Environmental Control

Passive solutions including the applications of natural ventilations, designing the three building components, the roof ceiling, the wall and the floor by applying sustainable and passive solutions. Also, local building materials, roof and wall insulation. Designing the indoor environment and designing the outdoor environment.
In addition, the second part of the book will discuss the technical solutions in applying the HVAC system, safety procedures, energy efficiency, and sustainability in buildings including the global assessment methods like LEED, BREEAM, GSAS, ESTIDAMA and Green Star Rating System.
The Third part of the book includes student scientific researches during this course that I teach for 15 years, those papers were published in international journals.

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Environmental Control

Khogali

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DEDICATION

In His Holy Book, the Almighty Allah mentioned: **"And says (unto Act! Allah will behold your actions, and (so will) His messenger and the believers, and you will be brought back to the Knower of the Invisible and the Visible, and He will tell you what you used to do"** (Surat Al-Tawbah. 105); and He mentioned: "**And We have enjoined Upon man concerning his parents - His mother beareth him in weakness Upon weakness, and his weaning is in two years - give thanks unto Me and unto thy parents. Unto Me is the journeying**" (Surat Luqman, 14). This dissertation is dedicated to my beloved mother Mrs. Al-Sareerah Mohammad Ata-Almanan. I cannot find more eloquent words than Prophet Mohmmad's words Peace Be Upon him as he mentioned: "**Who is the most worthy of your company? He mentioned: Your mother. Then, he added: Your mother and added: Your mother, then, your father**". My dear father, Engineer Dr. Abdel Moneim Khogali, who worked and struggled until his name flew up in the sky of Sudan. His plant has produced delicious fruits literally speaking. I pray Almighty Allah to watch over him, protect him, and bestow upon him His blessings and bounties. It is a great honour and source of ultimate happiness to me to dedicate this effort and dissertation to my beloved parents, in recognition of their love and care. I also dedicate this effort and dissertation to my respectable beloved husband, Dr. Al-Fatih Mohi Al Dein. I cannot forget, and I appreciate your endless and relentless support and love. I also dedicate this work and dissertation to my beloved children: Muhammad, Momen, Mazin and Noon. This work should be a guiding light for you to follow on the path of knowledge and learning

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1. My website www.hindamkh.blogspot.com

2. **https://sites.google.com/d/1k4D37HXAitHSihQdjQhNppSLpJzVSqdK/p/10_GhdFwiVQYuYAcSYtWlRpQbtLa3zA3I/edit**

3.

4. **Research gate, Hind Abdel moneim https://www.researchgate.net/profile/Hind_Abdel_moneim?ev=hdr_xprf&_sg=KghtHqizOFxUKtLD-GaPxlaEWEmBqTVl9HN1KBj5DbkQxokASq_tQ65Zf_7QjXiEeIeWKW8OfhF4sHu-LXQ2qtq3**

5. **LinkedIn Hind Abdel Moneim** https://www.linkedin.com/in/hind-abdelmoneim-khogali%D8%8C-ph-d-b80ab43b/

6. **Channel 1)** https://www.youtube.com/feed/my_videos
Channel 2) https://www.youtube.com/feed/my_videos

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Chapter One

Environmental Control

o study the site in project we need to study the following criteria:

1.1 Site selection

Local factors that affect site selection include the slope, orientation, topography, and land features. The five climatic factors, like temperature, wind, pressure, precipitation, and humidity as studied by Fajal (2002) in addition, became crucial during selecting the site locations.

1.2 The climatic factors

The research was conducted in Greater Khartoum, which is characterized to have a hot-dry climate. Thus, the design should incorporate solutions that would manage and deal with the building issues relevant to this climate.

1.3 Orientation

The orientation of the building should be perpendicular to the direction of the wind. Notably, some experiments proved that the greater velocities of air could be obtained inside a building if the orientation is kept at 45 degrees and offer more wind-shaded areas. Good orientation of a building makes the house healthier, and by studying the direction of sunrise and sunset at the building location; the design can be structured to ensure that the building has shades on the gardens and terraces.

1.4 Building layout

(i) Building layout on site:

Previously conducted studies on the movement of air around buildings in the tropics have proved that the distribution of buildings on the site, in fact, affects the movement of air around the buildings. Figure 1.1, Figure 1.2 and Figure 1.3 demonstrate the air movement through the staggered organization of buildings (Hassan, 2000). In the rural areas, it has been observed that the multi-story buildings are developed in the form of a network among the regions, which are still behind the first row of confrontation.

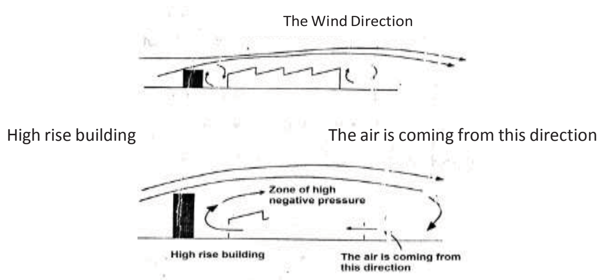


Figure 1.1 Air movement in case of a high-rise building in front of other low-rise building.
Source: Hassan (2000), P.150.

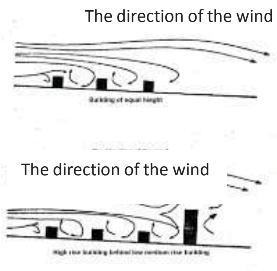


Figure 1.2: Shows the air movement besides high-rise building behind low-rise buildings.
Source: Hassan (2000) P.148.

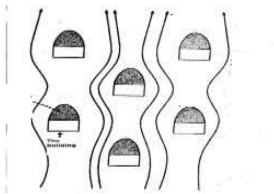


Figure 1.3 Air movement through staggered organization buildings. Source: Hassan (2000).

1.5 Natural ventilation

In Greater Khartoum, the climate is described as hot-dry climate, and accordingly, people are invariably intent on good ventilation, as cools the skin and dries up the sweat. Correspondingly, the architects' design windows to provide good ventilation to the buildings. Thus, window's location, size, and type also should be studied in-depth for an optimal eco-design. Idris (1984) discussed that natural ventilation could have an indirect effect on human comfort through its influence on the temperatures of the indoor air and inside surfaces. As well, as shows the air movement besides high-rise building behind low-rise buildings.

1.6 Ventilation control

It is very important to control the ventilation by natural means such as windows (Roaf, 2001). Incongruency, the following points for ventilation control constitute pertinent factors.
1. Use of pressure variations around the outside of the building causes wind effects.
2. Use of pressure differences caused by the pressure variations within the house.
There are several challenges in designing proper ventilation, including the variability of the wind, its speed, and direction. Nonetheless, a well-manipulated and assimilated ventilation can be of real advantage to the indoor climate of a house.

1.7 Vegetation

Vegetation has a moderating effect on the site climate in air temperature, humidity, and dust prevention. It also provides protection from the sun glare. A building site can use the native plants that do not need much water as well as, plant long trees at a suitable distance from buildings to protect the construction of the building.

1.8 Site services

The system that flows to the town, i.e., the sanitary grid in Khartoum 2 and in other areas in first and third classes demonstrated the use of well and septic tank, pit latrine in some areas in third class, sand and gravel in illegal areas in Greater Khartoum; however, this system needs regular maintenance and cleaning.
The energy supply to houses in Greater Khartoum is usually provided by the National Grid. Therefore, other ways of providing energy, such as solar or wind energy systems could be adapted to manage the shortage of energy in some areas of Greater Khartoum. The water supply is also provided from a local main station.

1.9 Soil

In hot-dry areas, the high evaporation because of the excessive heat due to the sun, sometimes causes cracking of house in the external and internal walls, which affects the building safety. This can be attributed to the type of soil used for the construction. For example, the expensive clay soil, which expands in the rainy season and shrinks in the dry season, thus leading to foundations and walls crack (Center, E. R., 2017).

1.2 Sample case study

5.2.1 Case Study sample in an Outdoor Environment (Al Rouda Park) in Riyadh

Al Rouda Park, with an area of about 3200 m^2, is in the middle of Riyadh.

Figure 1.4. Al Rouda park in the middle of Riyadh is the focus sample for studying the outdoor environment (Google Earth)

The Park provides several facilities for children, and adolescents. There is a sports area and a play yard for football and volleyball. Besides, there are children's play areas and there are sitting areas in seats or on the grass. The most important activity that attracts most of the visitors is the walkway around the park.

The walkway

Sitting area

The grass, which is also offered for families

Stand offering snacks and coffee

The play yard for sports

The children's play area

Figure 1.5. Facilities in Al Rouda Park, Riyadh

1.2.1 Environmental Issues

This section discusses the wide-area hourly average wind vector (speed and direction) at 10 m above the ground. The wind experienced at any given location is highly dependent on the local topography and other factors, and instantaneous wind speed and direction vary more widely than hourly averages.

The hot season in Riyadh lasts for 4.3 months, from 13 May to 23 September, with an average daily high temperature above 25°C to 44°C in July. The cool season lasts for 3.0 months, from 26 November to 26 February, with an average daily high temperature below 22°C to 7°C Figure 38. The coldest day of the year is 11 January.

The average hourly wind speed in Riyadh displays mild seasonal variation over the year. The windier part of the year lasts for 2.9 months, from 22 May to 17 August, with average wind speeds of more than 8.7 m/s per hour. The windiest day of the year is 4 July, with an average hourly wind speed of 10.0 miles per hour. The calmer time of year lasts for 9.1 months, from 17 August to 22 May. The calmest day of the year is 8 October, with an average hourly wind speed of 7.4 m/s per hour.

This section also discusses the total daily incident shortwave solar energy reaching the ground over a wide area, considering seasonal variations in the length of the day, the elevation of the Sun above the horizon, and absorption by clouds and other atmospheric constituents. Shortwave radiation includes visible light and ultraviolet radiation. The average daily incident shortwave solar energy displays significant seasonal variation over the year.

The brighter period of the year lasts for 3.5 months, from 12 May to 30 August, with an average daily incident shortwave energy per square meter above 7.4 kWh. The brightest day of the year is 21 June, with an average of 8.3 kWh. The darker period of the year lasts for 2.8 months, from 9 November to 2 February, with an average daily incident shortwave energy per square meter below 5.0 kWh. The darkest day of the year is 10 December, with an average of 4.2 kWh. We based the humidity comfort level on the dew point because it determines whether perspiration evaporates from the skin, thereby cooling the body. Lower dew points feel drier, and higher dew points feel more humid. Unlike temperature, which typically varies significantly between night and day, the dew point tends to change more slowly; thus, although the temperature may drop at night, a muggy day is typically followed by a muggy night. The perceived humidity level in Riyadh, as measured by the percentage of time in which the humidity comfort level is muggy, oppressive, or miserable, does not vary significantly over the year , remaining virtually constant at 0% throughout the year, i.e., the climate is hot and dry most of the year. Weatherspark (Park, Weather, 2021)

In both summer and winter, people visit parks near their houses. Al Rouda Park is well-designed to encourage daily visitors. The most suitable time for walking, especially during the COVID-19 pandemic, is from 6:00 to 8:00 a.m. and from 4:00 to 6:00 p.m. There are no crowds at these two times. There are no checkpoints to measure personal temperature. The environmental issues as follows

1.The Temperature

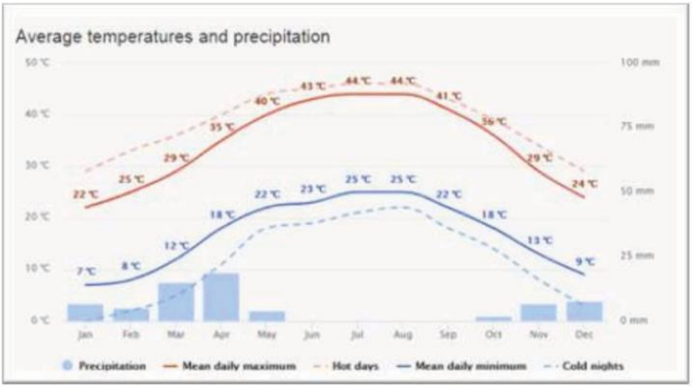
2.The Humidity

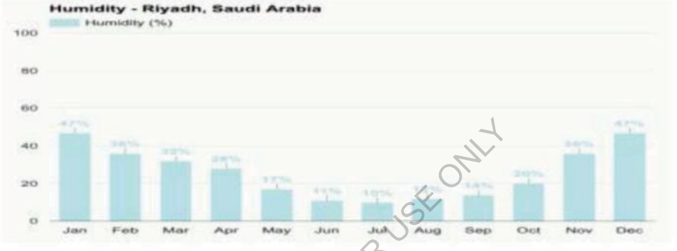
3.Average wind speed

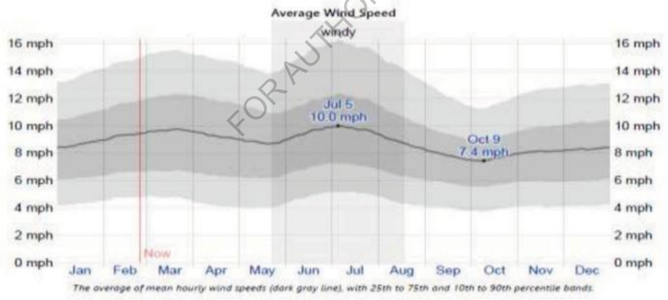
4.The rainfall

5.The pressure

6.The solar amount


Average temperatures and precipitation
50 °C
40 °C
30 °C
20 °C
10 °C
0 °C
100 mm
75 mm
50 mm
25 mm
0 mm
22 °C
25 °C
29 °C
35 °C
40 °C
43 °C
44 °C
44 °C
41 °C
36 °C
29 °C
24 °C
7 °C
8 °C
12 °C
18 °C
22 °C
23 °C
25 °C
25 °C
22 °C
18 °C
13 °C
9 °C
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Precipitation
Mean daily maximum
Hot days
Mean daily minimum
Cold nights


Humidity - Riyadh, Saudi Arabia
Humidity (%)
100
80
60
40
20
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec


Average Wind Speed
windy
16 mph
14 mph
12 mph
10 mph
8 mph
6 mph
4 mph
2 mph
0 mph
Now
Jul 5
10.0 mph
Oct 9
7.4 mph
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
The average of mean hourly wind speeds (dark gray line), with 25th to 75th and 10th to 90th percentile bands.

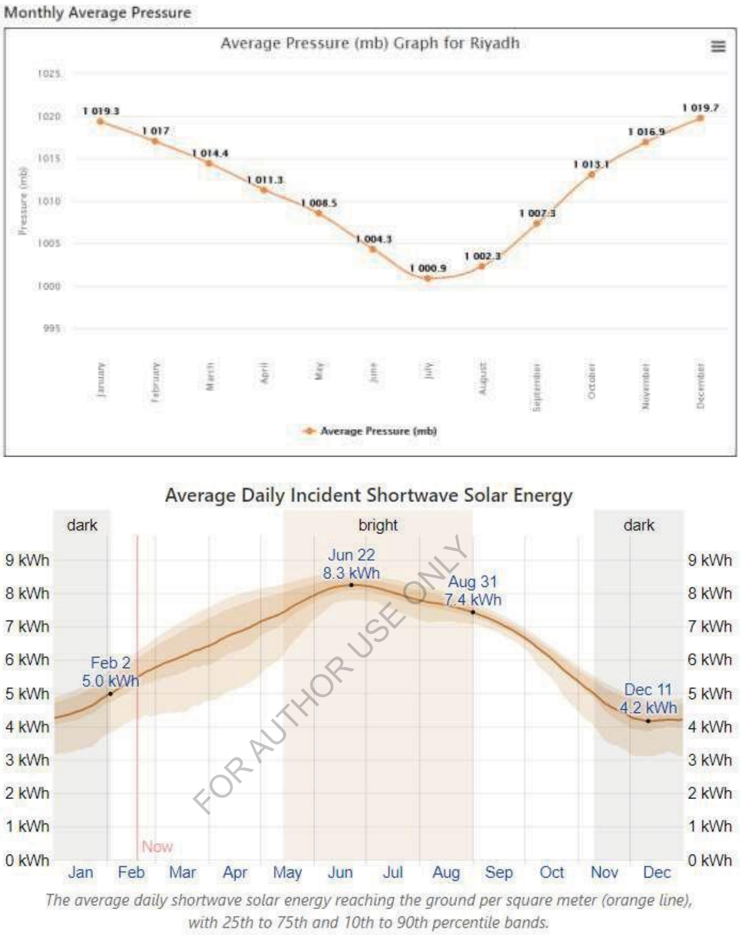


Figure 1.6. Annual weather variations in Riyadh. Source: Weatherspark (Park, Weather, 2021)

1.2.2 Simulation by Using ENVI-MET

Using a simulation program, the thermal image of the park was studied, with wind direction, and temperature at the microscale. For example, ENVI-MET software is a program used in the design phase that helps to reduce the urban heat surrounding the park by adding more trees and water features.

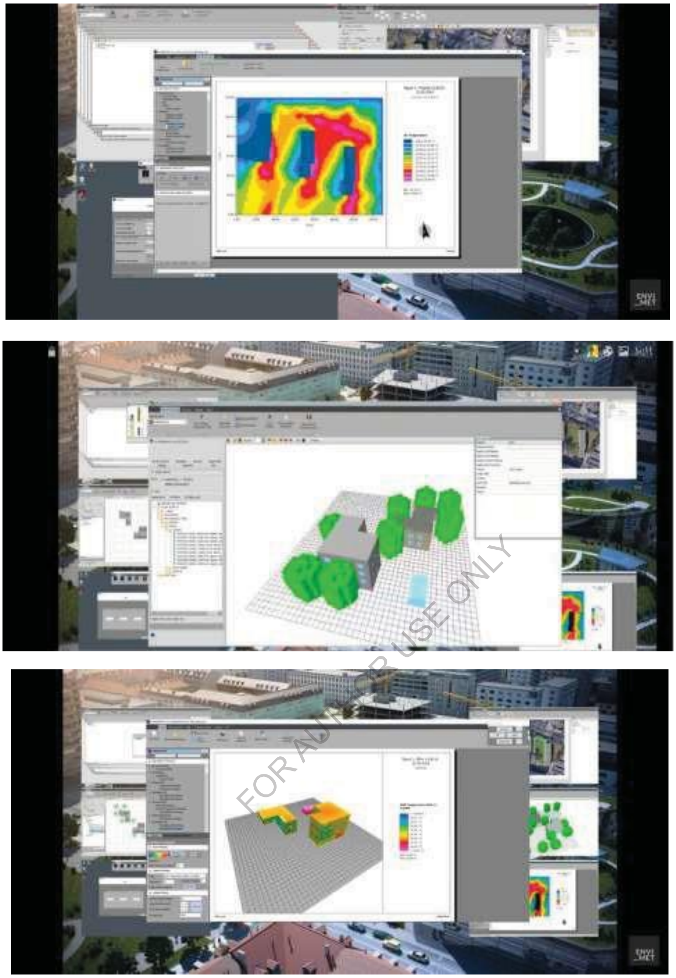


Figure 1.7. ENVI_MET (ENVI-MET, 2021) software program analyzing environmental issues

ENVI-MET software was used to study the environmental issues in the park, such as temperature, humidity, wind direction, and solar radiation, to identify potential solutions for exceeded temperature especially in summer such as planting tall trees to create a buffer zone between the buildings and the park to reduce the temperature.

The solar radiation in Figure 15 presented in red is the highest temperature (22 to 25°C) between the block buildings, the orange indicates 20 to 21°C; the yellow represents 19°C to 20°C, and green is the lowest temperature, between 15°C and 19°C. The prevailing wind direction is northwest, at 8 mph, and the humidity is 30% in March. It is important to plant high trees as a buffer zone between the park and the surrounding buildings to minimize the temperature, especially in summer.

The recommended health procedures regarding COVID-19 in parks include checkpoints near the main gate and main entrance. Notably, most parks in Riyadh, such as Al Rouda Park, have not had checkpoints during the COVID-19 pandemic.

- The Tawakkalna application was implemented by the government for entrance to all public spaces, which should be downloaded on personal mobile phones and presented at the checkpoint to ensure that a visitor is not infected with the virus (Prevention, C. O., 2020),
- Checkpoints in parks should be provided during the COVID-19 pandemic to ensure the health procedures are being applied, such as checking personal temperatures using smart devices and wearing a mask.
- People, including children and youth, should visit the park weekly for walking and practicing sports, as fresh air is required for their health, especially during COVID-19.
- People should be encouraged to use bicycles within their neighborhoods.
- Software such as ENVI-MET should be used to study environmental issues, such as temperature, humidity, wind direction, and solar radiation to provide solutions for exceeded temperature especially in summer furthermore, tall trees should be planted to create a buffer zone between the buildings and the park to reduce the temperature.
- Outdoor fans should be used in summer to increase the walkability of Riyadh.
- Health procedures should be applied to all park visitors.
- Some effective design solutions should be applied in the park such as, Figure 16 shows some effective solutions in designing the park during COVID-19 by applying the social distancing in the seats (b), Amphitheatre (e), drawing circles in the grass for families with social distancing (a), and drawing specific path for walking and running(d). Figure16 shows some effective solutions in designing the park.

 a. circles on the grass for sitting	 b. Social distancing on seats
 d. Drawing specific path for walking and running	 e.Social distancing in the amphitheater.

Figure 1.8 . Shows some effective solutions in designing the park post-COVID-19

Chapter Two
Definition of Thermal Comfort

2.1 Measurements and controlling Methods:
Thermal Comfort principles
Introduction to Thermal Comfort principles

On this section the researcher will discuss the basic thermal comfort principles; thermal comfort definition, the heat balance, the heat flow, the time lag, human thermal comfort and balance , building thermal behavior and the six basic factors of thermal comfort.

2.2 Definition of thermal comfort:
Thermal comfort is defined in British Standard BS EN ISO 7730 as:
'That condition of mind, which expresses satisfaction with the thermal environment.'
Roaf, S., Fuentes M. and Thomas, S. (2001)1 defined term 'thermal comfort and said that: "*it describes a person's psychological state of mind and is usually referred to in terms of whether someone is feeling too hot or too cold".*
1 Roaf, S., Fuentes M. and Thomas, S. (2001). , *ECOHOUSE: A Design Guide,* Architectural Press, Oxford, Great Britain.
2 MCMULLAN, R. (2002). , *Environmental Science in Building*, Published by PALGRAVE.
Another definition is provided by ; MCMULLAN, R. (2002)2 and said that the thermal comfort of human beings is governed by many physiological mechanisms of the body, and these vary from person to person. In any thermal environment, it is difficult to get more than 50% of the people affected to agree that the conditions are comfortable!

Why is thermal comfort important?
The people in Khartoum usually spend most of their times away from their workplaces, as they are not comfortable in their work environment, this makes it imperative and very

essential to improve the work environment to encourage people to stay longer in order to do their works. Roaf, S., Crechton, D. and Nicol, F. (2005)3 said that there are three reasons why thermal comfort is important to the design of buildings:

Roaf, S., Crechton, D. and Nicol, F. (2005). , *Adapting Buildings and Cities for Climate Change, A 21st century survival guide,* Architectural Press is an imprint of Elsevier, P.126. - 246.

Firstly, Thermal Comfort is an important aspect of user satisfaction.

Secondly, the temperature, which people try to achieve in their house, is an important factor in deciding the amount of energy that will be used.

Thirdly, if a building fails to be comfortable, the occupants will take actions to make it comfortable. These actions usually involve a form of energy – heating or cooling - which could possibly destroy a carefully constructed low-energy strategy.

2.3 Heat Flow through walls

There are four different methods through which a wall can be insulated:

Firstly, Resistive Insulation:

This is method which most of us think of as way insulation. These are the ‘bulk' insulation products, which include mineral wools, strawboard, wood-wool slabs, glass fiber products, kapok, and wool and cellulose fiber. They also include expanded and extruded polystyrene, polyurethane, urea formaldehyde, vermiculite and prelate.

Secondly, Reflective Insulation:

This requires a highly reflective material, aluminum foil, to face a cavity, across which high levels of radiant heat are being transmitted. The foil reflects the radiant energy back across the cavity, rather than absorbing it. This type of insulation will not work.

Thirdly, Relative Density:

conductivity and thermal capacity of a range of materials, note the excellent thermal capacity of water that made of an excellent heat storage medium .

Fourthly, Capacitive Insulation:

That is often described as ‘thermal mass' and was found in buildings in the form of ‘heavy walls. While resistive and reflective insulation work instantaneously, capacitive insulations affect the timing of the heat flows.

2.4 The Time Lag:

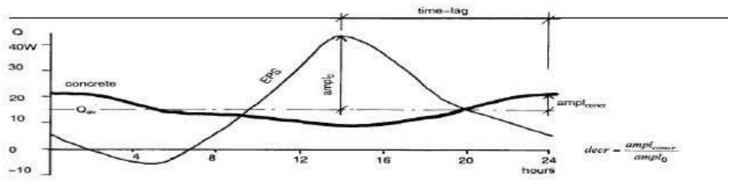


Figure 2.1: The periodic heat flow through a high and heavy wall of the same U value
Source: Roaf, S, Fuents, M. and Thomas, S. (2000)

The periodic heat flow through a light and heavy wall of the same U value

.

1. The heavy slab's heat flow is delayed: the term ‘time lag' is defined as the difference (in hours or days) between the peaks of the two curves. Shown in Figure 1.1.

2. The amplitude (means to peak) of the heavy slab's curve was reduced well below that of the lightweight material. The ratio of the two amplitudes was called the decrement factor.
If rooms back onto each other, the walls should be 150–200 mm thick. In more extreme climates, the time lag could be increased, or the decrement factor decreased, by altering the width of the mass wall. (Roaf, S., Fuentes M. and Thomas, S. (2001) .

1.4 Human Thermal balance and comfort

Szokolay, S. V. (2004) stated that the human body continuously produces heat by its metabolic processes. The heat output of an average body often recorded could vary from about 70W (during sleep) to over 700W during heavy work or vigorous activity

playing squash). This heat is dissipated to the environment; the deep-body temperature is normally about 37◦C, whilst the skin temperature can vary between 31 and 34◦C.
Fig. 3.9 shows Heat exchanges of the human body; the body's thermal balance could be expressed as (see Fig. 3.2).

$M \pm Rd \pm Cv \pm Cd - Ev = \_S$ (1.6)

Where:

M = metabolic heat production
Rd = net radiation exchange
Cv = convection (incl. respiration)
Cd = conduction
Ev = evaporation (incl. in respiration)
_S = change in stored heat for human.

A condition of equilibrium when the sum (i.e., the _S) is zero and such equilibrium is a precondition for thermal comfort. Figure (3.9) shows heat exchange of the body.

2.5 Thermal behavior of buildings

In addition, Szokolay, S. V. (2004) said that a building could be considered as a thermal system, with a series **of heat inputs and outputs** (analogous to Eq. (1.6) for the human body):
Szokolay, S. V. (2004).

Qi – internal heat gain
Qc – conduction heat gain or loss
Qs – Solar heat gain
Qv – ventilation heat gain or loss
Qe – evaporative heat loss
_S is a change in heat stored in the building.

The system could be depicted by the following equation:
$Qi + Qc + Qs + Qv + Qe = \_S$ (1.10), where **Thermal balance exists, when the sum of all heat flow terms, thus _S is zero.** If the sum is greater than zero, the temperature inside the building is increasing, or if it is less than zero, the building is cooling down.

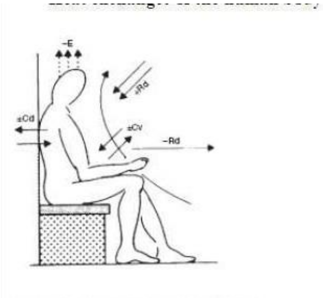


Figure 2.2: Heat exchange of human body. Source: Szokolay, S.V.(2004)

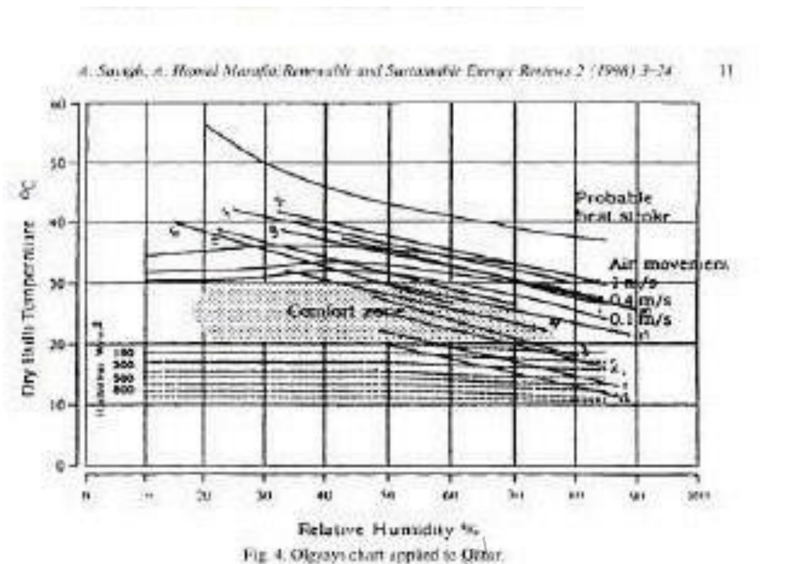


Figure 2.3: Heat Island Effect, source: Gallo, C., Sala, M. (1998).

Chapter Three

The Six basic factor affect thermal comfort

3.1 The Six Basic Factors of thermal comfort

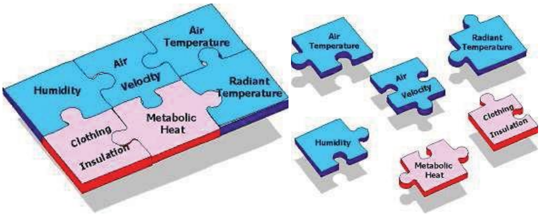


Figure 3.1: The six basic factors of thermal comfort

Source:(http: //www.HSE-Thermal comfort Homepage,2005) .

Figure (3.10) shows the six factors affecting thermal comfort are both environmental and personal. These factors may be independent of each other, but together contribute to a worker's thermal comfort.

a. Air temperature

Air temperature which is surrounding the body is usually given in degrees Celsius (°C) or degrees Fahrenheit (°F).

b. Radiant temperature

Thermal radiation is the heat that radiates from a warm object. Radiant heat may be present if there are heat sources in an environment. Radiant temperature has a greater influence than air temperature on how we lose, or gain heat to the environment. Our skin absorbs almost as much radiant energy as a matt black object, although this may be reduced by wearing reflective clothing. Examples of radiant heat sources include: the sun, fire, electric fires, furnaces, steam rollers, ovens, walls of kilns, cookers, dryers, hot surfaces, and machinery.

c. Air velocity

This describes the speed of air moving across the worker and may help cool the worker if it is cooler than the environment. Air velocity is an important factor in thermal comfort because people are sensitive to still or, stagnant air. In Khartoum people open windows for cross ventilation to improve the air velocity inside the buildings.

d. Humidity

HSE, defined thermal comfort as '***Relative humidity is the ratio between the actual amount of water vapour in the air and the maximum amount of water vapour that the air can hold'***

In Khartoum the weather is described as hot dry climate, the next section is provided solutions to improve the weather to be more humid rather than dry.

Personal factors

The nature of the person's clothing affects thermal comfort, heavy cloths make the person feels too hot, in hot climates, such as Sudan. Therefore, in Khartoum most of the year is hot and dry weather. In summer, people wear cotton clothes of light colours, mainly white colour to reflect back the sun radiations, cotton clothes absorb sweat. Operation of equipment (PPE) may be a primary cause of heat stress, even if the environment is not considered as warm or hot.

Chapter Four

The three components

Controlling the roof

4.1 Controlling

the design in a tropical hot dry climate:

4.1.1 Introduction:

Human thermal comfort aims at reducing the radiation reflected from the surrounding surfaces.

4.1.2 Passive Design:

Most of Sudanese houses are well ventilated through windows which provide natural air into the house. They use bricks in building construction and this material provides a good time lag that can save the house from high temperatures during hot day period and releasing of this heat during the night producing a good comfort to people living in the house. Mahmoud, M. Idris (Dec-1984)[1] stated that before considering the use of active energy, a building designer might logically ensure that all natural means of cooling and heating of a building have been economically tapped. This is achieved through what is known as passive architectural design. The concept of passive design is an energy conservation concept. Hamid, H.Y. (1984) published a Paper on *"Rational Thermal Design of Building Envelop in Sudan "*.For professionals and academicians, who intend to bridge the wide gap between the requirements of building energy efficiency and current building practices in Sudan, the paper recommends the following measures:

"1-Conduct research to establish optimum shell characteristic for different regions

2-Endeavour to establish a national standard code for energy conservation in Sudan

3-Review training of architects and building designers in Sudan in relation to:

- Steady and transient heat transfer.

-Thermal environment phenomena.

-Human body comfort.

-Energy conservation in buildings.

In this section the researcher will discuss and analyse how we can control thermal comfort design on buildings on hot dry climate like as in Greater Khartoum, through controlling six main components which are:

4.2.1 Firstly: Control of the Building's Envelope

4.2.2. The Roof.

4.2.3 Walls:

4.2.4 Floors

4.2.5 The form

4.2.6 Secondly: Control of thermal comfort of Indoor Environment (IEQ)

4.2.7 Thirdly: Controlling thermal comfort of outdoor Environment

4.2.1 Firstly: Control of the Building's Envelope

The Roof:

Building composite roofs is the most vulnerable to solar radiation. The protection of the solar radiation is one of the most difficult ways, which could be achieved through:

1. testing of building materials for roofs or with a thermal capacity fails significant time "Time lag" because these materials are storing high temperature during the day and then release it during the night.

2. Another way is to install a secondary roof over the main roof to be inseparable and to leave a ventilation gab between them "Hall of friendship:" Roofs should be double to allow air circulation.

3. The use of roof thermal insulation on the outside concrete slab, which increases the time lag during daylight hours. But this method, which is to prevent loss of heat at night, is not a practical way. A more practical solution is to insulate the roof with natural insulation material, cover this with light weight concrete and then covering the roof with tiles to provide protection against heat during the day and loss of heat during the night.

4. Use of bright colours, white or light coloured coating. The result is reduction of the heat absorption of inside of the building and the metal roofs should be avoided. Hassan, (2000).

5. Green roof:

Scientists found that green roofs minimize the solar radiation from the roof surface as well as heat island effect and reducing surface run off.

Alexandria, E. and Phil Jones, A. (2006) published a paper on" *Temperature decreases in an urban canyon due to green walls and green roofs in diverse climates"*. The paper discussed the thermal effect of covering the building envelope, with vegetation on the microclimate in the built environment for various climates and urban canyon geometries and as well as, Jim , M. (2008) presented a paper on "*The Green Roofs for Ecological and Economic Benefits in the compact Urban Environment of Hong Kong''*. The potential for greening the barren roofs in urban Hong Kong was evaluated. The city-wide ecological and economic benefits were assessed with reference to urban heat island effect. (Eco city world summit conference). In addition to that, Matlock, M. and Margom, R. (2011). Wrote on their book “Ecological Engineering Design” about green roof and said that green roof helps to reduce surface run off by slowing run off velocity across the rooftop and providing storage of water in the soil media and green oofs also provide a cooling effect for the building and the surrounding area. Green roofs may also provide some pollutant removal.

6. Solar Reflectance Index and cool Roofs and heat island effect

Scientists found that to minimize solar reflectance index we can provide such solution as:

- shades on site over parking areas, plazas, walkways

- As well as application of bright colours paints to buildings and roofs to reduce heat absorption.
- provide underground parking by 50% and undercover parking.
- vegetated roof surface
- Roof sloop constructed materials and the way of construction can affect heat island.

This has been discussed by Luckett, K. (2009) stated that heat island effect, the intent of that requirement was to reduce the microclimatic thermal gradient difference between the project being developed and adjacent lands that have wildlife habitats. Another discussion was provided by Gvorkian, P. (2008) from Environmental Building News, (Jan. 2008) encourages the use of light-colored and reflective surfaces heats up less in the sun. Roofing materials which meet LEED's target SRI of 29 in nearly any standard colour, are now available. Those and other cool roof materials help lower heat gain i.e., indoors heat. Green newsletter (2008), www.Building Green.com

Chapter Five

Second Component:The wall

5.1 Designing of the walls:

Walls are the second component of the house, which should be protected from solar radiation by:

1) Walls's construction building materials:

The first thing that affects wall design is choosing of the building materials:

In Sudan walls widely accepted materials are lime bricks which have the property of absorbing high temperature during daylight hours and release the heat at night by the help of ventilation openings.

2) Designing of windows openings:

The second factor that affects wall design is the windows:

1. Windows openings should be smaller during daylight hours and high in the walls to avoid thermal radiation reflected from the ground and protected with shade to cover from bright sunlight.

2. Increasing of windows openings assist in ventilating rooms and hence loss of heat, which is visibility of the internal surfaces of the walls and ceilings.

3. The optimal solution in the design of large openings by keeping the opening and closing of windows under control, will allow airflow in balance.

4. Painting under reproach and windows all with light coloured paint to reflect solar radiation away from the windows towards the outside.

5. Use of sunscreen and others, which operate to reduce radiation, will influence the air movement inside the vacuum. The framework can be used to guide the central air at the bottom and the use of sunscreen will also reduce the solar radiation inside the architectural vacuum. Hassan (2000)

6. Abu Sin, M.E. and Davies H.R.J. (1991). Stated that it is essential, as far as possible, to create shaded urban areas to allow a cool breeze channeled through the urban network. Canopies, shutters, and louvers and that can help to control the entry of heat through windows.

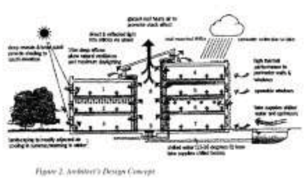
3) The Green wall:

Third factor in designing the wall which affects the thermal comfort is greening of the walls:

Benhalilou, K. (2009) presented paper on Eco City Built 2009 and said that" *using vegetation on frontages of building was a long time employed and known for its thermal advantages".* Plants provide oxygen and help to create a barrier to direct sun rays and both of which help in creating an atmosphere of natural cooling.

4) The Appropriate Technology in windows design:

The fourth factor is using the appropriate technology: Smart windows could make air conditioning superfluous. .http:// www.Green Building Magazine, (2007) announced a new technology, which greatly reduces the need for air conditioning in building

FIGURE (5.1)	**FIGURE (5.2)**
Architects Design Concept	**Building Shades**
	
SOURCE: Croome, D. C. (2003)	**Building Innovation .co.uk, winter 2007, ENQUIRY CARD/ONLINE NO 14www.link2enquiries.co.uk** ,(2007)

Many companies provide Aluminum building products with a good qualities as sustainable building materials such as Dales Aluminum Building Products. See Figure (5.2) shows the use of building shades on a typical glass building. In addition to that in Middle East market now a days consist of many of green product such as green paints, smart house equipment's. Figure (5.1) shows architecture design concept that should provide natural cross ventilation and roof insulation.

5) The Natural Ventilation:

In khartoum weather is discribed as hot dry climate, people always look for good ventilaton, architect design windows to provides a good ventilation to the buildings , windows location, size and type should be sudied as well.

Idris, M. M. (Dec-1984) discussed that natural ventilation could have an indirect effect on human comfort, through its influence on the temperatures of the indoor air and inside surfaces. Croome, D. C. (2003) has provided a cross section of the architect's design concept Allowing cross natural ventilation to the office buildings, is shown in Figure 5.4. Figures 5.5, Fig.5.6, show different positions for windows and air movement and how the sashes affect the air movement. Table3.2 shows the ventilation system of windows. Hassan, (2000).

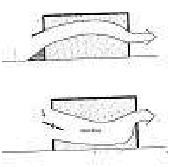
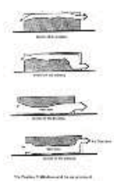
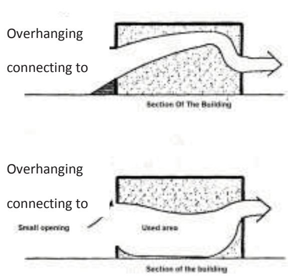
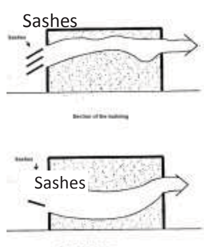
6) White washing:

In Khartoum its preferred to use white colour paints in walls to reflect the solar heat back from walls, and as well, the walls can regularly be washed from dust, this opinion had been discussed by Ahmed, A.M. (1975). where he stated that: regarding roofs and walls, whereas the dust absorbs solar radiation, it is preferred then to wash white painted walls with water, rather than re-painting them again, and which is expensive process. As for the roof, it may be whitewashed to minimize its thermal comfort.

7) Shading

Ahmed, A.M. (1975) discussed simple light shading of the roof and walls, serves several purposes, and he has concluded with the following points:

1. *Intercept direct and indirect radiation*
2. *Automatically, incorporated within the construction, a laye of nature's cheapest insulating material – air, thereby increasing the time lag and thermal resistance".*

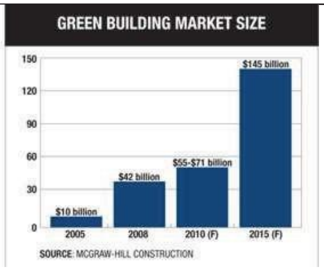
FIGURE 5.3 **Shows Air Movement and Windows Fixing Method Control**  SOURCE: Hassan, (2000)	**FIGUR 5.4** **Shows the relation between the position of windows and air** **Movement**  SOURCE: Hassan, (2000)
FIGURE 5.5 **Shows air movement and overhanging**  SOURCE: Hassan, (2000)	**FIGURE 5.6** **Shows air movement and Sashes in upper** **and lower**  SOURCE: Hassan, (2000)

Chapter six

THE THIRD COMPONENT: THE FLOOR

And the distribution buildings on site

6.1 The Floors:

FIGURE (6.1) **Green Building Market Size**	**FIGURE (6.2)** **showing different types of eco floors[2]**
	
Source: HamPton, V.H. (Nov.-2010) from MACGRAW-HILL CONSTRUCTION	Mc Craw –Hill Continuing Education Centre, Sustainability Courses (2010) **http://continuingeducation.construction.com/**

Floors are the third building component and in designing floors there are many points need to be considering being an eco-floor such as:

- Design the floor to be more comfortable.
- Made from ecofriendly building materials such as green concrete, heavy duty marbles, green products for floors there are wild range of tiles and green products ,follow this link www.sweets network.com
- Recycling from waste bricks, stones, rubber, organic materials, etc.
  Making some visible tiles to see the building how it works.

  Made it slip resistant, strength, heat and moisture.
- Durable, for indoor and outdoor applications, Manufactured with a high quality and standards, available in roll and tiles, multi-colours and easy and fast installations.
- Easy maintenance .See Figure (6.2) shows different types of Eco Floors. Mc Craw –Hill provides all new finishing's sustainable building materials.

Hampton, V.H. (Nov.-2010) said that building owners are looking forward to go further green for economic reasons rather than environmental" Hampton wrote an article published in Architecture Record magazine, showed that there is an increasing concern on green products. Figure (6.1) shows the green building product had grown by 50% in the past two years. The Clean Development Mechanism (CDM) has been provided by

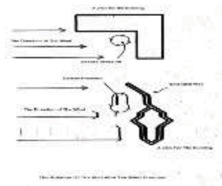
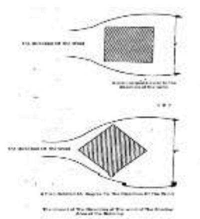
- United Nation Development Programme (UNDP), (Oct-2010).

(Provided) which helped the developed countries to reduce emissions anywhere in the world, they had counted these reductions among their own targets, the program has two dimensions, one was to allow developing countries to achieve low cost emission reduction, and the second was inward investment, technology benefits.

Chapter Seven
Building Form

7.2 The building form

7.2.1 The orientation of the house

FIGURE 7.1	**FIGURE 7.2**
The Relation between the building rotation and the wind direction	**Shows the impact of the direction of with building orientation**
	
SOURCE: Hassan, (2000) [Y]	SOURCE: Hassan, (2000)

The orientation of the building should be perpendicular to the direction of the wind. It is worth to note that some experiments proved that greater velocities of the air could be obtained inside a building, if the orientation is kept at 45 degrees with the direction of the wind and offer more wind shaded area. Fig (7.1) shows the impact of the direction of the wind with the shaded area of building and Fig (7.2) shows the relation between building orientation and the wind direction, Hassan (2000) The good orientation of the building makes the house healthier, and by studying of sun rises and sun sets locations we shall be more knowledgeable of the direction of the shades made for the gardens and terraces.

7.2.2 Ratio of exterior surface to enclosed volume

SVR= Surface Area

Total Volume

SFAR=Surface Area

Floor Area

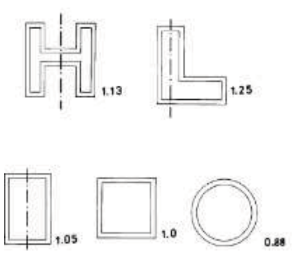
Experiments showed that, this ratio range from 1: 0.16 to 1: 0.12, in a hot dry climate. In the hot dry climate, the surface volume ratio (SVR) and the Surface Area Ratio (SFAR) should be as low as possible to minimize the radiation on the building. This can be achieved through multi - story buildings and rising the roof height (Fagal, Kh. S., 2000)

3) We have different buildings forms, cubic form, linear form, L-form, U- form, circular forms. **There are many factors that forces and ordering us to choose form one than the others:**

- Building location, whether the building is located on high of mountains or on flat area, cold areas or wet or hot dry climate each location requires specific form.
- The climate: whether the building is in hot climate zone or cold climate. In cold areas it is better to use cubic form but in hot climate its better use L-form or U-form for or leaner form, as they provide good ventilation for the house.
- Sun movement: it is very important to study the sun movement in a specific location to choose the building form and shape, the form in order to secure more shades to the buildings and minimize the solar radiation.
- The Heat exchanger: The greater the volume of the building the more surface area it has to lose or gain heat from, Roaf, S., Fuentes M. and Thomas, S. (2001) discussed the building form in several cases such as: building as an analogy, the Icehouse, the tea cozy cottage, the green house , the nomadic tents and the igloo. Figure 5.5 shows that different plan forms can have more or less wall area for the same plan area.
- *The surface area: volume ratio* is very important in conserving heat transfer into and out of a building. To conserve heat or cold the building must be designed with a compact form to reduce the efficiency of the building as a heat exchanger. Buildings can have very different perimeters: area ratios depending on their plan form. **B**auer.M. & Mosel. P. (2010) discussed on Fig. 7.3. Shows deferent building forms and their energy gain.

FIGURE 7.3

Buildings forms

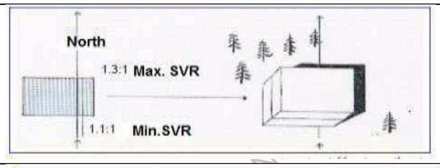
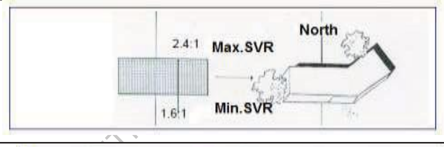
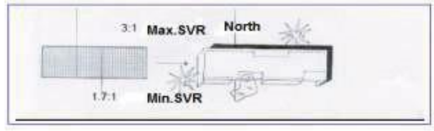
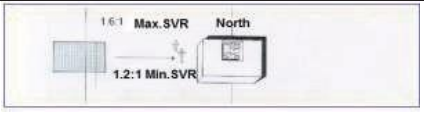
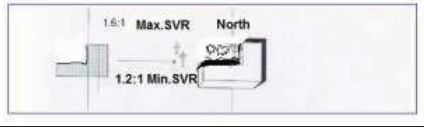


Source: (Roaf, S., Crichton, D. and Nicol, F. (2005).

- The building form is also change according to building function; we found that linear form is suitable to schools, office buildings. The Cubic and U form is suitable to hospitals and circular form is suitable to exhibitions.
- Building information modeling (BIM) and energy simulation software are used to understand and predict the effect of building form on energy use for various design concepts in the early stages of design.
- If we consider all the above mentioned criteria, we can apply the sustainability and durability of the building.

FIGURE 7.4

The Relation Between Building Form and The Surface Volume Ratio (SVR) and building orientation

Cold Climate	
Moderate Climate	
Wet hot climate	
Hot Dry Climate , Khartoum city	
Hot Dry Climate , Khartoum city	

Source: The Ministry of electricity and water, Riyadh city, KSA (Oct.2012)

6.2.3 Wind scaping Building

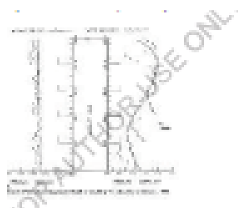
Split the winds. A single flagpole 20 m from a building in the direction of a strong prevailing wind can split the wind vertically. Most people in Khartoum use trees to protect their houses from the wind. We can orient the window corner into the strong prevailing wind direction. Wind can be split vertically, to reduce wind speed and turbulence on the face of the building. In the wind towers, to throw some wind over the top of a tower, while forcing some air down the wind catcher shaft. Beneath the vent the wind is again split leanly to force wind below the shaft down the face of the tower.

• Shape the roof carefully: (Figure 5.6 shows how much different existing roof shapes and negative pressure they generate. It is this negative pressure that typically rips roofs off buildings (Kindangen et al., 1997).

• Mold the wind impact on wind pressure on facades with features such as balconies. The use of features on building facades will cause an increase or decrease in pressure at different heights on the building facade as shown in Figure Fig 7.5.

FIGURE 7.5

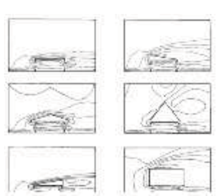
Pressure difference on the windward facade of a building with balconies (Chand et al., 1998)



SOURCE: Roaf, S., Fuentes M. and Thomas, S. (2007)

FIGURE 7.6

The influence of roof shapes on air pressure around the house (Kindangen et al.m1997). The higher the roof, the greater the positive pressure on its windward side and the greater the negative pressure on its leeward side.



SOURCE: (Roaf, S., Fuentes M. and Thomas, S. (2001)

7.2.4. Building Distribution

Introduction

In designing buildings in more than one location, we must take into account the distribution of buildings at the site, because it affects the movement of air around buildings and the cancellation of green spaces.

By studying the impact of high buildings on the distribution of buildings in the site and the air stream, when considering a building which is located in front of a high buildings, the lower part of the air stream tends to move upwards towards the roof of the building, and gradually continues to raise higher and higher, and this phenomenon is caused by virtue of the bottom air, of the high pressure, which enhances the air speed close to the earth's surface. Higher aspects of the building Fig (7.5) and Fig (7.6) show the effect of high rise building on the air movement near the low rise buildings. Hassan, (2000)

7.2.5 Distribution of buildings in the site:

Studies conducted on the movement of air around buildings in the tropics, proved that the distribution of buildings on the site affects the movement of air around the buildings. Fig (7.7) and Fig. (7.8) show air movement through staggered organization buildings Hassan, (2000) .

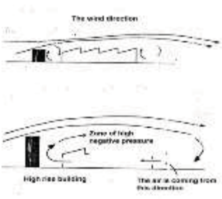
Results were as follows:

In the rural areas multi-story buildings are developed, in the form of a network among the regions, which are still behind the first row of confrontation. In this case, it is necessary to make the dimensions of buildings equivalent to six times the high-rise building, in the opposite direction of the wind. Hasan O.P. c. The same has been discussed by *(*Abu Sin, M.E. and Davies H.R.J. (1991)

FIGURE 7.7

Air movement in case of a high-rise building in front of other

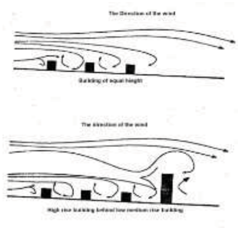
Low-rise building



SOURCE: Hassan, (2000)

FIGURE 7.8

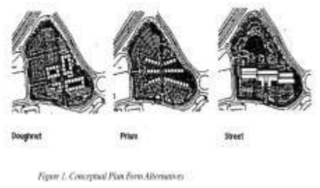
Shows the air movement beside high rise building behind low rise buildings



SOURCE: Hassan, (2000)

FIGURE 7.9

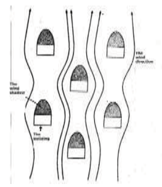
Conceptual plan from alternatives



Source: (Croome, D. C. (2003)

FIGURE 7.10

Air movement through staggered organization buildings



SOURCE: Hassan, (2000)

Croome, D. C. (2003) discussed an Example, which exhibited that it is very important to take into consideration, when conducting the initial study for an office building project , the natural ventilation, and the good orientation, the atrium which is good air circulation, as well as a buffer zone. Figure (7.9) shows that doughnut and prism plan forms would probably provide better natural ventilation, but the street form was chosen based on organizational requirements and, moreover, had an investment advantage, as it could be valued as three separate buildings. The complete building is, in effect is six buildings of between four to six stories, parallel to each other, on either side of a street. An early design decision was to cover the street with a glazed roof and form an atrium that acts as an amenity and circulation space, as well as a buffer zone.

7.2.6 Ceiling height

Ahmed, A.M. (1974) discussed ceiling height in the tropics and found that minimum heights of 3.00, 3.30 or at times 3.60 meters. Ceiling temperature and ceiling height affect the mean radiant temperature, a positive linear correlation, that is, the rise in mean radiant temperature is directly proportional to the rise in ceiling temperature.

Chapter Eight

Control the indoor environment

8.1: Secondly: Controlling the thermal comfort of Indoor Environment (IEQ):

8.1.1: Humidity control:

1. A way to relieve the humidity in the warm humid areas is by use of mechanical means, depends on the movement of air which reduces the impact of high humidity.

2. In tropical dry climates it is needed to increase the amount of moisture to mitigate the impact of dryness linked with the cooling of air process, cooling in this case, is provided by desert cooling system.

3. Buildings are closed to retain heated air at least from the outside.

4. Evaporative cooling

Evaporative coolers produce a moderate reduction in air temperature and increase humidity. They operate by passing hot air over water-saturated pads and the water evaporation effect reduces the air temperature.

8.1.2 : Temperature control:

1. The construction materials used in building walls and ceilings, with thermal capacity to store high operating temperatures during daylight hours and dispose it off during the night.

2. Thermal insulation:

There are many different types of thermal insulation materials, e.g. loose fills, rock wool and boards. Material acts as a barrier and slows heat flow in summer and heat loss in winter, but it is only effective, where there is a temperature difference between the inside and the outside of the building or, between two areas inside a building

8.1.3 : Air Movement control:

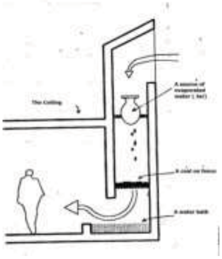
1. This is carried through the windows design to facilitate the supply of clean air to the house.

2. It is also carried through the wind tower system. The dry air, which flows down to the bottom of the tower, is cooled by a wet surface, causing the house becomes a cool space. Fig (3.27) shows the act of wind tower (Hasan op. cit)

8.1.4 The Cooling tower

FIGURE 8.1

The System of cooling tower



SOURCE: Hassan, (2000)

Gallo C., Sala M.and Sayigh A.A.M., (1998) discussed the traditional cooling tower construction in Qatar is shown in Fig. (3. 27). The cooling tower consists mainly of two parts, the catching device and the tower. It opens into either upstairs or downstairs rooms and was stopped about two meters above the level of the floor. The tower is subdivided by brick partitions to contain several shafts. The wind tower in Qatar is built in an X-shaped design, form, opened at the four sides to catch the breeze from all direction. The operation of the wind tower depends on wind conditions and the time of the day.

1. Cooling Tower: The cooling tower acted as a chimney when there is no wind

-Night operation: The tower wall, which absorbs heat during the daytime, transfers it to the cool night ambient air. The heated air is then exhausted through the tower openings. The chimney action of the tower maintains the circulation of ambient air throughout the building and hence cools the structure of the building, including the tower itself. When wind blows at night, the air circulation acts in reverse to the action described above and the walls and rooms become cool.

- Day operation: when there is no wind blowing during the day, the tower operates as the reverse of a chimney. The hot outside air in contact with the cold walls of the tower (cooled from previous night) is cooled and sucked down through the tower's passages. When the wind blows, both the air circulation and the rate of cooling increases, and thus, cooler air is devoured to further position inside the building and the performance of the cooling tower become effective. Beside its geometrical form (height, cross sectional plan, tower orientation and location of its outlets), by the climatic conditions, it is very effective in dry arid regions. In such regions the diurnal variation is high and night air temperature is low.

2. Using the desert air condition concept, which works by blowing air with a fan to pass through straw dowsed with water into the building inside, and the generated cool air causes the inside of the building to be cool. This method is used in areas with warm dry climate, as well as compact climate. Hassanop. Cit.

3. Wazeri, Y. (2010) . Has provided on his study square and circular cooling towers and stated that they give the same result; should be constructed 6.M. height near first floor building, 8M. Height with second floor buildings and the wet area height should be 2.5 M. above the floor. Rate 20 litres /minute.

8.1.5 Radiation Control:

By painting the interior walls and ceilings with white paint to act as a reflector of the sun glare.

8.1.6 Ventilation Control:

Roaf, S., Fuentes M. and Thomas, S. (2001) described the ventilation as the movement of air within a building and between the building and the outdoors. They said that it is very important to control the ventilation by natural means as windows, or mechanically which should adopt as the last solution in an eco-house.

1. Use of pressure variations around the outside of the building and which is caused by wind effect.

2. Use of pressure differences caused by the pressure variations within the house. There are many challenges facing proper designing for ventilation, including the variability of the wind, its speed and direction, but if it is well manipulated and assimilated, it can be of a real advantage to the indoor climate of a house.

United State Green Building Council, USGBC, (1996) has established temperature and humidity set points in accordance with occupancy patterns, scheduling, and outside climate and seasonal variances. Follow ASHRAE Standard 55-1992 (Thermal Environmental Conditions for Human Occupancy). Use building-control systems (computerized temperature-sensing and control technology) to establish, maintain, and document building climate conditions.

8.1 7 Quality of Light:

United States Green Building Council, USGBC, (1996) continued to say that in order to adjust lighting levels for different types of spaces, we should use and occupancy, following Illuminating Engineering Society standards. Repair lighting fixtures that produce glare, flicker, insufficient illumination on work surfaces, and other conditions that can cause eyestrain, headaches, and other discomforts

8.1. 8 Acoustics

In addition to that (United State Green Building Council, USGBC, 1996) discussed how we can control noise based on the needs of occupants rather than industrial exposure limits (decibels), which are geared toward protection from hearing loss. In open offices with little or no privacy, consider noise-masking technology such as “white-noise” generation. Inspect and repair or, replace noisy items. The amount of energy used annually by heating, ventilating, and air-conditioning (HVAC) systems , which, not only can be stressful and distracting to occupants, but may also indicate mechanical problems or inappropriate design or capacity.

8.1.9 Noise and traffic

FIGURE 8.2

Recommended Design Criteria for Background Noise from HVAC, Electrical, Plumbing, and elevator equipment

RECOMMENDED DESIGN CRITERIA FOR BACKGROUND NOISE FROM HVAC, ELECTRICAL, PLUMBING, AND ELEVATOR EQUIPMENT

Type of office space	Noise criteria
Studios	NC–20 to 25
Boardrooms, teleconferencing rooms	NC–25 to 30
Conference rooms	NC–30 to 35
Private offices, apartments	NC–35
Lobbies, toilets, corridors, computer terminal rooms, retail spaces	NC–40
Storage, locker rooms, laboratories without fume hoods	NC–45
Kitchens, laundry, computer rooms	NC–50
Garages, laboratories with fume hoods	NC–55+

Source: (United State Green Building Council, USGBC, 1996)

Noise and traffic are further identified as major pollutants, which need to be addressed in the construction and servicing of development. (John, Geraint and Sheared, Rod, third edition, 2001). Fig (8.2) shows the recommended design criteria for background noise from HVAC.

8.1.10 Emission Control

It is very important to minimize the emissions of CO_2 by combustion, minimize the use of traditional methods in cooking, and minimize the use of CFCS in homes sprays or in refrigerator.

Chapter Nine

Control of the Outdoor Environment

9.1 Thirdly: Control of Thermal Comfort in the Outdoor Environment:

On Eco building level:

Requirements of buildings in this kind of climate protection from various climatic factors such as: solar radiation, wind, and dust, and therefore, the compact design are one of the best solutions

1. Use of Internal Courtyard:

The use of internal courtyard practice, if designed properly, can retain a portion of the cool night air in its cool condition during daylight hours Fig. (9.1), shows the thermal performance of a large house with a courtyard. Large courtyards provide good ventilation especially, when opening to another courtyard or street, so that cross ventilation is promoted. On the other hand, small courtyards provide more protection against hot, dusty winds in hot-arid regions. Some courtyards contain fountains and trees to promote evaporative cooling and provide shade. Courtyards moderate the climatic extremes in many ways:

(i) The cool air of the summer night is kept undisturbed for many hours by hot and dusty wind, provided that the surrounding walls are tall, and the yard is wide,

(ii) The rooms draw daylight and cool air from the courtyard.

(iii) (iii) It enhances ventilation and filters dust.

(iv) (vi) It provides privacy to the family and keeps their activities and noise away from neighbours.

(v) (v) The courtyard with its gentle microclimate provides a comfortable outdoor space. (Gallo C., Sala M.and Sayigh A.A.M., 1998).

Wazeri, Yahia (2002) concluded on his study on "Applications on environmental Design" that the use of interior courtyard has been one of the useful solutions that are adopted in ancient Nubian Architecture especially, in Tushki village. The study approved that the best ratio for the courtyard is (1, 40:2, 00:1) and that the use of rectangular shape is better than the cubic shape. The same topic 'courtyard system has been discussed by Santamaria, M.(2006) and stated that courtyard system is used to provide the building with natural light and ventilation as well as reduce energy use.

1. Related high walls of buildings provide shade in the courtyard during daylight hours. Another important source of shade is vegetation and especially trees that help cool air inside courtyard by evaporation, as well as using of trees to protect buildings from dust and wind. It also provides cool shadows and relative comfort for people. So, the internal courtyard temperature, if well structured, is a common system in many cases, in most of the Arab states. Fig (9.1) shows the thermal performance of a courtyard inside small and large buildings.
2. 4. The use of barriers and fences:
3. The use of barriers and fences protects the environment of the house from dust and sandstorms. (The Haboob) Fig (3.30) shows the dust movement in the case of barriers being lower than the building.
4. 4.1. Part of the dust stream will increase in the case of the fence being far away from the building. Fig (3.31) shows the dust movement in the case of the fence being far away from the building.

4.2. Increase of the amount of dust passing to inside the area, to be protected by the barrier after the interface building by 6.1 m. Fig (9.2) shows the proper distance between the house and the fence.

5. Use of Fountains: will serve to cool ambient air and moist air is forced down, which works to reduce the temperature inside the house.

6. Other techniques: like sprinkling the courtyard with water will also reduce the temperature of air and replace the dry air loaded with moist air, which acts in cooling the surrounding air. Hassan, O.P. cit Most of the people in Khartoum City follow this practice and sprinkle the outdoor with water, usually at five p.m., to set up the outdoor environment to be wet and cool.

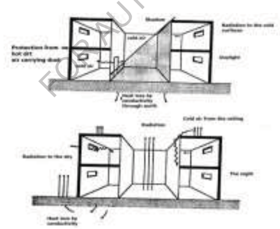
7. Passive Conditioning of outdoor air:

1. Wind breaks: these can be used, not only to lessen the impact of a strong hot or cold wind, but also it will be more effective if shrubs and trees are being planted, as air moisture will radiate from the leaves and be carried by air currents creating an increased humidity which ultimately cool down the surroundings.

2. Dust: The air that has passed over natural green covered area will reduce dust levels, ensuring that land on the windward side, is planted or maintained in such a manner that the earth's crust is not agitated by being subjected to erosion and hence become as a source of dust raising, where the eroded dust particles will be carried up by the wind current to the inside of the house. Avoid barren land and plant natural vegetation, if possible, even on unused plots in the center of towns. Adopt compact plans for groups of houses, in hot dry areas, to avoid the formation of dust. In addition, a small plot size will increase the likelihood more.

FIGURE 9.1

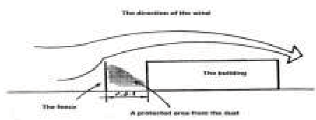
The thermal performance of a large house with courtyard

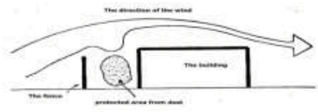


SOURCE: Hassan, (2000)

Of the site being landscaped and thus, reduces dust. Compact plans also provide more shade (Erell and Tsoar, 1997).

3. " Natural air-conditioning: use air that has travelled over water or vegetation, for cooling. If you are lucky enough to find a site downwind of a body of clean water, this will cool it evaporatively, and provide little resistance to the wind ". (Roaf, S., Fuentes M. and Thomas, S. (2001). Saliha, A and Louafi, B. S. (2010). Presented paper on "*Shading Effect on Outdoor Thermal and Visual Comfort". Laboratory, Abe* University Mentouri Constantine Algeria, Sustainable Architecture and Urban Development Conference, Aman City, (2010).

<table>
<tr>
<td>FIGURE 9.2
The dust movement in the case of the fence is far away from the building, D= 6.1 m. and the fence height equal to the building height only


SOURCE: Hassan, (2000)</td>
<td>FIGURE 9.3
The dust movement in the case of a barrier lower than the building


SOURCE: Hassan, (2000)</td>
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9.2 Control of the thermal comfort in outdoor environment

Relevant Issues

<u>Ecological</u>

LMDC, PANYNJ, and NYSERDA (2005) discussed thermal comfort in outdoor environment and said that bringing people outdoors reduces demands for in indoor spaces and provides increased opportunities for contact with the natural world. Reduced demand on indoor spaces reduces indoor light and air conditioning energy requirements.

In order to improve their health, urban dwellers are required to increase their exercise activities and inhale more fresh air during daylight since they spend a large portion of their time staying indoors. As their contact with natural environment increases, their life-stress will be reduced, and more opportunities for rest and relaxation will be available to them. Creating opportunities for people to go outdoors and be in connection with nature will also arouse their awareness of these atmospheres and their role in sustaining them.

<u>Economic</u>

Increasing and extending the amount of time that outdoor spaces are comfortable provides increased and extended opportunities for outdoor retailing, dining have direct economic benefits in both, increased productivity and reduced medical costs.

<u>Social</u>

Outdoor spaces could enhance the level of social interaction that occurs in a neighbourhood. A comfortable outdoor space is likely to be used more frequently and the increased presence of people outside adds to the security of the premises and works to deter crime.

9.3 A study on outdoor thermal comfort.

Steemers, K. and Steane, M.A. (2004) presented a study on outdoor thermal comfort. The study investigated whether thermal and, by implication, comfort conditions affect people's use of outdoor spaces, through the number of people using the spaces at various intervals. Streemerss, discussed landscaping, and said that areas with low rainfall or seasonal droughts, up to 60 percent of total seasonal water usage can be attributed to irrigation. In addition, Streemerss advised to provide the outdoor with protection from the wind, control is feasible with the use of vegetation for shading and as wind breakers, canopies made of various materials such as stone, strew which provide useful spatial variation in areas, provide environmental control from sun and rain. The same issues have been discussed by Thomas, R. and R. and Max Fordham (2006) .

9.4 Restore the native landscape.

United State Green Building Council, USGBC (1996) stated that restoration of the habitat helps to provide environments for wildlife displaced by development. Constructed landscapes that mimic ecological habitat models could decrease lifecycle maintenance costs, enhance wildlife survival, and blend edges of adjoining urban and rural areas. Minimize use of high-maintenance lawns.

9.5 Landscape and buildings working together

Ministry for Environment, Hamilton City Council and Auckland Regional Council (2006) stated that Using perm culture and organic techniques to work with, rather than those techniques which are against nature. The characteristic aim of perm culture is to create natural life supporting systems even in the smallest, most urban areas. Healthier, more integrated environment results, when we combine the inherent qualities of plants and animals with the natural characteristics of landscapes and structure. Shafiq, J. (2010) stated in his paper " Sustainability of Traditional and contemporary architecture' that uses of plants and trees reduce the cooling bill by 15-35% beside application of windows shades and sunscreen from plants serve 10% of cooling system costs.

9.6 UNEP (2012) announced the importance of urban greening

More trees provide shading which tends to cool city streets, more vegetation, in general, tends to improve air quality, because plants absorb or adsorb air pollutants.

9.7 The Basic understanding of Landscape design and its elements:

(Awad, A.H., (2007) discussed in a paper, "The elements of landscape or landscape architecture design" and said that these elements are divided into two main parts:

"*A-Elements of natural landscape are considered as the basic elements of landscape design:*

1. Plant world (flora), 2. Animal world (fauna), 3. Hydrology, 4. Relief

5. Space or air mass, b. Element of exotic or (manmade) landscape

1. Dwellings or (Buildings) of all types (residential, commercial, industrial…etc.)

3. Civil and mechanical engineering construction elements (bridges, cables and towers, transportation means, cars, trains, ships and planes…etc.)

2. The understanding of the elements of natural landscape and their pivotal role in landscape design:

1. To achieve successful professional goals, it is necessary for architects, planners and in particular, landscape architects and planners, to acquire a wide knowledge about elements of natural landscape.

2. The role of the plant world (Flora) represents the spearhead among the elements of natural landscape in design. Together with the hydrology and animal world (Fauna) natural elements, give the landscape its vitality".

Figure (4.30) shows design for hot dry summer.

The Solutions for outdoor environment

9.10 Category Four: Outdoor thermal control (OTHC)

The researcher added the outdoor thermal control as new category for the six LEED categories. it's very important to improve the outdoor thermal environment by controlling the design and provide shades to the building in North, South direction, enhance landscaping on side, with plants and trees that can provides more shades, fences protect the site from dust Swimming pools and fountains change the dry climate to humid climate. People in Khartoum take very much concern to the outdoor environment; because the climate is hot and dry, they spent part of their time, especially at nights, in the gardens which are also utilized during holidays and celebrations.

1) **Credit 1, for Shades to north –south direction**

Provides shades to North-South direction, this cool down the air temperature and reduce the solar radiation, the indoor natural temperature and give protection from rains and sun radian this can be achieved by designing canopies over windows.

OTHC Credit for Shades to north –south direction is two.

2) **Credit 2, shades to East west direction**

Provides shades to East West direction, sometimes the plot area forces the design to be directed to north south direction , in this case architect should provide canopies to cause shades over windows.

3) Credit 3 for shades to East West direction is one
4) Credit 4, balconies

Provide the design by balconies, this solution is good for hot dry climate, families can sit outdoor in summer, and it also protect the building from rains and dust as well as provide shades.

OTHC Credit for balconies is one

5) **Credit 5, vegetation**

Provide the outdoor environment by vegetation and plantation; it is preferred to plant trees which provide shades. These trees will improve the air movement around the building and cool down the air temperature of the outdoor and indoor environments, trees give relaxation and are healthier to human beings.

OTHC Credit for vegetation is one

6) Credit 6, Design Fences (height and d location)

The use of barriers and fences protects the environment of the building from dust and sandstorms. (The Haboob) Fig (3.30) shows the dust movement in the case of lower barrier than the building.

- Part of the dust stream will increase in the case of the fence being far away from the building. Fig (9.2) shows the dust movement in the case of the fence being far away from the building.
- Increase the amount of dust inside the area to be protected by the barrier after the interface building by 6.1 m. Fig (9.3) shows the proper distance between the house and the fence.
- The proper design will be achieved, when less quantity of dust inside the area to be protected will decrease, if the high barrier equal to the rise of the building and the distance between the barrier and the building is 6.1 meters. Fig (3.32) shows the dust movement in the case of the fence height being equal to the building height
  OTHC Credit for fences is one

7) Credit 7, swimming pools:

Design swimming pools in the outdoor environment, improve the air to be more humid than dry climate, architect should apply the standards in the design and choosing the pool materials and designing the surrounding areas.

- Design an Eco Friendly swimming pool, this concept can be achieved by simply using green friendly products. These would be products that do not contain chemicals that would hurt the earth. An Eco Friendly Swimming Pool would also be one that would include using equipment that would save water and energy.
- Al Hamzi, A.(2012) discussed paper on the third Saudi Green Building Forum In Approach towards Green Building in Saudi Arabia, in his paper he add sitting as measure element of green building and it consist of:
- Selecting a site well suited to take advantage of mass transit
- Protect and retain existing landscaping and natural features
- Select plants that have low water and pesticide needs
- Recycled content paving materials and Furnishings.
- If the swimming pool is in ground, the engineer should design plain RC, and cover with waterproof and then the final finish with ceramic.
- Above ground swimming pool, filterers, water supply systems should be considering. http://www.familyleisure.com/Discount-Pool-Supplies/Pool-Filter-Systems
- Choose the eco building materials, in finishing. http://www.familyleisure.com/Discount-Pool-Supplies/Pool-Filter-Systems.

OTHC Credit for swimming poles is one.

8) Credit 8, fountains

Designing fountains in the outdoor environment also improve the air temperature to be more humid than dry climate; fountains have different shapes and designs and makes people happier and healthier.

OTHC Credit for fountains is one.

9) Credit 9, Terraces

Provides the outdoor environment by terraces, it's very important in Sudanese occasions and it has social aspect.

Chapter Ten

Environment and Sustainability

Environmentally Sustainable principles

10.1 Definition of sustainable development:

Sustainable development that meets the needs of the present without compromising the ability of future generations to meet their own needs this concept has been explained by Conway, 1987

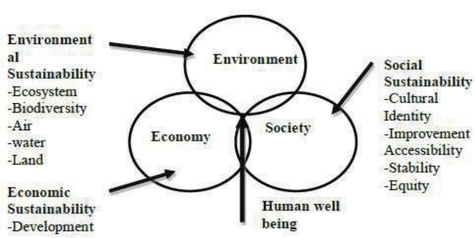
10.2 The Definition of Eco Building

An Ecosystem is an enclosed system that has the characteristics of sustainability, stability and self-dependence. From this definition we define the term of ecological building: it is a new technology for building houses so that they heat and cool themselves. This is achieved by from the design, the orientation, and the materials of the home, rather than a furnace, heat pump, or air-conditioner. The principle is to be friendly with the environment by using local environmental building materials and applications with new technology in using renewable natural resources like solar energy , wind energy, eco-sanitation and re-use of water supply .(www.Entria.com).

The meaning of eco-homes comes from the stem 'eco', which is derived from the Greek root 'oikos', meaning 'household'. The Greek root, as with many Greek words, has two meanings: the sense of 'ecological' relationships between organisms in nature, and 'economics' – relationships coqwww4tgbncerned with the use of 'resources. Hence, 'eco' has as its basis two dimensions that need to operate within an 'ecological' philosophy – that is, its relation in design and use should follow a natural order, while it also has the dimension of using resources in an economical and efficient manner.

FIGURE 10.1

The Three Dimensions of Environmentally Sustainable Design



SOURCE: http:// sustainable Architecture and building design (SABD)

(i) Social dimensions of sustainability

Worker health and safety impacts on local communities, quality of life- benefits to disadvantaged groups e.g., disabled the beauty of environment. www.arch.hku.hk/research)

(ii) Economic dimensions of sustainability:

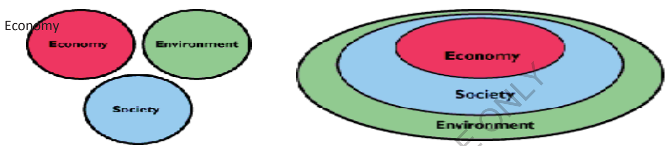
Creation of new markets, Opportunities for sales growth, Cost reduction through efficiency improvement , Reduced energy, Raw material inputs and Creation of additional added value.

(iii) Environmental dimensions of sustainability

Reduced waste, effluent, generation, and emissions to environment, reduced impact on human health, use of renewable raw materials and elimination of toxic substances and reduce the environmental impact to the buildings.

FIGURE 10.2

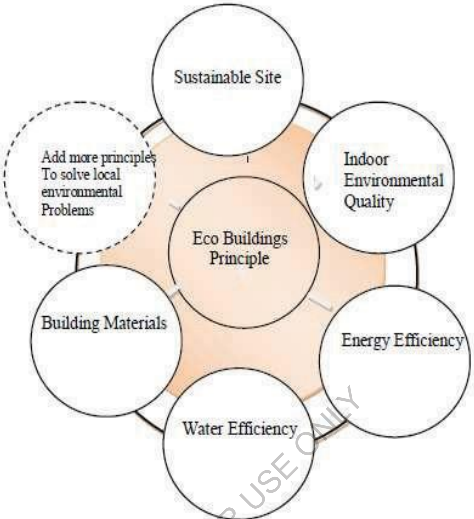
A view of community as three communities



Sww.arch.hku.hk/research

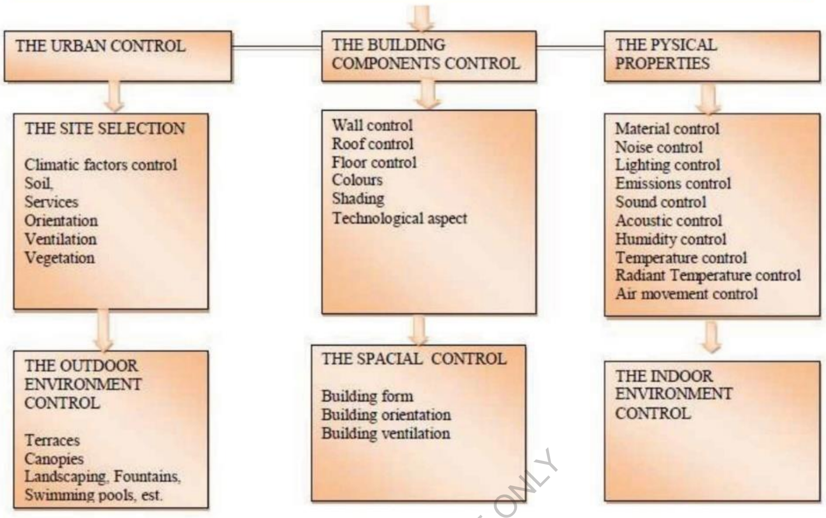
Figure 10.3

Eco-Building Principles



Source: Khogali, H. 2019)

Figure 10.4: Control the design in hot-dry climate



Source: Khogali, H. 2019)

First: The Environmental Aspect:

1. Sustainable Site

(i) Introduction

Sustainable site is one of the most important Category of Eco building includes smart location, enhance controlling system for cars, improve the outdoor environment, heat island effect. Control natural water features, control the noise from construction, Alternative transportation axis. Ecological land-use complementation' for building (Footprint).

(ii) Sustainable site belongs to the environmental aspect and provide sustainable solutions such as:

Use of isolated parking for cars, maximize the outdoor areas because it has economical, ecological and health aspect to human being, control the noise, natural water features, control construction activities and land ecology. The main issue of sustainable site is to have positive impact on environment.

2. CATEGORY TWO:INDOOR ENVIRONMENTAL QUALITY (IEQ)

The Indoor Environmental Quality (EQ) portion deals with materials and systems inside the building that affect the health and comfort of the occupants and construction workers. The Indoor Environmental Quality category of the method of assessment consists of nine prerequisite) for the assessment method of evaluation. The Requirements and Benchmark for the main categories of the Assessment Method of The research
May earn a possible 34 possible points as follows:

(I) IEQ POINT 1, BUILDING ORIENTATION

Building orientation, it is very important to affect the indoor environmental quality According to the sun movement; this affects the amount of solar radiation that can enter the building.

IEQ Point for Building orientation is four

1) The building is oriented to east west direction; the length is facing to North-South; In this case the amount of fresh air will be 90 %; we should design large windows to improve air movement.
2) The building is oriented to north-south direction, is a direct effect of bad ventilation to the building, but if the site location is forcing the architect to do so, then the architect is ought to design more canopies for provision of shades.
3) The building is oriented at 45˚, this will provide less amount of air movement by 50%, the architect should provide sunscreen to protect windows from solar radiation.

(ii) IEQ POINT 2, BUILDING DIMENTIONS

Experiments showed that, the solid void ratio range from 1: 0.16 to 1: 0.12, in a hot dry climate. SVR, SFAR should be as low as possible to minimize the radiation on the building. This can be achieved through multi- story buildings and rising of roof height .

IEQ Point for Building Dimension is one

(iii) IEQ POINT 3, ROOF THERMAL CONTROL

Design the ceiling, choosing the sustainable building materials that give the large time lag and storage of solar radiation during the day and release this heat during the night and this material with solar reflectance index for final roof finishing material (SRI) = 0. 65 - 0.75 reverse back to chapter Two point 2.6.2 . Solar Reflectance Index and cool Roofs and heat island effect

IEQ Point for Roof Thermal control is five.

1) Use of waterproof membrane two layers to protect the ceiling from rains, and in Addison to it thermal insulation layer will be good.
2) Researchers found that the use of suspended ceiling will be effective to minimizing the solar radiation from the roof and so from the indoor environment and minimize the radiation by 50%.

3) Design and choosing the roof painting colour is very important, use of white colour is found effective in minimizing the solar radiation away from the roof, reverse back to chapter Two point 2.6.2 No. IV
4) Green roof is found very effective in minimizing the solar radiation away from the final roof by 50% and this action minimize the heat island effete, reverse back to chapter Two, point 2.6.2 No V and read more about controlling the ceiling .

(iv) IEQ POINT 4:WALL THERMAL CONTROL

Wall is the second component of building envelop; architect should design wall to minimize thermal radiation from indoor environment.

IEQ POINT for Wall thermal control is ten:

1) Choose the sustainable building material available in the local environment and can absorb and store the solar radiation during the day and release this radiation during the night and has the large time lag.

Designing windows, the size, location, type of glass, window colour are affecting the amount of fresh air and air movement. Reverse back.

2) to Chapter Two Point 2.4.6: The Appropriate Technology in windows design.
3) The use of Sun devices , vertical or Horizontal or Both will be effective to minimize the radiation from indoor environment by 50%, and apply the appropriate technology in these devices, to gain the solar energy that can be used in the buildings by different ways in lighting, moving the shading devices. Reverse back to Chapter Two Point No.2.6.2: The Appropriate Technology in windows design.
4) Selection of the wall paint's color is a very important decision; the light colors reflect the sun radiation and reduces excessive heat absorption by the building, usually white colour, beige, and light pink are preferable. EST.
5) The research has found that the green wall is very effective in minimizing the radiations in the indoor environment.

(v) IEQ POINT 5:FLOOR THERMAL CONTROL

The floor is the third building component and designing the thermal effect of floor will be very affective in minimizing the radiation from the indoor environment, choose the floor finishing material as an eco-floor material, manufactured from recycled construction building materials like concrete, stones, bricks, ceramics, has long term of durability, easy to clean and ease of maintenance, resistance to strength, slip, heat, and moisture.

IEQ Point for Floor thermal control is one

(vi) IEQ POINT 6: DESIGN THERMAL COMFORT

Thermal comfort is defined in British Standard BS EN ISO 7730 as:

‘That condition of mind, which expresses satisfaction with the thermal environment's ‘.

Thermal comfort is based on many environmental factors and personal factors. Five common environmental factors are air temperature, air movement; radiant temperature, humidity, and airspeed**,** with air temperature redesign thermal comfort by controlling its basic component to achieve human thermal balance. Reverse back to Chapter Two Environmental comfort principles point 2.5

IEQ *Point for Design Thermal Comfort is four.*

1) Provide a high level of thermal comfort system control by individual occupants or by specific groups in multi- spaces to promote the productivity, comfort, and well-being of the building's occupants. Provide individual comfort controls for 50% (minimum) of the building's occupants to enable adjustments to suit individual task needs and preferences.
2) For naturally ventilated areas, there are two main requirements:

   There must be windows or opening (which can be opened) within 25 ft. of any area in a room which is liable to be occupied. Note that a roof opening is also essential. (Haselbach, 2008) stated that the requirements should meet the minimum of Sections 4 through 7 of ASHRAE 62.1-2004, Ventilation for Acceptable Indoor Air Quality. Mechanical ventilation systems should be designed using the Ventilation Rate Procedure or the applicable local code, whichever is more stringent. Naturally, ventilated buildings shall comply with ASHRAE 62.1-2004, paragraph 5.1. Reverse

3) **The traditional wind towers**

The use of internal courtyard: The use of internal courtyard procedure, if designed properly, can retain a portion of the cold night air in the cool period during daylight hours Fig. (3.21) shows the courtyard in large house.

IEQ point 7, MECHANICAL CONTROL

Mechanical ventilation systems must be designed using the ventilation rate procedure or the applicable local code, whichever is more stringent.

IEQ Point for Mechanical control is three.

1) The first requirement is that 50 % of the occupants have control over their thermal comfort at their typical workstation or living space. Thermal comfort controls usually refer to some form of conditioning and are usually for both heating and cooling. This conditioning can be active (mechanical HVAC systems) or passive (natural ventilation).
2) The use of efficient water cooling system

   The use of water cooling system provides humid air, and it is good in hot dry climate, it is an economical system and widely used in Khartoum City, it needs regular maintenance to guarantee long durability. (Yousif, 2013) discussed the using of efficient water cooling system (In Direct Unit) in mosque green design, in Dry-Semi dry climate this system minimizes water consumption by 55% by using of Wadu usage water.

3) Individual adjustments may involve individual thermostat controls, local diffusers at floor, desk or overhead levels, or control of individual radiant panels, or other means integrated into the overall building, thermal comfort systems, and energy systems design. In addition, designers should evaluate the closely tied interactions between thermal comfort (as required

by ASHRAE Standard 55-2004) and acceptable indoor air quality (as required by ASHRAE Standard 62.1-2004, whether natural or Mechanical ventilation).

4) Other effective solutions: Install permanent monitoring systems to ensure that ventilation systems maintain design minimum requirements. Configure all monitoring equipment to generate an alarm when airflow values or carbon dioxide (CO_2) levels vary by 10% or more from the design values via either a building automation system alarm to the building operator or a visual or audible alert to the building occupants.

3. The Environmental Impact of Building Materials

1) Introduction

Sustainable design includes the informed selection of materials and products to reduce product cycle environmental impacts, improve performance, and optimize occupant health and comfort. Roaf, S., Fuentes M. and Thomas (2001) stated that the processing may be minimal, as in the case of a traditional cottage constructed from materials available locally, as in the case of prefabricated construction. That processing of materials inevitably requires the use of energy and results in waste generation.

2) Building Materials belong to the Environmental and Economical aspect, and it provide sustainable solution such as:

There are many factors we should consider on building material in sustainable design such as energy required for manufacturing, transportation, degree of pollution from the material, maintenance required, flexibility, lifetime of material. All these issues have discussed by Roaf, S., Fuentes M. and Thomas (2001) and Berg-e, B. (2001).

3) The ecology of building materials

The second point that we should consider is that we should use the ecology building material available in the local environment such as basic materials like water, air, minerals, stones, soil materials: like sand and brick manufacture, fossil fuel, plastic and recycling, plants and timbers, industrials by products like gypsum, Sulphur, fly ash, fibers, surface building materials like bricks, earth blocks, mud bricks, gravels stones, earth covered roof, earth vaults. Earth dooms, earth walls, earth resistance buildings, structures building materials

4) Life Cycle Analysis (LCA)

The third point that we should apply in sustainable building material is The Life Cycling of Building Materials . Roaf, S., Fuentes M. and Thomas (2001) defined the life cycle analysis as:

> "*Life cycle analysis: It is used as a way of assessing the total impact of any building and shows the importance of the building's lifespan. The longer a house can last, the lower the impact of the energy and pollution resulting from the manufacture of its materials will be. A simple way to think about this is to consider the initial embodied energy of an entire building and divide this figure over its lifetime, making an allowance for maintenance*".

5) The embodied Energy

The fourth point that we should consider is calculating the embodied energy of the building material. , when the building material is produced in the factory and transported to the site, it has high embodied energy which ranges between 1500 and 2000; however, when it is casted in site it has lower embodied energy reaching -1500 . we notice that wood has low embodied energy than steel and that these are better than concrete the same issue has been discussed by Thomas, R. and Max Fordham & Partners (2005) and (http://www.ecosite.co.uk) credited to the BRE . Tariq, M.(2013) discussed the embodied energy for cement(830 IBCO2/TON), concrete 226 , steel 2750, playwoood(640),Aluminum (11560)

4. WATER EFFICIENCY SYSTEM

1) INTRODUCTION

Sustainable design conserves water and protects and improves water quality.

Conserve the main source of drinking water in Sudan which is The River Nile by building of dams; reduce the river water consumption by the industrial sectors and animal sector as well as for irrigation purposes.

2) Water Efficiency system is belonging to Environmental and Economical aspect, and it provides Sustainable Solution such as:

(i) Residents should have quality water with high efficiency and quality in accordance with the international standards such as WHO standards.

(ii) Efficiency of water supply treatment system plant should be in the project site.

(iii) Availability of rainwater conservation system.

(iv) Reduce water usage in toilets and bathrooms and kitchen.

(v) High performance dual flush toilets.

(vi) Low flow showerheads.

(vii) Water-conserving landscape and building design strategies.

Bennett, J. (2008). Discussed the Water Sense program from the U.S. Environmental Protection Agency (EPA) establishes criteria for water efficiency and performance and said that each product category has a different set of testing and certification protocols. These serve as benchmarks for licensed third-party groups to use in testing. Products that meet all criteria for their category are allowed to use the Water Sense label. Reuse strategies for water including use of rainwater, grey water, and wastewater.

5. Natural Resources for Energy systems

5) INTRODUCTION

Sustainable design conserves energy and resources and reduces the carbon footprint while improving building performance and comfort.

How the building design reduces energy loads for heating, cooling, lighting.

1) How the design and integration of building systems contributes to energy conservation and reduced use of fossil fuels, reduces greenhouse gas emissions and other sources of pollution, and improves building performance and comfort.
2) Techniques for systems integration, use of controls and technologies and efficient lighting strategies.
3) Use of on-site renewable and alternative energy systems Anticipation of future and carbon neutral fuel sources.
4) ENERGY IS BELONG TO ENVIRONMENTAL AND ECONOMICAL ASPECT .

   Roaf, S., Fuentes M. and Thomas (2007) said that solar electric PV systems are now an economic and viable technology in many parts of the world. Investment for ordinary householders, who want to begin to protect themselves from future changes related to energy and climate.

5.THE INNOVATION

YOUR OWN IDEA AND YOUR OWN INPUT TO YOUR PROJECT

ACCORDING TO ENVIRONMENTAL, SOCIAL AND ECONOMICAL ASPECTS

Table 10.1. Main categories of global building assessment methods

The Main Categories	BREBREEAMLEED V4		Australia Green Star Rating System	ESTIDAMAGSAS	
Sustainable Site	○	•	•	○	•
Indoor environmental quality	○	•	•	○	•
Energy and atmosphere	•	•	•	•	•
Water Efficiency	•	•	•	•	•
Material and resources	•	•	•	•	•
Innovation in design	•	•	•	•	•
Regional priority	○	•	○	○	○
Management and operation	○	○	•	○	•
Transportation	•	○	•	○	○
Land Ecology	•	○	•	○	○
Urban community	○	○	○	•	•
Culture and economic value	○	○	○	○	•
Integrated development	○	○	○	•	○
Natural system	○	○	○	•	○
Pollution	•	○	○	○	
Health	•	○	○	○	○
Waste	•	○	○	○	○

Source: Khogali, Hind, 2016. And (Khogali, Hind, 2

Chapter Eleven

HVAC System

11.1 Definitions (HVAC)

(Heating, ventilation, and air conditioning) is the technology of indoor and automotive environmental comfort. HVAC system design is a major sub discipline of mechanical engineering

11.1.1 Amis

- The main purposes of a Heating, Ventilation, and Air-Conditioning (HVAC) system are to help maintain good indoor air quality through adequate ventilation with filtration and provide thermal comfort
- HVAC systems are among the largest energy consumers in schools, universities and hospitals. HVAC is important in the design of medium to large industrial and office buildings such as skyscrapers
- HVAC system can also affect many other high performance goals, including water consumption

11.1.2 What is the important of this system

- provide ventilation
- reduce air infiltration
- maintain pressure relationships between spaces

11.2 Heating

Figure 11.1: Radiant Heating System

Figure 11.2: Gas heating system

Figure 11.3:Electricity heating system

- There are many types of heating:
- Central Heating is used in cold climate
- Such system contains a boiler, furnace, or heat pump to heat water, steam, or air in a central location such as a furnace room in a home or a mechanical room in a large building
- Heat transfer by convention in water system
- This system contains ductwork or piping
- Most modern hot water boiler heating systems have a circulator, which is a pump to send hot water to the distribution system
- Many systems use the same ductwork to distribute air cooled by an evaporator coil for air conditioning.
- The air supply is typically filtered or passed through air cleaners to remove dust and pollen particles
- One heat source is electricity, where heaters that are made with high resistance wire get hot from the resistance to electric flow
- The heat pump is a form of heating that gained popularity in the 1950's. Heat pumps can extract heat from the air (air source) or from the ground (ground source).
- The invention of central heating is often credited to the ancient Romans, who installed systems of air ducts called hypocausts in the walls and floors of public baths and private villas
- The use of furnaces, space heaters and boilers as means of indoor heating may result in incomplete combustion and the emission of carbon monoxide, NOx, formaldehyde, Volatile organic compound (VOC's) and other combustion by-products.
- We advise of good ventilation

11.3 Ventilation

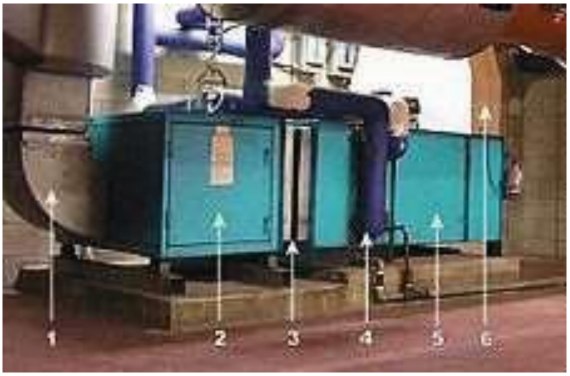


Figure 11.4: An air handling unit is used for the heating and cooling of air in a central location (click on image for legend).

11.3.1 Definition of ventilation

- Ventilation is the process of "changing" or replacing air in any space to control temperature or remove any combination of moisture, odors, smoke, heat, dust, airborne bacteria or carbon dioxide, and to replenish oxygen

11.3.2 Method of Ventilation

- Natural System
- Mechanical system

1) Mechanical System

- Mechanical" or "forced" ventilation is provided by an air handler and used to control indoor air quality. Excess humidity, odors, and contaminants can often be controlled via dilution or replacement with outside air
- Kitchens and bathrooms typically have mechanical exhausts to control odors and sometimes humidity.
- Ceiling fans and table/floor fans circulate air within a room for the purpose of reducing the perceived temperature by increasing evaporation of perspiration on the skin of the occupants

2) Natural Ventilation

- Natural ventilation is the ventilation of a building with outside air without the use of fans or other mechanical systems
- It can be achieved with openable windows or trickle vents when the spaces to ventilate are small and the architecture permits.

- Natural ventilation is a key factor in reducing the spread of airborne illnesses such as tuberculosis, the common cold, influenza and meningitis. Opening doors, windows and using ceiling fans are all ways to maximize natural ventilation and reduce the risk of airborne contagion. Natural ventilation requires no maintenance and is not costly

11.3.3 The Air Conditioning (AC)

- Definition

- Air conditioning and refrigeration are provided through the removal of heat. Heat can be removed through radiation, convection, and by heat pump systems through a process called the refrigeration cycle

1) **Central AC system**

Figure 11.5: HVAC System

Advantages

- In variable climates, the system may include a reversing valve that automatically switches from heating in winter to cooling in summer

- air ducts required to carry the needed air to heat or cool an area

- Used in educational buildings and office, commercial and hospitals

- The duct system must be carefully maintained to prevent the growth of pathogenic bacteria such as legionella in the ducts.

2) Separate indoor and outdoor coils in split systems

Figure 11.6: Split Unit AC Type

Advantages

- most often seen in residential
- The evaporator coil is connected to a remote condenser unit using refrigerant piping between an indoor and outdoor unit instead of ducting air directly from the outdoor unit
- Indoor units connected with directional vents mount onto walls, suspend from ceilings, or fit into the ceiling. Other indoor units mount inside the ceiling cavity, so that short lengths of duct handle air from the indoor unit to vents or diffusers around the room or rooms.
- Suitable for houses and office buildings and small shops
- Need regular maintenance
- equipped with internal air filters
- very dirty or plugged filters can cause overheating during a heating cycle, and can result in damage to the system or even fire.

3) Window type AC

Figure 11.7: Window Type AC

Advantages

- IT CONTAINS of one unit
- Need a hole in the wall
- Consisted of a filter
- This filter need maintenance regularly
- It controls the air temperature and air humidity
- Economic
- Suitable for houses.

Chapter Twelve

Fire Alarm System

12.1. Definition of Fire System

- An automatic fire alarm system is designed to detect the unwanted presence of fire by monitoring environmental changes associated with combustion
- a fire alarm system is classified as either: automatically actuated,
- manually actuated, or both. Automatic fire alarm systems

12.2 Design

- usually by referencing the minimum levels of protection mandated by the appropriate model building code, insurance agencies, and other authorities
- Equipment specifically manufactured for these purposes are selected and standardized installation methods are anticipated during the design

12.3 Fundamental configuration

- Fire alarm control panel: This component, the hub of the system, monitors inputs and system integrity, controls outputs and relays information.
- Primary Power supply: Commonly the non-switched 120 or 240 Volt Alternating Current source supplied from a commercial power utility. In non-residential applications, a branch circuit is dedicated to the fire alarm system and its constituents. "Dedicated branch circuits" should not be confused with "Individual branch circuits" which supply energy to a single appliance.
- Secondary (backup) Power supplies: This component, commonly consisting of sealed lead-acid storage batteries or other emergency sources including generators, is used to supply energy in the event of a primary power failure.
- Initiating Devices: This component acts as an input to the fire alarm control unit and are either manually or automatically actuated. Examples would be devices like pull stations or smoke detectors.
- the fire alarm system or other stored energy source, to inform the proximate persons of the need to act, usually to evacuate. This is done by means of a flashing light, strobe light, electromechanical horn, speaker, or a combination of these devices.
- Building Safety Interfaces: This interface allows the fire alarm system to control aspects of the built environment and to prepare the building for fire, and to control the spread of smoke fumes and fire by influencing air movement, lighting, process control, human transport, and exit

12.4 UK fire alarm system categories

M	Manual systems, e.g., hand bells, gongs, etc. These may be purely manual or manual electric; the latter may have call points and sounders. They rely on the occupants of the building discovering the fire and acting to warn others by operating the system. Such systems form the basic requirement for places of employment with no sleeping risk.
P1	The system is installed throughout the building - the objective being to call the fire brigade as early as possible to ensure that any damage caused by fire is minimized. Small low risk areas can be excepted, such as toilets and cupboards less than $1m^2$.
P2	Detection should be provided in parts of the building where the risk of ignition is high and/or the contents are particularly valuable. Category 2 systems provide fire detection in specified parts of the building where there is either high risk
L1	A category L1 system is designed for the protection of life and which has automatic detectors installed throughout all areas of the building (including roof spaces and voids) with the aim of providing the earliest possible warning. A category L1 system is likely to be appropriate for the majority of residential care premises. In practice, detectors should be placed in nearly all spaces and voids. With category 1 systems, the whole of a building is covered apart from minor exceptions.
L2	A category L2 system designed for the protection of life and which has automatic detectors installed in escape routes, rooms adjoining escape routes and high hazard rooms. In a medium sized premises (sleeping no more than ten residents), a category L2 system is ideal. These fire alarm systems are identical to an L3 system but with additional detection in an area where there is a high chance of ignition, e.g., kitchen) or where the risk to people is particularly increased (e.g., sleeping risk).
L3	This category is designed to give early warning to everyone. Detectors should be placed in all escape routes and all rooms that open onto escape routes. Category 3 systems provide more extensive cover than category 4. The objective is to warn the occupants of the building early enough to ensure that all are able to exit the building before escape routes become impassable

L4	**Category 4 systems cover escape routes and circulation areas only. Therefore, detectors will be placed in escape routes, although this may not be suitable depending on the risk assessment or if the size and complexity of a building is increased. Detectors might be sited in other areas of the building, but the objective is to protect the escape route.**
L5	**This is the "all other situations" category, e.g., computer rooms, which may be protected with an extinguishing system triggered by automatic detection. Category 5 systems are the "custom" category and relate to some special requirement that cannot be covered by any other category.**

Table 12.1: UK fire alarm system categories

12.5 Zoning

- An important consideration when designing fire alarms is that of individual zones. Specifically:
- A single zone should not exceed 2,000m² in floor space.
- Where addressable systems are in place, two faults should not remove protection from an area greater than 10,000m².
- A building may be viewed as a single zone if the floor space is less than 300m².
- Where the floor space exceeds 300m² then all zones should be restricted to a single floor level.
- Stairwells, lift shafts or other vertical shafts (nonstop risers) within a single fire compartment should be considered as one or more separate zones.
- The maximum distance travelled within a zone to locate the fire should not exceed 60m.

Table 12.2: Shows the icons used in fire system

FIRE ALARM SYSTEM	DESCRIBE	BASEMENT	GROUND FLOOR	FIRST FLOOR	SECOND FLOOR	THIRD FLOOR	NOTES
	Fire alarm (break glass)			•	•		In each corner in the main libby
	Fire extinguisher and fire hose reel			•	•		In each corridor
	Route to exit			•	•		In the main corridors
	track emergency exit signs			•	•		In the main corridor near staircase
	report to the person in charge of the assembly point			•	•		Did not Located in the write place
	leave the building by the nearest available exit			•	•		
	If possible call the fire brgade 4949000 or 9888	○	○	○	○		Not applicable
	raise the alarm	•	•	•	•	•	
	do not use lifts	•	•	•	•		Not place at write place
	do not stop to collect personal belonging			○	○	➢	Not applicable
	Smoke detector	•	•	•	•	•	
	Water sprinkler	•	•	○	○		Not applicable in first floor

Chapter Thirteen

Energy Efficiency

13.1 Landscape and building working together

1) Study the urban design concept, distribute the landscape and the buildings

2) change the zoning into masterplan

3) the landscape at the middle of the cluster

4) the landscape at the middle of the neighborhoods

5) Apply ideas such as green roof, green walkway

6) Use ideas such as mass overlapping

7)use shades and canopies. All these solutions could help in minimizing the massive temperature in Hot-Dry climate.

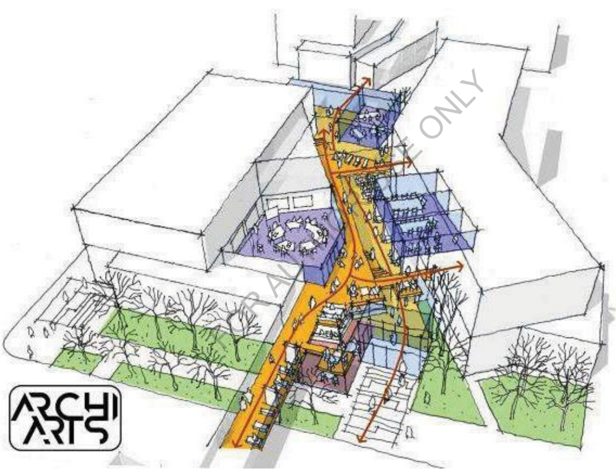


Figure 13.1: Landscape and building working together, building shades, green areas

Figure 13.2: The building mass making shades

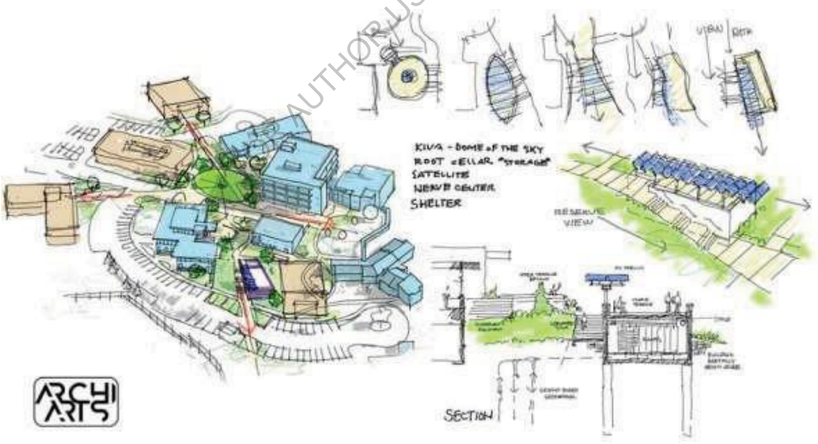


Figure 13.3: The cluster including green areas at the middle.

Figure 13.4: The green areas at the middle of the neighbourhood.

Figure 13.5: The roof garden.

Figure 13.6: The building canopy cause shades.

Figure 13.7:The building canopy cause shades

Figure 13.8: The green are in the back yard.

Figure13.9:The landscape is working with the building .

Figure 13.10: The green roof used as walkway.

Figure13.11: The Great canopy cause shade to the main entrance.

Figure 13.12:The landscape and he neighbourhood working together.

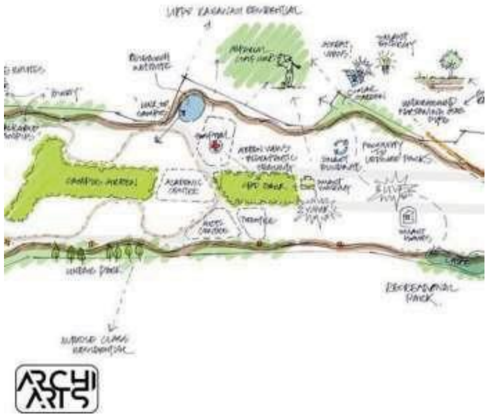


Figure 13.13:zoning to study the landscape and building cluster.

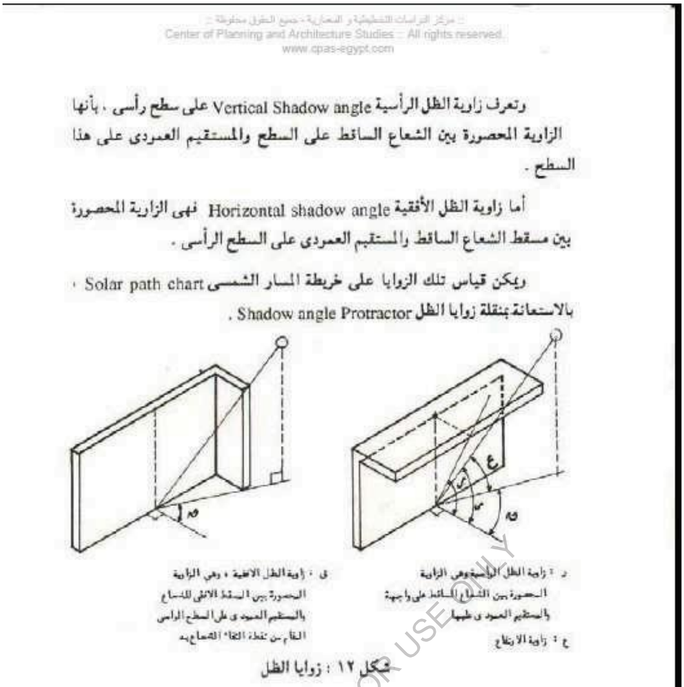
Figure 13.14: Change the zoning to masterplan.

Figure 13.15: The building overlapping to cause shades.

Figure 13.16: The building shades and building overlapping to cause shades.

Figure 13.17: The building shades and building overlapping to cause shades

Figure 13.18: The building shades and building overlapping to cause shades



وتعرف زاوية الظل الرأسية Vertical Shadow angle على سطح رأسى ، بأنها الزاوية المحصورة بين الشعاع الساقط على السطح والمستقيم العمودى على هذا السطح .

أما زاوية الظل الأفقية Horizontal shadow angle فهى الزاوية المحصورة بين مسقط الشعاع الساقط والمستقيم العمودى على السطح الرأسى .

ويمكن قياس تلك الزوايا على خريطة المسار الشمسى Solar path chart ، بالاستعانة بمنقلة زوايا الظل Shadow angle Protractor .

ق : زاوية الظل الافقية ، وهي الزاوية المحصورة بين المسقط الافقي للشعاع بالمستقيم العمودي على السطح الراسي القائم من نقطة التقاء الشعاع به

د : زاوية الظل الرأسية وهي الزاوية المحصورة بين الشعاع الساقط على واجهة بالمستقيم العمودي عليها

ع : زاوية الارتفاع

شكل ١٢ : زوايا الظل

Figure13.14: The incident angle with <45° to identify the window hight

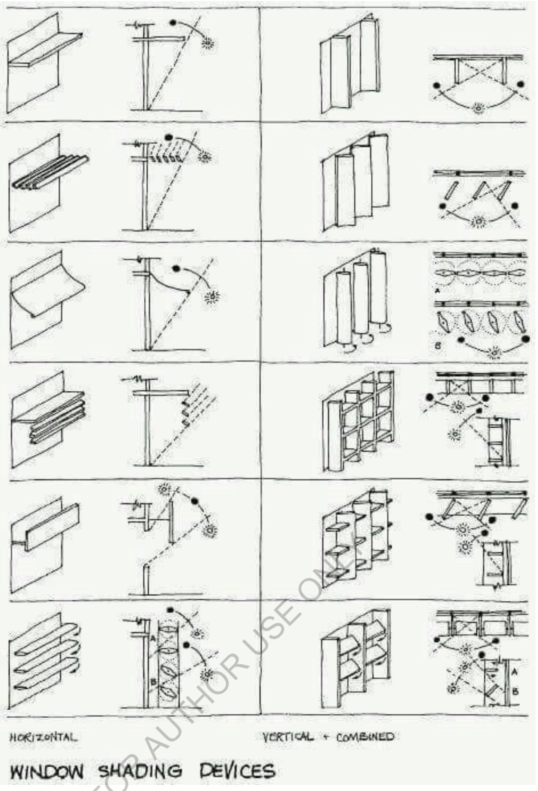
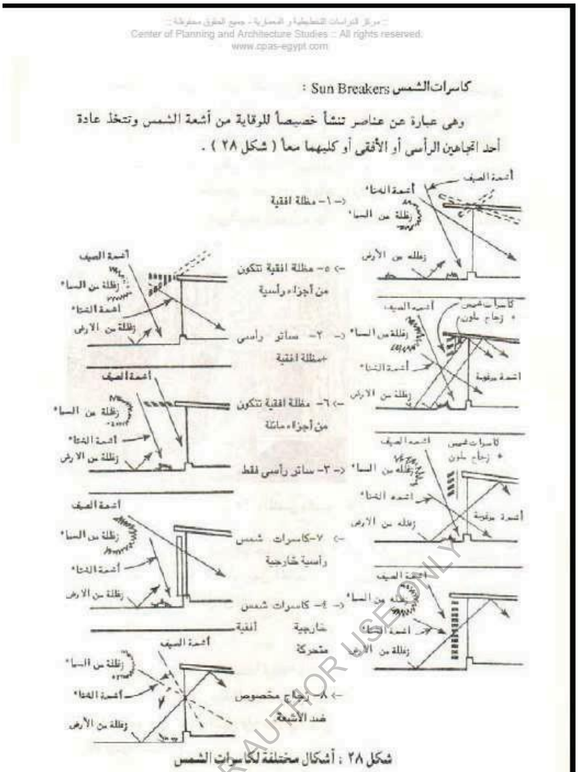


Figure 13.16: different types of window sunscreen , horizontal and virtical sunscreen.



كاسرات الشمس Sun Breakers :

وهى عبارة عن عناصر تنشأ خصيصاً للوقاية من أشعة الشمس وتتخذ عادة أحد اتجاهين الرأسى أو الأفقى أو كليهما معاً (شكل ٢٨) .

شكل ٢٨ : أشكال مختلفة لكاسرات الشمس

Figure 13.17: different types of windows

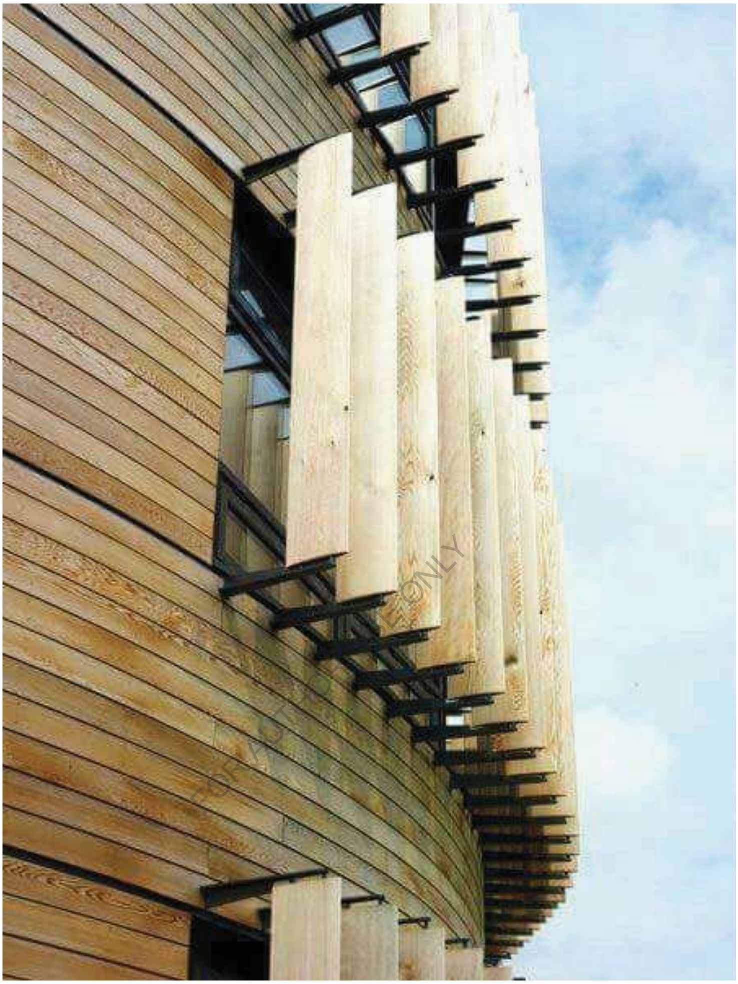


Figure 13.18: vertical wooden sunscreen

Figure 13.19: vertical metal sunscreen

Figure 13.20: Horizontal sliding wooden sunscreen

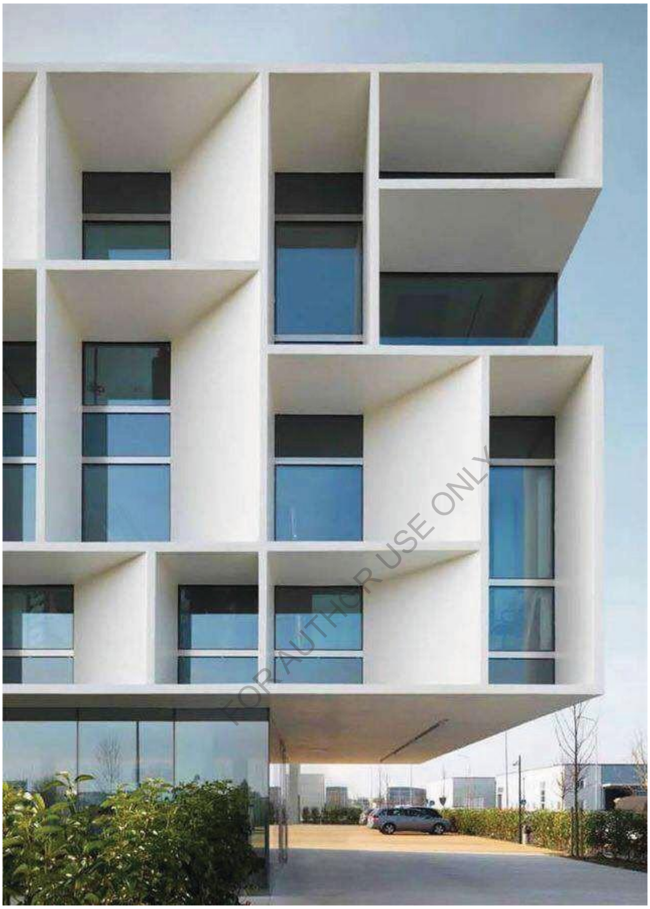


Figure 13.21: Horizontal and vertical concrete sunscreen

Figure 13.22: Horizontal and vertical fabric sunscreen

Figure 13.23: Folding wooden sunscreen

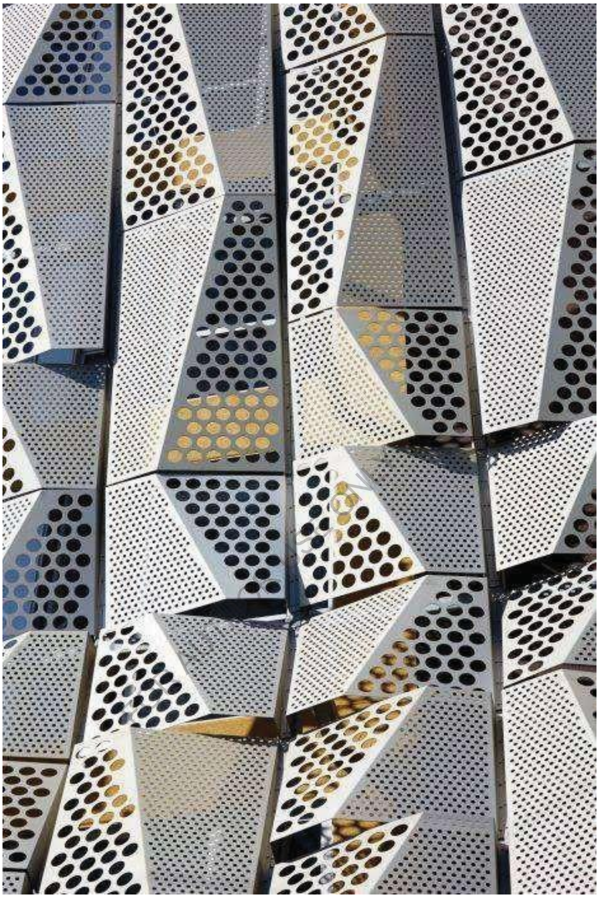


Figure 13.24: Vertical metal with holes sunscreen

Figure 13.25: Vertical metal with decor sunscreen

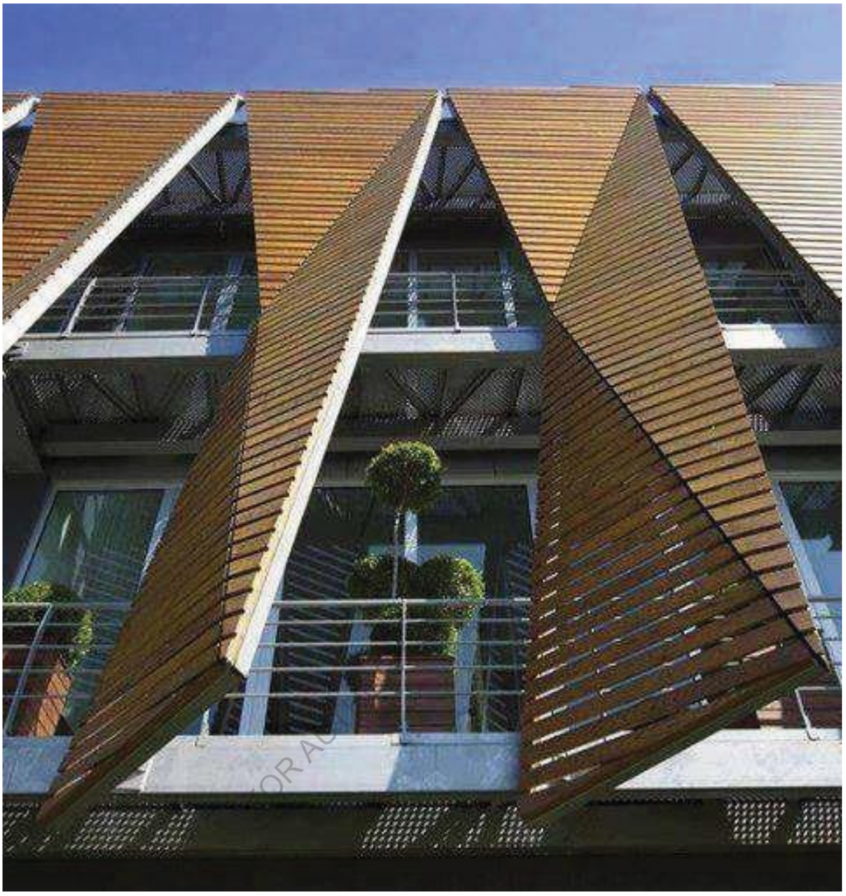


Figure 13.26: Vertical wooden sunscreen

Figure 13.27: Vertical concrete with <45° view sunscreen

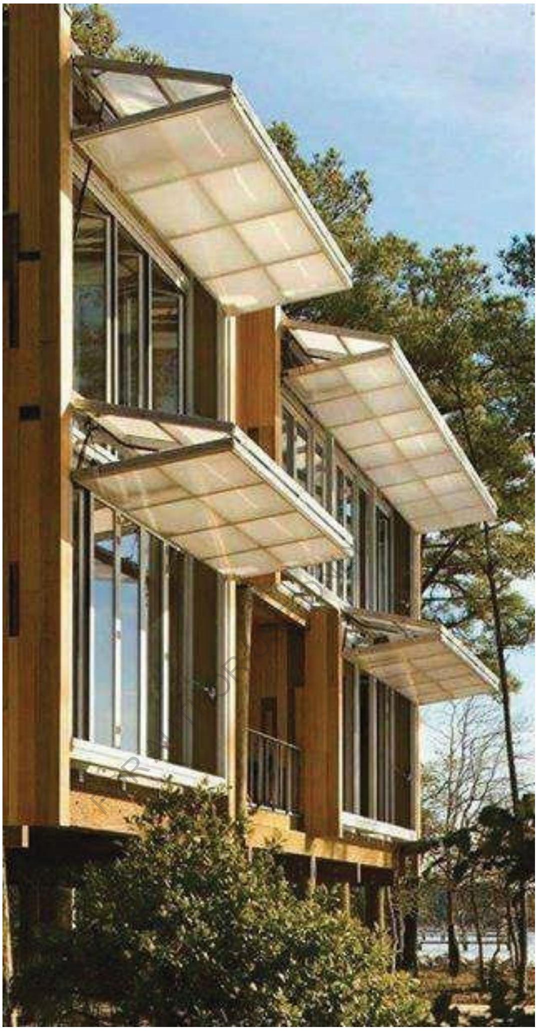


Figure 13.28: Vertical folding fabric sunscreen

Figure 13.29: Vertical and horizontal with <45° concrete with glass window sunscreen

Figure 13.30: Vertical and horizontal with <45° metal with wood window sunscreen

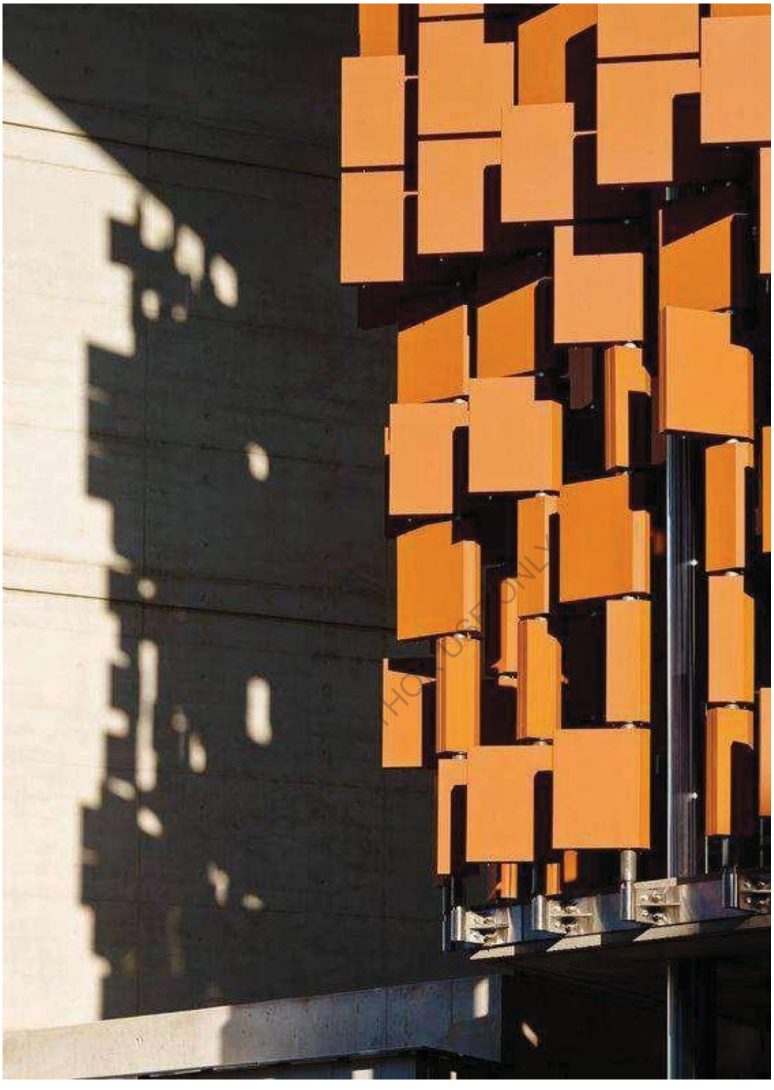


Figure 13.31: Vertical and horizontal with design with wood window sunscreen

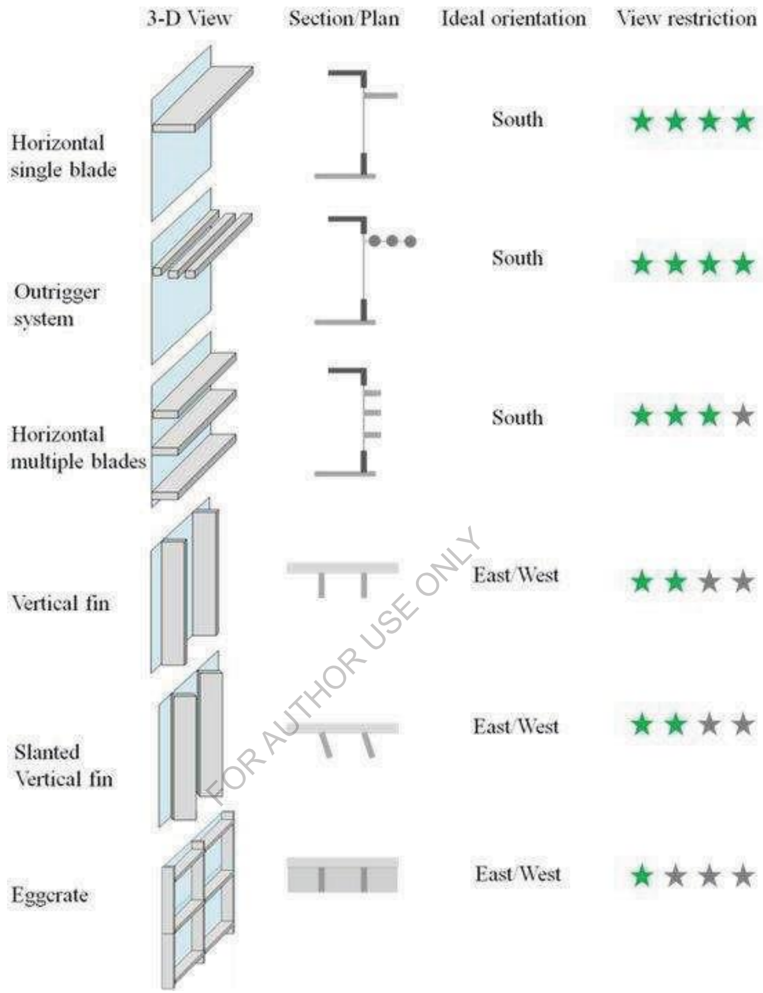


Figure 13.31: Vertical and horizontal with aluminum glass window sunscreen

Figure 13.32: Vertical with aluminum and glass window sunscreen

Figure 13.33: Vertical with <45° window wooden sunscreen

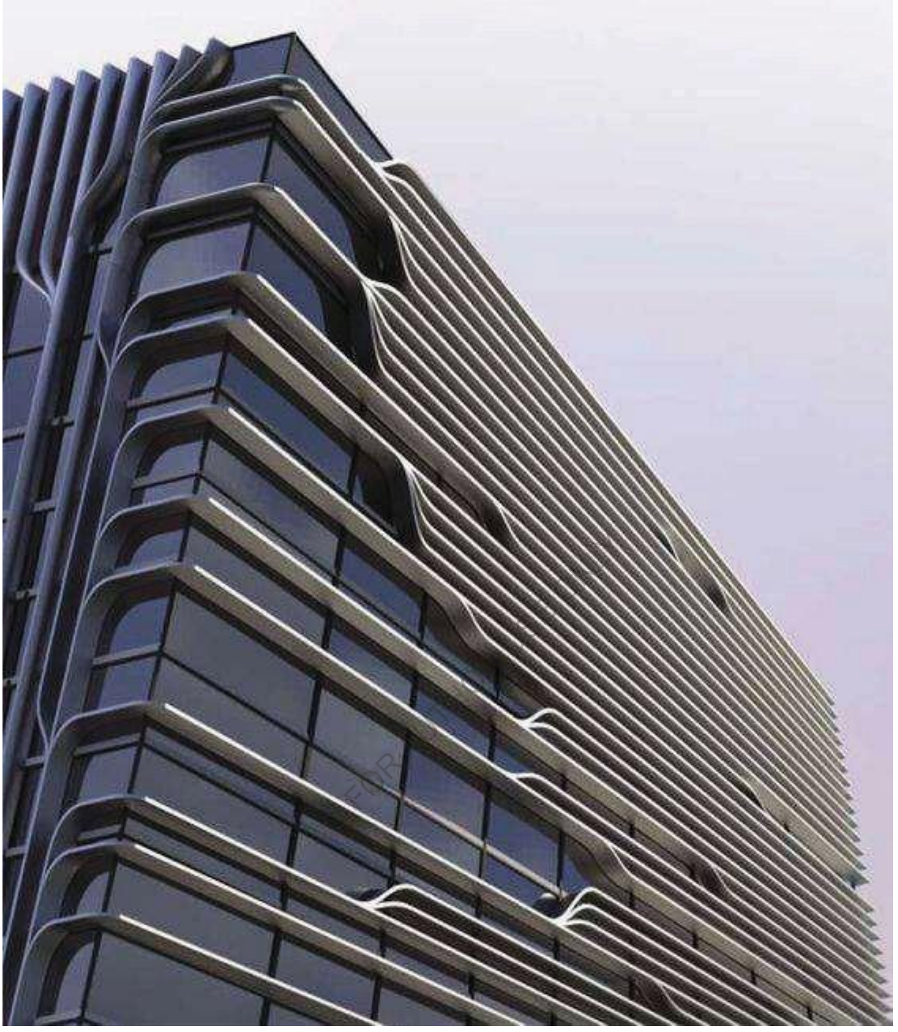


Figure 13.34 Horizontal, aluminum glass window sunscreen

Figure 13.35: Vertical, with aluminum glass window sunscreen

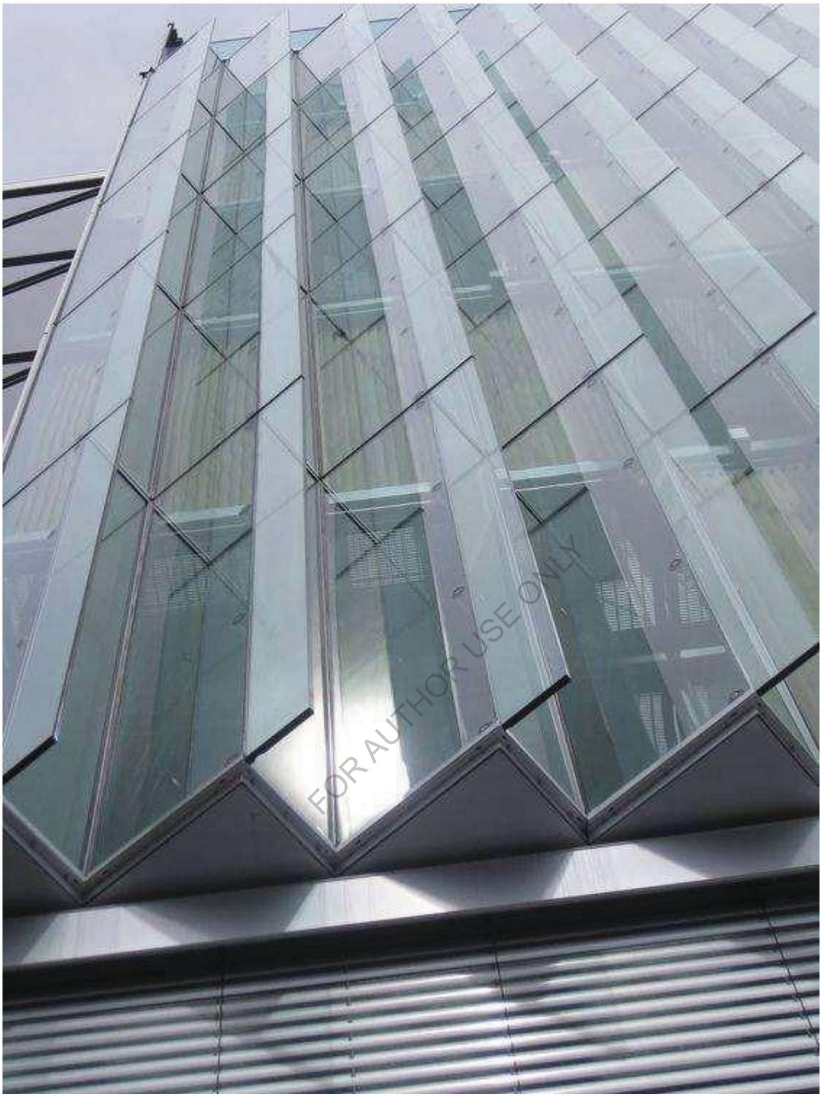


Figure 13.36: Vertical, with aluminum glass window sunscreen

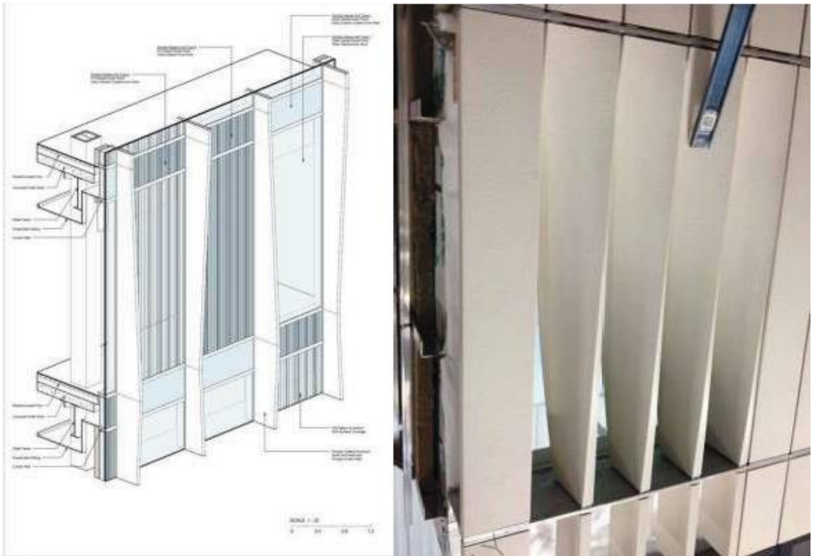


Figure 13.37: Vertical, with aluminum glass window sunscreen

Figure 13.38: Vertical and horizontal with special design white fabric, with aluminum glass window sunscreen, King Fahad Library in Riyadh City

Figure 13.39: Vertical, with aluminum glass window sunscreen

Figure 13.40: Vertical, wooden sunscreen

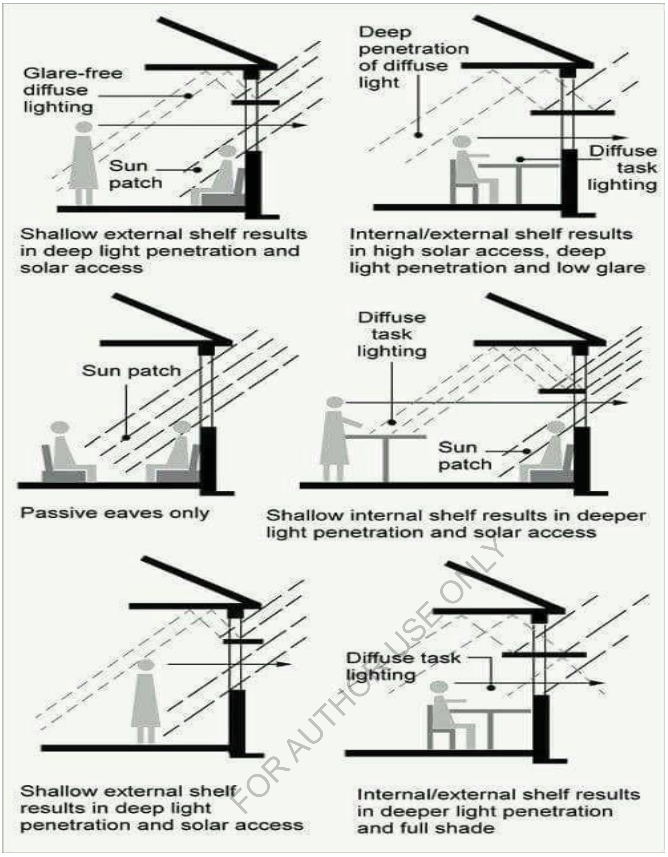


Figure 13.41: Horizontal concete sunscreen

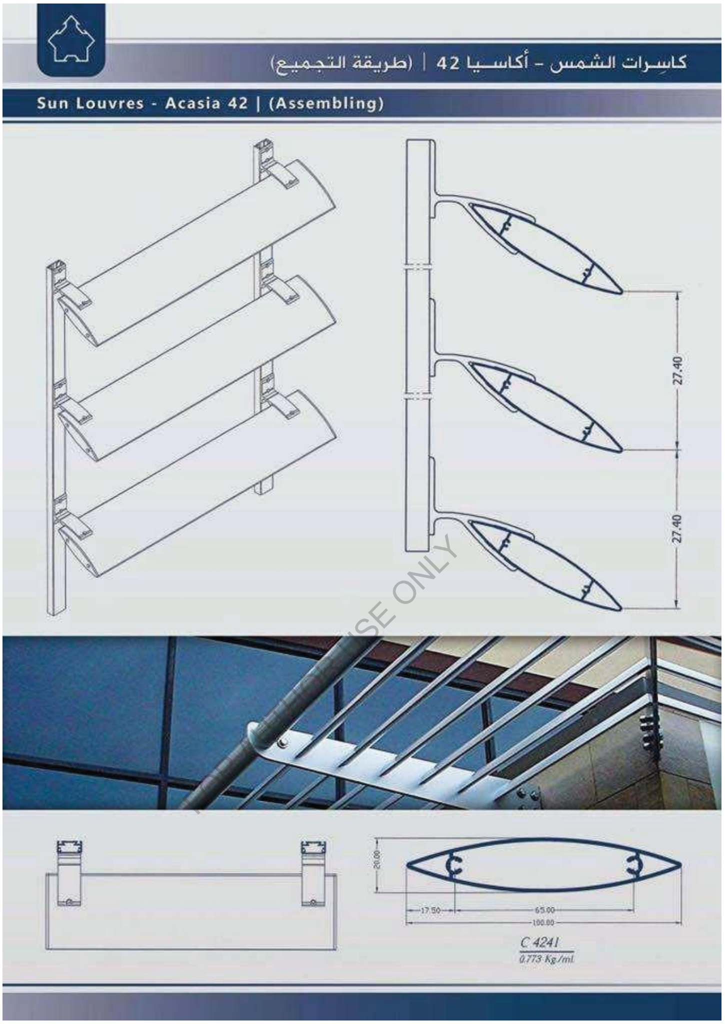


Figure 13.42: Horizontal with special design sunscreen

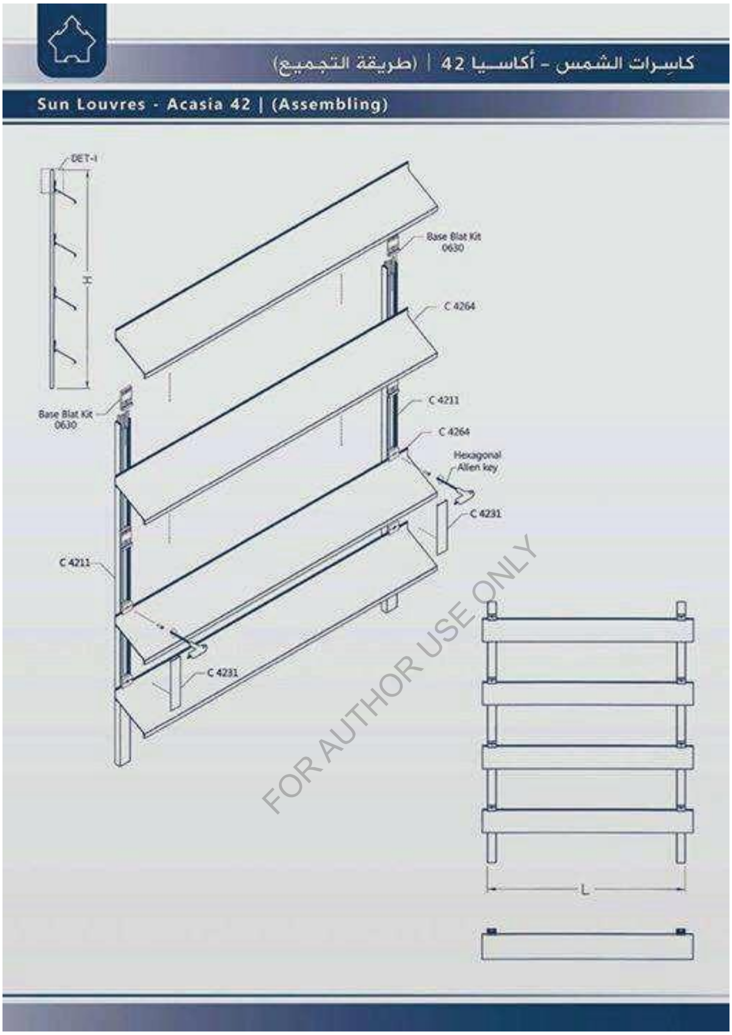


Figure 13.43: Horizontal concrete sunscreen

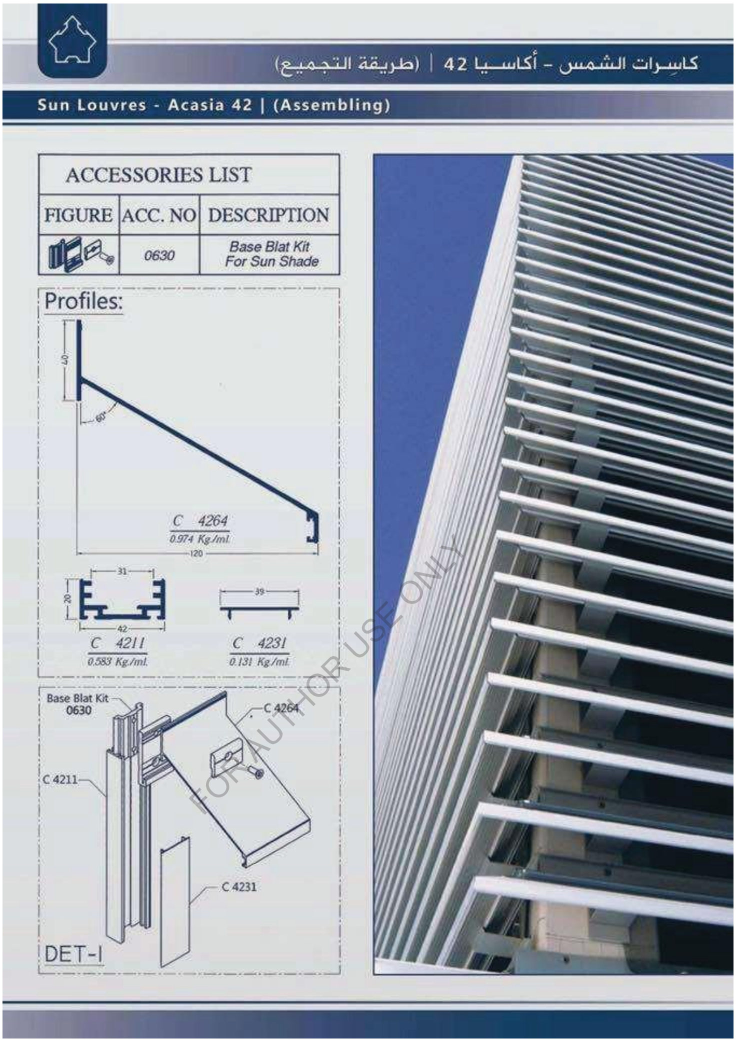


Figure 13.44: Horizontal concrete with <45 ° sunscreen

Figure 13.45: Horizontal concrete with special design sunscreen

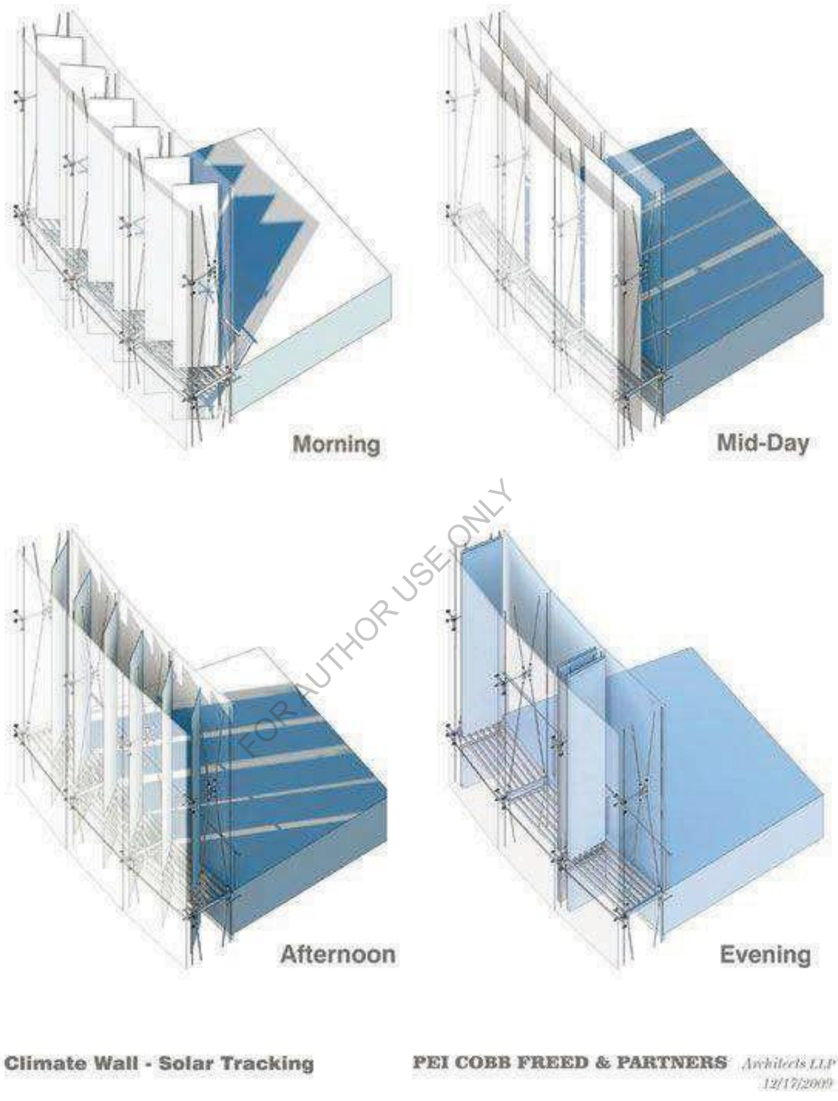


Figure 13.46: Vertical climate wall-solar tracking sunscreen

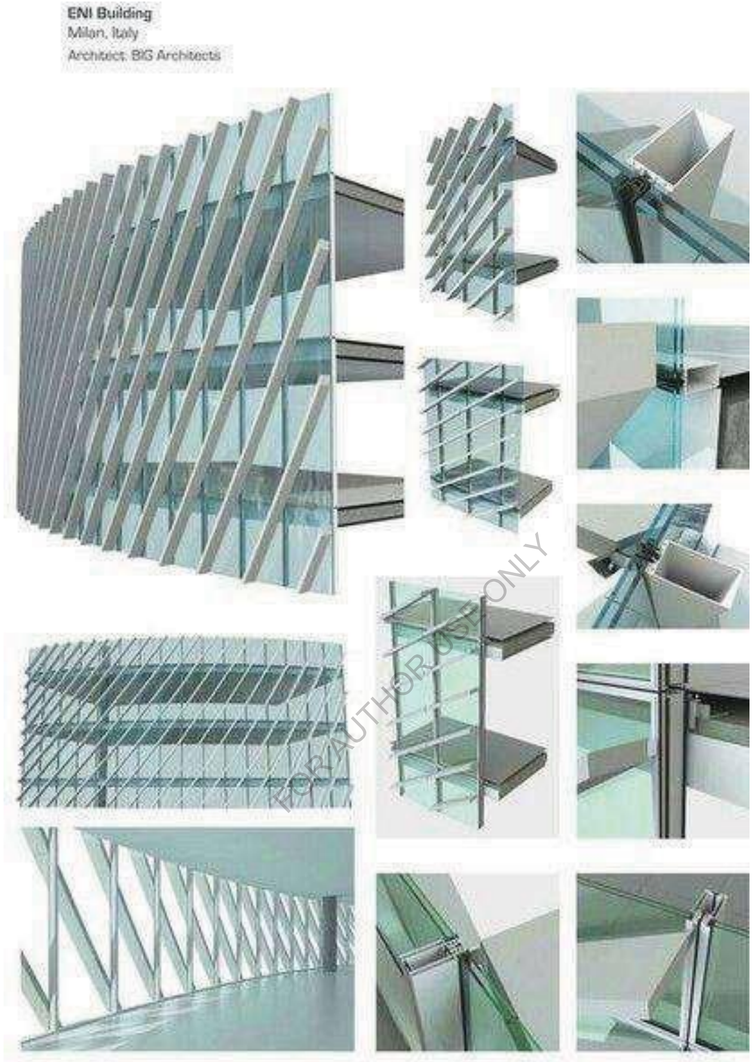


Figure 13.47: Vertical climate wall-solar tracking sunscreen

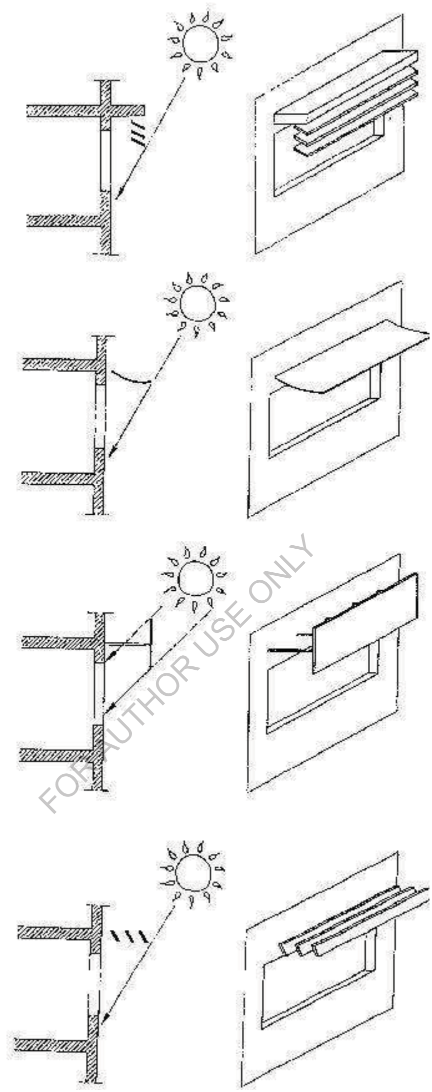


Figure 13.48: Horizontal sunscreen

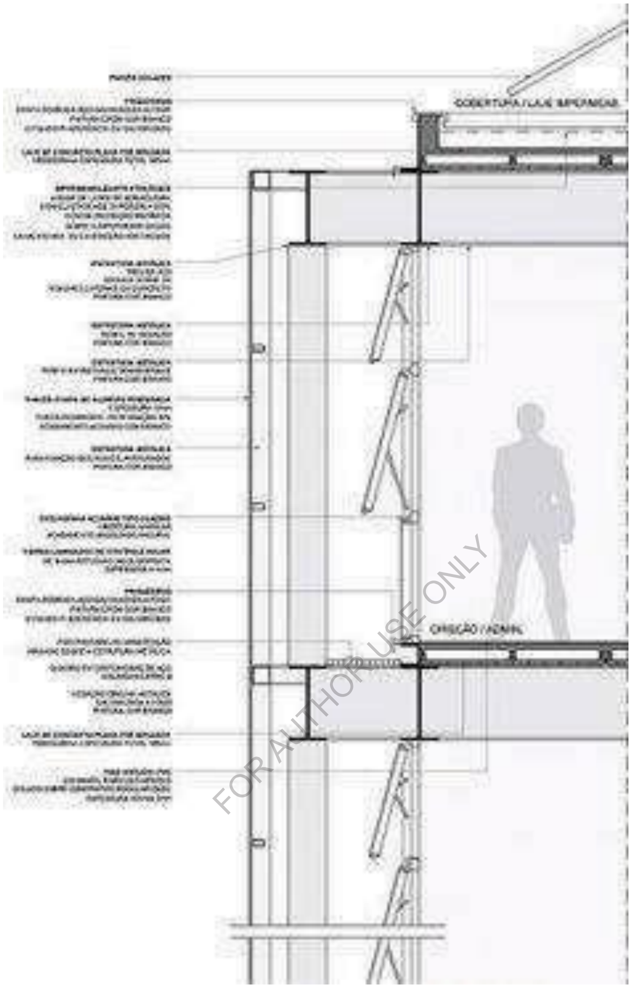


Figure 13.49: Cavity wall

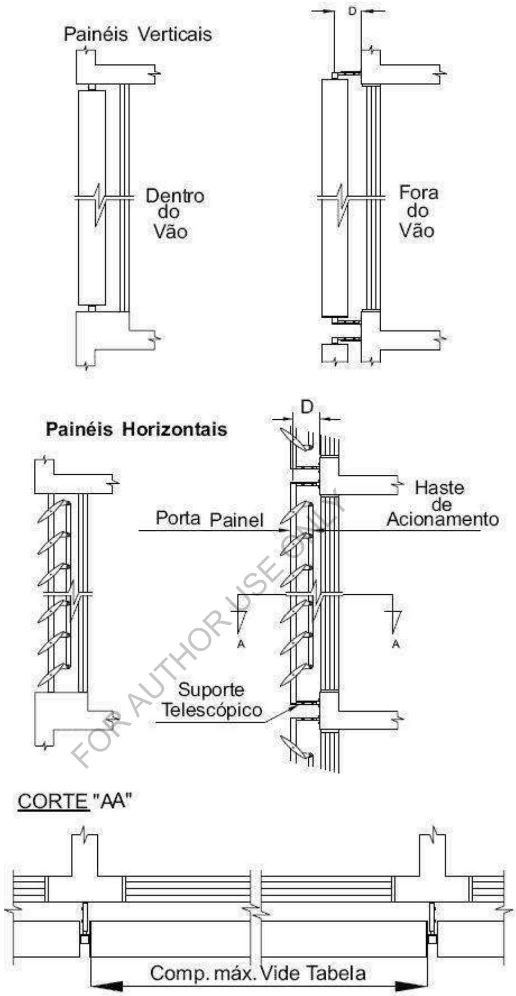


Figure 13.50: Cavity wall

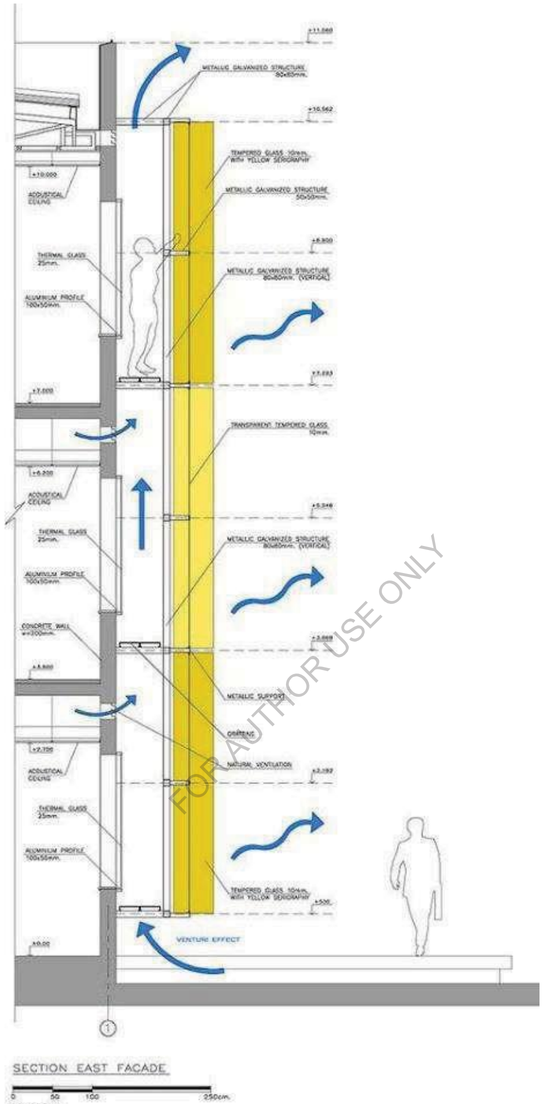


Figure 13.51: Cavity wall

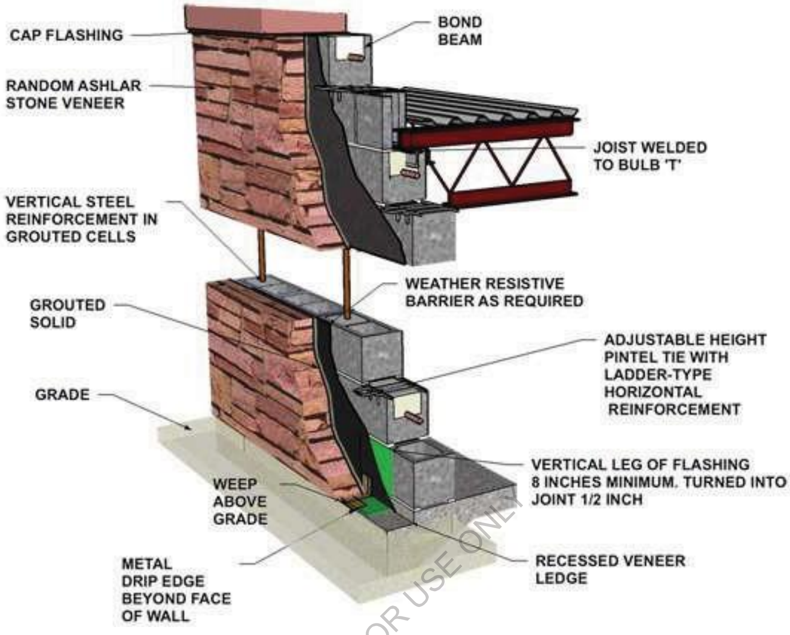


Figure 13.51: Cavity wall

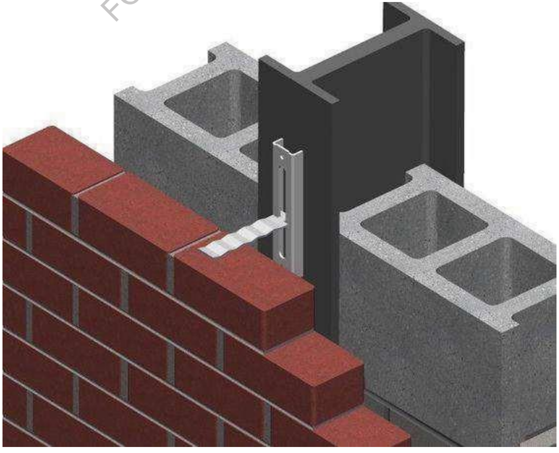


Figure 13.52: Cavity wall

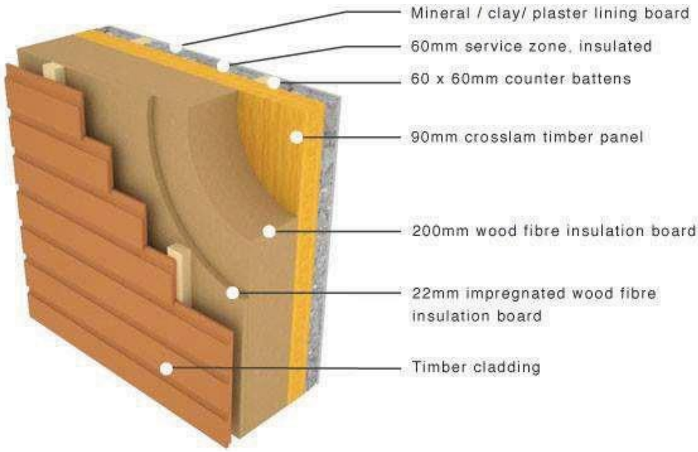


Figure 13.53: Cavity wall

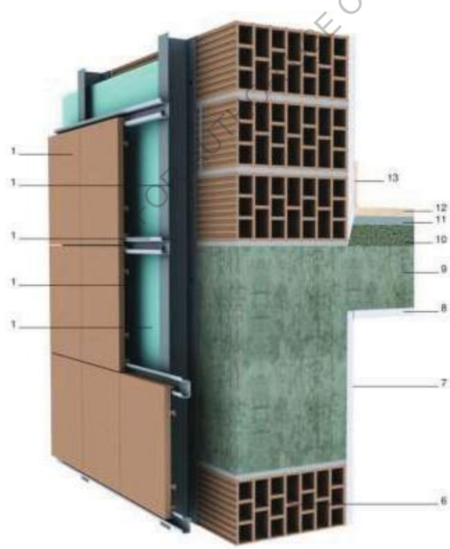


Figure 13.54: Cavity wall

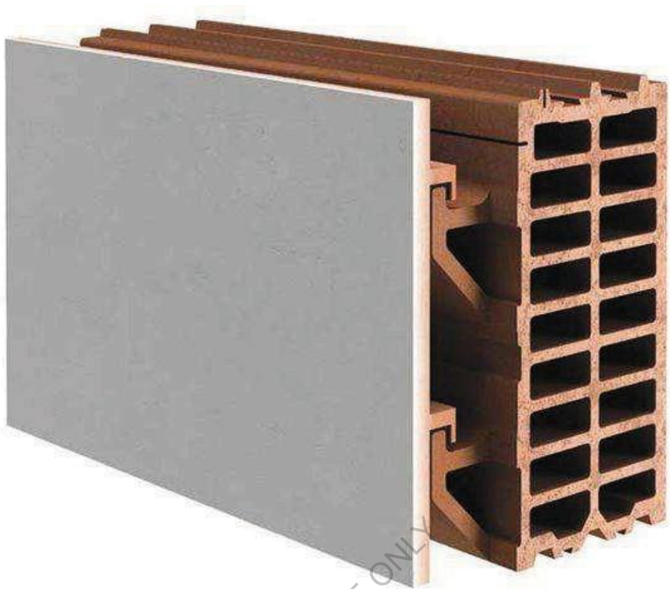


Figure 13.55: Cavity wall

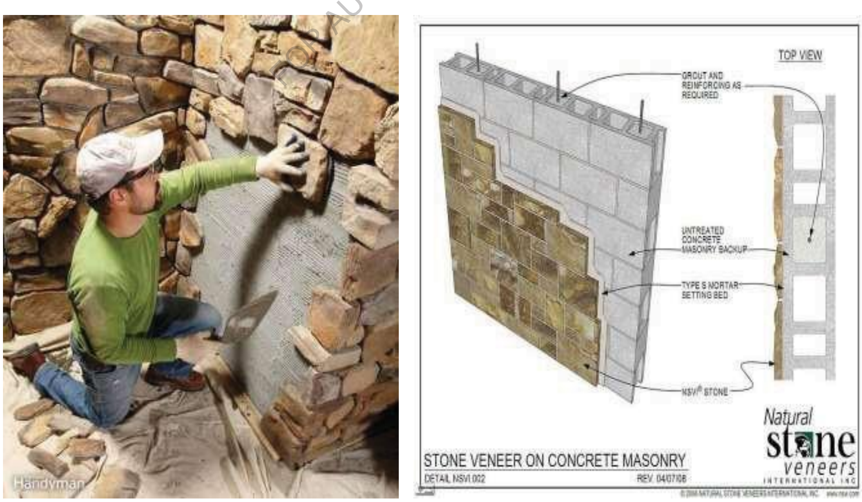


Figure 13.56: Cavity wall

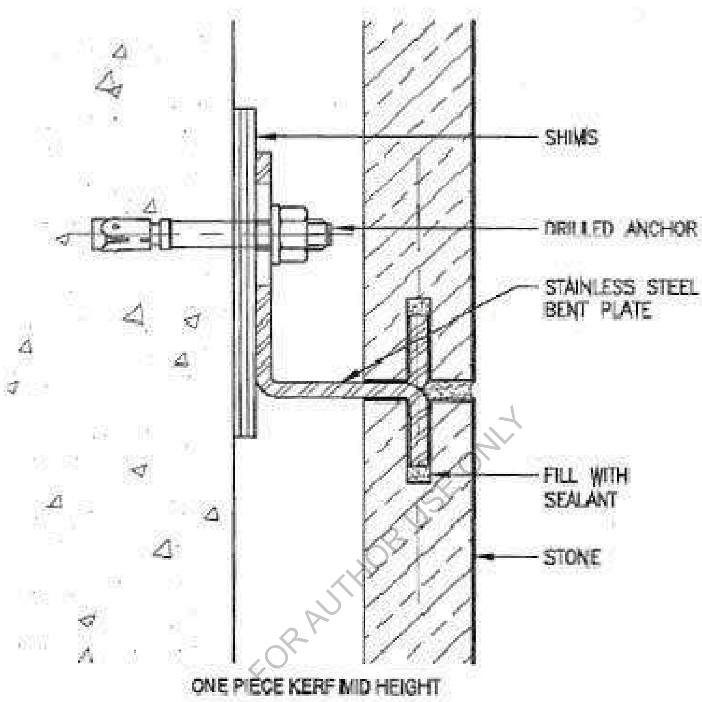


Figure 13.57: Cavity wall

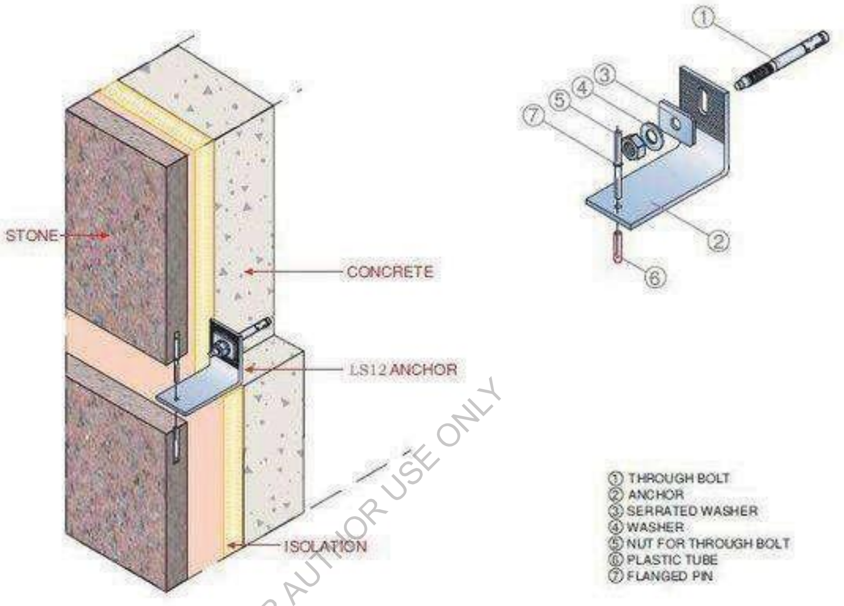


Figure 13.58: Cavity wall

Figure 13.59: Kinetic energy wall

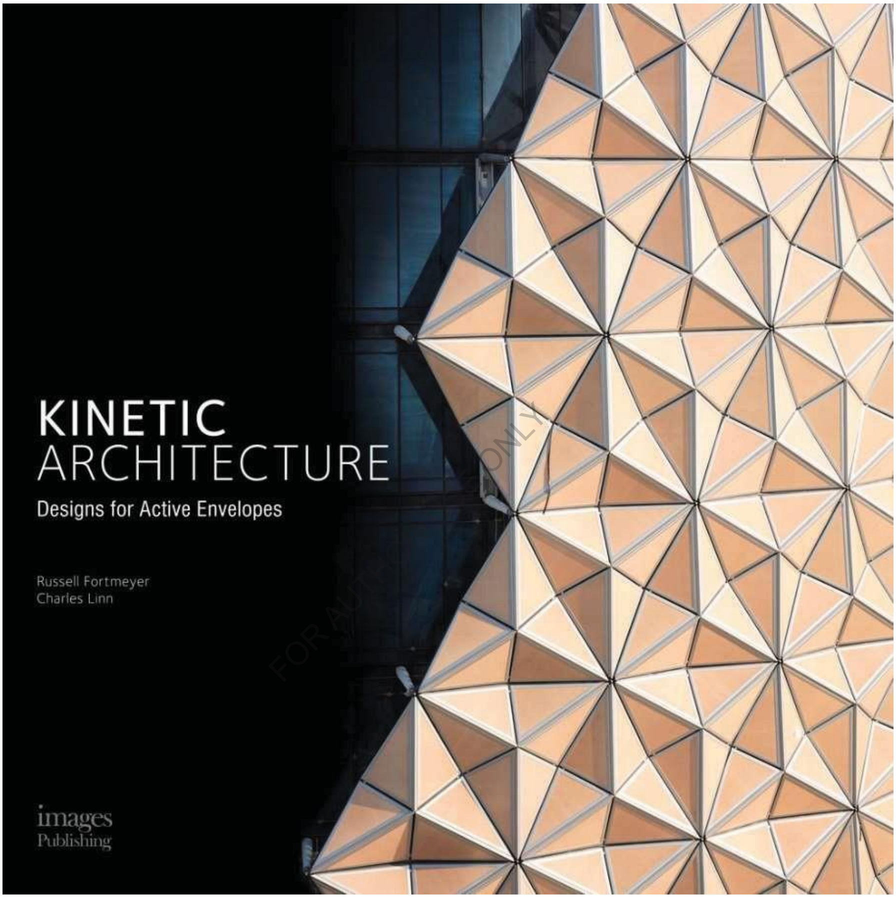


Figure 13.60: Kinetic energy wall

Figure 13.61: Kinetic energy wall

Figure 13.62: Kinetic energy wall

Chapter Fourteen

Students Researches

Measuring the Thermal Comfort and the Sound Level in Design Studio Classes in Architecture Engineering Colleges

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Abstract

Thermal comfort is one of the most important topics in the course *Environmental Control, ARC404* assign to Architecture program in the college of architecture Engineering and Digital Design, 6 students in this course will share in the research, will distribute in three groups. This research is aiming to let the students learn and practice how to measure the thermal comfort in-studio classes focusing on the temperature, the humidity, and the noise, analysing and find solutions. The methodology of the research is based on using monitor devices; *noise level smart meter*, *smart temperature and humidity measurement meter* with data analysis by using Excel computer program as well as, distrusting a survey to know the user's opinion. The college has three types of a studio class, one facing the courtyard, with large glass window, the second at the middle of the corridor with high-level window, the third one is far away from the courtyard without any window. The results compared by The United Nation Environut Protection Agency (EPA) noise levels. The results show that the studio class CBC09 level of sound exceed 60 dB which consider as noise. Also, the class CBC01 is the most comfortable class because of 25 C° temperature, 40% humidity and 55 DB the sound level is also exceed the limit by EPA. The conclusion of the research paper will highlight some scientific solutions in walls, ceiling and floors for the studio classes to be applied in the future.

Keywords: measuring thermal comfort, temperature control, humidity control, sound level control in studio classes, scientific solutions

1. Introduction

The design studio halls in Architecture department are suffering from noise because the main walls are made from glass plywood partitions, this cause problem of discomfort for the students and teachers during the lecture because of sound transfer... Also, because of the glasses are in the basement this cause high humidity in winter and high temperature in summer.

Although measuring the thermal comfort in design studio classes became significance in measuring the sound and noise level, temperature and humidity in the class and find out scientific solutions. its significant for the studio classes in DAU will provide more comfortable places for the students, and for the community, it will attract more students if we improve the situation in the internal environment.

1.1 Objectives of the Research

1) To measure the thermal comfort in the design studio classes in Architecture Department.

2) To let the student share in scientific research in course Environmental control.

3) To encourage the students using the monitoring system such as, sound smart meter and temperature smart thermometer

4) To encourage the students working in groups.

5) To learn the students the main steps of doing scientific research.

6) The research will be discussed in Prince Sultan Forum for students researches and this will let DAU students having the experience to share in conferences, discussing their results and have experience in presentation, and meet with the professionals.

7) To use the main instruments used in the research for other faculty members for other researches in the future and will establish scientific Lab for female students and faculty members.

a. Research Problem

The main research question: Do the design studio classes comfortable for students and teachers?

To answer this question, the research will monitor the thermal comfort in-studio classes in the college of architecture engineering and digital design, the researchers choose three classes in each side male/female

CBC01/ABC01, CBC07/ABC07 and CBC09/ABC09.

Because they have different designs, especially in window size, the amount of natural lighting

2. Literature Review

Abdelmoneim, H. (2020) discussed in the paper Benchmarking case study different global systems compare with the local system SEBAM, one of the major sustainable eco buildings principles is studying the indoor environmental quality focusing on the natural ventilation. Abdelmoneim, H. (2020) discussed the Greater Khartoum local system Assessment Method to Evaluate sustainable-eco -buildings (SBAM) the system discussed the indoor environmental quality in using the ecological building material, natural ventilation, sustainable lighting.

Laaeddine, R., Wu, S. & Del, E. (2019) discussed in their paper the Occupancy, windows, opening and, closing, shading control, equipment use, lighting control, Thermostat adjustment and give the Advantages and Disadvantages. Mahmoud, S.(2019) discussed in her paper different sources of noise such as image noise, speakers noise and mechanical system noise which are affect human health. Abdelmoneim, H., (2019) discussed the six basic factors of thermal confort which are the humidity, the temperature, radiant temperature, air velocity, metabolic heat, and human clothing this research is focusing on the humidity and temperature and the noise. Alserf, M., (2019) stated in his book '*Sustainable Houses in Saudi Arabia',* human health and well being are one important principle of LEED.

ASHRAE(2019) discussed Standard 62.1-2019 and stated Humidity control requirements are now expressed as dew point and not as relative humidity.

The united State Environmental Protection Agency EPA (2017) discussed the monitoring system that used in schools and universities and stated to set the cschool bus and other vehicles inside the school in particular space for airborne and noise. In addition the added establish and implement a regular schedule for maintaining unit ventilators, replacing air filters, cleaning supply air diffusers, return registers and outside air intakes and commission the HVAC system a minimum of once every 5 years.

Hassan, S., (2007) stated in his book 'Lighting *and Acoustics in Architecture'* most of the problems in the modern design with open spaces are because of using lightweight structure without acoustical privacy especially in open lecture halls and open spaces which cause spread of the noise between these lecture halls.

Jalil, A., Mjid, M. and Safa, Kh. (2012) published a paper about measuring the noise levels in college of architecture engineering, civil epartment and stated that the sound level in the whole building reach 76.7which exceed the limit of acepted sound level at universities.the EPA is recommended the sound level between 40-30 for universities.

(KAUST, 2013) stated in the report that energy-saving can be achieved by studying windows, solar screening, glazing and building insulations. Hassan, S., (2002) stated in his book the heat transfer in buildings through walls, heat exchange between the human and the surroundings, the internal thermal comfort can be controlled by using the natural ventilation through the windows or by using the mechanical means. Mcmullan, R.(2002) discussed the importance of natural ventilation in classes between 3-4 air changes per hour and added the moisture inside the buildings caused by human activities like breathing and cooking. (Schiavon, S., 2010) Personalized ventilation (PV) is an individually controlled air distribution system aimed at improving the quality of inhaled air and the thermal comfort of each occupant the study reach to the PV may reduce the energy consumption up to 51% following the natural ventilation. Wazeri, Y., (2010) concluded that the use of interior courtyards has been one of the useful solutions that have been adopted in ancient Nubian Architecture, especially evident in the Tushki village. The study proved that a square plan wind tower should not exceed a height of 6 metres in cases, wherein it is used for a building of 3 metres height. Moreover, the study revealed that the use of rectangular shape is better than the cubic shape; and its height does not exceed 1 metre over the water level, specifically when the water flow is 10 litres/min. (Araújo de, 2018) measured the thermal comfort in space by 2x2 in air temperature, relative humidity, wind speed, and solar radiation and computer by the research results. The surface/ volume ratio is very important in conserving heat transfer in and out of a building. To conserve heat or cold the building must be designed with a compact form in order to reduce the efficiency of the building as a heat exchanger. Specifically, buildings can have very different perimeters and area ratios depending on their plan form. For example, an important ration in eco-building is the Surface Volume Ratio (SVR), which refers to the ratio of the exterior surface to the enclosed volume of the building and it should necessarily be controlled. The main objective in calculating the SVR is to minimize the area of exposed surfaces in order to reduce heat gain. This can be achieved through multi-story buildings and by raising the roof height (Fajal, 2002).

Alwakil, Sh. (1989) discussed the building form as one of the important solutions of passive solutions, particularly for the Middle East, the researcher concurs that the building form could constitute a part of the indoor environment or a part of the environmental design process like other principles. Correspondingly, the factors of water, energy, material, and site present environmental, economic and social alignment, while, the outdoor environment shows environmental and social alignment.

Fanger, P.O., (1970) used heat balance equations and empirical studies in the context of skin temperature to define the comfort parameter, developed the Predicted Mean Vote index (PMV) model. The standard thermal comfort surveys ask subjects about their thermal sensation on a seven-point scale from cold (-3) to hot (+3). Correspondingly, Fanger's equations are used to calculate the Predicted Mean Vote (PMV) (Fanger, 1970). (Jaramillo, A. 2012) discussed the sound level in classes should not exceed 60 Db.

Noise levels in schools

- Noise level at proposed school façade 60 dB

Minimum distances between educational buildings and transportation noise sources: It is considered best practice to locate schools 328 ft (100 m) from any busy road or railway line; however, it is anticipated that achieving these

that acoustics in the classroom can impact on student memory retention and concentration levels. The research shows that the acoustic environment can alter performance in mathematics, problem-solving, reading ability, language skills, and impact on literacy levels

Acoustic Panels

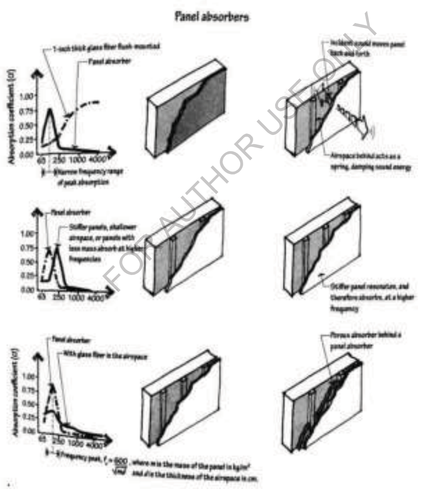

Figure 1. A good absorber, blow through it under moderate pressure. Absorption effectiveness is a function of thickness, fibre orientation, density, and porosity (Ermann, M. 2005), copyright @(Ermann, M. 2005)

Definition of the frequency

- *The Frequency is a study sound is produced by the repeated back and forth movement of an object at regular intervals. The time interval over which the motion recurs is called the period (Jaramillo, A. 2012)*

  Or

- *the rate at which something occurs over a particular period of time or in a given sample.* (Long, M. 2014)

3. The Methodology

3.1 Firstly: The Use of Sound Meter and the Thermometer

The methodology of the research is based on using monitor devices; *sound level smart meter*, *temperature and humidity measurement smart meter* with data analysis by using Excel computer program. Its quantitative research based on monitoring by smart meter

Using the Sound level meter(or SPL) is shows decibel values by measure the environmental noise, displays measured dB values in various forms. You can experience tidy graphic design with high frame by this smart sound meter

Figure 2. The sound level meter, used to measure the sound level in the studio class (SOUQ.com, 2020)

consumption; High stability & accuracy . Display temperature, humidity and time simultaneously; Memory of MAX & MIN measuring value; 12 hours / 24 hours displaying system selectable; /°F unit selectable; Clock &Calendar function (month and date) Desk-top placing or Wall

Figure 3. The thermometer used in measuring the temperature and Humidity in Studio class (SOUQ.COM, 2020)

3.2 Secondly: Distribution Survey

Distribution survey to the students in the studio classes to have their response to the temperature, humidity and sound level.

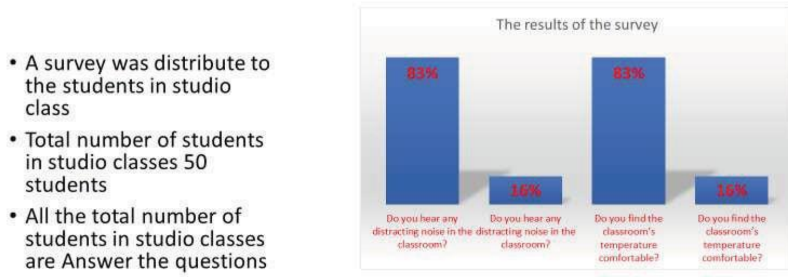

Figure 4. The result of the survey:83 % they hear disturbance noise in the classes

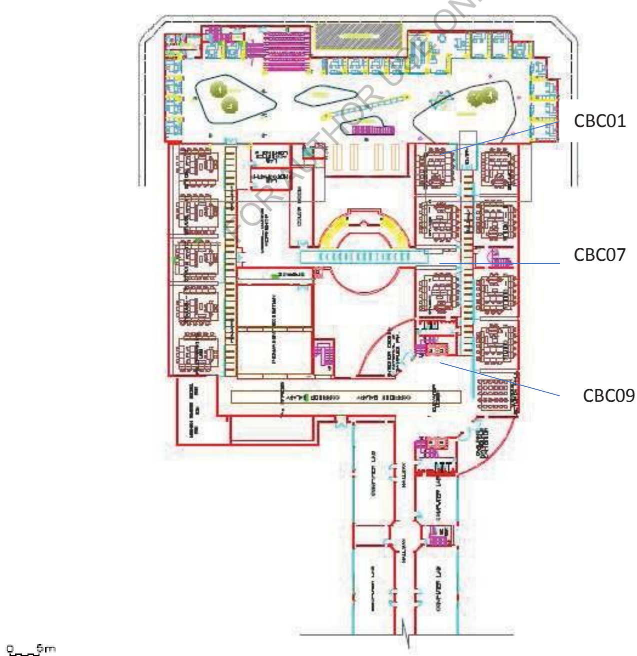

Figure 5. The location of the case study, Female section, Copyright@DAU

4. Findings

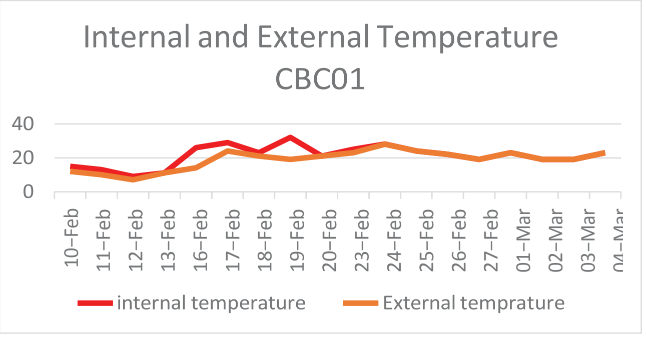

Figure 6. The average result of the internal 21 C°, The Average result of the External 18 C°

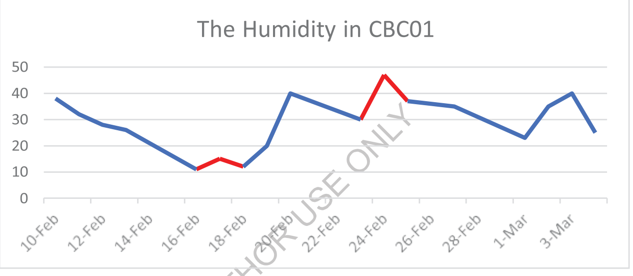

Figure 7. The Max Humidity 45%, Min Humidity is 15%

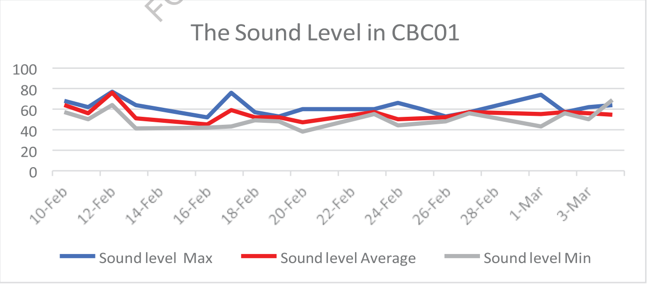

Figure 8. Max Sound Level 62 dB, Average 55 dB, Min 50 dB

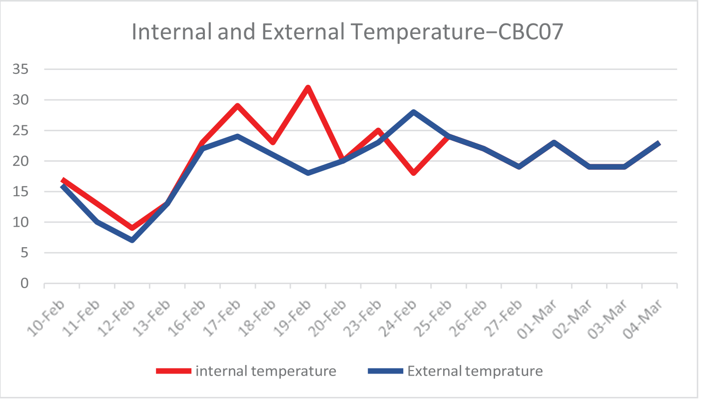

Figure 9. The average result of the internal 21 C°, The Average result of the External 20 C

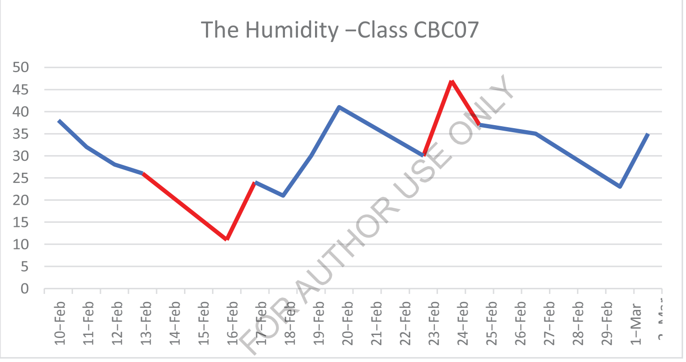

Figure 10. The Max Humidity 47 %, Min Humidity is 12%

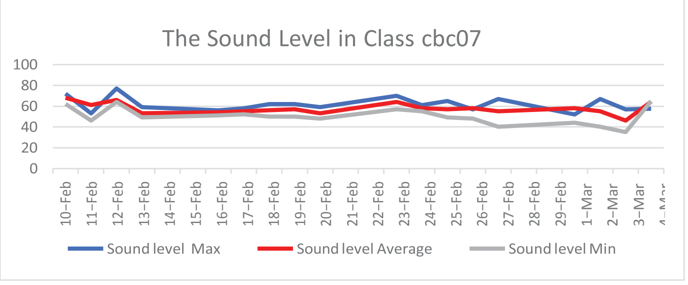

Figure 11. Max Sound Level, 62 Db. Average 58 dB, Min 50 dB

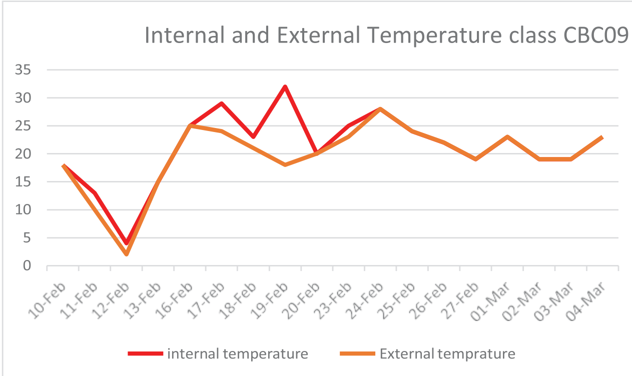

Figure 12. The average result of the internal 21 C°, The Average result of the External 20 C°

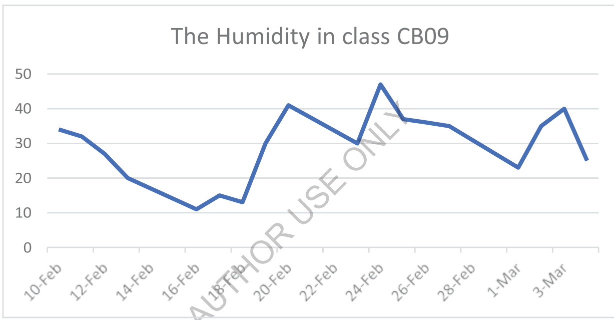

Figure 13. The Max Humidity 47 %. Min Humidity is 12 %

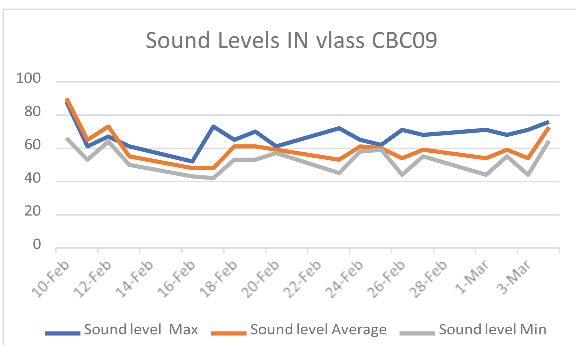

Figure 14. Max Sound Level 68 db. Average 60 dB, Min 63 dB

5. Discussion

The location is at the college of architecture engineering, architecture department. The measurements were done every day ate midday in the three classrooms CBC01, CBC02 and CBC09 this time is the peak time for these studio classes.

The results of sound level measured by sound meter (Figure 2) for class CBC01 is 55 dB which exceed the limit of sound for classroom announced by The Environmental Agency (EPA). In addition, the result of sound level measured for studio class CBC07 is 58 dB which is also exceed the limit 35 dB announced by EPA. In addition to that the measurements of sound level of class CBC09 is 60 dB, which is double 35 dB the limit announced by EPA.

The below table 2 shows the higher measurement of sound level is record for studio classroom CG09

Which is 68 dB at 12.00 pm to 13.00 pm which is the peak time for students at their break time and this studio classroom is facing the main hall. In addition, the lower measurement shows in Table 2 is measured for class CBC01 which is 60 dB which still far a way from the limit 35 dB by EPA.

The research results show the percentage of humidity and temperature are normal specially there is HVAC system in each class that the student could adjust the temperature in summer and winter.

Table 1. The sound level by United State Environmental Protection Agency (EPA)

The activity in the eternal spaces	The recommended Noise level (dB)
Seminar room	35-30
Faculty members room	40-35
Studio classes	30-35

Table 2. Shows the average results of the temperature and humidity and the sound level, (EPA, 2017)

The measurements	CBC01	CBC07	CBC09	The Average	Conclusion
Internal Temperature	21 C°	21 C°	21 C°	21 C°	Within the limit
External Temperature	18 C°	20 C°	20 C°	19.3 C°	Within the limit
Max Humidity	45 %	47%	47%	46.30 %	Within the limit
Min Humidity	15 %	12% Level	12%	13.00 %	Within the limit
Max Sound Level	62 dB	62 dB	68 dB	64.00 dB	
Average Sound	55 dB	58 dB	60 dB	57.66	

d
B

CBC09 Exceed the Limit of Sound
>35

Class Cbc01 the sound level withinthe limit < 35

Min Level	Sound	50 dB	50 dB	63 dB	54.00 dB	Class Cbc01 the sound level within the limit < 35

6. Recommendations

-The research recommends using of insulation materials in the wall panel between the two classes

-In addition, the research recommends closing the opening high-level window between the two classes.

-As well as the research recommends using of curtains for all the classes

-Change the doors into wooden door instead of glass materials.

-Using of solid walls portion's instead of lightweight partitions.

-The research recommends regular maintenance of Heating Ventilating Air Conditioning System.

-The researcher agreed to use control system in heating and cooling the class to control the temperature and the humidity in summer and winter.

-The researcher suggested to the false ceiling in 1m. depth for the HVAC system to avoid the vibration.

-The research recommends using carpet on the floor to minimize the noise.

-The research recommends using the monitoring system and measuring the sound level in 3D machine lab and in the main hall.

Acknowledgement

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Research Paper

SAFETY PROCEDURE AT UNIVERSITIES

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SAFETY PROCEDURE AT UNIVERSITIES

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Abstract

Architecture dewing should include in the design drawings, civil drawings, working drawing, electrical drawing, drainage system, current light drawings and fire alarm system and safety procedures drawings. All the word followed up the disaster happened in London when one apartment building was burnt, and 30 people was died. On 16 July 2017.So thinking in fire alarm system and safety procedure should be one of the most important responsibility of architects and engineers.

The aim of this paper is to learn the architecture student about the safety procedures at Dar Al Uloom University, in Riyadh city, KSA. Through the course environmental control to students in level four.

The method of the research is design check list to check the main requirements for the safety procedures at the university.

The results show that Dar Al Uloom University is Appling a very Good Fire Alarm plan the system

The research highlights the water sprinkler should be applied in all spaces, possible call to Fire Bridge should be available in all floors and the research outcomes that the sign of (not use the left) should be near to the lift and clear.

Key words: safety procedures at universities, fire alarm system main requirement's, Dar Al Uloom University safety plan

1. Introduction:

Safety procedures are coming crucial in the last decades, educational buildings are one of the most places should be designed with standards in spatial, lighting, sound, materials and in applying safety procedures. In this study the total number of the student are 19 students, were divided into four groups, each group is responsible about one floor. Basement, ground, first, second, and third floor. The students made survey at the university

2. Literature review

2.1 **Definition of fire alarm system**: "*An automatic fire alarm system is designed to detect the unwanted presence of fire by monitoring environmental changes associated with combustion. a fire alarm system is classified as either: automatically actuated, manually actuated, or both. Automatic fire alarm systems".*

2.2 Design: By using building code locally and internationally. (Distributor, 2017)

2.3 UK standards

There are many types of fire alarm systems each suited to different building types.
The categories of fire alarm systems are:

Table 1: UK standard for fire alarm system

The symbol	Explanation
M (manual system)	Manual systems, like hand bells, gongs, These may be purely manual or manual electric.
P1 (protect building)	The system is installed throughout the building - the objective being to call the fire brigade as early as possible to ensure that any damage caused by fire is minimized.
P2(protect building)	Category P2 systems provide fire detection in specified parts of the building where there is either high risk
L2 (protect life)	A category L2 system designed for the protection of life rooms adjoining escape routes and high hazard rooms.

Source: (BSI, 2002).

2.4 Occupancy Classifications

Potter Electric Signal Company, LLC (2011) stated that "*Each building is given a occupancy classification as defined by the NFPA 101 Life Safety Code. This Code states the fire alarm and sprinkler requirements for each building type in "Chapter 9.6: Fire Detention, Alarm, and Communications Systems." Some buildings fall into multiple occupancy classifications"*

2.5 Maintenance

(Goh, 2005) discussed the maintenance of fire alarm system and this include regular testing and inspection, false alarm management and common maintenance problems troubleshooting.

This system is used at Dar Al Uloom University:

1. The false alarm is set up regularly each semester
2. Manual book is published to explain all the fire alarm system to the staff at Dar Al Uloom University.(DAU, 2017)
3. Regular lectures were introduced by Fire System Institute at Riyadh city to DAU staff.

3. The Method

The method is based on designing a checklist with the symbols of fire alarm system and apply for the fourth floor in the university. Then analyses the data and get the percentage of achievements.

4. The Results

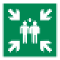
Table 2: shows the results of applying the checklist

FIRE ALARM SYSTEM	DESCRIBE	BASEMENT	GROUND FLOOR	FIRST FLOOR	SECOND FLOOR	THIRD FLOOR	NOTES
	Fire alarm (break glass)			•	•		In each corner in the main libby
	Fire extinguisher and fire hose reel			•	•		In each corridor
	Route to exit			•	•		In the main corridors
	track emergency exit signs			•	•		In the main corridor near staircase
	report to the person in charge of the assembly point			•	•		Did not Located in the write place

	leave the building by the nearest available exit				•	•	
	If possible call the fire brgade 4949000 or 9888	○	○	○	○		Not applicab le
	raise the alarm	•	•	•	•	•	
	do not use lifts	•	•	•	•		Not place at write place
	do not stop to collect personal belonging			○	○	➢	Not applicab le
	Smoke detector	•	•	•	•	•	
	Water sprinkler	•	•	○	○		Not applicab le in first floor

Table 3: shows the results by percentage of achievement

FIRE ALAR M SYSTE M	DESCRIBE	BASE MENT	GROU ND FLOO R	FIRST FLOOR	SECON D FLOOR	THIRD FLOOR	NOTES
	Fire alarm (break glass)	100%	100%	100%	100%	100%	In each corner in the main library
	Fire extinguisher and fire hose reel	100%	100%	100%	100%	100%	In each corridor

	Route to exit	100%	100%	100%	100%	100%	In the main corridors
	track emergency exit signs	100%	100%	100%	100%	100%	In the main corridor near staircase
	report to the person in charge of the assembly point	100%	100%	100%	100%		Did not Located in the write place
	leave the building by the nearest available exit	100%	100%	100%	100%	100%	Applied near staircases
	If possible call the fire brgade 4949000 or 9888	0%		0%	0%	0%	Not applicable
	raise the alarm	100%	100%	100%	100%	100%	Applied at corridors
	do not use lifts	80%	80%	80%	80%	80%	Not place at write place
	do not stop to collect personal belonging	0%		0 0%	0%	0%	Not applicable
	Smoke detector	100%		0 100%	100%	100%	Applied in all floors and offices, classes
	Water sprinkler	100%		1 0%	0%	0%	Applied in offices

5. *The Discussion*

Figure 1: shows the fire alarm plan, at Dar Al Uloom University, Basement plan, college of Architecture

5.1 The Basement

The result and analysis of the main file alarm system plan in the basement floor show that The Fire alarm (break glass)is revealed score of 100 % so its applicable in this floor, Fire extinguisher and fire hose reel received a score of 100%, Route to exit achieved a score 100%, track emergency exit signs revealed a score of 100%, report to the person in charge of the assembly point reach a score of 100%, leave the building by the nearest available exit received a score of 100%. If possible call the fire brigade 4949000 or 9888 disclosed a score 0%. Raise the alarm reached the score of 100%, do not use lifts

Achieved a score 80% because it placed in different and far place, do not stop to collect personal belonging (0%) because it is not applicable, Smoke detector (100%) because it is applicable in all spaces, Water sprinkler (100%).

Figure 1. Show the fire alarm plan at Dar Al Uloom University, Ground floor plan

5.2 The Ground Floor

The result and analysis of the main file alarm system plan in the basement floor show that The Fire alarm (break glass)is revealed score of 100 % so its applicable in this floor, Fire extinguisher and fire hose reel received a score of 100%, Route to exit achieved a score 100%, track emergency exit signs revealed a score of 100%, report to the person in charge of the assembly point reach a score of 100%, leave the building by the nearest available exit received a score of 100%. If possible, call the fire brigade 4949000 or 9888 disclosed a score 0%. raise the alarm reached the score of 100%, do not use lifts achieved a score 80% because it placed in different and far place, do not stop to collect personal belonging (0%) because it is not applicable, Smoke detector (100%) because it is applicable in all spaces, Water sprinkler (100%).

Figure 2. Shows the Fire alarm plan, at Dar Al Uloom University, First , second and third floor plan

5.3 Typical Floor, First, second and the third

The result and analysis of the main file alarm system plan in the basement floor show that The Fire alarm (break glass)is revealed score of 100 % so its applicable in this floor, Fire extinguisher and fire hose reel received a score of 100%, Route to exit achieved a score 100%, track emergency exit signs revealed a score of 100%, report to the person in charge of the assembly point reach a score of 100%, leave the building by the nearest available exit received a score of 100%. If possible, call the fire brigade 4949000 or 9888 disclosed a score 0%. raise the alarm reached the score of 100%, do not use lifts achieved a score 80% because it placed in different and far place, do not stop to collect personal belonging (0%) because it is not applicable, Smoke detector (100%) because it is applicable in all spaces, Water sprinkler (0%).

6. Conclusion

6.1 Dar Al Uloom University is Appling a very Good Fire Alarm plan the system contains
Fire alarm (break glass)is revealed score of 100 % so its applicable in this floor, Fire extinguisher and fire hose reel received a score of 100%, Route to exit achieved a score 100%, track emergency

exit signs revealed a score of 100%, report to the person in charge of the assembly point reach a score of 100%, leave the building by the nearest available exit received a score of 100%. If possible, call the fire brigade 4949000 or 9888 disclosed a score 0%. raise the alarm reached the score of 100%, do not use lifts achieved a score 80% because it placed in different and far place, do not stop to collect personal belonging (0%) because it is not applicable, Smoke detector (100%) because it is applicable in all spaces, Water sprinkler (50%).

6.2 The research highlights the water sprinkler should be applied in all spaces

6.3 The research outlines that possible call to Fire Bridge should be available in all floors.

6.4 The research outcomes that the sign of not use the left should be near to the lift and clear

7. Acknowledgement

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3) DAU, 2017, Fire Alarm System Manual, Dar Al Uloom University, Riyadh, KSA.

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Research paper

THE EFFECT OF BUILDING FORM TO DESIGN BUILDING SHADES WITH FOCUS ON HOT DRY CLIMATE

THE EFFECT OF BUILDING FORM TO DESIGN BUILDING SHADES WITH FOCUS ON HOT DRY CLIMATE

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Abstract

Studying of building form during the design process with the solar angle and north direction is very important, and it effect the thermal balance of the building, different forms, like L shaped form, U shaped form, linear form, cubic form, cubic form with court yard system, H form, during the day the form is provides shades, the direction and the amount of the shades can be studied and can be used in improving the outdoor environment and good managing for the landscape, and reflect this study to social impact for people.

The methodology of the research is applied research to students in level four in subject environmental control to recognize the effect of building form to building shades at different period during the day.

The aim of the study is to find proposal concept in designing building form according to the studying the effect of building shades during the day with solar angle

The research outline conclusion and recommendation to be applied in designing building form in hot dry climate

Building Forms, shades directions and amount, social impact, economic impact .Introduction:

1.1 Building service/volume ratio

We should control the building ratio of exterior surface to enclosed volume:

SVR= Surface Area / Total VolumeSFAR=Surface Area / Floor Area

Experiments showed that, this ratio range from 1: 0.16 to 1: 0.12, in a hot dry climate. The surface volume ratio (SVR) and the surface area ratio (SFAR) should be as low as ossible to minimize the radiation on the building. This can be achieved through multi - story buildings and rising the roof height (Fajal, 2002) .

1.2 Building orientation

Szokolay stated that orientation in relation to solar gain would have strong effect. The north and south walls should be longer than the east west walls. The ratio will be 1.3 to 2.0 depend on solar amount wanted study. Szokolay, S.(2008)

1.3 Use of internal courtyard system: the use of internal courtyard practice-if designed properly- can retain a portion of the cool night air in its cool condition during daylight hours Fig. (2.27), shows the thermal performance of a large house with a courtyard. Large courtyards provide good ventilation especially, when they are open to another courtyard or street, so that cross ventilation is promoted. On the other hand, small courtyards provide more protection against hot, dusty winds in hot-arid regions. Some courtyards contain fountains and trees to promote evaporative cooling and provide shade. Courtyards moderate the climatic extremes in many ways:

- **(I)** The cool air of the summer night should be kept undisturbed for many hours by hot and dusty wind, provided that the surrounding walls are tall, and the yard is wide.
- **(II)** The rooms draw daylight and cool air from the courtyard this enhances ventilation and filters dust.
- **(III)** It provides privacy to the family and keeps their activities and noise away from neighbors'.
- **(IV)** The courtyard with its gentle microclimate provides a comfortable outdoor space. (Gallo, 1998)3

As well as; (Littlefair, 2006) discussed the issue of courtyard system and said that in summary, in hot climates a well-designed courtyard improved solar control, reduces heat transfer through the walls and glazing and could be used to provide natural ventilation cooling taking advantage of the cool air of the courtyards. In addition to that (Wazeri, 2010) concluded on his study on "Applications on environmental design" that the use of interior courtyard has been one of the useful solutions that are adopted in ancient Nubian Architecture especially, in Tushki village. The study approved that the best ratio for the courtyard is (1, 40:2, 00:1) and that the use of rectangular shape is better than the cubic shape. The same topic 'courtyard system has been discussed by (Santamouris, 2006) and stated that courtyard system is used to provide the building with natural light and ventilation as well as reduce energy use. (Lau, 2014)7 discussed the environmental performance of traditional courtyard house in China and said that it has a good performance in providing natural lighting, natural cooling, and visual delight and comforts no need for using air conditioning system. (Canan, 2014) said that balconies and terraces have replaced the courtyard on current housing they are mostly smaller than the traditional courtyards on the other hand courtyard system provides better control to the microenvironment, water elements which provided moisture and evaporate cooling effect in courtyard .

In relation to this, the high walls of buildings provide shade in the courtyard during daylighthours; another important source of shade is the vegetation has and especially trees that help cool air inside courtyard by evaporation, as well as using of trees to protect buildings from dust and wind. It also provides cool shadows and relative comfort for people. So, the internal courtyard temperature, if well structured, is a common system in many cases, in most of the Arab states. Fig (1) shows the thermal performance of a courtyard inside small and large buildings.

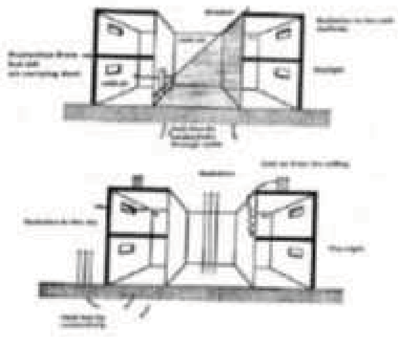


Figure 1: The system of cooling towerSource: (Hassan, 2000)[9] P.161

2. The cooling tower:

(Gallo, 1998) Discussed the traditional cooling tower construction in Qatar is shown in Fig. (2. 28). The cooling tower consists mainly of two parts, the catching device and the tower. It opens into either upstairs or downstairs rooms and was stopped about two meters above the level of the floor. The tower is subdivided by brick partitions to contain several shafts. The wind tower in Qatar is built in an X-shaped design, form, opened at the four sides to catch the breeze from all direction. The operation of the wind tower depends on wind conditions and the time of the day.

1. Cooling tower:

The cooling tower acted as a chimney when there is no wind.
Night operation: The tower wall, which absorbs heat during the daytime, transfers it to the cool night ambient air. The heated air is then exhausted through the tower openings. The chimney action of the tower maintains the circulation of ambient air throughout the building and hence cools the structure of the building, including the tower itself; when wind blows at night, the air circulation acts in reverse to the action described above and the walls and rooms become cool.

Day operation: when there is no wind blowing during the day, the tower plays the role of operates the reverse of a chimney. The hot outside air in contact with the cold walls of the tower (cooled from previous night) is cooled and sucked down through the tower's passages. When the wind blows, both the air circulation and the rate of cooling increases, and thus, cooler air is devoured to further position inside the building and the performance of the cooling tower become effective. Beside its geometrical form (height, cross sectional plan, tower orientation and location of its outlets), by the climatic conditions, it is very effective in dry arid regions. In such regions, the diurnal variation is high and night air temperature islow.

2. Using the desert air condition concept, which works by blowing air with a fan to pass through straw dowsed with water into the building inside, and the generated cool air causes the inside of the building to be cool. This method is used in areas with warm dry climate, as well as compact climate. Hassan op. Cit.

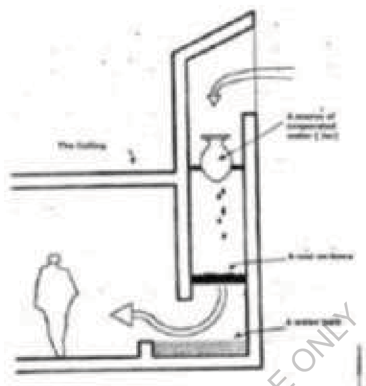


Figure 2.The system of cooling tower Source: (Hassan,2000) P.161

(Roaf, 2001)10 discussed the building form in several cases such as: building as an analogy, the Icehouse, the tea cozy cottage, the green house , the nomadic tents, and the igloo.

Figure 2.8 shows that different plan forms can have wall area for the same plan area.

1.3 The important of studying the building form

i) Building location: whether the building is located on a top of mountain or a flat land, cold areas or wet or hot dry climate each location requires specific form.

(ii) Building orientation: we should orient the building perpendicular to the directionof the wind. In Greater Khartoum, the wind in summer comes from the South and Southeast and in winter, it comes from North and north-West; these two directions should always be considered when orienting our buildings.

(iii) The climate: whether the building is located in a hot climate or cold climate zone.

(iv) Sun movement: it is very important to study the sun movement in a specific location to choose the building form and shape, the form in order to secure more shades to the buildings and minimize the solar radiation.

(v) The heat exchanger: The greater the volume of the building the more surface area it has to lose or gain heat.

2. Objectives:

Studying of the building form according to certain issues will provide the building by more shades, and this will cool down the air surrounding to the building. No need to turn on the air condition all day long if we manage the building passive design and solutions. We have different buildings forms, cubic form, linear form, L -shaped form, and U- shaped form, circular forms. There are many factors that forces and ordering us to choose form one than the others.

1. To manage the building thermal performance; through studding the building form; as one of the most important elements of the passive solutions
2. To have economic impact; when people spent part of their time in the outdoor environment, we can minimize the AC and HVAC electrical and lighting pill amount.
3. To have social impact, by improving the outdoor environment by providing shades and landscape, we can incur rage people to spent, part of their time in outdoor environment, sitting, reading, exercising, celebrating, in Sudan sleeping in good summer day night in outdoor environment is important in some areas.

3. Methodology:

3.1 **The** methodology is applied research with students in Architecturedepartment, Dar Al Aloom University, course environmental control. Distribute different building forms like, L shaped form, U shape form, linear form, cubic form, H shape form

3.2 Ask the students to study one form shades during the day, and noticethe shade direction and amount at three different times
At 8:00 am, At 12:00 PM and AT 4:00 PM

3.3 Analytical method by using Google sketch up computer program, the program giving the ability to identify the time, draw 3D mass, studying of building shades during the day in specific time.

3.4 Method of presentation is Table and Figures showing the buildingshades during the day

3.5 Discussion the results of each studying building form and giving adaptive solutions, and finding out the research outlines

4. Result/Findings:

1. U shape form provides long shades to courtyard to the north direction, at 8:00 am , short shades around the building at 12:00 pm, long shades to East directionafternoon at 4:00 pm
2. L shape form for provides long shades to north-west direction at the morning, short shades at mid-day and long shades to northeast direction afternoon.

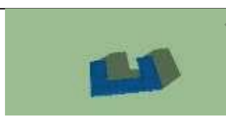
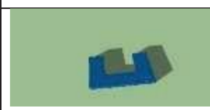
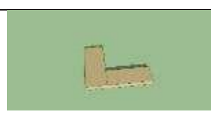
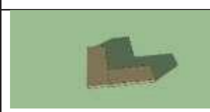
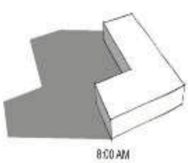
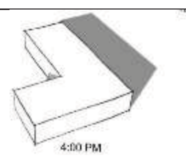
3. H shape form, provide long shades cover all the north courtyard at the morning, and these shades minimized at mid-day, and long shade afternoon to north and north-east direction
4. Cubic sorm is provides shades to north-west direction at the morning, this shade is minimized at the mid-day around the building and changed to northeast afternoon.
5. Linear form provides long shades along the building at north direction at the morning, short shades along the building at mid-day, and long shades to north- east direction.
6. Students must study the building form and its shades with solar angle in different times during the day and choose the best solution suitable to local climate.

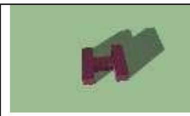
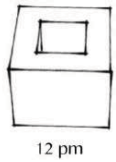
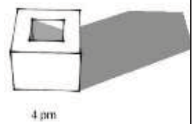
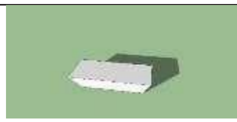
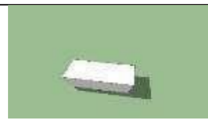
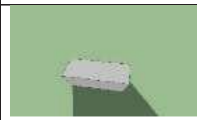
5. Discussion:

Discussion of the results of building form analyses:-

Table.1

Building form and the shades during the day

The form	At 8:00 am	At 12:00 pm	At 4:00 pm
U form			
L-shape			
L-shape			

H – Form			
Cubic form With courtyard			
Linear form			

Source: Applied research by the students in level four , Dar AL Uloom University, SaudiArabia, Riyadh city, Supervisor, Hind Abdel Moneim

The discussion consists of two parts

1. Discussion of the results in table 1 for all studied forms

2. Provide adaptive solutions to solve the problem of less shade.

The study is part of the passive solutions suitable to hot dry climate, one of these elements is controlling building envelop in its three components, the roof, the wall and floor, then controlling the physical components in the indoor environment like humidity, temperature, lighting, acoustic, emission's and building materials. The most important element that affect the building thermal performance is building form.

This study is focusing in building form as one of the architecture element that effect the building passive solutions.

The forms distributed to the students of Architecture college at Dar Al Uloom University, environmental control course, each student should study one building form. by computer programme "Google Sketch up" , studying the building form at 3 period of time. Identified by the teacher: 8 am, 12 pm and 4 pm. Then discussed the result at the class as a group work.

1. U shape form provides long shades to courtyard to the north direction, at 8:00 am , short shades around the building at 12:00 pm, long shades to East directionafternoon at 4:00 pm. See Table.1 we can use the shaded courtyard for swimming pool, sitting, meeting with family all day, because the shades are there from 8:00 am to 4:00 pm.
2. L shape form for provides long shades to north-west direction at the morning, short shades at mid-day and long shades to northeast direction afternoon.
   At the morning the shades is to north-west direction, at 12:00 pm the shades is minimum and on the afternoon at 4.00 pm the shades is at northeast direction We can use the both sides north-west direction at the morning as sitting area,and northeast direction at afternoon for sitting and celebration at night.
3. H shape form, provide long shades cover all the north courtyard at the morning, and these shades minimized at mid-day, and long shade afternoon to north and north-east direction, we can use the north courtyard during the day and afternoon.
4. Cubic form is providing shades to north-west direction at the morning, this shadeis minimized at the mid-day around the building and changed to northeast afternoon. We can use the both sides north-south direction at the morning for sitting, and northeast direction afternoon for celebration and meeting with family.
5. Linear form provides long shades along the building at north direction at the morning, short shades along the building at mid-day, and long shades to north- east direction.
6. This study gives the students good imagination for the relation between the building shades and the movement of the solar angle during the day
7. Incur rage the students to use the computer programs to study their building forms on the primary design concept.
8. Choose the form with large shades during the day, from this study I can see U shaped form and H form are the best solutions coming on the first and suitable tohot dry climate because they provide shades during the day, then L shape form and cubic form comes on the second because they provide shades to north-west at the morning, ant to north-east in the afternoon. Linear form is providing shadesall the north side at the morning, and to south in the afternoon.

Adaptive model:

Improvement of shades to east and west direction

1. In the east west direction, we can provide shades by vertical sunscreen
2. In the south, north direction we can provides shades by using horizontal sunscreen.
3. In nort-east or southwest orientation, we can use multi sunscreen vertical andhorizontal sunscreen.
4. We can use the structure element like slabs and cantilever and balconies to provideshades to nort and south direction
5. We can use columns to extend outside elevations and provide shades in east andwest.
6. Using of domes and vaults on the roof give more shadow on theses architectureelement and minimize solar radiation on the roof (Alwakil, SH. 1989).

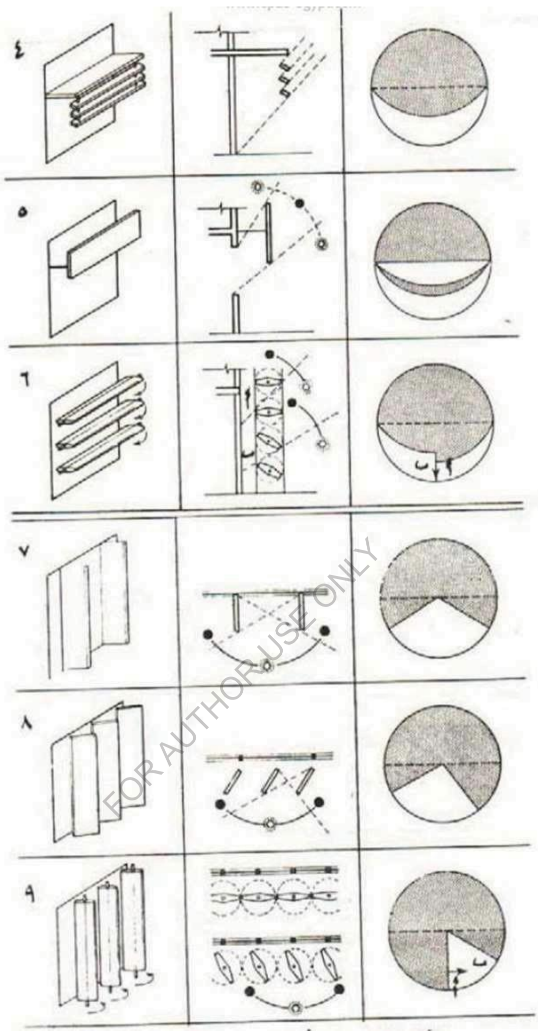


Figure .3 Virtical sunscreen used in nort and south direction, virtical sunscreen used ineast and west direction to provides shades .

Source: Alwakil, SH.(1989)[11].

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