EXPERIMENTAL STUDY OF A TYPICAL IRAQI WALL THERMAL PERFORMANCE WITH Q-BOND INSULATION IN WINTER CONDITIONS

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ABSTRACT

In this work, an experimental study was designed and conducted to investigate the effect of using Q-bond panels on a typical wall at Iraqi local winter conditions. The Q-bond panel's dimensions were 1 m^2 x 3 mm thickness. An air gap of 5cm is made between the wall and Q-bond panel. A through temperature measurements were made on both sides of the wall with and without using Q-bond panel all over 10 hours for different weather conditions (sunny , Partly clouded and runny days) on 2 , 5 , and 16 December 2010 respectively, and also for complete two days (24 hours) on 23-24 December 2010(sunny days). A point located in the middle of the wall face was found to be the most representative. The measured amplitude of the inside wall temperature variation with Q-bond was less than that for the same wall without the Q-bond.

NOMENCLUCHERS

T_1	Outside wall temperature
T_2	Air gap temperature
T_3	Inside wall temperature
T_4	Atmosphere temperature in shadow
N	Sequence points
X_k	Amplitude
x_n	Amplitude
W_n	Frequency
j	Complex number
k	Number of sequence points

دراسة عملية لاداء عزل لنموذج جدارعراقي باستخدام عازل الكيوبوند في ظروف الشتاء

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مدرس مساعد/ هيئة التعليم التقني /الكلية التقنية–بغداد

الموجز

تم في هذا البحث إجراء دراسة عملية لاستخدام عازل الكيو بوند المستخدم في تغليف الجداران في ظروف الشتاء لتقليل الحمل الحراري المفقود من خلال الجدار. تم استخدام عازل الكيو بوند بإبعاد ١ م٢ وبسمك مقداره ٣ ملم . تم عمل فراغ هوائي بين عازل الكيو بوند و الجدار بمقدار ٥ سم .تمت قراءة درجات الحرارة الداخلية والخارجية على جانبي الجدار بحالتين باستخدام عازل الكيو بوند وبدونه لمدة ١٠ ساعات

لظروف مناخية مختلفة (صحومشمس ، غائم جزئي و غائم ممطر) لايام ٢، ٥، ١٦-١٢-٢٠١٠ على التوالي ، و كذلك لمدة ٢٤ ساعة ليومي ٢٣ و ٢٤ -١٢-٢٠١٠ (صحو مشمس). أفضل نقطة للقراءات وجدت في منتصف وجه الحائط. قمة الموجة لدرجة الحرارة الداخلية للجدار باستخدام عازل الكيو بوند اقل بالمقارنة مع قمة الموجة لدرجة الحرارة الداخلية للجدار بدون استخدام عازل الكيو بوند لنفس تردد الدورة بالساعة.

INTRODUCTION

Thermal Insulation is an essential part of almost all buildings since it gives many advantages. Human race lives in a hostile environment. The degree of hostility varies from season to season and with the geographical area. For this reason mankind has to provide a comfortable environment for his living. In cold climate for example, heat should be added to the room to make the environment suitable for human comfort [٢]. Thermal insulations normally consist of the following basic materials and composites:: Inorganic, fibrous, or cellular aterials such as glass, rock, or slag wool; and calcium silicate, bonded perlite, vermiculite, and ceramic products. Asbestos insulations used to be applied, but asbestos has been shown to be a carcinogen. Extreme caution must be used if it is encountered [٤]

Thermal resistance of an enclosed airspace Ra has a significant effect on the total thermal resistance RT of the building envelope, especially when the value of RT is low. Thermal resistance Ra depends on the characteristic of the surface (reflective or non reflective), the mean temperature, the temperature difference of the surfaces perpendicular to heat flow, the width across the airspace along the heat flow, and the direction of airflow[١٠].

As the air cavity between the wall leaves or the roof and ceiling increases so does the degree of noise reduction. This concept is similar with other building elements such as double glazed windows. Where double glazing is also used for thermal efficiency the size of the air cavity may be determined by the required level of thermal efficiency as increasing the cavity size decreases the thermal effectiveness of the glazing.

(**Boeran, 1971**) [٦] used the matrix method to calculate the solar heat gain through roofs and walls , under assumption that both solar radiation and external temperature go daily through a similar period cycle , and that this cycle was periodic sinusoidal for both quantities.

(**Thomas W. Petrie, 2001**) [١١] Results are given from a field investigation of side-by-side houses in Knoxville,Tennessee. The houses were identical except one had insulating concrete form (ICF) exterior.

(**G. Baldinelli, 2010**) [٧] walls and the other had conventional wood-framed exterior walls. An outdoor experimental apparatus (a structure) was built combining in situ environmental conditions with common laboratory setups; the purpose is that of evaluating the ‘‘in situ’’ thermo physical properties (stationary and dynamic) of the radiant barrier-air gap system alone in vertical walls. Measurements were done in central Italy, during the summer, on the hottest days of July and August, thus exposing surveys to strongly variable outdoor conditions.

(**SALIHUDDIN RADIN SUMADI, 2008**)[٩] The development and construction of lightweight pre-fabricated sandwich structural elements in building construction is a growing trend in construction industry all over the world due to its high strength-to-weight ratio, reduced weight, and good thermal insulation characteristics. Sandwich construction element consists of thin face sheets or encasement of high performance material and a thick, lightweight and low strength material as core. Ferrocement is regarded as highly versatile thin material possessing superior properties which cannot be matched by other conventional thin materials.

(**A Abela, 2006**) [١] investigate and study how insulating materials used in local construction methods may enhance the thermal performance of a typical Maltese building envelope. The study provides a practical insight on how various insulation options within the cavity of a globigerina limestone and concrete block work wall affects the U-Value of the wall. This study investigates insulation materials such as expanded polystyrene, stone wool, glass wool with/without a reflective coating.

(**Ammar BOUCHAIR, 2008**) [٣] investigates the analytical assessment of the insulation capacity of external cavity walls made with different arrangements of holes with and without insulation material. The thermal analysis of the different fired clay hollow bricks was carried out using a steady state model which was developed by the author.
The minimum width of cavity in cavity wall construction which is acoustically beneficial is 50mm. wider cavities will improve low frequency performance. Increasing the size of a cavity also allows thicker acoustic insulation to be installed, achieving an increased level of sound insulation. It is important to note that there is no maximum cavity width for brick veneer walling however cavity wall construction has a maximum of 65 mm. [٥]

EXPERIMENTAL WORK

The wall is constructed from common brick. An iron frame made from square iron pipe of 5cm * 5cm cross sectional area is riveted to the wall. The Q-bond insulation (which is consists from layers of aluminum and rubber) is riveted to the iron frame producing an air gap between the Q- bond insulation and the wall. The surface area of the whole construction is 1 m^2. The temperature readings were taken for four points lined on the center line of the wall for both cases (with and without Q- bond thermal insulation). The measurement were made at the outside (T_1), air gap (T_2), and inside wall faces (T_3) as shown in **Figure 1**.
Temperature readings were taking for 10 hours for different weather conditions (sunny, Partly clouded and runny days) on 2, 5, and 16 December 2010 respectively. By comparing the results between the four points the variation was found small and can be neglected. Hence; point (2) was chosen as a representation through out a measurements made during rain, sunny, and partially clouded days as **Figures 2 to 5**.
These readings showed that the center point can be practically chosen to predict the performance since it is sufficiently far from edges and less affected by dimensionality.
After these preparations, the readings of point (2) for (24) hours with and without Q-bond on 23 to 24-December -2010 (sunny day) were conducted.
Since the temperature variations have cyclic nature, the Fast Fourier Transform Algorithms (FFT) [٨] was used to analyze the results obtained for two cases with and without using Q-bond thermal insulation by using Microsoft Excel to solve the equations of (FFT) as shown below:

1. the DFT of an N-point sequence $\{X_k\}$ is defined as:

$$X_k = \sum_{n=0}^{N-1} x_n e^{-j2\Pi kn/N}, k = 0,1,2,......, N-1 \tag{1}$$

2. The inverse DFT of the sequence $\{X_n\}$ is given by:

$$x_n = \frac{1}{N}\sum_{k=0}^{N-1} X_k e^{j2\Pi nk/N}, n = 0,1,2,......, N-1 \tag{2}$$

These are often written in terms of $W_n = e^{-j2\Pi/N}$

RESULTS AND DISCUSSION

Figure 10 shows the change in frequency cycle per hour with amplitude (^{0}C) for case without using Q-bond thermal insulation for the three reading temperatures outside wall temperature (T1) and inside wall temperature (T2) and shadow wall temperature (T3) while **Figure 11** shows the change in frequency cycle per hour with amplitude (^{0}C) for case with using Q-bond thermal insulation for the four reading temperatures outside wall temperature (T1) , air gap temperature (T2) , inside wall temperature (T3) and shadow wall temperature (T4) as shown in **Figure 11 to 13**.

It can be seen from **Figure 12** the amplitude of the inside wall temperature using Q-bond thermal insulation have a magnitude lower than the magnitude of inside wall temperature without using the Q-bond thermal insulation for the same frequency cycle /hour of about 0.04 . That means the better performance of using Q-bond thermal insulation and its ability to make good insulation for building and the absorbed heat will be stored in air gap and then passed through the outside wall.

A comparison was made between the sunny day, runny and clouded, and partly clouded day after analyzing its results by using (FFT) the results were shown in **Figures 14 to 17**.

CONCLUSIONS

From results above it can be list the following:

1. Q-bond panel has a great thermal resistance
2. Its ability to reflect most of the solar gain and this is the best in summer conditions and decrease the heat loss from buildings in winter conditions
3. Easy to fixed on building
4. Available in different colors

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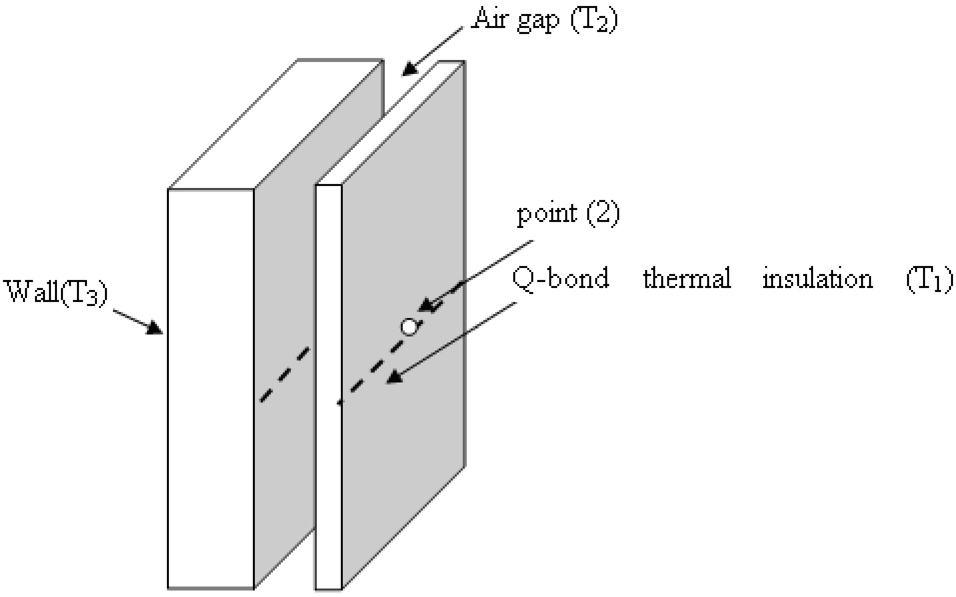

Figure 1 Experimental setup

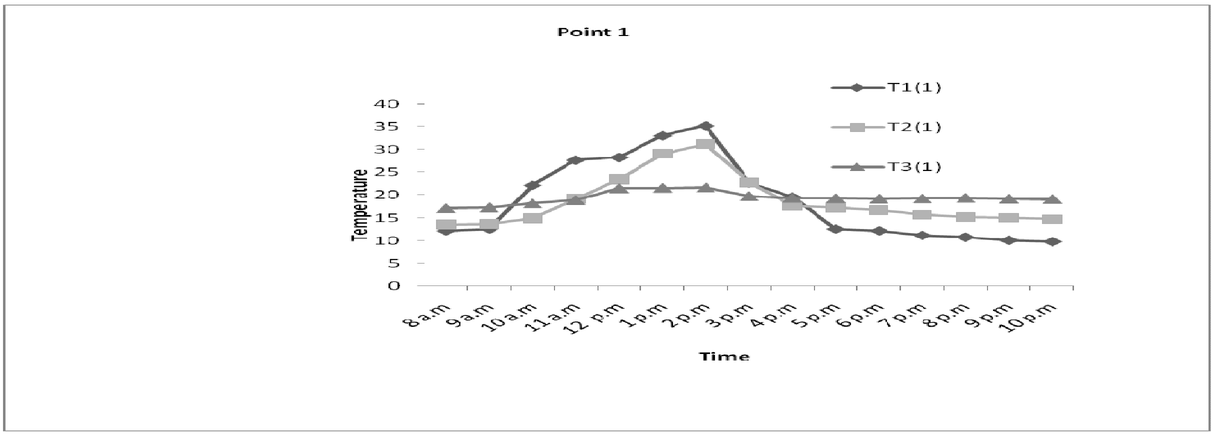

Figure 2 variation of temperature with time for a sunny day

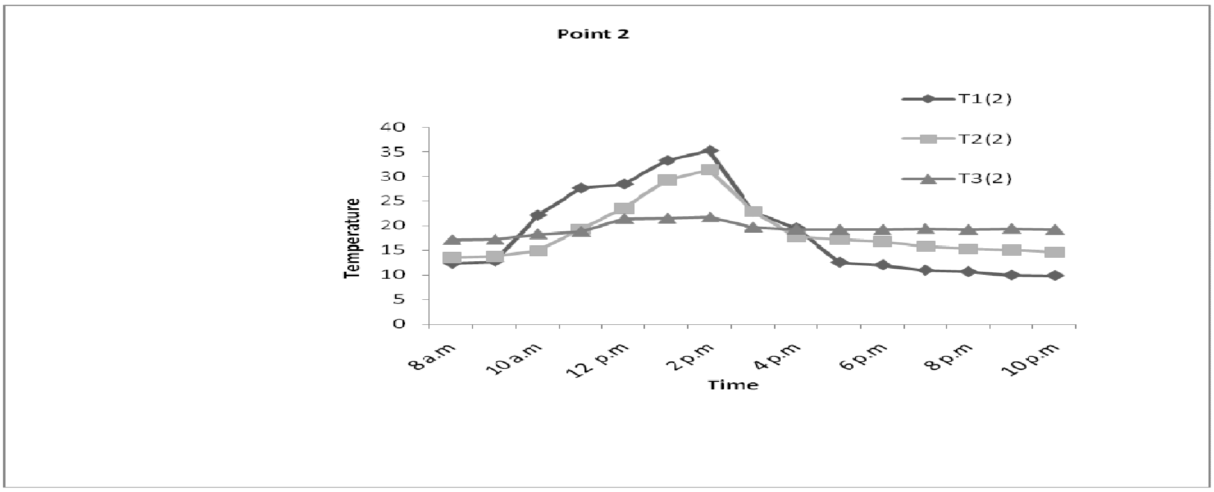

Figure 3 variation of temperature with time for a sunny day

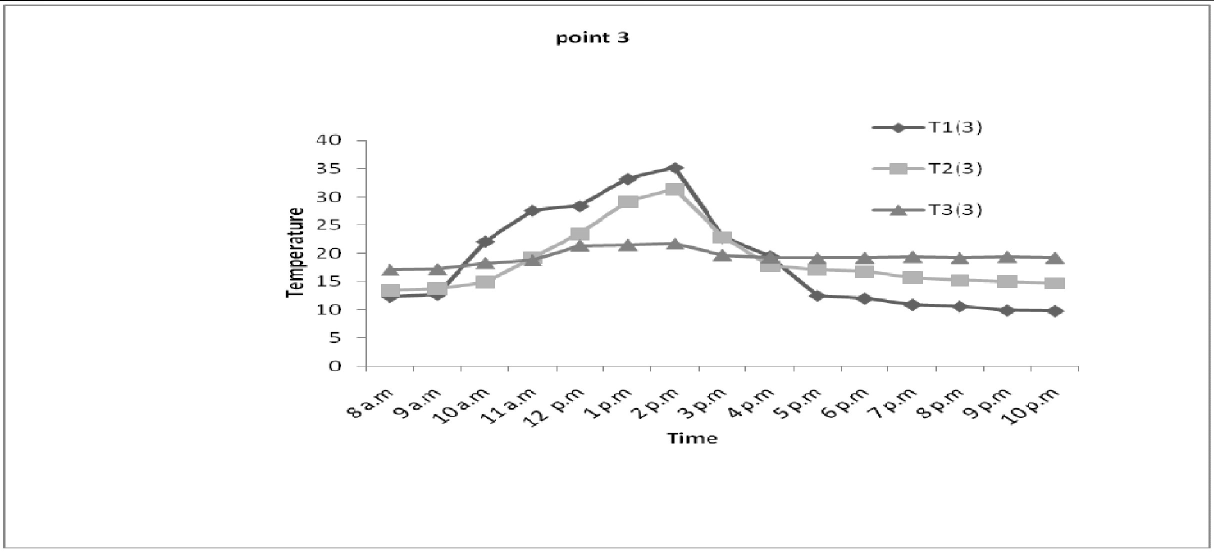

Figure 4 variation of temperature with time for a sunny day

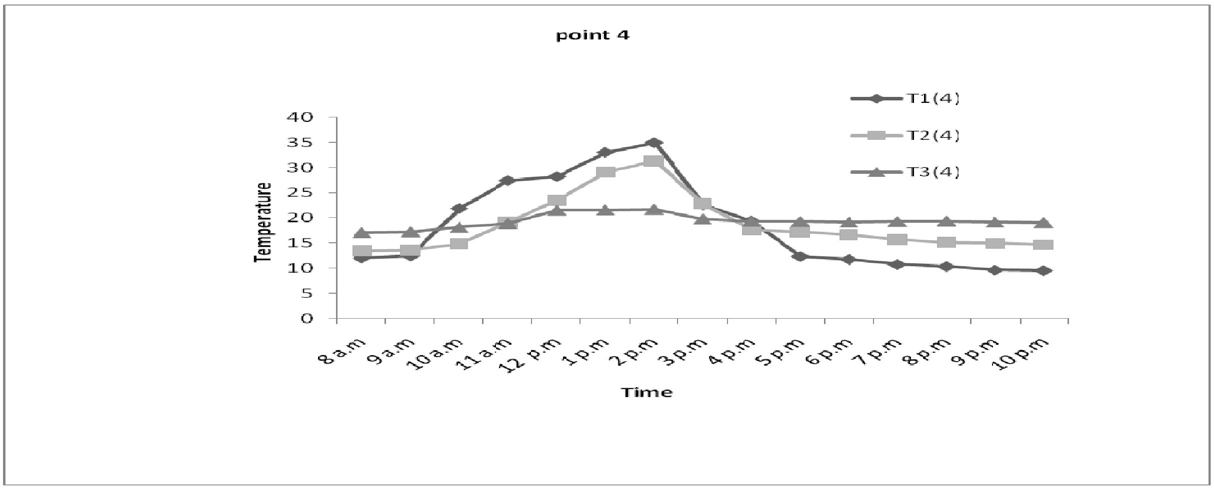

Figure 5 variation of temperature with time for a sunny day

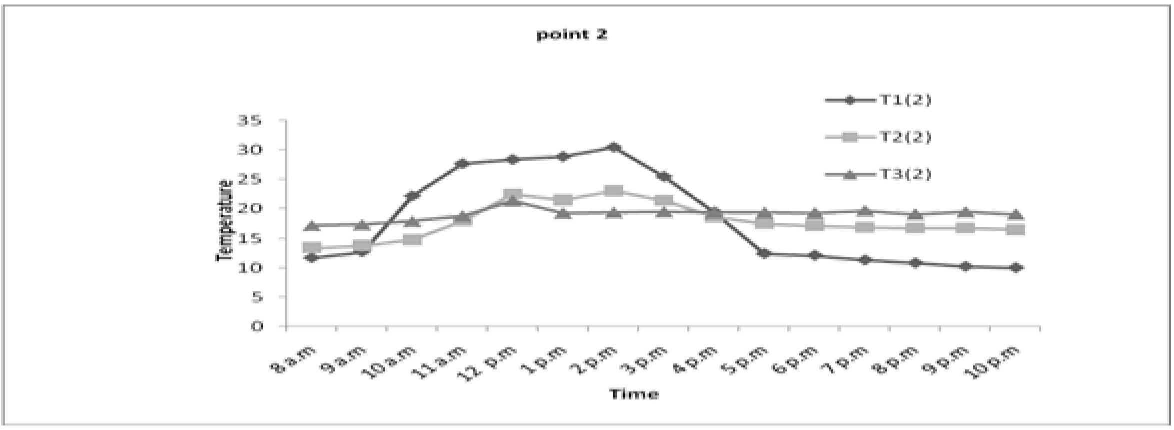

Figure 6 variation of temperature with time for a partly clouded day

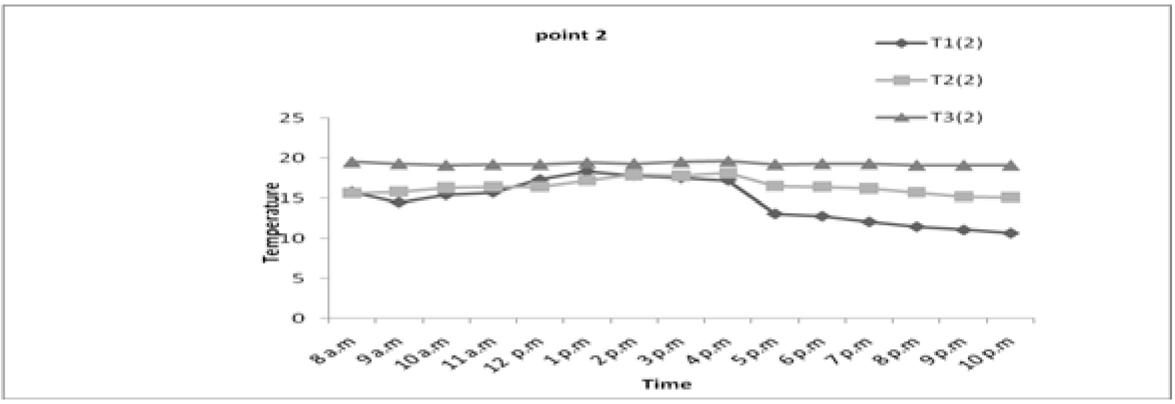

Figure 7 variation of temperature with time for a runny day

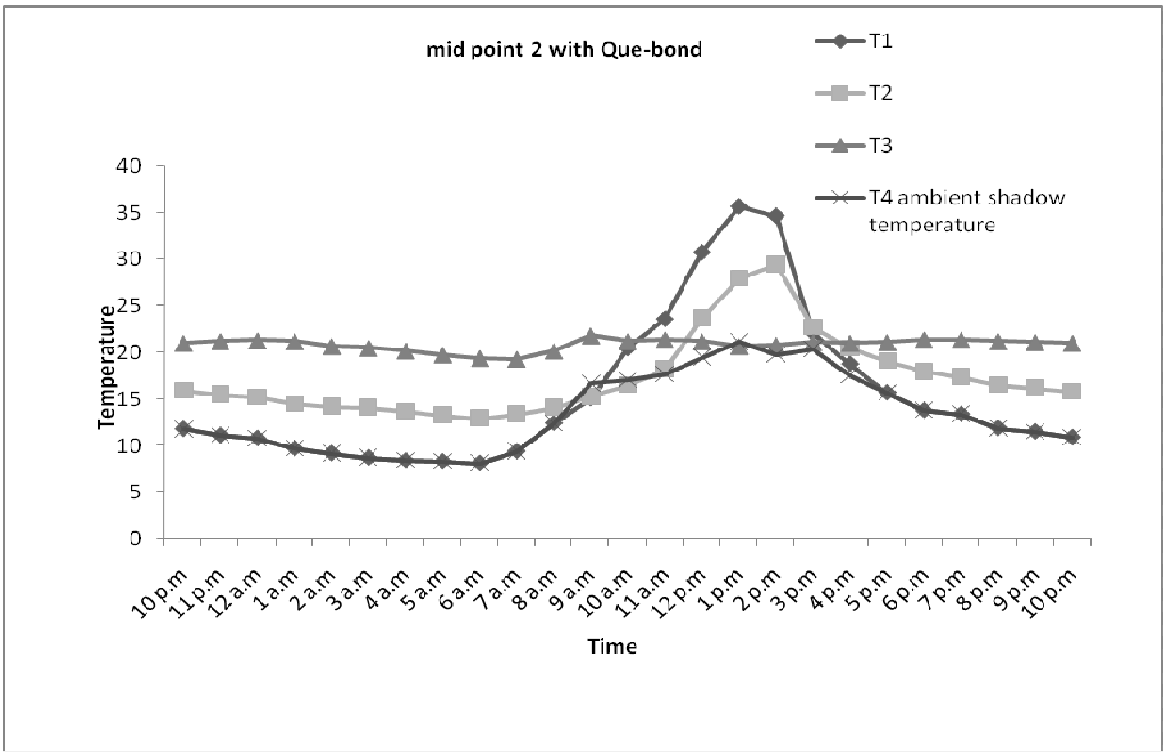

Figure 8 variation of temperature with time for sunny with Q-bond

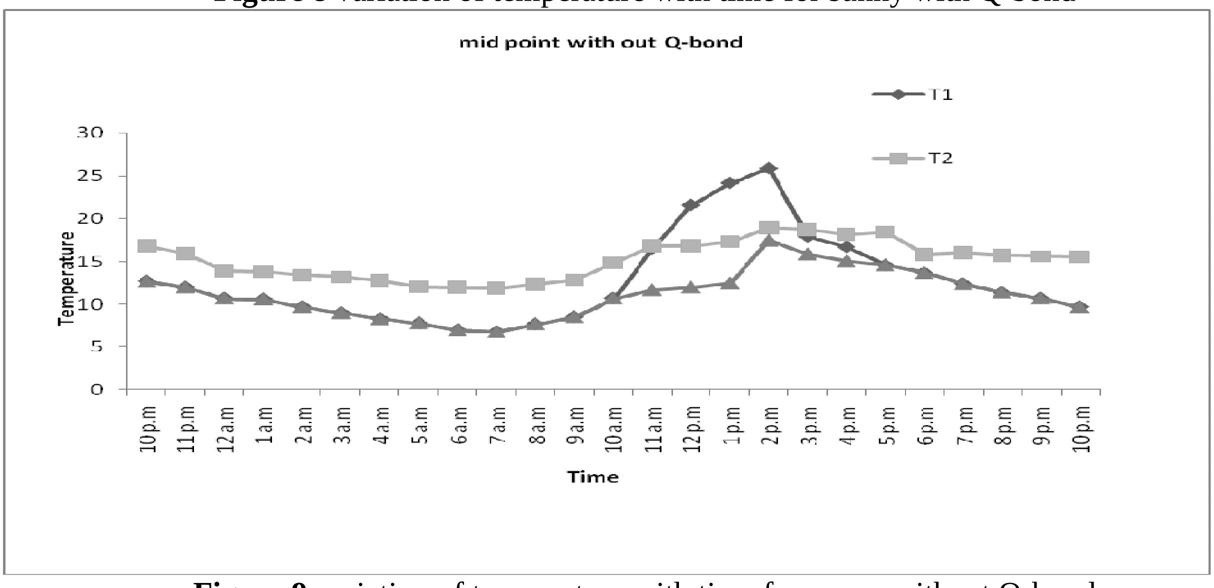

Figure 9 variation of temperature with time for sunny without Q-bond

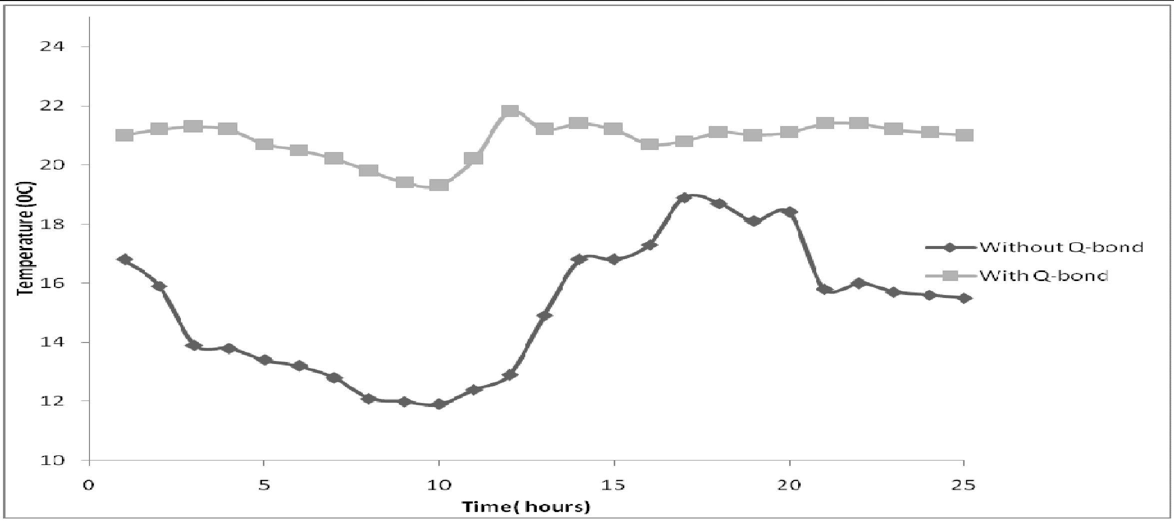

Figure 10 Comparison between in side wall temperature (T_3) in two cases with and without Q-bond for (24) hours.

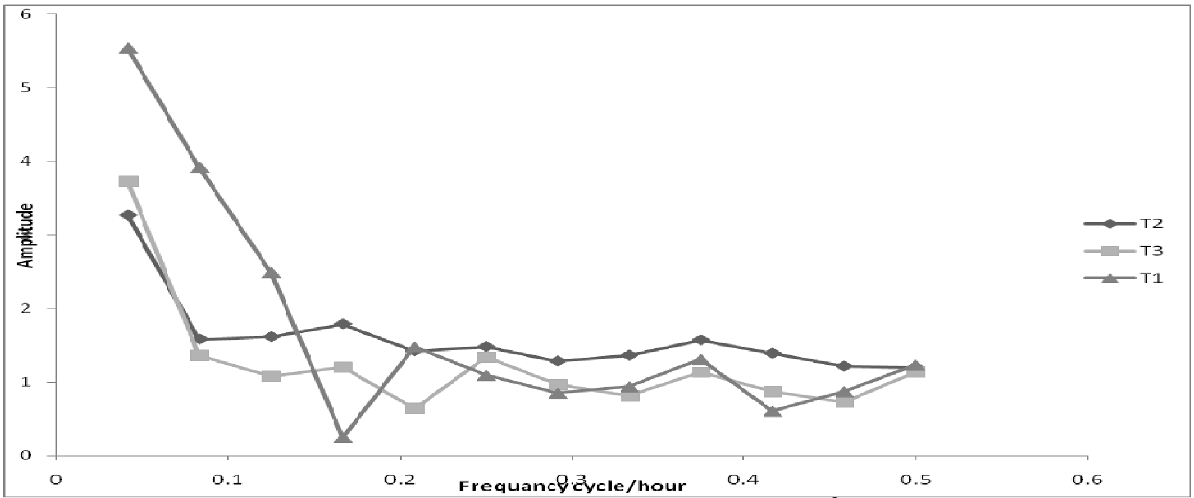

Figure 11 change in frequency cycle per hour with amplitude (^0C) for case without using Q-bond thermal insulation for 24 hours

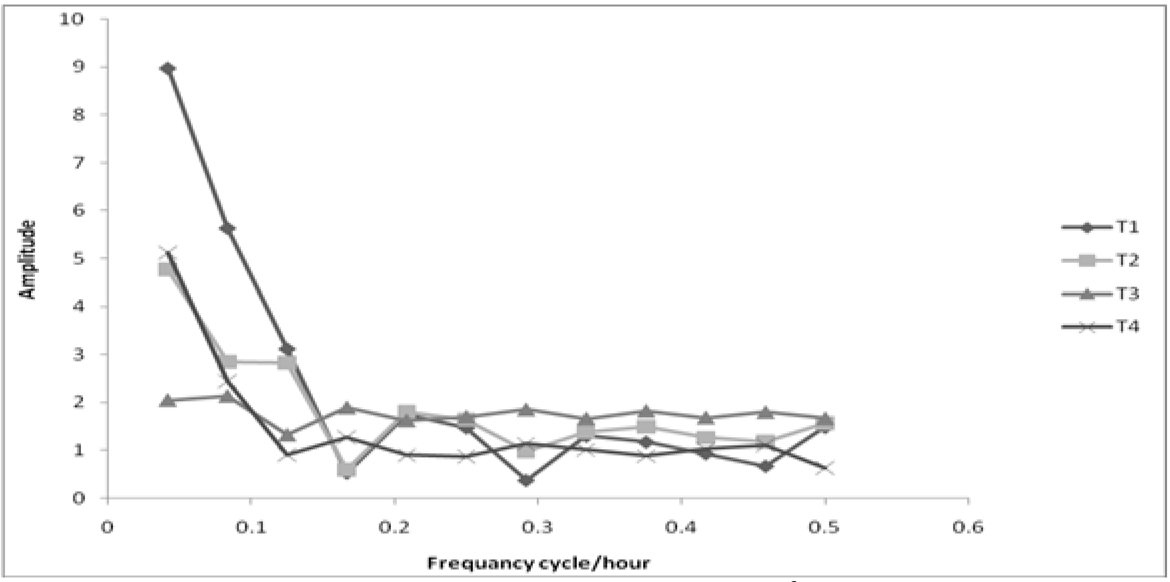

Figure 12 change in frequency cycle per hour with amplitude (^0C) for case with using Q-bond thermal insulation for 24 hours

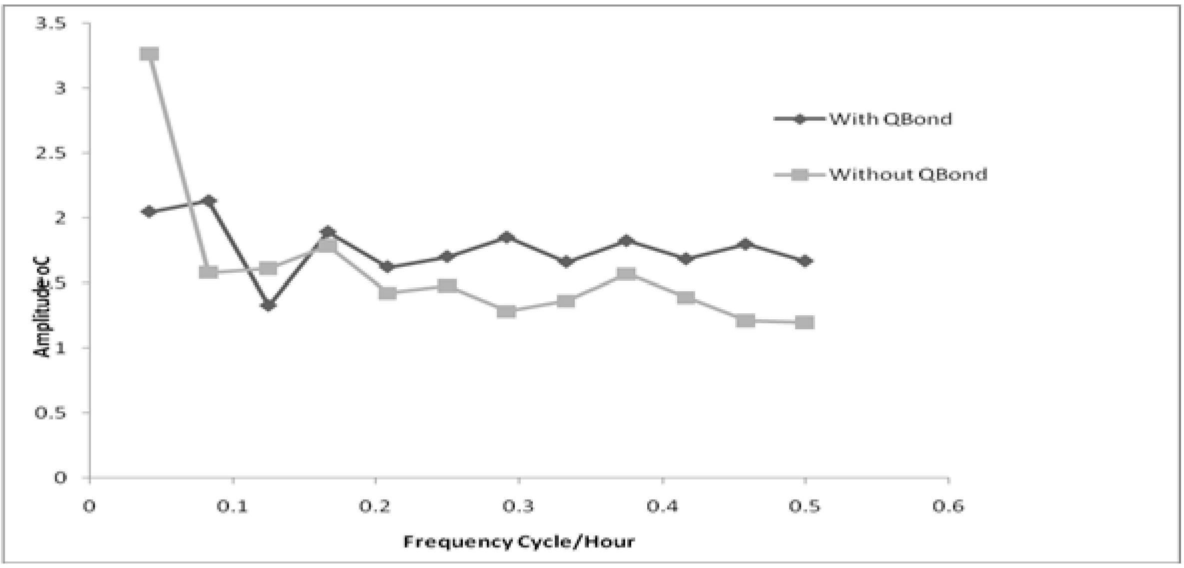

Figure 13 A comparison between the inside wall temperatures with and without using Q-Bond thermal insulation for 24 hours

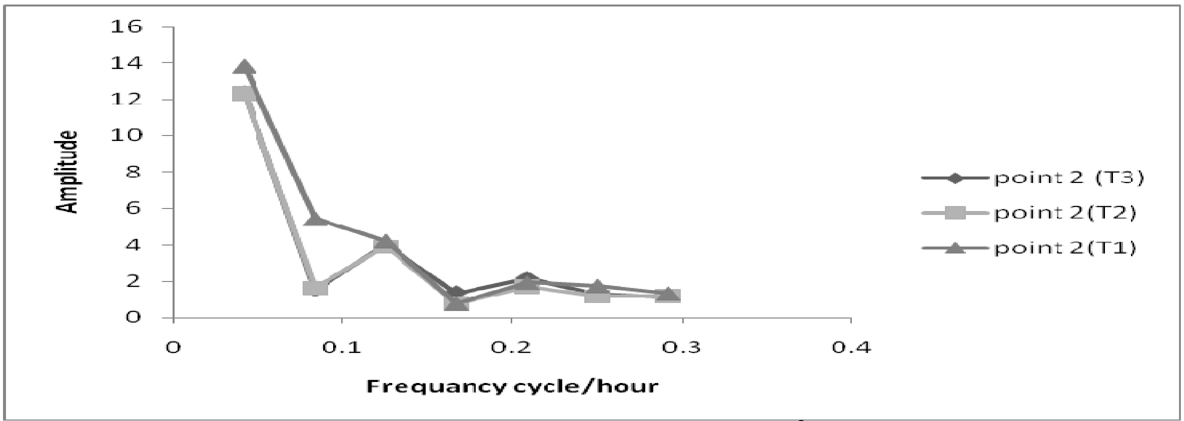

Figure 14 change in frequency cycle per hour with amplitude (^{0}C) for case with using Q-bond thermal insulation for 10 hours for runny day

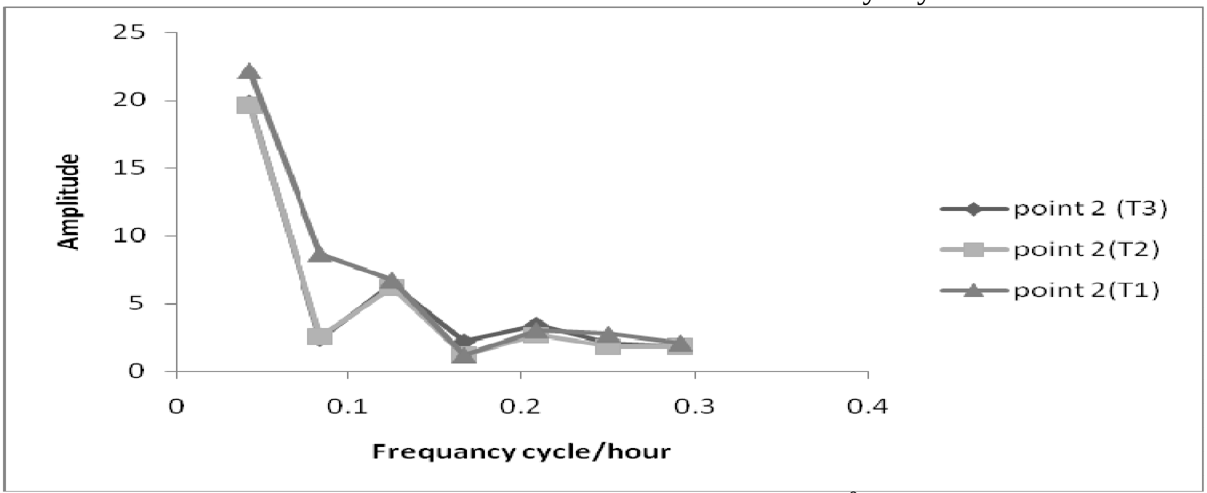

Figure 15 change in frequency cycle per hour with amplitude (^{0}C) for case with using Q-bond thermal insulation for 10 hours for partly clouded day

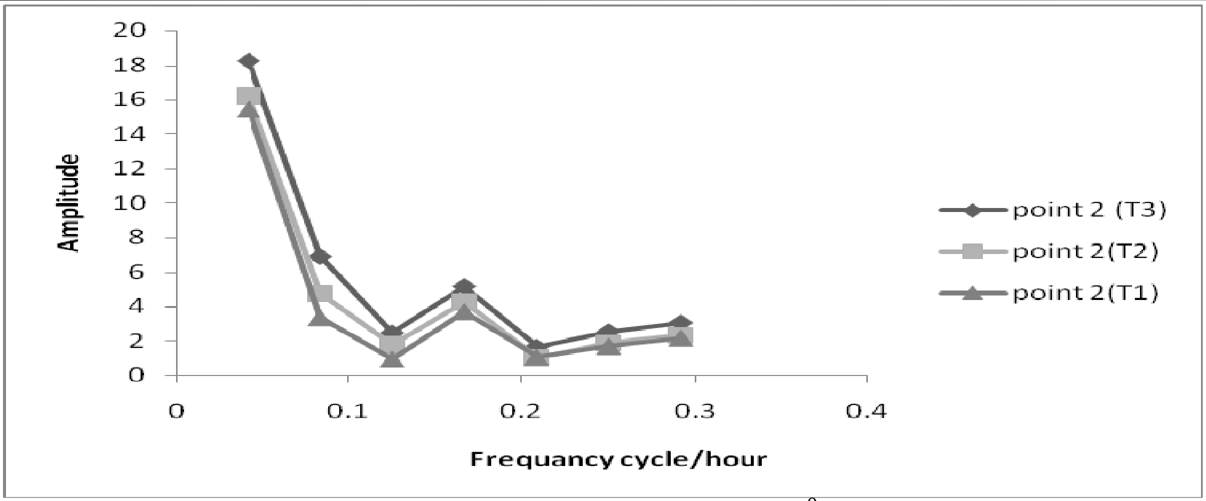

Figure 16 change in frequency cycle per hour with amplitude (^{0}C) for case with using Q-bond thermal insulation for 10 hours for sunny day

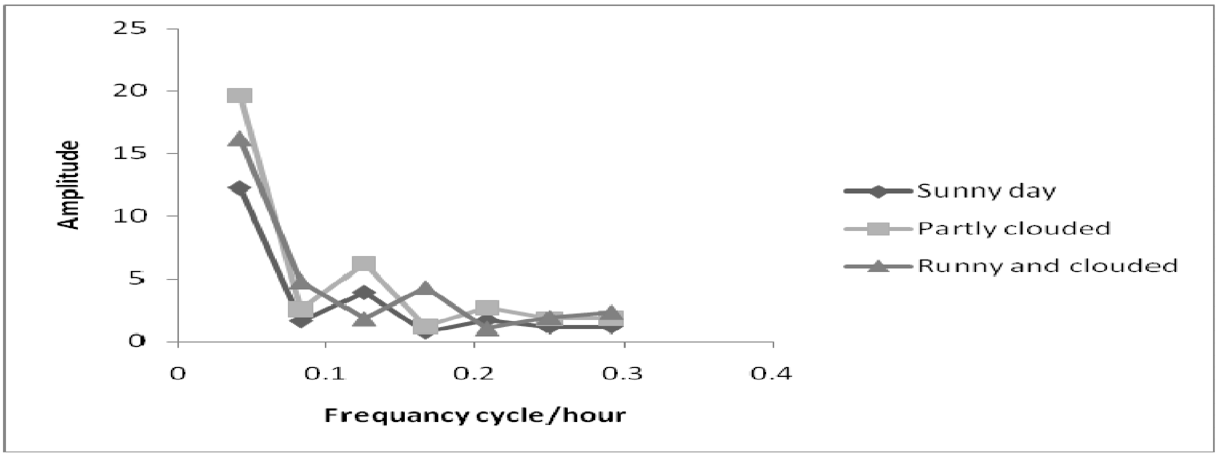

Figure 17 A comparison between the inside wall temperatures with using Q-Bond thermal insulation for 24 hours for three cases