INVESTIGATION AND ANALYSIS OF THERMAL EFFICIENCY OF HEAT INSULATION MATERIALS A COMPERISON OF MATERIAL PERFORMANCE OF THREE MODEL WALL IN NICOSIA, NORTH CYPRUS

A THESIS SUBMITTED TO THE GRADUATE SCHOOL OF APPLIED SCIENCES OF NEAR EAST UNIVERSITY

By

McDOMINIC CHIMAOBI EZE

In Partial Fulfillment of the Requirements for the Degree of Master of Science in Mechanical Engineering

NICOSIA, 2015

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

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ABSTRACT

The structural design in other to achieve climatic comfort conditions are key factor to reduce materials on building exterior walls. This study is based on the investigation of the insulation materials which are used on the building wall to minimize the heat lost in winter and minimize heat gain in summer. To reduce the heat losses firstly, the climatic and building parameters must be taken into account and the solar radiation which comes from the Sun should be used correctly and effectively so to ensure the maximization of to its full potentials. Since recital of a heat energy in our home and our building is a significant part when considering efficient energy of a construction. Performance heat energy depends on so many factors which the essence of mass, thickness of the wall and also material resistance of the wall. This research was aimed at illustrating array of wall combination system in Turkish Republic of North Cyprus (TRNC), and to recognize their problem and basically recommend solution by compare heat radiation effects of a three replica rooms. L1 (no insulation replica), L2 (Y- tong bricks wall replica) and then L3 (thermal insulated wall replica by using stone wool as insulate) was put up for testing purpose. Every replica has a four face walls. The study was consider a two stage procedures, the first stage was to access the effect of thermal radiation on the south facing wall and the next stage is to test the thermal performance of the no insulated wall replica, Y- tong wall replica and the heat insulated wall replica. The L3 replica consists of hallow bricks, stone wool, and gypsum while the replica L2 consists of concrete cement, at the outer surface and the inner surface and Y-tong stone. We determine the total heat of the wall, a 7T thermocouple was used in the connection and the reading was collect with a data logger system, the temperature change record at a period of 10 to 10 minutes. We achieve the result that replica L2 accumulate more power at night when compared to other replica followed, by non- insulation model and then the heat insulation model due to some similar material combination found in them. The non-insulation model and the heat insulation model at daytime obtained more thermal efficiency as a result maximum radiation the thermal insulated wall save more energy during days when concentration is at greatest.

Keywords: Y-tong wall; heat insulation; south face; wall insulated; solar radiation

ÖZET

Binalarda konforu sağlamak amaçlı dış duvarlarda malzeme seçimini iklim şartlarına göre dizayn edilmelidir. Bu çalışmanın esası, binalarda kışın ısı kaybını ve yazın ısı kazancını minimize etmektir. Kuzey Kıbrıs Türk Cumhuriyeti'nde binalardaki duvarları göz önünde bulundurduğumuzda görünen şey kullanılan izolasiyonanların ısı kaybını yeterli derecede engellememesidir. Ilk başta ısı kaybını azaltmak amaçlı, bina parametrelerinin iklim şartlarına göre seçilmesi ve güneşten gelen radiyasıyonu en iyi ve etkili şekilde kullanılmasıdır. Termal enerji performansını ev içinde ve binalarda kullanılması , binalardaki enerji verimini artırılmasına etkili bir faktördür. Termal enerji performansı bir çok faktöre bağlıdır, bunlardan biri termal izolasyon miktarını göz önünde bulundurduğumuz faktördür, duvarın kalınlığı ve kütlesi ve aynı zamanda duvardaki malzemenin termal direncine bağlıdır. Bu çalışmanın amacı değişik duvar sisteminin incelenmesi ve böylece problemlerin anlaşılmasıdır ve termal radyasyonu iki maket oda L1(izolasyonlu) , L2(yutong) 'yi üçüncü oda L3 (izolasyon olmayan) ile kıyaslamaktır. Her model duvarda dört cephe vardır. Bu çalışma iki aşamadan oluşur, birinci aşama duvarın güney cephesinde güneş radyasyonunu incelemek ve ikinci aşama ise kış boyunca iklim şartlarının etkisine bağlı olarak izolasyonlu, izolasyonsuz ve yotong için duvarların termal performansını incelenmesidir. Isı izolasyonlu duvar, delikli tuğla , taş yünü, gypsundan ve concretten oluşur .7T-thermocoupllar vasıtasıyla dış duvar yüzey sıcaklığı , iç duvar yüzey sıcaklığı, oda içi sıcaklıklar ve aynı zamanda dışarıdaki hava sıcaklıkları veri yükleyiciye her on dakikada bir kayıt edilerek ve toplam ısıya bakıldığında ve izolasyonsuz duvar ile kıyasladığımızda görünen şey güney cephesindeki yutong duvarında daha fazla ısıyı tuttuğunu yalnız genel olarak diye biliriz ki yutong yalnız gün boyunca ısı kazanır güneş battıktan sonra ısı kaybı görülmeye başlar etmeye başlar izolsiyonsuz ısı. Bu verilerden her bir duvar sisteminde depolanan toplam enerji hesaplanmıştır. Elde edilen sonuçlardan Y-tong duvarda daha fazla enerji tasarrufu elde edildiği anlaşılmıştı

Anahtar Kelimeler: Y-tong duvar; Isı yalıtımı; güney yüzü; yalıtımlı duvar; güneş radyasyon

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AAC: Aerated Autoclaved Concrete

OSB: Oriented Standard Board

MDF: Medium Dimension Fiber

TRNC: Turkish Republic Of North Cyprus

NEU: Near East University

CHAPTER 1
INTRODUCTION

1.1 Background

Recently, many countries in the world today where buildings are large consumer of energy, and its demand is ever growing .The required energy in building is usually aimed at improving comfort at home. The need for us to insulate our houses, this includes roofs, floors and building wall is a principal issue just as much as scaling down the heat flow rate into the building and out of the building. For us to lessen flow of heat proficiently we need to select the right insulation materials by their purposes, installation, easiness to handle and their charge. Since the importance of energy conservation cannot be emphases. Besides, a considerable share say (up to 40%) of total energy demand is consumed by the sector of residence Chwieduk (2003). Therefore, most of the energy consumption in residences is attributed to usually air conditioning, especially in a hot climate Al-Homoud (2004). On the other hand, the cooling load and annual heating demand can be noticeably decreased by applying thermal insulation materials to external building envelopes. Cyprus, with say more than 21000 annual cooling degree hours is a representative of a humid and hot country in which household energy consumption is responsible for nearly half of the final total, and the share is considerably rising as a result of global warming. However, construction companies in Cyprus do not consider insulation in external building envelopes as thermal performances of residences are comparatively low. Although an increasing number of literature studied the effect of thermal performance improvement of buildings on the annual consumption energy and consequently money saving in several countries and climate conditions, there are rather little literature published on effect in Cyprus Panayi (2004), Florides, Tassou, Kalogirou, and Wrobel (2001), Kalogirou, Florides, and Tassou (2002), Florides, Kalogirou, Tassou, and Wrobel (2000). As a result, of that the application of insulation materials is conventionally regarded as actions which solely increases the costs project initial. Besides, as there is less information on the 2 optimum thicknesses of materials insulation, thicker layers may be added to envelope layers and/or in the wrong place, which reduces the performance, imposing extra initial costs which cannot possibly be compensated in maybe the near future. Thermal comfort on the other hand we say, has never been mentioned in the current literature about Cyprus, even while it is one of the most important benefits of non-monetary improves which makes the living space more comfortable whether or not the inside air is conditioned. Kitsios (2009) reported that 43%

of energy total usage is attributed to dwellings and Zachariadis (2010) did predict that the electricity consumption will be three times higher in the year 2030 in Cyprus. However, after examining (482) dwellings among which most of them were 100-150 mm and built between mid-80 and 2001, it is concluded by Panayiotou, et al. (2010) that, say 80% of total building envelopes do not apply thermal insulation at all their buildings. In other For us to test their thermal properties a group of building materials was deployed in the construction of three model buildings (L1),(L2) and (L3) in Nicosia, it is necessary to understand the thermal performance of the building envelope on the indoor environment.

In other to save energy in a building we have to deploy a befitting efficacious energy design for enveloping buildings. Enveloping building compasses of a configuration of materials for the building, the thermo-substantial properties of which determine the climatic response of the envelope. The location for this study was at the heart of Nicosia in Turkish republic of north Cyprus (latitude 35˚ N). North Cyprus, Nicosia is characterized by a Mediterranean climate with an extreme thermal radiation. With such climate buildings are impose to extreme danger to the various components of the house and it creates a discomfort able circumstances. In other to approach this problem, we use an effective wall insulation material to prevent comfort. In other to reduce the consumption of energy in buildings we evaluate the total amount of energy in and out of the building wall. These are usually influenced by the in-house as well as peripheral surface temperatures of the building hedge. Objectives of current study is to carry out thermal performance comparison and analysis of building walls attributed just before the heat property of the construction material on southern directed wall in Nicosia.

1.2 Study Objectives

Overall study intent of this study is to investigate the efficacy of exterior wall when subjected to thermal radiation and detect measures towards the diminution of annual energy consumption, in conventional single family dwellings of Cyprus. Accordingly, the objectives are presented in order below:

- To evaluate and to identify the best combination of typical walls which are normally being used in the residential construction industry of Cyprus, from energy consumption point of view.

- To evaluate the efficiency and to calculate the construction parameters of each combination and provide a comparison in order to figure out the best one from cost point of view.
- To discover a potential or modification of design to enhancing performances as well as to come across the available thermal insulation materials in Cyprus.
- To detect the most proper thermal insulation material for Cypriot detached houses.
- To study the effect of improving thermal performance of residences and to demonstrate the effect of enhancing building's thermal performance on the thermal comfort of inhabitants.

1.3 Works Undertaken

In other to achieve the aforementioned objectives, several methods and calculations where utilized, several possible combination of conventional materials was used as external envelopes were generated according to probability formulas and, the thermal performance of each wall was studied, As each envelope comprises several layers according to types of available thermal insulation materials and their corresponding data was gathered from C.E.E LTD. one of the prominent material suppliers in Cyprus. To calculate the optimum insulation of each thermal insulation materials, which is related to the specifications of the external envelope and insulation material, weather condition and analysis period, several methods, was employed. The best combination of typical envelopes was insulated with each thermal insulation type; the sensitivity analysis on changes in characteristical behavior of insulation material in Cyprus was performed by utilizing Microsoft Excel. Thermal comfort level was studied by using several protocol and, a comparison was made between the insulated, y-tong bricks wall and non-insulated cases.

1.4 Limitation of Study

As a result of small amount of published literature on the case study of the current investigation and to avoid adding excess detail to the research, some simplifications was considered in number of study’s stages. Indeed, these simplifications led to the limitations of study below:

- The available time was not adequate for a thorough study
- Material availabity was in short supply; approval factor also delayed the process

- Only three models of wall types have been studied.
- Financial support as well as adequate funding for experimental research work was a barrier.

1.5 Report Organization

Report was separated in five sections.

- Section 1 preamble: This section deals primarily with the background of study, purpose of research, Works Undertaken, limitation of study and the organization of this report.
- Chapter 2 Review of literature: This section mainly deals with the significant literatures and the up to date work that is associated to the research, important relevant information and findings are addressed accordingly. Highlighted areas covered optimum thermal insulation material based on thermal performance situation, energy life cycle in residential buildings, the effect of air tightness on building energy demand and studies which considered Cyprus as their case study, from energy profile and energy consumption point of view.
- Chapter 3 Methodology and material: This chapter deals with the resources used and the methods adopted for the study. The study parameters and method of test are briefly given in this section,
- Chapter4 Discussion and Result: This section the calculations and test result analysis, tables and figures are offered in this section. Furthermore, corresponding and discussion is provided where needed
- Chapter 5 Recommendation and Conclusion: The significant findings and conclusion of studies are mentioned as well as recommendation for future studies in this area are all within this segment.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

Generally it is believed so as to the significance of storing up thermal energy is growing significantly. Facts aside, residential sector consumes usually a large proportion of energy total. Cyprus, Zachariadis (2010) predicted once that the consumption of electricity will be three times higher in 2030 which raise a concern for reducing energy consumption. The consumption of electricity of residential sector is largely as a result of using air conditioner systems to achieve thermal comfort in building especially in Cyprus since, the heating of water is performed efficiently by solar water heating systems (SWHS) which has high performances and are cheap. The electricity consumption of dwelling as a result air conditioners usage could be decreased in a significant amount by the application of thermal insulation materials which are also available in different performances and costs. In the current study, available materials for insulation in Cyprus are identified and the impact of applying them to building external envelopes on a model wall was setup and investigated. A considerable amount of investigation although has been performed on the effect of material insulation on energy consumption of buildings with use of different methods of calculations and, the optimum insulation thickness was also computed consequently. In this chapter, we took a comprehensive background study carried out on the following subjects Investigations in which Cyprus was a case study with respect to the energy consumption predictions and profile, construction preferences and method, conventional construction materials, lifestyle and statistical analysis of the building types.

2.2 Thermal Insulation Materials

There are several studies on the performances and properties of thermal insulating building materials. Some researchers did try to make a comparison between thermal properties, drawbacks of conventional insulating materials and benefits while, others focused on a specific one of investigating its feasibility of becoming a widely used material in construction industry. The characteristics and function of every single material may alter due to the context in which the materials are installed; a comparison table may lighten the passive building analysis burden and narrow the options. Detailed information on existing thermal insulation of building materials was made available by Lyons (2007). Al-Homoud

(2005) compared the characteristics performance of a five common building insulation materials available in view are (polyisocyanurate-form/ polyurethane, Polystyrene Expanded, fiber glass-blanket, fiber glass- rigid board, Vermiculite and polyethylene-blanket) base on their5cm R-Value thickness. There were also some sketches and recommendations for the application of materials in his work. Papadopoulos (2005) demonstrated the increasing trend of 20 thickness insulation, applicable in countries in Europe and provided the anticipated U-values for external building envelopes in the same region. Besides, installation procedure's briefings, feature tables, the environmental concerns of insulation materials and place were also provided. Mahlia, Ismail, Taufiq, and Masjuki (2007) carried out an analytical study between relation of the corresponding thermal conductivity feature and the insulation material thickness for walls. As a of his research result, a function nonlinear was developed and, urethane-fiberglass was proposed as the most economic material for insulation which saved say more than 70 thousand US dollars in Malaysian weather. Currently, there exist no solution or single insulation material capable of fulfilling all the requirements with respect to most crucial properties states Jelle (2011). He has performed one of the most quite and recent comprehensive studies and comparisons on all insulation materials in present, past and future and their characteristics. He took into account specifications such as perforation vulnerability, thermal conductivity, mechanical strength, building site adaptability and cuttability, fire protection, fume emission during fire, climate ageing durability, water resistance, robustness, thawing cycles/resistance towards freezing, environmental impact and costs. In addition, the future application feasibility of using some material insulation such as dynamic insulation material, Nano-insulation material and Nano Constructions, which is a load-bearing insulation material, was also investigated. In another similar work by Baetens, Gustavsen, and Jelle (2010) that compared the potential of, present state of the art materials to become future materials, (Nano insulation materials) NIM was suggested as the most feasible one due to its thermal conductivity was low. To develop dynamic materials, that can regulate a wide range thermal conductivity, was the objective of their research. The sensitivity of 7 different insulation materials on altering operating temperature was discussed by Abdou and Budaiwi (2005) and polyethylene reported to be highly sensitive among others, while polystyrene was one of the least sensitive one and the reason behind it was considered to be the different density of each subject of the analyzed group. An investigation on the environmental performance of the stone wool and production process of two insulation materials namely extruded polystyrene was done by Papadopoulos and Giama (2007), using

Emission Global Model for Integrated Systems computer program and corresponding tables were provided based on a ISO 14031 standard. Another study done by Liang & Ho (2007) focused on the properties toxicity of conventional insulation materials in Taiwan, based on an experimental study done according to United Kingdom Naval Engineering standards 713. They computed Toxicity Index for tested materials and concluded that toxicity characteristic index of all tested materials was way bigger than, polyethylene, organic foamy materials, polyurethane foam and untreated wood, which were not approvable in foreclosing fire in buildings. As a result, to install insulation materials in the middle or outside of the external building envelope and to cover those with fireproof materials were also suggested.

2.3 Thermal Convey Across Assemblies Materials

In buildings, the thermal energy is usually transferred in one of various ways, either by conduction (energy stream through materials), in convection (energy stream across atmosphere current), and in radiation (energy stream starting with resources). While all three forms are of importance, which discusses their properties.

- **K= Thermal Conductivity.** Velocity at which energy stream across a harmonized working materials, thickness per unit of temperature difference between a different material or its surfaces, can be express in Btu.in
- **C= Thermal Conductance.** It is energy flow rate across component region of substance for each entity of hotness amid 2 plains and their depth of a structure.
- **R = Heat Resistance or R-Values.** It is the heat conflict of substance as well as its common thermal conductivity for both materials.
- **U = The Co-efficiency of Thermal Diffusion or U-Factor.** It is heat flow rate across component region of construction packet or substance assemblage, which include their boundaries films, for each component temperatures dissimilarity amid the inner air and outer atmosphere through the material (the code supposes that insulation installed duly and is not pressed in any road).
- **Thermal Transmittance "U":** It is the conductance of heat move through a working frame within the system in close.

2.4 Heat Transfer

Stable state thermal flow through material or transfer is acknowledged at the same time as conveyance, it's a simplest outline otherwise base in favour of analysing power. The r-value is the universal means deployed to estimate the heat recital of a substance. It's a gauge if thermal conflict to energy flows, if stable state condition exists. This involves all the ambient state be thought to exist 24 hrs. per day, 365 days per year. R-Value give-and-take is a U-factor where U= i/R only sole material, then $U=1/(R_1 + R_2 + \ldots)$ for assembly.

- Stable state for U-factor and R-value computation is included in heat preservation study as well as comparison in favour of predicting the heat recital of structure apparatus and building; though, the real rate of energy flow across structure shroud not invariable, as well as stable-situation, calculation will not seize interest in descriptive vibrant, time-dependent circumstances such as the thermal storage space facility of equipment, random outside temperature, storm as well as previous variable.
- Designed in favor of a lot of middle-state to inconsequential resources as wood sidings, vinyl and timber toughen studs, stable state energy convey calculation (R-values) offer enough evaluation of their definite recital; however, for denser resources akin to brickwork as well as solid, this include a elevated heat accumulation, r-value perform less precisely replicate, their real recital beneath the unreliable situation establish in the genuine globe.

2.4.1 Heat Conduction for Wall Model

The process through which conduction takes place in a substance as soon as molecules habitually energized by energy source on one side of the substance. These molecules that are energized convey energy to the cold side of the same substance. Cern ,Z.T., (1951) illustrate that Poor conductors of heat are placed between materials as insulators.

2.4.1.1 Transfer of Heat through Layers in Series or Plane Wall

Evaluating the heat that is then conducts all the way across different layer or walls in heat make contact with express the same as follows:

$$Q = \frac{\Delta T}{\frac{L1}{k1*A}*\frac{L2}{k2*A}*\frac{L3}{k3*A}*\frac{L4}{k4*A}*\frac{L5}{k5*A}} \tag{2.1}$$

Given from the equation:

A= heat transfer area *(m^2, ft^2)*

K= thermal conductivity of the material *(W/m K or W/m °C, Btu/ (hr °F ft^2/ft))*

L= *material thickness (m, ft)*

Q=heat or thermal transfer (w, j/s, Btu/hr)

ΔT= temperature gradient- difference in materials *(K or °C, °F)*

2.4.2 Heat **Convection for Wall Model**

Convection heat is the heat transfer from a component of a solution either in the form of a liquid or gas to one more part at lower heat by a mix of flied particle. It is also in occurrence mostly next to surface of walls, roofs, and floors since of the dissimilarity in temperature.

$$Q_{convection} = h\,A\,(T_s - T_f) \qquad (2.2)$$

Note that:

T_s= temperatures of the surface (K)

T_f= temperatures of the fluid (K)

H= heat transfer co efficiency (W/m^2 -K)

The speed of the liquid, substantial property of the solution, and the surface direction, the numerical figure of heat coeff. Depends on the nature heat up stream.

2.4.2.1 External Forced Convection of Wall

Similarly, the alteration starting laminar stream to turbulent streams at critical Reynolds number which is given as:

$$Re\ x, cr = \frac{\rho v x, cr}{\mu} * 5 * 10^5 \qquad (2.3)$$

Where:

ρ: density kg/m^3

μ: Dynamic viscosity kg/m.s

X cr: Critical number

Re: Reynolds number

V: velocity m/s

Again the average Nusselt relations for a flow of a plane shield are::

The Laminer force:

$$Nu = \frac{hl}{k} = 0.664 Re_L^{0.5} Pr^{1/3} \qquad Re_L < 5*10^5 \qquad (2.3)$$

The turbulent force:

$$Nu = \frac{hl}{k} = 0.0.037Re_L^{0.5}Pr^{1/3} \qquad 0.6 \le Pr \le 60 \qquad (2.4)$$

$$5*10^5 \le Re_L \le 10^7 \qquad (2.5)$$

The Combined force:

$$Nu = \frac{hl}{k} = (0.0.037Re_L^{0.5} - 871)Pr^{1/3} \qquad 0.6 \le Pr \le 60 \qquad (2.6)$$

$$5*10^5 \le Re_L \le 10^7 \qquad (2.7)$$

Note that:

Re_L: Reynolds number for laminar

Nu: Nuselt number

h: Heat coefficient

L: Thickness of material (m)

Pr: Prandtl number

2.4.3 Heat Radiation

With building as the main focus, external surfaces are always reviewed to the atmosphere. Simply we can say for the case of radiation which is the same transfer of heat beginning with the organization of its temperatures; it also increases at the same time as the heat of a organization increase system if checked. ($Q_{radiation}$) is given by:

$$Q_{radiation} = A\ \varepsilon\ \sigma\ (T_s^4 - T_{sky}^4) \qquad (2.5)$$

Where

T_s = temperatures of a construction showing surface (K)

T_{sky} = the temperature of the sky also (K)

A = building surface area (m^2)

ε = the emissivity of the exposed surfaces

Total heat transferred to the room (Qtotal) determined by adding the heat radiation (Qrad), heat convection outside (Qconv-out), heat conduction (Qcond) and heat convection inside (Qconv-in).when the total heat is less than zero the room is losing heat.

$$Q_T = Q_{rad} + Q_{conv\ in\text{-}out} + Q_{cond} \qquad (2.6)$$

2.5 Wall Insulation

. Moisture protected, properly sealed and wall insulation help to increase comfort and reduce noise and equally save money. However, walls are though complicated in terms of enveloping to insulate air sail, and control moisture. Previous work done in the past show that it is seen that the insulated wall reduces leaks at the surface compare with un-insulated wall. The keys to an effective wall are:

2.5.1 Cavity Wall Insulation

Cavity walls insulation involves satisfying each gap between the spaces of two wall of a house with an insulate substance massively decreases the hest which escapes through walls.indications of cavity walls are shown in Figure 2.1. The evolution behind alwaus will help to create a more even temperature in the house, to cutail the amount of heat inside the house throughout temperate region spell the buiding region spfere is prevented moisture cloudness.

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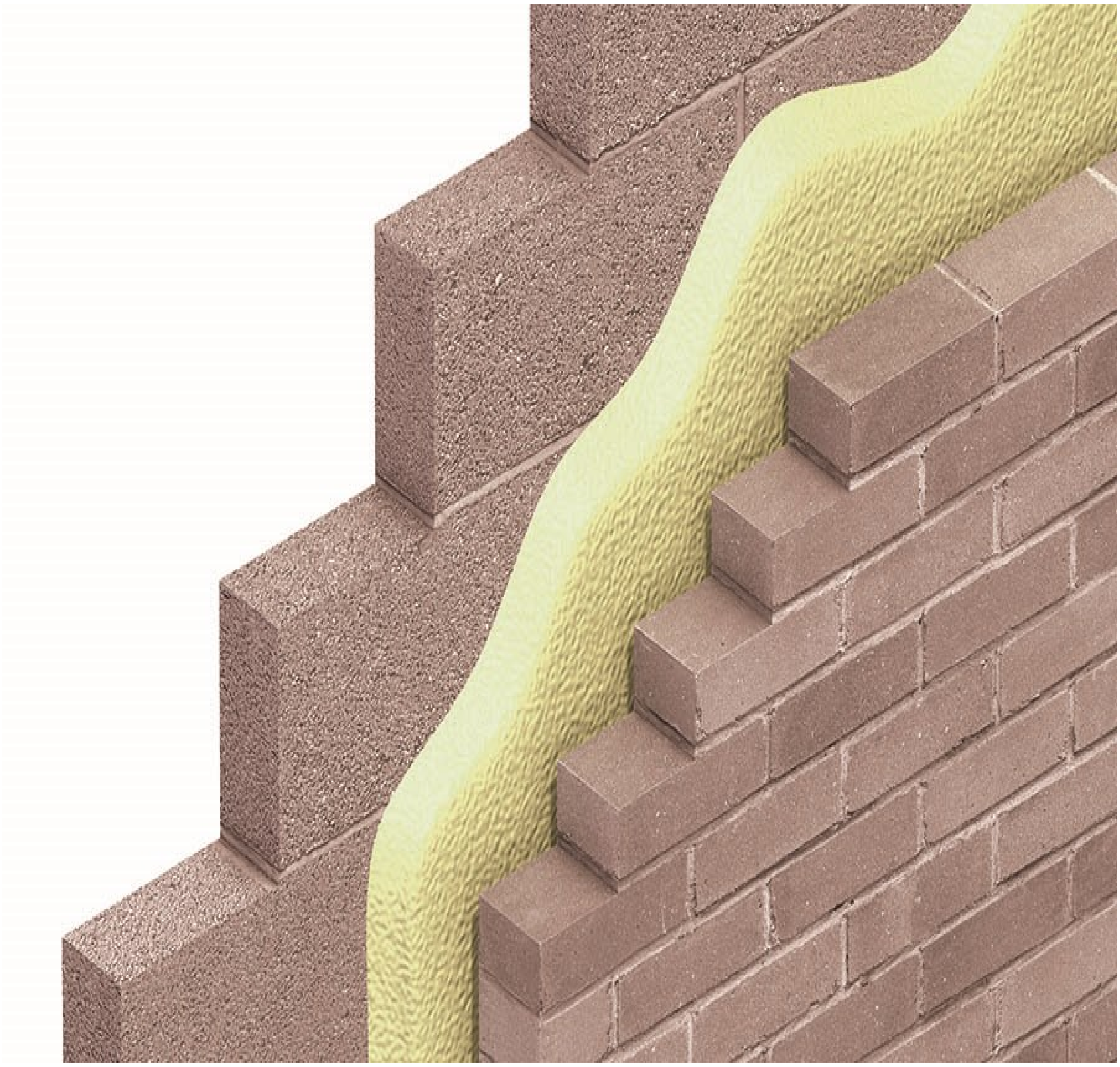


Figure 2.1: Typical brick formation for cavity walls

2.5.2 Solid Wall Insulation

Outside and inner hard wall padding are the two types of hard wall padding.Solid walls though drop heat than the cavity wall.There are two types of solid wall insulation, external and also internal.up inside the building during summer hot spells (floor insulation) the figure below shows a typical solid wall insulation.

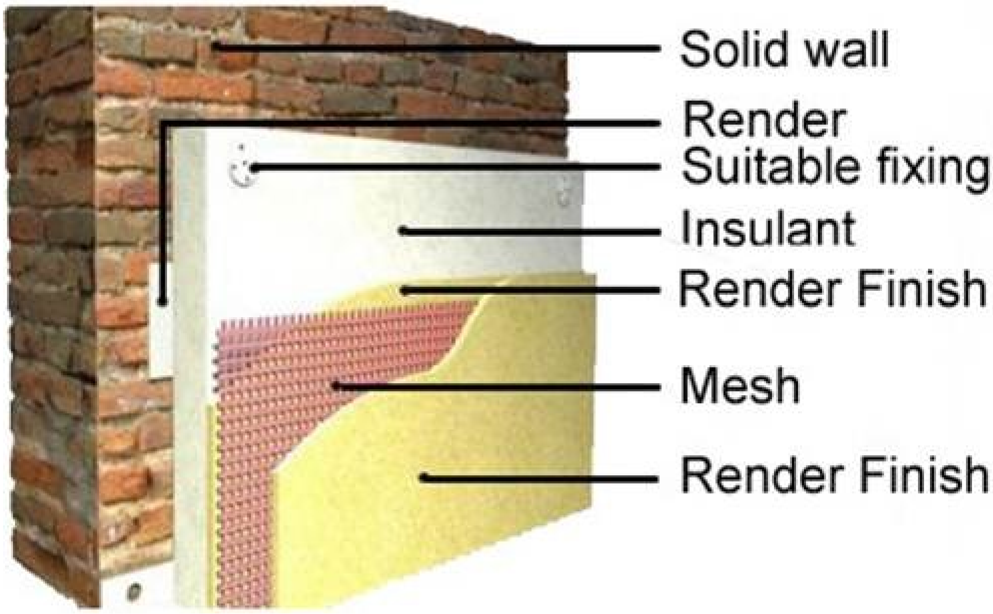


Figure 2.2: Typical brick formation for solid walls

2.5.3 Installation of Crawlspace Wall Insulation

Installation of crawlspace seems little more complex, no crawlspace is used in the houses of North Cyprus, an illustration of the application is shown in the diagram below.

Figure 2.3: Application area of crawlspace wall insulation

2.6 Choosing Insulation

The two main categories in which insulation comes are insightful. They are combined into a amalgamated maerial. There are many different products that avialble, to compare the insulating ability of each of the productavialable at their R-value,which resist heat flow.The way is that the higher the R-value the higher the level of insulation. But the same R-value will provide same performance insulation as specified. Product come with one material such as glass wool, wool, cellulose fibre, polyester and polystyrene for a given thickness.interpreted in this phenomenon through his demonstrations.

2.7 Determination of Where to Install Insulation

Structures having external walls should be insulated to reduce radiant, convicted and conducted heat transfer. Insulation of wall can be installed in either of the following ways:

- On the outside or inside of solid walls.
- Structures in stud frames.
- The side of the stud frames
- Within cavities with propel frame

Some forms of insulation can double as a vapor or moisture barrier. This depend on the situations Max and Maitlin (2013)

2.8 Cyprus as Case Study in Literatures

Although there are numerous studies on building thermal insulation materials, thermal performance, optimum insulation thickness in the Mediterranean climate and specially cooling load demand of dwellings and the effect of different factors on the heating, very little research has been performed taking Cyprus, which is located right in the middle of Mediterranean Sea, as case study. The electricity consumption profile of service and, relationship to climate condition changes and their residential sector as well as prices and peoples income in Cyprus was also studied by Pashourtidou and Zachariadis (2007). They drew a conclusion that climate conditions' changes have noticeable impact on the electricity consumption in a short term. Conversely, peoples income as well as market prices had a little effect on the electricity consumption in the same period while; their effect was reported significant to say in the long run. Employing this econometric analysis, Zachariadisoesadig (2010) predicted that the consumption of electricity will be three times higher in 2030 in Cyprus. He also took global warming into great account, as an effect of which, 1 degree centigrade increase in temperature rise is expected in the Mediterranean area by 2030, and calculated 2.9% increase in the electricity consumption by an aforementioned time still horizon as a result of which was, 200 million Euro (based on 2007) of welfare loss might still be tolerated. Mohamad, Guven and Egelioglu, (2001) found that the three important factors are major contributors to consumptions electricity yearly. These factors were the price of electricity, the number of tourists and the number of customers Mohamad, Egelioglu, and Guven (2001). In addition, modeling based on all these factors, declared to possess the prediction capability of future energy consumptions. Koroneos, Fokaidis, and Moussiopoulos (2005) discussed the feasibility of Cyprus and to employ renewable energy resources in order to reduce the amount of imported fuel 34 and coal for electricity production purposes. The introduction of building codes, focused on thermal insulation and developing public transport systems were two major suggestions as a result of their study. A climatically responsive houses and settlements in Northern Cyprus were analyzed as by Ozay (2005) in different architectural setting. Some elements of buildings like windows and fenestration areas as well as the design were considered in her analysis. Besides, the impact of socio-economy, technology, culture, politics and building management strategies was also taken into account. Isik and Tulbentci (2008) provided an investigation on the possible contribution of gypsum-stabilized earth which is called Alker in the sustainable construction as wall material as it is widely used in Cyprus for construction purposes. They concluded that the possibility is quite high since not only Alker has a comparatively low heat transfer characteristic, but also it provides health advantages. Embodied energy for construction material on other hand, is considerably low. Florides, Tassou, Kalogirou, and Wrobel (2002) modeled an absorption solar cooling system and determined several factors such as appropriate type of collector, the optimum size of storage tank, the optimum collector slope and area, and the optimum thermostat setting of the auxiliary boiler using TRNSYS simulation of engine. Panayi (2004) also studied the effect of building orientation, fenestration type and thermal insulation on the energy, applying thermal mass (Heating and cooling load) demand of Cypriot houses, using TAS Building Designer software, taking a detached house and an apartment as case studies. Double glazing was also suggested as the first measure and 2.5 centimeter wall insulation as the second measure to take for both cases while, applying 0.6 and 0.4 meter of thermal mass was suggested for apartments and detached houses respectively in order to reduce energy consumption. Additionally, the effect of orientation reported to be 35 minimal. The application of wall insulation and thermal mass leads to an increase of air-conditioning and dehumidification energy Panayi (2004) concluded. Florides, Kalogirou, and Tassou (2002) emphasized on thermal mass usage for buildings in Cyprus, using TRNSYS software. As a result, nearly 50% reduction in heating load demand was observed. Accordingly, optimum overhang size calculated 1.2 meter and the effect of wall cover, double glazing and altering air gap reported minimal. Besides, the impact of roof insulation found significant and, ventilation by the rate of 3 ACH per hour led to 7.5% reduction in cooling load. The evolution of residential buildings during 20th century in Cyprus, taking into account their energy (heating and cooling load) demand was carried out by Tassou, Florides, Kalogirou, and Wrobel (2001) using TRNSYS thermal simulation tool. Inside temperature of insulated and traditional dwelling was 16-20 degrees centigrade in winter time and, 25-30 degrees for summer. For the same seasons, corresponding temperatures was 11-20 degrees and 33-46 degrees centigrade for flat roof residences. Accordingly, a drop of 5 degrees was observed as a result of imposing ventilation during summer time and they draw a conclusion that construction methods and precautions such as allowing high ceilings and doors and positioning doors and windows towards the prevailing night winds provide the same inside temperature as modern, expensive and insulated houses. Panayiotou, et al. (2010) among which most cases were 100-150 square meter, and build between mid-80's and 2001. 68% of case studies were single house, 80% of total did not apply insulation to building external envelopes, where double glazed windows were installed to more than fifty percent of case studies and, 82% of residences employed solar heating systems for water heating purpose. Finally, the most comprehensive 36 study similar to current research was done by Florides, Kalogirou, Tassou, and Wrobel (2000), during which a typical modern 196 square meter Cypriot dwelling's energy (heating and cooling load) demand was computed in various cases, which differed from each other in construction materials for walls and roofs. For both walls and roofs the typical construction method which does not apply insulation to building external envelopes was regarded. Hollow bricks made of fired clay" was considered as the conventional construction material. The modeling process was followed by considering 2.5 and 5 centimeter of polystyrene insulation material in different cases, for both roofs and walls. The simulated house was divided into four identical thermal zones to provide the capability of studying diverse factor for each zone. Consequently, cooling and heating load for each, as well as heat losses and gains of all building external enveloped were computed for every case. The effect of natural ventilation, internal shading and inclined roof was also studied. Finally, an economic analysis was performed to calculate savings as a result of insulation in 20 years' time horizon. Results showed that maximum 68.1% reduction in heating at 18 degree centigrade occurs in case of applying 2.5 centimeter roof insulation and, 75.1% in case of 5 centimeter insulation, compared to the non-insulated roof case. Ventilation led to not more than 6.3% reduction in cooling load (to heating load reduction observed) in summer while, 19.9% was computed as a result of using internal shadings. Inclined roof demonstrated a negative effect on the load demand, accounting for up to 13.2% increase; although, if had been constructed for decoration purpose caused 41-55% reduction in cooling load. Considering life cycle costing, wall insulation's payback time was calculated 20 years, while in the same time more than 22 thousand euros could have been saved by insulating the roof (2000 prices and factors). In this investigation, Type 19 of TRNSYS simulation engine was 37 employed. Set values for the most important factors which are normally applied in thermal zone during the process of modeling, two model rooms in Nicosia show similar characteristic at day time against night time.

2.9 Climate of Cyprus

Typical weather of North Cyprus which is an isle is of a great Mediterranean kind with extremely hot dehydrated summer and equally icy winter. The majority of the precipitation is intense among December and January. The ocean heat in North Cyprus say in no way fall below16 degrees January and February; but in August it can also increase to some 28 degrees, during the spring and autumn in north eastern region of Cyprus are short with infrequent deep squall.

The Northern Cyprus enjoy over 300 time of sunlight and beginning at middle-September the sun shines on a daily basis at an adequate of 11 hour. Summer temperatures in Northern Cyprus are high in the lowlands, even near the Mediterranean Sea, and arrive at up to the highest reading in Masuria.

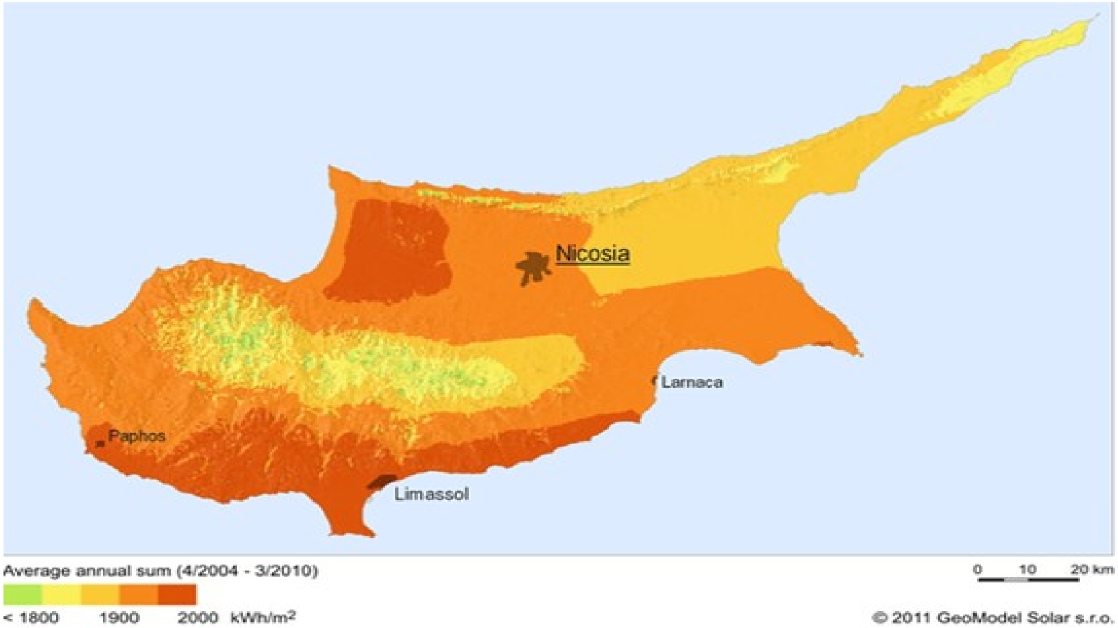


Figure2.4: Solar energy map of Cyprus

NICOSIA 35 15 N, 33 40 E, 161 meters (528 feet) above sea level.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Avg. Temperature (C^0)	12	12	15	20	26	30	32	32	28	24	17	13
Avg. Max Temperature (C^0)	14	15	18	23	29	33	36	36	32	27	20	16
Avg. Min Temperature (C^0)	5	5	6	10	15	19	21	21	18	15	10	6
Avg. Rain Days	5	3	3	1	1	0	0	0	0	1	3	3
Avg. Snow Days	0	0	0	0	0	0	0	0	0	0	0	0

Table 2.1: Nicosia monthly climate (8 years readings)

Name:	Turkish Republic of Northern Cyprus
Capital:	Nicosia

Area:	Total:9250 km^2 (of which 3355 km^2) North Cyprus 3355 km^2
Climate:	Temperature, Mediterranean with hot, dry summers and cool winters
Location:	Middle East, island in the Mediterranean Sea, south of Turkey
Geographic Coordinates	35 N, 33N
Coastline:	648 Km
Terrain :	Central plain with mountains to north and south; Scattered but significant plains along southern coast
Elevation extremes:	Lowest point Mediterranean sea 0 m, highest point: Olympus 1.951 m

Table 2.2: General information of Turkish Republic of Northern Cyprus

2.5 Köppen Climate Classification Systems

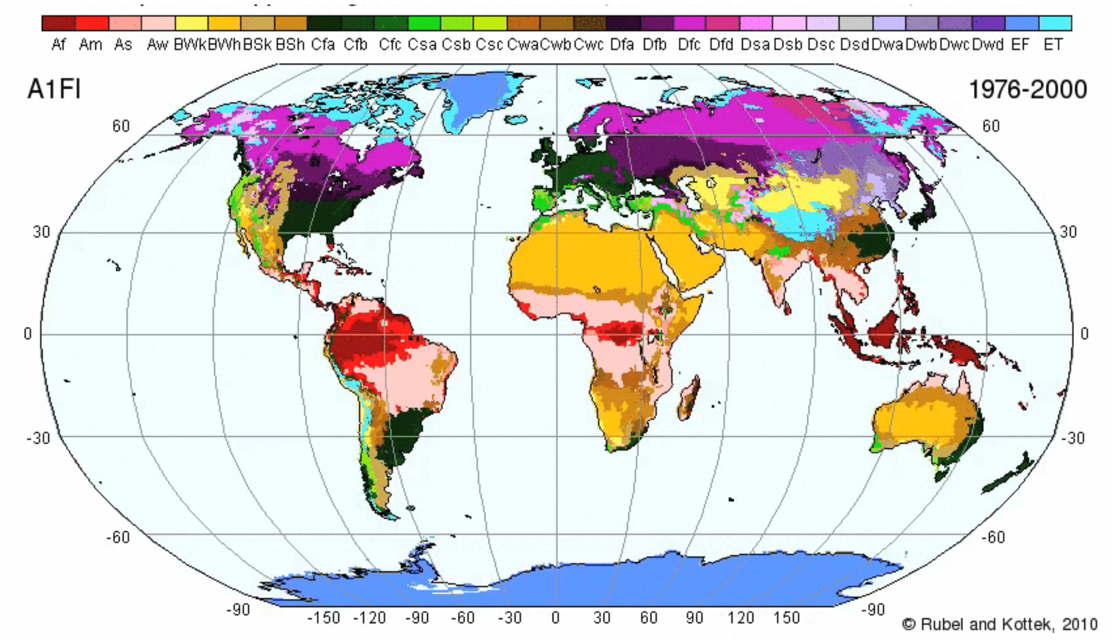


Figure 2.15: Koeppen's climate classification

The koppen climate classification system is the most vex used for classification of the world's climate. Most classification system that are used today are based on the one introduced in the year 1900 by the Russian-German climatologist Wladimir Köppen.

To further expand the variation in climate, a third letter was also added to the code.

- Hot summers where the warmest month is over 22 degree. These can be found C and D climates.
- Warm summer with the warmest month is over 22 degree. These can also be found in the C and D
- Cool, short summer with less than four month over 10 degrees. These can also be found in the C and D climates.
- Very cold winter with the coldest month below -38 degree it can be found in the D climates.
- h- Dry hot with a mean annual temperatures less than 18 degree it can be found in the B climates
- k- Dry cold with a mean annual temperatures less than 18 degree it can be found in the B climatic.

CHAPTER 3
MATERIALS AND METHODOLOGY

3.1 Heat Insulation Materials and Selection

To select the right material for performance application is really significant. There are quite some factors to be considered when it comes to designing an insulating system, they include safety, location, temperature, corrosion and installation and material cost. We endeavor to ease the work a little by consulting with some manufactures and dealers; they in most of the cases provide useful information including material data sheets, forms of charge and provisions.

3.1.1 Selection of Material, Thermal Conductivity and Performance Criteria

The exploit of dealer and manufacturer statistics in sequence in choosing the correct substance is a very important role of the scheme intend and fitting measures. The dealer and manufacturers data in sequence in general it include in sequence on the subsequent.

- explanation of the artifact
- compliance of principles
- contact of surroundings of the product
- property and recital
- urgent situation respond
- Safety precautions

3.1.2 Effects of Environmental Conditions

To ward off the need of installing thermal insulation in various types of adverse environment, the insulation material should have:

- fortification as well as weather for the intention of moistures
- Insulate opposition for fortification aligned with destruction
- Sufficient moisture resistance
- Chemical attack resistance.

3.1.3 Performance Requirement for material insulation

The following should be determined;

- Air rapidity
- Emissivity of external facade

- position of the lagging plant
- comparative clamminess of the ambient air
- scheme working temperature
- proposed ambient temperature

3.1.4 Materials Selection Chart for Insulation Material

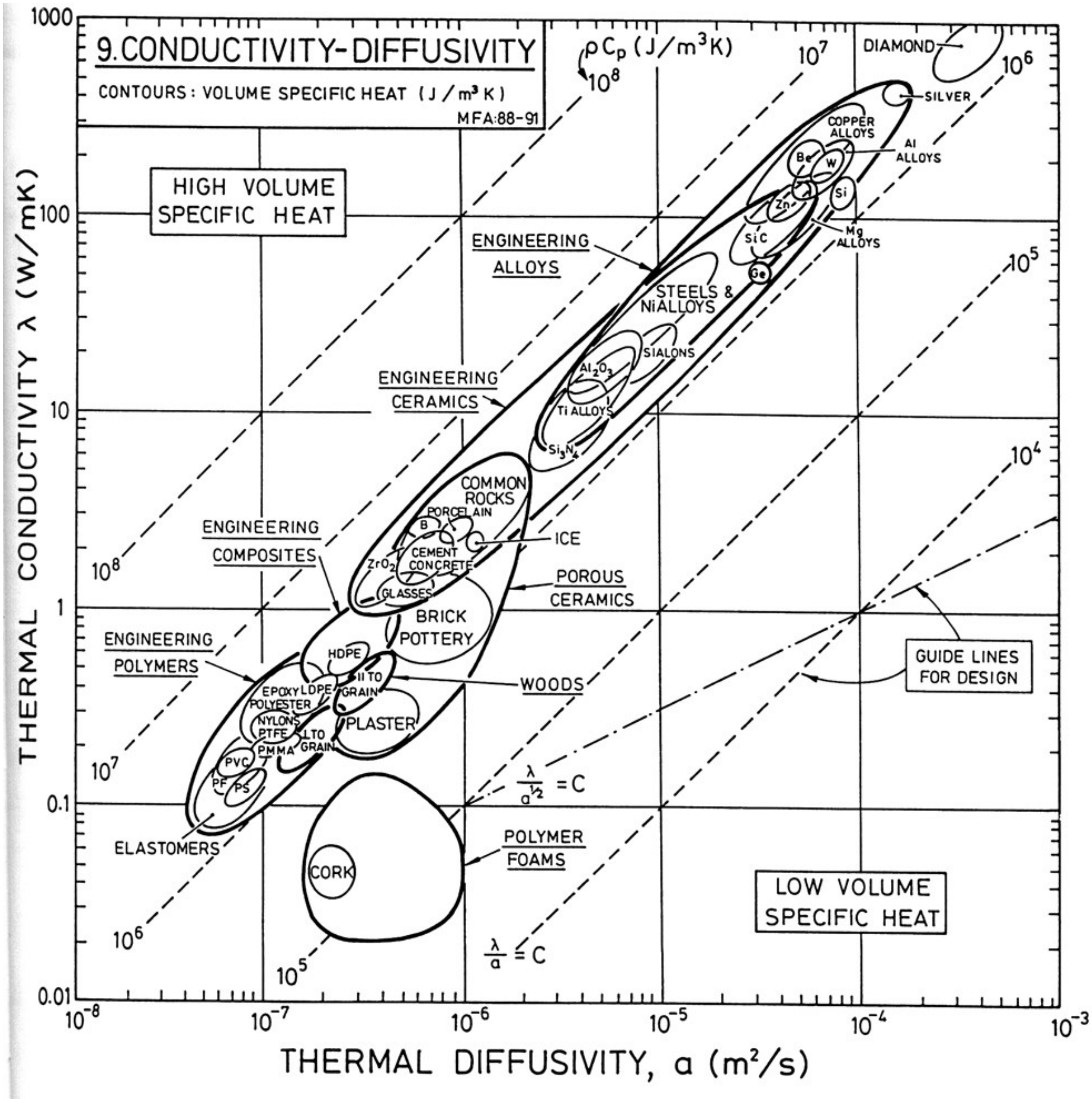


Figure 3.2: Ashby chart for thermal insulation material, thermal engineering

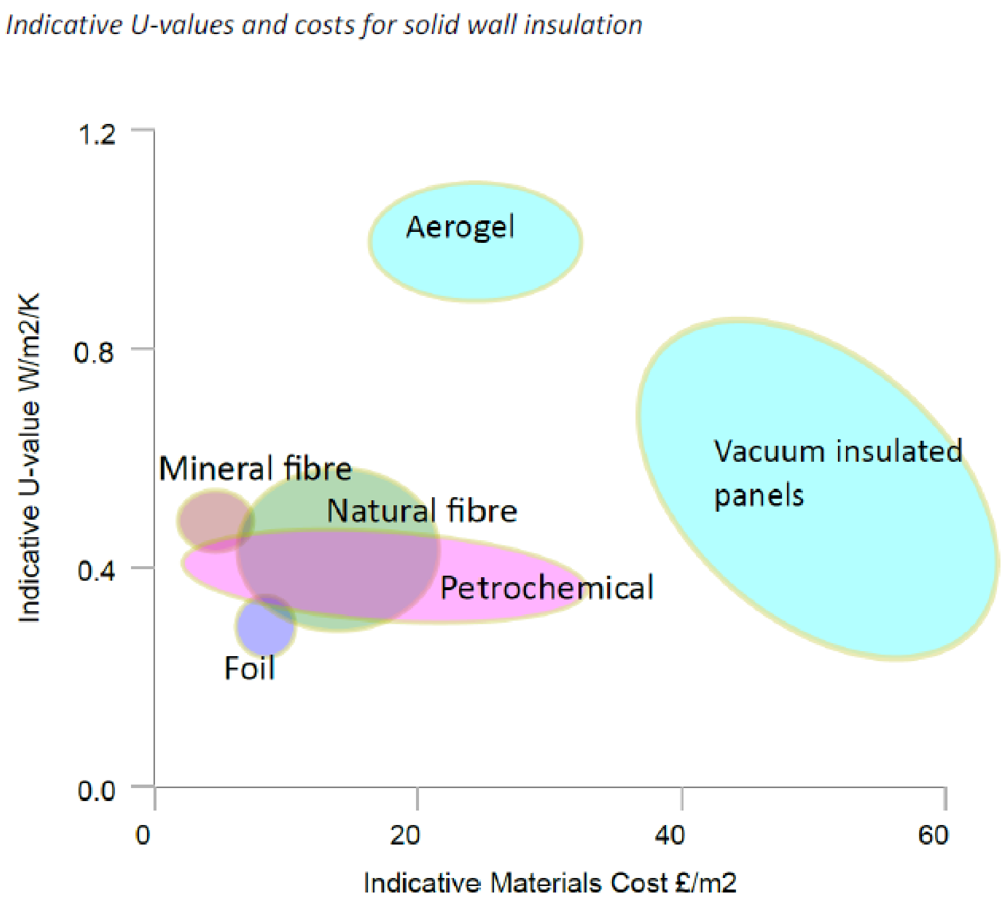


Figure 3.3: Ashby chart for thermal insulation material and cost benefit thermal engineering

The diagram shows that the ordinary stone wool is less expensive but requires being thick to achieve low U-value. Even though they are cheap when compare to aero gel as well as VIPs which are much thinner. They may lose heat through a hard wall.

3.2 Stone Wool

Stone wool fibers which had been used for isolation of buildings for decades have been used more and more also in high-temperature applications, especially since the health hazards associated with asbestos products loomed. The high-temperature behavior of stone wool has already been investigated by others e.g. Kirkegaard et al. (2005).

3.2.1 Specifications

- fire-resistant as well as heat insulation
- Stone wool. Board, blanket and pipe
- water-resistant

- Shock and noise absorption

Figure3.4: Stone wool and glass wool batts

3.3 Y-tong

The following attribute was the motive of selecting be although they can also be known as a brand of aerated concrete produces.

- Ecological – Y-TONG block which are fabricated of ordinary raw material includes cement, sand, gypsum, lime as well as irrigate.
- Vapor dispersion – Y-TONG walls breathe.
- Insulation characteristics- External walls of y-tong extra with a high thickness.
- Light weight.
- Straightforwardly to toil with.
- They are uninflammable in case of flames the Y-TONG walls do not deform and get destroyed.
- Precise dimensions.

The AAC blocks Y-TONG they are made from completely nature product materials which includes lime, sand, gypsum, water, cement. Producing them those not have effects on environmental order even as they go through a confined cycle within a moderate consumption of energy.

3.4 Stonebrick

They are contrived by either devastating the clay otherwise grinding or then integrating them with some amount of water to proportion to make it plastic. This plastic is then molded, textured, dried sometimes fired; they are of different colored sizes and textures.

3.4.1 Use of brick

The blistered bricks are stay strong, they are hard and durable, they are resistive to abrasion and fire, and are constructional materials for erecting structures

3.4.2 Advantages of Bricks

- They have good strength
- They are of different point of reference and sizes
- They are economical
- They are hard and durable and can be reusable
- They ate highly fire resistance
- They have low maintenance requirement
- Demolition of a brick is usually easy

3.4.3 Disadvantages of Bricks

- They absorb water easily
- Cannot be used in high seismic zones
- Their rough surfaces may cause mold growth
- Very Less tensile strength
- Time consuming construction

3.5 BH10 30 Hollow Heat Insulation Brick

3.5.1 Specifications

Product Code: for instance a common product code of this frame, say BH10 30 Description of specifications: Horizontal Perforated Non-load Bearing Wall Dimension: L 300x W 100 x H 200 (mm)

Main Advantages:

- They have compressive potency
- They have compactness and 60 percent less weight
- Water absorption ~15%   (alibaba,1999)
- Large size & low weight
- Excellent thermal insulation

3.6 Data logger and the Control Unit

From the power component has a recollection equal to 250000 reading and it is incorporated in the company of a print scheme for a customize print out, Also in the multi probe input and an integrated pressure are located in the control unit.

Figure 3.5: The power component 350/454

3.6.1 The Displays

The display system to the power component all flue gas quantity up to 6 percentage on a single display.

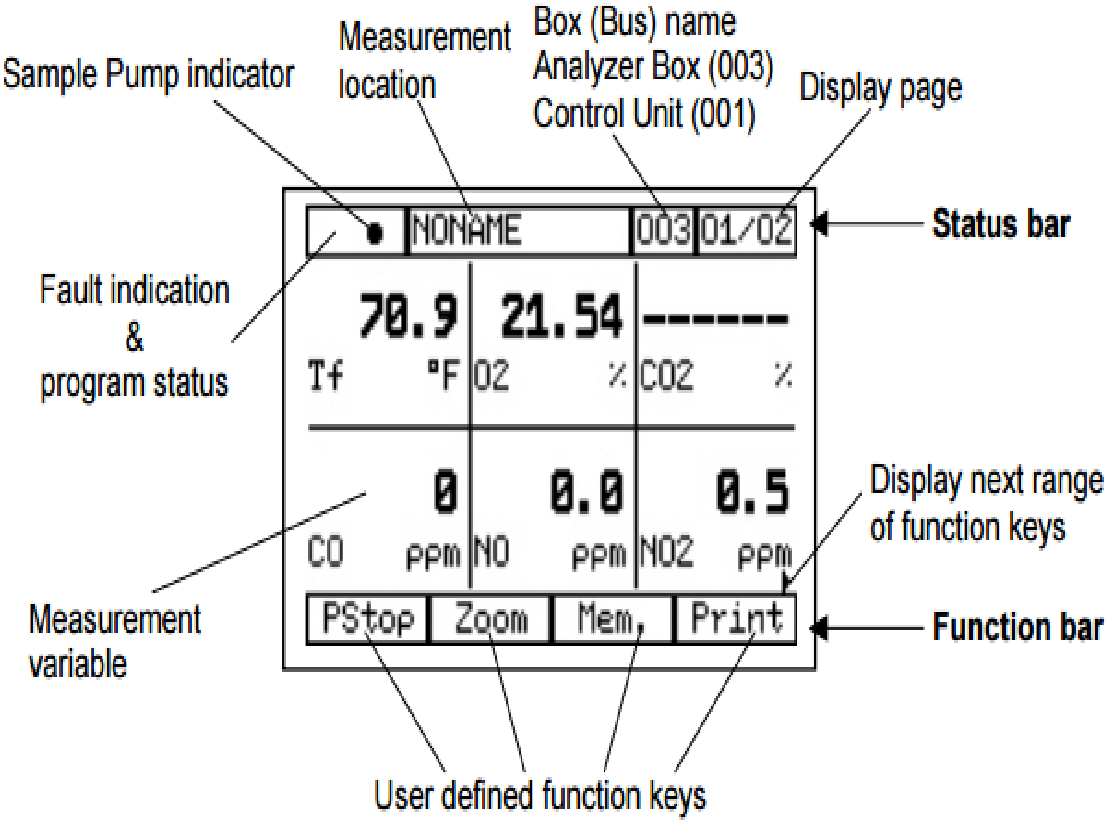


Figure3.6: The Display of Control Unit Screen

3.6.2 Control Unit 350/454 Charge Status

The control unit contains a sum of non rechargeable battery. While the analyzing box is plug in the display will show.

3.6.3 Ni Cr-Ni PROBE

Basically the probes are design for a temperature measurement in usually chemically non-aggressive environment. The probe output signal is the thermoelectric voltage type K, which depends on the major temperature.

Table 4.2 Features of Nicr-Ni PROBE

Air probes	Illustration	Measurer ange	Accuracy	T99s	Conn.	Part.no
Thermocouple made of fiber-glass insulated Thermal pipe ,Pack of 5 ,insulation twin,conductors,flat oval .opposed and covered with fiber-glass,both conductor are wrapped together with fiber-glass	 2000 mm  Φ :0.8mm	Φ :0.8mm -200...+400 ºC	Class A	5 S	Please order adapter 06001693	06441109

3.7 The Experiment Procedure of Model Rooms

The illustrious work plays an important role by trying to signify the impacts of solar radiation on simple wall construction and multi layer wall with heat insulation materials and Y-tong bricks materials for walls in TRNC. The experiment was divided into two stages: first stage tests effect of solar for south face of walls and second stage tests effect the solar of the wall with insulation and the Y-tong wall insulation. The study was experimented within the months of November, December and January.

The study was tested at the south face, because the south face takes more sun powered radiation beams than the others facades. The experiment was tested at the Mechanical Engineering Solar Laboratory Building in NEU, Lefkoşa. This study undertaken was based on the constructed three model rooms, room L1 was a square face construction but the study was focused on the at south face with no insulation material, the second model room was same construction as the first one with a difference in the south face, the model room L2 has with heat insulation material (stone wool) at the south face and the last model room L3 is a similar construction but the south-face was constructed with Y-tong bricks material. Rooms L1, L2 and L3 based floor was laid over a wood material and the floor wooden materials laying upon a concrete base floor with the model rooms constructed upon it.

Room L1, Room L2, and Room L3 consists of four side facing: wall, North, East, West and South. The experiment study was focused on south face where the solar radiation is at maximum, The three model rooms contains same setting for the (North, East, west) surfaces and multiple layers of wall of different combination for experimental purpose. For case one L1, the south face contains the combination of cement concrete, hollow bricks then cement concrete (outside and inside of the three walls surface). Room L2; for case two the south face contains insulation for heat stone wool, block of concrete, and plaster gypsum (outside and inside of the three walls). South face contains cement concrete (inside and outside of wall) and in the middle Y-tong.

Room L2 consists for four side face: North, East, West and South. The experiment study was again focused on the south face, The three walls (North, East, west) contains same materials insulation for heat stone wool, block of concrete, and plaster gypsum (outside and inside of the walls).South face contains plaster gypsum (outside and inside of the wall), insulation for heat Stone wool and at the middle blocks of hollow brick clay.

Whereas for roofs of three models room L1, L2 and L3 have same procedure. First of all wood OSB (Oriented standard board) was placed over the rooms structured, after OSB The glass wool batts was insulated, and over the glass wool insulation of water (yalteks) was insulated, The tiles was lay one after the others.

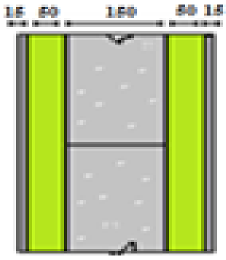
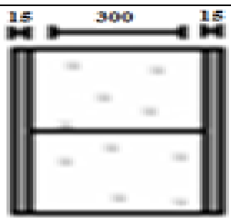
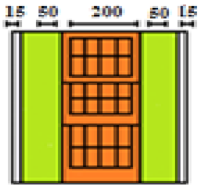
Wall reference	Construction material	Detail	U-value	Thickness (mm)	Image of material
Wall facades, North, East, West of room L1& L2 **LECA block**	• Plaster cement (15 mm) • Stone wool (50 mm) • LECA block (150 mm)		1.34	270 mm	
South wall of Room L1 **Y-tong**	• Sand & cement mortal (15 mm) • Y-tong (300 mm)		0.37	320mm	
South wall face of room L2 **Hollow brick**	• Plaster cement (15 mm) • Stone wool (50mm) • Hollow brick (200 mm)		1.3	320mm	

Table3.1: Categorization of conventional wall types

Figure 3.7: Laporatory setups (L-1 and L-2) at Near East University lab building

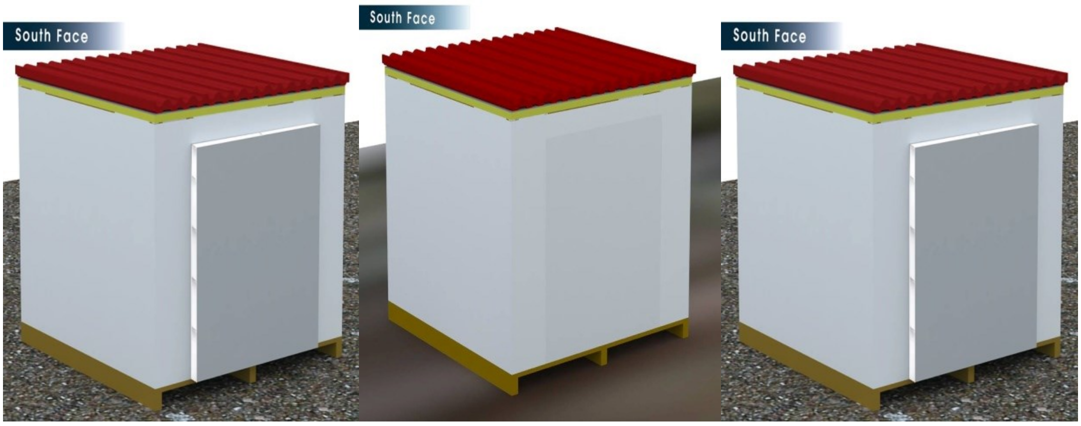


Figure3.8: Room L1, Room L2 and Room L3 respectively in (3D)

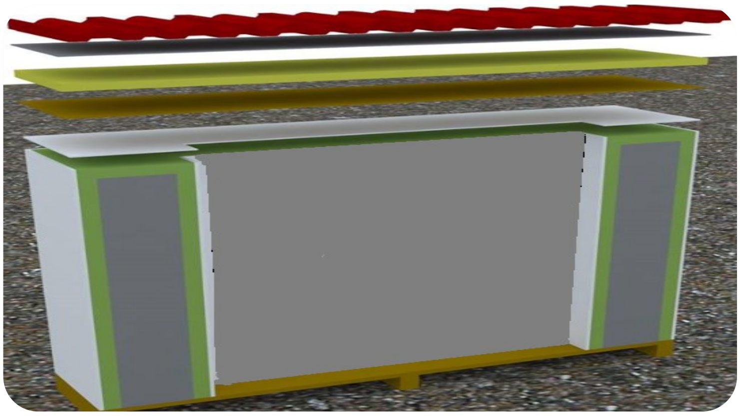


Figure 3.9: The cross section of the model room

3.8 Construction Stages of Model Rooms:

For the Three models room we used the same roofing materials and design structure. The roof was constructed with following materials First was OSB wood, insulation for heating glass wool batts, insulation for water (yalteks), and lastly roofing tiles. All materials were installed respectively. The base was constructed of wooden materials with a four standing legs and a wooden board MDF simply known as Medium density fiberboard which was inserted.

The following three walls which include North, East and West was built by laying hollow block concrete after the lay the stone wool was insulated and was plastered with plaster of gypsum.

The three walls of the three models rooms L1, L2 and L3 was constructed with the same procedure only the south face of the both three rooms was built with different materials and procedure. The first model room L1 of south face was constructed with concrete cement hollow bricks and still cement concrete.

The second room was constructed with layers of Y-tong block and was plastered with concrete cement at both the (outside and inside) surface.

The third model room, the south face was built by layers of Hollow clay brick after the laying the bricks the stone wool was installed before and after the bricks and plastered with gypsum plaster.

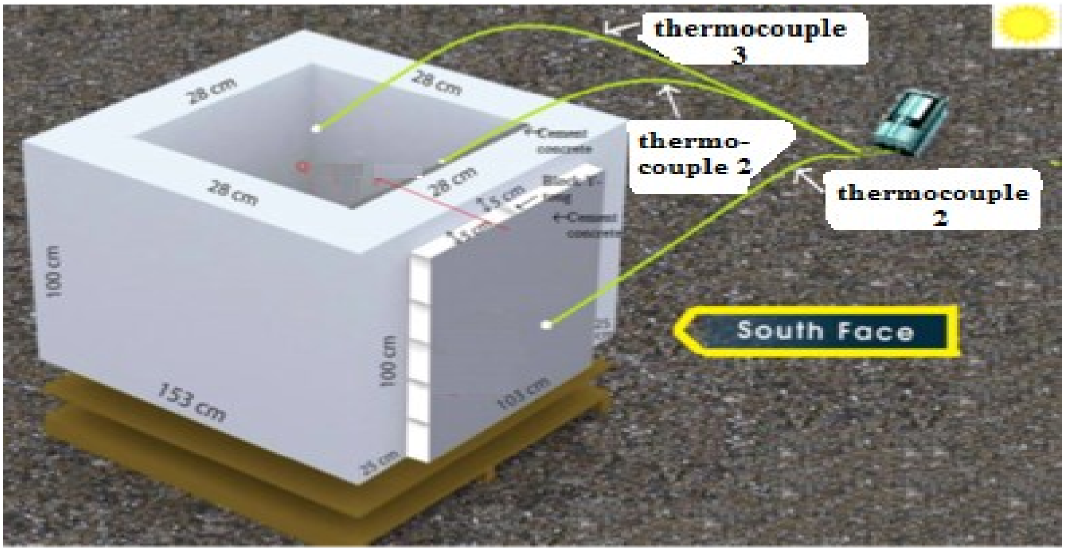
All top of the walls was finished with stone wool and was plastered by plaster of gypsum.

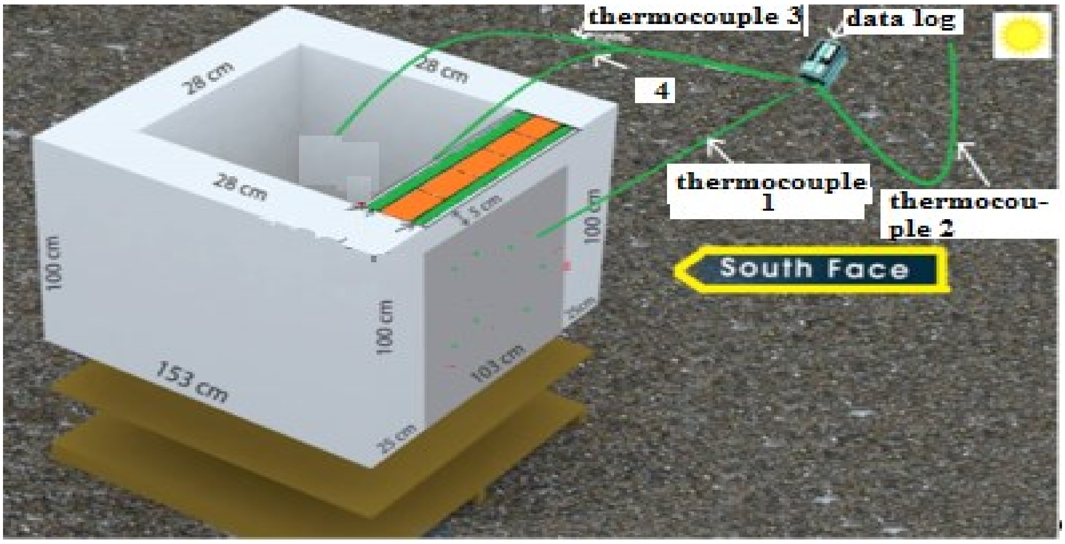
The place where the cables pass through into the room is between the roofs and the top end of wall and the place was sealed using glass wool. In three models room had a small plate of wooding material (tables) was screwed on the east face of the walls inside the rooms and the testo (data logger) was placed on the table for the collection of data which were saved for experimental reading.

3.8.1. The Materials Used in Walls of Three Models Room

- Cement concrete
- Cement plaster thickness 10 mm
- Hollow brick block 300 mm*100 mm*200 mm
- Insulation for heat stone wool 600 mm*1200 mm*50 mm
- Hollow concrete block 400 mm*150 mm*200 mm

- Block of Ytong 600mm*300 mm*100 mm





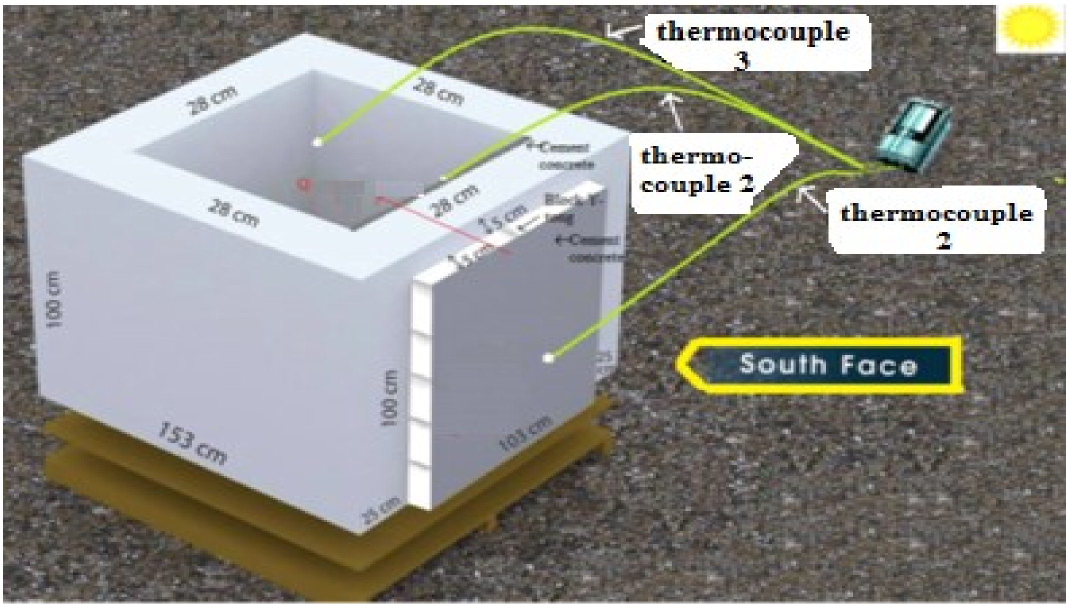


Figure 3.10: Schematic diagram and the room L1, L2 and L3 size and dimension

3.8.2 The construction material Used on Roofs

- Yalteks water insulation material The height of yalteks is 5 mm
- Glass wool batts height 50 mm
- Roof tiles has 40 mm height
- Wood OSB (oriented standard fiberboard) 1500 mm*1500 mm*20 mm

3.8.3 The Materials Used on Basement Floor

- Wood MDF (Medium dimension fiber) 1500 mm*1500 mm*2 mm
- Wood deck base 1500 mm*1500 mm

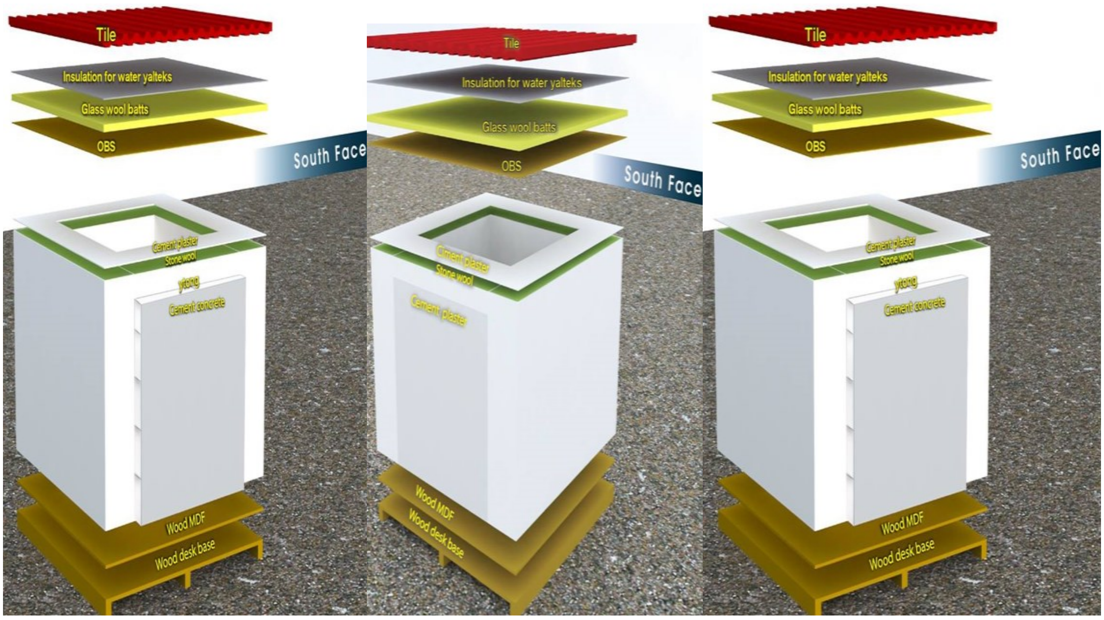


Figure 3.11: L-1,L-2,L-3 roof and floor layers

3.9 Roof Tiles

Roof tiles are planned mostly to keep out rainstorm, and are customarily produced using locally accessible materials, such as, terracotta or slate. Current materials like concrete and plastic are likewise utilized and some mud tiles have a waterproof coating. Roof tiles are hung from the structure of a rooftop by altering them with nails. The tiles are generally hung in parallel columns, with every line covering the line beneath it to bar water and to cover the nails that hold the line underneath. These tiles are held tight strips nailed to divider timbers, with tiles uniquely shaped to cover corners and frames. Frequently these tiles are molded at the presented end to give an improving impact. Another type of this is the supposed numerical tile, which was held tight slats, nailed and afterward grouted (William and Elizabeth, 1981). There are additionally rooftop tiles for extraordinary positions, especially where the planes of the few pitches meet. They incorporate edge, hip and valley tiles. These can either be had relations with and pointed in bond mortar or mechanically altered. So also to roof tiling, has been utilized to give a defensive climate envelope to the sides of timber casing structures. A tile is a fabricated bit of hard-wearing material, such as, artistic, rock, metallic, or even glass, for the greatest part utilized for layering roofs, floors, walls, or different objects Marilyn.

3.10 The Arrangement of Thermocouple Cable

The thermo-couple links are organized as illustrated below while the walls material layers were being finished by the laborers thermo couple links were put on each of the layers of materials to measure the temperature.. The temperatures of each material were taken at every 10 minutes. We picked outdoor and solar radiation temperatures from the meteorology office in Nicosia. There were four thermo couple links for each room of walls. Both of walls south faces wall material temperatures were measured by the thermocouples with the original set up link.

3.10.1 Connections Involved in Model Room L-1

- L1 Thermo couple cables arrangement;
- No:1 Inside on the surface wall (inside of hall 5 mm)
- No:2 Outside on the surface wall (inside of hall 5 mm)
- No:3 Inside of model room
- No: 4 outside temperature

3.10.2 Connections Involved in Model Room L-2

L2 Thermo couple cables arrangement;

- No:1 Inside on the surface wall (inside of hall 5 mm)
- No:2 Outside on the surface wall (inside of hall 5 mm)
- No:3 Inside of model room
- No: 4 outside temperature.

3.10.3 Connections Involved in Model Room L-3

L3 Thermo couple cables arrangement;

- No:1 Inside on the surface wall (inside of hall 5 mm)
- No:2 Outside on the surface wall (inside of hall 5 mm)
- No: 3 Inside of model room.

The study was carefully done with the thermo couple cable sensors were mounted at different points of the walls and the temperatures were recorded continuously at an interval of ten minutes to ensure proper documentation.

3.11 Thermal Envelope Design of a building- Calculations

Easy technique of heat system conformity is summiting the regulation of padding requests for edifice assembly such as roofs, walls as well as floors. The resolve of the heat resistance of structures material is the start up point for most construction envelope heat design calculation.

Heat efficiency of a structure is calculated from the energy flow rate across all the materials in the wall, per unit temperature between the inner and the outer air. This coefficientcy of energy transmission is the U-factor, largely expressed in Btu/(hr · °F · ft²).

For the simplest case, the U-factor is solved by adding the thermal resistances (R-value) of the component of the wall assembly as well as taking their reciprocal.

$U = 1/(R_1 + R_2 + R_3 \ldots)$.

Total heat was calculated by adding the 4 different heat types (Q_{Rad}, $Q_{con\text{-}out}$, Q_{cond}, $Q_{con\text{-}in}$) of the room where Q_T was represented in Figure 4.16 below.

Total Heat (Q_T):

$$Q_T = Q_{Rad} + Q_{Conv-out} + Q_{Cond} + Q_{Conv-in}$$

Heat radiation:

$$Q_{radiation} = A\, \varepsilon\, \sigma\, (T_{s(out)}^4 - T_{sky}^4)$$

Heat convection (inside-room)

$$Q_{convection} = h\, A\, (T_{s(in)} - T_\infty)$$ When we have still air h=8.3 (W/m^2-K)

Heat conduction

$$Q_{cond} = \frac{\Delta T}{\frac{L1}{k1*A} + \frac{L2}{k2*A} + \frac{L3}{k3*A} + \frac{L4}{k4*A} + \frac{L5}{k5*A}}$$

1. For homogeneous materials, doubling the thickness doubles the R-value and halves the C-factor.

$C_x = k/x$

$R_x = x/k$

$C_x = 1/R_x$

Where:

x = thickness of material in inches

k = conductivity

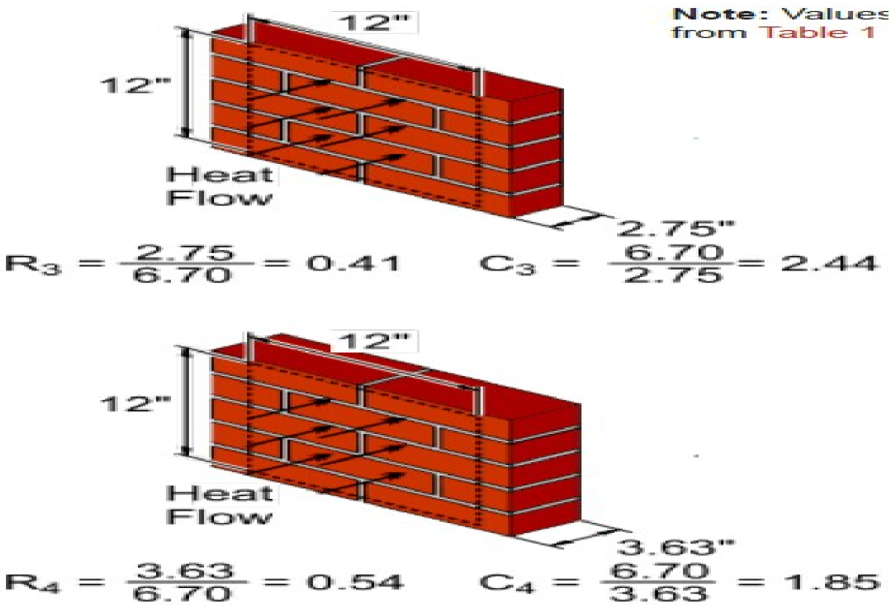
To determine the conductivity of brick, consider an assumed fired clay brick density of between 120 to 130 lb/ft³ and use the values in Table 1 as follows:

$k_{brick} = (5.6 + 7.8)/2 = 6.7$

For a 3 in. nominal brick, (2.75 in. actual dimension):

Resistance, R = 0.15 (h · ft² · °F/Btu · in.)

R = (0.15 (h · ft² · °F/Btu · in) · (2.75 in.) = 0.41 (h · ft² · °F)/Btu



Total heat at day time was calculated by the sum of heat conduction, heat radiation, heat convection in and heat convection out, where total heat was represented in Figure 4. below.

Second calculations.

Total heat was calculated by adding the 4 different heat types (Q_{Rad}, $Q_{con\text{-}out}$, Q_{cond}, $Q_{con\text{-}in}$) of the room where Q_T was represented in Figure 4.16 below.

Total Heat (Q_T):

$$Q_T = Q_{Rad} + Q_{Conv-out} + Q_{Cond} + Q_{Conv-in}$$

Heat radiation:

$$Q_{radiation} = A\, \varepsilon\, \sigma\, (T_{s(out)}^4 - T_{sky}^4)$$

Heat convection (inside-room)

$Q_{convection} = h\,A\,(T_{s(in)} - T_{\infty})$ When we have still air h=8.3 (W/m^2-K)

Heat conduction

$$Q_{cond} = \frac{\Delta T}{\frac{L1}{k1*A}+\frac{L2}{k2*A}+\frac{L3}{k3*A}+\frac{L4}{k4*A}+\frac{L5}{k5*A}}$$

1. For homogeneous materials, doubling the thickness doubles the R-value and halves the C-factor.

$C_x = k/x$

$R_x = x/k$

$C_x = 1/R_x$

Where:

x = thickness of material in inches

k = conductivity

To determine the conductivity of brick, consider an assumed fired clay brick density of between 120 to 130 lb/ft^3 and use the values in Table 1 as follows:

$k_{brick} = (5.6 + 7.8)/2 = 6.7$

CHAPTER 4

RESULTS AND DISCUSSION

Heat recital of a structure assembly varies as of what is anticipated. To maintain best performance it depends on top of a numeral factor, the most significant being setting up and ecological environment. Calculations, radiation, temperature, wind velocity are the results obtained theoretical from the data obtained from meteorological office (Nicosia, 2015) (Appendix A, A1, B, B1, C, C1).The result presented and discussed in this chapter was the undertaken .experiments performed in solar laboratory of Near East University (NEU) .

4.1.1 Midpoint Average Radiation Data for Nicosia 2015

The daily solar radiation changes from about 10 MJ/m^2 during winter and up to 28 MJ/m^2 during summer. Variations per day of solar radiation on horizontal surface in Nicosia, 2015 obtained from meteorological office of TRNC is given in Appendix A. figure shown below indicated that variation of daily total solar radiation throughout the year. The average of daily total solar radiations for each month is also shown in graph below.

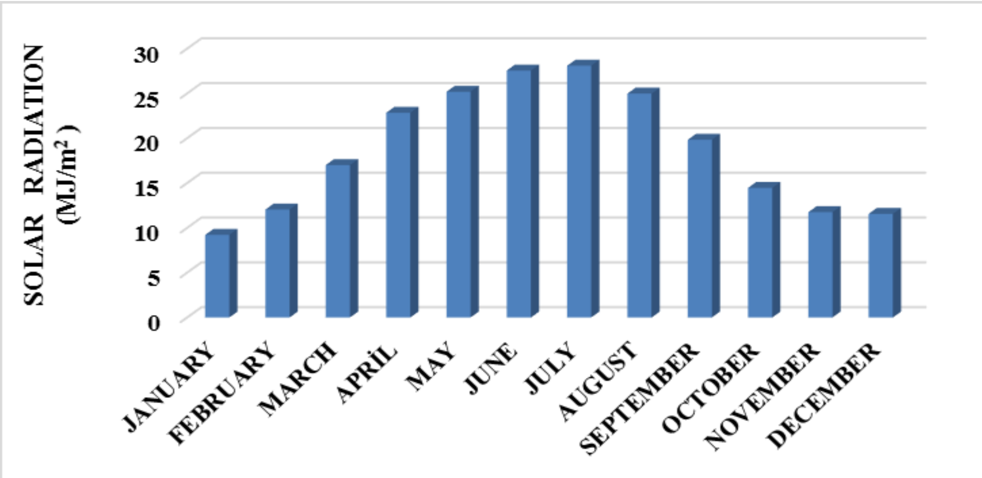


Figure 4.1: Variations per day of solar radiation in Nicosia, 2015

The weather in November as expected is changing as the season moves well into autumn and towards winter. Towards the end of November, the rainy season begins. November has more than an average of 7 rainy days. Variations per day of solar radiation on horizontal surface in Nicosia, 2015 obtained from meteorological office of TRNC is given in Appendix B. Figure 4.1 shows the variation of daily total solar radiation during November and December. So the month November has solar radiation more than December, the reason was month November had temperature more than month December.

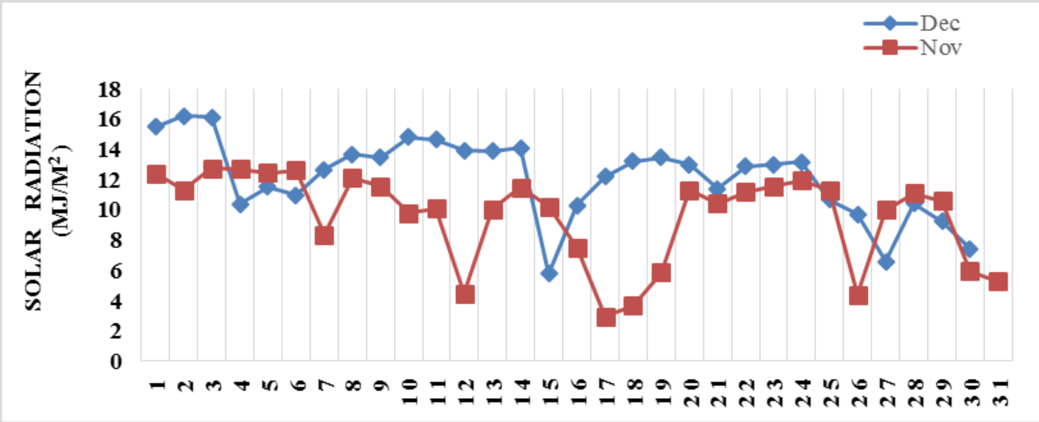


Figure 4.2: Variations per day of solar radiation in Nicosia, December and November 2015

4.1.2 Midpoint Average Temperature Data for Nicosia 2015

The average of daily temperature for each month is also shown in Figure 4.3. The daily temperature changes from about 10 ^{o} C during winter and up to 29^{o} C during summer. Monthly variation of Temperature in Nicosia, 2015 obtained from meteorological office of TRNC (appendix B). Figure 4.3 shows the variation of daily temperature throughout the year.

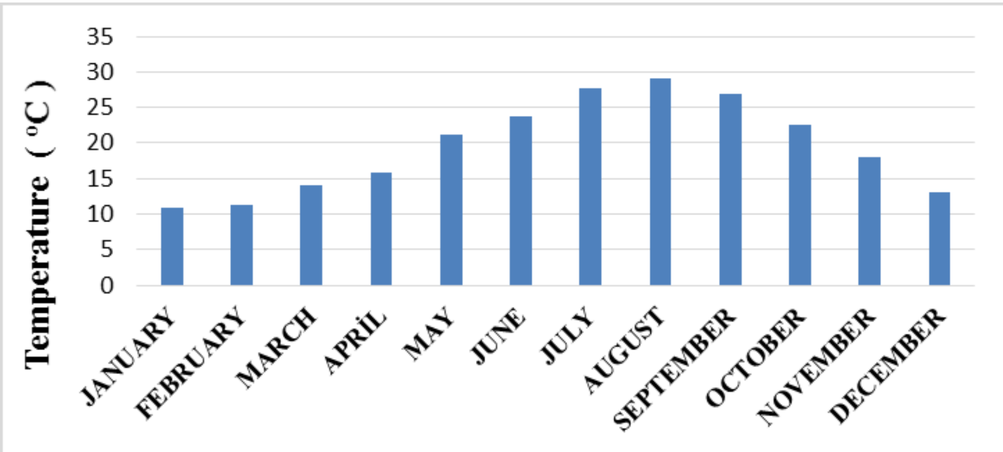


Figure 4.3: Variations per day of temperature in Nicosia, 2015

We noted that November had temperature more than December, the reason was month November had temperature more than month December. The weather in November as expected is changing as the season moves well into autumn and towards winter. Towards the end of November, the rainy season begins. November has more than an average of 7 rainy days. Daily variation of temperature in Nicosia, 2015 obtained from meteorological office of TRNC is given in Appendix B1. Figure 4.4 shows the variation of daily temperature during November and December.

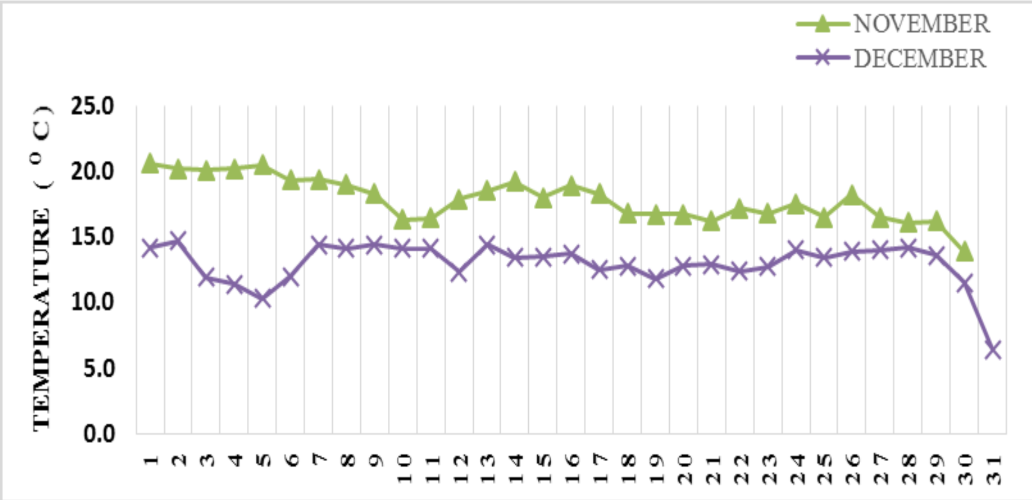


Figure 4.4: Variations per day of temperature in Nicosia, November and December 2015

4.1.3 Midpoint Average Air Velocity Data for Nicosia (Nov, Dec, 20015)

As indicated in (Appendix C). Variations per day in velocity m/s for the Nicosia during November and December 2015 shown in graph below

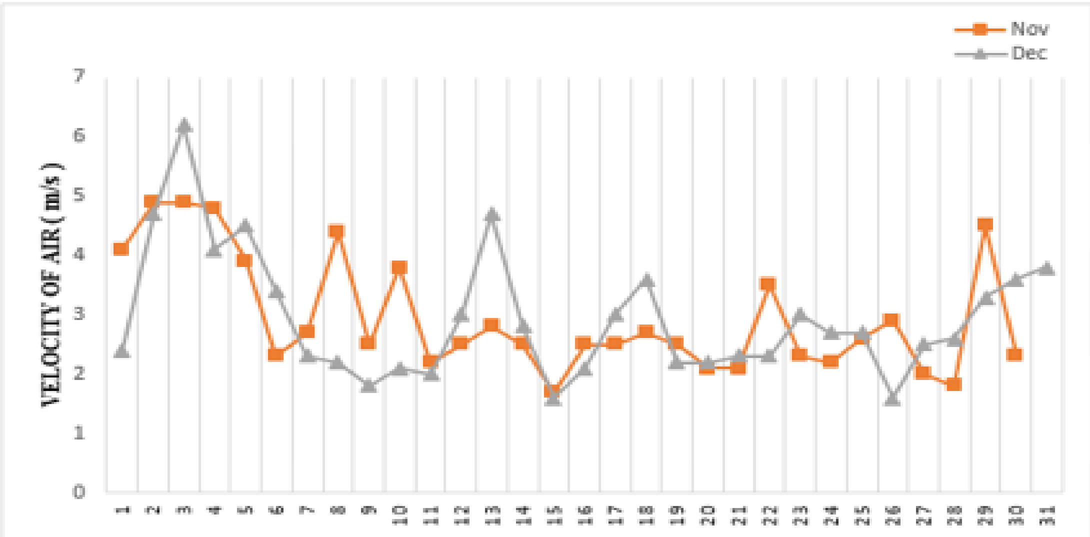


Figure 4.5: Variations per day of velocity in Nicosia, (Nov, and Dec, 2015)

4.1.3 Midpoint Average Day Time of Heat Convection-in, Convection out, Radiation and Conduction of Wall no Insulated

During the day the room was facing two convection processes one from outside of the room by the wind and the other is inside the room where there is only sill air. Daily variation of average day time in $Q_{con-out}$ and Q_{con-in} where calculated and presented in (Figure 4 and Figure 4) respectively. We can see from graph that the highest heat convection-in of wall no insulated was 160W and the lowest was 0.5 W. whereas heat convection inside the room varied during the day.

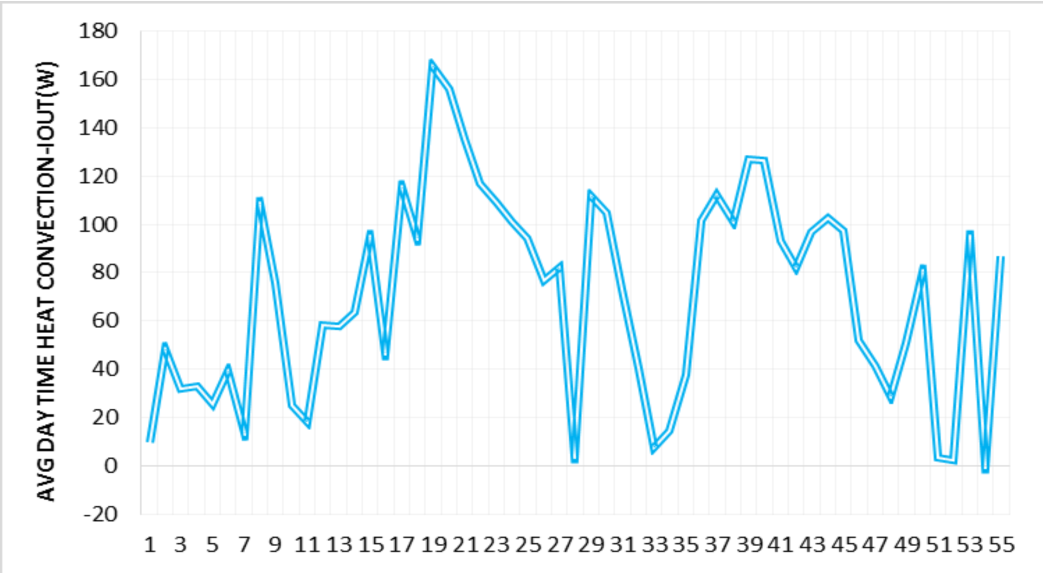


Figure 4.6: Variations per day of average day time of heat convection-out of wall no insulated

Daily average day time heat conduction cross the insulated wall was calculated and presented in Figure 4.7 below. We noted that highest heat conduction of wall no insulated was 3.8W at day 8 and lowest point was -0.5 at day 11.At the highest the difference temperature was high than, the molecule effect by more energy through the layers. Meanwhile when it gets low heat conductivity the difference temperature came low and it lost the effectiveness of molecule across layers.

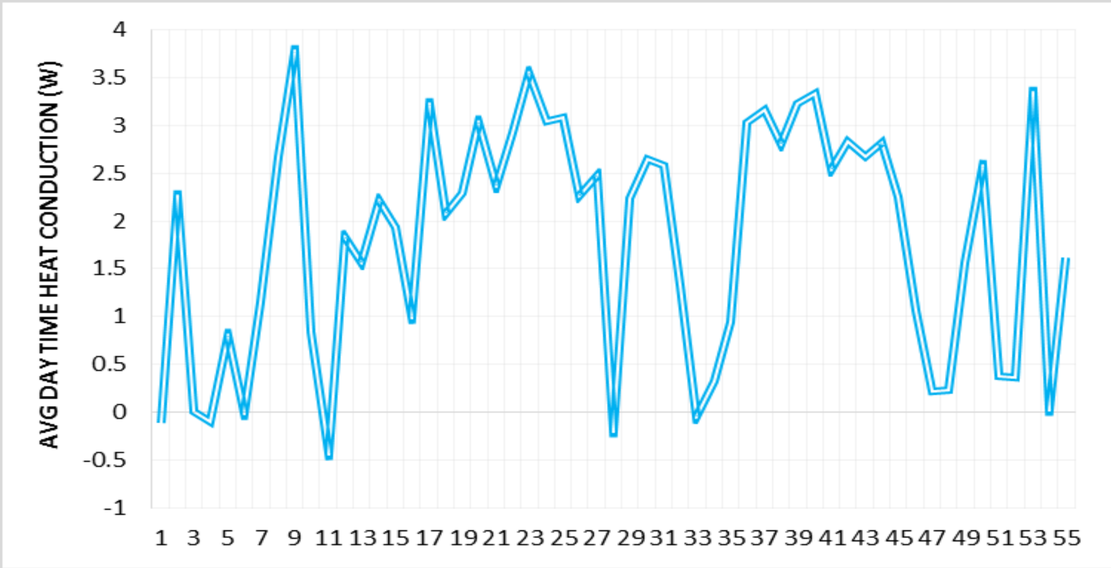


Figure 4.7: Variations per day of average day time of heat conduction of wall No insulated

The temperatures taken by the thermocouples during the same day represented by calculated to give the average heat radiation Q_{rad} which can affect in the heat gain of the room where the wall is directed to the south, daily Q_{Rad} was calculated and presented in Figure 4.8 below. As we can see that highest heat radiation was 160W, at this time the out surface of the wall that had temperature is too bigger than ambient temperature and when the radiation was zero W at day 53 that is means temperature out surface of the wall was equal of ambient temperature.

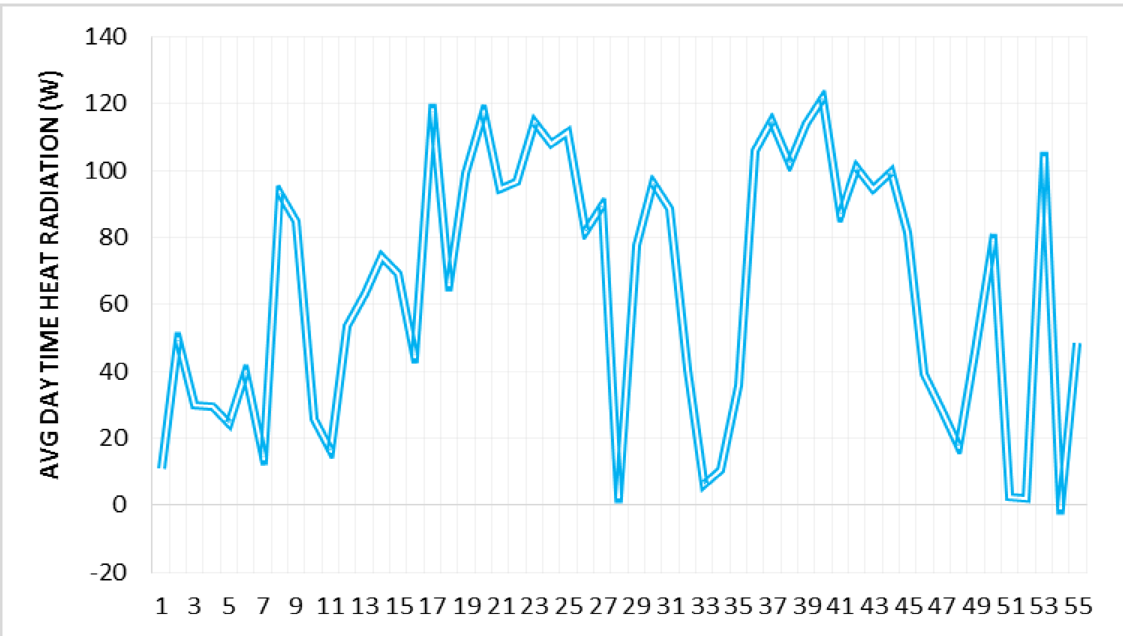


Figure 4.8: Variations per day of average day time of heat radiation of wall no insulated

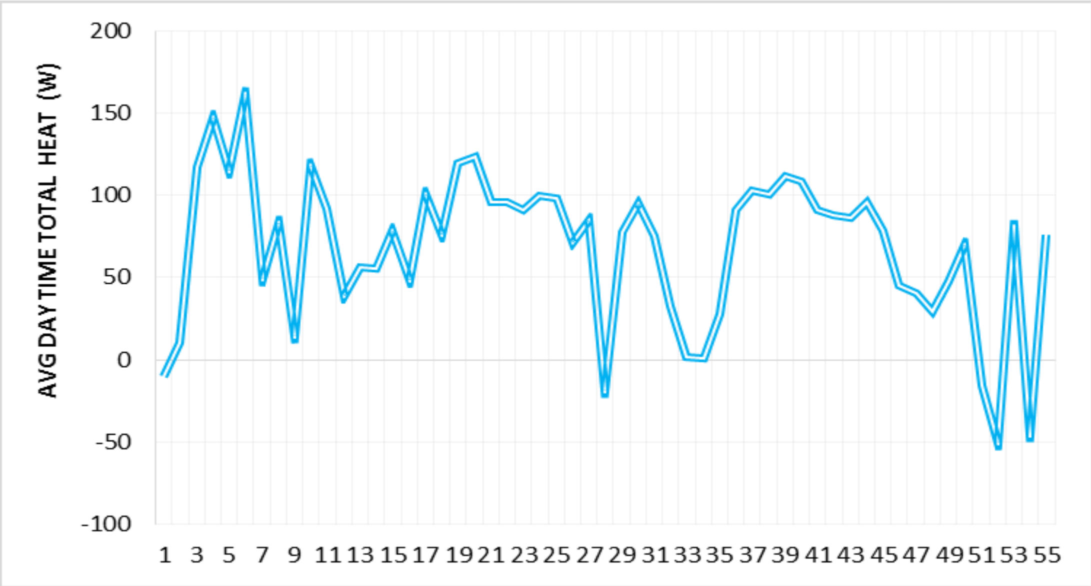


Figure 4.9: Variations per day of average day time of total heat of wall no insulated

4.1.4 Midpoint Average Night Time of Heat Convection-In, Convection-Out, Radiation and Conduction of Wall No Insulated

Daily variation average night time in $Q_{con\text{-}out}$ and $Q_{con\text{-}in}$ where calculated and presented in the two following Fig. below..

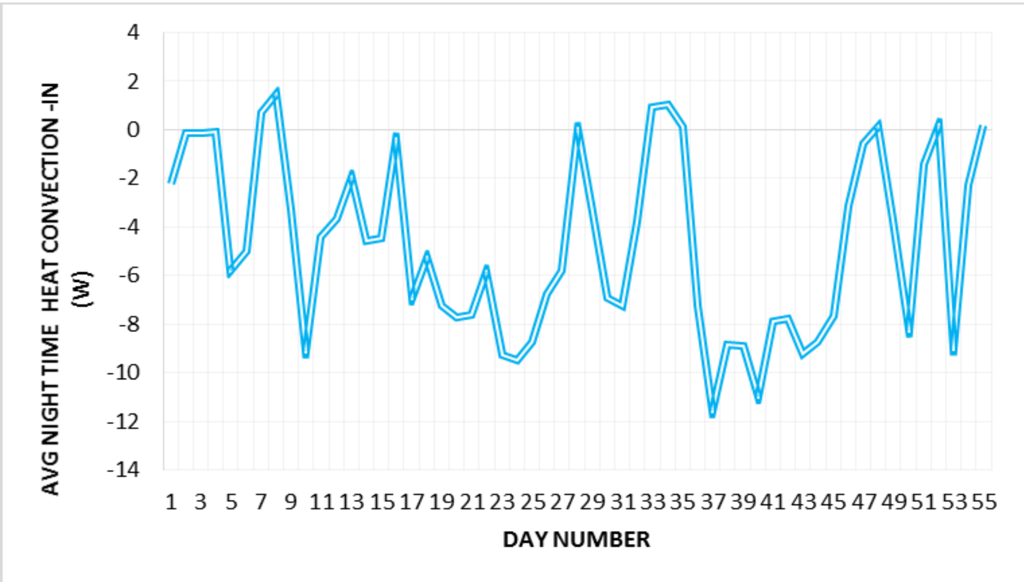


Figure 4.10: Variations per day for average night time of heat convection-in of wall no insulated

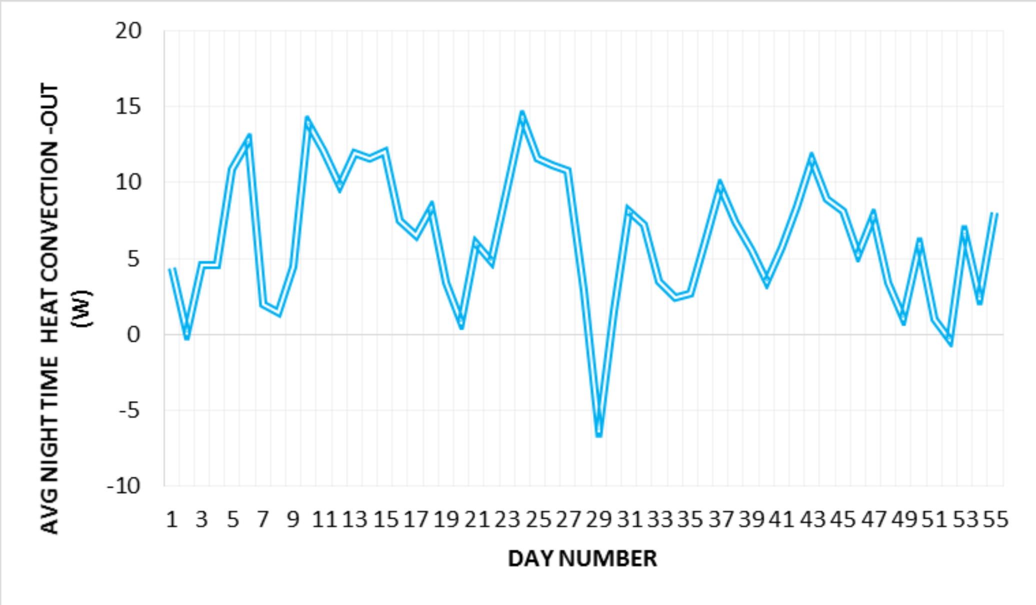


Figure 4.11: Variations per day of average night time of heat convection-out of wall no insulated

Daily average night time of heat conduction throughout the insulated wall was calculated and presented in Figure 4.12 below. During the night that material loss energy when we had loss of heat conduction, when the difference temperature was very low, the heat conduction through between material was too low and the effectiveness of energy transferred in material two another material is too low.

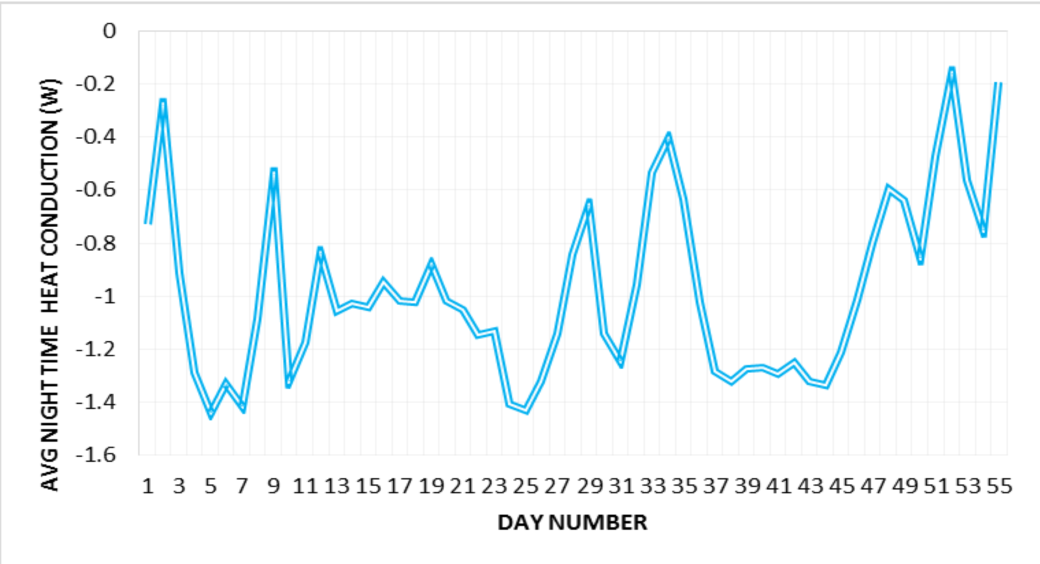


Figure 4.12: Variations per day of average night time of heat conduction of wall no insulated

Daily variation average night time in Q_R where calculated and presented in figure below. During the night no radiation emitted from the sun, but the material loss radiation remained from during the day time, for this reason we had loss of het radiation during the night. Whereas the temperature outer surface of the wall was less than ambient temperature during the night.

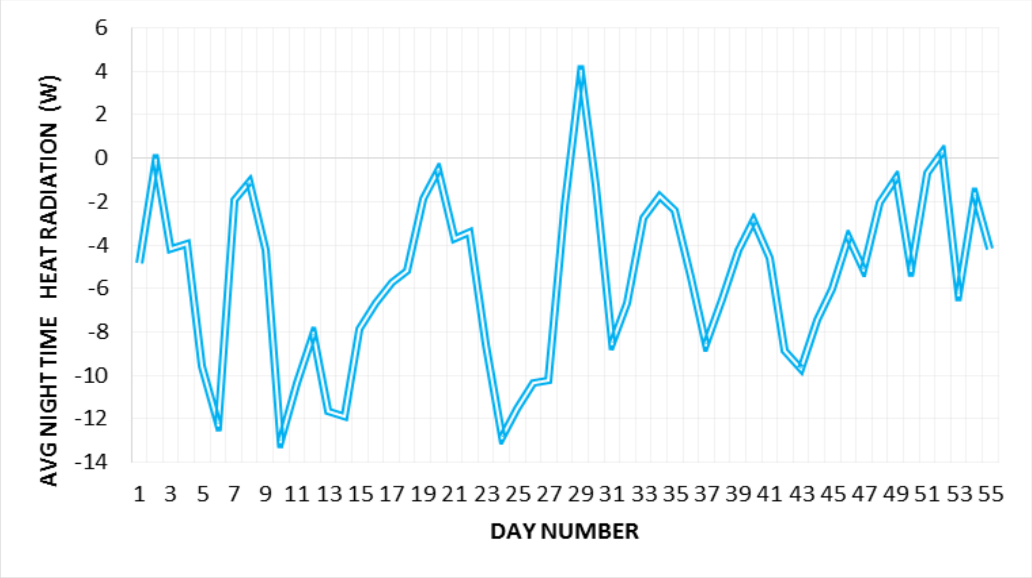


Figure 4.13: Variations per day of average night time of heat radiation of wall no insulated

Total heat was calculated by adding the 3 different heat types: Heat conduction, heat convection-out, heat radiation and heat convection-in of the room where total heat was represented in Figure 4.14 below.

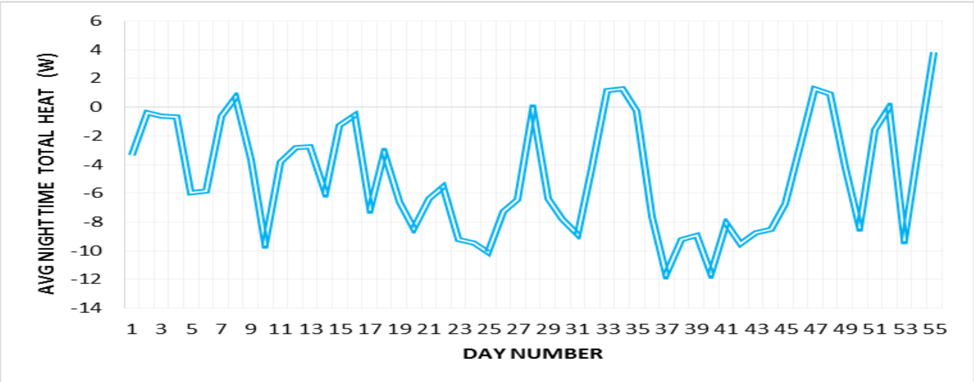


Figure 4.14: Variations per day of average night time of total heat of wall no insulated

4.1.5 Midpoint Average Day Time of Heat Convection-In, Convection Out, Radiation and Conduction of Wall Insulated

Daily variation of average day time in $Q_{con\text{-}out}$ and $Q_{con\text{-}in}$ where calculated and presented in Figure 4.15 below and Figure 4.16 indicated below.

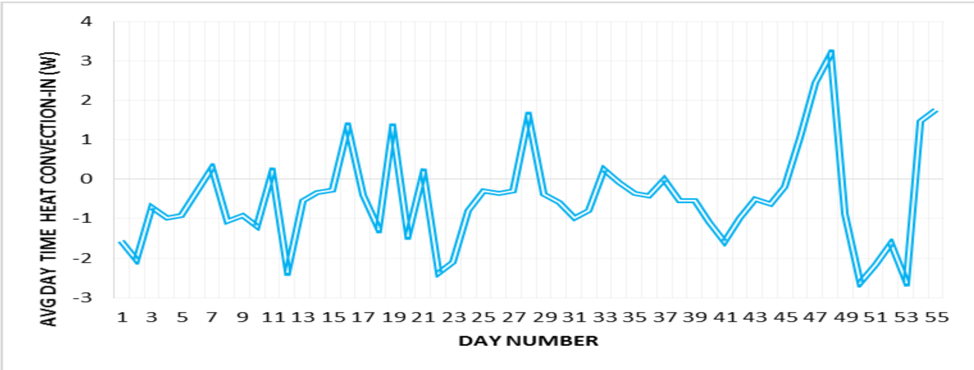


Figure 4.15: Variations per day for average day time of heat convection-in of wall insulated

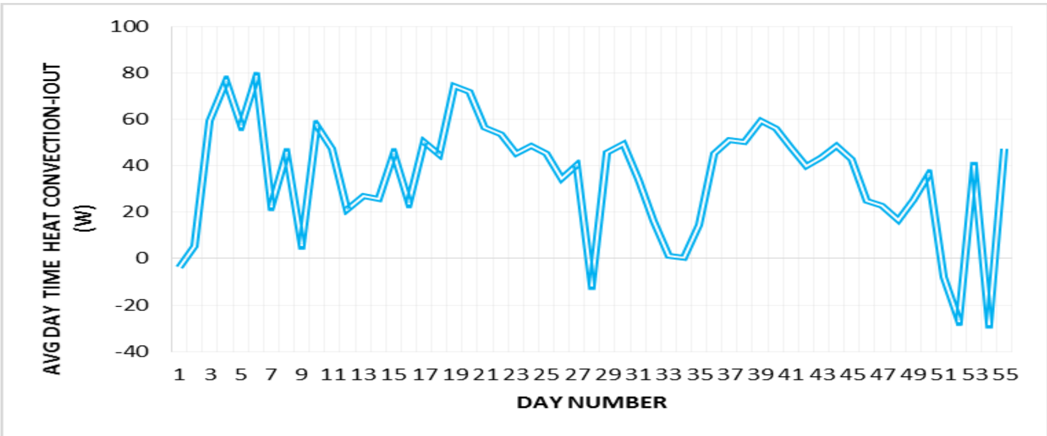


Figure 4.16: Variations per day of average day time of heat convection-out of wall insulated

Daily variation day time of heat conduction throughout the insulated wall was calculated and presented in Figure 4.17 below.

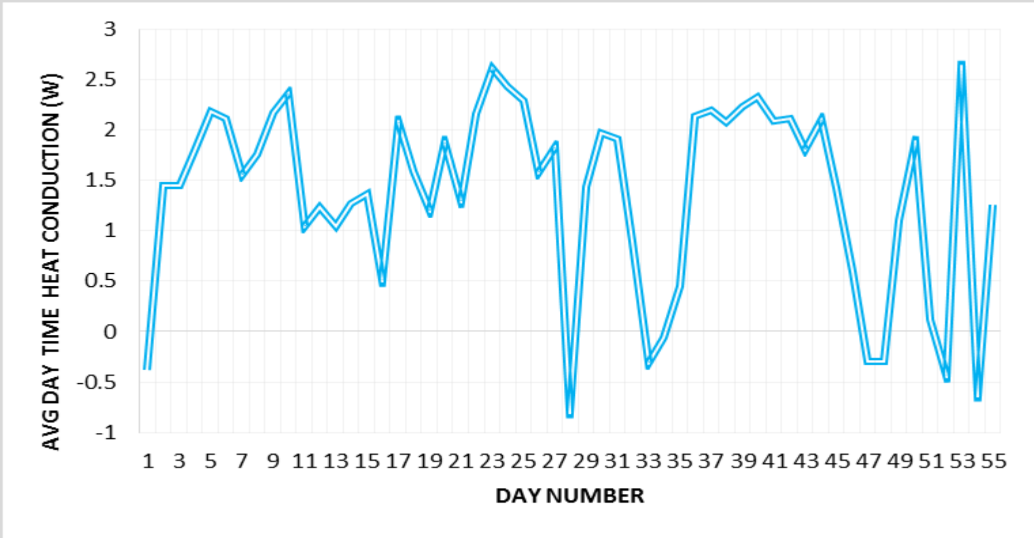


Figure 4.17: Variations per day of average day time of heat conduction wall insulated

Daily variation day time of heat radiation through the insulated wall was calculated and presented in Figure 4.16 below.

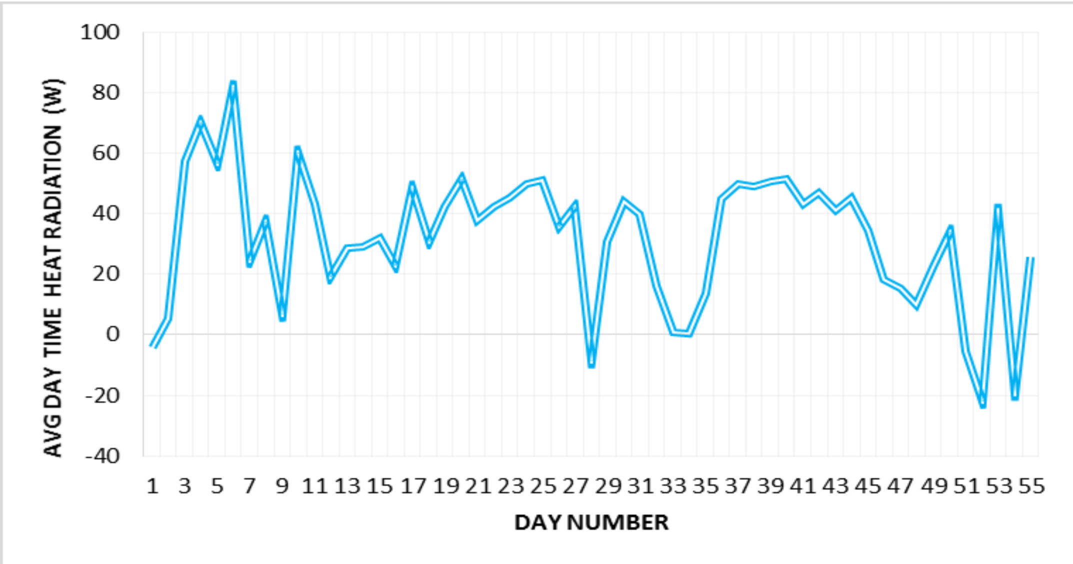


Figure 4.18: Variations per day of average day time of heat radiation of wall insulated

Total heat of day time was calculated by adding the 4 different heat types (Q_{Rad}, $Q_{con-out}$, Q_{cond}, Q_{con-in}) of the room where Q_T was represented in Figure 4.19 below.

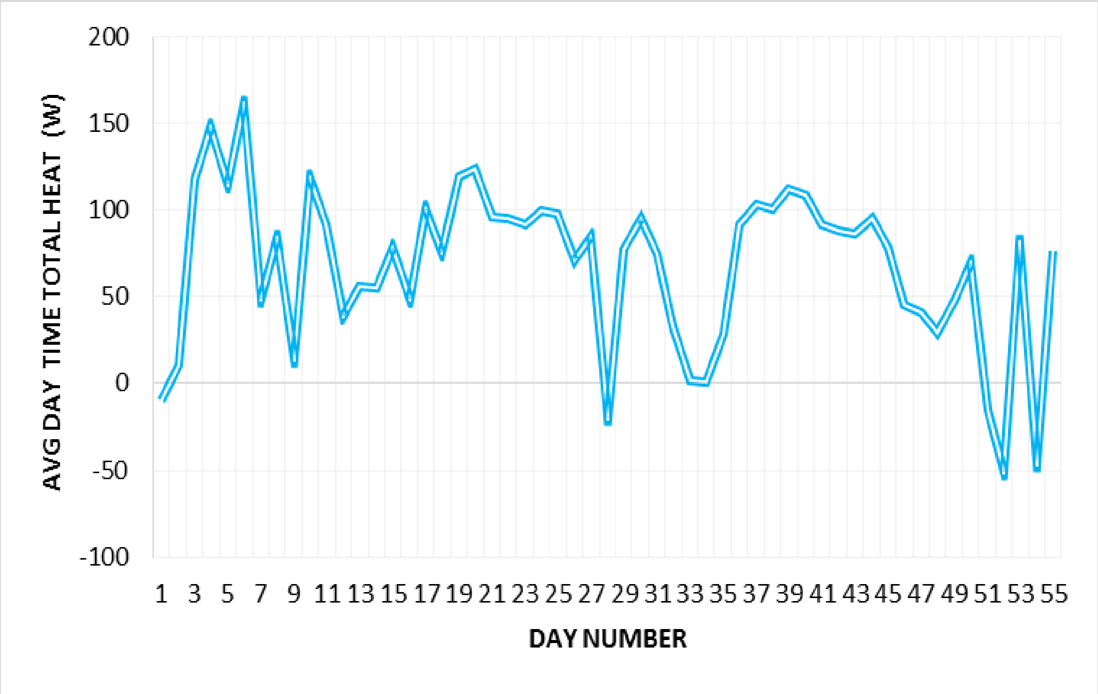


Figure 4.19: Variations per day of average day time of total heat of wall insulated

4.1.6 Midpoint Average Night Time of Heat Convection-In, Convection Out, Radiation and Conduction of Wall Insulated

Daily variation of night time in $Q_{con\text{-}out}$ and $Q_{con\text{-}in}$ where calculated and presented in figure below.

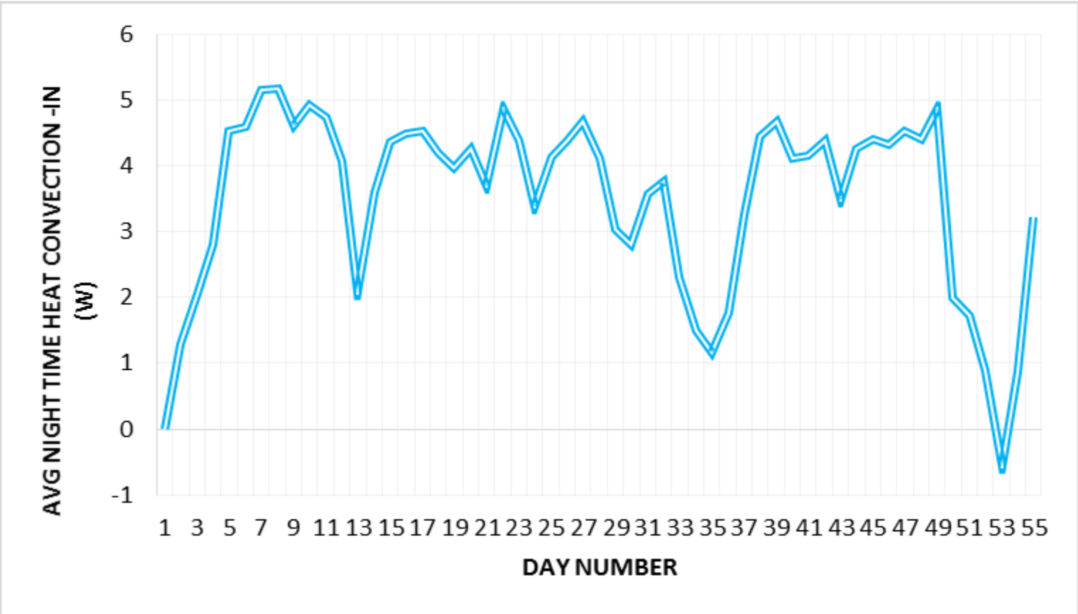


Figure 4.20: Variations per day of average night time of heat convection-in of wall insulated

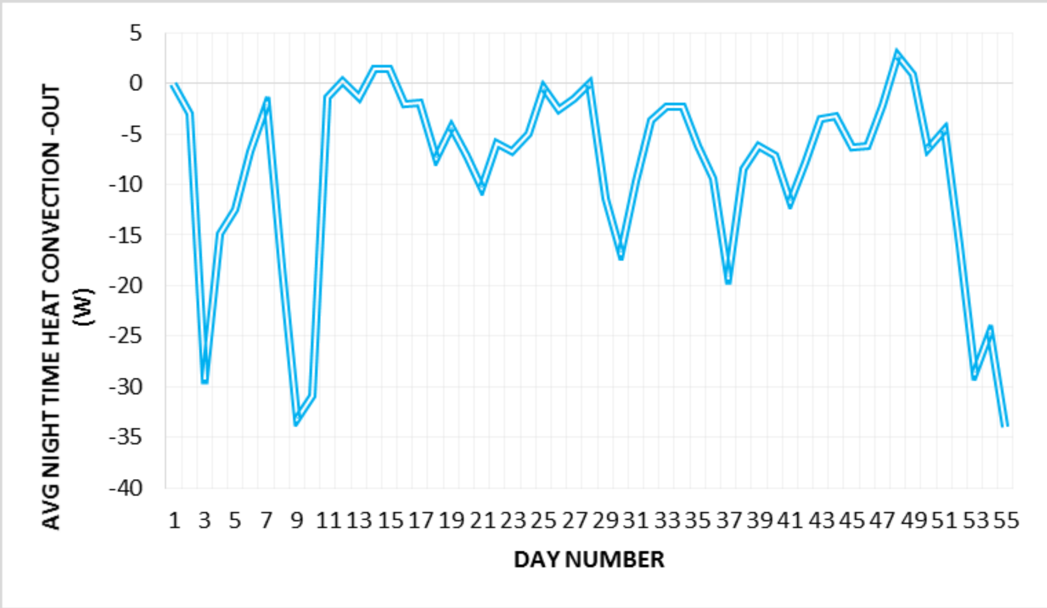


Fig 4.21: Variations per day of average night time of heat convection-out of wall insulated

Daily variation of night time of heat conduction throughout the insulated wall was calculated and presented in Figure 4.22 below.

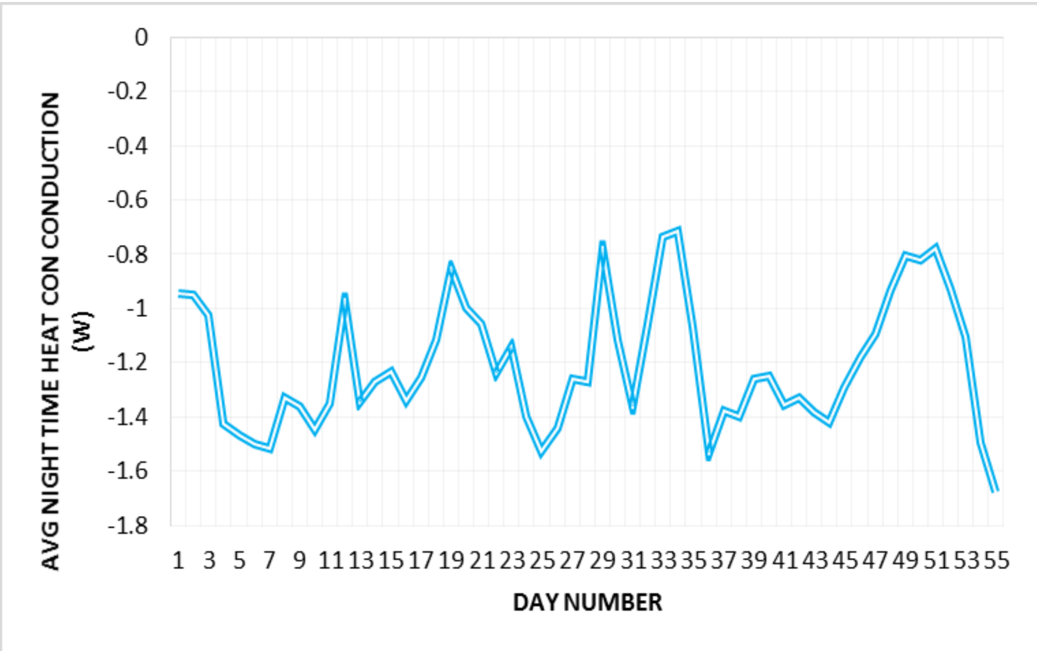


Figure 4.22: Variations per day of average night time of heat convection-in of wall insulated

Daily variation of night time of heat conduction of the insulated wall was calculated and presented in Figure 4.23 below.

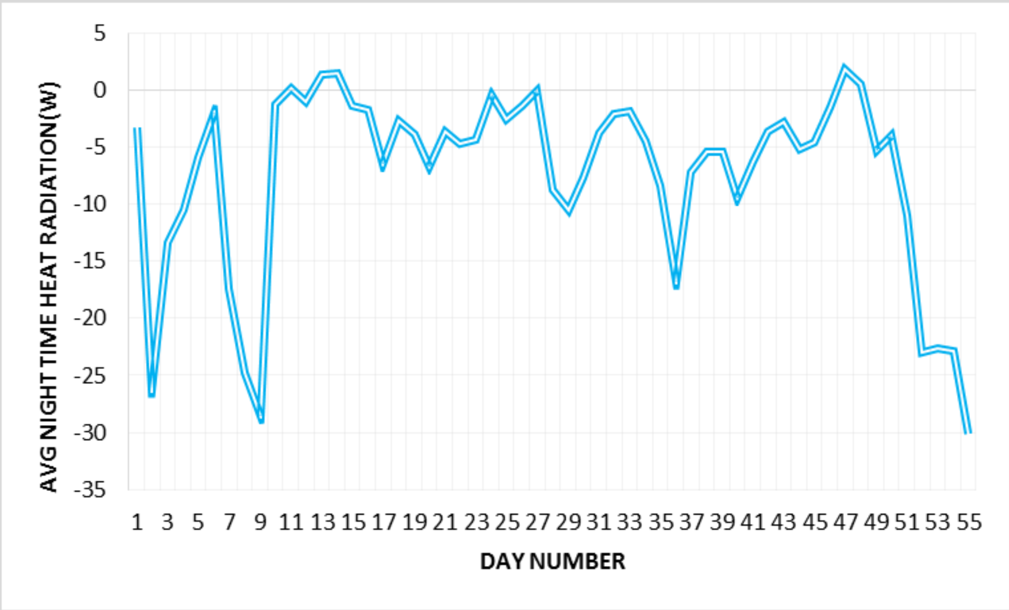


Figure 4.23: Variations per day of average night time of heat radiation of wall insulated

Total average night time of heat was calculated by adding the 3 different heat types ($Q_{conv-out}$, Q_{cond}, $Q_{conv-in}$,, Q_{Rad}) of the room where Q_T was represented in Figure 4.24 below.

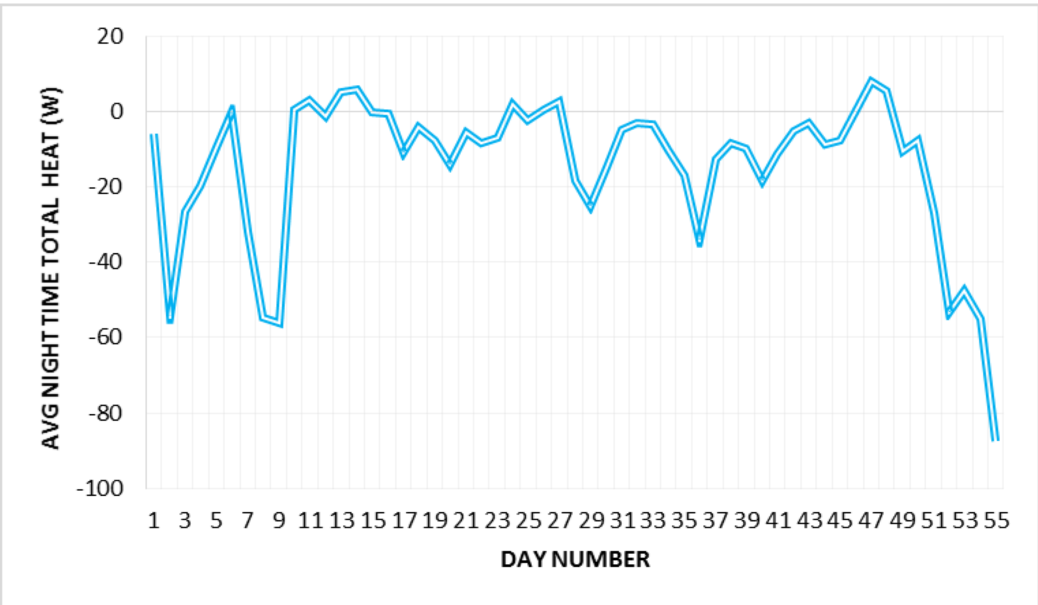


Figure 4.24: Variations per day of average night time of total heat of wall insulated

4.1.7 Midpoint Average Day Time of Heat Convection-In, Convection Out, Radiation and Conduction of Y-Tong Wall

Daily variation of night time in $Q_{con\text{-}out}$ and $Q_{con\text{-}in}$ where calculated and presented within below

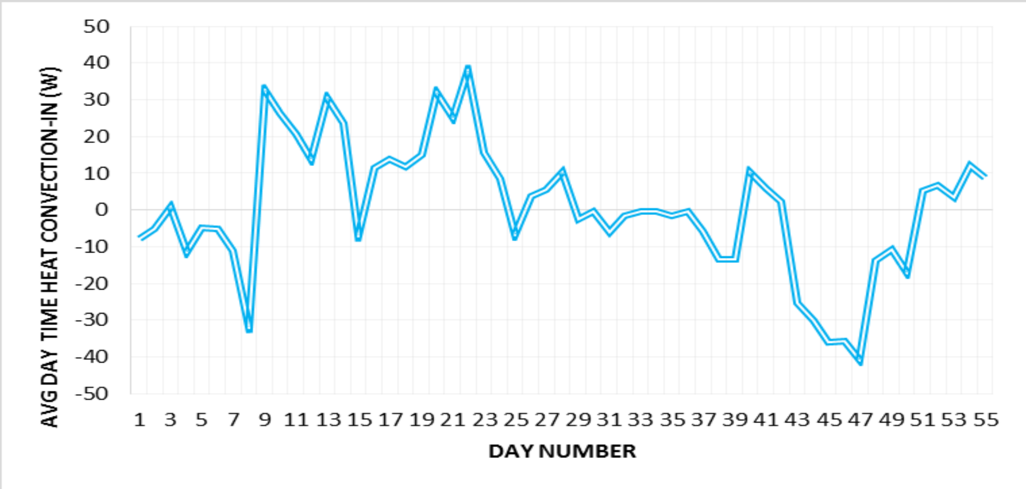


Fig 4.25: Variations per day of average day time of heat convection-in of Y-tong wall

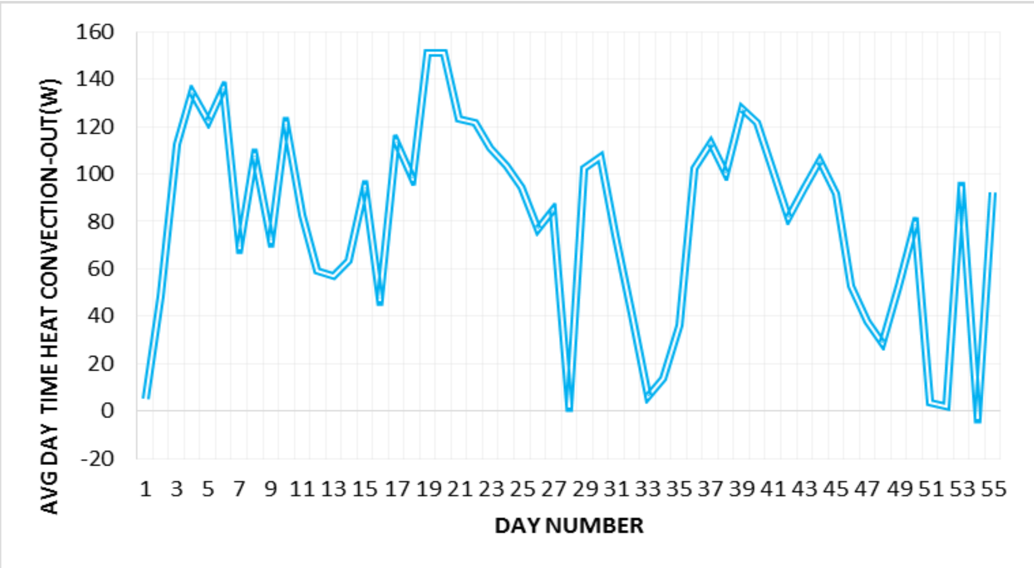


Figure 4.26: Variations per day of average day time of heat convection-out of Y-tong wall

Daily variation of night time of heat conduction of the Y-tong wall was calculated and presented in Figure 4.27 below.

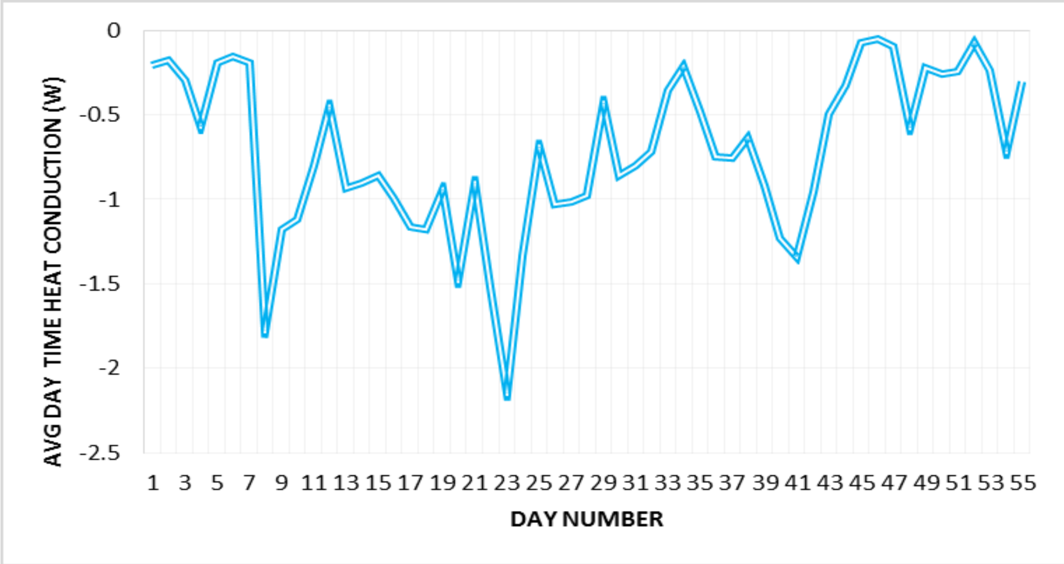


Figure 4.27: Variations per day of average day time of heat conduction of Y-tong wall

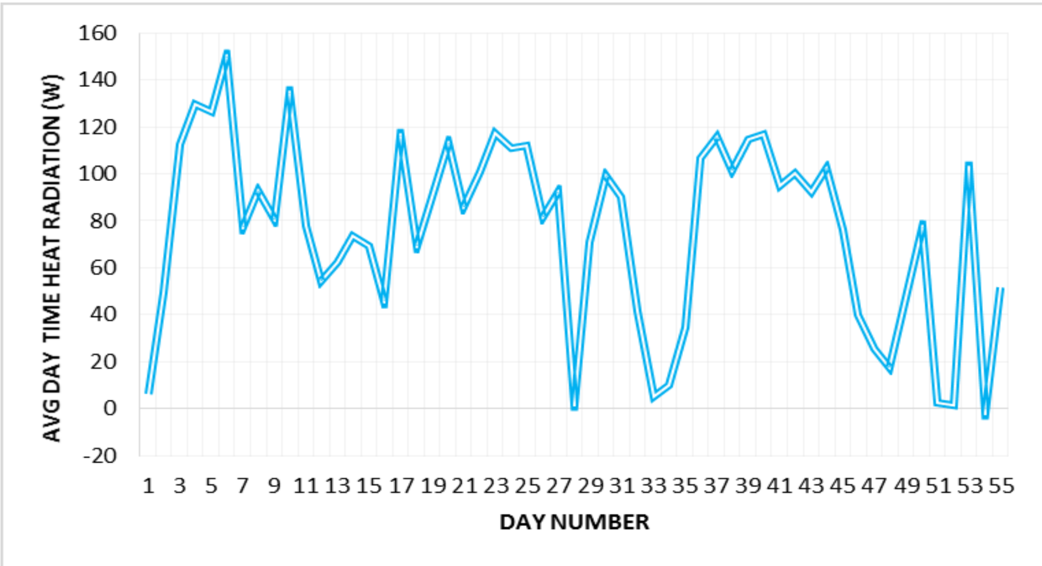


Figure 4.28: Variations per day of average day time of heat radiation of Y-tong wall

Total heat was calculated by adding the 4 different heat types (Q_{Rad}, $Q_{con-out}$, Q_{cond}, Q_{con-in}) of the room where Q_T was represented in Figure 4.29 below.

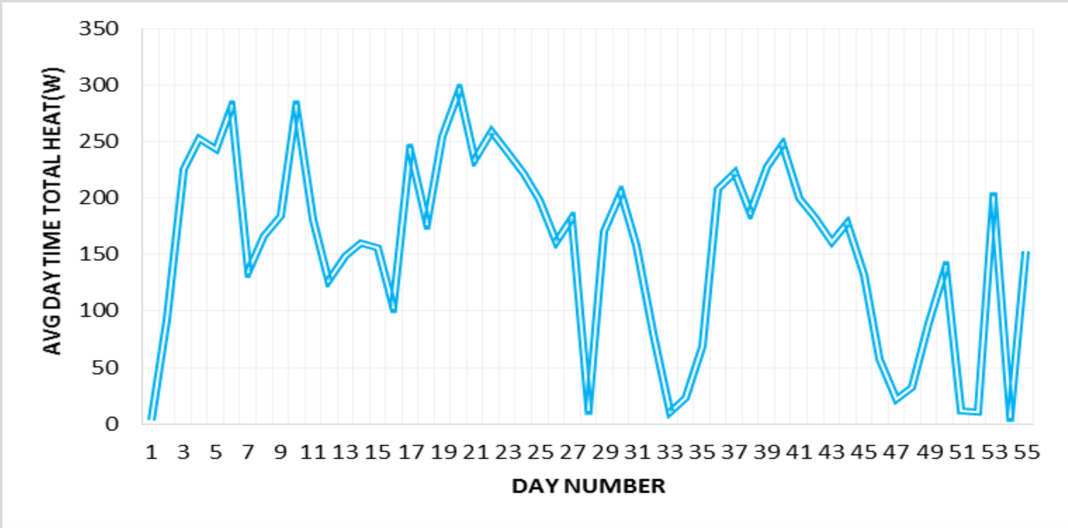


Figure 4.29: Variations per day of average day time of total heat of Y-tong wall

4.1.8 Midpoint Average Night Time of Heat Convection-In, Convection Out, Radiation and Conduction of Y-Tong Wall

Daily variation in $Q_{con\text{-}out}$ and $Q_{con\text{-}in}$ where calculated and presented in Fig. below.

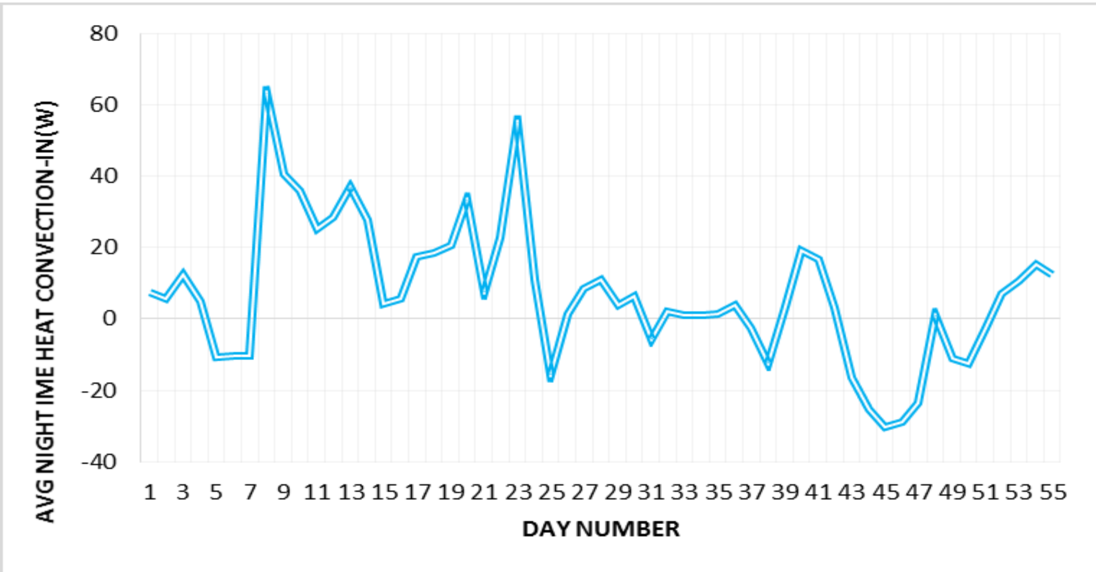


Fig 4.30: Variations per day of average night time of heat convection-in of Y-tong wall

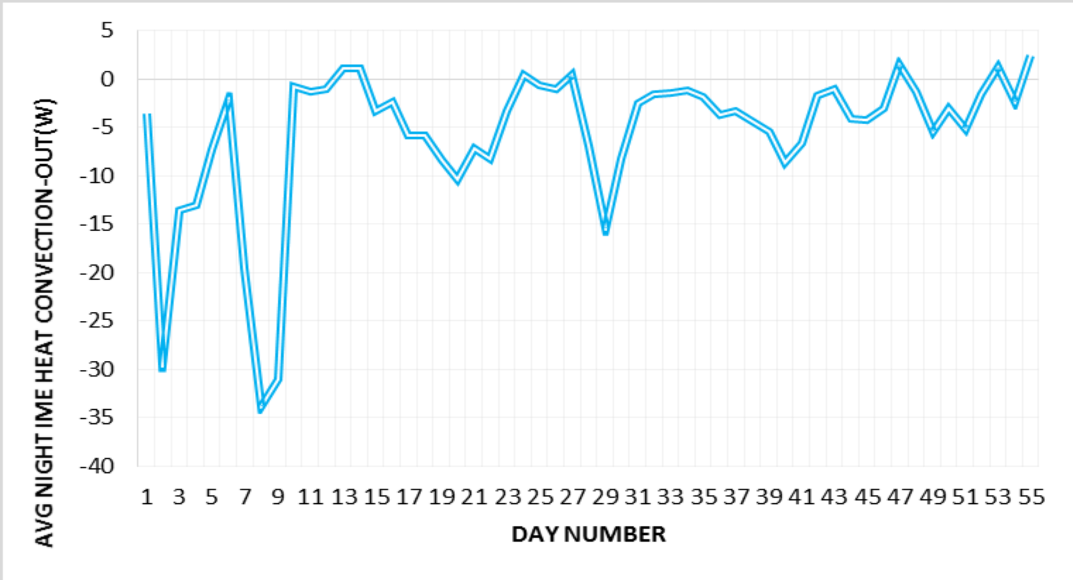


Figure 4.31: Variations per day of average night time of heat convection-out of Y-tong wall

Daily variation of night time of heat conduction throughout the insulated wall was calculated and presented in Figure 4.32 below.

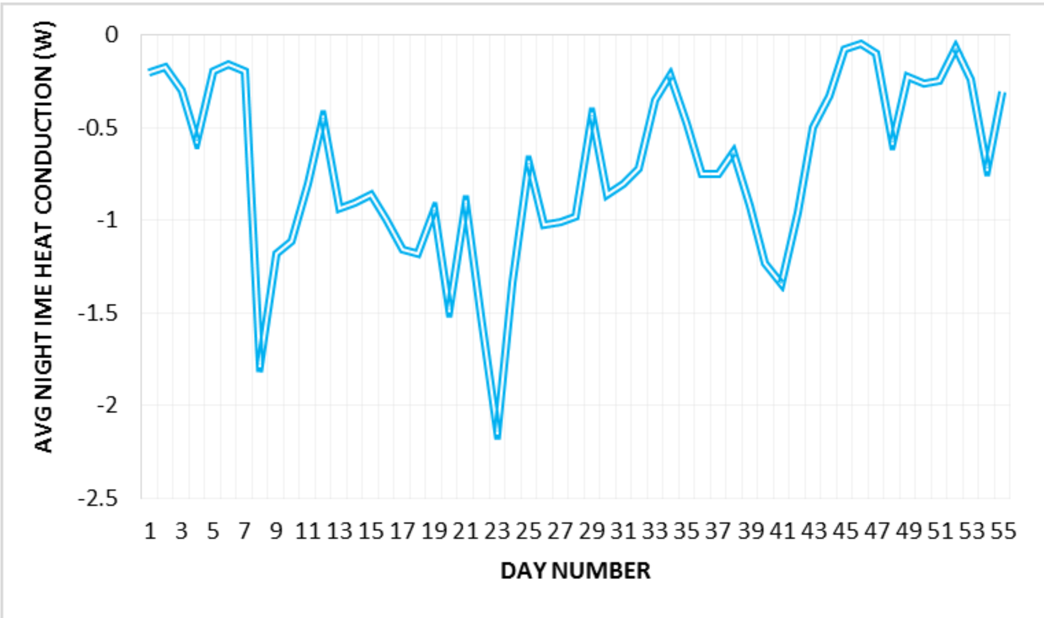


Figure 4.32: Variations per day of average night time of heat conduction of Y-tong wall

Daily variation of night time of heat radiation throughout the insulated wall was calculated and presented in Figure 4.33 below.

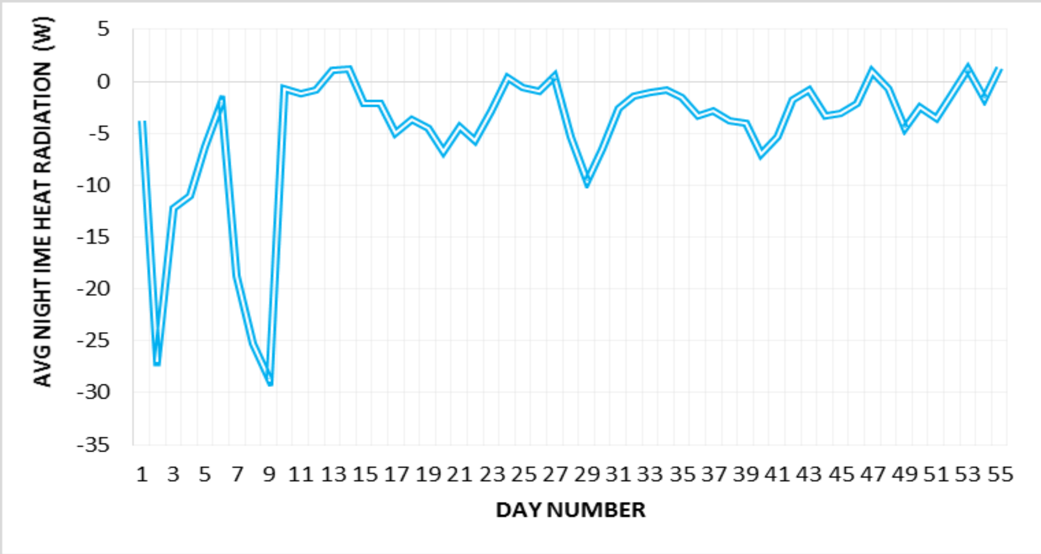


Figure 4.33: Variations per day of average night time of heat radiation of Y-tong wall

Total heat was calculated by adding the 3 different heat types ($Q_{conv\text{-}out}$, Q_{cond}, $Q_{conv\text{-}in}$, Q_{Rad}) of the room where Q_T was represented in Figure 4.34 below.

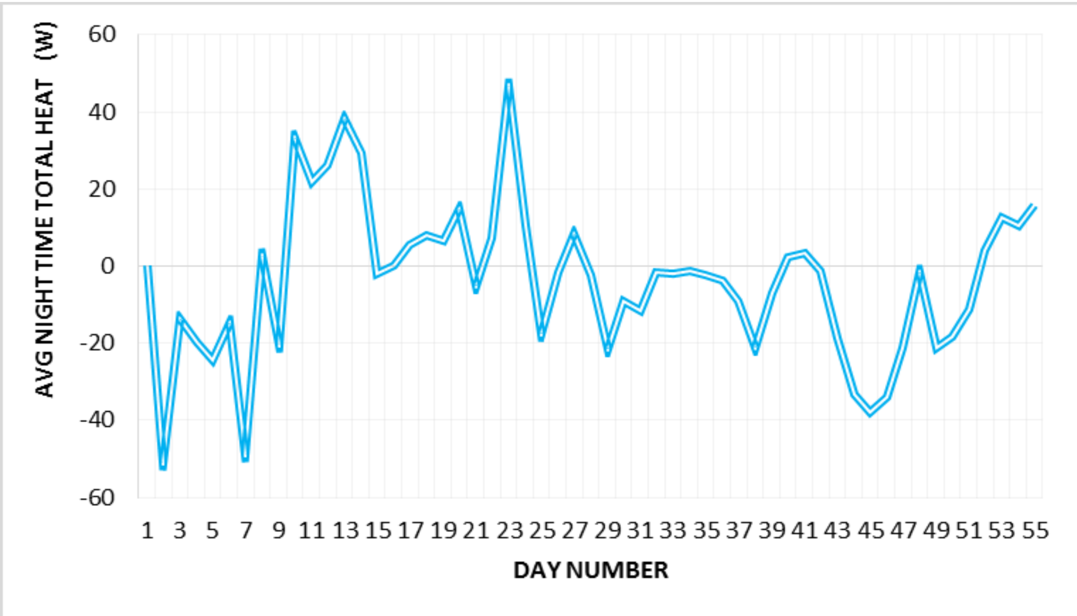


Figure 4.34: Variations per day of average night time of total heat of Y-tong wall

4.2.1 Midpoint Average Day Time of Heat Convection-In, Convection Out Radiation and Conduction of Wall No Insulated, Wall Insulated And Y-Tong Wall.

The Figure 4.35 and Figure 4.36 shown, is a daily comparison between heat convection of outer and inner surface of Y-tong wall, heat wall insulated, and wall no insulated during the day time. The Y-tong wall and no insulated (outside) had heat convection ($Q_{conv\text{-}out}$) greater than of wall insulated at day time. We noted that's fluid and wind velocity has effect on the outer wall surface. Meanwhile heat convection ($Q_{con\text{-}in}$) of Y-tong and wall with no insulation changed during the days, but wall insulated had heat convection ($Q_{con\text{-}in}$) approximately constant, the reason was the difference in temperature inside the room and inner wall surface. Heat coefficient transfer rate at the vertical wall is constant on inner surface because there is still air inside, h = 8.3W/k.m^2 (Appendix D).As the results the magnitude of convective heat flow upon from the area of contact with the solid wall, this thermal flow was characterized by the overall temperature difference between the two compared model.

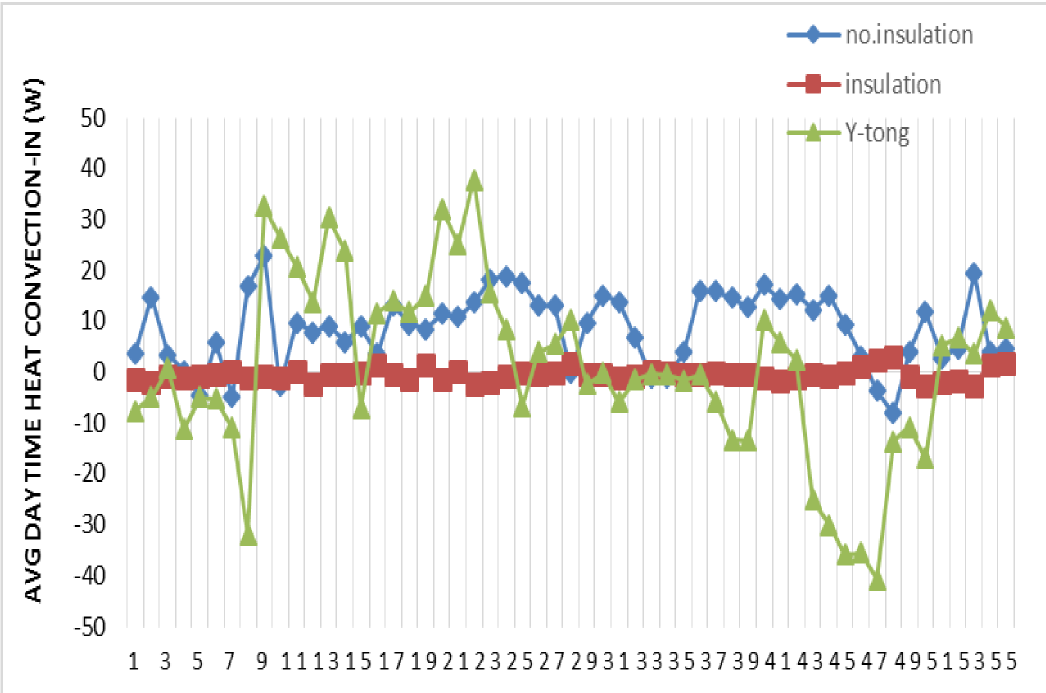


Figure 4.35: A comparison of the average day time heat convection-in between Y-tong, insulation and no insulation wall

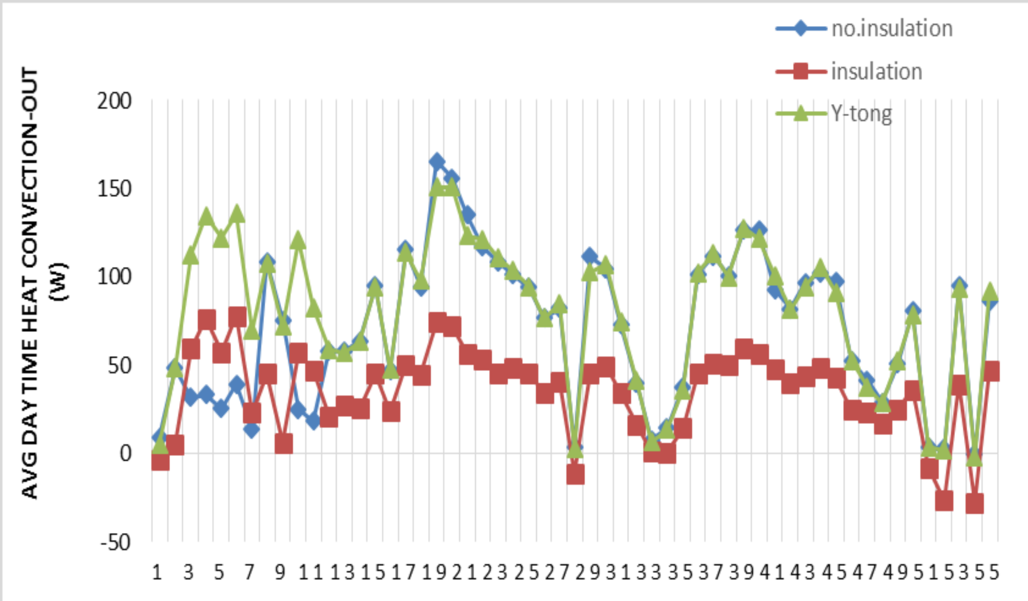


Figure 4.36: A comparison of the average day time heat convection-out between Y-tong, insulation and no insulation wall

The Figure 4.37 shown is a daily comparison of average day time of heat conduction between Y-tong wall, wall insulated and wall no insulated during the day time. The Y-tong wall has heat conduction greater than heat insulated wall and wall with no insulation. That is heat moves through a material at a specific rate. It is understood that Y-tong material absolved heat from the outside to the inside surface quickly and the heat insulation material absolved heat slowly. The reason was the Y-tong wall conducted more, when compared to stone wool as a result the heat conduction decreased with multi-materials and also it was depended upon the thermal conductivity for each layer.

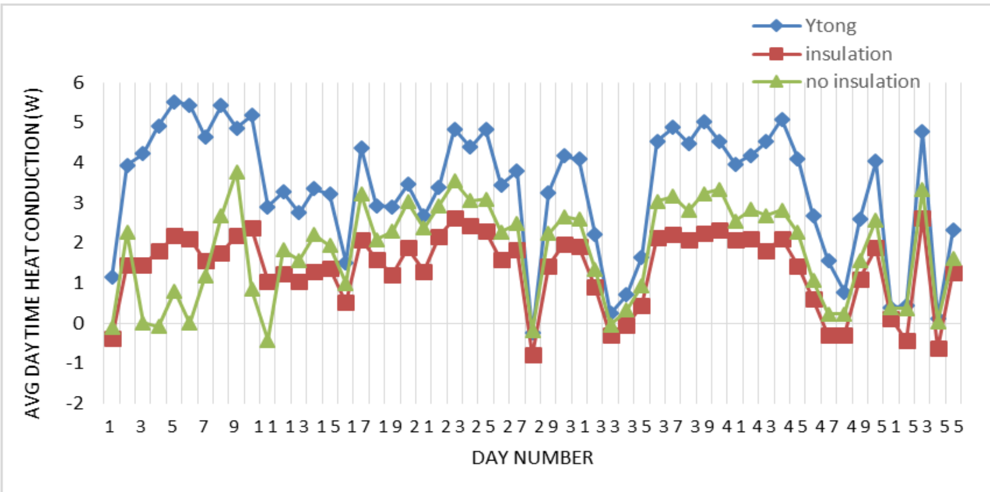


Figure 4.37: A comparison of the average day time heat conduction between Y-tong, insulation and no insulation wall

The Figure 4.38 shown is a daily comparison of average day time of heat radiation between Y-tong wall, wall with no insulation and wall with heat insulation during the days. We noted the Y-tong wall and wall with no insulation had heat radiation greater than of heat insulated wall. That explained why Y-tong wall and wall with no insulation takes more solar radiation. Reason was that their insulation value and their impact on energy consumed varies, Y-tong and hollow bricks without insulation had a more preferred thermal quality when compared to heat insulated wall during the period of intense heat or solar radiation.

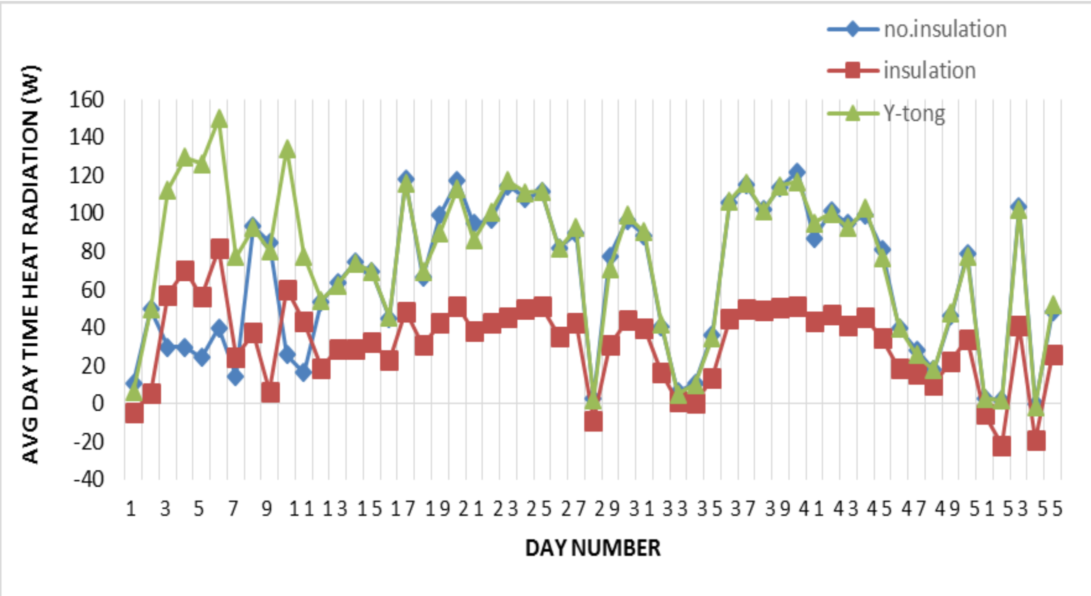


Figure 4.38: A comparison of the average day time heat radiation between Y-tong, insulation and no insulation wall

The Figure 4.39 shown below is a daily comparison of total heat between Y-tong, insulated and no insulated wall during the day time. From the graph we noted that the total heat of Y-tong wall is greater than of total heat of heat insulated wall. This is due to the high resistance to pressure and high tensile strength the considerable elasticity of Y-tong material has extended fibers both materials offer thermal insulation and acoustic insulation, long life production, water resistance and vapour permeability and they are ecological safe.

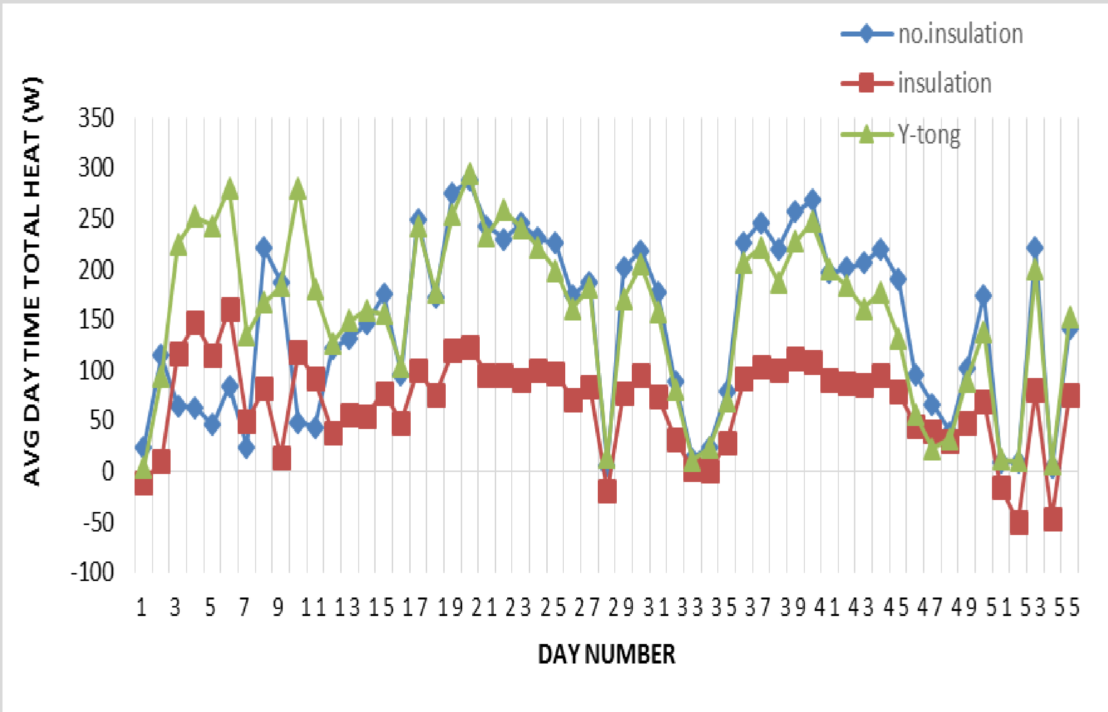


Figure 4.39: A comparison of the average day time total heat between Y-tong, insulation and no insulation wall

4.2.2 Midpoint Average Night Time of Heat Convection-In, Convection Out, Radiation and Conduction of Wall No Insulated, Wall Insulated and Y-Tong Wall.

The Figure 4.40 and Figure 4.41 shown below were a comparison of average night time of heat convection of outer and inner surface between Y-tong, insulated and no insulated wall. Y-tong wall and wall insulated have the same heat convection outside on the surface because there was no radiation during the night time and also depended on the materials. But heat convection at inner surface for the insulated wall during the night remains approximately constant but the y-tong and no insulated wall had same variation during the night.

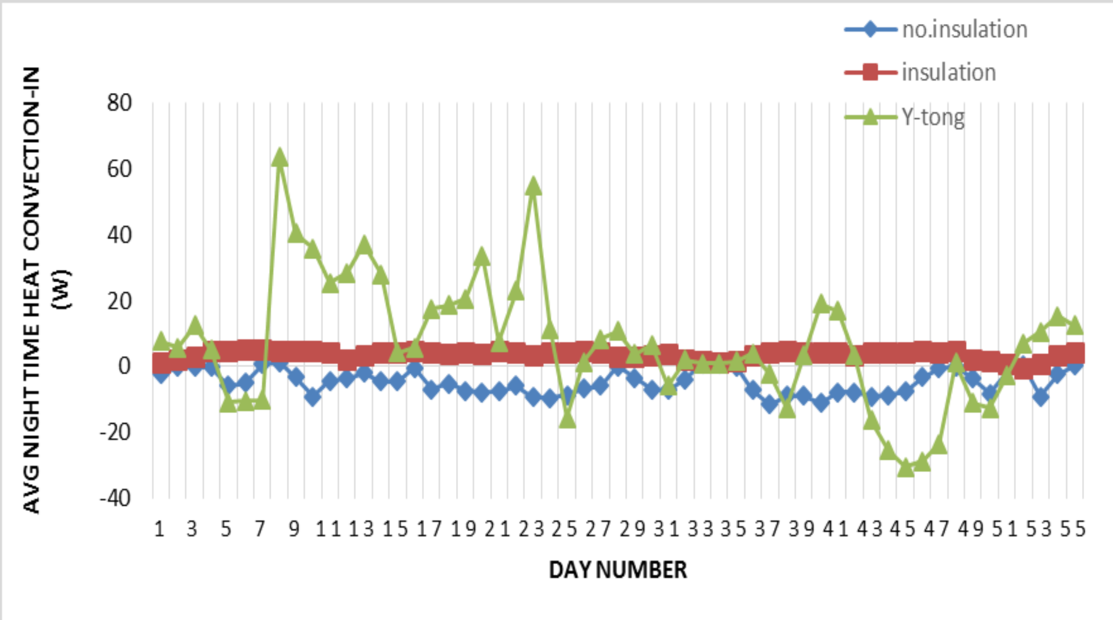


Figure 4.40: Comparison of the average night time heat convection-in between Y-tong, insulation and no insulation wall

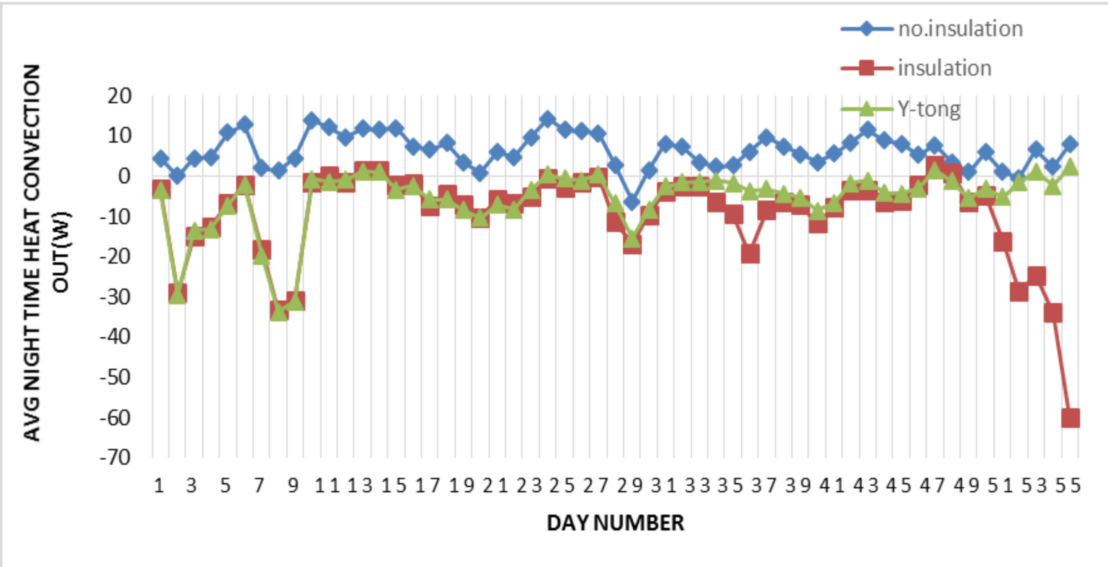


Figure 4.41: A comparison of the average night time heat convection-out between Y-tong, insulation and no insulation wall

The Figure 4.42, below were a daily comparison of average night time of heat conduction of Y-tong, insulated and no insulated wall. The sequence of transfer of heat conduction depends on 4 simple factors and temperature gradient, the properties of those materials, the section of the materials involved and their path light. The result indicated in the graph proved that at the night time heat conduction of Y-tong wall is greater than heat conduction of insulated wall and wall no insulated during the days. This is because of the thermal properties of both material combination, at the minimum level (heat is during the night time), there is a slight variation of heat conduction for insulated and no insulated wall material, it has a better time lag to decrement factor ratio as compared to Y-tong wall, that is sparsely varied.

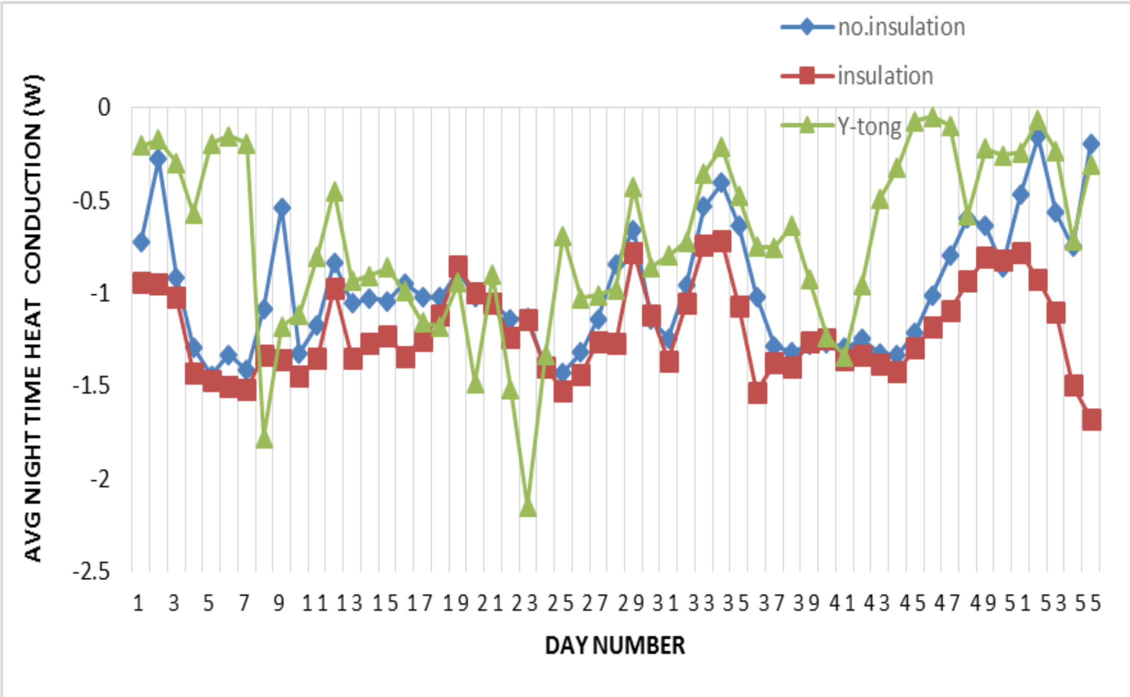


Figure 4.42: A comparison of the average night time heat conduction between Y-tong, insulation and no insulation wall

The Figure 4.43, below were a daily comparison of average night time of heat radiation of Y-tong, insulated and no insulated wall. During the night no radiation emitted from the sun, but the material loss radiation remained from during the day time, for this reason we had loss of het radiation during the night. Whereas the temperature outer surface of the wall was less than ambient temperature during the night.

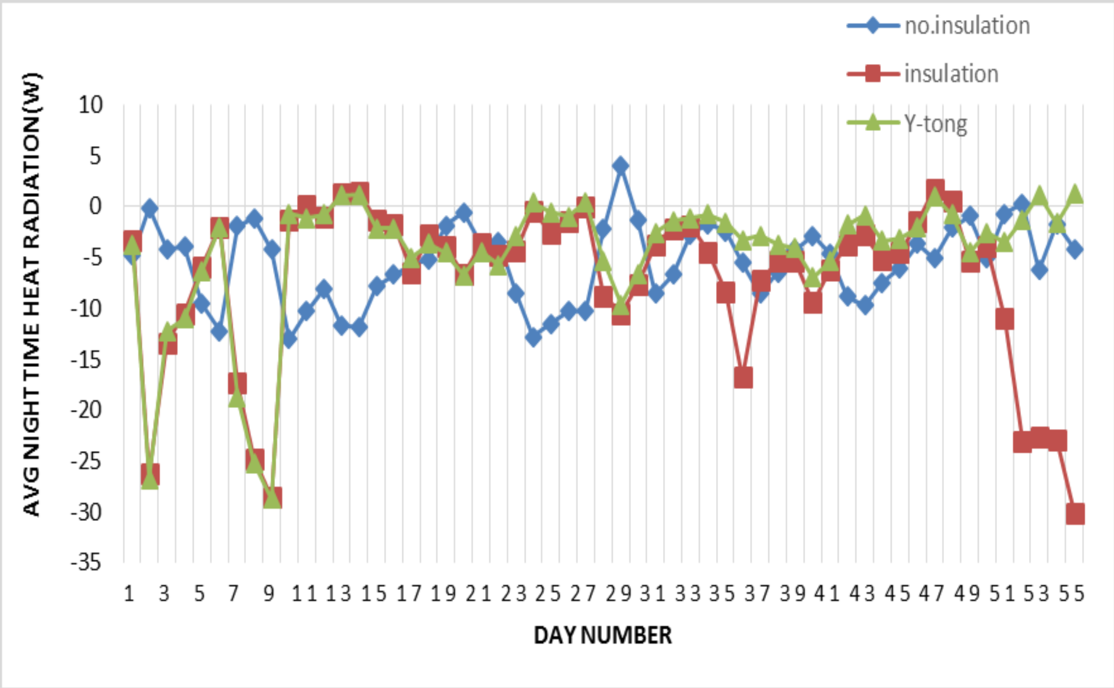


Figure 4.43: A comparison of the average night time heat radiation between Y-tong, insulation and no insulation wall

The Figure 4.44 shown below is the summary of the results from the graph above, and it gives clear explanations for heat loss and heat gain for Y-tong wall and heat insulated wall. Y-tong wall has heat gain more than the heat insulated wall at the maximum time (during the day) but it also has more heat loss then the insulated wall at minimum time (at night time).Considering the descriptive structure of both walls which is detailed below, The Y-tong which is aerated concrete rely deeply in its buildings properties, the main raw materials are quartz, sand, Portland cement, lime and water. The materials is put into autoclaves with approximately 190°C and 12 bar pressure, during this procedure the essential for Y-tong block, spherical, closed air pores are created and it can also be called isotropic building material with high construction speed , fire resistance, thermal insulation and comfort, acoustic insulation, lightweight construction material, ecological and durability. Whereas for the stone wool which is also known as mineral cotton, is generated from fiber materials that are formed by spinning or drawing cotton minerals (synthetic minerals such as slag and ceramics) it also offer thermal insulation, filtration, soundproofing and hydroponic growth medium. The heat resistance of stone wool is at a temperature between 700- 850 °C.

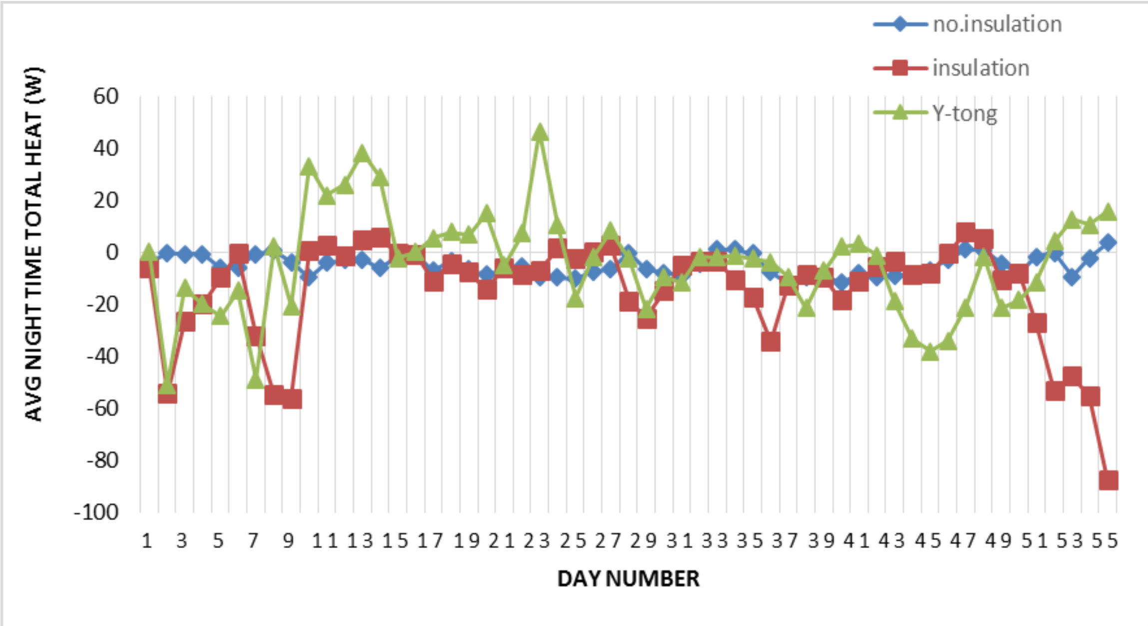


Figure 4.44: A comparison of the average night time of total heat between Y-tong, insulation and no insulation wall

Figure 4.45 shown is the average total heat loss and heat gain per day .Y-tong wall and no insulated wall had heat gain more than heat insulation.This is due toY-tong and wall no inslated save energy more than stone wool during the day.An analysis of the laboratory experiment reviewed that the Y-tong material as compared to the (stone wool) as the heat insulated materials has shown great deal thermal proporties in term of heat flux when comparing of the three models with a simple discription based on content L2 (Y-tong wall) and L1 had (no insulated wall) had more heat radiation than insulated model (L3). This indicated that Ytong bricks wall and hollow brick absorbed more thermal radiation with the model L2 having greater than heat conduction ,fluid and wind velocity on each of the outer surface of the wall .Meanwhile heat convection of Y-tong changed within the specified days.A review of illustrious work done on this subject which indicated that time lag and decrement factor are a great importance building walls are integrated parts of a buildings envelope,

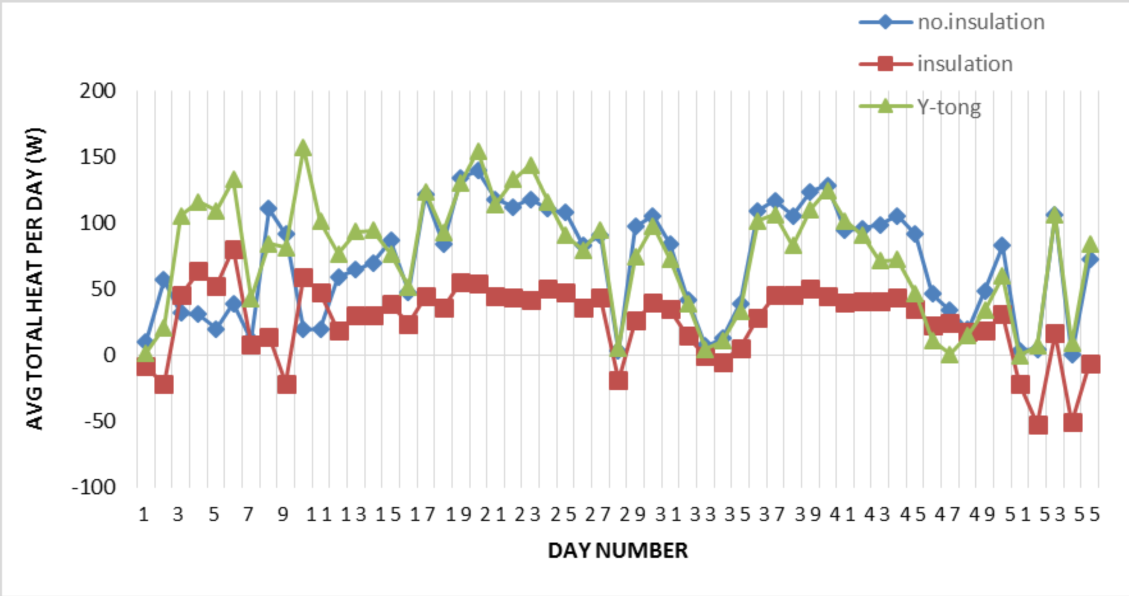


Figure 4.45: A comparison of the average heat per day between Y-tong, insulation and no insulation wall

4.12 Discussions

To provide building heat comfort, possible by using building wall insulation which are Suitable for TRNC climatic conditions energy and economical possession. When we choose heat insulation materials we must be careful about these points we have to note:

- When we choose heat insulation materials we should choose a material that suit say which has low heat conductivity. Furthermore the heat insulation material vapour in diffusion index, density, heat resistance and resistance for mmechanical effects are important. These features of material should be thought where the material is used.
- Water and heat insulations to be used together at the project design stage to make insulation materials effective and have economical solutions.

CHAPTER 5
CONCLUSION AND RECOMMENDATIONS

A total recital of a structure is usually founded on principles of some form of heat transfer. At some simple level, solar radiation recital of building partition assemblage is at some point, calculation of heat confrontation within every coat of the substance, we think of the heavy demand on energy and the continuous decreasing fossil fuel reserves this has induces the approach for an effective way to insulate our houses, schools, hospitals, etc. and to decrease the heat gain during summer and heat loss during winter period. Cyprus is characterized by seasonal differences having about 340 sunny days per year. The study was aimed to find the best type of insulation in Turkish Republic North Cyprus.

We classified the study in two stages which was conducted accordingly. In the first stage an insulated room was connected with four T-type thermocouples meteorological daily radiation, wind speed, temperature was studied together to find the heat transferred to the room and from the room, respectively. In the second stage a Y-tong room was studied using the same variables taken by the on-site experiment.

The experiment took the following light, three model building called L1, L2 and L3 were built. At the initial stage, Room L1 consisted of four side facing North, South, East and west which contained the same materials cement concrete hollow bricks then cement concrete but the south face which our experiment focused on consist of concrete in and out plaster with a hollow bricks wall set up in between,

Room L2 consisted of four side facing: North, East, and West which contained the same materials insulation for heat stone wool , block of concrete , and plaster gypsum (outside and inside of the three walls). South face contains cement concrete (inside and outside of wall) and in the middle of Y-tong.

Room L3 consisted of four side facing: North, East, West and South. The (North, East, West) contained insulation for heat stone wool, block of concrete, and plaster gypsum (outside and inside of the walls).South face contains plaster gypsum (outside and inside of the wall), insulation for heat stone wool and at the middle blocks of hollow brick clay.

The result obtained was that Y-tong wall save more energy during the night when compared to other model followed, by non- insulation model and then the heat insulation model due to some similar material combination found in them. The non-insulation model and the heat insulation model at daytime obtained more thermal efficiency as a result maximum radiation the heat insulated wall save more energy during the day when intensity is at maximum.

The results of the experimentation showed that, considering the three model building when exposed to thermal radiation, model L2 Y-tong wall has heat radiation greater than the compared models. Then again Y-tong wall took more thermal radiation.

Model L2 (Y-tong wall) has greater heat conduction as compared to thermal insulated wall and non insulated wall at a specific rate.

Also fluid and wind velocity has effect on the outer surface of the wall.

Meanwhile, heat convection ($Q_{\text{Con-in}}$) of Y-tong varied within the specified days, but heat insulated wall had heat convection ($Q_{\text{Con-in}}$) approximately constant and model without insulation was at static level, the reason was the difference in temperature inside the room and inner wall surface was changed during the time. Heat coefficient transfer rate at the vertical wall was constant on inner surface because there was still air inside, when h = 8.3w/k.m^2. Also, we noted that the total heat of Y-tong wall was greater than the other two model rooms at the maximum time. Again at the day time heat conduction for Y-tong was greater than the heat conduction of heat insulated wall with model without insulation almost at a horizontal level because of its R-value.

As a result of sunset, there is no thermal radiation at the outer surface during the night time, therefore, the two model wall L1 and L2 has same heat convection. Whereas Y-tong wall has a varied heat convection at the inner surface while the heat convection of heat insulated wall at the inner surface remained approximately constant.

The wall insulated is good for night time and Y-tong wall is good for day time during the winter season, in general case the Ytong wall is better than heat insulated wall during the day because the Ytong wall has heat gain more than heat insulation per day. The process of insulation is directed at slowing the speed of the temperature in an order so as to decrease the requirement in heat otherwise cool.

Finally, for the future work the need to prioritize good insulation materials that be able to cattail the thermal loss in houses in a arctic conditions as well as also it against heat loss during the winter which a economical insulation.In addition, further work is suggested on the comparative study between different wall systems and their efficiency in reducing heat loss and gain at when appropriate, then the introduction of advance insulation materials the use of cork as an insulation material to insulate a building. A work that could show the thermal performance of heat and water insulation for building wall during summer can as well be considered in the long future to produce the green house effect. To obtain a good heat recital of construction walls, it become desirable that much care must be taken to choose the insulation materials for the buildings and considering the variation of weather in the world. The outcome that is obtain are usually important in conniving a suitable structure or wall enclose setting for a inert thermal structure to obtain a most effective and comfortable insulation for Cyprus the total heat of the rooms with two different material stone wool and Y-tong can be put to use. Stone wool recommended to be used because it has high heat conductivity considering change temperature of the Cyprus.

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APPENDIX A

METEOROLOGICAL DATA (NICOSIA-2015)

Monthly solar radiation average values data (cal/cm^2)

JANUARY	221.4
FEBRUARY	289.2
MARCH	408.3
APRIL	548.2
MAY	604.6
JUNE	661.4
JULY	674.4
AUGUST	599.6
SEPTEMBER	476.1
OCTOBER	347.1
NOVEMBR	282.2

DECEMBER	277.6

APPENDIX A1

METEOROLOGICAL DATA (NICOSIA-2015)

Daily solar radiation average values data (cal/cm^2)

DAYS	OCTOBER	NOVEMBER	DECEMBER
1	295.0	372.0	297.9
2	290.1	389.0	271.5
3	427.4	386.4	305.6
4	466.4	248.7	305.1
5	462.3	276.9	298.6
6	398.1	263.5	303.1
7	392.3	303.4	200.3
8	368.1	328.5	290.9
9	461.9	323.0	277.9
10	455.0	355.2	234.9
11	384.8	351.1	241.8
12	422.9	334.2	107.9

13	388.0	333.4	241.0
14	405.9	338.0	275.6
15	389.4	139.1	245.3
16	412.6	247.4	180.7
17	421.4	292.5	71.0
18	360.0	317.1	88.5
19	364.3	323.3	141.2
20	419.0	311.8	271.7
21	372.5	273.2	250.0
22	166.8	309.1	268.1
23	180.2	311.8	277.9
24	204.8	316.3	286.7
25	202.2	256.2	271.4
26	257.9	233.1	105.7
27	360.1	157.7	240.5
28	247.1	250.3	265.9
29	148.8	221.4	254.5
30	269.3	178.1	143.5
31	357.4		126.6

APPENDIX B

METEOROLOGICAL DATA (NICOSIA-2015)

Monthly average temperature values data (^{o} C)

JANUARY	10.9
FEBRUARY	11.3
MARCH	14.1
APRIL	15.8
MAY	21.2
JUNE	23.8
JULY	27.6
AUGUST	29.0
SEPTEMBER	26.8
OCTOBER	22.6
NOVEMBR	17.9
DECEMBER	13.0

APPENDIX B1

METEOROLOGICAL DATA (NICOSIA, OCT, NOV, DEC, 2015)

Daily average temperature values data (^{o} C)

DAYS	OCTOBER	NOVEMBER	DECEMBER
1	24.5	20.6	14.2
2	25.0	20.2	14.7
3	25.2	20.1	11.9
4	24.6	20.2	11.4
5	23.5	20.5	10.3
6	22.8	19.3	12.0
7	22.2	19.4	14.4
8	21.4	19.0	14.1
9	22.5	18.3	14.4
10	23.1	16.3	14.1
11	24.1	16.4	14.1
12	24.5	17.9	12.3
13	22.9	18.5	14.4
14	22.2	19.2	13.4
15	22.8	18.0	13.5
16	23.8	18.9	13.7
17	24.2	18.3	12.5

18	23.6	16.8	12.8
19	23.3	16.7	11.8
20	22.5	16.7	12.8
21	22.6	16.2	12.9
22	21.8	17.2	12.4
23	23.3	16.8	12.7
24	21.4	17.5	14.0
25	19.3	16.5	13.4
26	18.7	18.2	13.9
27	20.0	16.5	14.0
28	18.8	16.1	14.2
29	18.7	16.2	13.6
30	19.4	13.9	11.5
31	20.3		6.4

APPENDIX C

METEOROLOGICAL DATA (NICOSIA, OCT, NOV, DEC-2015)

Daily wind velocity average values data (m/s)

day	Nov	Dec	JAN
1	4.1	2.4	8.0
2	4.9	4.7	10.5
3	4.9	6.2	10.5
4	4.8	4.1	9.5
5	3.9	4.5	13.5
6	2.3	3.4	11.0
7	2.7	2.3	11.0
8	4.4	2.2	10.0
9	2.5	1.8	
10	3.8	2.1	
11	2.2	2	
12	2.5	3	
13	2.8	4.7	
14	2.5	2.8	
15	1.7	1.6	
16	2.5	2.1	
17	2.5	3	
18	2.7	3.6	
19	2.5	2.2	

20	2.1	2.2
21	2.1	2.3
22	3.5	2.3
23	2.3	3
24	2.2	2.7
25	2.6	2.7
26	2.9	1.6
27	2	2.5
28	1.8	2.6
29	4.5	3.3
30	2.3	3.6
31		3.8

APPENDIX D

THE PROPERTIES OF AIR AT 1 ATM AND THE FILM TEMPERATURE

(Calculated in the present study)

Temp (C)	density	thermal conductivity	kinematic viscosity	dynamic viscosit	Pr
0	1.292	0.02364	0.00001338	0.00001729	0.7362
5	1.269	0.02401	0.00001382	0.00001754	0.735
10	1.246	0.02439	0.00001426	0.00001778	0.7336
15	1.225	0.02476	0.0000147	0.00001802	0.7323
20	1.204	0.02514	0.00001516	0.00001825	0.7309
25	1.184	0.02551	0.00001562	0.00001825	0.7296
30	1.164	0.02588	0.00001608	0.00001849	0.7282
35	1.145	0.02625	0.00001655	0.00001872	0.7268
40	1.125	0.026065	0.000017	0.00001895	0.7282

T∞	T surf(ou	Tf	V ∞(Wind Velocity)	ρ	K (thermal conductivit	ν (kinematic viscosity)	Dynamic viscosit	Pr
18	25.56	21.78	1.7	1.1969	0.02527172	1.53238E-05	0.00001825	0.7304
18.9	46.59	32.745	2.5	1.1536	0.02608313	1.6338E-05	1.86163E-05	0.7274
18.3	48.84	33.57	2.5	1.1504	0.02614418	1.64156E-05	1.86542E-05	0.7272
16.8	54.1	35	2.7	1.145	0.02625	0.00001655	0.00001872	0.7268
16.7	55.54	36.12	2.5	1.1405	0.02620856	1.66508E-05	1.87715E-05	0.7271
16.7	54.5	35.6	2.1	1.1426	0.0262278	0.000016604	1.87476E-05	0.727
16.2	53.12	34.66	2.1	1.1463	0.02622484	1.6518E-05	1.87044E-05	0.7269
17.2	48.3	32.75	3.5	1.1536	0.0260835	1.63385E-05	1.86165E-05	0.7274
16.8	54.94	35.87	2.3	1.1415	0.02621781	1.66283E-05	1.876E-05	0.727
17.5	56.52	37.01	2.2	1.137	0.02617563	1.67309E-05	1.88125E-05	0.7274
16.5	45.87	31.185	2.6	1.1595	0.02596769	1.61914E-05	1.85445E-05	0.7279
18.2	45.38	31.79	2.9	1.1572	0.02601246	1.62483E-05	1.85723E-05	0.7277
16.5	50.33	33.415	2	1.151	0.02613271	1.6401E-05	1.86471E-05	0.7272
16.1	48.15	32.125	1.8	1.1559	0.02603725	1.62798E-05	1.85878E-05	0.7276
16.2	44.42	30.31	4.5	1.1628	0.02590294	1.61091E-05	1.85043E-05	0.7281
13.9	45.9	29.9	2.3	1.1644	0.0258726	1.60708E-05	1.84852E-05	0.7282
14.2	52.15	33.175	2.4	1.1519	0.02611495	1.63785E-05	1.86361E-05	0.7273
14.7	45.14	29.92	4.7	1.1643	0.02587408	1.60726E-05	1.84862E-05	0.7282
11.9	42.75	27.325	6.2	1.1747	0.02568205	1.58339E-05	1.83616E-05	0.7289
11.4	45.11	28.255	4.1	1.171	0.02575087	1.59195E-05	1.84062E-05	0.7287
10.3	43.17	26.735	4.5	1.1771	0.02563839	1.57796E-05	1.83333E-05	0.7291
12	45.8	28.9	3.4	1.1684	0.0257986	1.59788E-05	1.84372E-05	0.7285
14.4	52.67	33.535	2.3	1.1506	0.02614159	1.64123E-05	1.86526E-05	0.7272
14.1	53.07	33.585	2.2	1.1504	0.02614529	1.6417E-05	1.86549E-05	0.7272
14.4	52.16	33.28	1.8	1.1515	0.02612272	1.63883E-05	1.86409E-05	0.7273
14.1	47.75	30.925	2.1	1.1605	0.02594845	1.6167E-05	1.85326E-05	0.7279
14.1	48.01	31.055	2	1.16	0.02595807	1.61792E-05	1.85385E-05	0.7279
12.3	16.98	14.64	3	1.2265	0.02473336	1.46683E-05	1.80027E-05	0.7324
14.4	39.33	26.865	4.7	1.1765	0.02564801	1.57916E-05	1.83395E-05	0.7291
13.4	49.96	31.68	2.8	1.1576	0.02600432	1.62379E-05	1.85673E-05	0.7277
13.5	46.59	30.045	1.6	1.1638	0.02588333	1.60842E-05	1.84921E-05	0.7282
13.7	34.46	24.08	2.1	1.1877	0.02544192	1.55354E-05	0.00001825	0.7298
12.5	17.71	15.105	3	1.2246	0.02476798	1.47097E-05	1.80248E-05	0.7323
12.8	29.21	21.005	3.6	1.2	0.02521437	1.52525E-05	0.00001825	0.7306