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ANALYSIS OF THERMAL COMFORT ENHANCEMENT USING VERNACULAR ARCHITECTURE IN SIWA OASIS, EGYPT

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ABSTRACT

Siwa Oasis has a unique vernacular architecture, built with walls of an earth martial called (Kerchief), and roofs of palm tree trunks. The uniqueness of Siwa's cultural heritage is accentuated by its natural heritage. However, modernization reached this exotic place. Concrete and multi-story buildings started to appear changing the original vernacular atmosphere, and local residents started to adopt new building technologies to suit a modern lifestyle, threatening the integrity of the cultural heritage. Vernacular Kerchief buildings are known to be cooler than conventional modern concrete; specially in hot daytime, but Kerchief walls are extremely vulnerable to water (scarce rain destroys the buildings and sanitary water used inside threatens the safety of the bearing walls). But, locals often prefer the modern (hot) buildings to the traditional cool yet vulnerable buildings. This paper aims at analyzing the thermal behavior of vernacular Kerchief buildings, compared to modern buildings, to define what exactly makes them perform better thermally (the material, the mass or the design). Simulation of ten parameters and combinations of a model building in Siwa was conducted, using EnergyPlus and Design Builder software to determine the parameters that affect thermal comfort.

KEYWORDS**:** Vernacular architecture**,** thermal comfort, thermal mass, kerchief bearing walls, adobe, simulation.

1. INRODUCTION

Shali Castle in Siwa Oasis has a unique style in construction [1]. It is now just ruins and houses on the verge of falling apart, whose traditional form can be

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distinguished by walls and windows. These ruins have a special morphology, distinguishing it as a landmark of Siwa Oasis [2].

In summer, thermal comfort is a major concern in Egypt arid climate [2]. Climate is an important element in determining the basis for the design of buildings; distances between buildings, building shapes, their orientation, and the outer envelope of the building [3]. Heat transfer is an important factor in the determination of the building design parameters; windows, wall thickness, and wall materials that improve thermal comfort [3]. It is claimed that the use of traditional building materials of Siwa; Kerchief bearing walls and palm trunk roofs, result in buildings with better thermal performance than that of the new building techniques and materials; concrete skeleton and brick walls. In new housing, i.e. concrete skeleton and masonry walls architecture does not fit the desert climate. Kerchief as a wall building material is known to have superior thermal properties compared to common brick walls. The wooden roof is also proven to have better insulation than the concrete roof. Using the traditional way in building houses by Kerchief requires the windows to be small–which formulates an important attribute in the traditional building that makes it always in good performance. The benefit of traditional building depends on using local materials [4-6]. Traditional architecture is always defined as a type of architecture that depends on materials available on site. This type of architecture reflects the traditions that match the climate and needs of Siwa’s society-

The current housing in Siwa is considered unsatisfactory to the community of the oasis, accordingly, the people are moving towards the use of contemporary building materials and techniques, despite the environmental sustainability of the traditional buildings. This community began to leave their traditional homes and demolish them for socioeconomic goals. Accordingly, new housing has been built with artificial modern materials. As a result of these movements, the Oasis started to lose its identity and its heritage buildings. In areas with hot, dry climate, especially in urban areas, the amount of energy and loads increase in summer. In Egypt, due to high temperatures, people have relied on the use of mechanical cooling systems to improve the indoor thermal performance of space. Currently, the economic need has increased which led to a change in the perception of the concept of indoor comfort [7]. Previous studies have shown that dry hot areas use 70% to 80% mechanical cooling systems [8]. Now people use mechanical cooling systems to improve the indoor thermal comfort, instead of creating new solutions through traditional architecture techniques.

Recently, building performance simulation tools played an important role during early stages of design [3]. This could help design decisions related to wall thickness and materials, hence, improving the indoor thermal comfort. The building envelope is the most influential parameter to indoor thermal comfort [9]. The manipulation of windows, wall thickness, insulation, and color is used to reach indoor thermal comfort. Thus, the traditional thickness of walls is an important element to minimize heat transfer through walls [10]. This research focuses on the study of traditional architecture in Siwa Oasis and the mechanisms for improving the existing houses within the climate conditions, by examining the techniques and methods required to reach a satisfying life for the society of Siwa in contemporary times.

It is important to conserve the distinctive architecture and urban character of Siwa Oasis and to utilize the advantages of local and traditional materials and techniques, while achieving good quality of life including thermal comfort, with low energy consumption.

2. LITERETURE REVIEW

2.1 Location

Siwa Oasis is the northernmost of the Egyptian Oases of the Sahara, it is situated 12 km east of the Libyan border [11] and 300 km south of the Mediterranean coast. The Oasis extends in east-west direction in a depression 17 m below the sea level [2]. long., 25.5°E lat., 29.2°N [12].

2.2 Climate

Siwa Oasis has a hot dry climate; it has high temperature most of the year exceeding comfort zone shown in Fig. 1, the mean maximum temperature exceeds 40°C in summer months (June till August) and the minimum temperature barely reaches the comfort limits during summer nights. In spring and autumn, the daytime temperature is hot 32°C to 39°C), with cold nights. The diurnal range is high (20°C) which opens way to utilizing thermal storage as a passive cooling technique which is needed nine months of the year, air movement is very weak in summer but high in winter, between (0.25 m/s to 4 m/s). In addition to that, the humidity is very low due to the desert climate.

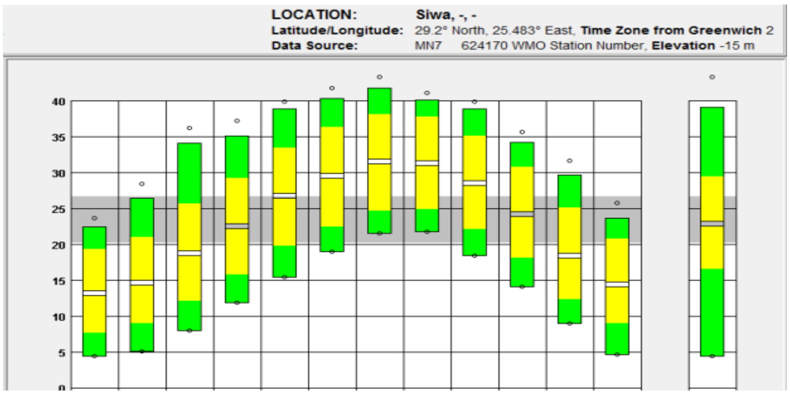


Fig. 1. Temperature of Siwa Oasis.

2.3 Traditional Building Materials

People in Siwa build their houses using Kerchief bearing walls and palm trunk roofs called (Fatimi) [13, 14] as shown in Figs. 2-4. Kerchief is a (concrete– like) building material composed of rock-salt blocks cemented by a mixture of salt, clay and sand; which exists naturally around salty lakes in Siwa.

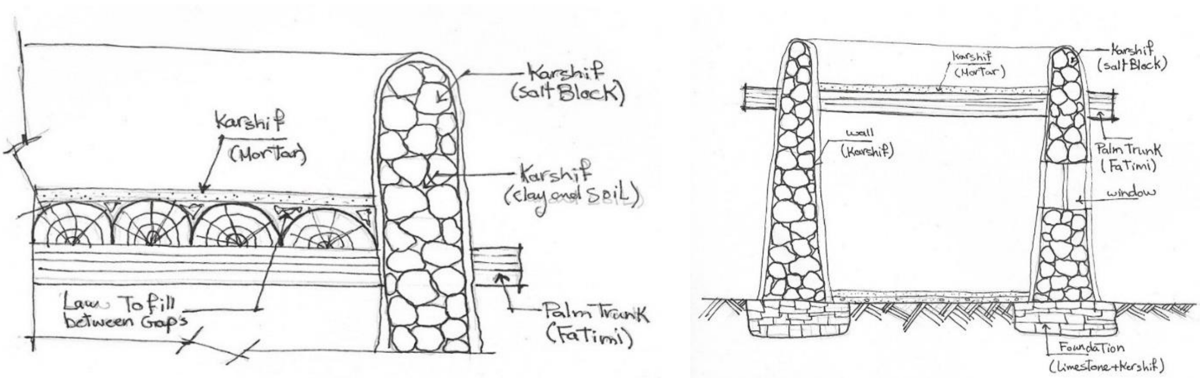


Fig. 2. Structure system in Siwa Oasis
(Kerchief bearing walls and palm trunks called Fatimi) [15].

Fig. 3. Structure system in Siwa Oasis Kerchief bearing walls and palm trunks called (Fatimi).

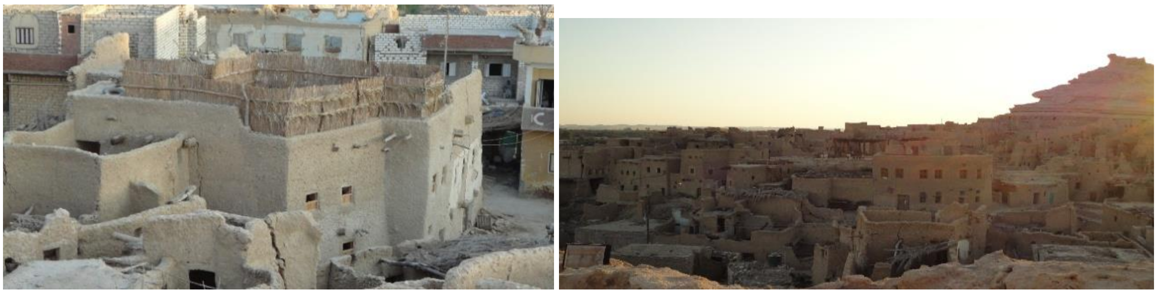


Fig. 4. Traditional Kerchief houses.

The Kerchief material is considered suitable for the climate conditions, due to its bearing capacity it is usually built with thickness exceeding 2 feet [16]. It varies from 0.5 m to 1.00 m, so it has high thermal mass that help keep the building cool in summer and warm in winter [17].

The house located in Siwa Oasis beside El Babenshal hotel as shown in Fig. 5. The house consists of several rooms on two floors (ground floor and first floor).

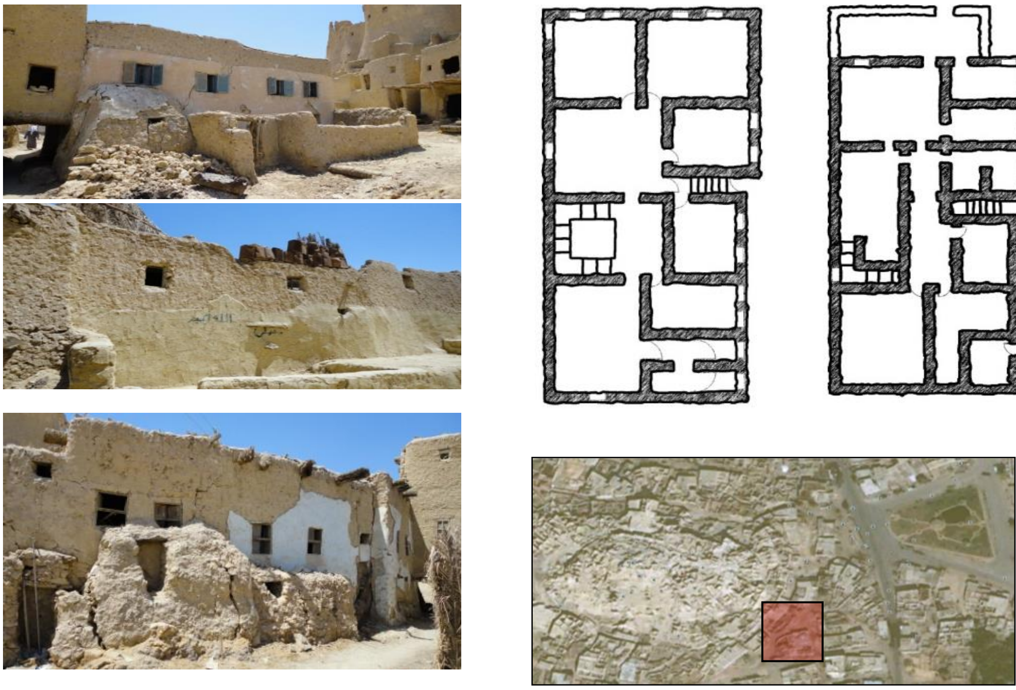


Fig. 5. A Sample traditional Kerchief house.

Kerchief is a (concrete– like) building material composed of rock-salt blocks cemented by a mixture of salt, clay and sand; which exists naturally around salty lakes[18, 19], the material is mainly NaCl salt crystals with impurities of clay and sand as shown in Fig. 4. Halite is commonly known as salt, chemically is known as a sodium chloride (NaCl) as shown in Fig. 6 and Fig. 7. In geology, it is defined as rock composed primarily of halite, known as “rock salt” [20]. The NaCl composes more than half of the Kerchief walls as shown in Table 1 [2]. It is widely accepted in architecture that traditional natural materials have thermal properties better than artificial materials [16, 21, 22]. Kerchief consists of seven salt rocks and mud [2, 11] one of the salt rocks is called halite and it’s about 86% of Kerchief as shown in Table 1, the halite conductivity is between 1.6 and 6 $W/m^2.K$ [23], but the measured thermal properties for the Kerchief as shown in Table 2. Based on a lab test for sample material [21] proves a different fact; thermal conductivity is between 1.6 W/m.K and 2.35 W/m.K which is much higher than adobe (0.4 W/m.K) [24] or even fired brick (0.6-0.7W/m.K) [25-27], this seemed strange and surprising. A confusion often happens considering Kerchief and adobe as one material while they are not, Kerchief consists of salt rocks and mud and adobe is a mix of clay and sand with some organic fibers (reeds) that are added to reduce cracking.

A mixture of sand, clay and halite can have conductivity higher than adobe (sand, clay and organic fibers). Further section of this paper explains why Kerchief construction has good thermal performance in spite of its high conductivity.

Fig. 6. Salt around the lake at Siwa Oasis.

Fig. 7. Halite (rock salt) [28].

Table 1. Kerchief material properties based on a lab test for sample material [2].

Material	Halite NaCl%	Quartz%
Kerchief	86	4

Table 2. Kerchief material properties based on a lab test for sample material [21].

Material	Thermal conductivity W/m.K	Density kg/m^3
Kerchief	1.65-2.35	2185-2400

2.4 Current Building Materials

In modern time, different materials and structure systems are used, (listed in Table 3). The most dominant building is bearing wall masonry structures followed by Kerchief buildings. Adobe and concrete skeleton types are both familiar.

Table 3. Structure Systems in Siwa Oasis [24].

Structure system	Area (Fadden)	Ratio%
Bearing wall	101.47	29
Kerchief	91.40	26.1
Adobe	74.40	21.3
Skelton	73.80	21.1
Stone	5.49	1.6
Metal	3.20	0.9
Wood	0.04	0.0
Total	349.80	100

Although vernacular architecture contributes to Siwa’s image as a tourism attraction, a lot of Siwan people replaced the traditional Kerchief houses with modern buildings using materials such as concrete, fired brick or limestone, both bearing walls and skeleton type are used as shown in Fig. 8.

Fig. 8. Mixed structure models of houses at Siwa Oasis.

By interviewing Siwan people in 2012 [29] to investigate why local residents started to adopt new building technologies, threatening the integrity of the cultural heritage site, it was found that there were many reasons that led them to the use of modern techniques, among them:

- Saving construction time.
- Seeking more spaces by multi-story building.
- Suit new modernized lifestyle with better quality of life.
- Protecting them from natural hazards that could damage their houses like rain and termites.
- Allowing modern showers and sanitary systems (which is a threat to earth material especially salty Kerchief).

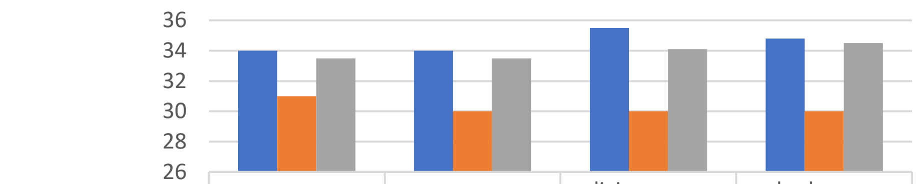
Some hybrid buildings exist as well, for example; an American woman who lives permanently in Siwa built a house using concrete and brick, and covered it with adobe, that gave her a wall that looks, that look like Kerchief traditional house but enabled her to overcome wet facilities problem and to use modern bathroom and kitchen in her (semi-vernacular) house.

When the government tried to enforce using Kerchief only buildings, locals covered their modern building with a Kerchief coating, a spontaneous Facadism conservation approach.

2.5 Comparing Thermal Performance of Traditional and Modern Buildings

Measurements were conducted in 2012 comparing between internal temperatures in main rooms of a traditional Kerchief house and a modern skeleton type house [29], it was found that temperature in the traditional house was closer to thermal comfort compared to skeleton type buildings Fig. 9. In spite of the fact that temperature was out of comfort in both houses, skeleton houses residents suffered from high temperature to the extent that they were not able to stay indoor during daytime. In contrast to Kerchief houses, residents were able to stay during daytime at home, but at night, indoor temperature became too high and they had to sleep on the roof.

That raised the question: why do traditional buildings perform better? and which elements affect thermal comfort? Is it possible to develop buildings that achieve modern quality, thermal comfort, and preserve culture heritage as well?



	men room	women room	living room	bed room
out temp.	34	34	35.5	34.8
traditional house	31	30	30	30
modern house	33.5	33.5	34.1	34.5

Fig. 9. The temperature between the traditional Siwan house and skeleton Siwan house [29].

3. RESERCH PROBLEM AND PAPER OBJECTIVE

Modernization is threatening the unique cultural heritage of Siwa, in spite of the fact that traditional buildings have lower daytime temperatures compared to modern buildings, locals prefer to use modern building techniques to have a better quality of life, but face uncomfortable thermal conditions in the modern buildings, or use air conditioning, hence increasing energy use and cost which is hard to compensate in a remote community facing poverty.

This paper aims at analyzing the thermal behavior of vernacular Kerchief buildings, compared to modern buildings, to define what exactly makes them perform thermally better (the material, the mass or the window wall ratio).

4. METHODOLOGY

In order to answer the question, it is necessary to analyze elements of the outer envelope of the building (walls, windows, ceiling) that affect building thermal performance, to define which element and its properties that have the most significant positive effect.

Simulation using Energyplus and DesignBuilder was used to assess the indoor temperature of a simplified model of a room resembling the house, with different combinations of wall material and thickness, roof type, and window sizes. After defining the best performing elements, new combinations of modern and traditional elements are tested.

4.1 Location and Case Study

The case study will be a simplified single room building of (4 x 3 m^2) used as a bedroom located on upper floor (exposed roof) as shown in Fig. 10.

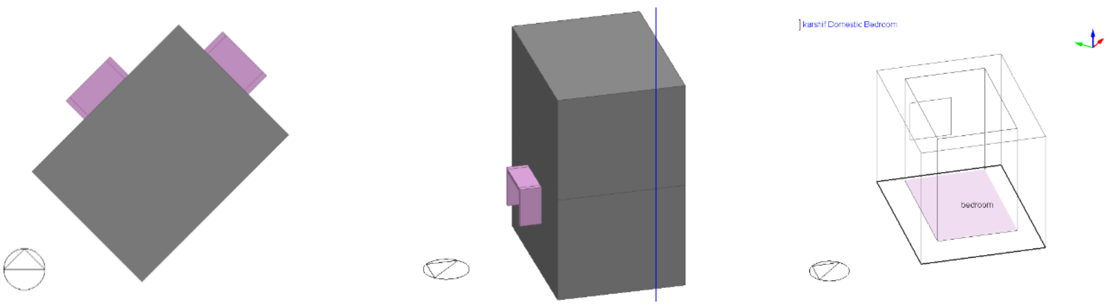


Fig. 10. DesignBuilder case study.

4.2 Simulation Parameters

The study will focus on the wall combinations; a sensitivity room having one window (1.0 x 1.0) m^2 area and roof will be traditional Siwan roof.

This study adopts "simulation study" as the main investigatory method by energy simulation software – namely Design Builder version 2011 which uses Siwa Oasis weather file (epw) to assess the thermal performance of the model. The experimental process began in January and continued until December. The thermal analysis of the room will be examined by several wall thicknesses as shown in Tables 4-8, windows as shown in Table 9, roofs as shown in Table 10. And floors as shown in Table 11.

Our experimental study will focus on the wall thickness and materials; their behavior with the outer and inner temperature.

The main material that we use is Kerchief, which is as a traditional material in Siwa Oasis, as well as brick and adobe because those are the most used materials in Siwa Oasis. We added the thermal properties of each material in DesignBuilder as shown in the Table 12 below and will simulate the variables to see the thermal behavior of the walls around the year especially in July.

Table 4. Kerchief walls [30].

All walls have a Kerchief plaster internally and externally 2cm thick, with conductivity 1.5 (W/m.K).	
Thickness(m)	U-value (W/m^2.K)
1.00	1.43
0.75	1.74
0.50	2.23
0.38	2.58
0.25	3.10
0.12	3.89
U-value calculated by DesignBuilder	

Table 5. Brick walls [30].

All walls have a cement plaster internally and externally 2cm thick, with conductivity 0.72 (W/m.K).	
Thickness(m)	U-value (W/m^2.K)
1.00	0.61
0.75	0.78
0.50	1.08
0.38	1.32
0.25	1.74
0.25	2.55
U-value calculated by DesignBuilder	

Table 6. Adobe walls [30].

All walls have an adobe plaster internally and externally 2cm thick, with conductivity 1.5 (W/m.K).	
Thickness(m)	U-value (W/m^2.K)
1.00	0.38
0.75	0.50
0.50	0.72
0.38	0.90
0.25	1.26
0.12	2.07
U-value calculated by DesignBuilder	

Table 7. Limestone walls [30].

All walls have a cement plaster internally and externally 2cm thick, with conductivity 0.72 (W/m.K).	
Thickness(m)	U-value (W/m^2.K)
0.25	2.55
0.20	2.78
0.12	3.27
U-value calculated by DesignBuilder	

Table 8. Another wall variables [30].

Wall	Type (cm)	Material	Thick. (m)	Conductivity (W/m.K)	U-value (W/m^2.K)
Kerchief + Brick	50	Clay	0.02	1.5	1.46
		Kerchief [21]	0.25	2.00	
		Brick	0.25	0.72	
		Cement	0.02	0.72	
	25	Clay or silt	0.02	1.5	2.28
		Kerchief [21]	0.12	2.00	
		Brick	0.12	0.72	
		Cement	0.02	0.72	
Brick + Insulation	25	Cement	0.02	0.72	0.54
		Brick	0.25	0.72	
		expanded polystyrene	0.05	0.04	
		Cement	0.02	0.72	
		Cement	0.02	0.72	0.32
		Brick	0.25	0.72	
		Expanded polystyrene	0.10	0.04	
		Cement	0.02	0.72	
		Cement	0.02	0.72	0.55
		Brick	0.12	0.72	
		expanded polystyrene	0.05	0.04	
		Brick	0.12	0.72	
		Cement	0.02	0.72	
		Cement	0.02	0.72	0.32
		Brick	0.12	0.72	
		expanded polystyrene	0.10	0.04	
		Brick	0.12	0.72	
		Cement	0.02	0.72	
		Cement	0.02	0.72	0.32
		expanded polystyrene	0.10	0.04	
		Brick	0.12	0.72	
		Cement	0.02	0.72	
U-value calculated by DesignBuilder					

Table 9. Windows variables [30].

Specifications	Identification	W1	W2	W3
	Windows	2.0 x 1.3m^2	1.0 x 1.0m^2	No window
Window layout	Glaze martial	Clear 3mm	Clear 3mm	-
	Glazing (%)	26%	11.1%	-
	Window width	2.0	1.0	-
	Window height	1.3	1.0	-
	Sill height	1.0	1.0	-
	Window spacing	0.1	1.0	-
	Vent spacing	0.1	0.1	-
	Frame width	0.040	0.040	-
	Divider width	0.020	0.020	-
	frame	Painted wooden	Painted wooden	-
Louvers	Material	Oak (radial)	Oak (radial)	-
	Thickness	0.002	0.002	-
	Numbers of blades	15	10	-
	Vertical spacing	0.1	0.1	-
	angle	15	15	-
	Distance from window	0.05	0.05	-
	Blade depth	0.05	0.05	-

Table 10. Roofs variables [30].

Identification	name	materials	Thick. (m)	Conductivity (W/m.K)	U- value ($Wm^{-2}K^{-1}$)
Roof 1	Palm roof	Kerchief [21]	0.02	2.00	0.025
		Clay or silt	0.02	1.5	
		Fatimi palm [13]	0.20	0.005	
Roof 2	Isolated concrete roof	Concrete tiles (roofing)	0.02	1.5	0.280
		Cement/plaster	0.02	0.72	
		Sand	0.06	0.25	
		expended polystyrene	0.10	0.04	
		Bitumen	0.002	0.17	
		Concrete /cast-dense, reinforced	0.12	1.9	
		Cement/plaster	0.02	0.72	
		Plaster (light weight)	0.02	0.16	
Roof 3	Non-isolated concrete roof	Concrete tiles(roofing)	0.02	1.5	1.014
		Cement/plaster	0.02	0.72	
		Sand	0.06	0.25	
		Bitumen, pure	0.02	0.17	
		Concrete, cast-dense, reinforced	0.12	1.9	
		Cement/plaster	0.02	0.72	
		plaster	0.02	0.16	
U-value calculated by DesignBuilder					

Table 11. Floors variables [30].

Identification	name	materials	Thickness (m)	Conductivity (W/m.K)	U-value($Wm^{-2}K^{-1}$)
Floor 1	Kerchief ground	Kerchief [21]	0.02	2.00	0.464
		Clay	0.02	1.5	
		Earth, gravel	1.00	0.52	
Floor 2	Original ground	Ceramic	0.02	1.3	0.831
		Plaster	0.02	0.72	
		Sand	0.10	0.25	
		expanded polystyrene	0.02	0.04	
		Sand and gravel	0.10	2.00	
Floor 3	Kerchief internal	Kerchief[21]	0.02	2.00	0.025
		Clay	0.02	1.5	
		Fatimi palm [13]	0.2	0.005	
Floor 4	Original internal	Ceramic	0.02	1.3	0.884
		Plaster	0.02	0.72	
		Concrete roofing slab	0.12	0.16	
		Plaster	0.02	0.72	
		Acrylic	0.02	0.02	
U-value calculated by DesignBuilder					

Table 12. Thermal properties of materials used in simulation.

material	Density kg/m^3	conductivity W/m.K	Thermal storage capacity J/kg.K
Kerchief [21]	2293	2.00	900
Adobe [24]	2400	0.42	840
Brick [30]	1920	0.72	840

5. RESULTS

The simulation takes place in July that represents a typical hot summer day, at which average air temperature is 43°C in Siwa. Simulation demonstrates the influence of material type and thickness on the air temperature inside the occupied space. The graph below shows assembled results for the comparative analysis of different variables used during the study.

The highest air temperature is recorded when applying Kerchief wall with thickness 12 cm, as shown in Fig.11.

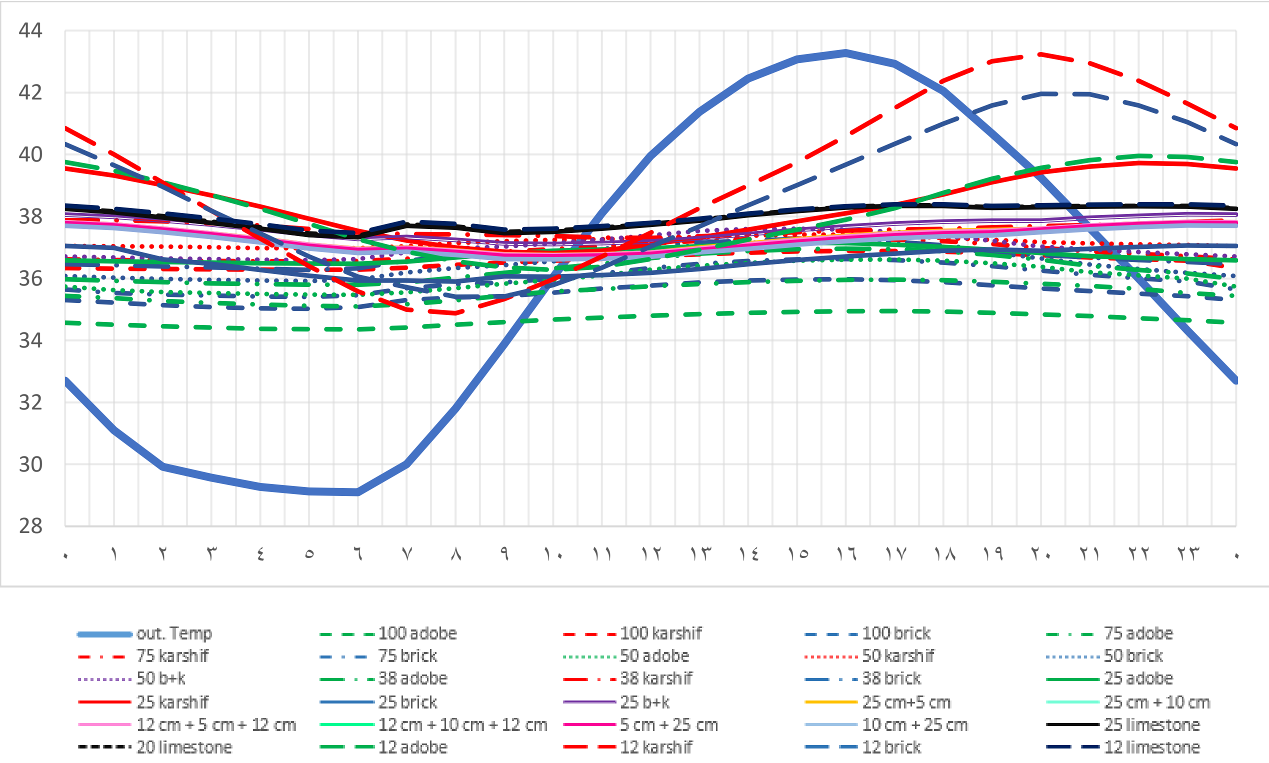


Fig. 11. Walls temperatures in July.

5.1 Existing Situation in Siwa

Two main construction methods are used in Siwa nowadays, the traditional method (75 cm Kerchief wall, with 1.0 m x1.0 m window, Fatimi palm roof) and modern method (25 cm brick wall, with (2.0 x 1.3) m^2 window, Nonconcrete roof).

By comparing the insulated existing situations, the analysis shows that the Kerchief wall is better than brick wall as shown in Fig. 12.

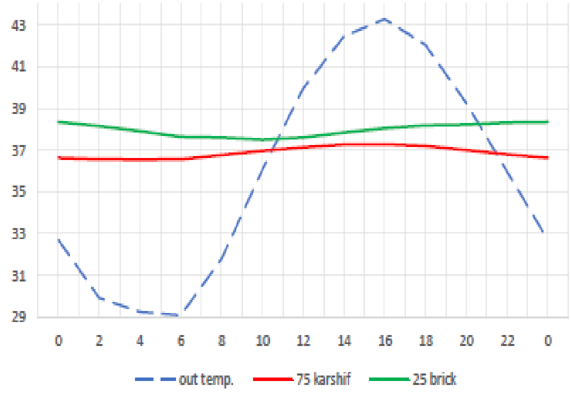


Fig. 12. Simulation the existing (traditional-modern) situation in Siwa.

5.2 Assessing Different Material Types

When considering the comparative analysis for the results, as shown in the below graphs, the thermal results show divergence in the air temperature when applying different materials.

5.2.1 12 cm Thickness

The analysis is held using different material types; Kerchief, adobe, brick and limestone at 2:00 p.m. The Kerchief wall recorded the highest temperature at 39°C, adobe wall was 39.26°C, and the brick wall was 38.36°C, while the limestone showed the lowest degrees at 37.49° C. A remarkable divergence in temperature is recorded during the whole day when using small wall thickness. The fluctuation between high and low temperature occurs as shown in Fig. 13.

5.2.2 25 cm Thickness

When comparing indoor temperatures using brick wall of 25 cm thickness, with using Kerchief wall of 25 cm thickness, better results are recorded for the brick wall at 35.90°C, as shown in Fig. 14.

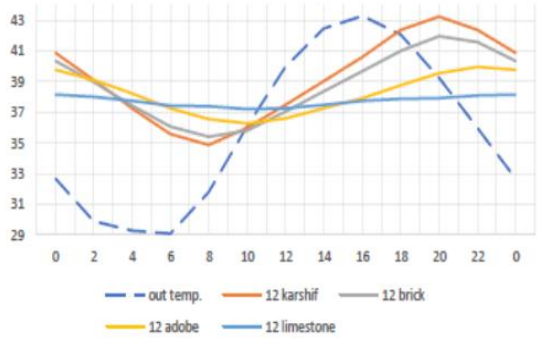


Fig. 13. (12 cm Thickness).

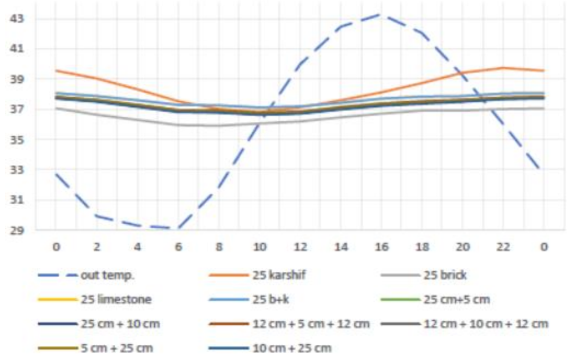


Fig. 14. (25 cm Thickness).

5.2.3 75 cm Thickness

When increasing the wall thickness to 75 cm, the Kerchief wall shows the highest air temperature when compared to other materials used as shown in Fig. 15.

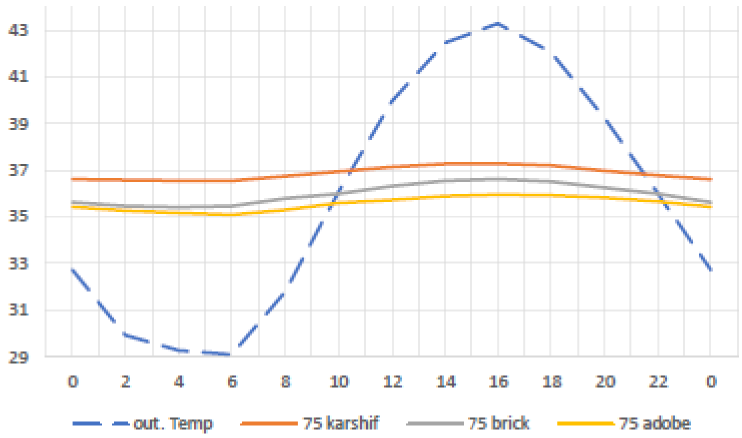


Fig. 15. (75 cm Thickness).

5.3 Assessing Different Material Thickness

5.3.1 Using kerchief wall

A comparative analysis is carried on a Kerchief wall type with different thickness, (100cm -75cm - 50cm - 38cm - 25cm - 12cm). The results show the higher wall thickness has better impact as it shows lower temperature at 36.33°C, as shown in Fig. 16.

5.3.2 Using Adobe Wall

The results show that the increase in thickness has a better influence on decreasing the air temperature when using adobe wall material. The 100 cm wall thickness is the best as it shows low air temperature, while the 12 cm thickness is the highest air temperature. A great similarity between the 38 cm and 75 cm is recorded, as Fig. 17 shows.

5.3.3 Using brick wall

By comparing the wall thicknesses (100 cm – 75 cm – 50 cm – 38 cm – 25 cm – 12 cm) when implementing brick material, the 100 cm brick wall has a better influence in decreasing the temperature when compared to other thicknesses as shown in Fig. 18.

Increasing the wall thickness increases the thermal conductivity of the material which results in decreasing the fluctuation and divergence in the temperature during the day. This is shown in the linearity that occurs in the curve at the below graph, Figs. 16-18.

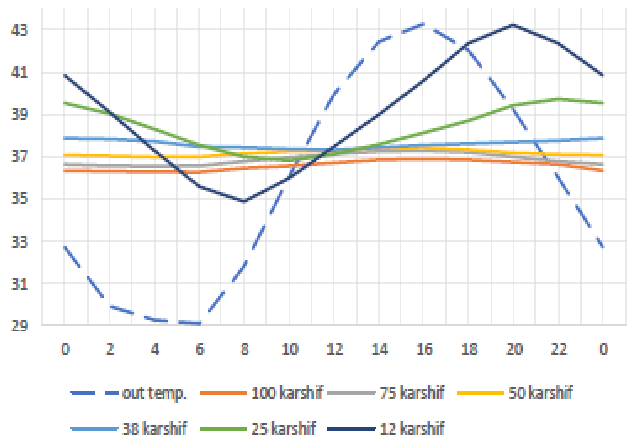


Fig. 16. Kerchief walls.

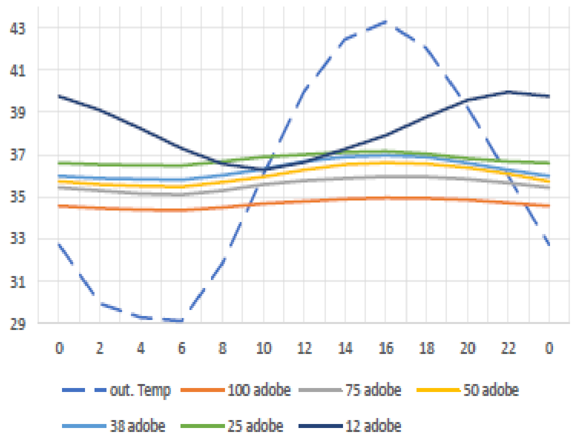


Fig. 17. Adobe walls.

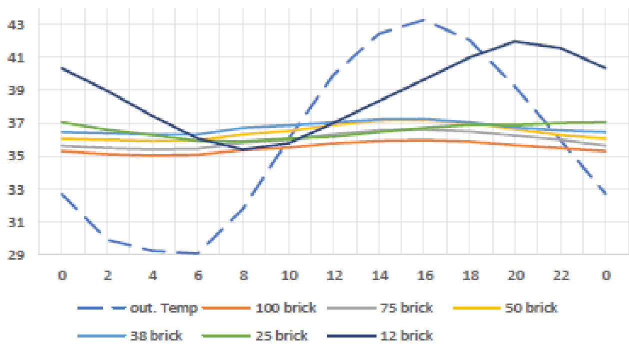


Fig. 18. Brick walls.

5.4 Assessing Variation in Material and Thickness

A lower temperature degree is achieved when using a smaller thickness (50 cm) of adobe material when comparing it to Kerchief material with greater thickness (75 cm). The temperature of the occupied space reached 36.5°C when applying the adobe material of 50 cm thickness, while one degree higher in temperature, 37°C, is recorded with Kerchief material of 75 cm thickness as shown in Fig. 19.

The brick material shows improvement on the air temperature when comparing it with adobe material of the same thickness (25 cm), and Kerchief of greater thickness (38 cm) as shown in Fig. 20.

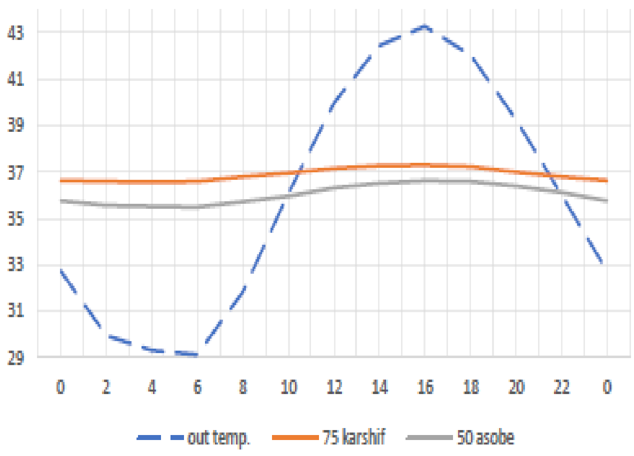


Fig. 19. 75 cm Kerchief wall, 50 cm Adobe wall.

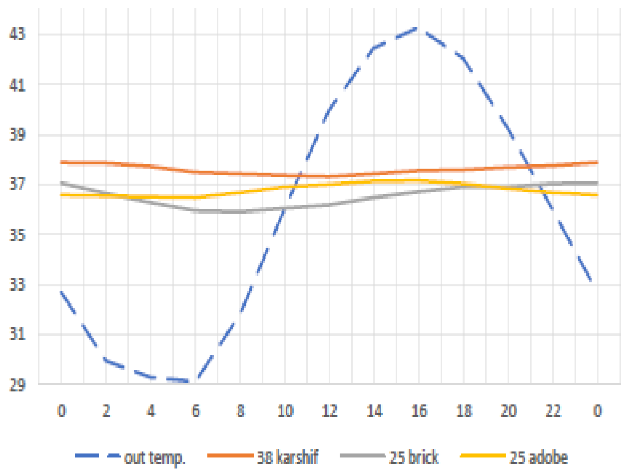


Fig. 20. 38 cm Kerchief wall , 25 cm Brick wall, 25 cm Adobe wall.

- A remarkable decrease in temperature counts for one and half degrees is realized, when comparing between (50cm brick+ Kerchief) wall and (25 cm Brick + Kerchief) wall, Fig. 21.
- The brick wall (25 cm) thickness and adobe wall (25 cm) thickness shows improvement on the air temperature when comparing it with Kerchief material (50 cm), Fig. 22.

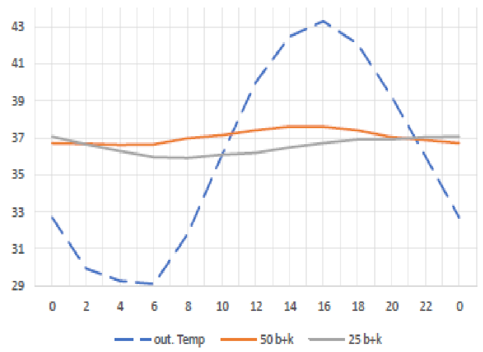


Fig. 21. Compined Brick and Kerchief wall in two thikness (50 cm – 25 cm).

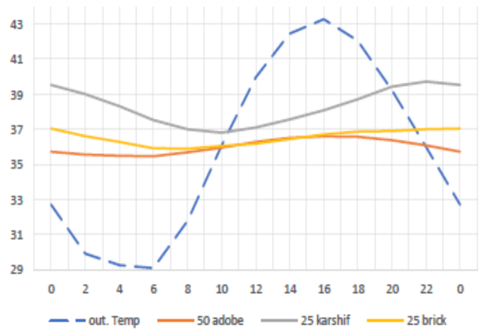


Fig. 22. 50 cm Adobe, 25 cm Kerchief, 25 cm Brick walls.

6. ANALYSIS AND DISCUSSION

Nowadays, traditional architecture proved to be more convenient to our climate. A better thermal performance is achieved while using traditional material in the residential units when compared with modern materials. Although traditional materials show improvement in the thermal performance inside the occupied space, the residents prefer the modern approach in construction material to avoid other problems that may occur like bugs, rain and outdated lifestyle. Enthusiasm for improving the weak points of the traditional materials is rising, as the resistance to it is increasing. More studies are required to ameliorate the construction method keeping the thermal properties of the material. The study proposes integration between the traditional and the modern materials to benefit from the properties of each of them. Diversity in parameters is used for analyzing the thermal performance inside the occupied space. Wall material and thickness together with the window size and the roof material and insulation are the parameters used for simulating the residential space. If we change the thermal properties for the roof and make the roof insulated it will make a difference and that means the uninsulated roof problem is solved. When the window area increases the heat that inter the space increases. when controlling for the roof insulation and window size, and changing the materials of the wall using adobe, brick or Kerchief, and when increasing the wall thickness between different material it is found that the Kerchief makes a considerable difference, from that it is found that the wall thickness is the parameter that is the most effective on thermal performance of the wall, not the thermal properties of the materials.

7. CONCLUSION

The parameters affecting the indoor thermal comfort that were considered in this study are wall thickness and material, roof insulation, and window size. The simulation proved that the traditional house shows better thermal performance than the modern house.

In Siwa, Traditional buildings are built by massive bearing walls of Kerchief material, which is an earth material consisting of rock salt aggregate cemented by clay, sand, and organic fibers, it is usually confused with adobe which does not have rock salt (Halite). Kerchief has higher thermal conductivity than adobe or even brick due to high conductivity of Halite. In spite of that, thick Kerchief walls assisted in improving indoor air temperature. Thermal mass of thick walls is more significant than their conductivity. Adobe and brick thick walls showed slightly better indoor thermal performance than Kerchief walls but comparing thin walls; Kerchief walls have worse thermal performance. Wall thickness proved to be a more effective parameter in indoor thermal performance than wall material. When it comes to window size and roofs, small size windows paired with insulated roofs proved to result in the best indoor thermal performance.

In the modern house, brick walls, and insulated roof, with small windows, resulted in the same indoor thermal comfort as the traditional building, and better in some cases. From the analysis, 25 cm brick wall with 1.0×1.0 m^2 window and insulated roof have the best thermal performance in the modern house.

The urban conservation of the heritage of Siwa is a major goal, as well as satisfying user demand for modern quality of life, integrating modern and traditional building materials and techniques could be the answer, while improving thermal performance of the building. In urban conservation sites; the study recommends the use of hybrid buildings with small windows and insulated concrete roof and a composite wall with an Internal brick layer of 25 cm, and an outer 25 cm Kerchief layer, to increase thermal mass and give a heritage- compatible façade.

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تحليل الأداء الحرارى للعمارة التقليدية فى واحة سيوة

يهدف البحث الى تحليل الاداء الحرارى لمادة الكرشيف مقارنة بالمواد الحديثة لتحديد ما الذى يؤثر على الاداء الحرارى للمبنى هل هى المادة ام الكتلة وذلك من خلال عمل محاكاة رقمية باستخدام برنامج (Designbuilder) للمواد التى يبنى بها فى واحة سيوة (الكرشيف – الطوب الاحمر – الطين – الحجر الجيرى) وظهر ان سمك المادة الحائط هو المؤثر على الاداء الحرارى للفراغ بصرف النظر عن نوع المادة وان مادة الكرشيف ادائها الحرارى جيد فى سمك الحائط الكبير على عكس ادائها فى السمك الصغير بالرغم من انها مادة طبيعية وذلك يرجع الى ان خصائصها الحرارية سيئة لاحتوائها على الملح الصخرى.