Journal of Environment and Earth Science
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol. 3, No.1, 2013

Thermic Presentation of Uncovered Composed Coverings in Jordan's Hot Dry Desert Province (Southern Badya)

Abed Al-Zahiri and Mohammad Al-Rawashdeh

Civil Engineering Department, Zarqa University, tel:+962-5-3821100, fax: +962-5-3821120, P.O.Box: 132222, Zarqa, Jordan

*E-mail of the corresponding author: dr_abed_alzahiri@yahoo.com

Abstract

Thermic performance for any building in hot dry province depend on the external climatic factor, the ability of the construction materials used in gained heat through day time and loss this heat through night time through the nocturnal radiation. Covering is considered the major part of the building envelop which exposed to high thermic load due to the high solar intensity and high outside air temperature through summer which reach to 6 months. In Jordan the thermic effect of covering is increased as one go towards from north to south. This study evaluate the thermic performance of different test rooms with different coverings construction; non-insulated concrete, insulated concrete, double, plant, and active concrete coverings, built under the effect of external climatic condition of very hot and dry province in Jordan (Southern Badya province). The external climatic conditions and the temperature distribution inside the covering construction and the interior air temperature were measured. The results of this study recognized that the thermic transmittance (UValue) has a major role in choosing the built materials. Also the thermic insulation considered the suitable manner for damping the thermic stresses among day time and makes the interior environment of the building near the console zone during most months of the a whole year. Natural night and forced ventilation are more important in improving the internal conditions. The construction covering systems show that the interior air temperature thermic damping reach to 96%, 90%, 89%, and 76% for insulated concrete, double, planted and non-insulated concrete coverings. The results also investigate the importance of using the ground as a cooling source through the active concrete system.

Keywords: Thermic insulation, covering, double covering, green covering, shaded covering, building envelope, and thermic console.

1. Introduction

Southern Badya province is a desert province located in the south east of Jordanian. This province is very hot and dry province; it is about 500-1100 m above sea level. In such climate human console is crucial to provide the reasonable environment for people in this new community and save energy. The thermic response of building is defined as the reaction of the building envelope to some form of heat input and amount of internal loads. It depends mainly on the orientation, size, windows to wall ratio, also on the thermo-physical and optical properties of the building material, and on the external environmental conditions. A building envelope is defined as the separation between the interior and the exterior environments of a building. It serves as the outer shell to protect the interior environment as well as to facilitate its climate control. Building envelope design is a specialized area of architectural and engineering practice that draws from all areas of building science and interior climate control. Building envelope design includes four major performance objectives; structural integrity, moisture control, temperature control, and control of air pressure boundaries of sorts, control of air includes air movement through the components of the building envelope (interstitial) itself, as well as into and out of the interior space, which affects building insulation greatly. The physical components of the envelope include the foundation, covering, walls, doors and windows. The dimensions, performance and compatibility of materials, fabrication process and details, their connections and interactions are the main factors that determine the effectiveness and durability of the building enclosure system.

Common measures of the effectiveness of a building envelope include physical protection from weather and climate (console), interior air quality (cleanliness and public health), durability and energy efficiency. In order to achieve these objectives, all building enclosure systems must include a solid structure, a drainage plane, an air barrier, a thermic barrier, and may include a vapor barrier(Building envelopes, 2003).

Thermic console has been defined as "the condition of mind which expresses satisfaction with the environment". The interior environment should be designed and controlled so that occupants console and health are assured. Although console models mostly talks about interior climate but both interior and outside climate should be taken into consideration not only in urban design but also in buildings. So both interior and outside console is a matter of attention for architects and urbanizes. In console and climate study there are some problems that architect face and for designing a successful model it is best to know them which are; human factors, building factors, climatic factors. Thermic console can be discussed on building bioclimatic charts. Bioclimatic charts facilitate the analysis of the climate characteristics of a given location from the viewpoint of human console, as they present, on a psychometric chart, the concurrent combination of temperature and humidity at any given time. They can also specify building design guidelines to maximize interior console conditions when the building's interior is not mechanically conditioned.

All such charts are structured around, and refer to, the console zone (2 - 4). Figure (1) shows the bioclimatic chart for Southern Badya province through the very hot and dry period (July, August and September). The figure illustrates that it is important to tack all the available passive system (evaporative cooling, massive building, thermic insulation and shading) to help the outside condition to inter or nearest to console zone (Khalil et. al., 2010).

Ventilating the shaded covering increase the effect of the shading and movable shading help the usefulness of nocturnal radiation in night hours (Abd El-Razek and Khalil, 2003). Evaluating the external climatic conditions of Southern Badya province and evaluating the thermic performance of some traditional building built their, give us a picture view about the climate of Southern Badya and the periods of warm, hot and very hot in it. This study shows that using Sweileh sandstone in wall alone is not correct due to the high storage, high thermic mass and thermic conductivity of it. The study also shows that domes or vault built from concrete without using material with special thermic characteristics is not the good solution, and if dome hasn't top opening to loss the hot air, a hot heat island is found and led to disconsole (Khalil et. Al., 2010, Housing and Building National Research Center, 1999, & 2000). Other study developed a new building material with three line defense of thermic insulation used in walls and apply the concept of domes and vault with good thermic insulation help in valid the thermic console in building in Southern Badya province, and let the interior climate of the building to be within the console zone in the very hot and dry period in summer (Housing and Building National Research Center, 2004). More theoretical and experimental study was carried out using different passive approach; shading, insulation, covering pond, movable shading, and evaporative cooling for covering (14-20). All these studies show that applying different passive approaches help in improving the interior air temperature of building. Theoretical and experimental study was carried out to evaluate the thermic performance of building with different building envelope; in Mediterranean countries, these studies investigate that ventilating coverings have been widely used. Also the effect of covering tiles on the thermic performance of ventilated ducts were studied (D'Orazio et. Al., 2008), and indicate that the presence of air permeable layer and elements to protect the ventilation duct eliminate any difference in performance which were due to the cross section of the ventilation duct (D'Orazio et. Al., 2009). A theoretical study was carried out using the finite element model to investigate the thermic performance of non air conditioned buildings with vaulted covering and flat covering. It clears that building with a vault covering have lower interior air temperature compared to those with a flat covering , that is because such covering dissipate more heat by convection and thermic radiation at night due to the enlarged curved surfaces (Runsheng, Meir, and Wu, 2006).

Different insulation materials (mineral wool, polyurethane, and polystyrene) were used to evaluate the thermic performance of building for decreasing the thermic demand and heating and cooling load (Cabeza et. al., 2010). The usefulness of low earth temperature was discussed theoretically and experimentally to show the effect of earth-pipe –air heat exchanger systems in reducing the cooling load of building in summer (Bansal et al., 2010). When building envelope is considered as the main construction element, this will benefit the thermic performance of unconditioned building and also will save energy in conditioning building. Covering is considered the major part of the building envelope. In Jordan the thermic effect of covering is increased as one go towards from north to south. This study evaluates the thermic response of different covering construction under the effect of the external climatic conditions of Southern Badya province. The study was carried out in January as a warm season and in July, August and September as the very hot and dry period in summer.

2. Materials and Methods

Measurement for all the climatic factors and the thermic performance of all the rooms were recorded through different seasons to illustrate the thermic behavior of the rooms through the different climatic period. In order to compare the thermic behavior of different covering structure 4 full scale test rooms with different covering systems (non-insulated covering, insulated covering, double covering, green covering and active concrete covering) were built with internal dimension of 3.5x3.2x3m and measured under the external climatic conditions of Southern Badya province in winter and summers, which are the critical and important period. Table (1) shows the maximum, minimum, and means temperature and the upper limit temperature for thermic console in Southern Badya province (Khalil et. al., 2010). Figure (2) show photos for the test rooms with (a) double covering, (b) green covering, (c) active concrete covering and (d) the active concrete covering description. The test rooms were made up by a single volume in order to grant the same interior condition to all the coverings. Local building materials were used. The description of the coverings and their thermic characteristics are illustrated in table (2). To specify the effect of the covering only on the thermic performance of the interior air temperature, the walls of all the rooms were built from the same material, from 12.5cm hollow clay brick, an air cavity of 10cm and 20cm light sand block covered from outside and inside with 2.5cm plaster. All the walls are painted with white color. The description of the wall and its thermic characteristics were illustrated in the first report “Thermic performance of exposed coverings and walls for test rooms in desert area, Southern Badya province”. For measuring the thermic performance of the coverings, thermocouple of type T were installed in different position of the coverings (the exposed and the interior covering surfaces, and at the interface surfaces) and the interior air temperature. All these thermocouple were connected to a scan thermometer instrument to measure and recorded the temperature. Thermo-hygrometers were installed in the rooms to measure and recorded the interior air temperature and humidity. The outside climatic factor (outside air temperature, the relative humidity, and wind speed and direction and the solar intensities) were measured and recorded.

3. Results and Discussion

3.1 The Thermic Performance of the Rooms in Winter Season

Figure (3) shows the hourly temperature variation of the exposed covering, ceiling, internal layers and the interior air temperature of room with insulated covering through 26-30 January 2009 in Southern Badya province. The figure also illustrates the outside air temperature.

The outside air temperature varies between 31 ^{o}C as a maximum value and 10 ^{o}C as a minimum value, i.e. with a mean value about 20.5 ^{o}C. The figure illustrates the nearest between the exposed covering surface temperature and the interior surface between the tiles and the insulation layer, this due to the accumulation of the heat above the insulation layer. The exposed covering surface temperature reaches to a maximum value of about 46 ^{o}C and decreased to a minimum value of about 5 ^{o}C with a range of about 40 ^{o}C. The ceiling temperature varies between 26 and 18 ^{o}C with a range of about 8 ^{o}C. The figure also clears that the interior air temperature varies around 20 ^{o}C which is lies in the console zone. This figure illustrate that, the covering system with the insulating material prevent the warm interior air temperature losses to the outside environment through night time. The same results as given in Cabeza et. al., 2010.

Figure (4) shows the hourly temperature variation of the exposed covering, shaded covering, ceiling, internal surfaces and the interior air temperature of room with double covering through 26-30 January 2009 in Southern Badya province. The figure also illustrates the outside air temperature. The covering as described in Table (2) composed of 14cm concrete slab, 70 cm air gap and 10 cm concrete slab. The figure investigates the similarity in the temperature distribution of both the exposed and internal surface of concrete slabs and the shaded surface. The figure also shows the gradual decrease in the temperature from outside to inside. In night and early hours of the day, the temperature of the different surfaces nearest to each other, due to the thermic radiation loss and the loss of heat from both the slabs due to the flow of air between the two slabs (Abd El-Razek et. al., 2003). The temperature of the exposed slab concrete surface varies between 38 and 8 ^{o}C, while the concrete slab of the room varies between 29 and 12 ^{o}C. This high variation of both the exposed covering and the shaded covering , led to the variation swing of the ceiling by about 8 ^{o}C and help the interior air temperature to be within 18-22 ^{o}C , i.e. within the console zone.

This table shows that people in this province have the ability to live in higher temperature reach to 30 ^{o}C through the very hot period, which is due to their adjusted with this very hot environment. Also the low relative humidity plays a significant role in the response with console in high temperature, where evaporating sweat led to balance between the people skin and the surrounding environment (Olgyay, 1969, and Givoni, 1998).

From the table we show that the total thermic transmittance of the covering didn't affect by the passive means, but decrease by using thermic insulation.

With the double covering help the interior air temperature to fluctuate around 18^{o}C which is a reasonable temperature in this month of the year. Figure (5) shows the hourly temperature variation of the interior air temperature of test rooms with different covering structure; un-insulated, insulated, double, green and active concrete Covering through 23-27 Feb. 2011 in Southern Badya province. As before the figure also illustrates the outside air temperature. The figure illustrate that the outside air temperature varies in a range between 29 ^{o}C and 8 ^{o}C. The thermic behavior of both un-insulated and double covering nearest to each other. The green covering investigates the lower interior air temperature, due to the evaporation process by the effect of the covering heat storage. The figure also shows that the interior air temperature of all room varies around 18 ^{o}C.

Generally all the covering system valid an interior air temperature between 15-21 ^{o}C which is a comfortable temperature, else the green covering which can also be a suitable in winter season were the growth of grass is negligible in winter season.

3.2 The Thermic Performance of the Rooms in Winter Season

Fig (6) show the hourly temperature variation of the exposed insulated / un-insulated covering and ceiling of tow rooms and the outside air temperature in Southern Badya province through 18-21 Aug. 2011. The figure illustrate that the outside air temperature reach to a maximum value of about 40 ^{o}C at 15.00pm and decrease to reach minimum value of about of 22 ^{o}C at 5.00am with arrange of 18 ^{o}C. The outside air temperature still over 30 ^{o}C for 18 hours, which is 2/3 of the day hours and this led to case the thermic load and increase the heat stress on occupation.

The thermic performance of the exposed coverings are the same reach a maximum value at noon, but the insulated covering gives higher temperature value than the non-insulated covering. That is due to the Accumulation of heat in the tiles and mortar layers above the insulation layer. The difference between the two exposed coverings is about 10 ^{o}C, while at night and early hours of the day the temperature of the exposed un-insulated covering is approximately the same as the outside air temperature. The thermic performance of the two ceilings is different, where the ceiling temperature of the insulated covering is approximately stable around 33 ^{o}C, while the temperature of the ceiling of un-insulated covering has a wide swing of about 7.6 ^{o}C and has the same thermic performance of its exposed covering, reduced from it by about 12 ^{o}C and late by about 4 hours. The temperature of un-insulated ceiling rises above the insulated ceiling by about 7.5 ^{o}C. Finally the figure shows the importance of thermic insulation in prevent heat to flow through the covering layers during day time and save the ceiling temperature approximately constant (Abd El-Razek, Helal, and Khalil, 2003). Fig (7,8) show the hourly temperature variation of the exposed covering, ceiling , internal layers and the interior air temperature of room with insulated covering in Southern Badya province through 19-26 Aug. 2011. The figures also illustrate the outside air temperature. Figure (7) shows the distribution of the temperature through the covering in the period 19-26 Aug. 2011, where the room was closed. The figure illustrates that 18 ^{o}C due to the high solar intensity in that month which reach to about 1000W/m2 and still over 850 W/m2 for about 6 hours and also the accumulation of the heat in the external layer above the thermic insulation. The temperature variation of the layer below the thermic insulation and the ceiling has the same thermic behavior and approximately the same value. This result show that how the thermic insulation (10cm thick) stopped the passage of heat from the external layer to the interior layer (14cm thick concrete layer). Also the thermic insulation help the interior air temperature to fluctuate in a range of 2 ^{o}C.

This insulation layer valid an interior thermic damping about 88%. We can note that although the outside air temperature decreased to reach the console level in night and early hours of the day, the interior air temperature is still higher than the console level (the study case is closed windows). Therefore the effect of ventilation through night and early hours of the day was studding. Figure (8) shows this effect where the windows were opened from 10.00pm to 6.00 am (opened case study). It is clear from the figure that, the interior air temperature through the night and early hours of the day reach to the console zone, i.e. the natural night ventilation improve the interior air temperature through this time period and help the interior air temperature to be within the console province through most hours of the day. Also this effect may be improved by using fan which help in drawn the low outside air temperature to the interior. Figure (9) shows the hourly variation of the interior air temperature of room with active concrete system through 26-29 Aug. 2011 in Southern Badya province. The figure also illustrates the hourly variation of the outside air temperature through this time, which varies between 40.9 and 24 ^{o}C as a maximum the temperature of the exposed surface is very high and rise above the outside air temperature by about and a minimum temperature and with a range of about 17.3 ^{o}C. Due to the covering system with more steel to carry the water tube, the ceiling temperature raise, which in turn led to raise the interior air temperature to 36oC as a maximum value and with a mean value about 31 which is nearest too the upper limit of the console zone in this month of the year. In general the interior air temperature of the room is comfortable for about 9 hours of the day wherever it is closed and this test carried out in a very hot and dry time in Southern Badya.

The figure illustrate that the interior air temperature vary in a big range about 5 ^{o}C due to the flow of water in the covering tube, which withdraw some of the heat storage of the concrete slab of the covering without using any protection like shading or insulation. Also the interior air temperature can be improved by using good thermic conductivity tube material like stanlistail and usefulness from the natural ventilation through night and early hours of the day.

Figure (10) shows the hourly variation of the interior air temperature of 4 rooms with different system covering structure through 14-17 Aug. 2011 in Southern Badya province. The figure also illustrates the hourly variation of the outside air temperature through this time. The figure clears that the outside air temperature varies between 35 ^{o}C & 39 ^{o}C as a maximum value and between 21 ^{o}C & 22 ^{o}C as a minimum value. The coverings systems are insulated / non-insulated double and green coverings. The figure shows that the interior air temperatures of all rooms have the same thermic performance but differ in their values and time lag. The figure illustrate that room with non-insulated covering valid the worst one where the maximum interior air temperature varies
between 33.2 ^{o}C & 35 ^{o}C and in the same time room with green covering appear as the best one where its interior air temperature varies between 25.3 ^{o}C & 31.3 ^{o}C i.e. the interior air temperature of this room is within the console zone. The figure also shows that the interior air temperature of rooms with thermic insulation and double coverings nearest to each other. For all the rooms the effect of natural night ventilation is appear on the interior air temperature,
where about half of the day hours is less than 28 ^{o}C and the other half lay near the console zone.

CONCLUSIONS

The results of this investigation show that:

1. All the rooms with different covering systems valid an interior air temperature between 17-23 ^{o}C which is a comfortable temperature in winter season.
2. As the green covering investigates the lower interior air temperature, due to the evaporation process by the effect of the covering heat storage, it is required suitable in winter season were the growth of grass is negligible in winter season.
3. The importance of thermic insulation in prevents heat to flow through the covering layers during day time in summer and vice verse in winter season. Also using thermic insulation save the ceiling temperature approximately constant and help in saving energy.

4. Double covering system helps the interior air temperature to fluctuate around 18 ^{o}C which is a reasonable temperature in winter season, i.e. shading the covering is also suitable in winter season, where it decrease the loss of heat by nocturnal radiation through night time.

5. In summer natural night ventilation help the interior air temperature to be within the console zone through most hours of the day.

6. Using fan improved the effect of natural night ventilation and increased the draw of the moderate outside air temperature to the interior of the rooms

7. The interior air temperature of room with active concrete can improved by shading this covering and using good thermic conductivity tube material like stanlistail.

8. The construction covering systems show that the interior air temperature thermic damping reach to 96%, 90%, 89%, and 76% for insulated concrete, double, planted and non-insulated concrete coverings.

9. Continues of outside air temperature more than 30 ^{o}C for about 18 hours in the day is the case of didn't improve the interior air temperature, so reducing the outside air a temperature before interring the building is more important to improving the interior air temperature

References

Ahmad, A. M., 1975, "The Thermal Performance of Concrete Roofs and Reed shading Panel Under Arid Summer Conditions", *Overseas Building Notes*, BRE, No.164, October.

Abd El-Razek, Helal M.M, and M.H. Khalil, 2003. "The Effect of Nocturnal Radiation on the Indoor Climate of Desert Architecture", *Al-azhar Engineering 7th International Conference*, Cairo, Egypt, 7-10 April, 248-259.

Bansal V., R. Misra, G. Das Agrawal, J. Mathur. 2010. "Performance analysis of earth–pipe–air heat exchanger for summer cooling", *Energy and Buildings*, 42(5), 645-648.

Building Envolopes. 2003. Building Envolopes, Innovation in Building Envelopes and Environmental Systems. http:www. buildingenvelopes.org

Cabeza, L.F., A. Castell, M. Medrano, G. Pérez, I. Fernández. 2010. Experimental study on the performance of insulation materials in Mediterranean construction, *Energy and Buildings*, 42(5), 630-636.

Chandra S., and Chandra S., 1983. "Temperature Control in a Building with Evaporative Cooling and Variable Ventilation", *Solar Energy*, 30(4), 381-387.

D'Orazio, M., C. Di Perna, P. Principi, and A. Stazi, 2008. "Effect of Roof Tile on the Thermal Performance of Ventilated Roofs: Analysis of Anunual Performance", *Energy and Building*, 40, 911-916.

D'Orazio, M., C. Di Perna, E. Di Giuseppe, 2010. "The Effect of Roof Covering on the Thermal Performance of Highly Insulated Roofs in Mediterranean Climates", *Energy and Building*, 42(10), 1619-1627.

Givoni, B. 1998. "Climatic Consideration in Building and Urban Design", Library of congress Cataloguing in Publication Data, C.

Hanna G.B. and M.H. Khalil, 1984, "Computer Simulation and Thermal measurements of Roofs", *Canada's*

Second International Energy Conference, Regina, Saskatchewan.

Housing and Building National Research Center, 1999. “First Report 1999, Bioclimatic Studies of Toshky Regionand Evaluation of Thermal Performance Rates for some Models Implementing the Region”, Cairo, Egypt, June.

Housing and Building National Research Center, 2000. “Third Report 2000, Bioclimatic Studies of Toshky Region and Evaluation of Thermal Performance Rates for some Models Implementing the Region”, Cairo, Egypt, Febrary.

Housing and Building National Research Center, 2004. “Second Report 2004. Developing an Effective System Building in the Desert Area in Egypt (Toshky Region)”, Cairo, Egypt.

Jain, S. P and K.R. Rao, 1974. "Movable Roof Insulation in Hot Climates", *Building Research and Practice*, 2(4), July/August.

Khalil M.H.1984. "Theoretical and Experimental thermal Investigation for A Number of Rooms with the use of insulated Roofs and External shading Devices", M. Sc., Thesis, Cairo University.

Khalil M.H. 2007. “Theoretical and Experimental Investigation of the Thermal Performance of A Pre-Fabricated Concrete Flat In 15 May City”, *HBRC Journal* 3(1), 150-164.

Khalil, M. H. , Sheble S.S., Morsy M. S. and S. Fakhry, 2010. “Thermal Performance of Exposed Composed Roofs in Very Hot Dry Desert Region in Egypt (Toshky)”, *Proceedings of the Tenth International Conference for Enhanced Building Operations, Kuwait,* October 26-28, 2010

Mansour Abd El N. 2002. “A study about the type and methods of Heat Insulation using Available Materials in Egypt”, Master’s Thesis. Al Azhar Unviersity, Faculty of Engineering, Civil Engineering Department.

Mukhtar, Y. A., 1978, "Roofs in Hot Dry Climates, with Special Reference to Northern Sudan ", *Overseas Building Notes*, BRE, No. 182, October.

Nayak, J. K., A. Srivastava, U. Singh, and M.S. Sodha, 1982. "The Relative Performance of Different Approaches to the passive Cooling of Roofs.” *Building and Environment* (187) 2, 145-161.

Novell, B. J. 1983. Passive Cooling Strategies, “A design Method, Based on Monthly Average Temperatures, has been Developed to Approximate the Need for Shading and other Stratgies”, *ASHRAR Journal*, Dec.

Olgyay V. 1969. Design with Climate, Princeton University, third edition, U K.

Runsheng, T., I.A. Meir, , and T., Wu, 2006. “Thermal Performance of non air – conditioned buildings with vaulted roofs in comparison with flat roofs”, *Building and Environment*, 41(3), 268-276.

Sodha M.S., A.K. Khatry and M.A.S. Malik. 1978. “Reduction of Heat Flux Through A Roof by Water Film”, *Solar Energy*, 20, 189-191.

Sodha, M.S., U. Singh, and G.N. Tiwari, 1982. "A Thermal Model of a pond System with Movable Insulation for Heating A Building", *Build. and Env.*, 187(2), 135-144.

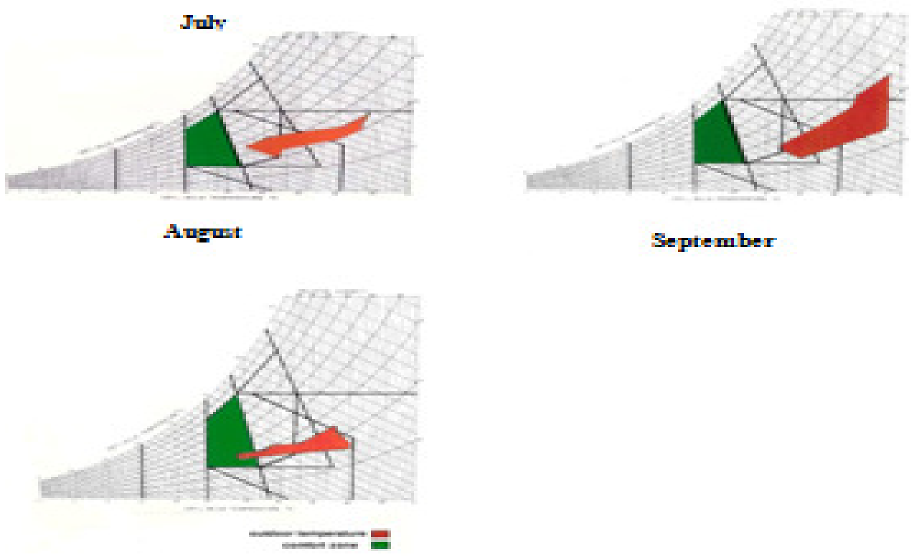

Figure 1. Bioclimatic Analysis of Southern Badya Area Through the Hot and Dry Period.

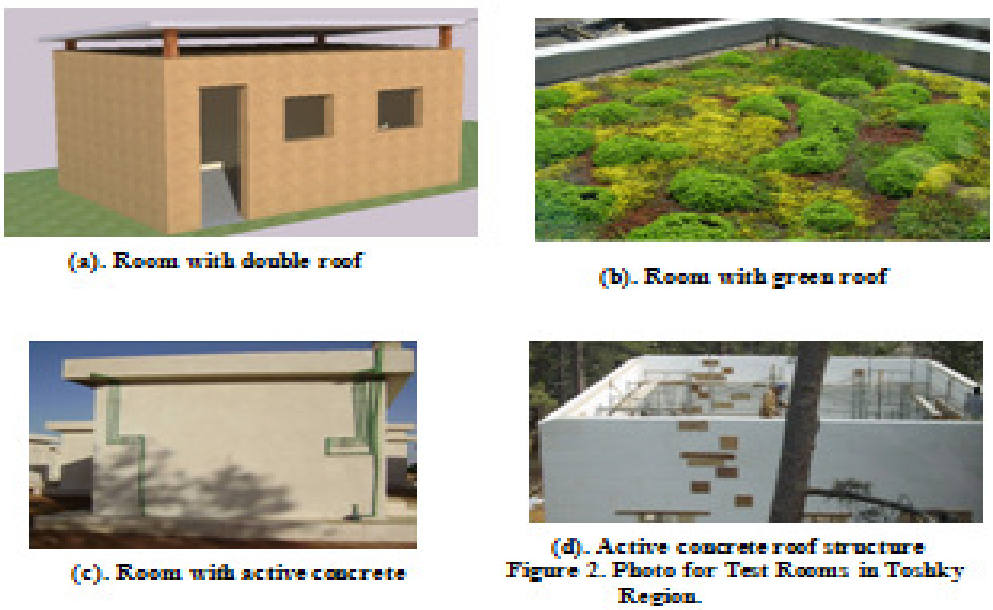

Figure 2. Photo for Test Rooms in Southern Badya Area.

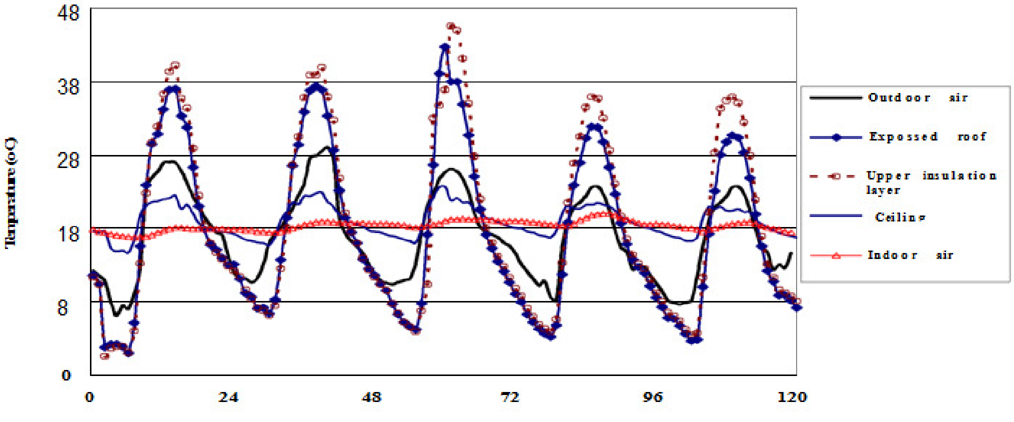

Figure 3. The hourly temperature variation of the exposed roof, ceiling, internal layer and the indoor air temperature of room with insulated roof through 20-25 February 2011 in Southern Badya of Jordan temperature of room with insulated covering through 23-27 February 2011 in Southern Badya province.

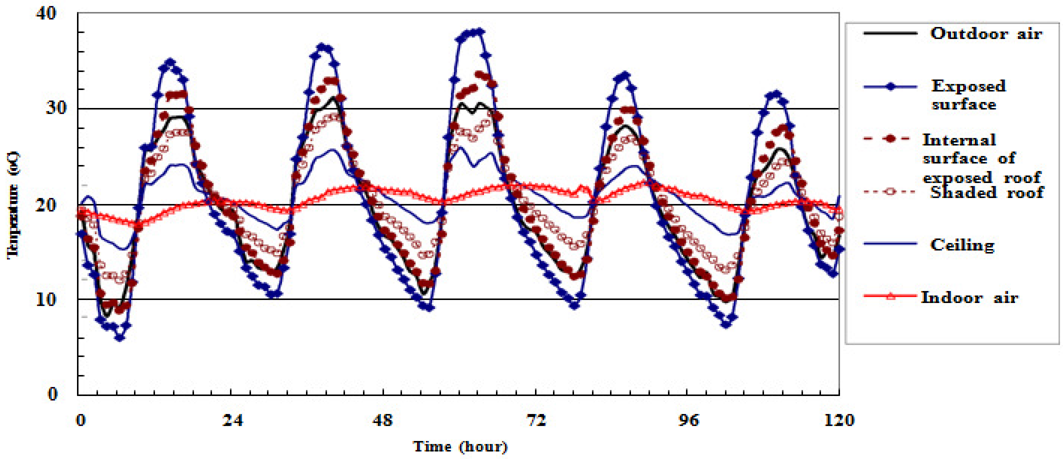

Figure 4. The Hourly Temperature Variation of the Exposed Roof, Shaded Roof, Ceiling, Internal Surfaces and Indoor Air Temperature of Room with Double Roof through 20-25 febuary 2011.

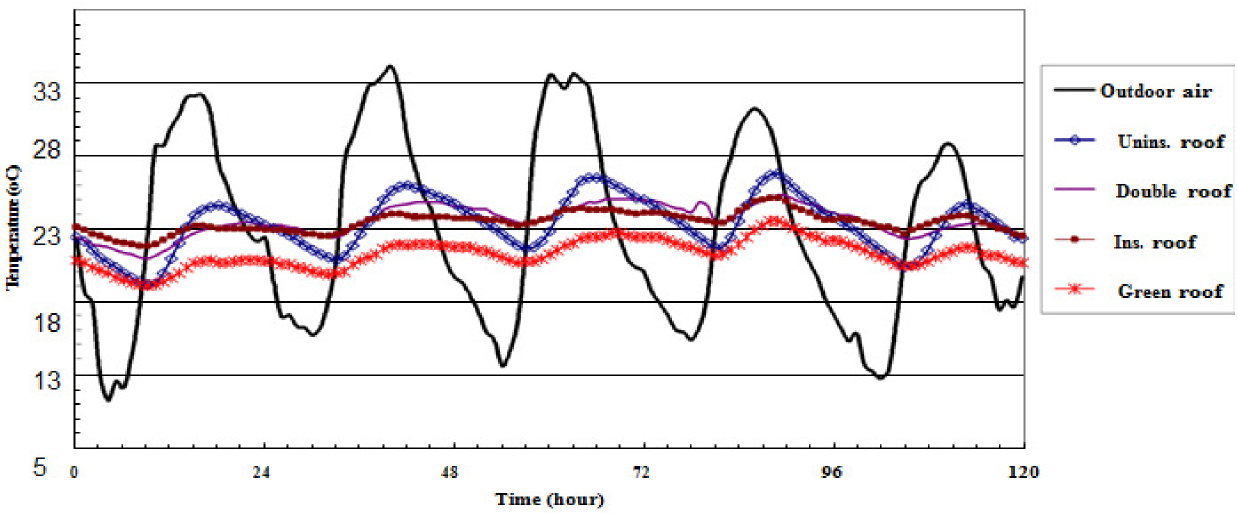

Figure 5. The Hourly Temperature Variation of the Interior Air Temperature of Test Rooms with Different Covering Structure; Un-insulated, Insulated, Double, Green Covering through 20-25 February 2011.

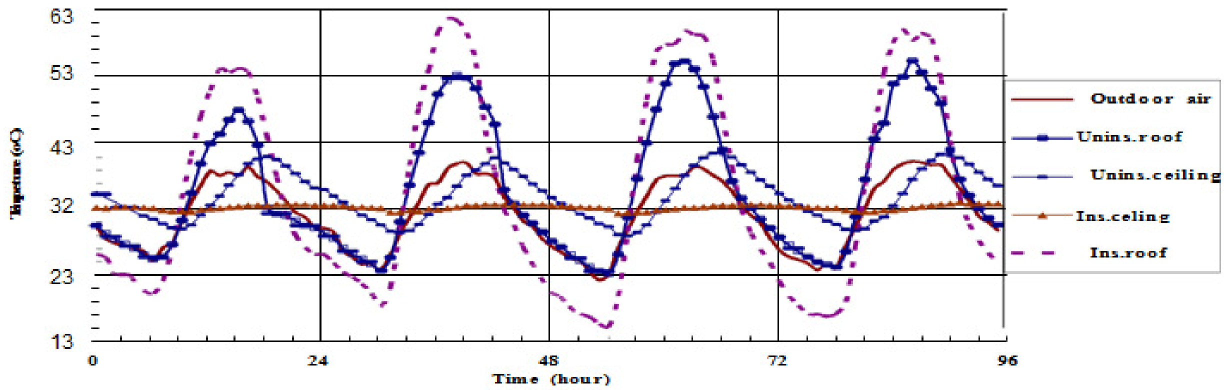

Figure 6. The Hourly Temperature Variation of the Exposed Insulated / Un-insulated Covering and Ceiling of Tow Rooms and the Outside Air Temperature through 20-23 August 2011.

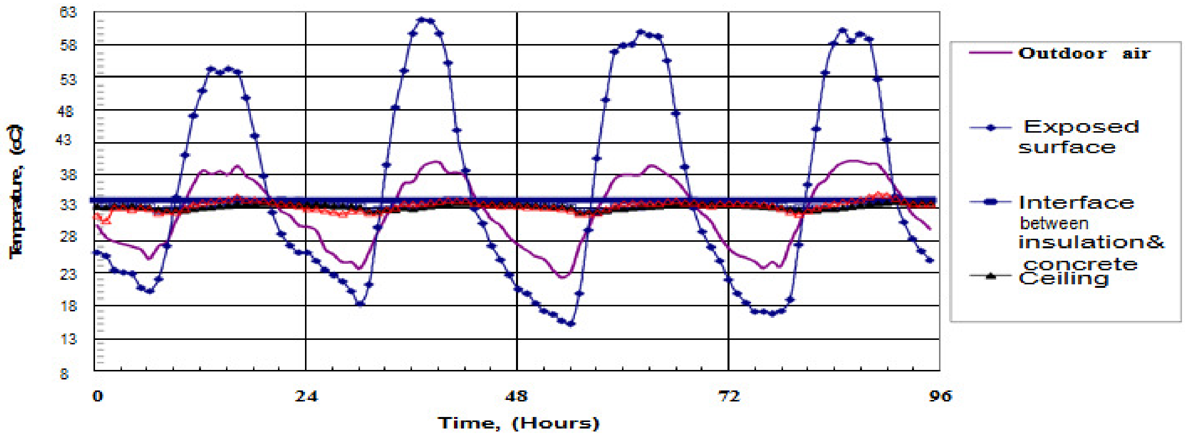

Figure 7. The Hourly Temperature Variation of the Exposed Covering, Ceiling , Internal Layers and the Interior Air Temperature of Room with Insulated Covering through 20-23 August 2011(Closed case).

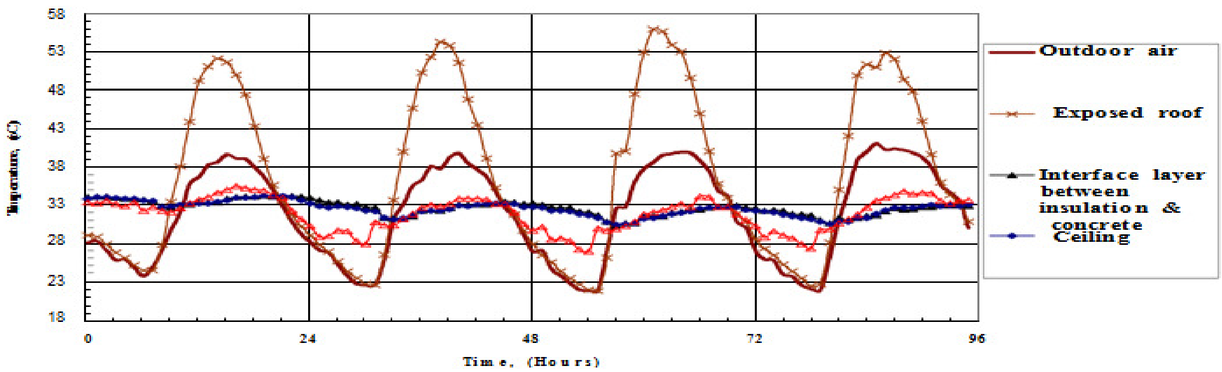

Figure 8. The Hourly Temperature Variation of the Exposed Covering, Ceiling , Internal Layers and the Interior Air Temperature of Room with Insulated Covering. through 22-25 August 2011 (Opened case)

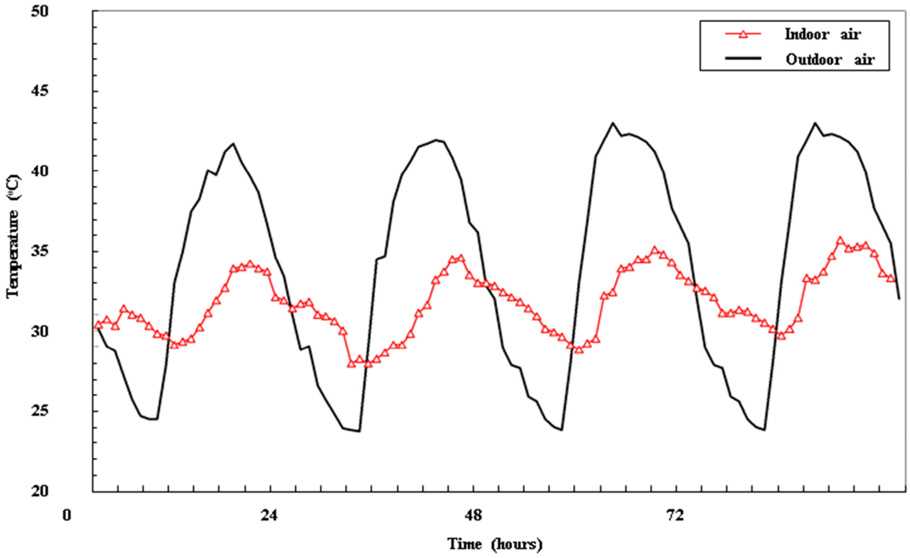

Figure 9. The Hourly Temperature Variation of the Indoor Air Temperature of Room with Active Concrete Through 23-26 Aug.2011.

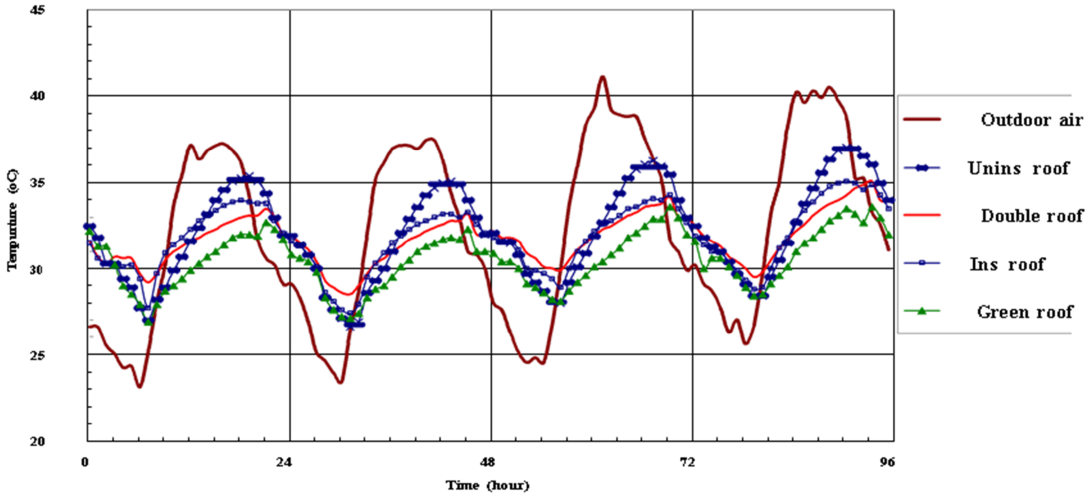

Fig. 10 The Hourly Variation of the Indoor Air Temperature of 4 Rooms with Different System Roof Structure Through 14-17 Aug. 2011 in Southern Badya.

Table 1. Maximum, Minimum and Mean Temperature and the Upper Limit for Thermal Comfort in Southern Badya Region.

Temperature	Month					
	May	June	July	August	September	October.
Maximum	38.6	38.4	41.2	44.3	41.3	38
Minimum	23	24	25	26	24	23
Mean	30.7	31.1	31.1	35.1	32.6	30.3
Upper Limit for Comfort	28.2	28.2	29.6	30.6	29.3	28.1

Table 2. The Roofs Description of the Test Rooms Built in Toshky Region and Their Thermal Properties and Characteristics.

No.	**Building materials used**	**Thickness**	**Thermal Conductivity**	**U-Value**	**R-Value**
		cm	W/m °C	W/ m^2 °C	m^2 °C/W
1.	Concrete slab	14	1.73	2.35	0.426
	Internal plaster	2.5	0.727		
	Gypsum layer	3	0.38		
2.	Concrete slab	10	1.73	1.9522	0.5122
	Air gap	70	-		
	Concrete slab	14	1.73		
	Internal plaster	2.5	0.727		
	Gypsum layer	3	0.38		
3.	Mortar	5	0.8	0.274	3.65
	Dry sand	5	0.59		
	Thermal insulation	14	1.73		
	Concrete slab	14	1.73		
	Internal plaster	2.5	0.727		
	Gypsum layer	3	0.38		
4.	Concrete slab	14	1.73	2.35	0.426
	Internal plaster	2.5	0.727		
	Gypsum layer	3	0.38		
	0.5inch propapline				
5.	Concrete slab	14	1.73	2.35	0.426
	Internal plaster	2.5	0.727		
	Gypsum layer	3	0.38		
	Vegetative roof				