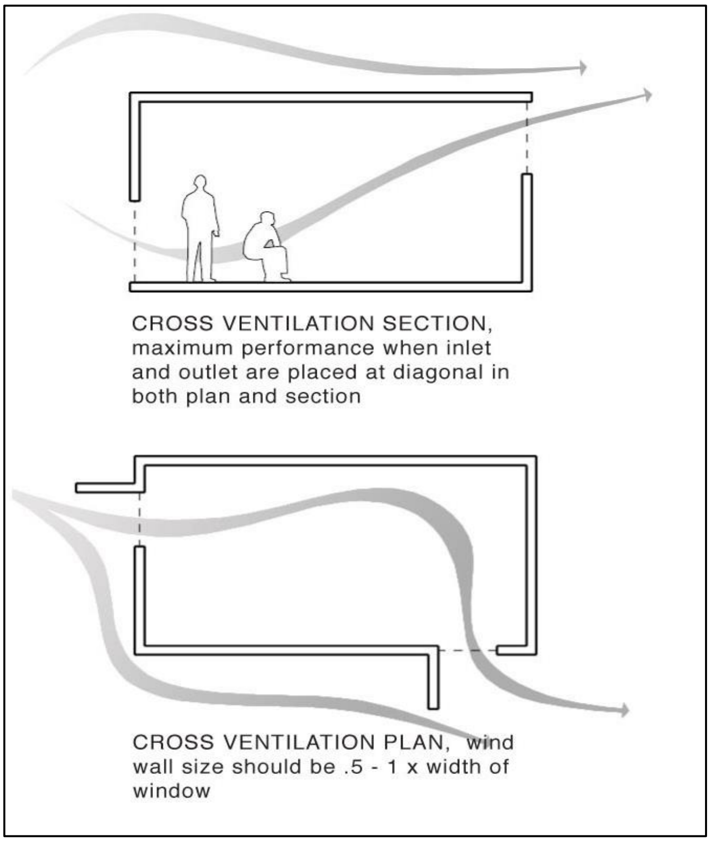


Figure 2.21: Cross ventilation (Services, 2019)

In general, openings should not be positioned in a room precisely across them. Although this gives efficient ventilation, it may lead to good cooling and ventilation in some areas of the space as long as other sections do not. When openings are placed across but not immediately opposed, the air in the room is mixed and coolers and fresh air are better distributed. Air inlets must be put on the high-pressure areas and outlets at low-pressure areas of a building. This creates effective cross ventilation (Mondal, 2015). Various ventilation types and air mixtures with different windows are shown in Figure 2.22.

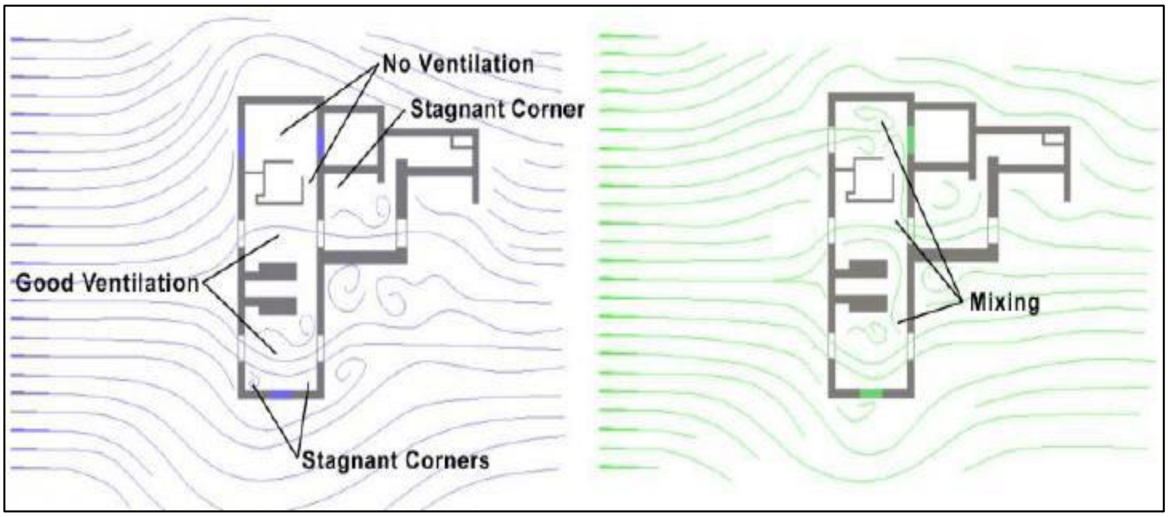


Figure 2.22: Different amounts of ventilation and air mixing with different window openings (Mondal, 2015)

- **Window characteristics that affect air flow**

Airflow impact depends on the type and positions of windows, skylights and roof windows. Typically, casement and windows that project can be opened completely to allow more ventilation. An external sash can assist, guide the air into a space. However, the inward planning sashes may be more viable if the wind is harder. Sliding windows have less than half of the total window region with restricted openings. Skylights or roof windows that are mechanically or manually operated enable warm air to go out and replace it by warmer outside air, which enters the opening windows at a reduced rate. If the air moves quickly enough, window positioning (location and opening size) will influence the occupant's cooling. The average air speed is determined by:

- The exterior wind velocity.
- The angle at which the wind strikes the opening.
- The size of the opening.

The Figure 2.23 demonstrates how the size, number, and location of the openings will affect the air flow (Brown and DeKay, 2001).

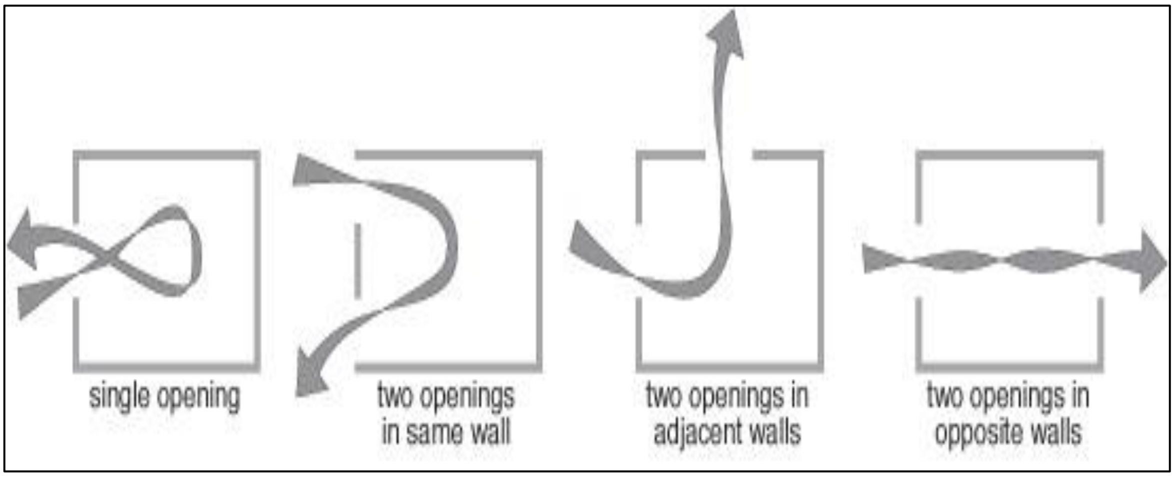


Figure 2.23: The size effect, number, and location of the openings on airflow (Brown and DeKay, 2001)

- **The neighbour effect of natural ventilation**

A distance between buildings of at least 5 times the height of the building offers greater opportunities for ventilation for the leeward building Figure 2.24(Manualimplanta, 2019).

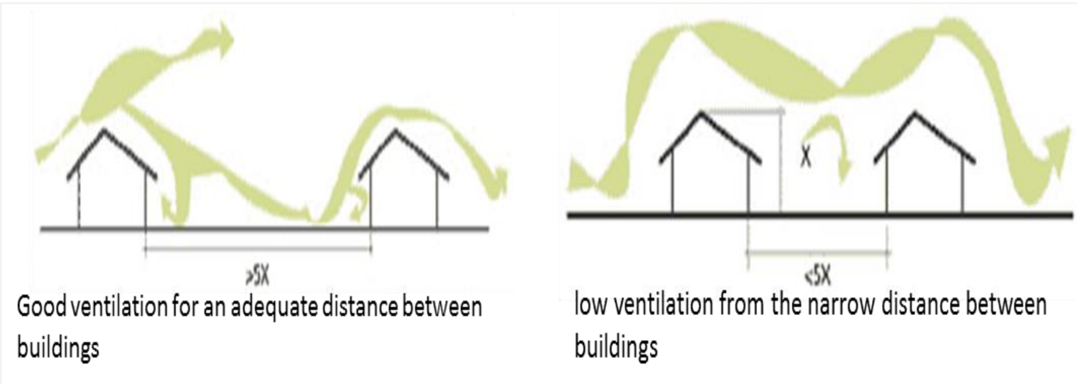


Figure 2. 24: Good distance between buildings for natural ventilation (Manualimplanta, 2019)

CHAPTER 3

THE AL BAYDA CITY IN LIBYA

3.1 Location Libya

Libya is located in central North Africa. The Northern Mediterranean border and the coastline are some 2,000 km, Figure 3.1. The country ranges from latitude (20° - 34°N) to length (10° - 25°E), which is approximately 90.5 percent of the region classified as arid (Ben Mahmoud, 1993). The topography is normally robust, with the exception of two areas between 500 and 1000 meters over sea level (Al-Haram 1995). The wet winter and hot and dry summers characterize the climate of Libya, and arid climate is evident in the transition from the Mediterranean to the tempestuous climate. The population of Libya has been approximately 5,323,991 in 2006, and the projected 2025 population is approximately 10 million.

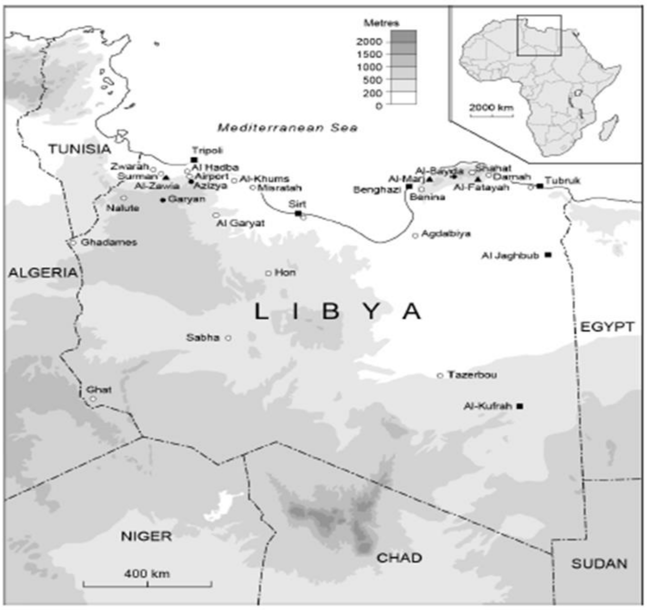


Figure 3.1: Map showing Location of Libya (Al-Haram 1995)

3.2. Location of the City of Al Bayda, Libya

The city of Al-Bayda in the north east of Libya is the highest peak of the Green Mountain at the junction of the latitude 21.44 North and the longitude 32.76 east (WorldAtlas, 2019). It is bordered to the east by the city of Qurena, to the west by the village of Massa, to the south of the village of Aslanta, and to the north by the intermediate forests, making it the middle of the green mountain.

Due to the mediation of the city's location between the governors of Darnah, Marj, Qubba and Benghazi; its location in the middle of Al-Jabal Al-Akhdar has become an urban complex of commercial nature and a shopping center for its neighboring towns and villages. It is close to the sea by 20 km and surrounded by forests.

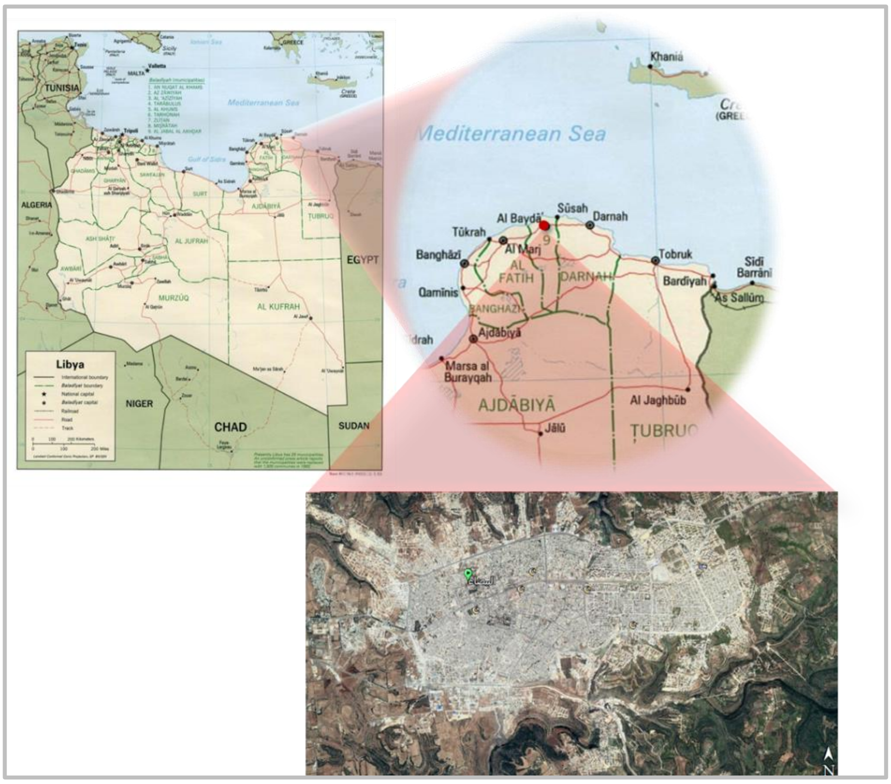


Figure 3.2: Map showing location of the city of Al Bayda, Libya

3.3 Climate of Al Bayda

In white, summer long, warm, arid, clear, winter is cool, windy, often clear. The temperature typically varies from one year to the next 42^{o} Fahrenheit to 83^{o} Fahrenheit, rarely below 38^{o} Fahrenheit or above 93^{o} Fahrenheit (Climatestotravel, 2019).

3.3.1 Temperature

Hot season is average in excess of 78^{o} Fahrenheit a day between 23 May and 9 October. The hottest day of the year on the 8th of August is 83° Fahrenheit and 67° Fahrenheit on average.

The cold period between 5th and 12th December is below 61^{o} Fahrenheit with a mean daily high temperature. The coldest days of the year is the month of February 1 with an average of 42 and 55 degrees.

The daily average temperature is indicated in Figure 3.3, ranging from 25 to 75 and 10 to 90 percentile (Red Line) to Low (Blue Line) percentiles. The thin dotted lines show the perceived average temperatures.

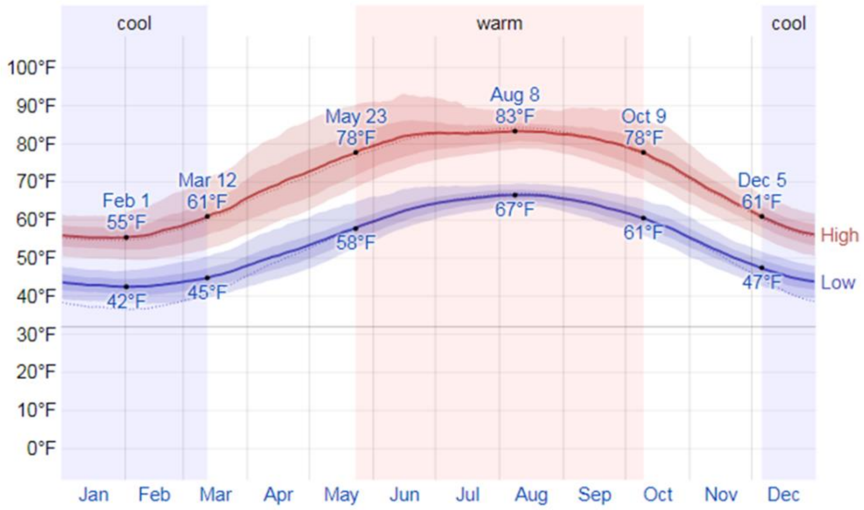


Figure 3.3: Average High and Low Temperature (Climatestotravel, 2019)

The following figure contains a complete description of the average temperature per hour. A vertical axis is the clock of day, the color is the hour-day average. The horizontal axiom is the day of year.

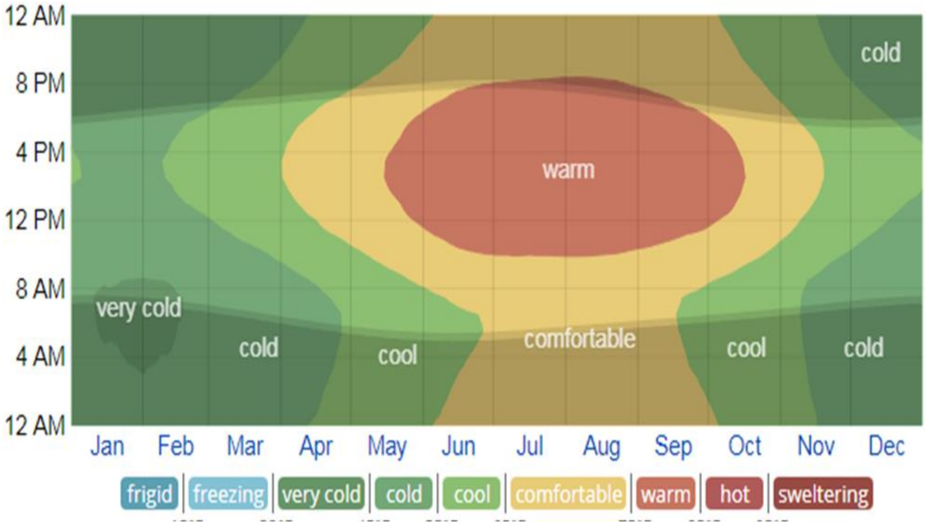


Figure 3.4: Hourly temperature average (Climatestotravel, 2019)

3.3.3 Winds

The maximum expected wind speeds are around 46 km/h but the average air speed is generally between 17 and 29 km/h. Furthermore, as shown in Figure 42.3 the main wind flow comes from the north.

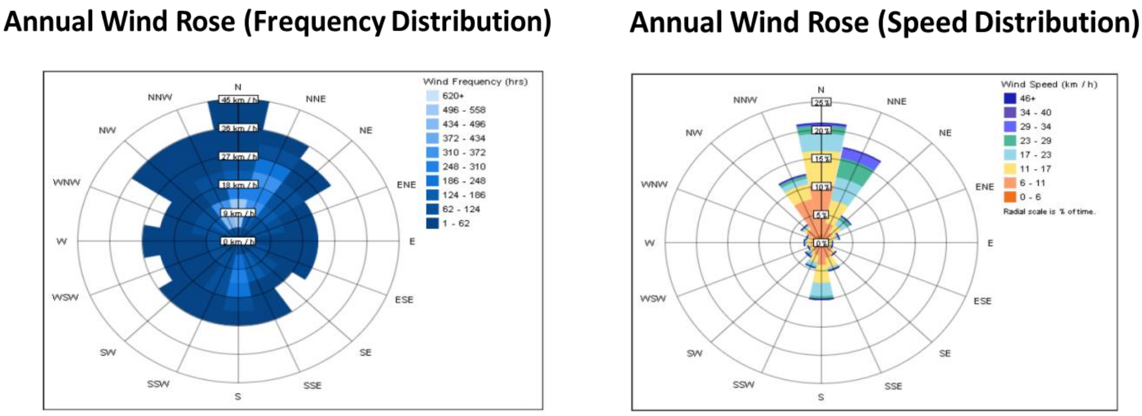


Figure 3.5: Annual Wind performance (Autodesk Revit, 2016)

CHAPTER 4

CASE STUDY: SHADING AND AIR FLOW ANALYSIS ON SELECTED RESIDENTIAL BUILDINGS IN AL - BAYDA CITY

This chapter demonstrates the analysis of energy efficiency strategies in residential buildings in the AL Bayda City, Libya. Research and findings for 9 from Residential Buildings are discussed in this chapter, in terms of orientation and solar energy in the summer and winter solstice and the study of the main winds and its effect on natural ventilation.

In addition, an interview is done with the owners of the houses selected for the study and the results are evaluated.

4.1 Survey Methods

A domestic building survey was carried in Al-Bayda city to reduce energy consumption. The study includes a range of buildings in terms of orientation, energy efficiency and the impact of solar radiation on buildings by simulating a computer (Autodesk Revit 2016).

The prevailing winds and levels of ventilation were studied in order to reach the consumption of buildings for energy and their impact on the environment.

Nine houses were selected randomly in Downtown city in Al-Bayda for the study .It is shown in, Figure 4.1.

Figure 4.1: Google map showing location of case studies.

An interview was conducted with the residents of the selected houses. And asked major questions to begin the interview with the residents.

1. Do you have heat insulation on walls?
2. Do you have heat insulation on glazing?
3. What kind of construction system is used in your building?
4. What are the cooling devices used in the home?
5. What kind of heating is used in the home?
6. How much do you pay monthly for electricity ranges?
7. How can you estimate the energy consumption in your home?
8. Do you know that energy consumption is harmful to the environment?
9. How often do you use natural ventilation in summer?
10. How often do you use mechanical ventilation in summer?
11. How often solar radiation reaches the bedrooms?
12. How often solar radiation reaches into the living room?
13. What are the shading devices available in your home?

14. How do you grade level of satisfaction in terms of ventilation in your home?
15. How do you grade level of satisfaction in terms of gaining sun's energy in your home?
16. Is there a difference in the thermal comfort between rooms in your home?
17. According to you, Are buildings adjacent to the building prevent the winds into the house?

At the end of the interview with the residents, was thanked and the data were recorded and later discussed.

4.2 Survey Results

Following up with the interview of the respondents from the owners of the selected houses, the following results were analyzed as:

Seventeen questions were asked for the owner of the houses in the interview, and it's worth mentioning that the interview was added with a house owner who was not chosen his house for the study to complete the number of the respondents for ten residents of the city of Al-Bayda.

Responses are given below:

Table 4.1: The age

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	30-40	3	30.0	30.0	30.0
	41-50	3	30.0	30.0	60.0
	51-60	3	30.0	30.0	90.0
	More than 60	1	10.0	10.0	100.0
	Total	10	100.0	100.0	

The age of the respondents was 30-40, 30%, 41-50, 30%, 51-60, 30% and more than 60 were the lowest, 10%.

Table 4.2: Heat insulation on walls

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	10	100.0	100.0	100.0

In Table 4.2, 100% of the respondents agreed that there was no heat insulation of the walls.

Table 4.3: Heat insulation on glazing

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	9	90.0	90.0	90.0
	Yes	1	10.0	10.0	100.0
	Total	10	100.0	100.0	

In Table 4.3., 90 % of the respondents agreed (Case Study 2,3,4,5,6,7,8,9) that there was no heat insulation of the glazing.

Table 4.4: The construction system

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Load bearing system	2	20.0	20.0	20.0
	Frame system	8	80.0	80.0	100.0
	Total	10	100.0	100.0	

In Table 4.4., 80 % of the respondents agreed (Case Study 1,2,3,4,5,6,8) that the construction systems in the buildings used are frame system and the remaining percentage, 20% (Case Study, 9) for load bearing system.

Table 4.5: Cooling devices

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Air conditioning	8	80.0	80.0	80.0
	Fans	2	20.0	20.0	100.0
	Total	10	100.0	100.0	

This question asked about the cooling devices which are used in the home. Two main types of air conditioning are mentioned in the survey to determine which type is the most popular. The results reveal that air conditioning in the house is very common, with 80% of those surveyed (Case Study 1,2,4,5,6,8,9) is using this type of cooling, and 20% (Case Study 3,7) used the fans.

Table 4.6: Heating used

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Electric heater	8	80.0	80.0	80.0
	Air conditioning	2	20.0	20.0	100.0
	Total	10	100.0	100.0	

This question asked about the heating devices used in the home. The results reveal that the heating devices used in the home 80% are electric heater of those surveyed (Case Study 3,4,5,6,7,8,9), and 20% used Air conditioning (Case Study 1,2).

Table 4.7: The pay to monthly for electricity

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less than 50 $	1	10.0	10.0	10.0
	150-200 $	3	30.0	30.0	40.0
	200-250 $	1	10.0	10.0	50.0
	250-300 $	5	50.0	50.0	100.0
	Total	10	100.0	100.0	

This table shows, how much do you pay monthly for electricity ranges. 50% these largest percentage of those surveyed (Case Study 2,3,4,6,8), they pay monthly 250-300 $, and 30% (Case Study 1,5) they pay 150-200 $ monthly ،and 10% (Case Study 9) they pay monthly 200-250 $ and 10% of those surveyed (Case Study 7) they pay monthly less than 50 $.

Table 4.8: Estimate the energy consumption

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Average cost	4	40.0	40.0	40.0
	High-cost	6	60.0	60.0	100.0
	Total	10	100.0	100.0	

This table shows, the results of the survey revealed that 60% of the house surveyed (Case Study 1,2,5,6,7), it has a high-cost and 40% have Average cost (Case Study 3,4,8,9).

Table 4.9: Know that energy consumption is harmful to the environment

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	10	100.0	100.0	100.0

This question asked respondents their knowledge of the environmental damage caused by energy consumption. The survey revealed that 100% of the respondents were not aware of the damage caused by energy consumption.

Table 4.10: The use natural ventilation in summer

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Sometimes	5	50.0	50.0	50.0
	Most of the time	5	50.0	50.0	100.0
	Total	10	100.0	100.0	

This table indicates, the results of the survey showed that 50% of the respondents (Case Study 3,4,6,8,9) use the natural ventilation opportunities sometimes and 50% of the respondents (Case Study 1,2,5,7) use natural ventilation opportunities very often.

Table 4.11: Use of mechanical ventilation in summer

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Never	2	20.0	20.0	20.0
	Sometimes	1	10.0	10.0	10.0
	Most of the time	7	70.0	70.0	100.0
	Total	10	100.0	100.0	

This question was included in this survey in order to understand people's behavior regarding the use of mechanical ventilation in summer. The survey asked about, how often do you use mechanical ventilation in summer. 70% of them which is the largest percentage of those surveyed (Case Study 1,2,6,7,8,9) mentioned that they use mechanical ventilation frequently and 20% of those surveyed (Case Study 3,5) said that they did not use mechanical ventilation.

Table 4.12: The aceess of solar radiation to the bedrooms

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Rarely	30	30.0	30.0	30.0
	Sometimes	5	50.0	50.0	80.0
	Most of the time	2	20.0	20.0	100.0
	Total	10	100.0	100.0	

This table shows, how frequent the solar radiation reaches to the bedrooms. The results showed that 50% (Case Study 1,4,5, 8,9) mentioned as sometimes, 30 %, mentioned (Case Study 2,6,7) rarely, 20% mentioned (Case Study 3) as most of the time.

Table 4.13: The access of solar radiation to the living room

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Never	2	20.0	20.0	20.0
	Rarely	3	30.0	30.0	30.0
	Sometimes	2	20.0	20.0	70.0
	Most of the time	30	30.0	30.0	100.0
	Total	10	100.0	100.0	

This table shows, how often solar radiation reaches the living room. The results showed that 20% (Case Study 4,6) said "sometimes", 30 %, (Case Study 2,7) said "rarely", 20% (Case Study 8,9) said "never" and 30% (Case Study 1,5) said "most of the time".

Table 4.14: The shading devices available in the home

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Curtains	60	60.0	60.0	60.0
	Nothing	40	40.0	40.0	100.0
	Total	10	100.0	100.0	

In Table 4.14, 40 % of the respondents agreed that no shading devices are available in the house (Case Study 3,4,5) and 60% use the curtains (Case Study 1,2, 6,7,8,9).

Table 4.15: Grade level of satisfaction in terms of ventilation at home

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very poor	2	20.0	20.0	20.0
	Poor	3	30.0	30.0	50.0
	Good	3	30.0	30.0	80.0
	Very good	2	20.0	20.0	100.0
	Total	10	100.0	100.0	

Table 4.15 shows the results of the survey revealed the grade level of satisfaction in terms of ventilation. 30% Poor (Case Study 4,5,9), 30% Good (Case Study 6,8), 20% Very good (Case Study 1,2), 20% very poor (Case Study 3,7).

Table 4.16: Grade level of satisfaction in terms of gaining the sun's energy in the home

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very poor	4	40.0	40.0	40.0
	Poor	2	20.0	20.0	60.0
	Good	3	30.0	30.0	90.0
	Very good	1	10.0	10.0	100.0
	Total	10	100.0	100.0	

Table 4.15 shows the results of the survey revealed a grade level of satisfaction in terms of gaining the sun's energy, 40% very poor (Case Study 3,7,5,9), good 30% (Case Study 2,8), 20% Poor (Case Study 4,6), 10% very good (Case Study 1).

Table 4.17: The difference in the thermal comfort between rooms in the home

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	4	40.0	40.0	40.0
	Yes	6	60.0	60.0	100.0
	Total	10	100.0	100.0	

Table 4.17 shows the results of the survey abut a difference in the thermal comfort between rooms in the home. 60% of those surveyed (Case Study 1,2,5,6,8,9) confirmed that there is difference in the thermal comfort between rooms in the house and 40% (Case Study 3,4,7) mentioned that there isn't difference.

Table 4.18: Adjacent buildings prevention for the wind

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	5	50.0	50.0	50.0
	Yes	5	50.0	50.0	100.0
	Total	10	100.0	100.0	

This table shows the results of the survey revealed that 50% of buildings adjacent to the building prevent the winds into the house (Case Study 1,2,5,6,8), and 50% does not prevent winds (Case Study 3,4,7,9).

4.3 Analysis of Research

A total of 9 random buildings was selected in the city of Al-Bayda. Analysis of energy efficient strategies of these residential buildings in AL Bayda City are done according to the selecter criteria. Several buildings have been observed that they contribute to high energy consumption and cause environmental damage.

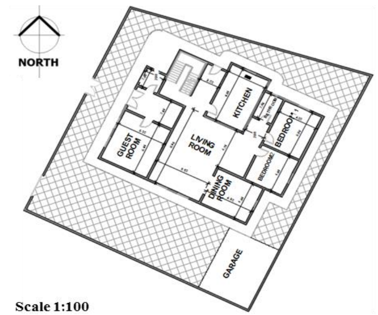
The buildings were analyzed in terms of climatic elements that affect the thermal comfort of the internal environment of the building. Basicly, summer and winter outdoor shading conditions and air movements that happened indoor and outdoor spaces are examined and criticized.

Table 4.19: Case Study 1

LOCATION

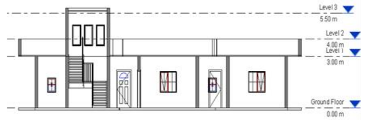
LOCATION	
Al-Bayda city, AL Gadeda	
Longitude 21°48'3.87"	Latitude 32°45'47.42"
Type of building	
Residential	
Construction System	Frame System
People	5 People

PLAN



Scale 1:100

SECTION



3D

PHOTO

FINDINGS

Floor area	330.50 m^2
Wall area	217 m2
Glazing area	12.8 m^2
Materials	
Roof	Concrete
Walls	Bricks
Ground cover	Tile
Green area	--

SHADE ANALYSIS OF BUILDING

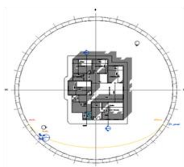
Summer solstice

1:00 PM

16:00 PM

Winter solstice

1:00 PM



16:00 PM

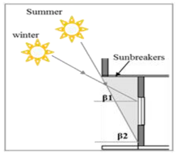
USER`S RESPONDS ON SOLAR EFFECTS

Question	Answer
How often solar radiation reaches the bedrooms?	Sometimes
How often solar radiation reaches into the living room?	Most of the time
What are the shading devices available in your home?	Curtains
Is there a difference in the thermal comfort between rooms in your home?	Yes

SUMMER AND WINTER NOON (1:00)

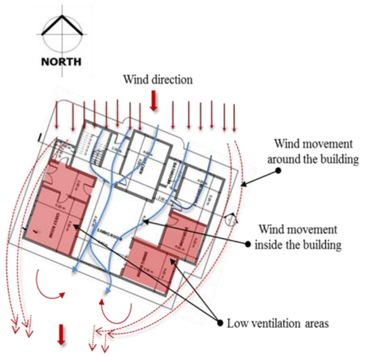
β2 Solar Altitude 40.8°

β2 Solar Altitude 74.21°



For window facing north

AIR FLOW ANALYSIS



USER`S RESPONDS ON VENTILATION EFFECTS

Question	Answer
How often do you use natural ventilation in summer?	Most of the time
How often do you use mechanical ventilation in summer?	Most of the time
How do you grade level of satisfaction in terms of ventilation in your home?	Good
Are buildings adjacent to the building prevent the winds into the house?	Yes

EVALUATION

Building form and material: The building can be said it's compact there is an overhang all around the building which acts as a horizontal shading device on the west side. There is no heat insulation on the building.

Indoor spaces: Overhang stops sun's rays on the south side of the building in summer and allows the sun's energy during winter which is positive. Shutters are used to stop the sun's energy through windows.

Outdoor Spaces: There is too much hard surface which absorbs and transfer heat to the building. There are no trees to stop sun`s rays

EVALUATION

The orientation of the building and the location of the windows caused the low ventilation to in some of the internal areas of the building. It is apparent that the bedroom, living room and the guest room are low ventilation There can be cross ventilation if they open doors and windows which are on the leeward side of the building provided that indoor doors are opened.

Table 4.20: Case Study 2

	PLAN	SECTION	PHOTO	FINDINGS
LOCATION: Al-Bayda city, Agnain; Longitude 21°46'13.72"; Latitude 32°46'11.84"; Type of building: Residential; Construction System: Frame System; People: 6 People	 Scale 1:100	  3D	  	see below

LOCATION	
Al-Bayda city, Agnain	
Longitude 21°46'13.72"	Latitude 32°46'11.84"
Type of building	
Residential	
Construction System	Frame System
People	6 People

FINDINGS	
Floor area	225 m²
Wall area	312 m²
Glazing area	11 m²
Materials	
Roof	Concrete
Walls	Bricks
Ground cover	Concrete
Green area	--

SHADE ANALYSIS OF BUILDING

Summer solstice

1:00 PM

16:00 PM

Winter solstice

1:00 PM

16:00 PM

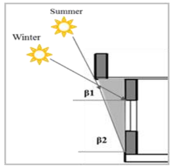
USER`S RESPONDS ON SOLAR EFFECTS

Question	Answer
How often solar radiation reaches the bedrooms?	Rarely
How often solar radiation reaches into the living room?	Rarely
What are the shading devices available in your home?	Sun-breakers
Is there a difference in the thermal comfort between rooms in your home?	Yes

SUMMER AND WINTER NOON (1:00)

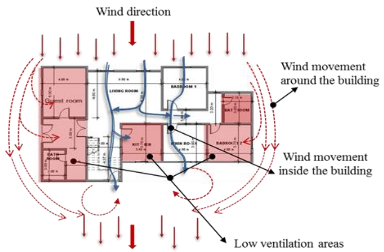
β2 Solar Altitude 31.42°

β2 Solar Altitude 80.35°



For window facing north

AIR FLOW ANALYSIS



USER`S RESPONDS ON VENTILATION EFFECTS

Question	Answer
How often do you use natural ventilation in summer?	Most of the time
How often do you use mechanical ventilation in summer?	Most of the time
How do you grade level of satisfaction in terms of ventilation in your home?	Good
Are buildings adjacent to the building prevent the winds into the house?	No

EVALUATION

Building form and material: The building can be said it's compact there is an overhang all around the building which acts as a horizontal shading device on the west side. There is no heat insulation on the building.

Indoor spaces: Overhang stops sun's rays on the south side of the building in summer and allows the sun's energy during winter which is positive. Shutters are used to stop the sun's energy through windows.

Outdoor Spaces: There is too much hard surface which absorbs and transfer heat to the building. There are no trees to stop sun`s rays

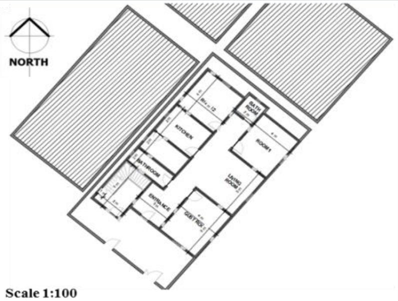
EVALUATION

The location of the windows caused the low ventilation to in some of the internal areas of the building. There are different levels of ventilation, the bedroom2, kitchen and guest room are low-ventilated This gives a temperature variation and a sense of thermal discomfort and this contributes to the rise of air conditioning requirements and high energy costs.

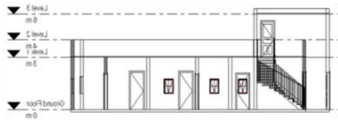
Table 4.21: Case Study 3

	PLAN	SECTION	PHOTO	FINDINGS

LOCATION	
Al-Bayda city, Al-Daiyr	
Longitude 21°18'43.57"	Latitude 32°46'.93"
Type of building	
Residential	
Construction System	Frame System
People	5 People



Scale 1:100



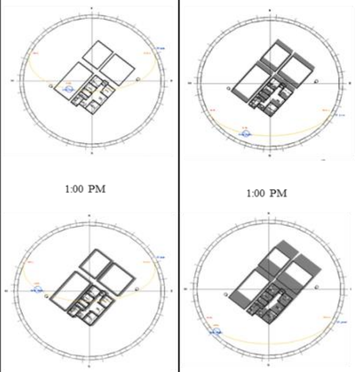
3D

Floor area	122 m²
Wall area	283 m²
Glazing area	8 m²
Materials	
Roof	Concrete
Walls	Bricks
Ground cover	Concrete
Green area	--

SHADE ANALYSIS OF BUILDING

Summer solstice

Winter solstice



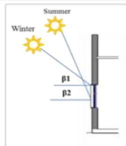
USER`S RESPONDS ON SOLAR EFFECTS

Question	Answer
How often solar radiation reaches the bedrooms?	Most of the time
How often solar radiation reaches into the living room?	Most of the time
What are the shading devices available in your home?	Nothing
Is there a difference in the thermal comfort between rooms in your home?	No

SUMMER AND WINTER NOON (1:00)

β1 Solar Altitude 24.22°

β2 Solar Altitude 73.29°



For window facing west-south

AIR FLOW ANALYSIS

USER`S RESPONDS ON VENTILATION EFFECTS

Question	Answer
How often do you use natural ventilation in summer?	Sometimes
How often do you use mechanical ventilation in summer?	Never
How do you grade level of satisfaction in terms of ventilation in your home?	Very good
Are buildings adjacent to the building prevent the winds into the house?	Yes

EVALUATION

Building form and material: The building can be said it's compact there is no overhang around the building. There is no heat insulation on the building. There is no shading device on the west side but the neighbours building makes a shadow on the west side which is good for summer but bad for winter time.

Indoor spaces: No overhang around the building there allows the sun's rays in the summer, which is good for winter but bad for summer time.

Outdoor Spaces: There is too much hard surface which absorbs and transfer heat to the building. There are no trees to stop sun`s rays.

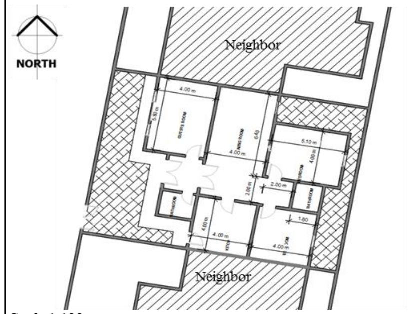
EVALUATION

Natural ventilation is very low in the building because to, adjacent buildings and the orientation impede wind movement.

The windows in the south-west facade are not used for ventilation purpose because of privacy, as an adjacent building is very close.

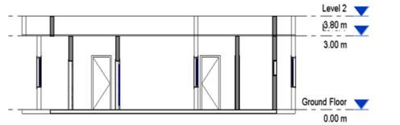
Table 4.22: Case Study 4

PLAN



Scale 1:100

SECTION




3D

PHOTO

LOCATION

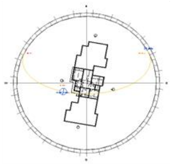
LOCATION	
Al-Bayda city, AL Gadeda	
Longitude 21°47'53.50"	Latitude 32°45'49.09"
Type of building	
Residential	
Construction System	Frame System
People	6 People

FINDINGS

Floor area	165 m^2
Wall area	245 m^2
Glazing area	7.20 m^2
Materials	
Roof	Concrete
Walls	Bricks
Ground cover	Tile
Green area	--

SHADE ANALYSIS OF BUILDING

Summer solstice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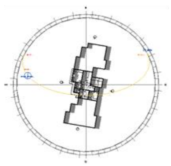
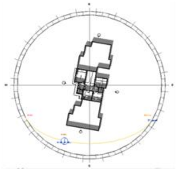

16:00 PM

Winter solstice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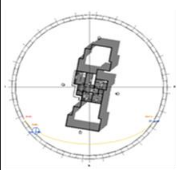

16:00 PM

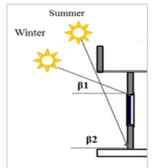
USER`S RESPONDS ON SOLAR EFFECTS

Question	Answer
How often solar radiation reaches the bedrooms?	Sometimes
How often solar radiation reaches into the living room?	Sometimes
What are the shading devices available in your home?	Nothing
Is there a difference in the thermal comfort between rooms in your home?	No

SUMMER AND WINTER NOON (1:00)

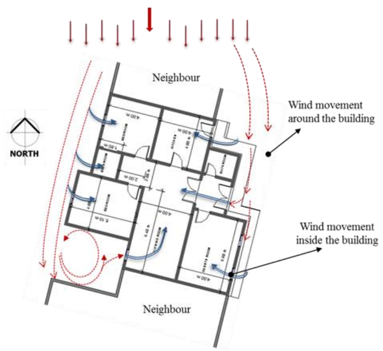
β1 Solar Altitude 41.23°

β2 Solar Altitude 75.35°



For window facing south-west

AIR FLOW ANALYSIS



USER`S RESPONDS ON VENTILATION EFFECTS

Question	Answer
How often do you use natural ventilation in summer?	Sometimes
How often do you use mechanical ventilation in summer?	Sometimes
How do you grade level of satisfaction in terms of ventilation in your home?	Poor
Are buildings adjacent to the building prevent the winds into the house?	Yes

EVALUATION

Building form and material: On north and south side the building is in touch with neighbors. They share the same wall. Therefore there is no heat loss or gain. There is no heat insulation on the building.

Indoor spaces: The overhang has no function because on the east and west side sun angle very low.

Outdoor Spaces: There is too much hard surface which absorbs and transfer heat to the building. There are no trees to stop sun`s rays

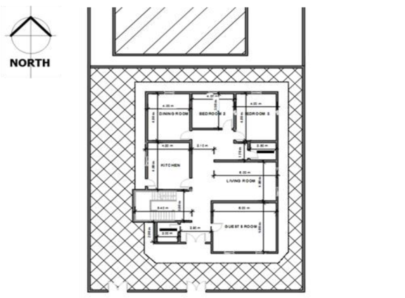
EVALUATION

Low natural ventilation due to the orientation of the building and adjacent building that blokes the ideal movement of the wind to create cross ventilation inside of the building.

Table 4.23: Case Study 5

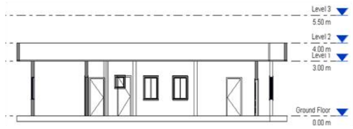
PLAN

LOCATION	
Al-Bayda city, Agnain	
Longitude 21°46'10.94"	Latitude 32°46'11.08"
Type of building	
Residential	
Construction System	Frame System
People	7 People



Scale 1:100

SECTION



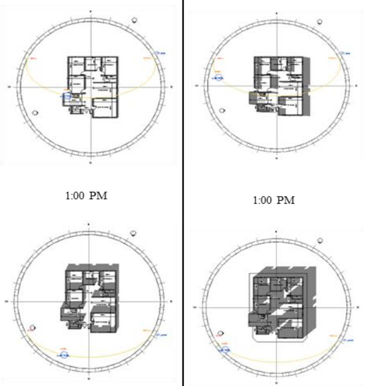
PHOTO

FINDINGS

Floor area	270 m^2
Wall area	283 m^2
Glazing area	13.5 m^2
Materials	
Roof	Concrete
Walls	Bricks
Ground cover	Tile
Green area	--

SHADE ANALYSIS OF BUILDING

Summer solstice | Winter solstice



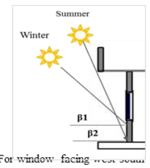
USER`S RESPONDS ON SOLAR EFFECTS

Question	Answer
How often solar radiation reaches the bedrooms?	Sometimes
How often solar radiation reaches into the living room?	Most of the time
What are the shading devices available in your home?	Nothing
Is there a difference in the thermal comfort between rooms in your home?	Yes

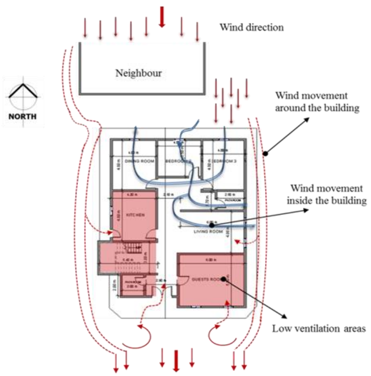
SUMMER AND WINTER NOON (1:00)

β1 Solar Altitude 31.42°

β2 Solar Altitude 80.35°



AIR FLOW ANALYSIS



USER`S RESPONDS ON VENTILATION EFFECTS

Question	Answer
How often do you use natural ventilation in summer?	Most of the time
How often do you use mechanical ventilation in summer?	Never
How do you grade level of satisfaction in terms of ventilation in your home?	Good
Are buildings adjacent to the building prevent the winds into the house?	Yes

EVALUATION

Building form and material: The building can be said it's compact there is an overhang all around the building which acts as a horizontal shading device on the west side. There is no heat insulation on the building.

Indoor spaces: Overhang stops sun's rays on the south side of the building in summer and allows the sun's energy during winter which is positive. shutters are used to stop the sun's energy through windows.

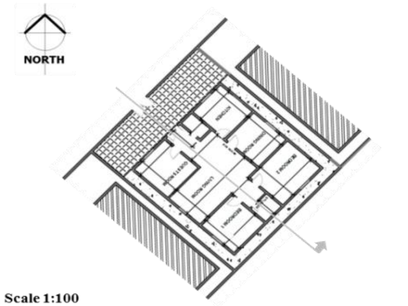
Outdoor Spaces: There is too much hard surface which absorbs and transfer heat to the building. There are no trees to stop sun`s rays

EVALUATION

The orientation of the building and the location of the windows caused the low ventilation to in some of the internal areas of the building. It is apparent that the bedroom, living room and the guest room.

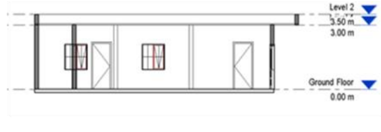
Table 4.24: Case Study 6

PLAN



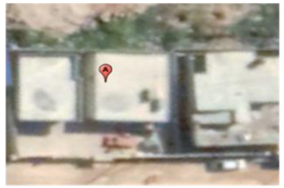
Scale 1:100

SECTION



3D

PHOTO



LOCATION

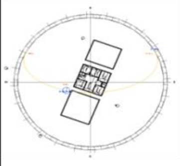
LOCATION	
Al-Bayda city, AL Gadeda	
Longitude 21°48'3.75"	Latitude 32°45'46.34"
Type of building	
Residential	
Construction System	Load bearing system
People	5 People

FINDINGS

Floor area	225 m²
Wall area	280 m²
Glazing area	7.2 m²
Materials	
Roof	Concrete
Walls	Bricks
Ground cover	Concrete
Green area	--

SHADE ANALYSIS OF BUILDING

Summer solstice



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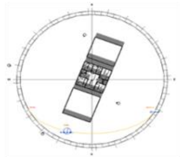
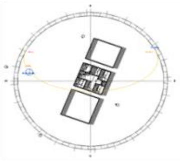
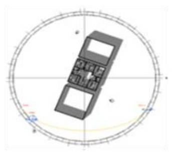


16:00 PM

Winter solstice



1:00 PM



16:00 PM

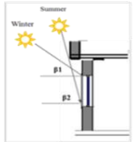
USER`S RESPONDS ON SOLAR EFFECTS

Question	Answer
How often solar radiation reaches the bedrooms?	Sometimes
How often solar radiation reaches into the living room?	Never
What are the shading devices available in your home?	Curtains
Is there a difference in the thermal comfort between rooms in your home?	No

SUMMER AND WINTER NOON (1:00)

β1 Solar Altitude 39.90°

β2 Solar Altitude 79.83°



For window facing north-west

AIR FLOW ANALYSIS

USER`S RESPONDS ON VENTILATION EFFECTS

Question	Answer
How often do you use natural ventilation in summer?	Most of the time
How often do you use mechanical ventilation in summer?	Most of the time
How do you grade level of satisfaction in terms of ventilation in your home?	Very poor
Are buildings adjacent to the building prevent the winds into the house?	Yes

EVALUATION

Building form: Neighbour building on the south side is very close and protests desirable lower sun's radiation during winter, while it also protests undesirable sun's radiation during summer.

Indoor spaces: The overhang has no function because on the east and west side sun angle very low.

Outdoor Spaces: There is too much hard surface which absorbs and transfer heat to the building. There are no trees to stop sun`s rays

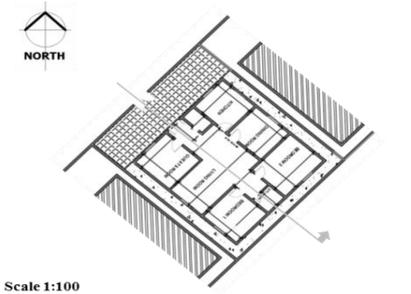
EVALUATION

The adjacent buildings impede the prevailing wind movement causing too low Natural ventilation in the building, excluding the dining room and the kitchen, which faces the wind ventilation with a slanting angle, allowing the wind to enter by the kitchen window into the dining room causing natural ventilation comparatively.

Table 4.25: Case Study 7

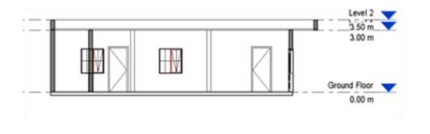
PLAN

LOCATION	
Al-Bayda city, AL Gadeda	
Longitude 21°48'3.75"	Latitude 32°45'46.34"
Type of building	
Residential	
Construction System	Load bearing system
People	5 People



Scale 1:100

SECTION



3D

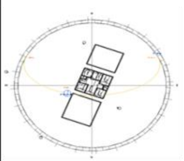
PHOTO

FINDINGS

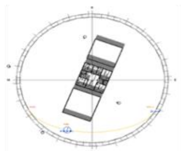
Floor area	225 m^2
Wall area	280 m^2
Glazing area	7.2 m^2
Materials	
Roof	Concrete
Walls	Bricks
Ground cover	Concrete
Green area	--

SHADE ANALYSIS OF BUILDING

Summer solstice

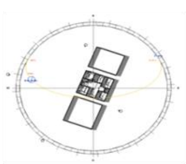


1:00 PM

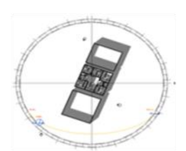


16:00 PM

Winter solstice



1:00 PM



16:00 PM

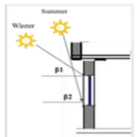
USER`S RESPONDS ON SOLAR EFFECTS

Question	Answer
How often solar radiation reaches the bedrooms?	Sometimes
How often solar radiation reaches into the living room?	Never
What are the shading devices available in your home?	Curtains
Is there a difference in the thermal comfort between rooms in your home?	No

SUMMER AND WINTER NOON (1:00)

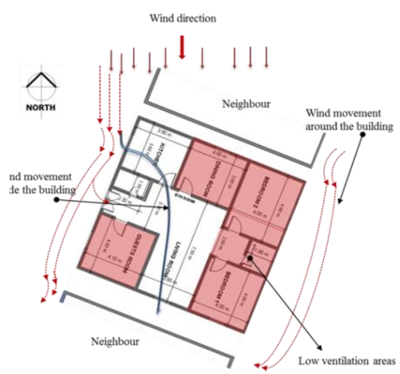
β1 Solar Altitude 39.90°

β2 Solar Altitude 79.83°



For window facing north-west

AIR FLOW ANALYSIS



USER`S RESPONDS ON VENTILATION EFFECTS

Question	Answer
How often do you use natural ventilation in summer?	Most of the time
How often do you use mechanical ventilation in summer?	Most of the time
How do you grade level of satisfaction in terms of ventilation in your home?	Very poor
Are buildings adjacent to the building prevent the winds into the house?	Yes

EVALUATION

Building form: Neighbour building on the south side is very close and protests desirable lower sun's radiation during winter, while it also protests undesirable sun's radiation during summer.

Indoor spaces: Overhang stops sun's rays on the south side of the building in summer and allows the sun's energy during winter which is positive. shutters are used to stop the sun's energy through windows.

Outdoor Spaces: There is too much hard surface which absorbs and transfer heat to the building. There are no trees to stop sun`s rays

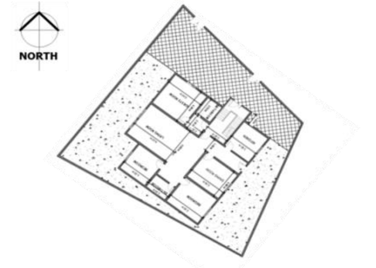
EVALUATION

The adjacent buildings impede the prevailing wind movement causing too low Natural ventilation in the building, excluding the dining room and the kitchen, which faces the wind ventilation with a slanting angle, allowing the wind to enter by the kitchen window into the dining room causing natural ventilation.

Table 4.26: Case Study 8

LOCATION	
Al-Bayda city, AL Gadeda	
Longitude 21°48'5.76"	Latitude 32°45'41.81"
Type of building	
Residential	
Construction System	Frame System
People	6 People

PLAN

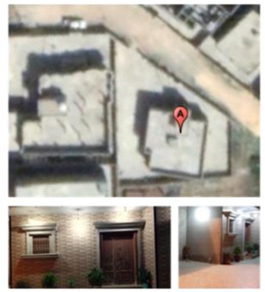


Scale 1:100

SECTION

3D

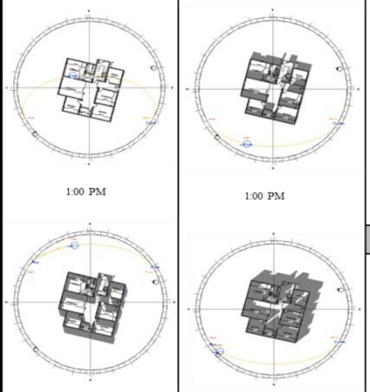
PHOTO



FINDINGS

Floor area	216 m²
Wall area	275 m²
Glazing area	11m²
Materials	
Roof	Concrete
Walls	Bricks
Ground cover	Tile
Green area	--

SHADE ANALYSIS OF BUILDING



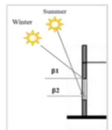
USER`S RESPONDS ON SOLAR EFFECTS

Question	Answer
How often solar radiation reaches the bedrooms?	Sometimes
How often solar radiation reaches into the living room?	Never
What are the shading devices available in your home?	Curtains
Is there a difference in the thermal comfort between rooms in your home?	Yes

SUMMER AND WINTER NOON (1:00)

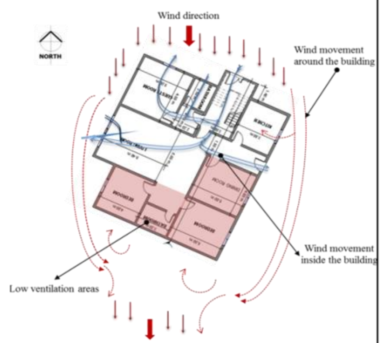
β1 Solar Altitude 38.80°

β2 Solar Altitude 78.73°



For window facing north-west

AIR FLOW ANALYSIS



USER`S RESPONDS ON VENTILATION EFFECTS

Question	Answer
How often do you use natural ventilation in summer?	Sometimes
How often do you use mechanical ventilation in summer?	Most of the time
How do you grade level of satisfaction in terms of ventilation in your home?	Very poor
Are buildings adjacent to the building prevent the winds into the house?	No

EVALUATION

Building form and material: The building can be said it's compact there is an overhang all around the building which acts as a horizontal shading device on the west side. There is no heat insulation on the building.

Indoor spaces: Overhang stops sun's rays on the south side of the building in summer and allows the sun's energy during winter which is positive. shutters are used to stop the sun's energy through windows.

Outdoor Spaces: There is too much hard surface which absorbs and transfer heat to the building. There are no trees to stop sun`s rays

EVALUATION

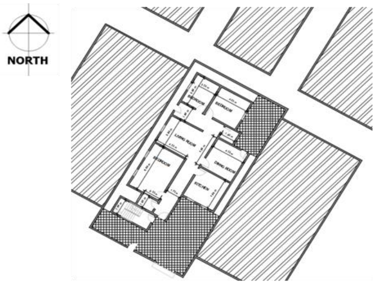
The orientation of the building and the location of the windows caused the low ventilation to in some of the internal areas of the building. It is apparent that the bedroom, living room and the guest room are low ventilation as shown in the Figure above, this is contributing to the high requirements of air conditioning, high energy costs. There can be cross ventilation if they open doors and windows which are on the leeward side of the building provided that indoor doors are opened.

Table 4.27: Case Study 9

LOCATION

LOCATION	
Al-Bayda city, AL Gadeda	
Longitude 21°43'56.92"	Latitude 32°45'41.81"
Type of building	
Residential	
Construction System	Load bearing system
People	4 People

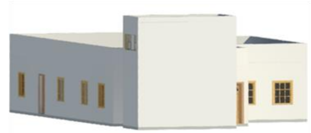
PLAN



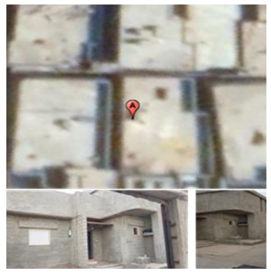
Scale 1:100

SECTION

3D



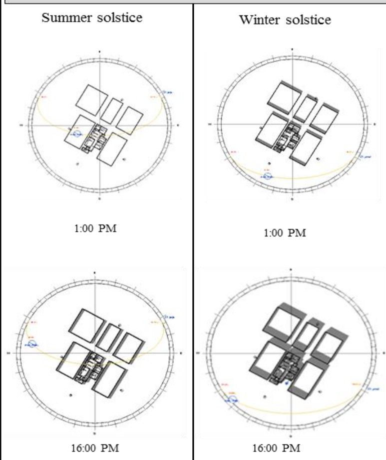
PHOTO



FINDINGS

Floor area	122 m^2
Wall area	265 m^2
Glazing area	8.2m^2
Materials	
Roof	Concrete
Walls	Bricks
Ground cover	Concrete
Green area	--

SHADE ANALYSIS OF BUILDING



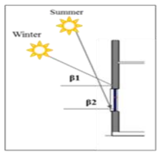
USER`S RESPONDS ON SOLAR EFFECTS

Question	Answer
How often solar radiation reaches the bedrooms?	Sometimes
How often solar radiation reaches into the living room?	Never
What are the shading devices available in your home?	Curtains
Is there a difference in the thermal comfort between rooms in your home?	No

SUMMER AND WINTER NOON (1:00)

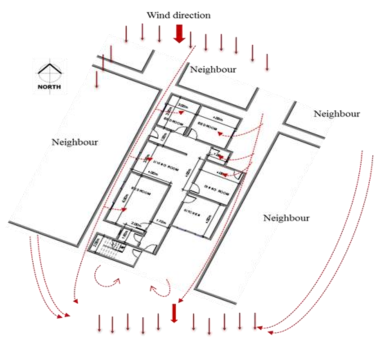
β1 Solar Altitude 26.21°

β2 Solar Altitude 75.29°



For window facing west-south

AIR FLOW ANALYSIS



USER`S RESPONDS ON VENTILATION EFFECTS

Question	Answer
How often do you use natural ventilation in summer?	Sometimes
How often do you use mechanical ventilation in summer?	Most of the time
How do you grade level of satisfaction in terms of ventilation in your home?	Poor
Are buildings adjacent to the building prevent the winds into the house?	No

EVALUATION

Building form and material: The building can be said it's compact there is an overhang all around the building which acts as a horizontal shading device on the west side. There is no heat insulation on the building.

Indoor spaces: Overhang stops sun's rays on the south side of the building in summer and allows the sun's energy during winter which is positive. shutters are used to stop the sun's energy through windows.

Outdoor Spaces: There is too much hard surface which absorbs and transfer heat to the building. There are no trees to stop sun`s rays

EVALUATION

Natural ventilation is very low in the building because to, adjacent buildings and the orientation impede wind movement.

The windows in the south-west facade are not used for ventilation purpose because of privacy, as an adjacent building is very close.

CHAPTER 5
CONCLUSION AND RECOMMENDATIONS

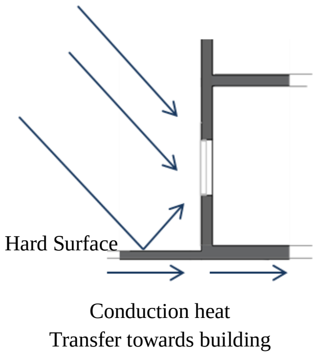
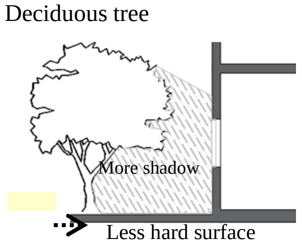
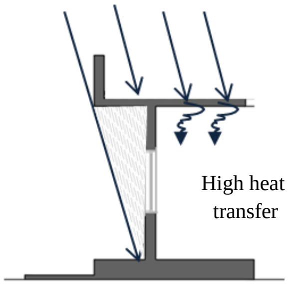
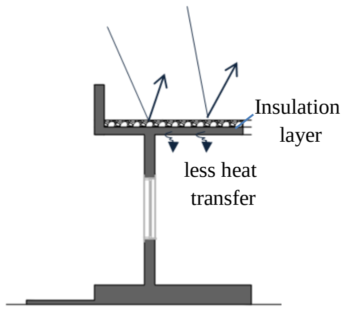
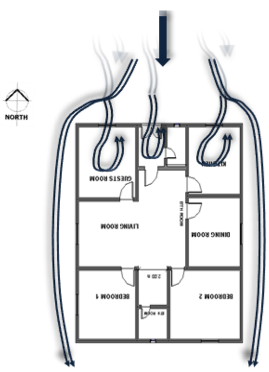
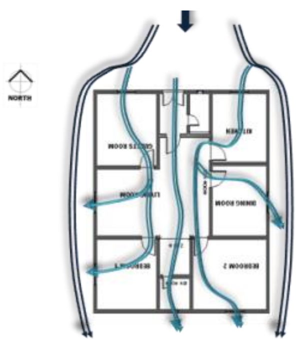
This study was conducted to analyze the energy efficiency strategies of residential buildings in the city of Al-Bayda, the research discussed the principles of climate design which plays an important role in the internal environment quality and energy consumption of residential buildings.

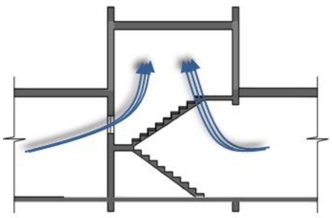
Nine houses in Al-Bayda city were selected and conducted with climate analysis based on shading and air movement. Orientation and solar radiation effects are examined through computer simulation (Autodesk Revit 2016) to find out the suitability of homes with their local environment. The impact on energy consumption can be summarized as follows;

- Buildings are affected by solar radiation in the summer in large quantities and roof becomes the dominant building element which absorbs radiation and transfers into the living spaces. This initiates wide use of air – conditioners together and causing high energy costs.
- Unappropriate orientation of buildings are not in harmony with their surroundings and cannot benefit or prevent themselves from climatic factors on the required time of seasons.
- Generally, wind movement is negatively affected by adjacent buildings and causes low natural ventilation.
- Lack of interest in the outer space of the buildings are observed. Plants and/or landscape elements are not used as an architectural tool for solar control and windbreak purposes.

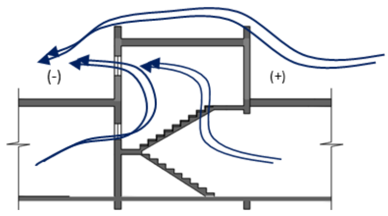
All of these factors have affected houses to pay high energy costs and indirectly increased CO_2 emissions. Through the interview and respondents of the house owners, it has been observed that there is no heat insulation in the walls of buildings which are studied. Also almost no insulation on windows (90% of buildings have no double glazing) is observed. There is also a large consumption of air conditioners (80%). The highest monthly bill cost for electricity consumption is found $250-$300. On the other hand, 100% of respondents were unaware that the environmental damage is caused by energy consumption. On Table 5.1., general recommendations are expressed on the studied buildings.

Table 5.1: General recommendations for the studied buildings

Existing	Recommendations
	 Deciduous trees on the south and south-west site increase shadow area during summer, which allows sun's radiation during winter
 During summer Although overhang will protect the harsh radiation effect on walls, heat transfer through slabs cannot be prevented because of lack of insulation.	 A flat roof can be insulated with several methods of earth, gravel fill may be the cheapest and effective way of obtaining heat insulation
 No cross-ventilation	 Cross-ventilation can be created through indoor spaces by introducing openings over the internal doors.

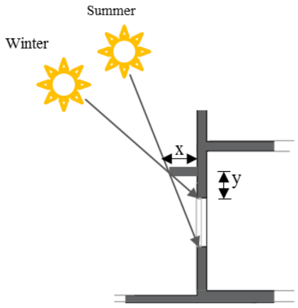


Stagnant hot air



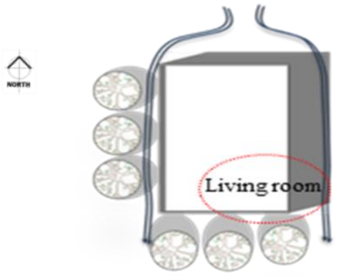
Moving air cooling effect

An opening or mechanical fan at the top of staircase can exhaust dirty air outside, while stacking relatively cool air. Thus convective air movement will create a cooling effect.



For facades direction facing south

The slab prevents solar radiation in the summer and allows to through in the winter.



Area for living rooms, outdoor terraces can be located on the south-east corner of the building where shaded area and the desirable wind is available

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The table is organized in such a way that, existing negative situations of buildings, in terms of solar radiation and natural air movement behavior are reflected together with recommended positive architectural sections. One of the important outcomes of the research is that for the city of Al – Bayda, architects can consider location of living rooms and outdoor terraces on the south-east corner of the buildings where shaded area and the desirable wind is available (See Table 5.1). It is also recommended to use thermal insulation for buildings and to exploit outer space with plants and water bodies.

After the evaluation of these results, it can be adviced that there should be an awareness campaign for the population about the damage to energy consumption. Architects must be well educated with seminars about climate – responsive building design. Chamber of architects must encourage life long learning seminars on climatic design.

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