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Effect of Using External Packaging Materials for New Building Walls on Heating Load

Sajjad Shakir Ali[*1], Hassan Kareem Abdullah[1]

[1]Mechanical Eng. Dep . Wasit University, Iraq.
*Corresponding author sajjadshakir8@gmail.com

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Abstract-Experimental and theoretical investigation of three types of external packaging materials (Gypsum board, Alucobond, Ceramic) for the residential building were carried out in the present work, to reduce heating load in winter. Experiments were carried out at the university of Wasit (Al-Kut city, late 32.5N), winter season by building small room from sandwich panel. The room's dimensions were 2m width, 2m length and 2.4m height. The south wall was made two slots. The slot dimensions are 0.3m width and 1m height. Two types of walls were built in the two slots. The first wall was built from common bricks. The second wall was built from bricks covered with packaging material. The radiant time series (RTS) method was used for calculating the experimental heat losses through the walls. The ESP-R program from Energy Systems Research Unit (ESRU) - University of Strathclyde used to calculate the theoretical results[1]. It is the intensity of the radiation and temperature on the walls. The results of the experimental work show that the maximum values of percentage energy saving as follows: External packaging materials; 16.77% Gypsum board,2.73% Alucobond and 2.3% Ceramic.

Keywords: *heating load, external packaging*

دراسة تأثير استخدام مواد التغليف الخارجي للجدران الداخلية في الابنية الحديثة على حمل التدفئة

سجاد شاكر، حسن كريم

الخلاصة- أجريت دراسة عملية ونظرية لثلاثة انواع من مواد التغليف لجدران الخارجية(الواح جبسية، الوكوبوند، سيراميك) للابنية السكنية الحديثة لتقليل حمل التدفئة . أجريت التجارب في جامعة واسط (مدينة الكوت خط عرض ٣٢.٥ شمال)، في فصل الشتاء ببناء غرفة صغيرة بقياس ٢م طول * ٢م عرض * ٢.٤م ارتفاع من السندويج بنل. شرق في الجدار الجنوبي فتحتيين . ابعادها هي ١م ارتفاع* ٠.٣م عرض في كل فتحة بني جدار . الجدار الاول بني من الطابوق . الجدار الثاني بني من الطابوق تم تغليفة بأنواع مختلفة من مواد التغليف . برنامجESP-R من وحدة الطاقة نظم البحوث (ESRU) – جامعة ستراثكلايد تستخدم لحساب النتائج النظرية. هي شدة الإشعاع و درجة الحرارة على الجدران [١]. حسب فقدان الحرارة عمليا باستخدام السلاسل الزمنية (RTS). اظهرت نتائج العمل التجريبي ان القيم القصوى من نسبة توفير الطاقة على النحو التالي: مواد التغليف الخارجي :١٦.٧٧% الواح جبسية و ٢.٧٣% الوكوبوند و ٢.٣% سيراميك.

I. INTRODUCTION

Many buildings were constructed in the present and most of them are far from the principles of energy conservation, as the main reason for the lack of controls and regulations which oblige a designer to observe this building control during the design process.

They have arisen and they will arise in future construction which do not deal intelligently with harsh climatic conditions of Iraq, where estimated current statistics the number of housing units constructed in advance had exceeded three million units in 2009 [2], housing in Baghdad alone surpassed three quarters of a million units, and this number has certainly increased in subsequent years. It must study the thermal performance of buildings during the design or implementation of choosing construction materials and building systems that reduce heat loss from buildings, especially when using modern construction or non-traditional materials. In this time where, new roads and types of decorative materials and new building materials have emerged. It must know the thermal properties, its effect on convection and energy consumed for air conditioning equipment [3].

II. CLIMATE OF IRAQ

Iraq is located between latitude (29.5°- 37.22°N) and longitude (38.45°- 48.45°E). Iraq has a hot, dry climate characterized by long, hot, dry summers and short, cool winters. The climate is influenced by Iraq's location between the subtropical aridity of the Arabian Desert areas and the subtropical humidity of the Arabic Gulf. January and February are the coldest months with temperatures from 5°C to 10°C.August and January are the hottest months with temperatures rising up to 50°C and more [4].

Iraqi Environment dries hot in summer and cold in winter. The advantage of traditional Iraqi house needs high power to be used for winter heating and summer cooling.

III. EXPERIMENTAL WORK:-

The experimental work consists of preparing a packaging material and then building an test room to investigate the effect of packaging material on heat loss from the space to the outside of the room. Experiments were carried out at the university of Wasit (Al Kut city, lat 32.5N) by building a room to be in direct contact with solar radiation, in the winter season, especially for the coldest monthly (February 2016).

The study concentrated on the south wall of the test room. Many kinds of packaging materials were used to minimize the heat loss transmission through the wall from the inside room to outside.The packaging was fixed on the south wall at external side; Gypsum board, Alucobond and ceramic.

A. Room Model

The model consists of one room, the walls and roof of the room built from the sandwich panel of polyurethane foam (thermal conductivity 0.029 W/(mK)) with 5 cm thickness to reduce the heat transmission to minimum value from all walls direction: north, west, east and south except a slot in the south wall which was under this study. The room's dimensions were 2 m width, 2 m length and 2.4 m height as shown in Figure.1. In the south, the wall was made of two slots, the slot dimensions are 0.3 m width and 1 m height. All the walls were exposed directly to the outdoor conditions. The room floor is made from wooden pallet 17 mm thickness.

Fig.1. Room model

The first wall (without packaging) was built from common bricks as shown in Figure.2. This will be the same in all tests to compare it with the second wall (with packaging))which was built from common bricks with external packaging.

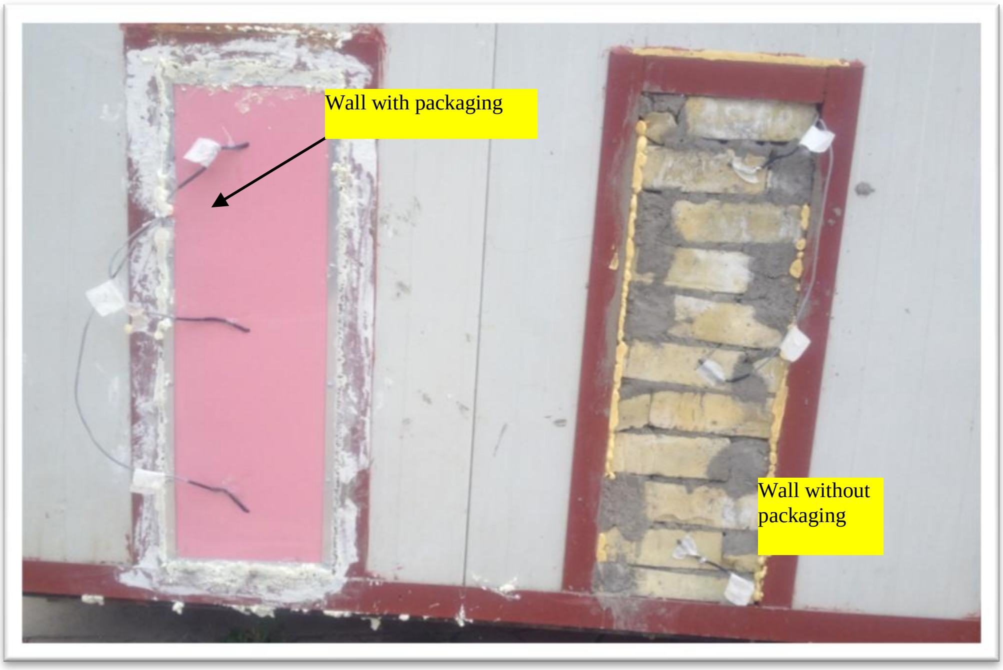

Fig.2.A brick wall with and without packaging

B. Packaging Materials Models:

Three types of packaging material were tested: Gypsum board, Alucobond and Ceramic, packaging fixed on external walls, as shown in Figure. 3

a b c

Fig.3.wall with external packaging, a) Gypsum board, b) Alucobond, c) Ceramic.

C. Measurement Instruments

- *Temperature Data Logger (Labjack With Thermistors) LabJack:*

In this study, a LabJack model, U3-LV, data logger was used. This data logger has 16 inputs channel with labjack extension, which were used to measure the temperature data.

- Solar Power Meter

Solar radiation was measured by solar power meter type (TES-1333R) in W/m², made in china. The device was used for measuring the solar radiation intensity during all day at experimental times.

- *Heating Equipment*

The room model was heated by a heating unit (model no.: KPT-2000B 5207L) which maintains at constant temperature about 25°C by using the heating unit (Ceramic fan heater). The heating unit has a capacity of 1000 to

2000 W. The unit consists of two electric heaters with fan and thermostat to control the room temperature. This unit works during day and night-time continually.at the inside north wall, 1.5m above the floor.

D. Experimental Procedure:

1. The location of the test room - Wasit University in an open location area to avoid impeding the arrival of sunlight during daylight hours, and heat loss during night-time.
2. All testing during the winter season, the coldest month is February and all experiments start at 8a.m. then continue 24 hr/day.
3. All experiments were done on the two slots walls which were in south direction, at the same time, in order to compare them.
4. The test was done by measuring in the inside and outside wall temperature of the two walls continuously during 24 hr as well as inside and outside air temperature.
5. Solar radiation measured during day-time during all the experiments.
6. External packaging materials are Gypsum board, Alucobond and Ceramic, compared with brick wall without packaging.

All the result data plotted with time by using Microsoft Excel.

E. Types of Tests

- *Gypsum Board*

A wall composed of bricks added Gypsum board sheet of 0.3m * 1m.The probationary period of 9-Feb-2016 at 8a.m. to 10-Feb-2016 at 7a.m., comparing the results with a second wall of bricks only.

- *Alucobond*

A wall composed of bricks added Alucobond hollow sheet of 0.3m x 1m and thickness (3mm). Contains air gap between the bricks and Alucobond thickness (7 mm).The probationary period of 10-Feb-2016 at 8a.m. to 11-Feb-2016 at 7 a.m., comparing the results with a second wall of bricks without packaging.

- *Ceramic*

A wall composed of bricks thick added ceramic sheet of 0.3m x 1m. The probationary period of 13-Feb-2016 at 8am to 14-Feb-2016 at 7 am., comparing the results with a second wall of bricks without packaging.

IV. METHOD OF CALCULATION

A. Theoretical Calculation

The theoretical results were calculated by using the program ESP-R.
Three steps required for using the program:-

1-Model creation, 2-Simulation, 3-Results analysis

B. Experimental Calculation

Heat Loss: using Radiant Time Series (RTS) Method to calculate heat loss**:**

The radiant time series (RTS)" method is a new simplified method for performing design heat load calculations that was derived from the heat balance (HB)"[5].
Conductive Heat loss Using Conduction Time Series

$$Q_{i,\theta-n} = UA(T_{e,\theta-n} - T_{r,\theta-n}) \quad (1)$$

Where
$Q_{i,\theta-n}$: Conductive heat input for the surface n hours ago, W.
U : Overall heat transfer coefficient for the surface, W/m^2K.
A : Surface area, m^2.
$T_{e,\theta-n}$: Sol-air temperature n hours ago, °C.
$T_{r,\theta-n}$: Presumed room air temperature n hours ago, °C,

Conductive heat loss through walls or roofs can be calculated by using conductive heat inputs for the current hours and past 23 h and conduction time series

$$Q_{\theta} = C_0 Q_{i,\theta} + C_1 Q_{i,\theta-1} + C_2 Q_{i,\theta-2} + C_3 Q_{i,\theta-3} + \cdots + C_{23} Q_{i,\theta-23} \quad (2)$$

Q_{θ}: Hourly conductive heat loss for the surface, W.

$Q_{i,\theta}$: Heat input for the current hour, W.
$Q_{i,\theta-n}$: Heat input n hours ago, W.
C_0, C_1, etc. : Conduction time factors.

V. RESULTS AND DISCUSSIONS

A. *Experimental Results:*

- *Temperature Distribution:*

Figures 4, 5, 6 show the temperature gradient of a brick wall and packaging wall; ambient temperature (T_a), room air temperature (T_r), temperature on the inner surface of a brick wall (T_{bi}), temperature on the outer surface of a brick wall (T_{bo}), temperature on the inner surface of packaging wall (Gypsum board, Alucobond, Ceramic) (T_{pi}), temperature on the outer surface of packaging wall (T_{po}) and solar radiation (I_r).

Figure 4. shows the comparison between brick and Gypsum board wall, Maximum value of $\Delta T_{p_{i-o}}$ ($T_{pi} - T_{po}$)is (10.3℃) at 5 a.m., and maximum value of $\Delta T_{b_{i-o}}$ ($T_{bi} - T_{bo}$) is (7.8°C) at the same time, so the maximum save percent is 24.41%because the increase in the thermal resistance of the packaging wall.

Figure 5. shows the comparison between brick and Alucobond wall, Maximum value of $\Delta T_{p_{i-o}}$ Is (8.4°C) at 6 a.m., and maximum value of $\Delta T_{b_{i-o}}$ is (7°C) at 7 a.m, so the save percent is 21.37% for heating load during night-time (coldest time at 6a.m.).

Figure 6. Show the comparison between brick and Ceramic wall. In the daytime the high temperature of the outer surface of the walls because of solar radiation falling on it, and this leads to reduce the heating load. But at night-time this difference because of solar radiation falling on, it was zero. Maximum value of $\Delta T_{p_{i-o}}$ Is (8.1°C) at 6a.m., and maximum value of $\Delta T_{b_{i-o}}$ is (7°C) at the same time, so the save percent is 13% for heating load during night-time (coldest time at 6a.m.).

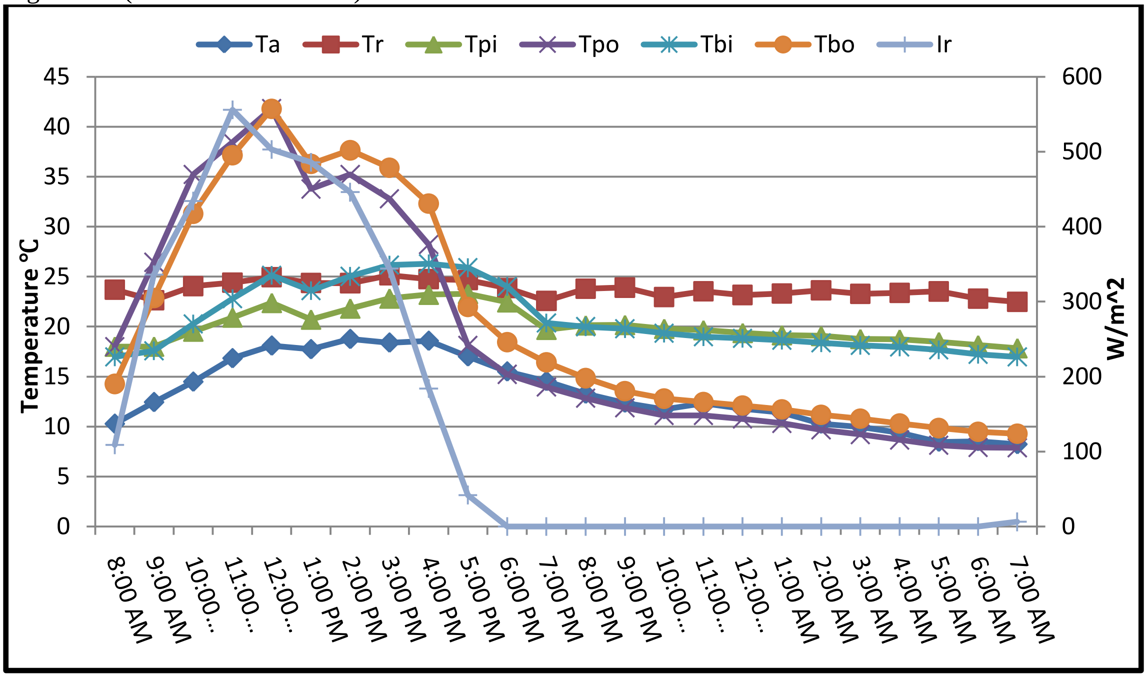

Fig.4. Temperature gradient & solar radiation of Gypsum board wall compare with brick wall at 9-Feb-2016.

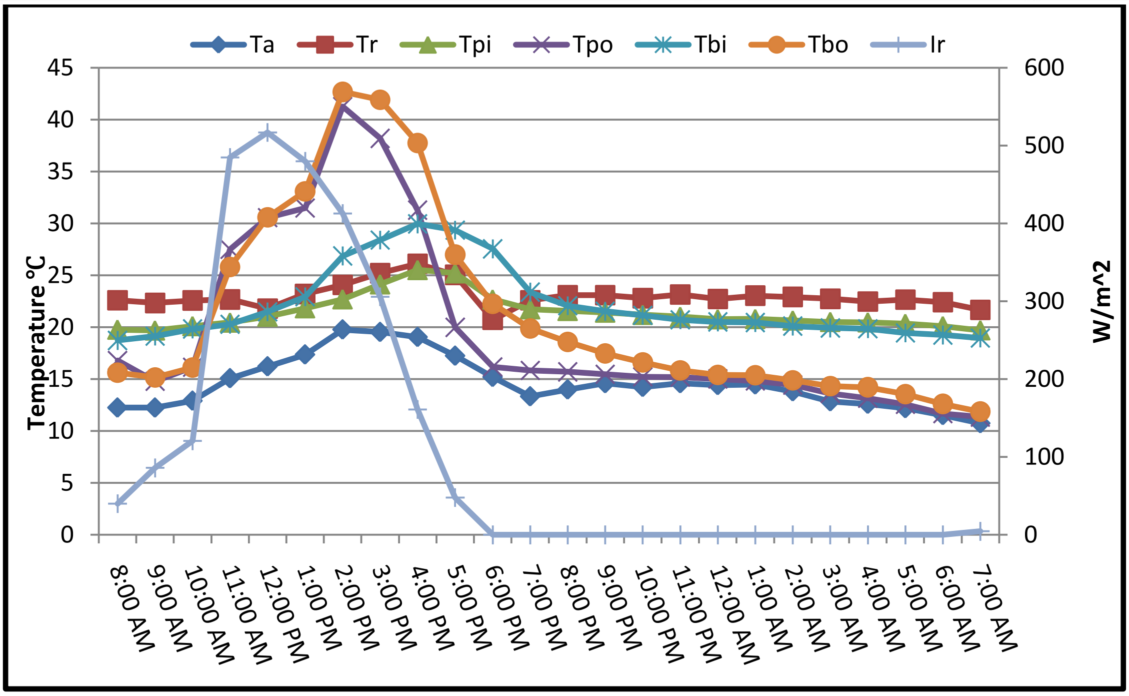

Fig.5.Temperature gradient & solar radiation of Alucobond wall compare with brick wall at 10-Feb-2016.

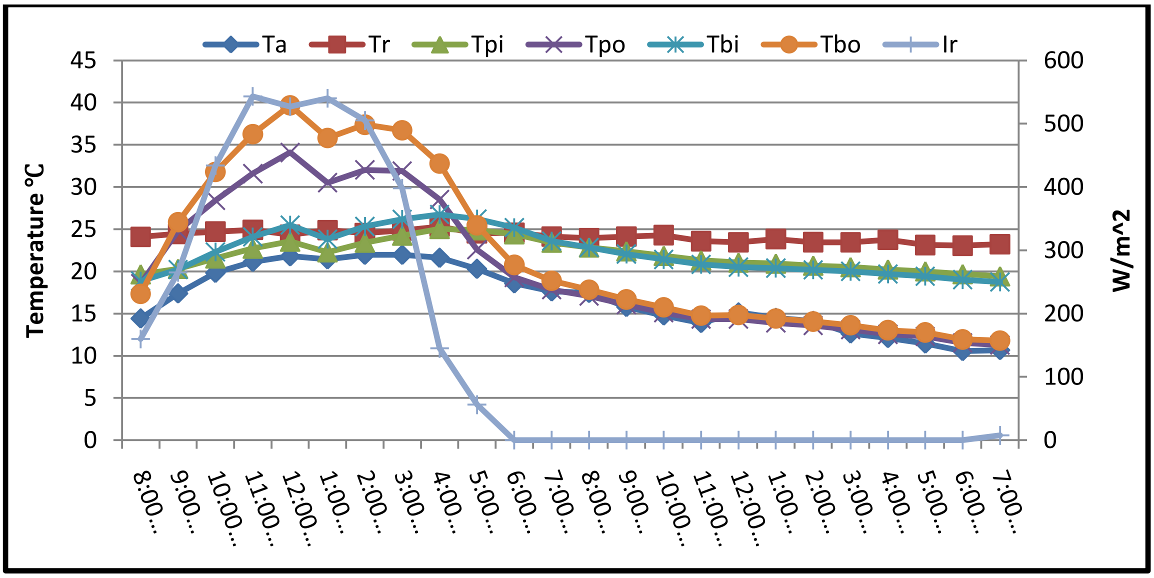

Fig.6.Temperature gradient & solar radiation of Ceramic wall compare with brick wall at13-Feb-2016.

- *Heat Loss From the Walls*

Figures 7, 8, 9 show the heat loss was started and decreased at day-time because the increasing Sol-air temperature and solar radiation. At night time heat loss starts increasing due to drop in ambient temperature reaches the highest.

Figure 7. shows the comparison between brick and Gypsum board wall , The maximum value of heat loss of brick wall without packaging was (-36.96W/m^2) At 9a.m., and heat loss of brick wall with the packaging Gypsum board was (-30.76W/m^2) at 9a.m., so Gypsum board packaging gave saving energy (16.77%) at 9a.m.

Figure 8. shows the comparison between brick and Alucobond wall, The highest value of heat loss of brick wall without packaging was (-27.47W/m^2) at 10a.m., and heat loss of brick wall with the packaging Alucobond was (-26.72W/m^2) at 10a.m., so Alucobond packaging gave saving energy (2.73%) at 10a.m..

Figure 9. shows the comparison between brick and Ceramic wall, The most value of heat loss of brick wall without packaging was (-29.67W/m^2) at 9a.m., and heat loss of brick wall with the packaging ceramic was (-28.98W/m^2) at 10a.m., so ceramic packaging gave saving energy (2.3%) at 10a.m..

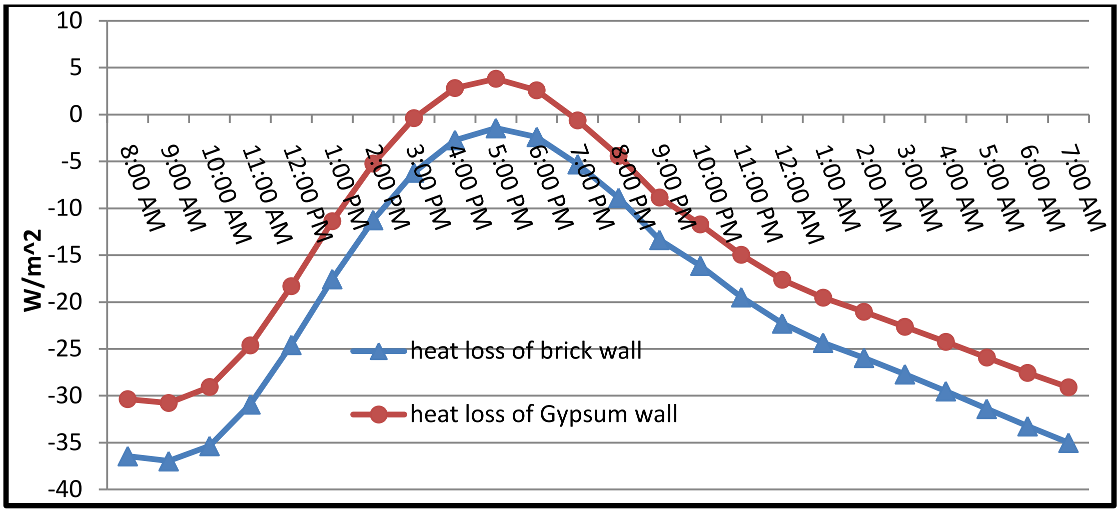

Fig.7. heat loss of brick and Gypsum board wall (9-Feb-2016)

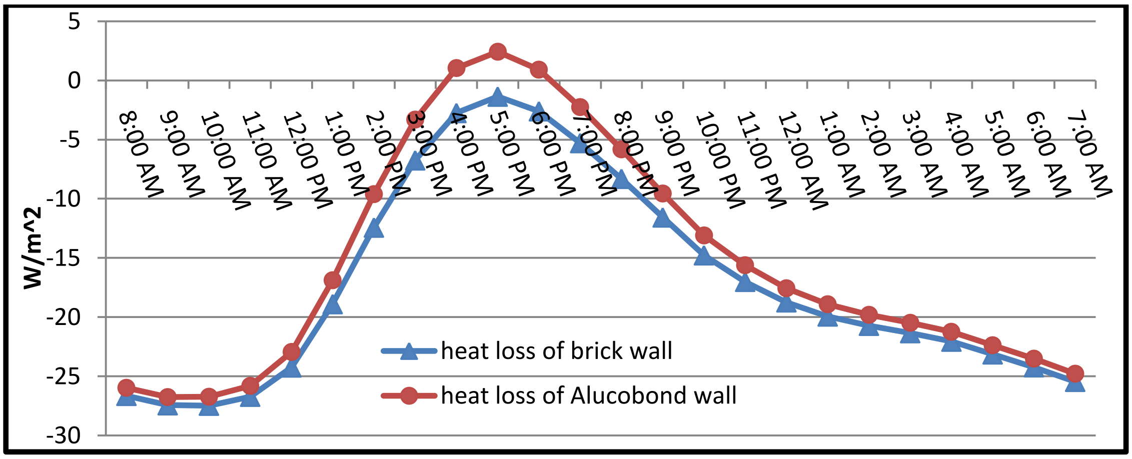

Fig.8. heat loss of brick and Alucobond wall (10-Feb-2016)

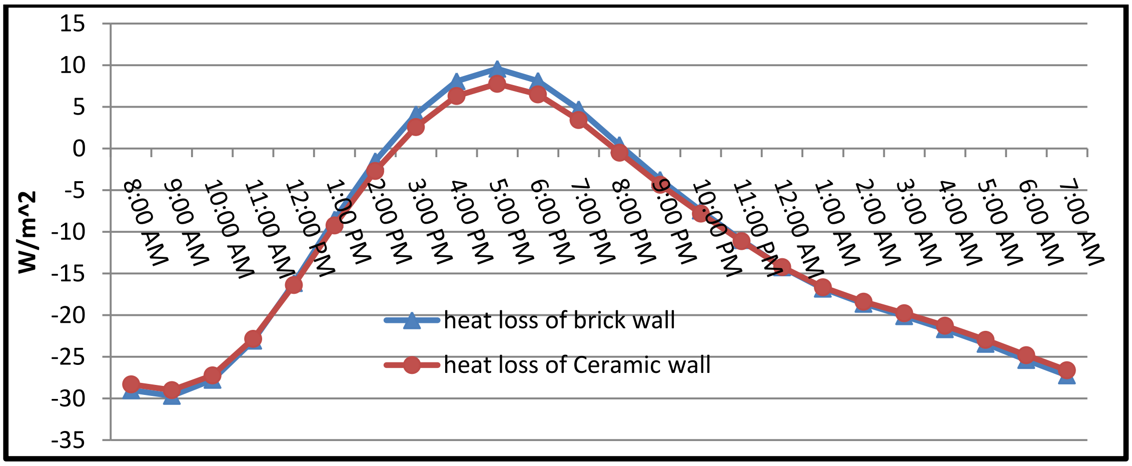

Fig.9. heat loss of brick and Ceramic wall (13-Feb-2016)

B. Theoretical Results:

- *Temperature Distribution:*

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Using ESP-R program to calculate temperature for surface wall, room (indoor and outdoor) and solar radiation.

Figures. 10, 11, 12 shows the temperature gradient of a brick wall and packaging wall. Figure 10 shows the comparison between brick and Gypsum board wall, Maximum value of $\Delta T_{p_{i-o}}$ is (9.27℃) at 6a.m., and maximum value of $\Delta T_{b_{i-o}}$ is (9.14℃) at the same time, so the maximum save percent is 1.4%.The value of $\Delta T_{p_{i-o}}$is lower than of the experimental results because because they used the weather file of Baghdad and Weather conditions change every year.

Figure 11. shows the comparison between brick and Alucobond wall, Most value of $\Delta T_{p_{i-o}}$ Is (11.13℃) at 6a.m., and maximum value of $\Delta T_{b_{i-o}}$ is (8.83℃) at 6a.m, so the save percent is 20.71 % for heating load during night-time (coldest time at 6a.m.). Convergent results from experimental.

Figure 12. shows the comparison between brick and Ceramic wall. Highest value of $\Delta T_{p_{i-o}}$ Is (7.96℃) at 6a.m., and maximum value of $\Delta T_{b_{i-o}}$ is (10.39℃) at same time, so the save percent is -30.4%

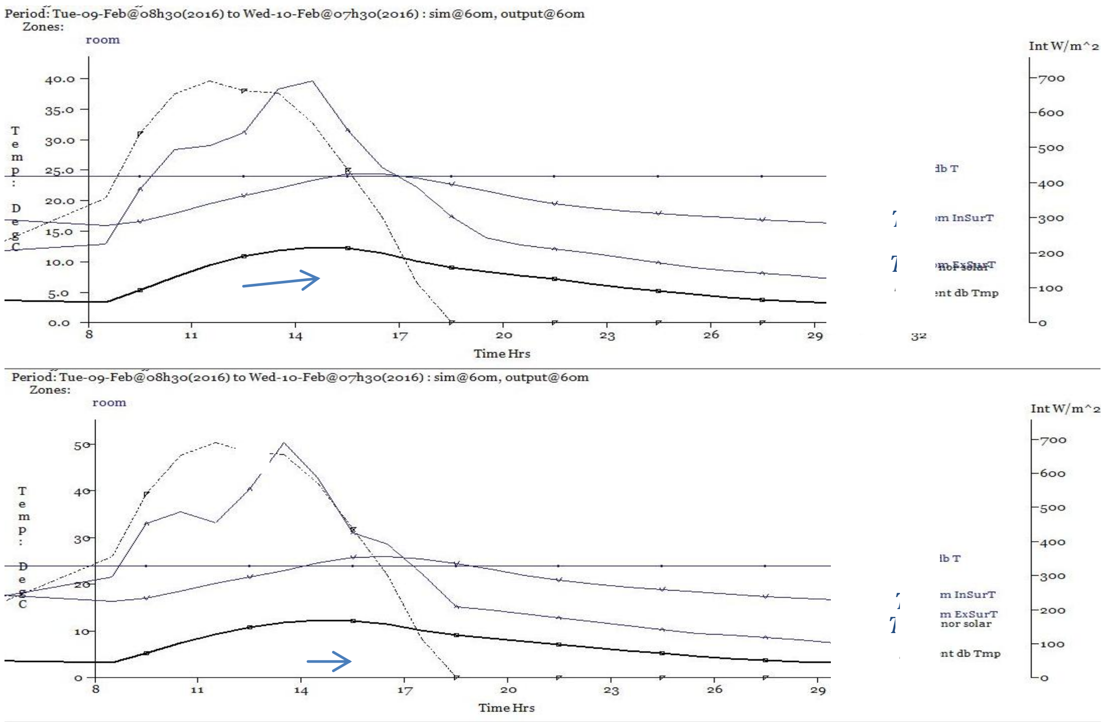
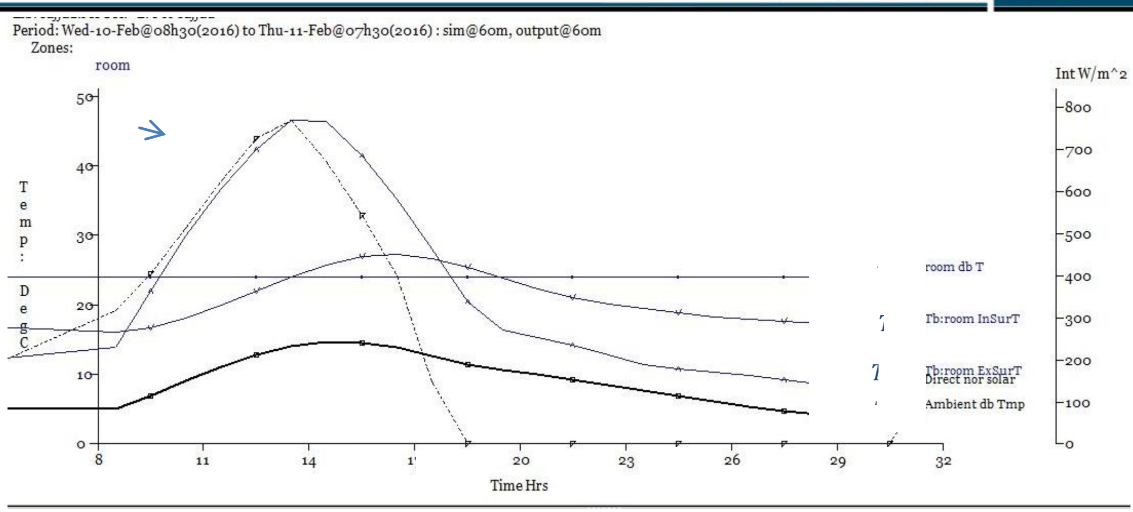


Fig. 10: Temperature gradient & solar radiation of Gypsum board wall compare with brick wall at9-Feb-2016.



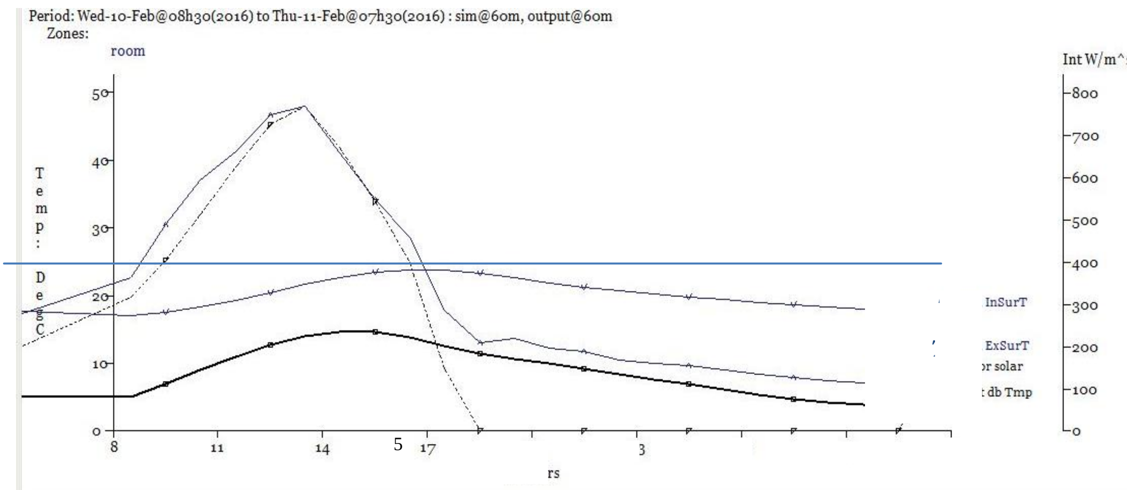
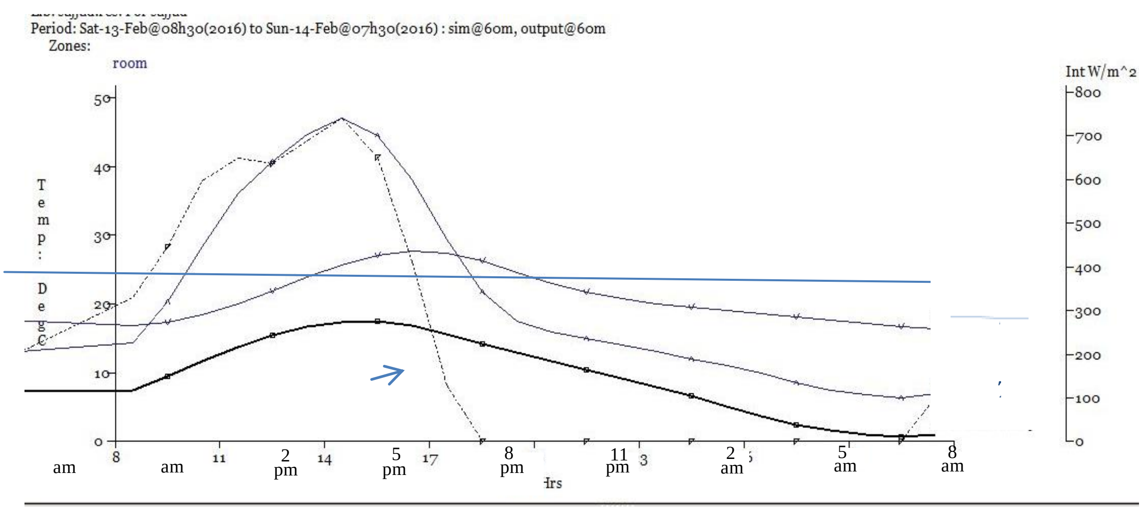


Fig.11.Temperature gradient & solar radiation of Alucobond wall compare with brick wall at10-Feb-2016.



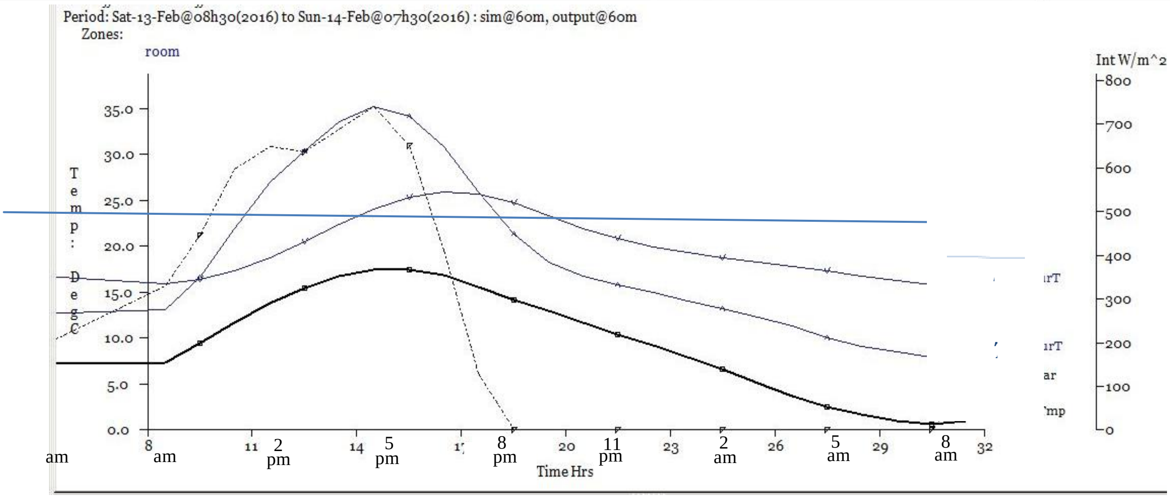


Fig. 12.Temperature gradient & solar radiation of Ceramic wall compare with brick wall at13-Feb-2016.

VI. CONCLUSIONS:

The saving energy for experimental tested, external packaging material can be arranged from a maximum value of saving as follows: 16.77% Gypsum board,2.73% Alucobond and 2.3% Ceramic. The author recommended to use the external packaging material for new building and also for the old, to decrease heat loss then save electric power save and running cost for heating load.

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