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ASSESSMENT OF THE ENVIRONMENTAL IMPACT OF BUILDING ENVELOP IN EGYPTIAN OASIS VILLAGES "USING DESIGN BUILDER SIMULATION PROGRAM"

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ABSTRACT

Due to the privacy of the five Egyptian oases (Dakhla, Kharga, Farafra, Bahariya, and Siwa Oasis) because of its distance from urban communities in the Nile Valley, so it has preserved much of its cultural and architectural heritage for decades, which is evident in building materials and openings patterns used in small rural villages, which represent The smallest urban nucleus, and the focus of governorate attention in its currently development projects, but there are some openings patterns and new building materials that are extraneous to this environment, so the research aims to assess the environmental impact of traditional and contemporary building materials and openings patterns used in these villages, due to their great impact as a "building envelop" on the thermal comfort, energy saving and healthy environment inside the building. The research adopts the comparative analytical method, to compare between the behavior of traditional and contemporary building materials and openings patterns in these villages, through field survey for 55 houses in 11 villages in the oasis, and analyze it using the "Design Builder" program to evaluate the environmental impact, to come up with specific design recommendations and determinants for suitable wall material, thickness and opening criteria to achieve the best possible building environmental performance, and to find out what this great architectural heritage can offer us using modern technologies and simulation programs.

KEYWORDS: Egyptian Oasis, Design Builder Simulation Model, Building Envelop.

تقييم الأثر البيئي للغلاف الخارجي للمبنى بقرى الواحات المصرية من خلال محاكاة باستخدام برنامج "Design Builder"

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الملخص

نظرا لما تتمتع به الواحات المصرية الخمس (الداخلة والخارجة والفرافرة والواحات البحرية وواحة سيوة) من خصوصية بحكم بعدها عن الحضر في وادي النيل، لذا فقد احتفظت بالكثير من موروثها الحضاري والمعماري لعقود طويلة والذي يظهر جليا في أنماط ومواد البناء المستخدمة في القرى الريفية الصغيرة والتي تمثل النواة العمرانية الأصغر، ومحور اهتمام للدولة حاليا في مشاريعها للتطوير، إلا أن هناك بعض أنماط الفتحات ومواد البناء المستحدثة الدخيلة على هذه البيئة، لذا يهدف البحث لتقييم الأثر البيئي لأنماط الفتحات ومواد البناء التراثية والمستحدثة المستخدمة بهذه القرى، حيث تشكل الغلاف الخارجي للمبنى، ويتبع البحث المنهج التحليلي المقارن، حيث يقوم بمقارنة خصائص مواد البناء المستخدمة في هذه القرى سواء كانت تراثية، محلية، مستحدثة، وأنماط الفتحات المستخدمة، ومن خلال مسح ميداني لعدد (55) منزل في (11) قرية ريفية بالواحات، وباستخدام برنامج "Design Builder" يقوم بتحليل وتقييم الأثر البيئي لها كغلاف خارجي للمبنى، ونظرا لتأثيرها البالغ على الراحة الحرارية وتوفير الطاقة وتوفير بيئة صحية داخل المبنى، للخروج بتوصيات ومحددات تصميمية محددة لاستخدام المواد والحلول التراثية أو المعاصرة لتحقيق أفضل أداء بيئي ممكن للمبنى، وللوقوف على ما يمكن أن يقدمه لنا هذا الموروث المعماري الضخم باستخدام

التقنيات وبرامج المحاكاة الحديثة.
الكلمات المفتاحية : الواحات المصرية، نموذج محاكاة باستخدام الحاسب، المواد والفتحات، غلاف المبنى.

INTRODUCTION

Many architectural studies dealt with the Egyptian oases, focused on it as Heritage sites at risk [1], and the vernacular models in the ancient villages and urban communities of the oases, which have mostly become part of the past -as a residential community - with the great around urban development in recent decades, especially in the great neighborhoods, districts, and towns. These studies have dealt with many aspects such as urban planning, urban design, architectural, environmental, social, and so on [2, 3].

However, part of this architectural heritage remains in some of the remote rural communities, such as opening, the use of building materials and traditional local building methods, until now with some minor influences by using contemporary common building materials from outside the oases, such as concrete, cement and clay brick. So, this research will address these points.

Due to the large urban expansion in these oases, because of population growth and the migration of farmers from the Nile Valley to these oases and their need to establish new urban communities and to achieve the optimum performance of building and its sustainable criteria such as achieving thermal comfort, energy saving, healthy environment, good ventilation and lighting, orientation of the building, and the possibility of using solar cells to generate energy, and the use of rational systems for water consumption in the building, and other sustainable criteria. Oasis habitants use mixed building construction styles and materials between oases environment, and some are alien to it from their mother environments, so the need arose for the necessity Evaluating the environmental impact of it,Therefore, this paper will focus on the assessment of the environmental impact of two specified aspects on the building envelop:

- The local and alien (imported) used building materials.
- Traditional and contemporary opening patterns (shape - proportions - orientation) of openings.

Which represent the building envelop and because of the great impact of these two aspects on the thermal comfort level in the building spaces, and thus the provision of energy, which is one of the basic governmental needs, especially in these remote areas, where the local authorities in these small communities depend mainly on generators to supply electricity, and recently it use of solar photovoltaic cells on a small scale due to its relatively high cost for this society segment.

Therefore, the research aims to: To assess the environmental impact of opening patterns, traditional and contemporary building materials in the oases, using the "Design Builder" program to come up with specific design recommendations and determinants to achieve the optimum possible building performance of lighting, ventilation, thermal comfort, and energy consumption.

The research follows the comparative analysis method, to compare between the behavior of traditional and contemporary openings patterns and building materials in these villages using the "Design Builder" program to analyze and evaluate the environmental impact, to come up with specific design recommendations and determinants to achieve the best possible building performance in terms of lighting, ventilation, thermal comfort, orientation, and energy consumption, and to find out what this huge architectural heritage can offer us using modern technologies and simulation programs.

Historical Background

The Egyptian oases community formed an isolated urban environment from the Nile valley, which enabled it to preserve its characteristics and cultural components for many decades. Its environment also provides it with many elements of survival and prosperity, and provided an economic backbone that enabled it to survive and withstand until now, represented in agricultural activity, industries dependent on it, and tourism.

The ancient Egyptians called it the Islands of Mercy, and the Romans called it Oasis, which means the end of the journey, and the ancient Egyptians used it to exile the miserable and criminals away from the valley, and as a cemetery for their bodies when they die so as not to pollute the sacred land of Nile valley, then it became a refuge for the persecuted, expelled, monks and ascetics. The papyri mention that the god Horus denied the evil god Set in (Otto) Kharga Oasis now.

There are five main oases in Egypt, **Fig. 1**, located in the Western Desert of Egypt, which has an area of about 681,000 km2 (about two-thirds of the total area of Egypt), distributed administratively over three governorates, each consisting of small cities and communities from which a group of villages of varying size, these oases are:

1. Siwa Oasis in Matrouh Governorate
2. Bahariya Oasis in Giza Governorate
3. Farafra Oasis in New Valley Governorate
4. Dakhla Oasis in New Valley Governorate
5. Kharga Oasis in New Valley Governorate

Fig. 1: Egyptian Oasis Map, [4].

Basic characteristics of the Egyptian oases

There are many important basic characteristics of Egyptian oases such as climatic, geological, social, and cultural considerations, that affect building materials choice and opening design.

1.1. Climatic charactristics

The five Egyptian oases are in the desert region (70% of Egypt area), it is one of Egypt's eight climatic regions, [5], **Fig. 2**.

It has a hot dry climate in summer, tends to be cold in winter ranging from 5°C in winter to 39°C in summer in Siwa oasis [6,7], with rare rainfall, and high solar radiation up to 2000 kWh/m2/year. There are favorable north and northwesterly winds at 6.3m/sec., so it is preferable to put the openings in the north direction. However, there are undesirable south and southwesterly hot and dusty wind "Khamasin" blowing at speeds of up to 60 km per hour in February, April, May and June, and causing the movement of sand dunes at a rate of 7 to 10 m / year, this sand is carving the building facade, so it is preferable that the external finishing materials be resistant to wear and friction, and it is preferable to raise the openings as much as possible on the ground level, and protect the southern and western openings from the dusty winds[8,9]. The following **Table 1**, shows main climate characteristics and its effects on building materials and openings.

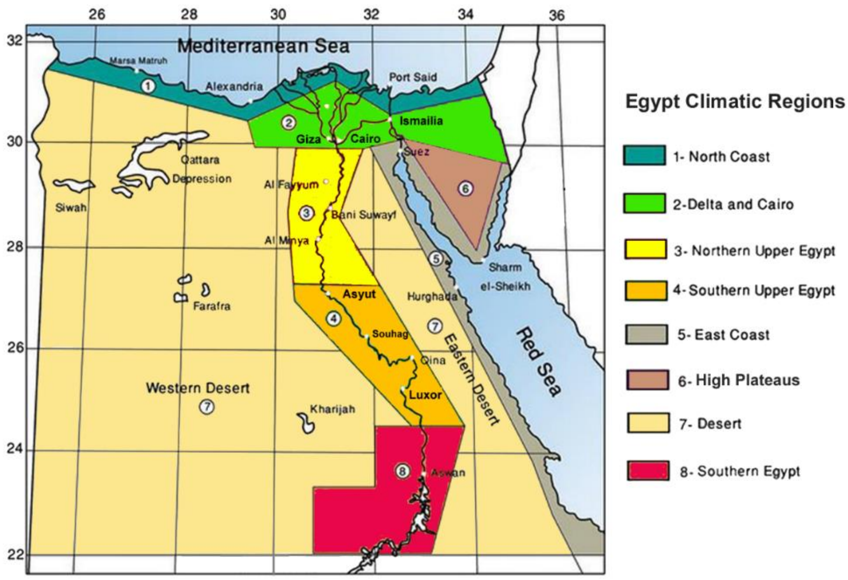


Fig. 2: Egypt Climatic Regions, [5]

Table 1: Oasis main climate characteristics and its effects on building materials and openings, Authors.

Basic Climate Characteristics		Effects on:	
		Building Materials	Openings
Temperature and Humidity	▪ hot dry climate in summer, tends to be cold in winter	▪ Thermal Insulation Needed ▪ Long thermal time lag	▪ Low conductive materials ▪ Long thermal time lag
Wind	▪ Desirable north and northwesterly winds ▪ undesirable south and southwesterly hot and dusty wind	▪ Anti wear and friction external finishing materials	▪ Opening in the northern and western elevations ▪ sheds and wind bumpers in southwest elevation ▪ Lift ground floor openings
Sunshine	▪ high solar radiation	▪ Low conductive materials ▪ Long thermal time lag	▪ Sun sheds protection
Perception	▪ Rare rains	▪ Rain protection not required	▪ Rain protection not required

1.2. Geologically

Oases are geologic depressions formed by wind erosion, and the of groundwater emergence because of the intersections of the water surface with Earth surface that reveals by the wind. The Egyptian oases are surrounded from the west and south by the Great Sand Sea, which is one of the greatest seas of sand in the world. It covers about 7,000km2.

Soils are generally formed from calcareous and sandy deposits and layers of limestone and sandstone with high salinity, it contains sulfate salts, calcium, lime carbonate, bicarbonate, and chlorine. These salts affect the salinity of water and agricultural land significantly.

Springs and wells are The main water sources in the oases, where the oases are located above the largest groundwater basin in North Africa, and the water overflows the need of the population and agricultural land, but the salinity is excessive in some springs and wells, and is divided into cold springs less than 15℃ and hot more than 20℃ in the winter season, and there is a problem of the expansion of some lakes at the cultivated area where agricultural drainage water accumulates.

1.3. Social:

The oasis population is a mixture of indigenous people and immigrant farmers from the Nile Valley, and they are conservative, the privacy is an important factor affecting on openings design, such as: small and high-up openings from ground level.

- Use opaque materials to obscure vision.
- Indirect entrance or using partition or tree in front of the door to block the view.
- high parapet for roof about 180cm or more.

Traditional and contemporary Building Materials:

Karsheef is the main cultural construction
in siwa oasis only. It is the product of soil salts flowering due to the capillary property and the evaporation of ground water consisting of calcium sulfate, sodium chloride and silicon dioxide united with each other. It has medium hardness. It also used as a mortar and still use until now , **Fig. 3**, There are also mud bricks "Adobe" which still used in Kharga and other oasis since pharaoh era, there are previous studies treat physical characteristics of mortars and karshif blocks [10], while not dealing with thermal behavior.

The traditional external wall thicknesses up to 50cm, which is sloped from the bottom up, **Fig. 7**, Roof is built from olive wood, palm trunks, topped with slices of palm leaves and then 10cm of compacted layer of clay, **Fig. 4, 7**, columns are also made of limestone and sandstone blocks, foundations are made of limestone or sandstone with a depth of 50 cm below ground level. The floor and walls of the rooms are covered with clay plaster, it consists of pure clay mixed with hay and water, fermented for months until smooth, for more waterproof and thermal insulation, lime paint around windows,with mortar of clay mixed with broken Karsheef then fermentation, Egyptian oasis preserves many of these traditional buildings in a good condition until now, **Fig. 9,10**.

There are many other alien contemporary construction materials in oasis such as reinforced concrete usually used for ceiling, cement and burned clay bricks which have more water resistance. Many villages were previously sunk due to high agricultural drainage levels, which pushed them to use these modern materials, but some of them are inappropriate to oasis environment, such as using curtain walls, **Fig. 5**.

Traditional and contemporary building materials can be summarized for building construction elements in the following **Table 2,3.**

Fig. 3: Karsheef, Authors.

Two bricks thick of mud-brick walls and ceilings of palm trunks topped with slices of palm leaves and then a layer of clay, Sharq Albalad, Kharga

Karsheef walls and palm trunks for ceiling, Shally, Siwa

Fig. 4: Traditional construction materials, Authors.

Limestone bearing walls and brick vaults in a farmhouse, Bahariya

Reinforced concrete and burned clay bricks in a new house, Khargh

Glass Curtain walls, Athena Mall, Dakhla

Fig. 5: Alien Contemporary materials in the Egyptian oasis, Authors.

Table 2: Field Survey for Contemporary used construction materials in oasis villages, Authors.

No.	Oasis	Governorate	Village Name	General Information			Construction Materials								
							Walls						Roof		
				Number of Occupants	Number of Floors	House .Approx Area (m2)	Karsheef or	Adobe	Rubble Stone	Bricks	Concrete	Others	Reinforced Concrete	Wood, Palm Trunks	Brick domes or vaults
1	Siwa	Matrouh	Tenkomamo, Almaraaqi	4	1	100				1			1		
2				9	1	110			1				1		
3				7	1	150			1				1		
4				6	1	100						1		1	
5	Siwa	Matrouh	Rahmoon, Almaraaqi	10	1	154				1			1		
6				4	1	120			1	1			1		
7	Siwa	Matrouh	Abadwiah, Almaraaqi	6	1	200				1			1		
8				6	1	110				1			1		
9	Siwa	Matrouh	Algari, Almaraaqi	8	1	110	1							1	
10				7	1	100				1			1		
11				8	1	120				1			1		
12				5	1	90			1	1			1		
13	Siwa	Matrouh	Haj Ali, Almaraaqi	9	1	130			1				1		
14				8	1	120			1				1		
15	Siwa	Matrouh	Bashandat,	7	1	90			1				1		
16	Dakhlah	Alwadi Algadid	Al-Jadidah	4	1	98				1			1		
17				5	2	100					1		1		
18				6	3	85					1		1		
19				7	3	75					1		1		
20				8	2	95					1		1		
21				7	2	85				1			1		
22				5	2	95				1			1		
23				8	2	100				1			1		
24				3	1	105				1			1		
25	Dakhlah	Alwadi Algadid	Al-Hindaw	6	2	95					1		1		
26				6	2	110					1		1		
27				5	2	120					1		1		
28				6	2	75					1		1		
29				6	4	130					1		1		
30				6	2	75				1			1		
31				7	3	150						1	1	1	
32				6	3	120					1		1		
33				5	2	110					1		1		
34	Dakhlah	Alwadi Algadid	Al-Qalamoon	2	3	95					1		1		
35				5	3	105				1			1		
36				5	3	95				1			1		
37				6	3	95					1		1		
38				9	3	120					1		1		
39				5	3	105					1		1		
40				4	2	100				1			1		
41				5	2	80					1		1		
42	Dakhlah	Alwadi Algadid	El-Rashda	7	3	115					1		1		
43				4	3	115					1		1		
44				5	2	100					1		1		
45				5	2	100				1			1		
46				3	2	120					1		1		
47				8	2	100					1		1		
48				7	2	80					1		1		
49				8	3	90					1		1		
50				8	2	100					1		1		
51	Khargah	Alwadi Algadid	Sharq Albalad	6	2	120		1							
52				5	2	100			1				1		
53				6	1	110		1						1	
54				5	2	100		1						1	
55				4	1	90				1			1		

Table 3: Common Traditional and Contemporary used construction materials in oasis, Authors.

Construction Elements	Traditional Materials	Existing Contemporary used Materials
Foundations	▪ Limestone and Sandstone with average depth 50cm	▪ Limestone and Sandstone with average depth 50cm ▪ Reinforced Concrete
Columns	▪ Limestone and Sandstone	▪ Limestone and Sandstone ▪ Reinforced Concrete
Walls	▪ Karsheef, ▪ Limestone and Sandstone (Sloped thickness up to 50cm) ▪ Wood or palm trunk lintel	▪ Karsheef, ▪ Limestone, Sandstone ▪ Cement bricks ▪ Cement Lintel
Mortar	▪ Karsheef mortar mixture ▪ Or mud mortar	▪ Karsheef mortar mixture ▪ Cement mortar mixture
Roofs	▪ Olive wood, palm trunks, leaves, and clay	▪ Reinforced Concrete, ▪ Cement Bricks and Stones (usually used as vaults or domes)
Flooring	▪ 10cm of mud mortar mixture	▪ Contemporary tiles
Plaster	▪ Pure fermented clay mixed with hay and water	▪ Cement mortar mixture
Painting	▪ Lime Painting	▪ Plastics

The Egyptian Energy code [11], determined Comfort Ranges in Egypt, Temperature (from 21.8℃ to 30℃), Humidity (from 20 to 50%), Wind Speed (from 0.5 to 1.5m/sec), the minimum thermal requirements and absorption rates of building envelop (external surface of walls and roofs) at desert region, which the five Egyptian oases belong, **Table 4,5**, The Egyptian Masonry code [12], determine the minimum sound insulation required limits for residential activities[13], **Table 6**.

Table 4: Requirements of External Building Envelop at Desert Region (for non-A/C buildings).

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Direction		External Surface Absorbing	Required Thermal Resistance	Construction elements Thermal Resistance			Required Solar Heat Gain Coefficient or Opening required Shaded Glass Ratio							
				0.4	0.6	0.8	Opening Ratio in elevations							
				Required Thermal Resistance for Thermal Insulator			O < 10%	10%→20%	20%→30%	O > 30%	O < 10%	10%→20%	20%→30%	O > 30%
							SHGC				SGR			
Ceiling		0.7	3	2.6	2.4	2.2								
walls	N	0.38	0.8	0.4	0.2	NR	NR	NR	0.7		NR	30%	40%	
		0.5	0.9	0.5	0.3	NR								
		0.7	1	0.6	0.4	0.2								
	NE/NW	0.38	0.9	0.5	0.3	NR	NR	0.7			NR	30%		
		0.5	1	0.6	0.4	0.2								
		0.7	1.1	0.7	0.5	0.3								
	E/W	0.38	1.1	0.7	0.5	0.3	NR	0.5			NR	70%		
		0.5	1.2	0.8	0.6	0.4								
		0.7	1.3	0.9	0.7	0.5								
	SE/SW	0.38	0.9	0	0.2	NR	NR	0.6			NR	50%		
		0.5	1.1	0.7	0.5	0.3								
		0.7	1.2	0.8	0.6	0.4								
	S	0.38	0.8	0.4	0.2	NR	NR	NR			NR	NR		
		0.5	0.9	0.5	0.3	NR								
		0.7	1	0.6	0.4	0.2								

NR = not required SHGC = Solar Heat Gain Coefficient SGR = Shaded Glass Ratio

Most of the cultural traditional materials verify these requirements over the past years, but there are some disadvantages such as cracks because of weakness and unaffordability of pressure and shear forces and affected by moisture especially in low places and affected by rainfall despite its scarcity. The decay of Wood and palm tree trunks with time and because of terminates.

Cement plaster on mud bricks, Kharga, Author. | Cracks in mud-brick houses in sharq albalad, Kharga | Cracks in Karsheef houses in Shalley, Siwa

Fig. 6: Disadvantages of traditional materials , Authors.

Table 5: Thermal Characteristics of most common Traditional Insulation Materials, Masonry, [14].

Material	Density (Kg/m³)	Conductivity (w/m. ◦c)
Karsheef	2185-2400	1.65-2.35
Sandstone	2000	1.3
Limestone	1650	0.93
Solid Cement brick	1800	1.025
Hollow Cement brick	1140	1.6
Solid Clay brick	1950	1.0
Hollow Clay brick	1790	0.6
Concrete	2240	0.920
Adobe (mud bricks with straw)	1700	0.35 →0.57

Note: Figures are based on several sources and include estimations and interpolations, [15].

Table 6: Required Insulation levels for residential activity.

The wall is between		Sound Insulation Level (dispel)	
Used Room	Neighbor Room	Minimum	Maximum
Bedroom	Other rooms in the house	32	47
Other rooms	Other rooms in neighbor house	51	54

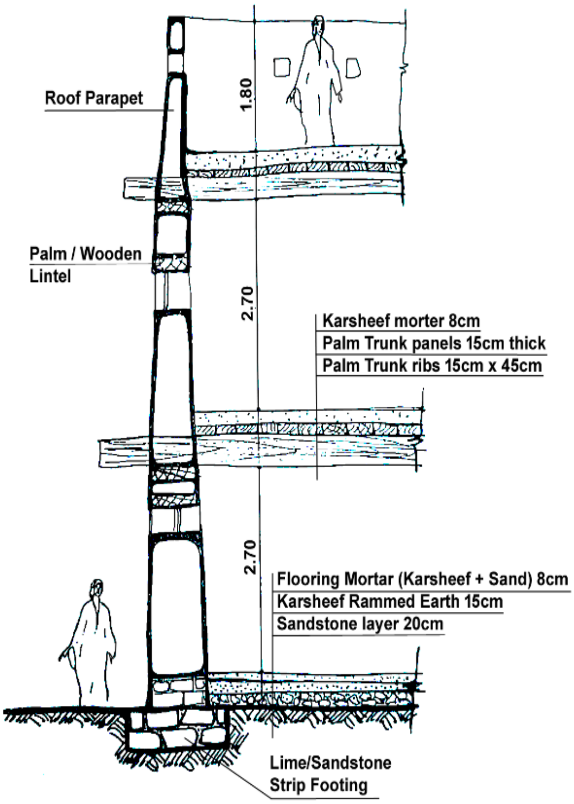


Fig. 7: Cross Section in Traditional House.

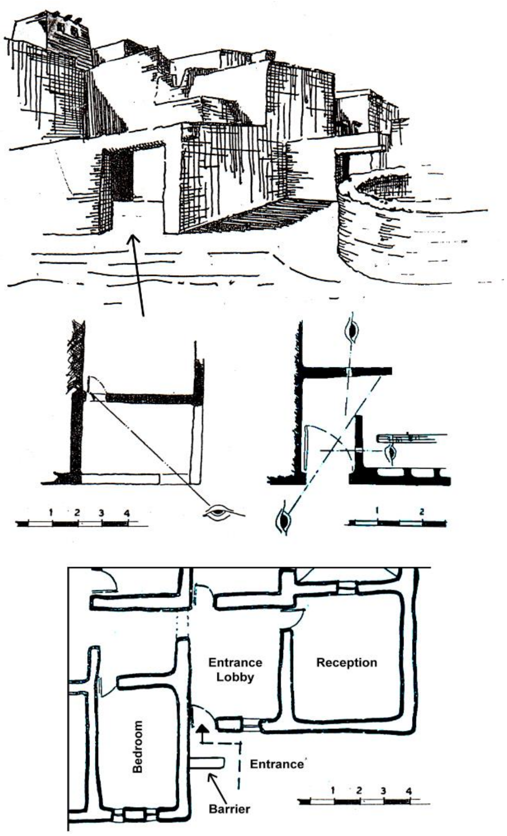


Fig. 8: Indirect Entrance traditional solutions.

Opening Patterns:

There are cultural openings characteristics in traditional oasis architecture, such as:

1. The opening percentage ratio on the external façade is often less than 15%, it enough to achieve the required luminous intensity, **Table 4,7**.
2. It is small and usually has a rectangular shape, but sometimes has a triangle shape to prevent lintel, while it is larger on the internal open courts.
3. Small and rise openings at ground floor, sill height about 2m, for more privacy and external dust protection, but opening dimension in the typical floor about 80cm × 120cm, and 120cm sill height[16].
4. Sometimes the entrance door has a rise sill 20cm height from the ground level to prevent water, dust, and vermin With low head to make the visitor bow in respect, **Fig. 12**.
5. The kitchen usually has large windows, sometimes located at ceiling, and opened with a hanging rope.
6. Roofs used for summer sleep, so they used heigh parapet up to 2.50m, sometimes built from palm leaves to provide ventilation with privacy.
7. Openings common cultural materials are olive wood, palm tree trunks, **Fig. 9**, but now it used the contemporary materials, such as aluminum, Glass, exported beech pine wood and metal.

Many of the existing buildings retain some of these characteristics in the Egyptian oasis, **Fig. 13,14**. So, the architect should consider it for the future designs there.

Fig. 9: Luminosity Lighting level through cultural openings, Shalley, Siwa, Authors.

Fig. 10: Cultural traditional opening in shalley, Siwa, Authors.

Fig. 11: Contemporary opening patterns in sharq albalad, Authors.

Motel in Baharia Oasis **Adrir Amilal Hotel, Siwa Oasis**

Fig. 12: Contemporary opening patterns in Egyptian oasis, Authors.

Table 7: luminous intensity standards and measured for residential spaces, Authors.

Space	**Luminosity (Lux)**		
	Standard		Actual field Measures “Average”
Entrance	120		250
Living	General	150	220
	Reading surface	300	NV
Bedroom	120		150
Office	General	300	NV
	Reading surface	500	NV
Bathroom	300		150
Kitchen	General	120	200
	work surface	500	200
Terrace	120		380

Design Builder Simulation

In order to select the most suitable materials for the construction of a building in Swia, Oasis, we have chosen to use a simple model. This model allows us to adjust the different materials with varying thermal properties, thus allowing us to select the best one for the building without the need to simulate a full model with complete details[17]. The primary goal of this simulation is to select materials with the optimal thickness to ensure the best selection of materials when constructing the building.

In this study, the building was simulated using Design Builder software . Design Builder has the Plus analysis engine V.7 and can calculate the solar thermal gain and energy consumption associated with lighting, heating and cooling. The ASHRAE temperature setpoint for the building was 22 ◦C and the cooling temperature setpoint was 24 ◦C in the simulation. The building’s orientation, occupancy rate and other characteristics are also represented in **Table 8**.

The simplified single case study building (10 x 10 m2) utilized as the case study's which contain living room,2 bedroom , kitchen and bathroom is seen in **Fig. 13**.

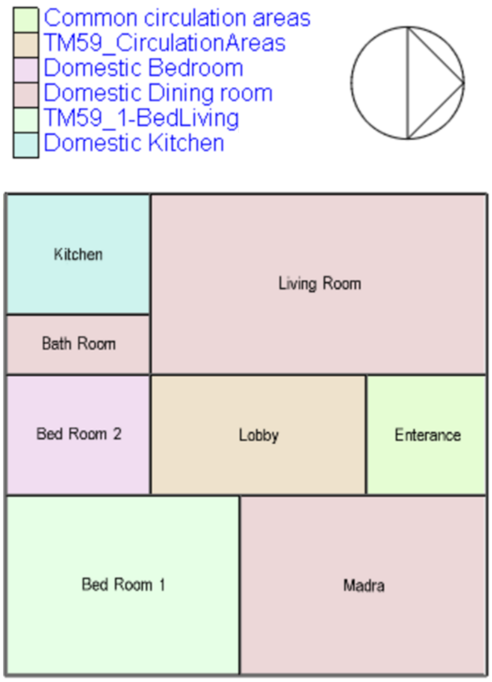


Fig. 13: Architecture plan of the case study (Design Builder screen shoot).

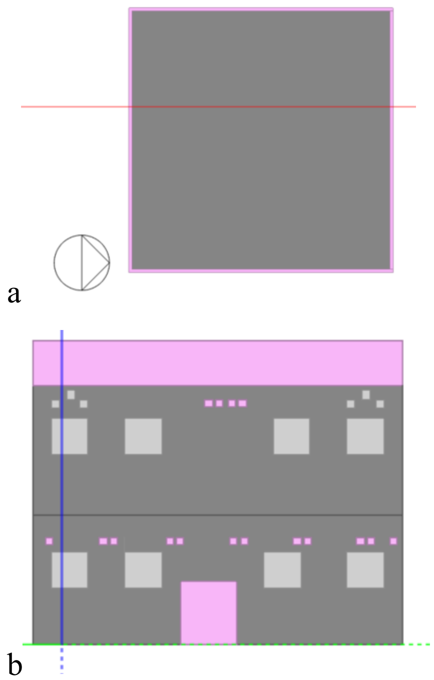


Fig. 14: a) Layout, b) 3D model of the Design Builder simulation case study, Authors.

Table 8: Design Builder parameters of the case study, Authors.

Building type	Residetial home
Location	Siwa
Activities	Living room
Floor height	3.5 m
HVAC	Natural ventilation+Fan units
lighting	Flurosecent
Orientation	N/S/W/E

The envelope and interior partitions of the buildings are constructed, while the specifications of wall building materials used in the simulation are presented in **Table 9,10**.

Table 9: Thermal characteristics of the external wall’s materials, Authors.

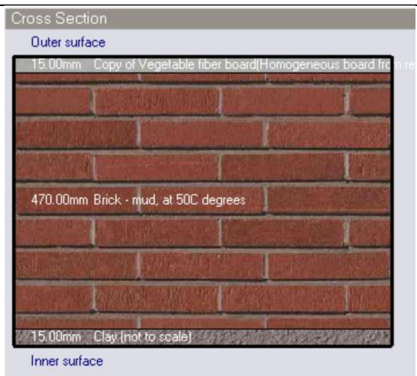
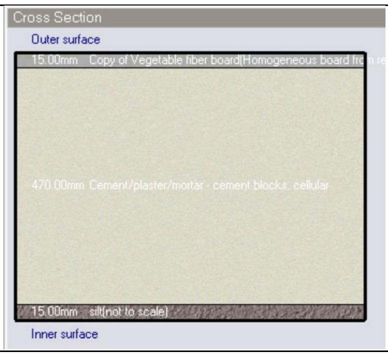
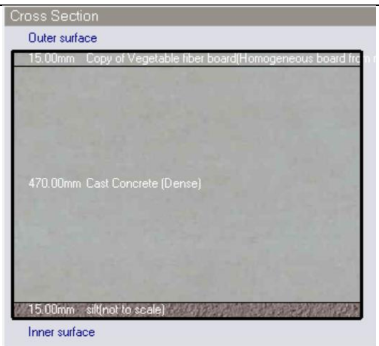
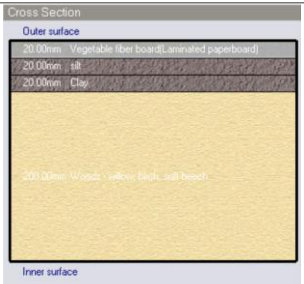
Design Builder External Wall Cross Section	**Karsheef**	**Adobe**
		
	Conductivity -K	
	1.65	**0.5**
	Limestone	**Sandstone**
		
	Conductivity -K	
	0.93	**1.3**
	Solid Cement brick	**Concrete**
		
	Conductivity -K	
	1.025	**0.920**

Table 10: Construction component layer of the base case.

<table>
<tr><th>Roof</th><th>Internal Partations</th><th>Ground floor</th></tr>
<tr>
<td>
</td>
<td>
</td>
<td>
</td>
</tr>
<tr><td colspan="3">U-Value (W/m². K)</td></tr>
<tr><td>0.335</td><td>0.416</td><td>1.624</td></tr>
</table>

The environmental variables that influence the conditions of thermal comfort include:

- **Operative (Internal) air temperature**

The average of the internal air temperature as calculated in **Table 10** which shows that the adobe has the lowest air temperature at 25.29 ºC. On the other hand, Karsheef achieves 28.15 ºC.As a result of the ASHRAE guidelines [18] mention the comfort air temperature lie between 20 ºC to 23.3 ºC in the winter and 22.2 ºC to 26.6 ºC in the summer, which indicates that the adobe falls within the comfort range value.

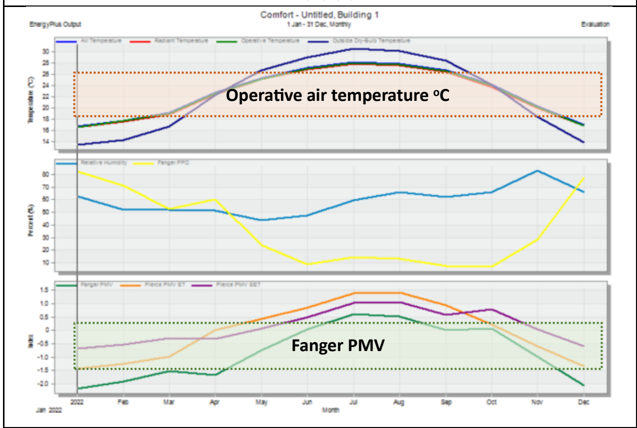
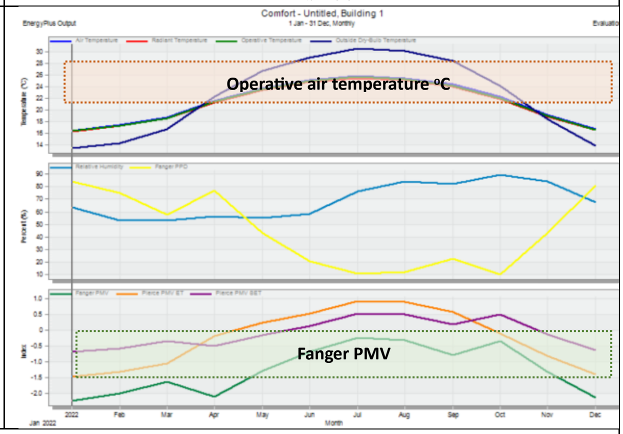
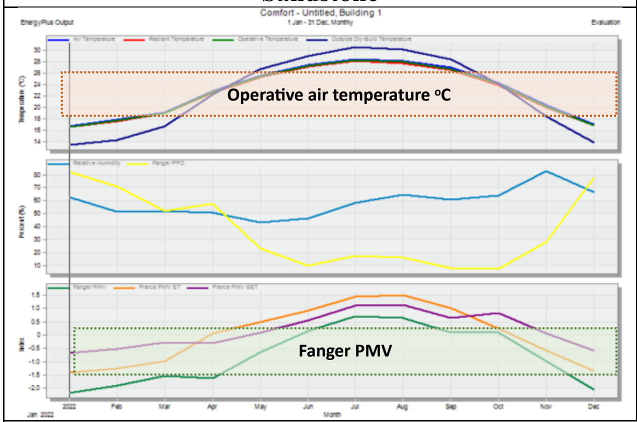
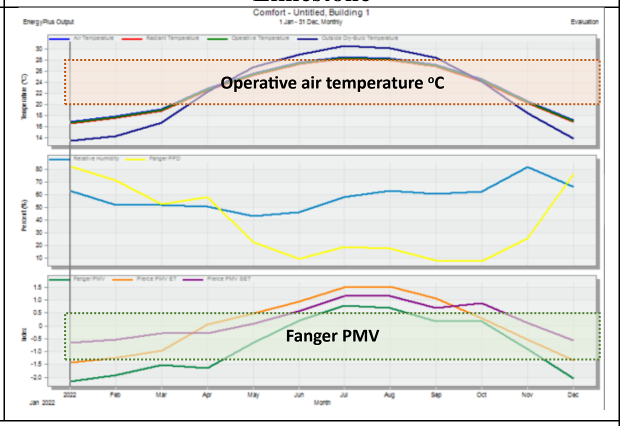
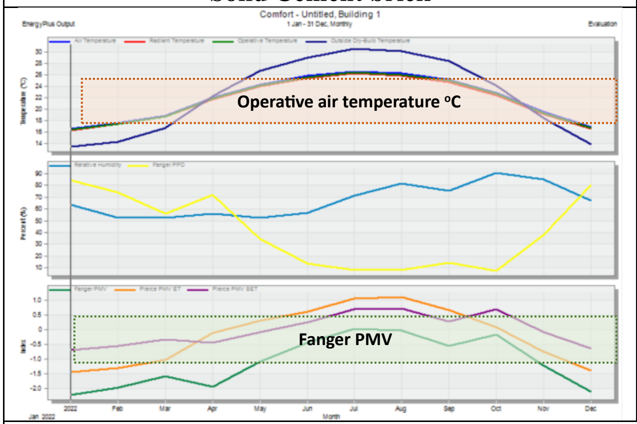
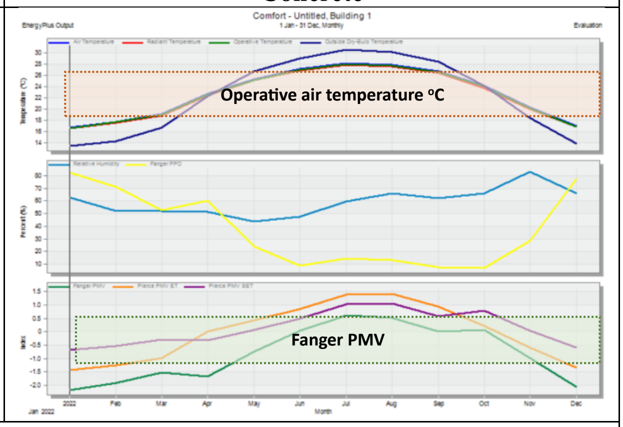
- **Predicted Mean Vote (PMV)**

PMV stands for "Predicted Mean Vote." It's a scale used to measure how cold and warm people feel about their surroundings. The value of PMV indicates the temperature range in which people feel about their environment.

The Fanger's model is a method used to assess the thermal performance of a building by calculating the influenced parameters that result in the predicted mean vote of the building (PMV), which is expressed as a numerical value between -3 (extreme cold) and +3 (extreme hot).

Fanger used the seven-point form of a thermal sensation scale along with numerous experiments involving human subjects in various environments. He related the subjects in response to the variables, which influence the condition of thermal comfort. The PMV achieved 1.26, -0.73, -0.76, -0.94, -0.81, and 1.10 for Karsheef, Adobe, Sandstone, Limestone, Solid Cement brick, and Concrete respectively as shown in **Table 11**. In conclusion, according to Ashrae Standard 55, the optimal thermal comfort range is between +0.5 and -0.5,which show that the adaptation of the adobe achieve the optimum value of thermal comfort inside the spaces while the karsheef and concrete achieve the highest value of thermal comfort .

Table 11: Thermal comfort simulation Comparison between the supposed materials, calculated by Design Builder Program, Authors.

<table>
<tr><th>Adobe</th><th>Karsheef</th></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="2">Operative air temperature ºC (August)</td></tr>
<tr><td>25.29 ºC</td><td>28.15 ºC</td></tr>
<tr><td>Fanger PMV:-1.26</td><td>Average Fanger PMV:-0.94</td></tr>
<tr><th>Sandstone</th><th>Limestone</th></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="2">Operative air temperature ºC (August)</td></tr>
<tr><td>27.96 ºC</td><td>27.03 ºC</td></tr>
<tr><td>Average Fanger PMV:-0.76</td><td>Average Fanger PMV:-0.73</td></tr>
<tr><th>Solid Cement brick</th><th>Concrete</th></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="2">Operative air temperature ºC (August)</td></tr>
<tr><td>26.06 ºC</td><td>27.71 ºC</td></tr>
<tr><td>Average Fanger PMV:-1.10</td><td>Average Fanger PMV:-0.81</td></tr>
</table>

- **Fabric and Ventilation**

Buildings transport thermal energy through their fabric in two ways: partially as a result of the requirement for sufficient ventilation and partially as a result of heat fleeing from a heated area to a cooler one. Building fabric refers to the components and materials used in the construction of a building, including the walls, flooring, roof, ceilings, and windows. In this module, energy performance in buildings will be discussed, as well as how to mitigate heat loss from building fabric.

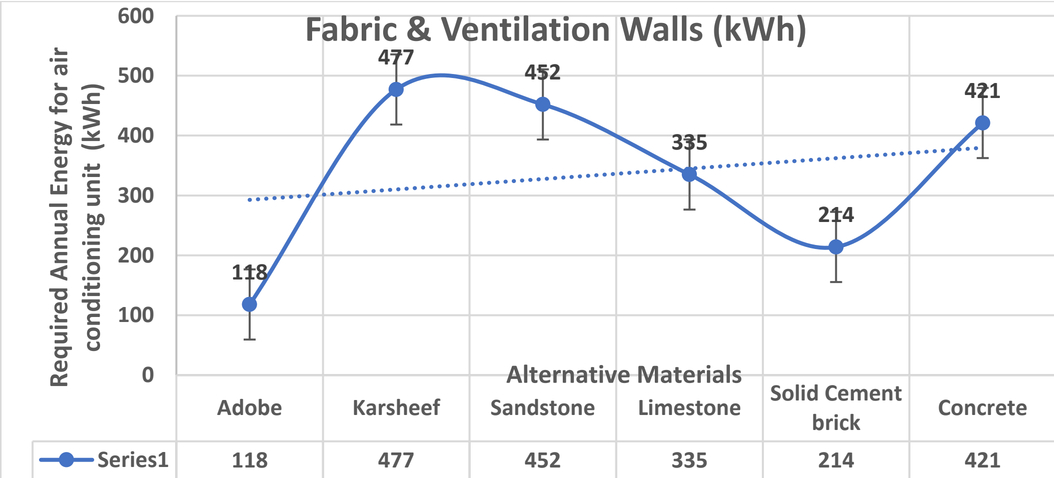


Fig. 15: Fabric and ventilation of the external wall for the Various materials, Authors.

Fig. 15 shows the required annual energy for air conditioning to Zone from External Wall with a different materials which show that the Adobe, Karsheef, Sandstone, Limestone, Solid Cement brick and Concrete achieve 118 kWh, 477 kWh, 452 kWh, 335 kWh, 214 kWh and 421 kWh. As aresult from the simulation of the fabric and ventilation, you can see that the heat loss through the Karsheef is higher than the other contributions materials.

Figure 16 Shows the annual air temperature for the internal spaces of the supposed materials which shows the the Adobe, Karsheef, Sandstone, Limestone, Solid Cement brick and Concrete intended 25.29 ºC, 28.15 ºC , 27.96 ºC, 27.03 ºC, 28.15 ºC, 26.06 ºC and 27.71 ºC respectively. From the output of operative air temperature simulation, we can see that the use of adobe can decrease air temperature by about 2 degrees Celsius compared to karsheef; however, karsheef isn't the most effective material to reach the comfort zone within the spaces compared to other material.

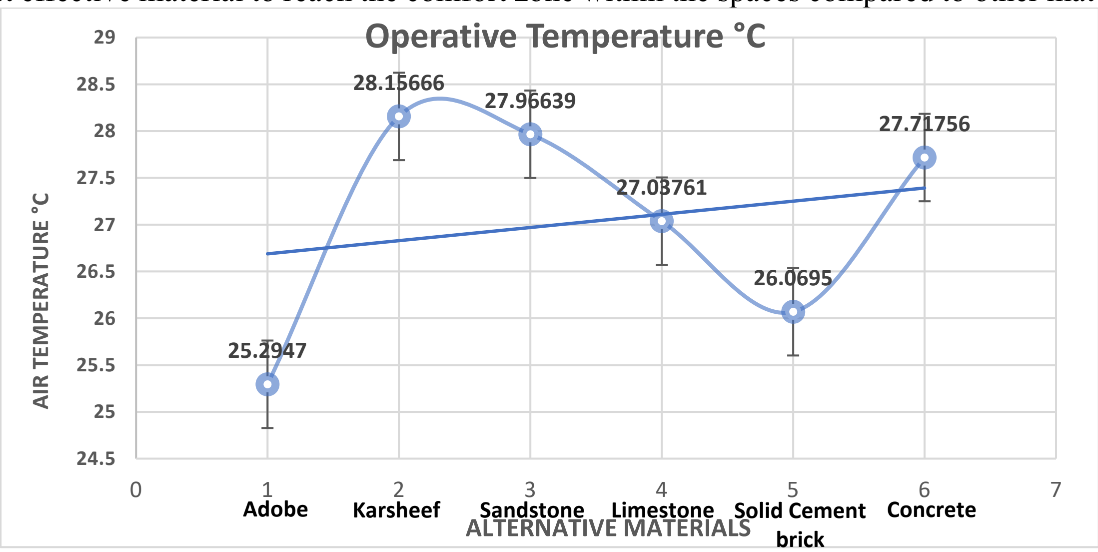


Fig. 16: Operative Air Temperature Cº for the Various materials, Authors.

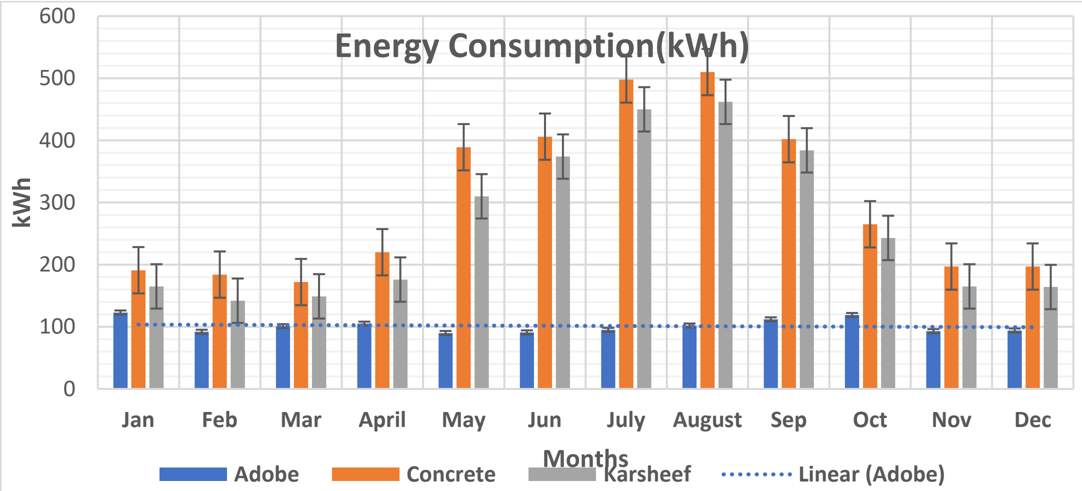


Fig. 17: Eenergy consumption value for a) Karsheef b) Concrete, Authors.

The rate of Energy Consumption was contingent upon the internal gain measurements performed by the construction, which included room fan units, **Fig. 17** shows the comparison of the energy consumption for the Traditional Materials and Existing Contemporary used Materials while the adobe material can save energy more than 85 % of the base case of the concrete materials and karsheef materials configuration.

Results and recommendations:

Addationally, traditional architecture has proven to be more suitable for our climate. The thermal performance of traditional material in residential units is better than that of modern materials.

In the simulation, the indoor air temperature was expected based on the outside conditions. The simulation results showed that energy consumption could be reduced while reducing the thermal comfort range PMV and reducing environmental impact by reducing fabric and ventilation through the materials of the walls.Walls thickness and material were two factors that influenced indoor thermal comfort in this study. Adobe brick walls performed slightly better in terms of indoor thermal performance compared to Kerchief walls.

Traditional building materials achieved thermal comfort for building users over the past decades, and this part aims to compare the thermal performance of it with contemporary materials which is still use some of these cultural materials till now, assuming some constant values:

K: Average Thermal conductivity coefficient for Adobe = 0.5 w/m. ◦c

ΔT: Temperature difference = 15̊c

ΔX: Material Thickness = 0.25m (the minimum common traditional thickness)

A: Exposed surface area = 15m²

Q: "Heat Transfer rate by conduction through adobe" = 15×0.5× (15/0.25) = 450watt

$$\Delta X = (A \times K \times \Delta T) / Q$$

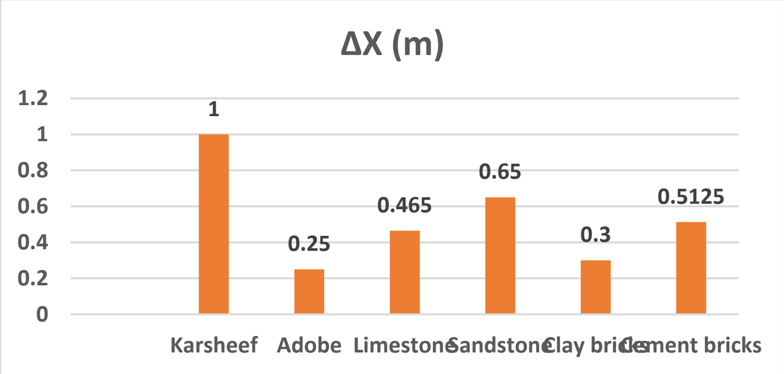
The following chart, **Fig. 18** explains the equivalent wall thickness constructed by studied contemporary materials to achieve the same heat transfer value for mentioned materials in **Table 5**, which show the thermal Characteristics of most common Traditional Insulation Materials. It shows that the adobe has the best thermal performance of building traditional materials, which is still widely used in many communities until now such as Kharga Oasis, it shows the thermal performance of clay bricks as the best contemporary used materials. Karsheef that characterizes Siwa Oasis is not the best in thermal performance, especially for the small thickness of the walls, due to the involved salts composition .

The following Chart expalins the appropriate thickness of the different materials for the wall which show that the karsheef , adobe , Limestone , sandstone , claybricks and cement bricks achieve 1.0 m , 0.25 m , 0.465 m , 0.65 m , 0.30 m and finally 0.5125 m respectively with the thermal conductivity of each materials . As a result, we can conclude that the Adobe materials adjust the minimum thickness of wall to 0.15m compared to the Karsheef achieves the largest thickness of wall thickness to 0.49m with the higgest value of energy usage.

Fig. 18: Equivalent thicknes for contemporary oasis building materials, Authors.

The following **Table 12** concloude the main results and recommendations.

Table 12: Main results an recommendations, Authors.



Building Envelope		Results
Materials of Construction Elements (Walls, roofs, columns …etc.)		▪ Adobe has a good thermal performance as a traditional material, which is still used in Egyptian oasis except Siwa, **Tabe 2,5,10,11, Fig 15,16,17,18.**
		▪ Karsheef, in Siwa has the worst thermal performance because of its salt content, **Fig 15,16,17,18.**
		▪ It is not preferable to use Karsheef and mud bricks in structural elements subject to pressure or shear forces, as well as places exposed to water.
		▪ Most oasis habitants preferred reinforced concrete in construction elements (columns, beams, ceiling, and foundations), **Table 2**, but the clay bricks with 30cm minimum thickness is preferred in outer wall where has most of building envelop conduction with outdoor environment, **Fig 18.**
		▪ External finishing materials should be anti wear and friction, to protect it from dusty wind, **Table 1.**
Openings	Orientation and position	▪ Opening prefered orientation for ventilation is north and west/north direction, **Fig 13,14, Table1.** ▪ Lift ground floor openings, **Table 1.** ▪ Small and rise openings at ground floor, sill height about 2m, for more privacy and external dust protection, **Fig 13,14**.
	Proportion	▪ Opening dimension small and rise at ground floor, but in the typical floor about 80cm × 120cm, and 120cm sill height.
	Ratio	▪ The common traditional and conentemporary opening ratio fulfil the minimum required ratio in **Table 4, Fig13,14**. ▪ The opening percentage ratio on the external façade is often less than 15%, it enough to achieve the required luminous intensity, **Table 4,7.**
	Material	▪ Wooden shutters and sheds fulfill energy code requirement for shading, transparency, and insulation, **Table 4**.
	Shading	▪ Sheds needed and wind bumpers in southwest elevation, **Table 1**.

It is recommended that further research be conducted in order to expand the scope of the project to include other sustainable development objectives, such as the utilization of renewable sources of energy, water conservation, and waste management, in order to create a comprehensive solution for the use of these resources in the oasis of Siwa.

Conclusion:

The research does not present a new construction materials or opening patterns for building envelop in the Egyptian oasis, but it evaluates the behavior of the existing building envelop to concludes the suitability of some of the existing used materials, with some modifications of wall and roof thickness, or openings criteria, through a field study of many case study houses in the oasis villages and simulation model using "Design Builder" program, it provides specific and clear recommendations to help these small communities to build their simple homes, to improve their quality of life.

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