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Efficient Natural Ventilation in Traditional and Contemporary Houses in Hot and Dry Climate

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***Abstract*:** *In current building design many ideas and building materials are inverted from Europe and America, without careful considerations for local climate conditions in the region. For example, most new buildings include no overhangs or any shading devices, resulting easy solar radiation penetration into inside the buildings. The contemporary building envelopes are made of materials with high thermal mass, such as cement block, which constructed as relatively thin envelope layer. This lack on appropriate thermal mass results in overheating of the indoor environment of the buildings. This effect is further increased by glass façades, which effects also radiation based summer overheating.*

As a result, houses are too hot without assistance of an air-conditioner. This caused an excessive energy consumption of the built environment, due to the negligence of the climate factor by architects and designers, although in traditional buildings these climate considerations were integrated as an important factor in building construction.

This paper will discuss the difference between traditional and contemporary houses in hot and dry climate zones with special focus on natural ventilation and different building materials. The investigation concentrates on a particular, typical settlement in hot and dry climate zones: Sulaimani, Iraqi Kurdistan. During the investigations of dynamic thermal building simulations will be carried out, in order to assess building energy and comfort performance as well as to develop low-tech building technologies. The purpose of this study is the application of the traditional techniques to the contemporary houses, in order to reduce energy consumption and to provide high quality of natural ventilation to contemporary houses.

Keywords: *natural ventilation, thermal comfort, traditional house, contemporary house.*

1. Introduction

Energy shortage is currently one of the most important worldwide. Typically, the energy cost of a natural ventilation in building is 40% less than that of an air-condition building. Natural ventilation is an energy efficient alternative for reducing the energy use in buildings, achieving thermal comfort, and maintaining a health indoor environment. In addition, It is an effective measure to save energy in buildings [1].

In Iraqi Kurdistan Region, the energy consumption has increased gradually, as a hot and dry climate especially in the summer; air conditioning tends to be the single largest use of electricity [2]. On the other side dense areas creates a hot microclimate and discourage the use of natural ventilation. In addition, using in-appropriate building elements and materials with microclimate [3].

According to the annual report of the Suleiman Department of Electricity and Energy in 2011, the residential sector consumed 66% of the total national generated electricity, as shown in Figure (1).

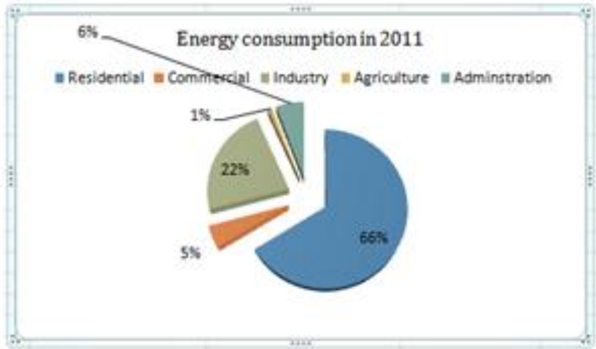


Fig. 1: Shows the energy consumption in Sulaimani [9].

2. Natural Ventilation

Ventilation is generally defined as a supply of outside air to the interior for air motion and replacement of stagnant air by fresh outside air for healthy and comfortable interior environment .The main purpose of natural ventilation as a passive cooling strategy is to achieve high indoor air velocities with the air that has appropriate temperature and relative humidity[5].

For natural ventilation, there are two causes of air motion through the building namely:

- Wind Force: When wind strikes a building, a region of higher pressure is created on the windward side while the leeward wall and roof are subjected to reduced pressure. A pressure difference is created across the building in the direction of the incident wind. This pressure difference causes the air flow through the building from openings in the region of higher pressure to openings located in the region of lower pressure.
- Thermal Force: When two openings are provided at different heights and the indoor temperature is higher than outdoors, a pressure difference is formed. Excess indoor pressure builds up at the upper opening, where air flows outwards, while a depression is created at the lower level, indicating an inward flow of air. When the indoor temperature is lower, the positions are interchanged and flow direction is reversed[6].

As the thermal force of ventilation depends on the indoor-outdoor temperature difference and the vertical distance between the openings, then temperature difference can be increased by using traditional techniques in the new buildings.

3. Thermal Comfort Analysis

Comfort is a psychological situation which is formed by the all conditions giving satisfaction in adaptation to environment without necessity of consumption of additional energy[4].Thermal comfort is viewed as a state of mind where occupants are satisfied with their surrounding thermal environment and desire neither a warmer nor a cooler condition. Six primary factors affecting thermal sensation are either environmental or personal parameters. These factors are: air temperature, mean radiant temperature, air velocity, humidity, metabolic rate and clothing [6]. In addition, physiological factors as age, gender, characteristics of occupants, social activity and clothing [4].

The ASHRAE standard 55 on thermal Environmental Conditions for Human Occupancy, gives the upper limit of comfortable temperature as 26 °C, and dry bulb temperature upper limit as 20°C [5]. The latest version of ASHRAE Standard 55 starts to adopt the idea of acclimatization and gives higher upper limit for thermal comfort that could be as high as 27-28°C and 0.012 humidity ratio for the situations where there is a system to control humidity[5].

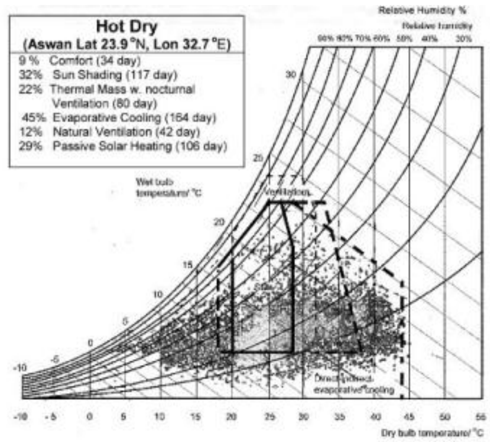


Fig. 2: Shows the psychometric chart analysis for Aswan, Egypt as a hot and dry[7].

Thermal comfort standards help designer to establish indoor conditions that suit occupant's expectations, in addition, it attempts to reduce energy consumption in residential buildings.

4. Climate Analysis in Kurdistan Region

Natural ventilation efficiency in residential buildings require appropriate climates. It is well known that natural ventilation can work in a moderate climate, such as those in western and northern Europe, California, and others. However, Kurdistan is located between Latitude 36.2268N. and Longitude 44.76106 E. According to the Koppen map for climate classification zone, Kurdistan Region is Warm temperate rainy climate with dry and hot summer[2].

Fig. 3: Shows the location of Sulaimani, Kurdistan.

The hot summer months from (June to August) are characterized by a high sun angle, high temperature and moderate north-west wind. The rainy season from (September to March). The monthly air temperature for the year ranges from (2 to 40)°C, while the relative humidity varies from (25 to 70%), as shown in figure (4) and (5) This investigation used Sulaimani city conditions as a reference case. The prevailing wind of the city is northwest, and there is other winds it is from northeast, where blowing suddenly usually it be very fast, locally is called (Rashaba), and it may takes from one day to three days[8].

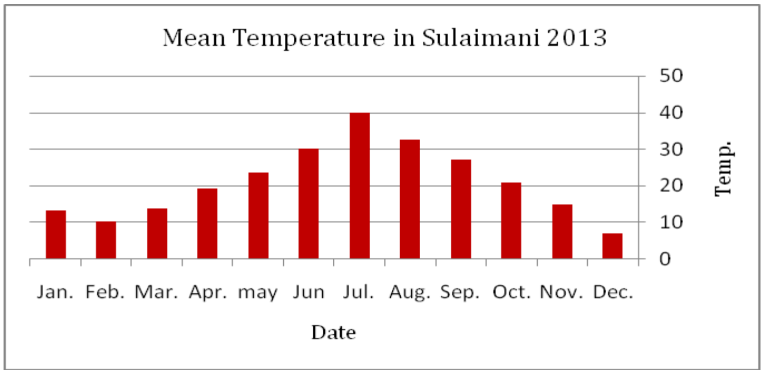


Fig. 4: Shows mean outdoor monthly temperature in Sulaimani [8].

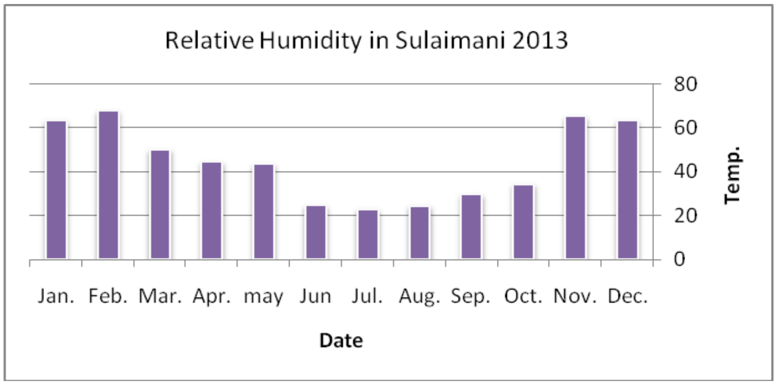


Fig. 5: Shows mean monthly Relative Humidity in Sulaimani [8].

5. Type of Traditional Houses

It is the traditional type which characterized by an open front big yard, mostly containing water basin and home garden. It consist of two floors, the ground floor is mainly reserved for services such as bakery, kitchen, bathroom and public reception or guest reception, where the upper floor is purely private, and contain two or three rooms that overlooking on inner Iwan* as shown in figure (6), which often supported by two or three wooden columns. the division between the public and the private domains has been achieved vertically.

The object of these characteristics was to benefit from prevailing winds for ventilation which was considered as one of the main methods of traditional architecture to provide thermal comfort for occupants in buildings especially in hot and dry climate.

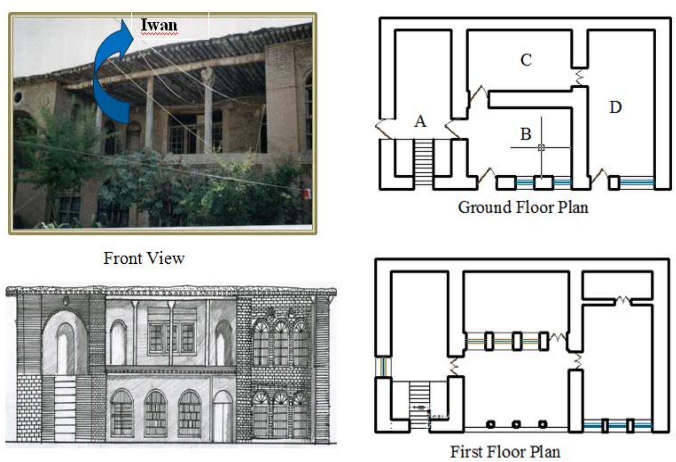


Fig. 6: Shows the plans and elevation of traditional house type [Source: Author].

Typically, the building materials were clay brick or heavy stone for wall buildings, with stone foundation and using mud or clay for interior and external wall as a finishing material, these help to regulate moisture and temperature in the surrounding air. While the houses were roofing by bole of trees, their diameter do not exceed than 15cm, it was used in the form of cross-beams which covered by a layer of mat, then placed layer of compressed soil with a thickness 20cm on it. The thickness of the wall ranges between (40-80)cm, which was suitable for hot and dry climate, because it play a big role for conditioning the house in the cold and hot days during the year.

6. Type of Contemporary Houses

This type is tending to modern houses, it characterized by front small yard and consists of two floors, ground floor contain living room, bed room, kitchen and health facilities which located in a zone far from the living room. In addition, it has external and internal staircase both of them lead to the upper floor, in the upper floor it can see nearly the same spaces that exist in ground floor, therefore, it is more likely to accommodate more than one family.

It has two entrances, the small one leads to the house's space while the big entrance leads to the garage. It used cement blocks for constructing external and internal walls with a thickness 20cm and roofing the house by reinforced concrete with a thickness15cm. It is well known that the concrete materials have a high thermal mass, this leads to overheating of the indoor environment of the buildings. As a result, houses are too hot without assistance of an air-conditioner. This caused an excessive energy consumption of the built environment.

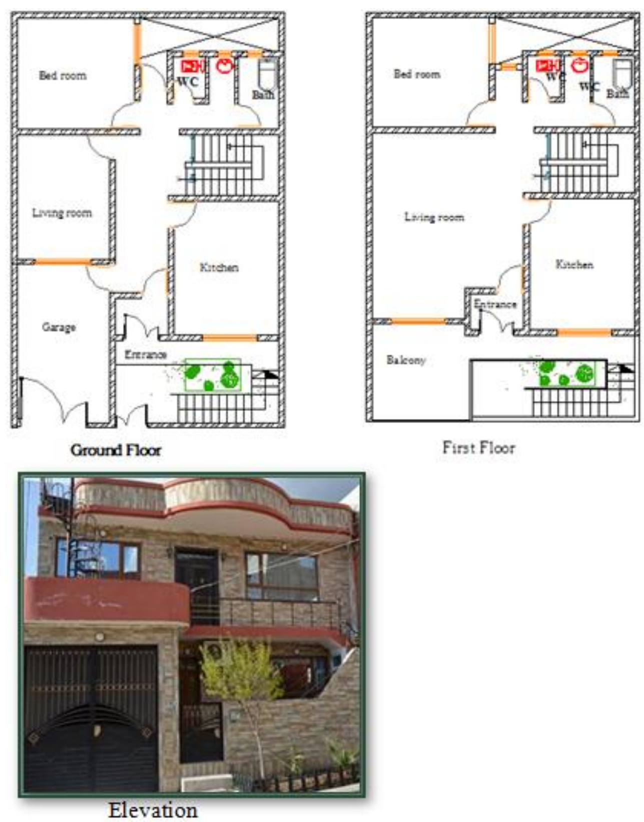


Fig. 7: Shows plans and elevation of contemporary house type [Source: Author].

**Iwan:is a hall covered three wall and only the fourth is completely open.*

TABLE I: The Characteristics of Traditional and Contemporary House in hot and dry region

Parameters	Tradition House	...	Contemporary House
Location	Urban center	...	Urban center
Building construction	Roof : Flat Roof made of wood and thick layer of compressed soil. External Wall: 60cm mud Brick wall. Internal Wall: 40cm mud Brick wall. Column : Wood Floor : Brick tile Door &Window: Wood door and windows with one pane glazing Story : Tow story Height of ceiling: 2.8 m	...	Roof : Flat Roof made of Reinforce concrete. External Wall: 20cm Cement Block. Internal Wall: 20cm Cement Block. Column : Concrete Floor : Marble tile Door &Window: Aluminum door and window with one pane glazing Story : Tow story Height of ceiling: 2.8 m
Building appearance in accordance with ventilation	The roof made of cross-beams wood which cover with a thick layer of compressed soil to enable wind blows through the roof. It has front big yard.	...	Reinforced concrete roof which prevent wind blows through the roof. It has front small yard.
Building Orientation	South- East	...	South-East
Ventilation Characteristic	Vary open with Iwan. traditional construction (Brick, wood, compressed roof soil)		Vary open with modern construction (concrete, glass, etc)
Equipment	Electricity fan, and air conditioning are not necessary	...	Split unit usage for conditioning the house in summer and winter.

7. Methodology

The methodology used in this study is the Indoor Climate and Energy Software (IDA ICE), with data from measurements made on the assumption (Meteorology Authority in Sulaimani) height of 10m from ground level. Objects being compared are the traditional and contemporary houses in one of the old residential area in Sulaimani, Kurdistan. Assuming the same weather data at the hottest temperature (July) and coldest (January), and same orientation. While the building materials and wall thickness are aspects that distinguishes the measurements.

8. Result and Analysis

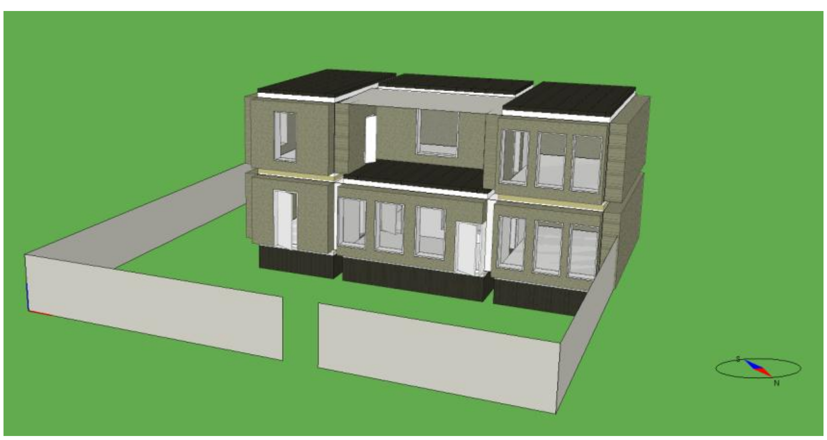


Fig. 8: Elevation of the traditional house. Original building simulation model [Source: Author].

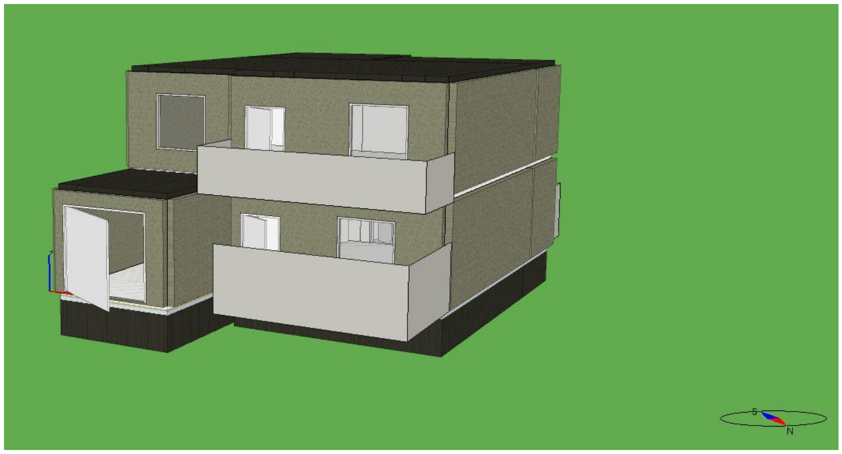


Fig. 9: Elevation of the contemporary house. Original building simulation model [Source: Author].

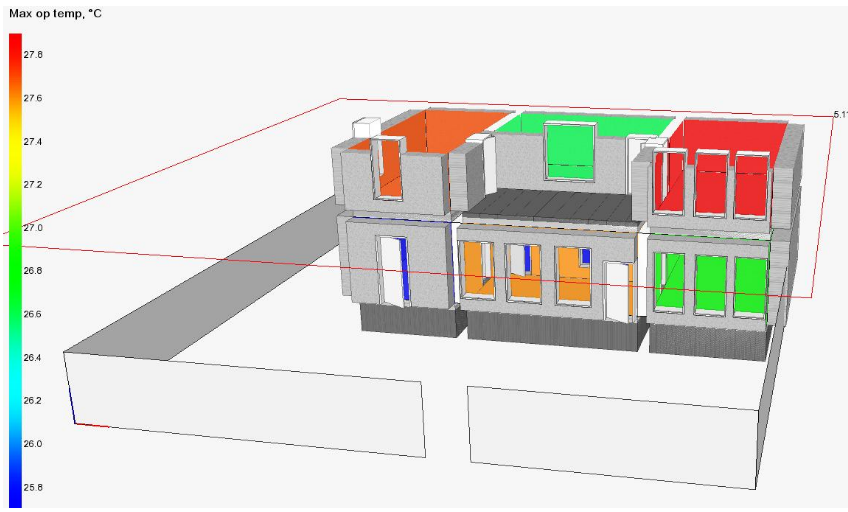


Fig. 10: Maximum operative temperature in the traditional house during occupancy (7/22/2015) 11:54 [Source: Author]

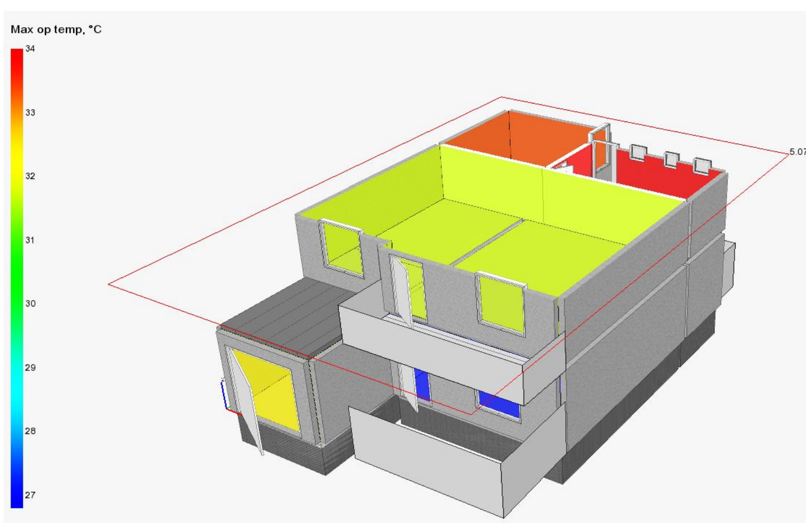


Fig. 11: Maximum operative temperature during occupancy (7/21/2015) 20:21[Source: Author].

The Maximum operative temperature in the traditional house in July is 27.8^0. While the Maximum operative temperature in the contemporary house in July is 34^0.

building1	Traditional house in the center of the city
building2	Contemporary house in the city center

Comfort Reference

	building1	building2
Percentage of hours when operative temperature is above 27°C in worst zone	0	18
Percentage of hours when operative temperature is above 27°C in average zone	0	9
Percentage of total occupant hours with thermal dissatisfaction	24	30

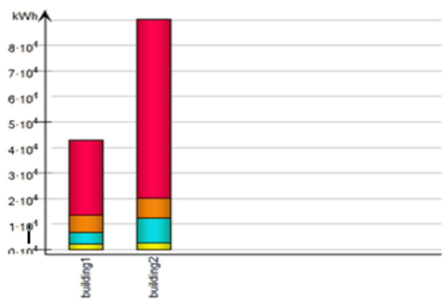
Best comfort per metered energy: building1

Supplied Energy

Meter Energy

		building1		building2	
		kWh	kWh/m²	kWh	kWh/m²
■	Lighting, facility	2095	13.2	2704	13.0
■	Electric cooling	4662	29.3	9587	46.2
■	HVAC aux	0	0.0	0	0.0
■	Electric heating	6923	43.6	7709	37.1
	Total, Facility electric	13680	86.0	20000	96.3
■	Fuel heating	29412	185.0	70002	337.1
	Total, Facility fuel*	29412	185.0	70002	337.1
	Total	43092	271.1	90002	433.4

*heating value

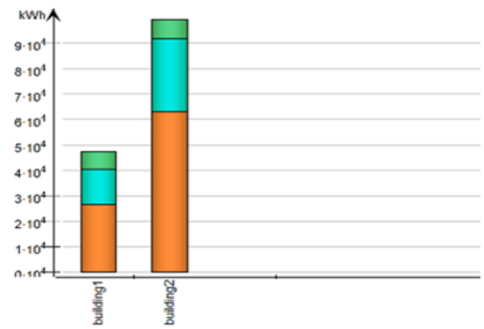


Systems Energy

Used energy

kWh

Case	Zone heating	Zone cooling	AHU heating	AHU cooling	Dom. hot water
	■	■	■	■	■
building1	26477.0	13983.4	0.0	0.0	6923.1
building2	62946.6	28756.7	0.0	0.0	7708.6

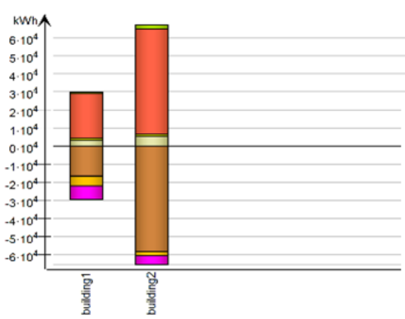


Energy for all zones (sensible only)

During heating

kWh

Case	Envelope & Thermal bridges	Internal Walls and Masses	Window & Solar	Mech. supply air	Infiltration & Openings	Occupants	Equipment	Lighting	Local heating units	Local cooling units	Net losses
	■	■	■	■	■	■	■	■	■	■	■
building1	-16582.5	-155.2	-5349.1	0.0	-7439.6	3348.4	0.0	1081.7	24562.9	0.0	955.2
building2	-58098.8	-154.9	-2390.1	0.0	-4850.9	5312.3	0.0	1358.9	57961.2	0.0	2461.4



During cooling

kWh

Case	Envelope & Thermal bridges	Internal Walls and Masses	Window & Solar	Mech. supply air	Infiltration & Openings	Occupants	Equipment	Lighting	Local heating units	Local cooling units	Net losses
	■	■	■	■	■	■	■	■	■	■	■
building1	2855.8	-215.4	6420.0	0.0	800.9	1656.3	0.0	803.1	0.0	-12354.7	0.1
building2	20228.4	-1802.3	3706.0	0.0	627.3	2231.0	0.0	1131.1	0.0	-26085.7	-27.0

Fig. 12: The results from comparative report between two house buildings [Source: Author].

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9. Conclusions

It can be concluded that the use of mud brick for external and internal as a building materials , window and door materials, roofing materials in traditional house proved to result in temperature and wind speed are comfort. The traditional house is cooler than the modern house during the day, This demonstrate the ability of traditional house to store heat at day to keep the rooms cool and release it at night to the space again.

10. Acknowledgements

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