

The role of building technology to reach an architectural design that is compatible with the local environment

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Abstract

Building technology is one of the important factors that affect the environment and nature as it attempts to find special determinants with the framework of the environment surrounding the human being, which defines, establishes and evaluates the relationship between architecture and the natural environment and the human being. The interaction between man and the natural environment through building techniques is one of the most important elements of human civilization. Emphasis is placed on the importance of preserving the environment and the lives of human societies on the ground, by using means of addressing negative phenomena and how to develop them.

The main aim of this study is to identify the different building materials that are environmentally compatible and the extent of the interaction of these materials with the environment in an integrated way. To obtain that most areas of the Arab world are dominated by a desert climate that is characterized by drought and urbanization there requires appropriate ingredients and characteristics. Therefore, many public and private agencies concerned with the construction and urban affairs and sector in the Arab regions have begun to adopt urban properties and include them within the conditions and standards required in desert projects.

The research problem focuses on inconsistency and compatibility between building materials used in architecture and the surrounding environmental and climatic conditions, which is a real crisis and one of its most important elements is lacking creative values and neglect of the functional aspects. How can we take advantage of traditional materials in a modern way and how to provide solutions that start from the environment to preserve them and achieving self-sustaining sustainability, despite the availability of many compatible building technologies that are suitable for the local environment in the Arab world and many urban and architectural **vocabulary**, which are not applied and included as part of the laws and regulations.

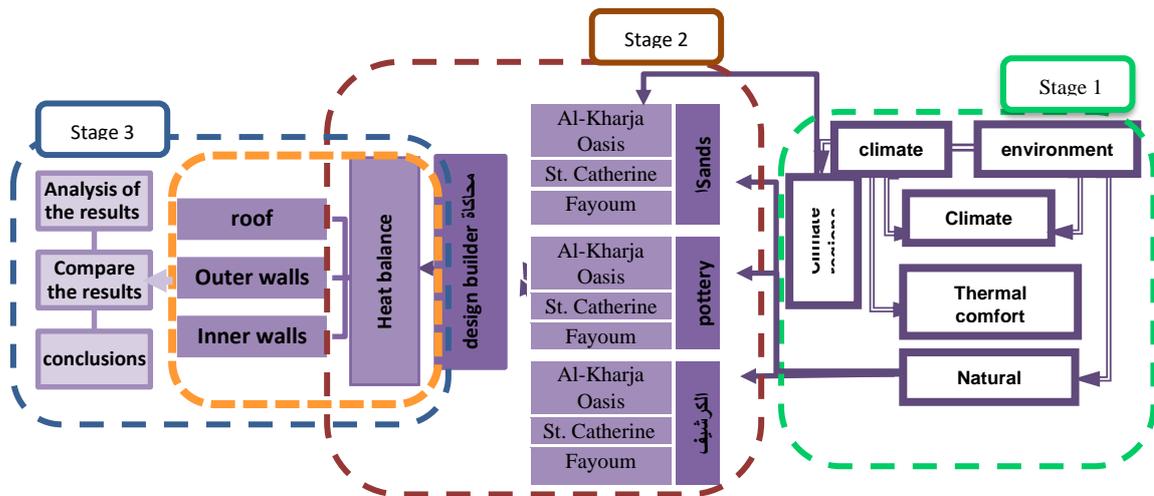
The purpose of this study is to focus on the importance of the role of local building materials and sustainable urban development in the desert environment, and to identify

mechanisms that define compatible building technologies that are most appropriate for each region included within specific urban regulations and laws within a balanced framework, providing a method that starts from the presence of building materials available in each region. It allows for effective, sustainable development and helps in achieving environmental balance in desert regions. Generally, it aims to try to conform to the natural data and climatic factors and adapt to its hot dry climate and try to reach some criteria for building technologies (building materials) that are environmentally compatible.

The main objectives of research can be summarized as follows:

1. To create a building that achieves thermal comfort and stability and remains compatible with the outer atmosphere of climate change
2. To access to an environmentally compatible architecture that achieves sustainability with natural resources in the desert.
3. To attempt to reach criteria for designing environmentally friendly buildings in hot dry areas.
4. To know, examine and analyse the natural materials available in Egypt and how to make optimal use of them in a sustainable environmental design.

Method



Introduction

One of the most important questions that are asked is "What are the elements that achieve sustainability and thermal comfort in the areas of hot dry climate? How to make use of natural building materials to achieve the best results for the building?" The concept of the environment and its types will be identified, then we address the climate and the elements that produce climatic regions. It was clarified to which climatic region Egypt belongs to and how it was classified into climatic regions.

The research included knowing the extent of thermal comfort related to climate design, so that the thermal balance that a person requires in a space is to be achieved in order to feel comfortable while he is inside the space throughout the year.

In the end, building materials were defined, and their types in terms of how they exist and examples thereof, and the importance of using local sales materials to build with them, and they underlined the importance of examples that were already erected and attracted attention and considered as environmentally friendly buildings.

Definition of the environment

The word “environment” in the Arabic language refers to the buildingal (Bawa), from which the previous verb (baa) was taken, and it is mentioned in dictionaries that are concerned with the verb (Tabawa), the first: reforming the place and preparing it for the dwelling in it, and the second: the meaning of staying and living. In the Holy Qur'an, God say (and give you habitations)¹

It is the whole or part of the planet which is considered a vital medium that contains living creatures, water, air and inanimate objects. In other words, it is the ocean that includes everything that God Almighty created. This ocean with everything it contains operates according to a divine system and universal and ideological laws that last all the lifetime.

- In the dictionary of the environment it is the physical, chemical and biological milieu that surrounds an organism.
- The environment is defined in (Webster Al-Wajeez) dictionary as the climate structure, soil effect, biological factors affecting wildlife in the communities of living organisms and ultimately determining its forms and survival after the demise of life.²

In a broader sense, the term 'environment' is not used to describe the physical environment of people only, but also social as culture, language, traditions and political systems.

In general, the environment can be defined as (the environment surrounding a person, which includes all the material and non-material aspects, human and non-human, and this means that the environment means what is outside the human being, as it includes the assets surrounding it, air, water, land and everything surrounded by living or inanimate objects, which are the elements of the environment in which he lives, and which are considered the framework in which a person practices his life and his various activities.³

From the perspective of architects, the environment is the ultimate image of the visible environment perceived at a specific place and time. It is characterized by its own natural and homogeneous features, and is linked between the elements of the place and other natural factors that are man-made affecting the place, and that occurs after a continuous interaction, and achieving compatibility between nature and man-made for the place².

Types of the environment

The environment at Stockholm conference was divided into three types:

- 1- Natural Environment: It consists of four closely related systems: atmosphere, hydrosphere, land, biosphere.

2- Ecological Environment: it includes the "individual" human being, his family and his community, as well as living organisms in the biosphere.

3- Social environment: means the group of relationships that link a person with others, and these relationships are those that organize groups and the patterns of those relationships constitute what are known as social systems and a civilized environment⁴



The climate

Climate definitions

Climate is generally defined as the characteristics of a particular region or region in terms of temperatures, droughts, winds, lighting, sun brightness, cloud accumulation and fog, as well as all elements that can be measured or monitored.

Where the climate is divided into: ⁵

1- Marco climate: the climatic conditions recorded by the weather stations of a region in a country.

2 - Micro climate: it is the climatic conditions that pertain to a small urban settlement (city or village), or even a small site around the building.

3- Indoor climate: It is the climate concerned with the interior of the building, and differs from the climate outside the building.

Climate elements

They are all phenomena that can be measured or monitored, in addition to some phenomena that can be estimated or described as the weather when a sandstorm or thunderstorm occurs.

1. The sun (solar radiation)
2. Air temperature
3. Moisture
4. The wind
5. Rain
6. Sometimes (lightning strikes - earthquakes - dust storms ...) are factors that affect the climate.⁶

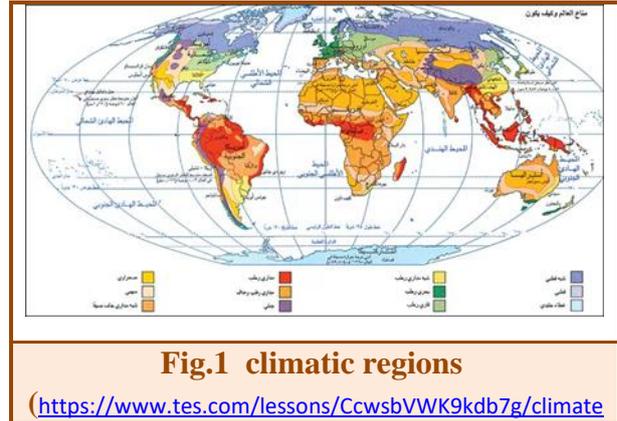
Climatic regions

The climate region is known as the part that is characterized by general climate characteristics and features that are distinct from other neighboring regions, and in which the weather conditions are similar. ⁷

Sections of climatic regions

Basic climatic zones have been determined that depend largely on latitude and how close they are to the oceans and apply to areas near the sea level. These areas are ⁶:

- 1- The hot region with dry and wet regions.
- 2- The Mediterranean climate region.
- 3- The region with a moderate climate.
- 4- Cold climate region (Arctic climate).

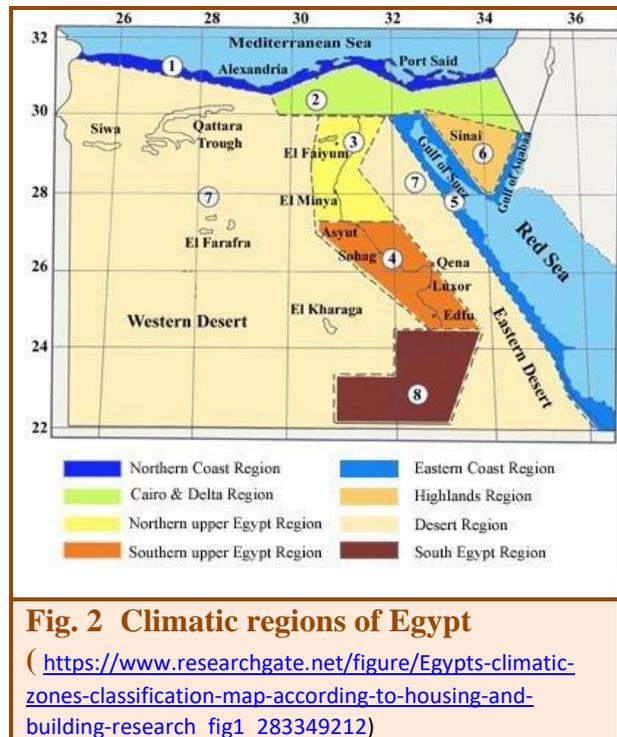


Climatic regions of Egypt

According to the climate classification of the Housing and Building Research Center (HBRC), Egypt is divided into eight climatic regions, as shown in Figure ⁷:

1. North Coast area.
2. Cairo and Delta region.
3. North Upper Egypt region.
4. Southern Upper Egypt region.
5. East Coast region.
6. The highlands region .
7. The desert region.
8. South Egypt region.

This classification depends on the temperature, humidity, wind speed, rain, solar radiation, latitude and various terrain for Egypt.



Thermal comfort

Achieving comfort is one of the primary functions of a building, and comfort refers to the resistance to the main negative elements to the climate of the surrounding area of the building, where the building has the ability to purify or absorb and expel the climatic factors according to its harm or benefit in the comfort of the occupant or the user.

Human comfort cannot be measured in terms of functional (physiological) factors only. One of the main requirements for this comfort is to maintain the thermal balance between the body and its environment, ensuring that the internal body temperature is preserved within a specified range regardless of the external environmental factors.

Thermal comfort concept

The feeling of well-being and comfort differs from person to person and is not necessarily the same at all times. There are many variables that affect the sense of comfort, and therefore it is not possible to give a specific and explicit definition of comfort, as there are several definitions, including:

-American Society of Heating (ASHRAE) definition is "a state of mind in which a person expresses his or her satisfaction with the thermal environment" (ASHRAE, 2001) ⁸

- Fanger (1967) defines thermal comfort as "a state of thermal neutrality, which is the situation in which a person prefers that the surrounding environment be at the same temperature and cold as that in which he exists and we interpret it as that environment that one cannot judge by being cold or hot, i.e. it represents a state of equilibrium Thermal in the absence of any feeling of discomfort".

-Hensen - (1991) defines comfort as "a situation in which there are no strong impulses that drive the correction of the environment by adopting a specific behavior".

Accordingly, thermal comfort can be defined as the state of mind that leads to a person's sense of contentment. This satisfaction occurs only in the case of thermal balance between the body and the surrounding environment without the need to sweat in summer and shiver in winter ⁹.

Climate design

Climate design is defined as an aspect of the internal environment design process that is concerned with providing climatic conditions that bring comfort to people at the lowest possible cost, and this definition is limited to the main goal of climate design.¹⁰

As the climatic design depends on the typical or usual weather conditions, it is usually relatively easy for a designer to obtain the necessary climatic information for any region through the various published data. Contrary to the regional climate data, information about a site's own climate is not usually readily available and is often obtained through personal observations and local experiences. ¹¹

Climate design linked to thermal comfort

The first thing related to thermal comfort is the climate design, where it is supposed to maintain the stability of the internal body temperature, and that requires reaching a temperature appropriate to the environment surrounding the human being, and it is possible to define the basic determinants of the architectural space to achieve human comfort. Here are some of the basic determinants to be met:

- 1- Achieving thermal comfort (treatment of heat flow and treatment of moisture levels within the architectural vacuum air)
- 2- Providing psychological and security comfort (providing a safe, secure vacuum that achieves the emotional connection between man and the vacuum)
- 3- Achieving audiovisual comfort (color treatment, natural interior lighting and noise treatment)

4- Providing comfort in the ease of internal exploitation of the architectural vacuum (the functional success of the vacuum) ¹²

Climate design must achieve 70% of the previous determinants, as climate design is related to ventilation, lighting, humidity, energy saving and harmony with the surrounding environment and the protection from sand and cold storms, thunder, rain and noise, and it has to do with the surrounding landscape in order to work as a natural insulator of noise to achieve human comfort ¹³.

Heat balance

Tests were conducted on the value of the heat balance of the most important elements of the building (roofs - exterior walls - interior walls), and heat balance means that it is the state in which the body temperature becomes constant and the amount of heat energy expelled by it to the surrounding (lost) medium is equal to the amount of heat that it draws from it. Any material exchanges thermal energy with the surrounding medium where it is taken (acquired) and given (lost) at the same time. ¹⁴

If the heat energy lost is greater than the heat energy gained, the temperature of the material decreases, and if the amount of heat energy lost is less than the amount of heat energy gained, the temperature of the material increases. When the amount of heat gained becomes equal to the amount of heat lost, the temperature of the substance is established and kept, that is, it is in a state of thermal equilibrium.

Building materials

Building materials are all items used in construction. Humans used different types of materials during different eras to build buildings, streets, and different establishments. Throughout the ages, different types of building materials differed in terms of the nature of their presence as they were divided into ¹⁵:

1. Natural building materials: which are used as they are without treatment, such as stone, clay, reeds and plant types. They are collected and built directly with them, and they are the oldest types.
2. Treated natural building materials: bricks and wood, before starting construction they should be treated a little bit like making blocks and cutting trees.
3. Manufactured building materials: Like bricks, concrete, and steel, the natural materials go through a manufacturing stage before being used for construction.
4. Industrial building materials: glass and plastics

In the current era, most organizations tend to use local natural materials for construction, as they are distinguished by their availability, low cost, and benefit from local labor. The impact of environmental factors cannot be neglected, as they affect the durability and behavior of materials and thus affect the building. In other words, each region has its own materials that cannot be used in another region, where climatic characteristics can affect the materials and cause damage and a harmful impact on building materials. The materials used should be appropriate in the design, detail and nature of climatic conditions. ¹⁶

Some famous examples of buildings that have been completely built with local natural building materials from the surrounding environment:

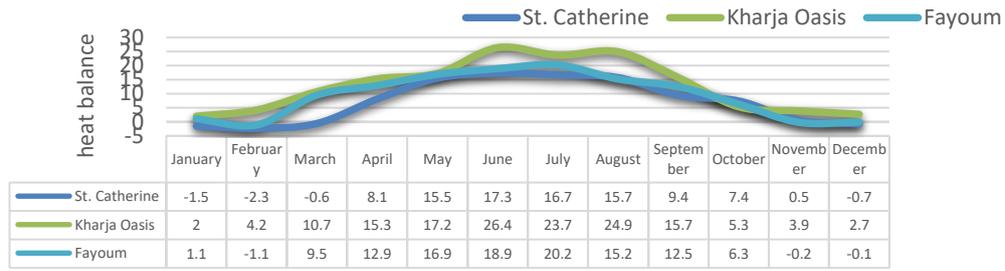
| Table 1: Examples of buildings with natural materials | | |
|---|---|--|
| Papenshal Hotel ¹⁷ | | |
| Egypt, Siwa | The Papenshal traditional hotel is the most important initiative for sustainable development in Siwa, to decrease poverty and protect cultural and natural buildings. This initiative focuses on housing, traditional hand-made arts, organic agriculture and renewable energy. |  Fig.3 /4 Papenshal Hotel(https://www.booking.com/hotel/eg/albabenshal.html). |
| Al-Karchive, tapped soil, woods | | |
| 1996 | | |
| Honey House ¹⁸ | | |
| Kiffmeyer, Moab, UT, USA | It was built with available, appropriate local building materials to the house environment. Dust bags method is the most widely used for being cheape and provide jobs for the local manual labor. |  Fig. 5/6 Honey House (https://okokokproductions.com/okcontent/uploads/2016/11/Honey-House-Mud-Roof.jpg) |
| Tapped soil. Straw, clay | | |
| 1998 | | |
| Dancing Ground of the Sun ¹⁹ | | |
| New Zealand | Structure was built with recycled wood. Hand-made bricks from local soil were used in building. Floors are a compressed layer from stone chips with a sand and clay mix, a plastic wall to stop absorbing moisture. |  Fig. 7/8 Dancing Ground of the Sun (https://www.theresasjoquist.com/wpcontent/uploads/2015/04/Brown-Ecohouse-450x250.jpg) |
| Wood, stones, bricks | | |
| 2005 | | |

The sand

Sandbags are made mostly of burlap, or polypropylene or other materials, and are filled with sand or dirt, and the first use of it was to make fortified walls against the enemy or for control, and sometimes it is a protective element for military buildings or gatherings of soldiers and barracks.²⁰ Burlap and sand are inexpensive, available, and easy to find. Therefore, with some technology and architectural development, it was used to build entire houses.

| U-value (W/m ² -K) 1.007 | |
|--|---|
| Roof layers | Wall layers |
| <ul style="list-style-type: none"> External paint layer = 4 cm Sandbag layer= 15 cm Inner white layer= 2 cm | <ul style="list-style-type: none"> an outer white layer = 2 cm cement fiber = 2 cm A layer of sandbags = 30 cm cement fiber = 2 cm * Inner white layer = 2 c |

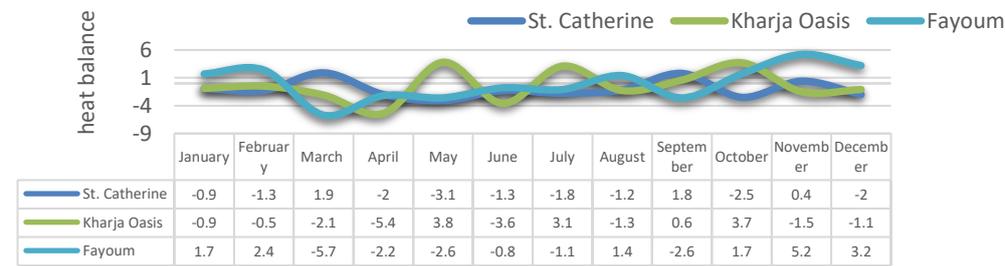
Roofs



-Al-Kharja area is the highest and is affected by acquiring temperature about 27. All the months the roofs gain an amount of temperature different from month to month.

-St. Catherine area gains the least In temperature. In winter, it loses temperature.

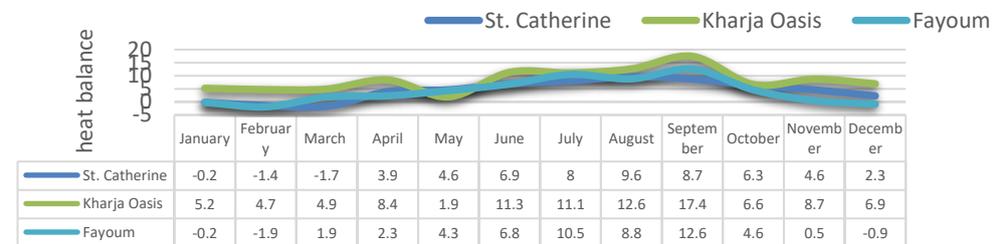
Inner walls



-The value curve for Al-Kharja shows variance and difference between acquiring and losing temperature all the year round.

-The values for Fayoum and St. Catherine are similar the most value is losing temperature. But in summer months they gain temperature

Outer walls



-Values rise in summer months and the highest values are for Al-Kharja area followed by Fayoum and the least are for St. Catherine.

Pottery

Pottery is the material resulting from burning clay, and clay is considered the main material used in making pottery. The use of the pottery unit as construction in the building is considered an element of suitability of this unit for the climate in hot dry areas, as it is porous and there is air used for insulation and it takes a large time to transfer heat from outside to inside, and the general external pattern of the pottery buildings appears as an organic, compact and organic construction where its image appears to be carved in nature.²¹

U-value (W/m2-K)= 2.055

| Wall layers | Roof layers |
|--|--|
| <ul style="list-style-type: none"> Outer white= 2 cm Pottery layer= 30 cm Inner white= 2 cm | <ul style="list-style-type: none"> *outer white= 2 cm *pottery layer= 30 cm * inner white= 2 cm |

| Roofs | <table border="1"> <thead> <tr> <th></th> <th>January</th> <th>February</th> <th>March</th> <th>April</th> <th>May</th> <th>June</th> <th>July</th> <th>August</th> <th>September</th> <th>October</th> <th>November</th> <th>December</th> </tr> </thead> <tbody> <tr> <td>Kharja Oasis</td> <td>3.3</td> <td>8.3</td> <td>11.8</td> <td>23.9</td> <td>16.7</td> <td>28.1</td> <td>20.3</td> <td>25.5</td> <td>16.2</td> <td>4.1</td> <td>4.9</td> <td>2.4</td> </tr> <tr> <td>St. Catherine</td> <td>-0.5</td> <td>-2.5</td> <td>-0.8</td> <td>9.3</td> <td>16.9</td> <td>18.2</td> <td>17.6</td> <td>16.3</td> <td>9.3</td> <td>8.1</td> <td>2.6</td> <td>1.7</td> </tr> <tr> <td>Fayoum</td> <td>-0.8</td> <td>3.8</td> <td>13.5</td> <td>15.2</td> <td>21.9</td> <td>18.6</td> <td>19.7</td> <td>14</td> <td>15.5</td> <td>5</td> <td>2.6</td> <td>-1.6</td> </tr> </tbody> </table> | | January | February | March | April | May | June | July | August | September | October | November | December | Kharja Oasis | 3.3 | 8.3 | 11.8 | 23.9 | 16.7 | 28.1 | 20.3 | 25.5 | 16.2 | 4.1 | 4.9 | 2.4 | St. Catherine | -0.5 | -2.5 | -0.8 | 9.3 | 16.9 | 18.2 | 17.6 | 16.3 | 9.3 | 8.1 | 2.6 | 1.7 | Fayoum | -0.8 | 3.8 | 13.5 | 15.2 | 21.9 | 18.6 | 19.7 | 14 | 15.5 | 5 | 2.6 | -1.6 |
|---|---|---------|----------|----------|-------|-------|------|------|--------|-----------|-----------|----------|----------|----------|--------------|------|------|------|------|------|------|------|------|------|------|-----|------|---------------|------|------|------|------|------|------|------|------|-----|------|-----|------|--------|------|-----|------|------|------|------|------|------|------|-----|-----|------|
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| Kharja Oasis | 3.3 | 8.3 | 11.8 | 23.9 | 16.7 | 28.1 | 20.3 | 25.5 | 16.2 | 4.1 | 4.9 | 2.4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| St. Catherine | -0.5 | -2.5 | -0.8 | 9.3 | 16.9 | 18.2 | 17.6 | 16.3 | 9.3 | 8.1 | 2.6 | 1.7 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Fayoum | -0.8 | 3.8 | 13.5 | 15.2 | 21.9 | 18.6 | 19.7 | 14 | 15.5 | 5 | 2.6 | -1.6 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| | | January | February | March | April | May | June | July | August | September | October | November | December | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Kharja Oasis | -0.8 | -1.1 | -1.4 | -4.7 | 3.3 | -2.5 | 2.4 | -0.7 | -0.4 | 3.8 | 1.9 | -1.9 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| St. Catherine | 0.7 | 1.2 | 1.4 | -1.4 | -2.1 | -1.3 | -0.9 | -0.8 | 1.2 | -1.1 | 0.2 | -0.2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Fayoum | 0.8 | 1.4 | -4.1 | -1.9 | -1.5 | -0.1 | -1 | 0.8 | -2.5 | 1.5 | 3.4 | 1.7 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| Outer walls | <table border="1"> <thead> <tr> <th></th> <th>January</th> <th>February</th> <th>March</th> <th>April</th> <th>May</th> <th>June</th> <th>July</th> <th>August</th> <th>September</th> <th>October</th> <th>November</th> <th>December</th> </tr> </thead> <tbody> <tr> <td>Kharja Oasis</td> <td>4.7</td> <td>3.6</td> <td>1.7</td> <td>2.6</td> <td>3.4</td> <td>7.3</td> <td>12.7</td> <td>10.4</td> <td>17.6</td> <td>11.2</td> <td>7.3</td> <td>5.2</td> </tr> <tr> <td>St. Catherine</td> <td>1.7</td> <td>-0.3</td> <td>-0.7</td> <td>0.6</td> <td>0.4</td> <td>5</td> <td>5.7</td> <td>7.7</td> <td>9.6</td> <td>3.2</td> <td>4.5</td> <td>2.2</td> </tr> <tr> <td>Fayoum</td> <td>2.8</td> <td>0.5</td> <td>-1.3</td> <td>1.3</td> <td>2.34</td> <td>6.17</td> <td>10.4</td> <td>11.1</td> <td>11.7</td> <td>7.3</td> <td>6.6</td> <td>4.7</td> </tr> </tbody> </table> | | January | February | March | April | May | June | July | August | September | October | November | December | Kharja Oasis | 4.7 | 3.6 | 1.7 | 2.6 | 3.4 | 7.3 | 12.7 | 10.4 | 17.6 | 11.2 | 7.3 | 5.2 | St. Catherine | 1.7 | -0.3 | -0.7 | 0.6 | 0.4 | 5 | 5.7 | 7.7 | 9.6 | 3.2 | 4.5 | 2.2 | Fayoum | 2.8 | 0.5 | -1.3 | 1.3 | 2.34 | 6.17 | 10.4 | 11.1 | 11.7 | 7.3 | 6.6 | 4.7 |
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| Kharja Oasis | 4.7 | 3.6 | 1.7 | 2.6 | 3.4 | 7.3 | 12.7 | 10.4 | 17.6 | 11.2 | 7.3 | 5.2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| St. Catherine | 1.7 | -0.3 | -0.7 | 0.6 | 0.4 | 5 | 5.7 | 7.7 | 9.6 | 3.2 | 4.5 | 2.2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Fayoum | 2.8 | 0.5 | -1.3 | 1.3 | 2.34 | 6.17 | 10.4 | 11.1 | 11.7 | 7.3 | 6.6 | 4.7 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <ul style="list-style-type: none"> -Al-Kharja area is the highest to have positive values, this means hat walls help acquire temperature from outside. -Fayoum area comes second, and in all months it gains temperature. St. Catherine is the least area in acquiring temperature. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Alkarshif

It is a layer of salt stones found in the soil near the semi-saltlake areas, or the salts that formed a burning salt layer thousands of years ago. ²²

U-value (W/m²-K)= 2.055

Wall layers

- Outer white= 2 cm
- Alkarshif layer= 25 cm
- Inner white= 2 cm

Roof layers

- Outer paint layer= 4 cm
- Alkarshif layer= 25 cm
- Wool blog layer= 2.5 cm
- Inner white layer= 2 cm

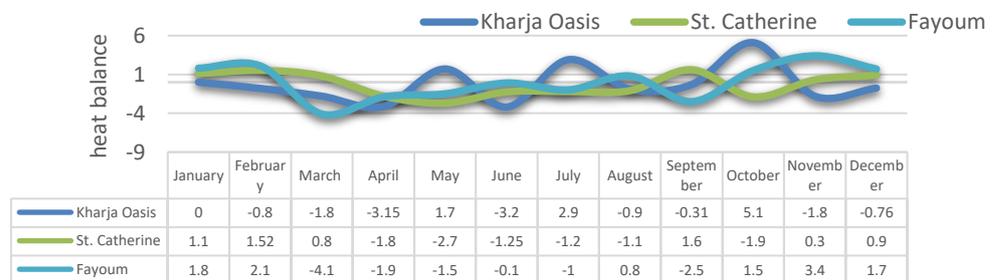
Roofs



-The graph shows that Al-Kharja and Fayoum areas see clear variance in acquiring and losing values for temperature in summer.

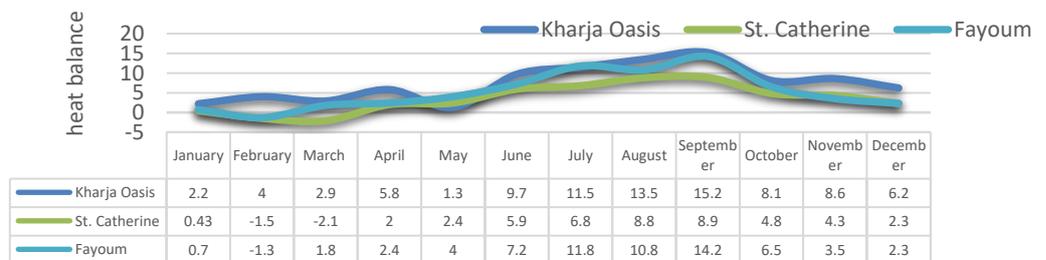
-St. Catherine area is the least in acquiring temperature and values rise and drop equally.

Inner walls



-In this case, values vary in three areas in acquiring and losing temperature all the year round, and the greatest variance is in Al-Kharja area.

Outer walls



-High values appear from June to October, and there is little variance in values, and in winter the difference levels drop.

Results

- Pottery material is high in heat transfer and has a value of 2.055 W / m²-K, followed by sandbags W / m²-K 1.007 and the territory of Kharshif, which is 391 (W / m²-K).

In the city of St. Catherine:

- As for the roof, which is the element exposed to direct sunlight, use sand and scrap materials to build the roof because they are less heat acquiring and loss than clay.
- When looking at the values of thermal balance of the outer walls, which are considered an element exposed to the sun in a wide way, the values differ, so we notice that Kharshif is the least to gain heat in summer, the most lost heat and the least lost heat in winter compared to sand and pottery.
- For internal walls, there is no clear difference between the amount of acquisition and loss in relation to materials, where the amount of loss (Kharshif -2.7 / sand -2.5 / pottery -2.1) and in relation to the amount of acquisition (Kharshif 1.5 / sand 1.9 / pottery 1.4)
- When comparing the values, we note that the best material used in St. Catherine is Kharshif, followed by sand, and the last is pottery.

Fayoum City:

- The values are considered for the materials when used in the roof. There is no noticeable variation in it. The values range from the 20.2 gain to -1.6 loss.
- When looking at the values of the thermal balance of the external walls, we notice a clear difference between the values of the sand and the crepe and the clay materials, the thermal gain value of the clay material is 10.7 and the ones that follow the clay material 12.6 and the last of them is Karshif 14.2
- With regard to the internal walls, there is no clear difference between the amount of acquisition and loss with respect to pottery and curved materials ranging from 3.4 / -4.1, but the amount of sand ranges between 5.2 and -5.6
- When comparing the values, we note that the pottery material gives the best evaluation of the acquisition and heat loss in the city of Fayoum

- Kharja Oasis

- We note that the pottery material values (18.2 / -2.5) have a clear difference between sand and karshif materials (26.4 / 2 - 27.4 / 1.2) which are considered to be the same values and do not give any values for thermal loss.
- Looking at the thermal equilibrium values for the outer walls, we find that they do not give values for three of the test materials, and we notice that karshif is the least of them to gain heat (15.2 / 1.3), sand (17.9 / 1.9) and pottery (17.6 / 1.7)

- o While the interior wall values show clear dispersion and discrepancy, sand material is (3.7 / -5.4), pottery material (1.4 / -2.1) and karshif material (2.9 / -3.4)
- o When comparing the values, we note that the sand substance gives the most values that have a negative effect on the thermal balance, and the preference in choosing ranges between two materials: karshif and pottery.

Recommendations

- Spreading the intellectual and architectural awareness of the importance of the environment and environmental design to produce environmentally friendly and compatibly buildings.
- The importance of knowing the climate and its specifications for the building site before starting the design process of a building.
- Knowing how to adapt to the hot dry climate, how to design environmentally friendly buildings, so that they take into account the adaptation of the hot dry climate and adapt to it.
- All architects and designers should know how to calculate thermal comfort and how to achieve thermal balance appropriate to each space throughout the year.
- Taking into account the structural comfort of the building design.
- Attention to using local natural materials for construction.
- Determining the natural materials available in each capable region.
- Reliance on local resources such as mud and wood and the exploitation of plant elements in the environment.
- Paying attention to local architecture and its development, and avoiding the closed box architecture.
- Conducting more theoretical and applied studies on architectural formation on ceilings and facades in hot dry climate because of its very influential role in reducing thermal load.
- Moving towards requiring the applicant to build with a study that explains the sustainability of handling building materials and considers them part of the licensing requirements.
- Conducting more theoretical and applied studies of the impact of environmental and climatic factors on buildings.
- Study the concepts of environmentally friendly design that contribute to overcoming these climatic factors.

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