International Journal of Sciences: Basic and Applied Research (IJSBAR)

ISSN 2307-4531
(Print & Online)

http://gssrr.org/index.php?journal=JournalOfBasicAndApplied

Enhance the Thermal Performance of Iraqi House using New Passive Systems in Summer Season

Prof. Dr. Jamal H. Waheb[a*], Taisir A. Yaseen[b]

[a,b]University of Anbar, Iraq
[a]Email: jamalwaheb@yahoo.com
[b]Email: taiseer.a.yaseen@gmail.com

Abstract

The hot summer season in Iraq where the ambient temperature may reach up to 50 ^{o}C make a necessary needing to use cooling device continuously. Cooling of the building by A/C system consumes more than 60 % of the total electricity supplied to residential building. So, there is really need to minimize the energy consumption by enhancement the performance of Iraqi buildings. It is looking for methods to increase the thermal performance of the building by increasing the resistance of walls, roofs and windows. This research presents theoretical and experimental study for the significance of passive cooling and the major factors effect on the amount of cooling load which are able to be controlled, from the analysis sufficient insulation system can save in annual cooling load for existing building by 35 %, where the indoor temperature in summer time could be reduced from 42 ^{o}C to about than 35 ^{o}C, and the contribution of windows in energy saving.

Keywords: insulation materials; passive use; solar energy.

1. Introduction

In hot climates in earlier day man had to protect himself against the temperature rise because there was no possibility to cool his living space by any artificial means.

----

* Corresponding author.

The average temperature in Iraq in summer (April to September) ranges between 40 ^oC to more than 50 ^oC. The high temperature range during summer time requires more energy consumption. Energy consumption of buildings depends essentially on the criteria used for the indoor environment; indoor environment additionally influences health, productivity and comfort of the occupants. Energy consumption is protected at low levels; however the proficiency of systems and their applicability is greatly improved

Reference [1] provided a complete guide to passive solar home, greenhouse, and building design, which illustrates many different applications of direct heat gain concepts for both commercial and residential buildings. In terms of building shape, he recommended, for all climates, that the optimal building is elongated in an east-west direction, resulting in more exposed surface area facing south. This configuration minimizes heating needed in winter and cooling in summer.

Imarori and his colleagues [2] explained a radiant cooling that is considered a passive cooling option and has even higher potential for energy and peak power saving. When radiant cooling is used with displacement ventilation, i.e., when ventilation air is introduced at low level, it flows by natural means to replace ventilation air; such a system has been suggested to offer quiet comfort and energy efficiency superior to that of conventional air-conditioning systems.

Mathur and his colleagues [3] investigated the effect of using a solar chimney for enhancing natural ventilation, they found that there was a tradeoff between the absorber inclination and stack height, experiments showed that the optimum absorber inclination angle varies from 40 to 60, depending on the latitude of the place, they compared the experimental results with the proposed mathematical model and found good agreement between the two.A flat plate was used by [4] for cooling eastern and southern walls of 1 m3 test room. The plate was stated in front of the wall with an air gap of 10 mm and it was extended underground to 1 m depth. The experimental data showed that the indoor temperature could be reduced from (34.5 °C) to (31.7°C) with a reduced percentage of (8.1%) when using aluminum plate. It was also found that when using glass wool insulation instead of air gap, the indoor temperature was reduced to (29.9 °C). A numerical simulation was performed using finite difference method and the sets of simulation equations were solved by Matlab program.

Reference [5] researched the performance of a glazed solar chimney for heat recovery in naturally-ventilated CFD program was validated against experimental information from the literature, and great agreement between the prediction and measurement was reported. The predicted ventilation rate is found to raise chimney wall temperature and heat gain.

Tetsu Kubota and his colleagues [6] examined the performance of night ventilation systems for private structures in the hot-damp atmosphere of Malaysia. They presumed the indoor humidity control during the daytime, such as by dehumidification, would be needed when the night ventilation method is applied to Malaysian terraced houses. Otherwise, full-day ventilation would be a superior choice compared with night ventilation

The aim of this research is to evaluate the possibility of used passive cooling system to reduce heat gain and reduce the internal temperature to a lesser extent possible.

2. Analysis

The energy balance through the walls describes the amount of heat transferred through the structure. Heat escapes from higher temperature outdoor to homes through walls, and ceilings. It is made efforts to reduce this heat by adding better insulation to walls and roofs. The conduction heat transfer through the walls and the roof can be calculated by:

$$Q_{cond} = U\,(T_o - T_i\,) \qquad (1)$$

Since the outdoor temperature (T_o) and indoor temperature (T_i) are dominated by the ambient or design features, so there are not considered as parameters of control by passive techniques. The overall heat transfer coefficient (U) is the only parameter that contributes to decrease the amount of heat transfer, and it depends on the resistance of construction materials and insulation layers used with [7]:

$$U = \frac{1}{\sum R} \qquad (2)$$

Where, the resistance for any layer could be calculated depending on the layer thickness (x) and the thermal conductivity (k) as following:

$$R = \frac{x}{k} \qquad (3)$$

The window provides direct solar radiation, natural lighting and natural ventilation The amount of heat loss or gain through the window is affected by following characteristics like: window glazing, window frame, thermal bridging, shading and air leakage. The heat transfer through the window included the effect of glass resistance as well as given:

$$Q_{wind} = U_w A_w.(t_{out} - t_{in}) + \text{SHGC}\;\; A_w.I \qquad (4)$$

3. Method and Materials

The basic requirement for thermal insulation is to provide a significant resistance path to the flow of heat through the building elements. To accomplish this, the insulation material must reduce the rate of heat transfer by conduction, convection and radiation, the recent experimental study suggested the extruded polyethylene (XPE) with reflected layer as a insulation material in order to evaluate the effect of insulation materials on the building performance. The experimental study was carried out in the building of Mechanical Engineering Department, Al-Mustansiriyah University in Baghdad (33.3^o N, 44.3^o E) during the period 3 May – 4 June 2015. The selected room was at the terrace floor of the building and located at the south-east corner where both south and east walls are exposed to direct solar radiation. The dimensions of the room are (4m x 4m x 3m), the insulation is purchased from local market which is the extruded polyethylene 1 cm layer with a reflected alu-foil, as shown in figure (1**).**

Figure 1: Insulation material

Measurements were made for all effective parameters in the building. Several thermometer sensors are used in different positions to measure indoor and outdoor temperatures. Also, some sensors are embedded into the walls or material surfaces to ensure temperature reading. Surface temperature sensors are connected to data logger system. Outdoor air readings are also compared with climatic data that obtained by Iraqi Meteorological Organization and Seismology (IMOS) [8]. Readings were taken for a period of several days before the insulation and for several days after the insulation. It is advised to take more stable readings into consideration. The insulated material is covered the exposed walls (eastern and southern) as well as the roof.

Figure 2: Room before and after insulatin

Windows that have been selected for this experiment have no overhang. The intensity of the radiation was measured by solar meter which was putted indoor beside the window. The effect of orientation were taken for all directions (east, west, north, south and horizontal),in study the effect of glass this experiment is to compare between two types of windows glazing: single glass and double glass. The reading were taken by a thermometer for a south-direction window and without overhang. The tested window (0.5 m^2) has two partitions; one was single layer (upper part) while the other (lower part) was covered manually by a second layer of glass (4 mm thickness) in order to compare in between at the same time, while in SHGC effect were compare between two types of windows: one of them was a transparent glass (clear), and other was colored glass. The colored glass is made manually by using adhesive sheet of blue transparent layer pasted on the glass from the inside, readings were taken by using thermometer and solar meter devices for a south orientated window without overhang, in shading effect , a comparison is done between the upper part and the lower part of a window with overhang located toward the south orientation. The dimensions of the overhang were (200 cm by 78 cm), the reading were taken by using solar meter and thermometer devices.

4. Results and Discussions

It is very important to measure the internal temperature of the walls and ceiling, because it gives a clear perception of the amount of transmitted heat by conduction to inside, as well as the amount of accumulated heat in the construction. Generally, the temperatures of the internal surfaces in the case of a thermal insulation is lower compared with that of conventional situation and the range of reduction is about (2^oC – 6^oC), as shown in figures (3) and (4). It should be noted that the cases tested at different duration in summer where the impact of ambient temperature and the solar radiation are variables.

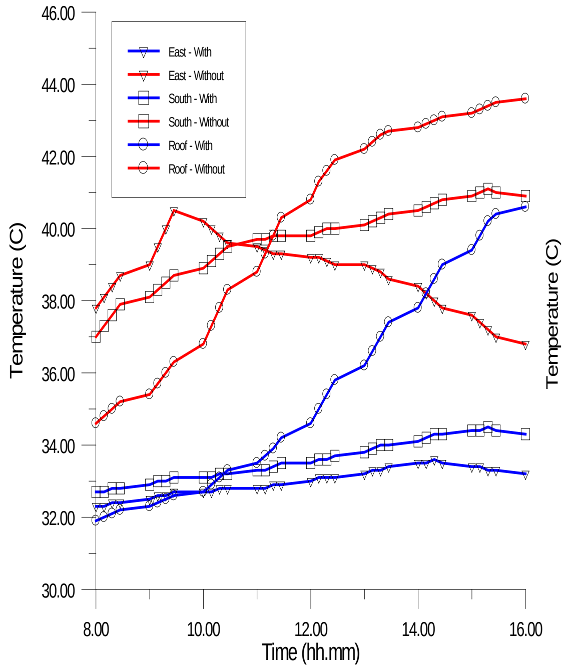

Figure 3: Variation of internal surface temperature

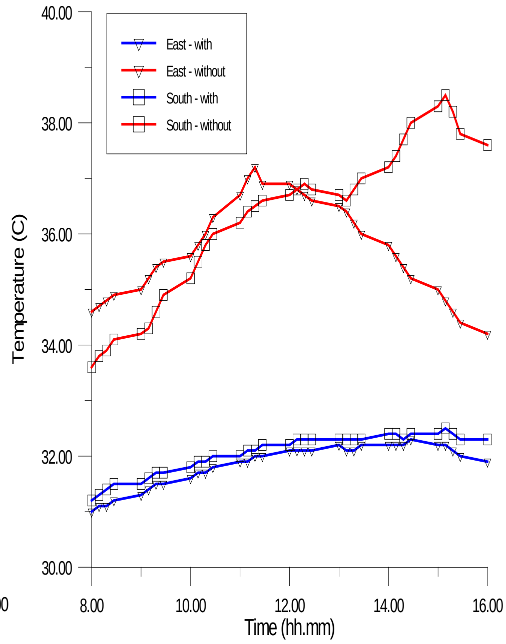

Figure 4: Variation of internal surface temperature

In recent years, windows have undergone a technological revolution. High-performance, energy-efficient window and glazing systems are now available that can dramatically cut energy consumption and pollution sources: they have lower heat loss, less air leakage, and minimize condensation.

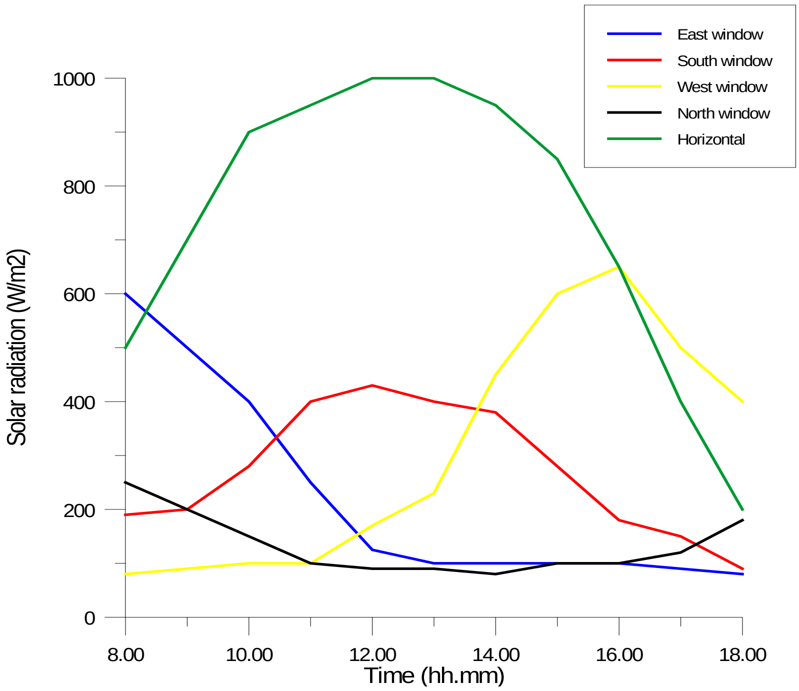

Figure 5: shows the effect of the orientation on the solar intensity reading for several windows in the local area (Baghdad). The readings for a horizontal surface have the maximum values because of continuous solar exposure, so that it is used as a reference of the amount of solar irradiance for certain location and time.

Figure 6 Effect of orientation on the local windows in Baghdad on 20-25/8/2015

Figure (6) shows a comparison between the thermal performances of conventional single glass window with an efficient double glass window. The results show that the fluctuating in the internal surface temperature of efficient window is small and the maximum temperature did not exceed 38^{o}C, while the internal surface temperature of conventional window was closed to 46^{o}C and highly fluctuating. It is clear that double glass window has less heat transmissibility, thus less temperature of internal surface which leads to minimize the load.

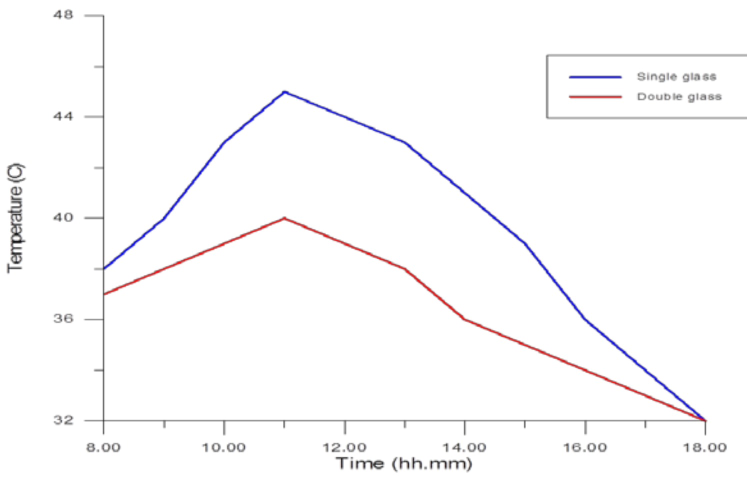

Figure 6: Comparison for internal surface temperature of window on 20/9/2015

Figure 7 show the comparison of thermal performances between conventional clear glass and one coated

by an opaque stick layer.

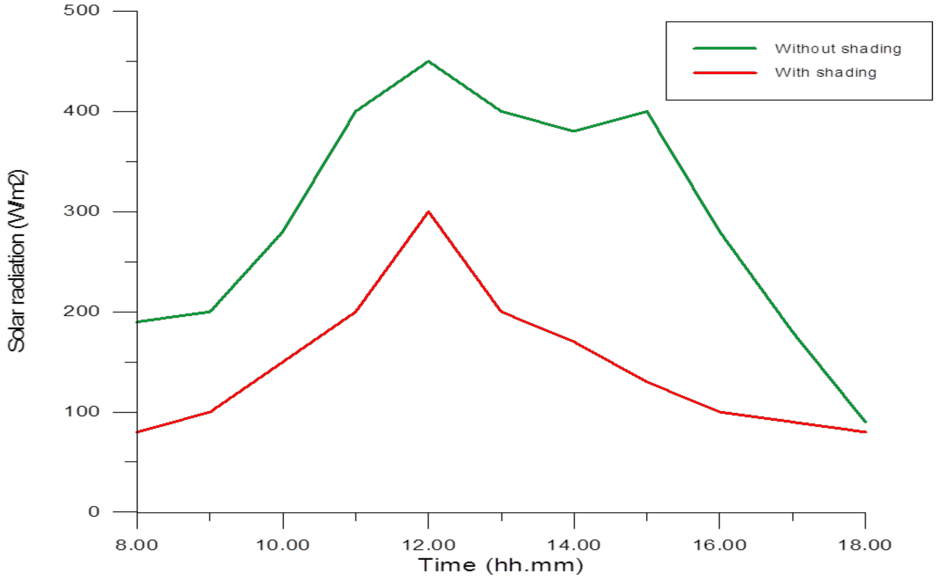

Figure 7: Effect of glass coating on the transferred radiation on 22/8/2015

In the present work, the effect of overhang shading on the internal surface temperature of the window is presented in figure (8). The overhang usually offers continuous shading upon the upper part of the window for the most daytime hours in summer unlike the lower part. The results show a decrease in the case of shading by 4^{o}C averagely.

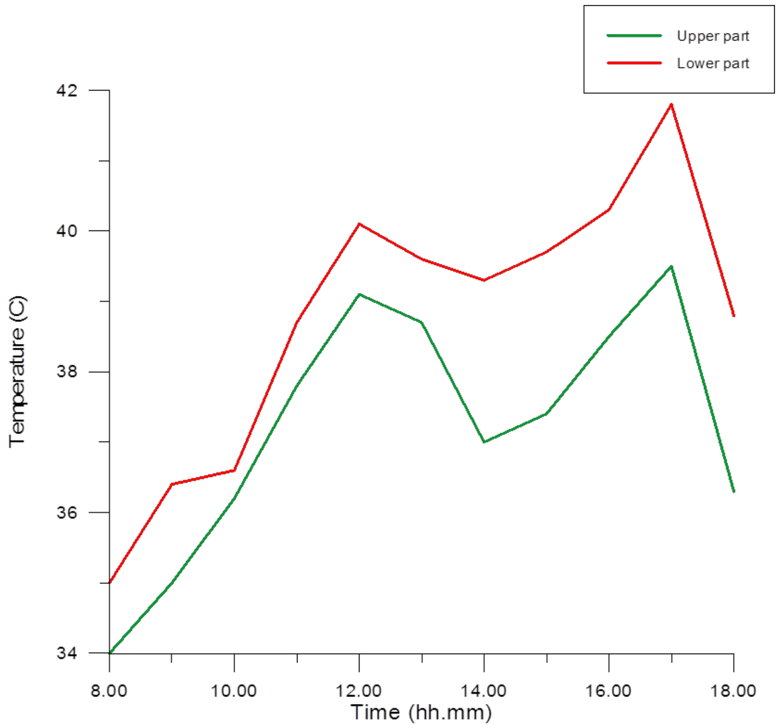

Figure 8: Effect of overhang shading on the performance of window (5/9/2015)

5. Conclusions

A comfortable house with passive techniques satisfies minimum energy consumption and green house effects. This project presents good ideas with successful solutions and suggestions of improving the performance of buildings and how passive techniques could be applied in Iraq, from the analysis sufficient insulation system can save in annual cooling load for existing building by 35 %, where the indoor temperature in summer time could be reduced from 42 ^{o}C to about than 35 ^{o}C, . Sufficient windows decrease the heat gained in summer by more than 50 % thus decrease the overheating by third.

Acknowledgements

First of all, thanks to Allah for great graces, help, and conciliation. Thanks to those who have commitment to complete this study and kind people with whom I had discussed during the research the head and staff of mechanical engineering department. I would like to express sincere thanks to my family specially Mom, Dad and my husband.

References

[1] Mazria, E.(1979), "Passive solar energy", Rodale Press, Emmaus.

[2] Imarori T, Omori, Bogaki K., "Thermal comfort and energy consumption of the radiant ceiling panel system: comparison with all air systems", Energy Build 1999;30:167-178.

[3] Mathur J, Bansal NK, Sanjay Mathur, Meenakshi Jain, Anupma., "Experimental investigation on solar chimney for room ventilation", Solar Energy 2006;80:927-935.

[4] Wathiq A., "Numerical and Experimental Investigation of the Geothermal Heat Sink Effect on Cooling Load of a Space", MSc Thesis, 2009, Al-Mustansiriyah University, Iraq.

[5] Thomas V., "Energy Efficient Building Design - Heat Gains and Losses: Roofs and Walls", Syllabus Notes, College of Architecture, Illinois Institute of Technology, Chicago, 2003.

[6] Tetsu Kubota a, Doris Toe HooiChyee, Supian Ahmed, "The effects of night ventilation technique on indoor thermal environment for residential buildings in hot-humid climate of Malaysia", Energy Build 2009;41: 829-830.

[7] Holman J., "Heat Transfer", 10th Ed. Book, McGraw-Hill Company, 2010

[8] Iraqi Meteorological Organization and Seismology (IMOS), Ministry of Transportation, Iraq, www.meteoseism.gov.iq.