UNIVERSITY OF GAZİANTEP
GRADUATE SCHOOL OF
NATURAL & APPLIED SCIENCES

THERMAL AND ECONOMIC ANALYSIS OF COMMONLY USED BUILDING WALLS FOR COOLING APPLICATIONS

M. Sc. THESIS
IN
MECHANICAL ENGINEERING

BY
Nebihe SARIKÇIOĞLU
JULY 2011

Thermal and Economical Analysis of Commonly Used Building Walls for Cooling Applications

M. Sc. Thesis
in
Mechanical Engineering
University of Gaziantep

Supervisor
Assoc.Prof.Dr. Recep YUMRUTAŞ

By
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July 2011

T.C.

UNIVERSITY OF GAZ1ANTEP

GRADUATE SCHOOL OF

NATURAL & APPLIED SCIENCES

DEPARTMENT OF MECHANICAL ENGINEERING

Name of the thesis: Thermal and Economical Analysis of Commonly Used Building Walls for Cooling Applications

Name of the student: Nebihe SARIKQIOGLU

Exam date: 11/08/2011

Approval of the Graduate School of Natural and Applied Sciences

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This is to certify that we have read this thesis and that in our consensus/majority opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

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ABSTRACT

THERMAL AND ECONOMIC ANALYSIS OF COMMONLY USED BUILDING WALLS FOR COOLING APPLICATIONS

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M.Sc. inMechanical Engineer
Supervisor: Assoc.Prof.Dr. Recep YUMRUTAŞ

July 2011, 164 pages

In this thesis, thermal and economical analysis of commonly used building walls is carried out to determine the most economical wall material to be used in the building exterior walls. For that reason, heating or cooling loads are required to obtain this data. Total heat gain from the exterior walls consists of great amount of cooling load for a building. The total heat gain from exterior walls of a building can be determined by using the Total Equivalent Temperature Difference (TETD) method. The TETD values for the walls are calculated by using the mathematical method. The TETD is functions of solar radiation flux, outside air and sol-air temperature, time lag (TL) and decrement factor (DF). The hourly solar radiation on a tilted surface is computed using hourly measured solar radiation data on horizontal surface. The hourly values of solar radiation flux on horizontal surface and outside air temperatures have been measured in Gaziantep for ten years (1997-2007) and are taken from the Turkish State Meteorological Service. The different values of TL and DF are estimated for different types and thicknesses of walls. The economical analysis is based on a Life Cycle Cost Analysis (LCCA). A computer program is developed to perform these numerical calculations. This program is used for briquette, brick, blokbims, Autoclaved Aerated Concrete(AAC) which are commonly used materials in Turkey. As a result of this work, optimum thickness of briquette, brick, blokbims and AAC are obtained as 29.21, 25.61, 15.74 and 9.84cm, respectively.When briquette, brick, blokbims and AAC walls which are considered 15cm are insulated with XPS, the optimum insulation thickness of briquette, brick, blokbims and AAC are obtained 0.06 , 0.06 , 0.04 and 0.03m , respectively.

Key Words: Total equivalent temperature difference, sol-air temperature, hourly solar radiation, heat gain, cooling load, economical analysis

ÖZET
SOĞUTMA UYGULAMALARINDA BİNALARDA YAYGIN OLARAK KULLANILAN DUVARLARIN ISIL VE EKONOMİK ANALİZİ

SARIKÇIOĞLU, Nebihe
Yüksek Lisans Tezi,Makine Mühendisliği Bölümü
Tez Yöneticisi: Doç. Dr. Recep YUMRUTAŞ
Temmuz 2011, 164 sayfa

Bu çalışmada, binalarda en ekonomik dış duvar malzemesini seçmek için binalarda yaygın olarak kullanılan duvarların ısıl ve ekonomik analizi yapılmıştır. Bu nedenle ısıl ve ekonomik analizi gerçekleştirmek için ısıtma ve soğutma yükleri gerekmektedir. Soğutma yükünün büyük bir kısmını dış duvarlardan olan ısı kazanımı oluşturmaktadır. Dış duvarlardan olan toplam ısı kazanımı Toplam Eşdeğer Sıcaklık Farkı (TESF) metodu kullanılarak elde edilmiştir. TESF değerleri matematik metod kullanarak hesaplanmıştır. TESF güneş ışınımının, dış hava ve güneş hava sıcaklığının, faz kayması ve sönüm oranının bir fonksiyonudur. Dikey yüzeye gelen güneş ışınımı, yatay yüzeye etki eden saatlik ışınım değerleri ve dış hava sıcaklıkları kullanılarak hesaplanmıştır. Gaziantep iline ait 10 yıllık (1997-2007), yatay yüzeye etki eden saatlik ışınım değerleri ve dış hava sıcaklıkları meteorolojiden elde edilmiştir. Farklı duvar tipleri ve farklı duvar kalınlıkları için faz kayması ve sönüm oranları hesaplanmıştır. Ekonomik analizi Ömür Döngüsü Maliyet Analizine dayanmaktadır. Tüm bu hesaplamaları gerçekleştirmek için Fortran'da bir program hazırlanmıştır. Bu programda Türkiye'de yaygın olarak kullanılan briket, tuğla, blokbims ve gazbeton malzemeleri kullanılmıştır.Yapılan hesaplamalar sonucunda, sırasıyla briket, tuğla, blokbims ve gazbetona ait optimum duvar kalınlıkları 29.21, 25.61, 15.74 ve 9.84cm olarak elde edilmiştir. 15cm kalınlığındaki briket, tuğla, blokbims ve gazbeton duvarların XPS ile yalıtımının yapıldığı düşünüldüğnde sırasıyla 0.06 , 0.06 , 0.04 ve 0.03m optimum yalıtım kalınlıkları elde edilmiştir.

Anahtar kelimeler: Toplam eşdeğer sıcaklık farkı, güneş hava sıcaklığı, güneş ışınımı , ısı kazanımı, soğutma yükü, ekonomi analizi, ömür döngüsü maliyet analizi

ACKNOWLEDGEMENTS

The presented dissertation would not have been possible without the guidance and the help of several individuals who in one way or another contributed and extended their valuable assistance in the preparation and completion of this study.

First and foremost, my sincere gratitude to my supervisor, Assoc.Prof.Dr.Recep YUMRUTAŞ whose sincerity and encouragement I will never forget. He has supported me throughout my thesis with his patience and knowledge. I attribute the level of my Masters degree to his encouragement and effort and without him this thesis, too, would not have been completed or written.

I would also like to thank my brother, İbrahim SARIKÇIOĞLU a fellow mechanical engineer, who is pursing his Master's degree in Economics in the United States for his ongoing support and assistance with proof-reading.

I would like to thank Assist.Prof.Dr. Önder KAŞKA for his suggestions during the progress of this thesis.

I would like to show my gratitude to the examining committee members for spending their valuable time for attending my Ph. qualification.

I can not find the right words to express to appreciation to my parents İbrahim SARIKÇIOĞLU and Zeynep SARIKÇIOĞLU. They have been behind me and supportive throughout all of my studies. I would like to give my utmost gratitude to my parents for their valuable sacrifices in every stage of my studies.

Lastly, I offer my regards and blessings to all of those who supported me in any respect during the completion of this project.

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LIST OF SYMBOLS

A	Surface area of wall
c	Specific heat
C	Cost
C_E	Cost of electricity
C_{ins}	Insulation cost
C_w	Wall cost
COP	Coefficient of performance of cooling system
d	Inflation rate
E	Equation of time
G_{on}	Extraterrestrial radiation measured on the plane normal to the radiation on the *n*th day of the year
G_{sc}	Solar constant
h_i	Combined heat transfer coefficient for interior surface
h_o	Combined heat transfer coefficient for exterior surface
i	Complex argument
I_b	Beam radiation
I_d	Diffuse radiation
I_o	Extraterrestrial radiation on a surface
I_T	Hourly solar radiation on a tilted surface
k	Thermal conductivity
k_{ins}	Thermal conductivity of insulation materials
k_T	The hourly clearness index
k_w	Thermal conductivity of wall materials
N	Lifetime
n	Number for day of a month
q	Heat gain through walls
q_k	Complex Fourier coefficient of dimensionless solar heat gain

R	Thermal resistance
R_b	Ratio of hourly solar beam radiation on a tilted surface to that on a horizontal surface
t	Time
T	Temperature of wall
T_o	Outside air temperature
T_i	Interior design dry bulb temperature
T_n	Complex Fourier coefficient of temperature
t_{ea}	Daily average sol-air temperature
t_e	Solar-air temperature
x	Thickness
ω	Sunset hour angle for a horizontal surface
ω_1	Sunset hour angle at time 1
ω_2	Sunset hour angle at time 2
U	Overall heat transfer coefficient

Greek Symbols

α	Thermal diffusivity of roof or wall material
α_s	Absorptance of exterior surface of wall
β	Wall slope or tilt angle
δ	Declination angle
γ	Azimuth angle
ε	Emissivity
ρ	Density of roof and wall material
ρ_g	Ground reflectance
ϕ	Latitude angle
θ	Incidence angle
θ_z	Zenith angle
τ	Dimensionless time

Abvreviations

AAC	Autoclaved Aerated Concrete
DF	Decrement Factor
LCCA	Life cycle cost analysis
PWF	Present worth factor
TL	Time lag
TETD	Total equivalent temperature difference
XPS	Extrude polystyrene

Subscripts

A	Annual
i	Inside
ins	Insulation
max	Maximum
min	Minimum
o	Outside
w	Wall material
un	Uninsulated

CHAPTER 1

INTRODUCTION

Energy is an important necessity for the growth of a society. The energy required per capita continuously increases and it results in serious implications on pollution, climate change and resource depletion. To put it a different way, consumption of energy has been a very serious problem for many countries in the recent years. The increased use of energy causes reduction of energy sources and increases the cost and the negative effects on the economy of countries. Energy consumption worldwide is rapidly increasing due to population, urbanization, improvement in standard of living and development of indoor comfort conditions in living medium. The ability to maintain desired temperatures is one of the most important accomplishments of modern technology. Keeping our living and working spaces at comfortable temperatures provides a healthier environment, and uses a lot of energy. The efficient use of energy and reducing the amount of energy required to provide products and services is very important in Turkey. Decreasing energy consumption can be achieved through increased efficient energy use. In other words, effective utilization of energy is required to conserve energy and reduce unwanted pollution. Making houses energy efficient leads to a reduction in the amount of energy used. Efficient use of energy will pave the way for sustainable development, as it results in better utilization of energy and less pollution. The energy consumption is distributed among four main sectors; industrial, building (residential/commercial), transportation and agriculture. Buildings are large consumers of energy in all countries. It takes a lot of energy to heat rooms in winter and cool them in summer. To be more precise, large amounts of energy are consumed by the air conditioning systems of the buildings. The air conditioning has been the most important solution for a more comfortable living environment. The primary purpose of an air-conditioning system, whether heating or cooling, is to maintain conditions that provide thermal comfort for the building occupants and conditions that are required by the products and processes within the space. In the selection of a suitable air-conditioning system, the calculation of the cooling load of a building has a very important role [1,4]. Cooling load is the thermal energy that must be removed from the space in order to maintain the desired comfort conditions, when an air conditioning system is operating [5].

Cooling load calculations may be used to accomplish one or more of the following objectives:

- Provide information for equipment selection, system sizing and system design (to size HVAC (heating, ventilating and air-conditioning) systems and their components). A correct cooling load calculation method should be built up and applied to enhance the operating efficiency of air-conditioning system components. For that reason, the selection of suitable components of the air-conditioning system requires correct calculation of a cooling load for summer design conditions.
- Provide data for evaluating the optimum possibilities for a load as required
- Permit analysis of partial loads as required for system design, operation and control.
- Provide information for economical analysis. Calculation of cooling loads is necessary to obtain economical analysis which is carried out to determine and select which one of material used in building constructions is economic or not.

Cooling load can be classified into two categories; external and internal[2]. External cooling loads are formed because of heat gains in the conditioned space from external sources through the building envelope or building shell and the partition walls. Sources of external loads include the following cooling loads :

- Heat gain entering from the external walls and roofs
- Solar heat gain transmitted through the fenestrations
- Conductive heat gain coming through the fenestrations
- Heat gain entering from the partition walls and interior doors
- Infiltration of outdoor air into the conditioned space

Internal loads are formed by the release of sensible and latent heat from the heat sources inside the conditioned space. These sources contribute internal cooling loads

- People
- Electric lights
- Equipment and appliances

The energy used by the buildings is mainly determined by the thermo-physical properties and construction of building envelope. Thermal behavior of the building envelope is the ability of the building to maintain comfortable inside living despite outside conditions (temperature, humidity and air velocity) variations from season to season. One way a building gains heat is from solar radiation. It can also gain lose heat to the environment by convection, depending upon the outside conditions. The inner surface temperature of the wall changes with time. It depends on solar radiation on the wall, the outer air temperature, the indoor conditions and the thermo-physical properties of wall and roofing materials. In other words, the heat transfer between the outer and inner surfaces of the wall depends upon the thermal conductance of the layers of the wall, roof, window and door materials. For that reason, choosing the appropriate wall types to be used in building construction is crucial in order to reduce the space cooling load of the building. In many buildings, heat gain from external walls constitutes a major portion of the total cooling load of the building. [3] Building walls have important roles in decreasing or increasing of the energy used for heating and cooling loads due to heat loss and heat gain through these structures. To put in a different way, types of walls to be used in building constructions and calculations of the heating and cooling load due to heat loss and heat gain from these structures are very significant. [1,4] To be more precise, capacities of air-conditioning systems depend on the types of walls used and calculations of heat gain in the summer season and heat loss in the winter season.

Heat gain is the rate at which energy is transferred to or generated within space at any given time. The heat gain and loss, must be equally, balanced by removal and addition to get the desired room comfort desired. The heat gain or loss can occur through an element of the building envelope (walls, floors or roofs/ceilings) by three primary mechanisms:

- Conduction
- Convection
- Radiation

In addition, the heat gain or loss through a building depends on the following:

- The amount of shade that is on building's windows, walls and roof. The orientation of the building with respect to the direction of sun rise and fall is important.
- The temperature difference between outside temperature and our desired temperature. (Weather conditions)
- The surface area of the walls. The larger the surface area, the more heat ~~can~~ gain possible.
- Thermal properties of the building (insulation, glass transmittance, surface absorptivity)
- Construction quality in preventing air, heat and moisture leakage.
- The amount of air leakage into indoor space from the outside.
- People
- Amount of lighting in the room.
- Activities within a building.
- Amount of heat the appliances generate. Number of power operated items such as ovens, computers, and televisions inside the space all contribute to heat.

Heat gain to a building through its walls and roof make up a large fraction of the cooling load. Consequently, estimation of the heat gain to a space through the external walls is the first essential step in calculation of the cooling load, and thus in selection of the HVAC system components.

Over the years, several methods have been developed to estimate the building cooling loads due to heat gain through the external walls, and roofs, which can be categorized as exact, numerical and transfer function methods. The exact method (also referred to as the heat balance method) involves the application of heat balance equation to the inner surfaces and finding a solution to the heat transient heat conduction equation for the walls and roof using suitable numerical methods such as finite difference method. The exact method is more direct and clear in load calculation methodology. It is a rigorous procedure requiring the use of computers.

The Transfer Function Method (TFM) or weighting factor method is a simplification of the laborious heat balance method. The wide application of the TFM is due to the user-friendliness of the inputs and outputs of the TFM software and the time saved during computing. In the transfer function method, interior surface temperatures and the space cooling load were first calculated by the exact heat balance method for many representative constructions. [3] The transfer function coefficients (weighting factors) were then calculated which converted the heat gains to cooling loads. Sometimes, transfer function coefficients were also developed through test and experiments. Today, TFM is the most widely adopted computer-aided load calculation method in HVAC&R consulting firms.

Based on the concept of transfer functions, three basic methods that are easy to use have been developed for calculating air conditioning cooling load for sizing cooling equipment. These methods are Transfer function method(TFM), cooling load temperature difference (CLTD) / solar cooling load (SCL) / cooling load factor (CLF) method and total equivalent temperature difference (TETD) / time averaging (TA) method [2,8,9]. The TFM is widely used computer aided cooling load calculation method in air-conditioning industry[6]. In this method the hourly heat gain due to walls, roofs, glass and other components ~~is~~ are computed. The conversion of heat gain to cooling load is then calculated by multiplying transfer coefficients [7] which are tabulated for certain types of walls, partitions, roofs, floors, and ceilings in ASHRAE. [8] Some works have also been done to produce improved data for use with the TFM. [10-11]

CLTD/ CLF/ SCL method is derived from TFM method for manual use when computer methods cannot be used and uses tabulated data to simplify the calculation process.[3] This method can be fairly easily transferred into simple spreadsheet programs but has some limitations due to the use of tabulated data. CLTD, CLF and SCL include the effect of time-lag in conductive heat gain through opaque exterior surfaces and time delay by thermal storage in converting radiant heat gain to cooling load. This approach allows cooling load to be calculated manually by use of simple multiplication factors. CLTD is a theoretical temperature difference that accounts for the combined effects of inside and outside air temperature differences, daily temperature ranges, solar radiation and heat storage in the construction assembly/ building mass. It is affected by orientation, tilt, month, day, hour, latitude, etc. CLTD factors are used for adjustment to conductive heat gains from walls, roof, floor and glass. CLF accounts for the fact that all the radiant energy that enters the conditioned space at a particular time does not become a part of the cooling load instantly. CLF factors are used for adjustment to heat gains from internal loads such as light, occupancy, and power appliances. SCL factors are used for adjustment to transmit heat gains from glass.

TETD/ TA method was originally presented as a manual procedure. The TETD/ TA method is also a member of the TFM family and is developed primarily for manual calculation. TETD/ TA is simpler in the conversion of heat gains to cooling loads. However, the time-averaging calculation procedure is subjective; it is more of an art form than rigorous scientific method. Also the TEDT/ TA method inherits the limitations that a TFM possesses if the TFM is used to calculate the TETD. This was the preferred method for hand or simple spreadsheet calculation before the introduction of the CLTD/ CLF method. Most engineers use the TETD and CLTD methods because these methods are simple to use, give component loads and tend to predict loads on a conservative side.

The TETD method differs from the CLTD method in that heat gains are handled to obtain cooling [7], and it includes both conduction heat gain through the walls and roofs and the effects of solar energy impinge on the external surfaces of the structures.

In 1967, ASHRAE introduced the TETD/ TA method. This method is an alternative simplification of the heat balance technique and it uses total equivalent temperature differential values and a system of time-averaging (TETD/ TA) to calculate cooling loads. In the total equivalent temperature differential (TETD) method, the response factor technique was used with a number of representative wall and roof assemblies from which data derive to calculate TETD values as a function of maintained room temperature and sol-air temperature [7]. The sol-air temperature is related with time lag and decrement factor [12-13]. The time lag and decrement factor have been affected by thickness of material and type of the material [14-17].

In the work presented in this thesis, The Total Equivalent Temperature Difference (TETD) method is used to calculate annual cooling loads. The heat gains coming from walls and roofs can be obtained by using TETD method. Because the economical analysis needs these data.

The economical analysis calculations are based on a life cycle cost analysis (LCCA)[46]. Life cycle cost analysis is an economic engineering tool useful in comparing the relative merit of competing project implementation alternatives. LCCA can be performed on large and small buildings or on insolated buildings[47-48]. Many building owners apply the principles of LCCA in decisions they make regarding the construction of or improvements to a facility. LCCA is an essential design process for controlling the initial and the future costs of ownership. It can be used to evaluate the cost of a full range of projects, from an entire site complex to a specific building system component.

There are several kinds of wall materials commercially available in Turkey right now such as briquette, brick, blokbims and autoclaved aerated concrete (AAC). Nonetheless, it is very difficult to choose which one is best overall; where it is inexpensive but still useful enough to significantly save on electrical power for the air-conditioning needs. The cost of external walls increase with increasing thickness. It is very difficult to assertain which thickness is optimal. All of these difficulties can be solved by economical analysis. The economical analysis is used to determine and select the most economic building construction and to analyze the optimum wall thickness.

This study has three objectives:

- Calculate TETD values which consider the effects of solar radiation on wall orientation and surface color during cooling season.
- Analyze the optimum wall thicknesses and the life cycle total costs (life cycle savings and payback periods of insulation materials with a typical residential wall) based on life cycle cost analysis in Gaziantep.
- Develop an approach for selecting the most economic wall materials.

This thesis includes seven chapters. In the second chapter, related studies occupied in the literature are briefly summarized. Historical background on the concept of using the cooling load calculation methods such as Transfer Function Method (TFM), Cooling load temperature difference (CLTD), and total equivalent temperature difference (TETD) are introduced. The research on basic design conditions, decrement factor and time lag related with TETD are described. The concept of economical analysis related with life cycle cost analysis (LCCA) is also briefly explained.

In the third chapter, the methodologies for calculating Total Equivalent Temperature Difference (TETD) values for building walls commonly used in Turkey are given. An analytical solution of the transient heat transfer problem for multilayered walls, the estimation of solar radiation flux on the inclined wall surfaces, and the calculation procedure of sol-air temperature using averages of hourly ambient air temperatures and heat flow through these structures are all introduced[1].

In chapter four, the procedure of the economical analysis is given. The concept of Life Cycle Cost Analysis is explained. An approach is developed for selecting the most economic wall materials and for finding the optimum thickness for the walls.

In chapter five, the computational procedure is presented and a simplified flowchart of program is shown. Some informations about building materials and climatic data used in this thesis is given. Thermophysical characteristic of the wall materials are tabulated.

In chapter six, results of TETD values, cooling loads and economical analysis are obtained from execution of computer programs for Gaziantep and some types of walls.The effects of some of the parameters on these calculations are depicted in a graphical manner. All of these results are discussed. The obtained results are analyzed and compared with literature.

In chapter seven, the conclusions and recommendations related with TETD values, cooling load calculations and economy are summarized.

CHAPTER 2

LITERATURE SURVEY

The objective of this chapter of the thesis is to give a historic background about cooling load calculation studies and methods, such as the Transfer Function Method (TFM), the Cooling Load Temperature Difference (CLTD), and especially the Total Equivalent Temperature Difference (TETD) method introduced previously and economical analysis calculations related with Life Cycle Cost Analysis (LCCA). Literature survey consists of two subjects which are cooling load calculations and economical analysis. The general concept of the thesis is to obtain TETD values and economical results. Therefore, the study touches on required parameters in calculations of TETD values such a decrement factor, time lag, sol-air temperature and of economical analysis such as cooling load, cost of building wall material, current inflation, discount rates are also surveyed. Results obtained from the other studies and present study are compared in this chapter. The sol-air temperature is the function of hourly radiation on walls and ambient air temperature therefore, some information is given about the calculation of solar radiation and the gathering and selecting of meteorological data.

Cooling load is the rate of heat which must be removed from the space to maintain a specific space air temperature and moisture content when worst case outdoor design temperature is being experienced. The parameters affecting cooling load calculations are numerous, for example, the outside air temperature, the humidity ratio, the number and activity level of people, etc. These parameters are often difficult to precisely define and are always intricately interrelated. Cooling loads are generally estimated by summing the internal and external instantaneous heat gains formed by the release of sensible and latent heat from the heat sources inside the conditioned space. Internal heat gains are completely independent from outdoor effects. External heat gains are formed because of heat gains in the conditioned from external sources through the building envelope or building shell and partition walls.

Cooling load is the heat energy to be removed from any space in order to maintain indoor air temperature at previously defined value. Space cooling load and space heat gain have different meanings. The heat received from the heat sources (conduction, convection, solar radiation, lightning, people, equipment, etc.) does not go immediately to heating the room air. Only some portion of it is absorbed by the air in the conditioned space instantaneously leading to a minute change in its temperature. The convective component is converted to space cooling load instantaneously. Space heat gain is the rate at which heat enters a space, or heat generated within a space during a time interval. Most of the radiation heat especially from sun, lightning or people is first absorbed by the internal surfaces, which include ceilings, floors, internal walls, furniture, etc. The large but finite thermal capacity of the roof, floors, walls, etc, causes their temperatures to increase slowly due to absorption of radiant heat. The radiant portion introduces a time lag and decrement factor depending upon the dynamic characteristic of the surface. Due to time lag, the effect of radiation will be felt even when the source of radiation, in this case the sun is removed. To sum up, differences between space heat gain and space cooling load are due to heat storage effect. The methods used in this survey are based on hourly calculations of cooling loads. The most commonly recommended methods in the cooling load calculations are ASHRAE methods[9] and VDI methods[23].

Before the twentieth century, there was very little attention put towards the calculation of cooling loads compared to the costs of operating an air-conditioning system. This practice often resulted in substantially oversized heating and cooling systems. Now, in present day, load calculation methods are directed more towards accurately sizing systems which result in more economical system performance.

Air-conditioning was first commented on in the 1923 edition of the American Society of Heating and Ventilating (ASHVE) Guide. It is apparent from the advice given in the guides of this period that the main applications of air-conditioning at this time were industrial and in large public spaces (theatres and department stores) so that equipment capacities were mainly dependent on internal gains and fresh air loads. Calculation of cooling loads arising from “Sun Effects on Buildings” was not specifically discussed in the Guide until 1933. Concerns about the transmission of solar energy into buildings had prompted a series of experimental projects in which solar fluxes: wall conductance, surface temperatures and absorptivity were measured (Houghten and Gutberlet 1930) [18]. In the 1930’s, Houghten et al. introduced the analysis of heat transmission through the building envelope and discussed the periodic heat flow characteristics of the building envelope. The cooling load calculation methods that were introduced in the 1933 Guide allowed an engineer to calculate instantaneous heat gains based on the surface temperature and conductance data measured by Houghten. It was also noted that “a customary rule-of-thumb is to add 25ºF (14F) to the outside dry-bulb temperature in calculating the heat transmission through walls, glass, and roof, which may be exposed to the sun for sun time.”

In 1937, the ASHVE Guide introduced a systematic method of cooling load calculation involving the division of various load components. In the ASHVE Guide, solar radiation factors were introduced and their influence on external walls and roofs were taken into consideration. Both the window crack and number-of-air-changes methods were used to calculate infiltration.

Experimental measurements of solar fluxes and material absorptivity continued through 1930’s so that in the 1938 Guide tabulated solar flux data were given for the first time. This data was used to calculate the transfer of absorbed solar radiation through walls and roofs using the relation $H_R=AF_\alpha I$, where A is the area, α is the absorptivity of the source, and I is the incident flux. The factor F was taken from a graph that correlated this reduction factor directly with the U-factor of the structure (Faust et. al. 1935) [19]. Solar gains through glazing were obtained at this time by multiplying fluxes by shading coefficients.

The work on time varying heat gains through building fabrics published by Mackey and Wright (1944, 1946) marked a change from these semi-empirical methods. They adopted what they noted as being the English practice of using the sol-air temperature as the driving temperature. They developed a method of calculating the net flux to the inside of the wall or roof based on the theoretical consideration of a sinusoidal variation of this external temperature. Using Fourier analysis, they were able to define the response to each harmonic of the driving function by a decrement factor and an associated time lag. Using tabulated decrement factors and time lags it was possible for the engineer to calculate manually the overall heat gains using only a few harmonics. To briefly sum it up, Mackey and Wright first introduced the concept of sol-air temperature in 1944 [20]. In the same paper, they recommended a method of approximating the changes in inside surface temperature of walls and roofs due to periodic heat flow caused by solar radiation and outside temperature with a new decrement factor. The original work by Mackey and Wright (1944) treated homogeneous walls and roof but was later extended (Mackey and Wright 1946) to include constructions and was included in the 1947 ASHVE Guide [20-21]. The treatment of composite walls and slabs by this method, however, was thought at the time to be too complex for practical application.

Stewart (1948) later used the method to calculate "Equivalent Temperature Differentials" for different materials and hours of the day [22]. In this method, the U-factor was simply multiplied by the equivalent temperature difference to calculate the conduction gain. However, various "ad hoc" corrections needed to be made for conditions that varied from those under which the tabulated data had been calculated. This method was then adopted in the 1949 Guide. The concept of this method is appealingly simple and is used in the Total Equivalent Temperature Difference/ Time Averaging (TETD/TA) method and the Cooling Load Temperature Difference/ Solar Cooling Load/Cooling Load Factor (CLTD)/ (SCL)/ (CLF) method described in the 1997 ASHRAE.

The models proposed to deal with dynamic conduction and solar gains were not integrated in any way with a model of the zone radiant and convective heat transfer. Little attention was paid to dynamic effect of internal radiant gains until later (Mackey and Gay 1949, 1952). In 1952, Mackey and Gay analyzed the difference between the instantaneous cooling load and the heat gain owing to radiant heat incident on the surface of the building envelope [23].

Danter (1960) attributed development of the Admittance Method [24]. He presented a method for dealing with heat flow transmitted through the structure driven by sinusoidal external excitation. He expressed the flow conducted into the interior per unit variation in external temperature as *fU*. The 'U' is the usual steady state transmittance and '*f*' is a decrement factor, dimensionless and less than unity, and having an associated time lag expressed in hours. Loudon (1968) developed the method to treat internal excitation [25]. The method uses a very similar analytical approach to finding the response of the zone fabric to sinusoidal external excitation used by Mackey and Wright (1944). The mathematical technique used to find the properties of composite constructions however owes more to the matrix methods given by Van Gorcum (1951) and Pipes (1957) [26-27].

In 1964, Palmatier introduced the term thermal storage factor to indicate the ratio between the rate of instantaneous cooling load in the space and the rate of heat gain [28]. One year later, Carrier Corporation published a design handbook in which heat storage factor and equivalent temperature difference (ETD) were used to indicate the ratio of instantaneous cooling load and heat gain because of the heat storage effect of the building structure. This cooling load calculation method was widely used by many designers until the current ASHRAE methods were adopted.

In 1967, ASHRAE suggested a time-averaging (TA) method to allocate the radiant heat over successive periods of 1 to 3h or 6 to 8h, depending on the construction of the building structure. Heat gains through walls and roofs are tabulated in total equivalent temperature differentials (TETDs). In the same year, Stephenson and Mitalas [29] recommended the thermal response factor which includes the heat storage effect for the calculation of cooling load. The thermal response factor evaluates the system response on one side of the structure according to random temperature excitations on the other side of the structure. This concept had been developed and forms the basis of the weighting factor method (WFM) or transfer function method (TFM) in the 1970s. In 1968, Stephenson [30] oriented the TETD/TA method, which was directed primarily as a manual procedure in ASHRAE handbooks of fundamentals in 1967 and 1972 editions. Stephenson listed a number of representative wall and roof assemblies as tables of calculated time lags and decrement factor and total equivalent temperature differential values. This data was based on a Fourier series solution to the one-dimensional unsteady state conduction equation for a multiple component slab as used to calculate the heat flow through each of the walls and roofs selected for that purpose. All calculations were based on an inside air temperature of 24ºC and a sol-air temperature. Calculation methodology of sol-air temperature widely found in literature was given in Duffie and Beckman (1991) [31] as a methodological order. The sol-air temperature is the fictitious outdoor dry-bulb temperature such that in the absence of solar radiation, the surface will exchange the same amount of energy to air at the sol-air temperature as is exchanged in the actual environment. TETD/ TA is the most well done and applied method in Turkey. This method gives effective results in wide intervals for experienced users. Equivalent Temperature Difference has taken the place of absolute temperature difference in the method due to ability of massive building materials heat storage capacity [32]. Building materials store energy they absorb during the day and then release this energy to the space after time lag. In the TETD/ TA method the response factor technique introduced by Mitalas and Stephenson [29] was used to calculate TETD values as functions of sol-air temperature and maintained room temperature. Various components of space heat gain associated TETD value and results are added to internal heat gain elements to get instantaneous total rate of space heat gain. This total heat gain then converted to an instantaneous cooling load by a time averaging technique. Time averaging technique recognizes thermal storage by building mass and contents of radiant portions of heat gain entering a space at any time, with subsequent release of stored heat to the space at any time. It further recognizes that the cooling load for a space at a given hour is the sum of all the convective heat gain and non radiant portion of conductive heat gain to that space, plus the amount of previously stored radiant heat gain released back to the space during that same hour ASHRAE [8].

In the 1970s, Mitalas [33] introduced the Transfer Function Method (TFM) in cooling load calculation similar in principle of TETD/ TA method. His method uses series of Weighting Factor (WF) or conduction transfer function (CTF) coefficients to the various exterior opaque surfaces and to differences between sol-air temperature and inside temperature to determine heat gain with appropriate reflection of thermal inertia of such surfaces. CTF coefficients are used to describe the heat flux at the inside walls, roofs, partitions, ceilings or floors as a function previous values of the heat flux and previous values of inside and outside temperatures. The WF coefficients are used to translate the zone heat gain into cooling loads. To put it a different way, the calculation of space cooling load using the Transfer Function Method (TFM) consists of two steps. First, heat gains or heat losses from exterior walls, roofs, and floors are calculated using response factors or conduction transfer function (CTF) coefficients; and the solar and internal heat gains are calculated directly for the scheduled hour. Second, room transfer function coefficients or room weighting factors (WF) are used to convert the heat gains to cooling loads, or heat losses to heating loads. The TFM is limited because the cooling loads thus calculated depend on the value of transfer function coefficients as well as the characteristics of the space and how they are varied from those used to generate the transfer function coefficients. In addition, TFM assumed that the total cooling load can be calculated by simply adding the individual components-the superposition principle. However, this assumption can cause some errors. Due to TFM complexity, this method forces engineers to spend valuable time consulting tables and performing repetitive calculations.

In 1975, Rudoy and Duran [35] developed a new method in order to overcome complexity of TFM and make the TFM a more manual friendly cooling load calculation procedure. This new method is called as CLTD/ SCL/ CLF method. This method is a single step cooling load calculation procedure that uses the cooling load temperature difference (CLTD), solar cooling load (SCL), and cooling load factor (CLF); these are produced from the simplified TFM. The CLTD/ SCL/ CLF method first calculates the sensible cooling load based on the TFM. The result is divided by the U value, shading coefficient, to sensible heat gain to generate the CLTD, SCL or CLF. Thus, it provides a direct, one-step space cooling load calculation instead of a heat gain-cooling load conversion, a two-step calculation in TFM. Cooling load calculation using the CLTD/ SCL/ CLF method can be either computer-aided or performed manually for a check or rough estimate. The CLTD/ SCL/ CLF method is one of the members of the TFM family. In the CLTD/ SCL/ CLF method, the CLTD is used to calculate the sensible cooling load for the exterior walls and roofs. Recently, an SCL factor has been added which represents the product of the solar heat gain at that hour and the fraction of heat storage effect due to various types of room construction and floor coverings. CLF is used to calculate internal sensible cooling loads. The limitations of the TFM are also carried through to the CLTD/ SCL/ CLF may cause additional errors.

Many computerized thermal load and energy calculating software programs had been developed in the 1980's. Since then, because of the wide adoption of personal computers, the use of computer-aided HVAC&R design was rapidly increased and many thermal load and energy analysis programs were developed in this period.

Hill and Furlong (1973) gave a qualitative comparison of TETD/TA and TFM [35]. Shah (1983) qualitatively compared the TETD/TA methods and CLTD/CLF method [36]. However, no need-to-head comparisons were reported.

In the ASHRAE Fundamentals (1989), three cooling load calculation methods are explained in detail, which include the TETD/TA method, the TFM and the CLTD/CLF method.

ASHRAE has a long history of developing and revising load calculation methods. Romine (1992) gives a good summary through to 1992. At present, ASHRAE recommends three methods in the Handbook of Fundamentals (ASHRAE 1997) and the Cooling and Heating Load Calculation Manual (Mc Quiston and Splitler 1992): the Transfer Function Method (TFM), CLTD/SCL/CLF method and the TETD/TA method. Each method attempts to approximate the results of the Heat Balance Method, either directly or indirectly.

More recently, ASHRAE has funded a research project entitled "Advanced Methods for Calculating Peak Cooling Loads (875-RP)". The goal of this project has been to replace the existing methods with two "new" methods: the Heat Balance Method (Pedersen, Fisher and Liesen 1997) [37] and the "Radiant Time Series Method" (Splitler, Fisher and Pedersen 1997)[38]. The Heat Balance Method is the most fundamental of all design load calculation methods and may be the method most understandable by practicing engineers, as it closely follows physical processes and has a minimum of mathematical abstraction. However, it does require the solution of several simultaneous equations. The second method, the "Radiant Time Series Method," is intended to be simpler from a calculation standpoint and builds on the concepts of the TFM and TETD/TA method.

The heat balance method involves the solution of heat balance equations for each of the outside and inside zone surfaces, along with the zone air. Radiant and convective heat exchanges are treated separately at both inside and outside surfaces, with interior radiant exchange being calculated using the mean radiant temperature/balance algorithm of Walton (1980) [39]. Transient conduction through the zone fabric is dealt with using conduction transfer functions. The two simpler methods combine radiant and convective heat transfer into a single equivalent resistance. All conduction procedures involve some kind of model requiring simplifying assumptions. The heat transfer between various surfaces takes place under the following assumptions:

- Only one-dimensional transient heat flow through the building envelope is considered.
- The room air is perfectly mixed with the supply air so that the resulting room air temperature is uniform.
- The materials of the building envelope are homogenous. The surface temperature, the surface heat-transfer coefficient, and the absorptivity for each surface are uniform values. Reflectivity is very small and can be ignored.
- The cooling load is calculated based on the mean value of a fixed time interval, such as 1h.

In the heat balance method, the estimation of cooling load for a space involves calculating a surface-by-surface conductive, convective and radiated heat balance for each room surface and a convective heat balance for the room air. The heat balance model is viewed as four distinct processes:

- Outside face heat balance: An exterior surface heat balance equation is formed for each exterior surface by ensuring that all heat transfer into the surface is balanced by heat transfer out of the surface. Convection, radiation, and absorbed solar into the surface must be equivalent to the conduction from the surface into the wall. Note that, in actuality, the convection and radiation resistances may both be variable, non-linear functions of the surface temperature and air or radiation sink temperatures.

- Wall conduction process: Transient conduction heat transfer is modeled using conduction transfer functions (CTF), which are used as part of the exterior and interior surface heat balance equations to solve for the interior and exterior surface temperatures and interior and exterior conduction heat fluxes. Unlike some of the simplified methods, the conduction transfer functions do not include surface conductance on either side of the wall.
- Inside face heat balance: An interior surface heat equation is formed for each interior ensuring that all heat transfer into the surface is balanced by heat transfer out of the surface. The interior surface radiation is estimated using Walton's (1980) Mean Radiant Temperature/Balance algorithm.
- Air heat balance: A heat balance equation for the zone air balances the convective contributions from each of the surfaces. The heat balance ignores the thermal capacity of the air. When the heat balance procedure is being used to determine design cooling loads, the zone air temperature, T_z is set by the user. In other cases, some representation of the system capacity as a function of zone temperature and schedule mat be made, in which case the program may solve for the zone air temperature.

The heat balance method demands laborious work, more computing time, complicated computer programs, and experienced users. The heat balance method is generally used for research and analytical purposes.

The radiant time series (RTS) method is the simplified method for performing design cooling load calculations that is derived from the heat balance (HB) method. The design cooling loads are based on the assumption of steady- periodic conditions. The radiant time series method relies on a 24-term response factor series to compute conductive heat gain, and it relies on a 24-term "radiant time series" to convert instantaneous radiant heat gain to cooling loads.

The radiant time series method is simpler to apply than heat balance method since, there is no zone heat balance and the storage and release of structure energy are approximated with predetermined zone response instead. RTS method is exactly the same as previous simplified methods (TFM and TETD/TA). The radiant time series method uses a two-stage calculation procedure. First, convective and radiant heat gains are calculated for each hour assuming a constant zone air temperature. Second, the resulting cooling loads are calculated. The method models exterior convection, long-wave radiation, and absorbed solar radiation using a sol-air temperature and combined, constant, radiant/convective surface conductance. Transient conduction is calculated using a series of response factors that are used with the hourly outside sol-air temperatures and a fixed zone air temperature as their boundary conditions. The radiant heat gains are converted to cooling loads using a set of zone response factors (the so-called radiant time series) that define how much of the radiant load at a particular hour becomes a cooling load on the zone air at future hours.

The Radiant Time Series method differs from the heat balance procedure, in a number of important respects:

- Exterior convection, long wave radiation, and absorbed solar radiation are all modeled using a sol-air temperature and combined exterior surface conductance. The sol-air temperature is supposed to give the same heat flux into the surface as would be determined by modeling each heat transfer separately. This involves several approximations - fixed convection coefficient, fixed radiation coefficient, and fixed radiation sink temperature. The exterior surface conductance includes both the convection and radiation.
- Transient conduction heat transfer is modeled using a set of 24 response factors that, given the constant zone air temperature, T_Z , and the current 23 past values of sol-air temperature, T_{SAi} , give the current hours conduction heat gain. The response factors include both interior and exterior surface conductance.
- During the heat gain calculation step, the interior convection and radiation are modeled using a combined interior surface conductance. In effect, the wall is convecting and radiating to the zone air temperature. This is, of course, physically incorrect. As an approximation, it has the effect of over-predicting the conduction heat gain, particularly for cases where multiple surfaces are exposed to the outside.

- The cooling load produced by the radiant portion of the heat gains is calculated using set of zone response factors. (The convective portion of the heat gains produces a cooling load instantaneously.) The response factors are pre-calculated using a heat balance model of the zone. The heat balance model treats the radiant heat gain with reasonable fidelity, and does not make the assumption that the radiant temperature is equal to the zone air temperature.

A theoretical methodology was developed by Yumrutaş et. al. [1] to find total equivalent temperature difference (TETD) values for multilayer flat roofs and walls of buildings by using periodic solution. The theoretical model used in the study is the same with used in the present thesis. The time lag and decrement factor in the study are obtained numerically using periodic solution of one-dimensional transient heat transfer problem for the building structures and that values are compared with Mackey and Wright [20-21]. The study shows that change of sol-air temperatures for different directions as well as time lag and decrement factor, and these values are used to determine the TETD values of structures. The study is a significant reference with validation of the theoretical model point of view and comparison of the results in the present thesis.

Yumrutaş and Kaşka[40] performed an experimental investigation for determining total equivalent temperature difference (TETD) values of building walls and flat roofs. The study shows that the TETD values are functions of the time lag, decrement factor and sol-air temperature and the time lag and decrement factor depend on the highest and lowest temperatures at the inner and outer surfaces of the walls or roofs, and also the sol-air temperature depends on essentially solar radiation and outside air temperature. Therefore, they constructed two testing rooms each consisting of four walls and one flat roof, an air-conditioner, thermocouples, data logger and a computer to measure all required temperatures. They measured inside and outside temperatures and surface temperatures of each wall and roof layers in each minute and saved on the computer over a period of 24h in the summer season of Gaziantep, Turkey. Finally they obtained TETD values of eight types of wall and two types of roofs commonly used in Turkey by using experimental method and compared these results with the other theoretical works in the field in order to increase reliability of the results.

Asan and Sancaktar [14] investigated the effects of thermophysical properties and thickness of a wall of a building on time lag and decrement factor. For this reason, one dimensional transient heat conduction equation was solved using Crank-Nicolson scheme under convection boundary conditions. Time lag and decrement factor are very important characteristics to determine the heat storage capabilities of any material. Depending upon the thermophysical properties and thickness of the wall materials, different time lags and decrement factors can be obtained the effects of heat capacity, thermal conductivity and thickness of wall on time lags and decrement factor. The walls inner surface temperature goes to a constant value for increasing heat capacity where the thickness of the wall and thermal conductivity are fixed to a certain value. As heat capacity goes up the maximum value time lag goes up exponentially to infinity however, decrement factor goes to zero. In the case of varying thermal conductivity and constant heat capacity, for small values of thermal conductivity (insulation materials), almost constant wall inner temperature is obtained. Inverse exponential relationship exists between time lag and thermal conductivity however direct relationship exists between decrement factor and thermal conductivity. Thermal conductivity smaller than 0.01 results in very high time lags. As thermal conductivity increases, the time lag gets smaller and after a certain value of thermal conductivity, $k>100$, time lag takes a certain value around 2h. There exists a direct relationship between thermal conductivity and decrement factor. Small values of thermal conductivity, $k<0.01$, results to zero decrement factor. As k increases after this value, the decrement factor also increases. The study shows that, increasing the thickness of the walls will cause increases in heat capacity and increases in time lag but decreases in decrement factor.

Asan [15] investigated the effects of the walls insulation thickness and position on time lag and decrement factor numerically. In this study, the total wall thickness (insulation thermal mass) was kept constant in such a way that when the insulation thickness was increased, the thermal mass thickness was decreased in the same amount. The insulation was placed in four different locations of the wall. The study shows that insulation thickness and position have profound effect on time lag and decrement factor. In the study, computations were repeated for three different insulation materials namely polyurethane foam, cork board and rubber and for two different thermal masses namely brick and wood.

Vijayalakshmi et al. [41] introduced a study which is related to the thermal behavior of building wall elements. They investigated the thermal behavior of opaque wall materials under the influence of solar energy and analyzed the influence of thermophysical properties of different wall types on the interior environment. The thermal capacity and thermal diffusivity of the building material determines the time lag, decrement factor and magnitude of heat loss or heat gain. The study shows that the multilayer cavity walls and insulated walls have better ability to reduce inner surface temperature fluctuations due to lower U value, lower decrement factor and higher time delay. The values of thermal time delay and decrement factor are greatly influenced by the volumetric heat capacity and thermal diffusivity of the material. The increase in heat storage capacity increases the thermal time delay and decreases the decrement factor, because of its ability to store more heat so as to delay the heat transfer. However, the increase in thermal diffusivity increases the heat spreading rate thereby reducing the thermal time delay and decrement factor. Location of the insulation has influence on thermal time delay. Thermal time delay is increased by the replacement of insulation to the outer surface.

Konteleon et al. [13] made a study about the influence of wall orientation and exterior surface solar absorptivity on time lag and decrement factor. Their investigation was carried out for various insulated opaque wall formations comprising of typical material elements during the summer period in the mild Greek region. They extensively examined the influence of exact environmental conditions, as a function of wall orientation and solar absorptivity, on time lag and decrement factor. In the study, the walls have an orientation according to each compass point (north, east, south and west), while the outdoor absorption coefficient varies from 0 to 1. The transient thermal analysis was carried out by using an appropriate lumped thermal-network model, in which distributed thermal resistances and capacitances are linked to each other via a discrete number of nodes. In the paper, the non linear nodal method was used. Given technique in the study simulates the combined process of conduction, convection and radiation under specified environmental conditions. The study shows that, the influence of the outdoor absorption coefficient combined with the effect of solar radiation on sol-air temperature, for every wall formation and orientation, are factors that must be seriously considered in order to obtain the best possible time delay of the heat wave propagation and to reduce the decreasing ratio of indoor temperatures.

El-Sebaii et al. [42] made a study about global, direct and diffuse solar radiation on horizontal and tilted surfaces. In the study, they developed empirical correlations to estimate the monthly average daily global solar radiation on horizontal surface in Jeddah using the available meteorological data, propose empirical correlations for estimating diffuse radiation on horizontal surfaces and calculate the total solar incident on tilted surface facing south in Jeddah using both Liu and Jordon isotropic and Klucher's anisotropic models. They compared the two models. As a result of comparing, they inferred that, the isotropic model is able to estimate Ht more accurately than the anisotropic one. They found that at Jeddah, the solar energy devices have to be tilted to face south with a tilt angle equal to the latitude of the place in order to achieve the best performance all year round. However, they are orientated to face south with tilt angles equal (latitude+15) and (latitude-15) during the winter and summer seasons, respectively. In the study, total radiation incident on a tilted surface consists of three components; beam radiation, diffuse radiation and ground reflected radiation. The isotropic model on the paper is that developed by Liu and Jordon using the simplifying assumption of isotropic distribution of diffuse radiation which is independent of zenith and azimuth angles. On the other hand, the anisotropic models assume the sky as anisotropic source of diffuse radiation. The isotropic models can be used for estimating horizontal diffuse radiation in Jeddah with good accuracy.

Nijmeh and Mamlock [43] reported on the testing of two models, isotropic (Liu and Jordon, 1961) and anisotropic (Hay, 1979), using a database consisting of horizontal global and diffuse solar radiation, to predict the global solar radiation on a south-facing surface tilted at 45^{o} in Amman, Jordon. They compared the predicted global solar radiation to that measured by a pyranometer on a 45^{o} tilted surface. They found that the performance of the models was a function of the time of the year, namely, season.

Evseev and Kudish [44] made a study about the assessment of different models to predict the global solar radiation on a surface tilted to the south. The aim of the study was to compare 11 models that predict the diffuse radiation on a south-facing surface tilted at 40^o and compare the results to that measured by a pyranometer facing south at a tilt angle of 40^o. They utilized data measured in Beer Sheva, Israel in order to test 11 models. The data consist of hourly global and diffuse solar radiation on a horizontal surface, normal incidence beam and global radiation on a south-oriented surface tilted at 40^o. The horizontal diffuse radiation measured using a shadow ring was corrected using four different correction models. In the study, the individual model performance is assessed by an inter-comparison between the calculated and measured solar global radiation on the south-oriented surface tilted at 40^o using a combination of graphical and statistical analysis. They studied the relative performance of the different models under different sky conditions. They used different grading systems in order to obtain the relative performance of the models. The study shows that the Ma-Iqbal model (1983) was found to perform best under all sky, clear and partially cloudy conditions, whereas the Muneer model (1997) was found to give the best results for cloudy sky conditions.

Energy savings and the effective use of energy are more crucial for Turkey since we import most of our energy. A significant part of Turkey's consumption goes towards the energy for space heating and cooling in buildings. The annual energy demand of a building for heating and cooling is affected to some extent by thermal stability of the building itself. Building thermal stability is understood as the ability to hold the internal temperature within a certain interval, given normal external temperature oscillations and either with a constant energy supply from the plant or without any plant action. This building thermal stability depends on the dynamic thermal responses of all building envelope components (exterior walls, internal partitions, ceiling, and floors) to external and internal temperature variations. Dynamic responses are determined by the thermal properties of materials and the total amounts of materials used [49].

The use of conventional construction materials is one of the most effective ways a building can conserve energy for cooling and heating. Effective construction materials play an important role in the reduction of heat flow rate and energy consumption for space cooling and heating. Heat gains and losses in buildings generally occur through external walls, roof, ceiling, floors, windows and air filtration. The gains and losses of heat through a buildings wall are the largest component of cooling and heating load. The external walls and roof of a building are the interface between its interior and outdoor environment. The materials of the external walls and roof are the most effective way of controlling the outside elements to make homes more comfortable. Therefore, a proper wall material with the objective of achieving acceptable comfort for building occupants and reduced cooling load is imperative. The selection of a proper wall material and insulation material are particularly vital [50].

Determining and selecting all building envelope components are the prime interest of many engineering applications. The selection of wall materials and insulation materials are based on the thermal conductivity and the price. The lower the thermal conductivity and price are, the higher the economic efficiency of the wall and insulation material. The increase of building wall and insulation thicknesses will decrease the energy consumption for cooling and heating. The investment in wall materials for the building will also increase. Therefore, there must be an optimum point where the total investment cost for the wall materials and energy consumption can be minimized over the lifetime. The selection of proper wall materials and insulation materials, as well as the determination of optimum wall and insulation thickness are very critical for the economical analysis.

The economical analysis has a profound effect in the determining and selecting of the appropriate wall material for the building. Economical analysis depends on the cost of building wall materials and the cost of energy, as well as cooling loads, heating loads, efficiency of the heating system, cop of the cooling load equipment, lifetime of the building, current inflation and discount rates. The economical analysis of building calculations are based on heating and cooling load.

The economical analysis can be carried out using the life-cycle-cost analysis [46]. One of the most common and useful tools of engineering economic analysis is the life-cycle-cost of a system which compare the relative merit of competing project implementation alternatives. Life cycle cost analysis is an economic evaluation technique applicable for the consideration of investment decisions. It determines the total cost of owning and operating a facility over period of time. Life cycle cost analysis is an essential design process for controlling the initial and the future cost of building ownership. It will assist in determining the best and lowest cost options. Building related costs usually fall into the following categories:

- Initial costs- Purchase, acquisition, and construction costs
- Fuel costs
- Operation, maintenance, and repair costs
- Replacement costs
- Residual values- Resale or salvage values or disposal costs
- Finance Charges- Loan interest payments
- Non-Monetary benefits or costs

Life cycle cost analysis can be performed on large and small buildings or on isolated building systems. Many building owners apply the principles of life cycle cost analysis in decisions they make regarding constructions or improvements to a facility. A life cycle cost analysis can be used to determine the optimum wall and insulation thickness in order to take into account the changes in interest and inflation that directly affects both the cost of wall and insulation materials along with fuels.

One of the most common measures of engineering economics is the life-cycle cost of a system and one method of calculating the life-cycle cost is referred to as the P_1-P_2 method which proposed by Duffie and Bechman [31]. The idea of the method is that the life-cycle cost of a purchase option or alternative is calculated based on two economic indicators. The first (P_1) is the ratio of the life-cycle cost to the first year fuel cost or electrical cost. P_1 is the life cycle energy related to market discount rate d, electricity cost inflation rate i, and economic analysis period N. A low value of P_1 indicates that immediate fuel costs or electrical costs are high and that consequently, potential immediate fuel or electrical savings are important. The second indicator (P_2) is the ratio of life-cycle expenditures incurred as a result of the investment to the investment amount. A high value of P_2 indicates that the investment has a low first cost but higher costs over the life of the equipment.

Bolattürk [51] analyzed the determination of optimum insulation thickness on external walls of buildings with respect to cooling and heating degree-hours in the warmest zone of Turkey. The transmission loads calculated by using measured long-term meteorological data for selected cities. In the study, an economic model (P_1-P_2 method) is used in order to determine the optimum insulation thickness and the annual energy consumption of a building is calculated by using degree-hours method by considering solar radiation over a lifetime of 10 years. The results show that optimization of insulation thickness in building walls with respect to cooling degree-hours is more significant for energy savings compared to heating degree-hours in Turkey's warmest zone. For heating load, the optimum insulation thickness vary between 1.6 and 2.7cm, energy savings vary between 0.2 and 6.6 $/m^2 , and payback periods vary between 4.15 and 5.47 years depending on the city. On the other hand, for cooling loads, insulation thicknesses vary between 3.2 and 3.8cm, energy savings vary between 8.47 and 12.19 $/m^2, and payback periods vary between 3.39 and 3.81 years.

Söylemez and Ünsal [52] investigated optimum insulation thickness for refrigeration applications. They reported that the optimization technique leads to general formula which may be used to determine the economically optimum insulation for many different economic parameters. The P_1-P_2 method is used in the study, including the effects of all economic parameters. It is clear that both excessive and deficient insulation is not desirable economically. Excessive insulation leads to lower life cycle energy cost but requires too much capital investment. On the contrary lack of insulation causes larger life cycle energy cost with lower initial capital investment. It is also seen that the optimum insulation thickness is inversely proportional to the thermal conductivity cost of the insulating material.

Uçar and Balo [53] reported a study in 2009, in which the optimum insulation thicknesses of external walls, energy savings and payback periods over a lifetime of 10 years were calculated using the P_1-P_2 method for five different energy types and four different insulation materials and various cities from four climate zones of

Turkey. The results show that optimum insulation thicknesses vary between 19 and 47 \$/m^2, and payback periods vary between 1.8 and 3.7 years, depending on the city and the type of fuel. These results show that energy savings are directly proportional to the cost of fuel and climate conditions.

Dombaycı [54] reported a study in 2006, in which five different energy-sources (coal, natural gas, LPG, fuel oil and electricity) and two different insulation materials (expanded polystyrene, rock wool) were compared when calculating the optimum insulation thickness of external walls for Denizli in Turkey. The optimization is based on a life-cycle cost analysis. According to the results, the optimum case has been obtained by using coal as the energy source and expanded polystyrene as the insulating material. When the optimum insulation thickness was adopted the life-cycle saving and payback period were 14.09 \$/m^2 and 1.43 years, respectively.

Hasan [55] used life cycle cost analysis to determine optimum insulation thicknesses for rock wool and polystyrene insulation which was regarded as a function of degree-days and wall thermal resistance in Palestine. Savings over a lifetime of 10 years were computed for different wall structures and number of degree days. Even for climates with as few as 500 degree days, the savings will be realized by adding insulation. Savings up to 21 \$/m^2 of wall area are possible for rock wool and polystyrene insulation. Payback periods between 1 and 1.7 years are possible for rock wool and payback periods between 1.3 and 2.3 years for polystyrene insulation, depending on the type of wall structure. Generalized charts for selecting the optimum insulation thickness as a function of degree days and wall thermal resistance were prepared.

Çomaklı and Yüksel [56] studied the optimum insulation thickness of external walls for energy savings for the coldest cities of Turkey. The optimization was based on the life-cycle cost analysis. When the optimum insulation thickness was applied, a considerable energy saving of 12.113 \$/m^2 of wall was obtained in Erzurum over lifetime of 10 years.

Daouas and et al. [57] reported a study in which an exact analytical solution of transient heat transfer through multilayer walls has been provided using the CFFT technique. In order to analyze the thermal performance of building walls in presence of periodic outside ambient temperature and solar radiation specific to the city of Tunis and optimum insulation thickness of building walls in Tunisia was determined under steady periodic conditions. A matlab program was developed in order to perform numerical calculations based on the analytical model. The analytical model (CFFT technique) was extended to rigorously estimate the yearly cooling transmission loads for two types of insulation materials and two typical wall structures. Estimated loads are used as inputs to a life-cycle cost analysis over a building lifetime of 30 years in order to determine the optimum insulation thickness of the insulation layer. Results show that, the most profitable case is the stone/brick sandwich wall and expanded polystyrene for insulation, with an optimum thickness of 5.7 cm. In this case, energy savings up to 58% were achieved with a payback period of 3.11 years. The thermal performance of the walls under optimal conditions was also investigated. The comparison of the study with the degree-days method was performed for different values of indoor design temperature.

Daouas [58] reported a study in 2010, in which optimum insulation thickness, energy savings and payback periods are calculated for a typical wall structure based on both cooling and heating loads. Yearly cooling and heating transmission loads through a typical building wall with an insulation layer in the middle are rigorously estimated using an analytical method based on Complex Finite Fourier Transform (CFFT). Considering different wall orientations, the west and east facing walls are least favored in the cooling season, whereas the north-facing wall is the least favored in the heating season. Calculated annual transmission loads were used as the main inputs in an economic model. Optimum insulation thickness and resulting energy savings and payback periods based on both cooling and heating loads were determined in a life-cycle cost analysis over a lifetime of 30 years. The results show that the south orientation is the most economical with an optimum insulation thickness of 10.1 cm, 71.33% of energy savings and a payback period of 3.29 years. A sensitivity analysis shows that economic parameters, such as insulation cost, energy cost, inflation and discount rates and building lifetime, have a noticeable effect on optimum insulation and energy savings.

Şişman et al. [59] investigated a study, in which optimum insulation thickness for different degree-day (DD) regions of Turkey have been determined for a lifetime of N years, maximizing the present worth value of annual energy savings for insulated external walls.

Kaynaklı [60] reported a study on residential heating energy requirement and optimum insulation thickness. Degree-hour (DH) values were calculated by using long term and current outdoor air temperature values. The variation of annual energy requirements of the building was also investigated for various architectural design properties. The study shows the effects of the insulation thickness on the energy requirements and total costs. The optimum insulation thickness based on life-cycle cost (LCC) analysis was determined for different fuel types. As a result of the study, the length of the heating period is an average of 221 days, and the mean heating DH values was found at 45113.2 besides changing 38000 and 55000. The optimum insulation thicknesses for Bursa vary between 5.3 and 12.4 cm depending on the fuel types.

CHAPTER 3

THEORETICAL ANALYSIS

3.1. Introduction

The aim of this chapter is to calculate hourly and seasonal total heat gain from a building's exterior walls during cooling season using total equivalent temperature difference (TETD) method. Therefore, it is necessary to find the TETD values of the building structures commonly used in Turkey. The calculation of TETD values consists of: the calculation of sol-air temperature for each direction, the time lag and decrement factor of each wall configuration, and the hourly solar radiation on tilted (vertical wall) surfaces. In order to find TETD values of the building's exterior walls, a mathematical model is used. This model was developed by Yumrutaş et al. [4], and is used for finding daily and monthly variations of TETD and heat gain values. The model consists of four main sections, which are;

- The first section contains the solution for the periodic transient heat transfer problem for multilayered walls. Hourly temperature distributions in the wall will be estimated by using this solution.
- The second is for the calculation of solar radiation flux on any wall surfaces. This will be done by using hourly solar radiation flux on horizontal surfaces measured by meteorological stations over a period of ten years for Gaziantep in Turkey.
- In third section, the calculation of TETD and heat gain values from the exterior walls is presented.
- The last one includes estimation of hourly inside and outside wall surface temperature distribution.

3.2. Solution of Transient Heat Transfer Problem

Temperature variations at the inside and outside surfaces of building exterior walls as a function of solar radiation flux are required to find total equivalent temperature differences (TETD) values and heat flux for the walls. For this reason, the analytical solution procedure for periodic transient temperature field problem for the walls is presented in this section. The walls are composite structures which consist of n layers with thicknesses of L_n. There is convection heat transfer between the left side of the structure and inside air, which relates directly to the air conditioning load required to maintain the inside design temperature, T_i. The right hand side of the wall is exposed to outside air which is at a known time varying periodic ambient air temperature, $T_o(t)$ and solar radiation flux, $q_s(t)$. There is convection heat transfer between right side of the structure and outside air at the temperatures of $T_N(L_N,t)$ and $T_o(t)$, respectively. The geometrical configuration of the wall is shown in Fig.3.1. Each layer has homogenous structure with constant thermal properties. The following assumptions are considered.

- There is a good contact between the layers; hence the interface resistance is negligible.
- There is no heat generation in each layer of the walls.
- The variation of thermal properties is negligible.
- The convection coefficients are constants and are based on the direction of heat flow.

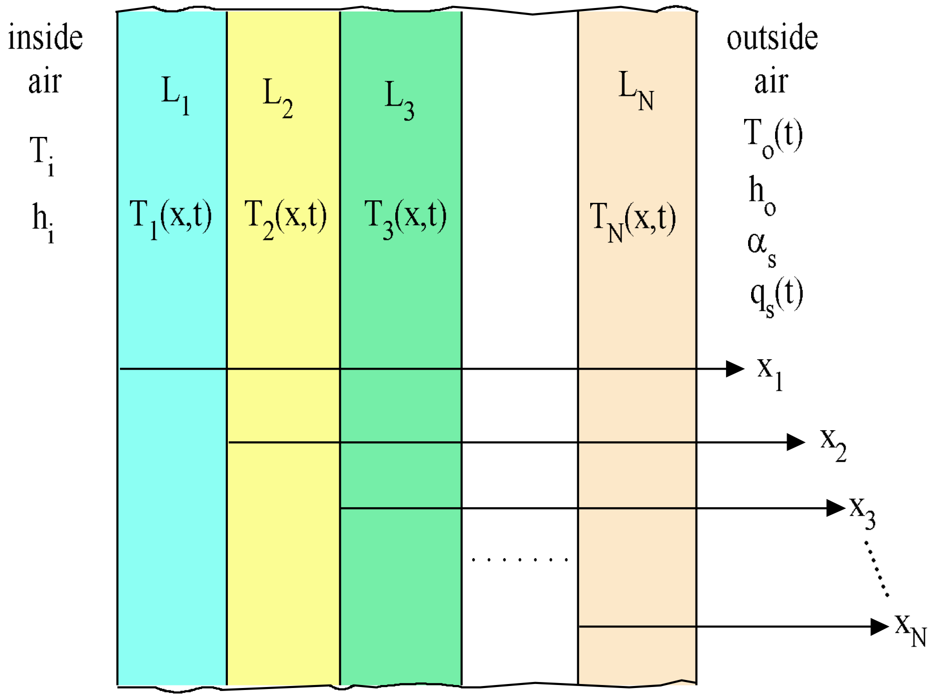

Figure 3.1. Geometrical configuration of a multilayer wall

Under these assumptions, the transient heat flow through the building exterior walls can be expressed as functions of the TETD and overall heat transfer coefficient. Therefore, it is necessary to find the inside and outside surface temperature of the exterior walls. The temperatures can be found by solving the transient heat transfer problem for the composite walls. The transient periodic heat transfer problem can be defined as partial differential equation, boundary and periodic conditions,

$$\frac{\partial^2 T}{\partial X_n^2} = \frac{1}{\alpha_n}\frac{\partial T_n}{\partial t} \quad , \quad 1 \le n \le N \tag{3.1}$$

where α_n is the thermal diffusivity ($k_n/\rho_n c_n$) and the subscript n refers to the layer, i.e., n=1,2,…N. Two boundary conditions at the inside and outside surfaces can be expressed as

$$h_i(T_i - T_1) = -k_1\frac{\partial T_1}{\partial x_1} \quad , \quad at \quad x_1 = 0 \tag{3.2}$$

$$-k_N \frac{\partial T_N}{\partial x_N} = h_o\left[T_N - T_o(t)\right] - \alpha_s I_T(t) \ , \quad at \quad x_N = L_N \tag{3.3}$$

where k_n is the thermal conductivity of *nth* layer, h_i and h_o are the combined heat transfer coefficients at the inner and outer surfaces. In Eq. (3.3), I_T and α_s are solar radiation flux on the walls and solar absorptivity of the outer wall surface. In order to solve the differential equation, it is necessary to give additional conditions since the periodic solution is independent of the initial temperature distribution. These conditions are given as

$$-k_{n-1} \frac{\partial T_{n-1}}{\partial x_{n-1}}\left(x_{n-1} = L_{n-1}\right) = -k_n \frac{\partial T_n}{\partial x_n}\left(x_n = 0\right) \ , \ for \ \ 2 \le n \le N \tag{3.4}$$

$$T\left(x_{n-1} - L_{n-1}\right) = T\left(x_n = 0\right) \quad , \quad for \quad 2 \le n \le N \tag{3.5}$$

The problem formulation consisting of Eqs. (3.1)-(3.5) is converted into dimensionless form by introducing dimensionless variables and periodicity condition $T_n(x_n, t) = T_n(x_n, t+p)$, which are presented in Yumrutaş et. al. [4]. The following Complex Finite Fourier Transform (CFFT) is applied to the dimensionless formulation of the problem.

$$T_n(z_n, \tau) = \sum_{j=-M}^{M} T_{nj}(z_n) e^{i\omega_j \tau} \quad , \quad \omega_j = 2\pi j \tag{3.6}$$

$$T_{nj} = \int_{-1/2}^{1/2} T_n e^{-iw_j \tau} d\tau \quad , \quad \omega_j = 2\pi j \tag{3.7}$$

The transform take the following form for j=0,

$$T_{no} = \int_{-1/2}^{1/2} T_n d\tau \tag{3.8}$$

The transformed problem is then solved, and the solution is given in Yumrutaş et. al. [4] in detail. The detailed solution is not presented in this paper again. The solution is presented in the following two expressions.

$$T_{no} = A_n z_n + B_n \qquad , \quad for \quad j = 0 \tag{3.9}$$

$$T_{nj} = C_{nj} sinh(\gamma_{nj} z_n) + D_{nj} cosh(\gamma_{nj} z_n) \qquad , \quad for \quad j \neq 0 \tag{3.10}$$

In Eq.(9)-(10), A_n, B_n, C_{nj} and D_{nj} are constants, γ_{nj} and z_n are variables and dimensionless distance, respectively. They are all given in Yumrutaş et. al. [4]. When the solution given in Eqs. (3.9)-(3.10) are inserted in the inverse transform of the CFFT, general closed solution of the problem for finding hourly temperature variation of the wall is then obtained.

$$T_n(z_n, \tau) = \sum_{j=-M}^{M} T_{nj}(z_n) e^{i\omega_j \tau} \qquad , \quad \omega_j = 2\pi j \tag{3.11}$$

3.3. Hourly Solar Radiatıon Flux on Exterior Wall Surface

Solar radiation flux on the wall is required to find TETD values and heat gain of any space. Because the TETD value of a wall depends on sol-air temperature which is a function of solar radiation flux $I_T(t)$ presented in Eq.(3.26). The $I_T(t)$ is the hourly total solar radiation incident on the wall surfaces. It is computed using hourly measured solar radiation on a horizontal surface which were measured by meteorological station in Gaziantep in Turkey from 1997 to 2007.

Theoretical upper limit of solar radiation available at the earth surfaces is called as the extraterrestrial radiation. In other words, the extraterrestrial radiation is the solar radiation incident outside the earth's atmosphere. The radiation emitted by the sun and its spatial relationship to the earth result in a nearly fixed intensity of solar radiation outside of the earth's atmosphere. The solar constant, G_{sc} , is the energy from the sun, per unit time, received on a unit area of surface perpendicular to the direction of propagation of radiation, at mean earth sun distance, outside of the atmosphere. The extraterrestrial radiation depends on earth-sun distance and varies 3% throughout the year. The dependence of extraterrestrial radiation on time of the year is indicated by the following

$$G_{on} = G_{sc}(1 + 0.033\cos\frac{360n}{365}) \tag{3.12}$$

where G_{on} is the extraterrestrial radiation measured on the plane normal to the radiation on the *n*th day of the year. The solar radiation received from the sun without having been scattered by the atmosphere is called beam radiation which is direct solar radiation. Diffuse radiation defined as the solar radiation received from the sun after its direction has been changed by scattering by atmosphere. The beam and diffuse radiation are required to calculate the hourly radiation on a tilted surface from the measurements of solar radiation on a horizontal surface.

To describe the position of the sun in local standard time, one needs to know the relationship between solar time and local standard time. Local time is the same in the entire time zone whereas solar time relates to the position of the sun with respect to the observer. Local Standard Time (LST) is equal to clock time in the winter but it changes in the summer. Because the clock time is typically shifted by one hour in the summer to provide for Daylight Savings Time. Solar time is the time based on the apparent angular motion of the sun across the sky, with solar noon being the time the sun crosses the meridian of the observer. It is not the same as clock time. Solar time is related to standard time and it is represented as follow

$$solartime - standardtime = 4(L_{st} - L_{loc}) + E \tag{3.13}$$

where L_{st} is the standard meridian for the local time zone, L_{loc} is the longitude of the location and E(in minutes) is the equation of time. As the earth moves around the sun, solar time changes slightly with respect to local standard time. This time difference is called the equation of time(E) which is determined by following

$$E = 229.2(0.000075 + 0.001868\cos B - 0.032077\sin B - 0.014615\cos 2B - 0.04089\sin 2B) \tag{3.14}$$

where B is the function of day of the year, n, and it is given

$$B = (n - 1)\frac{360}{365} \qquad (3.15)$$

Declination angle, δ, is an angle made by the line joining the center of the sun and the earth with its projection on the equatorial plane, north positive. The range of declination angle is given by -23,45≤ δ ≤ 24,45. The declination angle can be given by a sinusoidal variation at the intervening periods of the year

$$\delta = 23.45 sin(360\frac{284+n}{365}) \qquad (3.16)$$

Hour angle, ω, is angular displacement of the sun east or west of the local meridian due to rotation of the earth on its axis at 15° per hour. The hour angle is measured in the plane of the "apparent" orbit of the sun as it moves across the sky. Since the earth rotates approximately once every 24 hours, the hour angle changes by 15 degrees per hour and moves through 360 degrees over the day. Typically, the hour angle is defined to be zero at solar noon, when the sun is highest in the sky. It takes negative value at morning and positive value at afternoon. It can be expressed by

$$\omega = 15(t-12) \qquad (3.17)$$

Angle of incidence, θ, is the angle between the beam radiation on a surface and the normal of that surface. It can be given by the relation

$$\begin{aligned} Cos\theta = {} & \sin\delta\sin\varphi\cos\beta - \sin\delta\cos\varphi\sin\beta\cos\gamma + \cos\delta\cos\varphi\cos\beta\cos\omega \\ & + \cos\delta\sin\varphi\sin\beta\cos\gamma\cos\omega + \cos\delta\sin\beta\sin\gamma\sin\omega \end{aligned} \qquad (3.18)$$

where latitude, ø, is the angular position of the sun at solar noon and surface azimuth angle,γ, is the angle made in the horizontal plane between the line due south and projection of the normal to the surface on the horizontal plane. The slope of the surface, β, is the angle between the plane of the surface and the horizontal.

Zenith angle, θz, is the angle between the beam radiation and normal of earth surface. Therefore, for horizontal surfaces, the incidence angle is equal to the zenith angle of the sun. for this situation slope angle, $\beta=0$, and then the equation above becomes as

$$Cos\theta_z = \cos\varphi\cos\delta\cos\omega + \sin\varphi\sin\delta \tag{3.19}$$

The geometric factor R_b, is the ratio of beam radiation on the tilted surface to that on a horizontal surface at any time. It can be given by

$$R_b = \frac{Cos\theta}{Cos\theta_z} = \frac{\cos(\phi-\beta)\cos\delta\cos\omega + \sin(\phi-\beta)\sin\delta}{\cos\phi\cos\delta\cos\omega + \sin\phi\sin\delta} \tag{3.20}$$

The extraterrestrial radiation on a horizontal surface for an hour period is calculated for a period between hour angles ω_1 and ω_2 which define an hour (ω_2 is the larger) and it can be expressed as

$$I_o = 12\frac{3600}{\pi}G_{SC}\left[1+0.033\cos\left(360\frac{n}{365}\right)\right](\cos(\phi)\cos(\delta)[\sin(\omega_2)-\sin(\omega_1)]+ 2\pi\left(\frac{\omega_2-\omega_1}{360}\right)\sin(\phi)\sin(\delta)) \tag{3.21}$$

The ratio of hourly radiation on a horizontal surface to hourly extraterrestrial radiation is called the hourly clearness index, k_T, which is expressed as

$$k_T = \frac{I}{I_o} \tag{3.22}$$

The ratio of hourly diffuse radiation on a horizontal plane to that of total hourly radiation on horizontal plane is correlated for different range of clearness index and it is represented by the following equation

$$\frac{I_d}{I} = \begin{cases} 1-0.09k_T\,; k_T \le 0.22 \\ 0.9511-0.16k_T + 4.388k_T{}^2 - 16.638k_T{}^3 + 12.336k_T{}^4\,; 0.22 \le 0.8 \\ 0.165; k_T > 0.8 \end{cases} \tag{3.23}$$

Beam radiation is defined by

$$I_b = I - I_d \tag{3.24}$$

The hourly solar radiation on a tilted surface is given by considering the radiation to be made up of three components which are beam, diffuse and solar radiation diffusely reflected from the ground. The hourly total solar radiation on tilted surface, I_T, for an hour is the summation of these three components

$$I_T = I_{bT} + I_{dT} + I_{rT} \tag{3.25}$$

The hourly total solar radiation on the tilted surface is given in Duffie and Beckman,1980; Liu and Jordon,1961 [66,67]

$$I_T = I_b R_b + I_d\left(\frac{1+\cos\beta}{2}\right) + I\rho_g\left(\frac{1-\cos\beta}{2}\right) \tag{3.26}$$

where, ρ_g is the ground reflectance and is usually taken as 0.2.

3.4. Heat Gain From A Building Exterior Wall

The heat gain through walls, floor, and ceiling will vary with the following factors; which are construction, type of wall and insulation, thickness of wall and insulation, outside wall area and temperature difference between the space and ambient air. In other words, heat gain of an indoor space of a building from exterior walls is functions of inner surface temperatures of structure, inside room air temperature and convection heat transfer coefficient. The inner surface temperature of the structures changes with time which is function of solar radiation on the structures, outdoor air temperature, the indoor conditions, and thermophysical properties of the wall materials. Accordingly, the TETD value includes both conduction heat gain due to the temperature difference between the indoor and the outdoor environment and the effect of solar radiation on opaque external surfaces. In this study, the TETD method is used in order to calculate heat gain through a wall. The heat gain of an indoor space of a building from exterior walls can be calculated by multiplying overall heat transfer coefficient (U) and Total Equivalent Temperature Difference (TETD) values of the wall [8]

$$q = U(TETD) \tag{3.27}$$

The overall heat transfer coefficient, U for a typical external wall is given by

$$U = \frac{1}{R_i + \sum_{n=1}^{N} R_{nw} + R_o} \tag{3.28}$$

where R_i and R_o are the inside and outside air film thermal resistances, respectively, R_{nw} is thermal resistance of the n'th layer of wall.

The TETD value for any surface at any time is obtained by [62]

$$TETD = t_{ea} - t_i + (DF)(t_{eTL} - t_{ea}) \tag{3.29}$$

where t_i is inside air temperature, t_{ea} is daily average sol-air temperature and t_{eTL} is sol-air temperature time lag hours ago. The sol-air temperature is that temperature of the outdoor air which, in the absence of all radiation exchanges, would give the same rate of heat entry into the surface as would exist with the actual combination of incident solar radiation, radiant energy exchange with the sky and other outdoor surroundings, and convective heat exchange with the outdoor air. The sol-air temperature, t_e , is expressed as follows

$$t_e = T_o + \frac{\alpha_s I_T}{h_o} - \frac{\varepsilon \Delta R}{h_o} \tag{3.30}$$

where, T_o is the outside air temperature, and α_s is absorptivity of the wall. Parameters used in Eq.(3.30) for horizontal surfaces that receive long-wave radiation from the sky only, the appropriate value of ΔR is about 63 W/m2, so that if ε=1 and h_o≡17W/(m2K), the long-wave correction term is about -3.9 ^oC. In Eq. (3.30), the ΔR is taken zero for vertical surfaces. In Eq.(3.30), I_T is solar radiation on the wall surface, and its calculation procedure is given in section 3.3.

The TETD given by Eq.(3.29) is functions of time lag(TL) and decrement factor(DF). The time lag and decrement factor are very important characteristics to determine the heat storage capabilities of any material. Depending on the thermophysical properties and thickness of the wall material, different time lags and decrement factors can be obtained. Walls with high time lags and small decrement factors give comfortable inside temperatures even if the outside is very hot [63]. By designing special walls in which decrement factors are very low and time lags are high, the propagation of the inside can be prevented and almost constant inside temperatures can be obtained, which results good comfort level [64-65].The schematic representation of TL and DF are shown in Fig.3.2. In this study, the TL and DF values are calculated from the following equations :

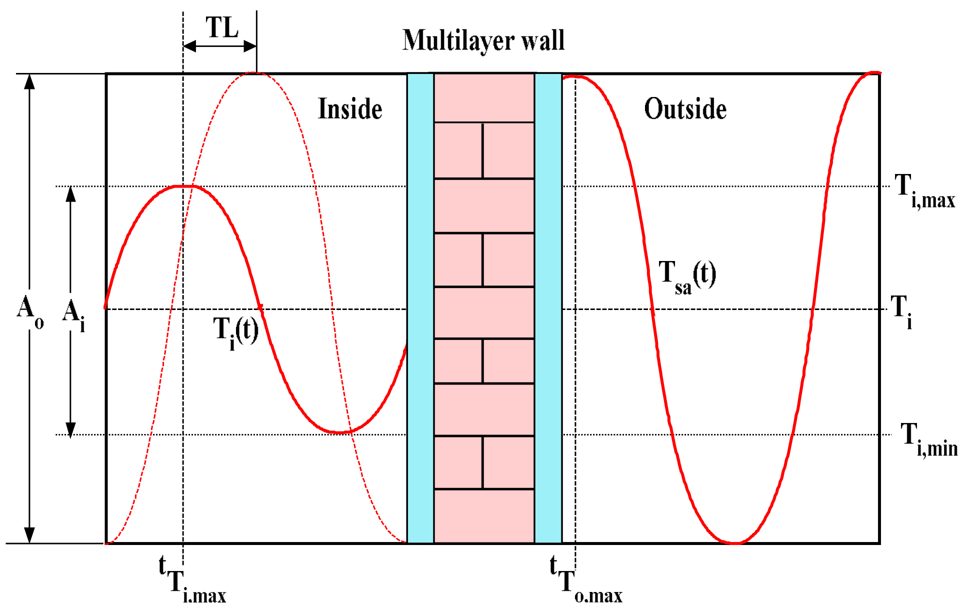

Fig.3.2. Schematic representation of time lag (TL) and decrement factor (DF)

$$TL = t_{T_{i,\max}} - t_{T_{o,\max}} \tag{3.31}$$

$$DF = \frac{A_i}{A_o} = \frac{T_{i,\max} - T_{i,\min}}{T_{o,\max} - T_{o,\min}} \tag{3.32}$$

where, $t_{To,max}$, $t_{Ti,max}$ express the times when interior and exterior surface temperatures are at their maximums, respectively. Also, $T_{i,max}$, $T_{i,min}$, $T_{o,max}$ and $T_{o,min}$ are the minimum and maximum temperatures on both of the interior and exterior surfaces, respectively.

3.5. The Interior And Exterior Surface Temperatures

Since purpose of the paper is to find seasonal heat gain from external building walls by total equivalent temperature difference (TETD) method, seasonal TETD values for commonly used for walls in Gaziantep, Turkey, will be obtained. The TETD values are defined as functions of temperature variation at the inside and outside surface of the external walls. Therefore, it is necessary to find these temperatures of the external walls.

As it is seen in the Eqs. (3.31)-(3.32), time lag (TL) and decrement factor (DF) are given as functions of minimum and maximum temperatures at the inside and outside surface of the external wall, and time period to reach these temperatures. For that reason, temperature variation in the wall is given in Eq. (3.11) will be used to find these temperatures. A procedure for finding temperature variation at the inside and outside surfaces of the exterior walls will be given in this section.

Temperature variation with respect to time at the inside surface of the exterior wall may be obtained by inserting layer number, n=1 and dimensionless distance, z1=0 into Eq.(3.11).

$$T_1(0,\tau) = \sum_{j=-M}^{M} T_{1j}(0) e^{i\omega_j \tau} \quad , \quad \omega_j = 2\pi j \tag{3.33}$$

where $T_{1j}(0)$ is transformed temperature of the inside surface

$$T_{1o}(0) = B_1 \qquad , \qquad j = 0 \tag{3.34}$$

$$T_{1j}(0) = D_{1j} \qquad , \qquad j \neq 0 \tag{3.35}$$

The derivative of Eq.(3.33) is set equal to zero in order to find the highest and the lowest temperatures and the period can be determined from

$$\frac{\partial T_1(0,\tau)}{\partial \tau} = 0 = \sum_{j=-M}^{M} T_{1j}(0)\,(i\omega_j)\,e^{i\omega_j \tau} \qquad , \quad \omega_j = 2\pi j \tag{3.36}$$

when Eqs.(3.34) and (3.35) are inserted into Eq.(3.36) the following equation is found

$$B_1 + \sum_{j=-M}^{M} D_{1j}\left[-sin(2\pi j\tau) + icos(2\pi j\tau)\right] = 0 \tag{3.37}$$

where B_1 and D_{1j} are constants and given in Yumrutaş et. al. [4], τ' s are periods of dimensionless time. It is a value corresponding j=0 ; D_{1j} for j≠1. Roots of the Eq.(3.37) give the periods of time at which the highest and lowest temperatures take place. The highest and the lowest temperatures, and the time period can be obtained when they are inserted in the Eq. (3.37).

It is necessary to find the highest and the lowest temperatures and the time for the exterior surfaces. Therefore, the procedure given above for the interior surfaces will be applied. When N is inserted into the solution Eq. (3.11) for layer number of N and dimensionless distances of z_N=1, temperature distribution for the exterior wall surface is obtained as;

$$T_N(1,\tau) = \sum_{j=-M}^{M} T_N(1)e^{i\omega_j \tau} \qquad , \qquad \omega_j = 2\pi j \tag{3.38}$$

When the temperature distribution Eq.(3.38) is derivated and equated to zero, and constants given from Yumrutaş et al.[1,61] are inserted into that equation, the following equation can be obtained.

$$A_N + B_N + \sum_{j=-M}^{M} \left[C_{Nj} sinh(\gamma_{Nj}) + D_{Nj} cosh(\gamma_{Nj}) \right] \left[-sin(2\pi j \tau) + icos(2\pi j \tau) \right] \omega_j = 0 \quad (3.39)$$

where A_N, B_N, C_{Nj}, and D_{Nj} are constants given in Yumrutaş et. al. [4]. The time periods for reaching the highest and lowest temperatures at the surfaces are obtained using these constants. If the obtained time is inserted into Eq.(3.38), the highest and the lowest temperatures can be determined.

CHAPTER 4

ECONOMICAL ANALYSIS

4.1. Introduction

The objective of this chapter is to calculate the optimum insulation thicknesses of external walls and insulation layer of buildings during cooling season based on cooling loads. The cooling loads, calculated by using measured long-term meteorological data for Gaziantep, are used as inputs to a life-cycle cost analysis in order to determine the optimum thickness of the external wall and insulation layer. The life-cycle cost analysis is applied by using the TETD method. The life cycle cost analysis which consists of life-cycle total costs and life-cycle savings, is often applied to energy technologies and building projects. The calculation of life-cycle cost analysis includes the change in interest and inflation that directly affect the cost of wall and insulation materials and electric. This chapter consists of three sections which are;

- This first section includes calculation of heat gain through external walls with insulation or not.
- In the second section, the cooling energy consumptions of external walls is presented.
- The last one contains the economic analysis which computes the total cooling cost over the lifetime of the building.

4.2. Heat Gain From External Walls

Energy consumption of buildings for heating or cooling is high in buildings Turkey, especially in the hot climate zone. Heat gains at buildings mostly occur from external walls, windows, ceiling, floor, and air infiltration. The air infiltration is not affected by external wall construction while heat gains through external walls. Also, heat gain reduces with increasing resistance or decreasing conductance.

The calculation of optimum thickness of external wall and insulation layer include heat gains from external walls. The external walls of building are affected by three heat transfer mechanisms which are conduction, convection, and radiation. The outer surface of wall absorbs the solar radiation and transmits it into the inner surface of building by conduction. At the same time, convective thermal transmissions occur between ambient air and the outer surface of wall, also between the inner surface of the wall and indoor air.

Yearly cooling loads are calculated based on TETD method above-described in chapter 3. Hourly variation of heat gain for a given external wall and a given wall orientation is calculated over a 24h period to obtain total load. The procedure is repeated for each day of cooling season in order to get annual cooling load per square meter of the wall surface.

The heat gain from a unit area of external wall is given by

$$q = U\,(\,TETD\,) \tag{4.1}$$

where, U is the overall heat transfer coefficient, TETD is total equivalent temperature difference which is described in chapter 3.

The overall heat transfer coefficient, U_{un} , for a typical wall with no insulation is expressed as

$$U_{un} = \frac{1}{R_i + R_w + R_o} \tag{4.2}$$

where R_i and R_o are the inside and outside air-film thermal resistances, respectively. R_w is total thermal resistance of the composite wall materials excluding the insulation layer resistance. These are given by the following equations

$$R_i = \frac{1}{h_i} \tag{4.3}$$

$$R_o = \frac{1}{h_o} \tag{4.4}$$

$$R_w = \frac{x_1}{k_1} + \frac{x_2}{k_2} + ... + \frac{x_n}{k_n} \tag{4.5}$$

where $h_i \equiv 9W/(m^2K)$ and $h_o \equiv 17W(m^2K)$ are combined convection and radiation heat transfer coefficient of inside and outside, respectively. x_n and k_n are thickness and thermal conductivity of the composite wall materials.

The overall heat transfer coefficient, U_{ins} , for a typical wall that includes a layer of insulation is given by

$$U_{ins} = \frac{1}{R_i + R_w + R_{ins} + R_o} \tag{4.6}$$

where R_{ins} is the thermal resistance of the insulation layer, which is

$$R_{ins} = \frac{x}{k} \tag{4.7}$$

where x and k are the thickness and conductivity of the insulation material, respectively.

The difference between U_{un} and U_{ins} can be written as

$$\Delta U = U_{un} - U_{ins} = \frac{1}{R_i + R_w + R_o} - \frac{1}{R_i + R_w + R_{ins} + R_o} \tag{4.8}$$

4.3. Cooling Energy Consumptions of External Walls

Energy consumption is one of the most important problems of modern life. In some countries like Turkey which imports most of their energy, energy saving and the effective usage of energy has become much more important every passing day. Large amounts of energy are consumed by buildings. Energy consumption for cooling purpose increases because air-conditioning is the major energy consumer in the buildings. Therefore, recently, electric energy consumption, used for air-conditioning loads, has been reached its maximum level during summer days. Any reduction in this energy requirement can be achieved by using optimum external wall and insulation thickness.

The heat gains during cooling seasons, calculated by using measured long-term meteorological data for Gaziantep, are used as inputs in order to determine energy consumptions of external walls.

The annual energy requirement per unit area can be calculated by dividing the annual heat gain to COP

$$E_A = \frac{q}{COP} = \frac{U\,(TETD)}{COP} \tag{4.9}$$

where U is the overall heat transfer coefficient which is given in section 4.3.2. TETD is the annual total equivalent temperature difference during cooling season which is described in chapter 3. COP is coefficient of performance of cooling system.

The annual amount of the energy expended for cooling without insulation is expressed as

$$E_{A\,un} = \frac{q_{un}}{COP} = \frac{U_{un}\,(TETD)}{COP} \tag{4.10}$$

The annual amount of the energy expended for cooling with insulation is represented by

$$E_{A\,ins} = \frac{q_{ins}}{COP} = \frac{U_{ins}\,(TETD)}{COP} \tag{4.11}$$

4.4. Economic Analysis

The use of optimum external wall and insulation thickness reduces the air-conditioning load and, thus, the cooling energy cost in summer. However, increasing external wall and insulation thickness causes increasing the initial cost of the construction. Therefore, an economic analysis should be performed in order to estimate the optimum external wall and insulation thickness which minimizes the total cost including the external wall, insulation and the energy consumption costs. The optimum thickness of external wall and insulation depends on the electricity tariff as well as the cost of external wall and insulation material, lifetime of the building, inflation and discount rate, and coefficient of performance of the air-conditioner.

The economical analysis which is calculated based on the estimated cooling loads can be carried out by using life-cycle-cost analysis. The life-cycle-cost analysis which computes a present value of the energy consumption cost over the lifetime of the building by accounting for the effects of the inflation rate (rise in costs) and the discount rate (value of money) over this period.

In order to obtain a present value of the cost of energy consumption over a lifetime of n years, a factor which is called present worth factor, PWF, is used. The present worth factor, PWF, is function of the inflation rate (d), and the interest rate(i). According to the interest and inflation rates, the present worth factor, PWF, is the defined as below

$$PWF = \sum_{j=1}^{N} \frac{(1+i)^{j-1}}{(1+d)^{j}} = \begin{cases} \dfrac{1}{(d-i)}\left[1-\left(\dfrac{1+i}{1+d}\right)^{N}\right] & \text{if } i \neq d \\[2ex] \dfrac{N}{1+i} & \text{if } i = d \end{cases} \tag{4.12}$$

4.4.1. The Life-Cycle Cost of Building without Insulation and Optimum External Wall Thickness

The actual value of annual energy consumption cost per unit area over a lifetime of N years without insulation, is obtained by multiplying the annual consumption of energy, calculated per unit area in section4.3, by electricity cost C_E , by present worth factor(PWF)

$$Energy\ Cost = \left(\frac{q}{COP}\right) * C_E * PWF \qquad (4.13)$$

$$Energy\ Cost = \left(\frac{U_{un} * TETD}{COP}\right) * C_E * PWF \qquad (4.14)$$

The wall cost per unit area can be calculated by the following equation

$$Wall\ Cost = C_w * x_w \qquad (4.15)$$

where C_w is the price of wall material ($\$/m^3$), and x_w is the thickness of wall (m).

As a result, the life-cycle total cost (LCT) of the building without insulation is given by the following equation

$$Total\ Cost = Energy\ cost + Wall\ cost \qquad (4.16)$$

$$Total\ Cost = \left(\frac{U_{un} * TETD}{COP}\right) * C_E * PWF + C_w * x_w \qquad (4.17)$$

The optimum thickness of external wall can be determined by minimizing the life-cycle total cost of building. In other words, the optimum thickness of external wall is obtained mathematically by taking the derivative of the life-cycle total cost of building function with respect to x_w and setting it equal to zero :

$$\frac{\partial(Totalcost)}{\partial(x_w)} = \frac{\partial U_{un}}{\partial x_w} \frac{TETD \ * C_E * PWF}{COP} \ + \ C_w * \frac{\partial x_w}{\partial x_w} \tag{4.18}$$

so that optimum thickness of external wall is obtained by

$$x_{wall-opt} = \left(\frac{PWF * C_E * TETD * k_w}{C_w * COP} \right)^{1/2} - \left(\frac{1}{R_i + R_o} \right) * k_w \tag{4.19}$$

4.4.2. The Life-Cycle Cost of Building with Insulation and Optimum Insulation Thickness

The insulation cost per unit area can be calculated by the following equation

$$C_{ins} = C_i \ * x_{ins} \tag{4.20}$$

where C_i is the price of wall material (\$/m^3), and x_i is the thickness of wall (m).

The life-cycle total cost (LCT) of the building with insulation is given by the following

$$Total\ Cost = \ Energy\ cost \ + \ Insulation\ cost \tag{4.21}$$

$$Total\ Cost = \left(\frac{U_{ins} * TETD}{COP} \right) * C_E * PWF \ + \ C_i * x_{ins} \tag{4.22}$$

The optimum insulation thickness is obtained mathematically by taking the derivative of the life-cycle total cost of building function with respect to x_i and setting it equal to zero :

$$\frac{\partial(Totalcost)}{\partial(x_{ins})} = \frac{\partial U_{ins}}{\partial x_{ins}} \frac{TETD \ * C_E * PWF}{COP} \ + \ C_i * \frac{\partial x_{ins}}{\partial x_{ins}} \tag{4.23}$$

The optimum insulation thickness is obtained by

$$x_{ins-opt} = \left(\frac{PWF * C_E * TETD * k_w}{C_i * COP} \right)^{1/2} - \left(\frac{1}{R_i + R_w + R_o} \right) * k_{ins} \qquad (4.24)$$

Life-cycle saving (LCS) which is the difference between the saved energy cost over the lifetime and the insulation payout, is given by

$$Saving = \left(\frac{\Delta U * TETD}{COP} \right) * C_E * PWF - C_i * x_{ins} \qquad (4.25)$$

CHAPTER 5

COMPUTATIONAL PROCEDURE

5.1. Introduction

The purpose of this chapter is to represent the computation procedure of all of numerical calculations explained in chapters 3 and 4. A computer program was prepared in Fortran in order to carry out all of the numerical calculations which are the calculations of solar radiation flux, sol-air temperature, TETD and heat gain values and economical analysis. The program is based on two sections which are the periodic transient heat transfer problem for composite building walls and life-cycle cost analysis. The solution of the periodic heat transfer problem was given in Yumrutaş et. al. [4] , which is used to obtain TETD values for different types of walls and heat gains. The solution of the economical analysis was carried out by using life-cycle cost analysis. The program includes four types of wall commonly used in our country, four main directions and three different surface colors.

Some parameters are used as input parameters in this program. These parameters are hourly solar radiation flux on horizontal surface measured by meteorological stations, thermal and physical properties such as number and thickness of layers, density, specific heat, thermal conductivity and diffusivity, combined convection heat transfer coefficient for both sides of inside and outside air, hourly outside air temperature and inside design air temperature. All of these input parameters which are used in program are presented below in detail.

In this program, each calculation result was used as input parameter in order to calculate the other ones. Firstly, the solar radiation flux on tilted surface is calculated. Then the sol-air temperature is calculated by using the solar radiation flux as input parameter. After that, TETD value is obtained by using the sol-air temperature in order to obtain heat gain. Finally, the calculation of life-cycle cost analysis was carried out by using the heat gain. All of these calculations for a given wall and a given wall orientation and surface is calculated over a 24 hour period. The procedure is repeated for each day of cooling season in order to get annul cooling load per square meter of the wall surface and to obtain optimum external wall and insulation thickness. A simplified flowchart of program is shown in figure 5.1.

5.2. Building Materials

Thick building walls, reflective surface, glazing, curtains and trees near the building are cut down on the size of the air-conditioning system and energy requirement. Increasing external wall and insulation thickness reduces the energy consumption of the air-conditioning system. Using a good external wall and insulation material is regarded as one of the most effective means of energy conservation in buildings. The thermal resistance offered by external wall and insulation layer increases with increasing layer thickness hence decreasing thermal conductivity. In this study, the commonly used four different external wall materials are selected. These are briquette, brick, blockbims and autoclaved aerated concrete (AAC). The building structure consists of 2cm inner plaster, 2cm outer plaster, and selected external wall type and insulation material.

5.3. Thermophysical Characteristics of the Wall Materials

Thermal and physical properties are important for the all of calculations described in chapters 3 and 4. These are used as input parameters for the calculations. In order to obtain TETD values and heat gains for the commonly used walls of briquette, brick, blokbims, and AAC, it is necessary to know the thermal and physical properties which are thickness, conduction heat transfer coefficient, density and specific heat of the wall materials. Thermal and physical properties of the four wall materials used in this study are listed in Table 5.1.

Table 5.1. Thermophysical properties of wall materials

Wall types	Thermal conductivity k (W/m K)	Density ρ(kg/m^3)	Specific heat c (kJ/kg K)	Thermal Diffusivity α (m^2/s)
Briquette	0.920	1600	0.840	6.84 x10^{-7}
Brick	0.690	1580	0.840	5.20 x10^{-7}
Blokbims	0.230	770	0.835	3.57 x10^{-7}
AAC	0.150	400	1.047	3.58 x10^{-7}
Plaster	0.7	2778	0.840	2.99 x10^{-7}

5.4. Climatic Data

TETD values and heat gains from exterior walls are also functions of design and outdoor conditions, climatic data of hourly outside air temperatures and solar radiation flux on horizontal surface. The data affect the temperature and heat gain variations of the structures. The temperature variations and heat gain are functions of climatic conditions. The climatic data are the two of the most important factors. Therefore, it is necessary to know the design conditions and climatic data.

The inside air temperature is taken to be 25ºC. Combined heat transfer coefficients at the inner and outer surfaces are taken to be 9 and 17 W/m^2, respectively. In order to calculate the hourly solar radiation flux on any wall surface and hourly outside air temperatures, 10 years long term hourly measured outside air temperatures and solar radiation flux data on horizontal surface are used. The measured outside air temperatures are used in the calculation of the sol-air temperature. These 10 years long term measured data were taken from the local meteorological stations located in Gaziantep.

5.5. Solar Absorptivity

Absorptivity of a building wall is another important parameter. Because absorbed solar energy depends on the absorptivity constant. The different colors absorb different amounts of solar energy. Therefore each color has a different absorptivity constant. In this study, dark, black, green, brown, white, light and gray colored walls are used. Their absorptivity constants, α_s , are taken as 0.884, 0.85, 0.80, 0.75, 0.48, 0.442 and 0.663, respectively.

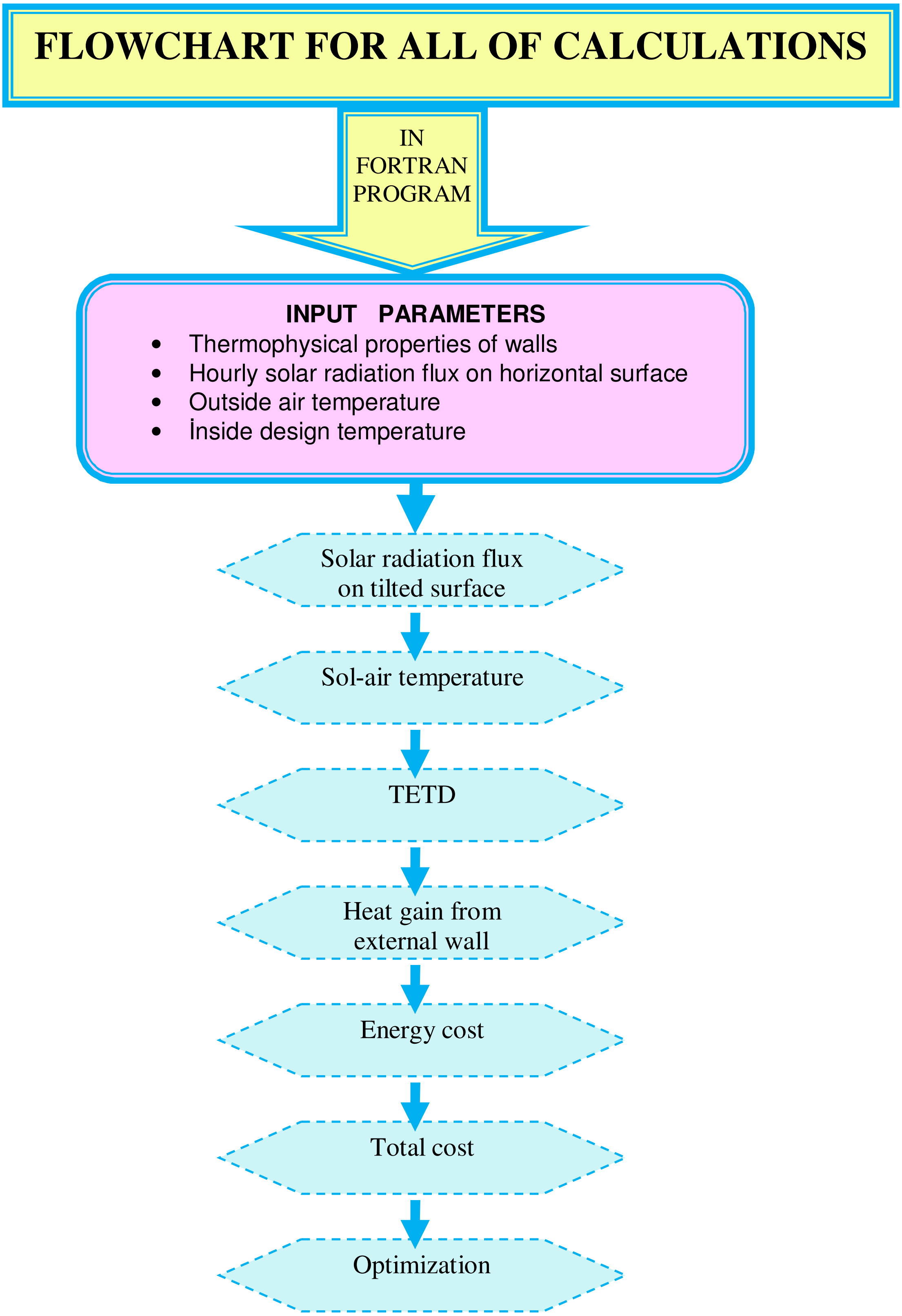

Figure 5.1. Simplified flowchart of program

CHAPTER 6

RESULTS AND DISCUSSIONS

6.1. Introduction

This chapter describes the results of the calculations of the cooling load and economy. The cooling load calculations were carried out using the TETD method. The heat gain from building walls was calculated hour by hour during cooling season and then the annual cooling load was obtained. The results of cooling load calculations were used as input parameters in order to obtain the calculations of economical analysis. The economical analysis was based on the life-cycle cost analysis. Finally, the life-cycle total cost (LCT) of the building with insulation or no insulation and the optimum thickness of external wall were obtained. In this study, dark, gray, light colored walls and four different type walls were used. All of these calculations are performed by preparing a computer program in Fortran. The computation procedure of this program was described in detail in chapter 5.

6.2. Comparison of TETD Results with Other Study

In this study, the cooling load calculations were calculated by using the TETD method. In this section, the calculated results of TETD values were compared with a study in Kaşka et. al.[61]. The mean values of hourly outside air temperature and solar radiation on horizontal surface for 23 July which are main data in order to obtain TETD values are given in Fig.6.1 for the city of Gaziantep in Turkey.

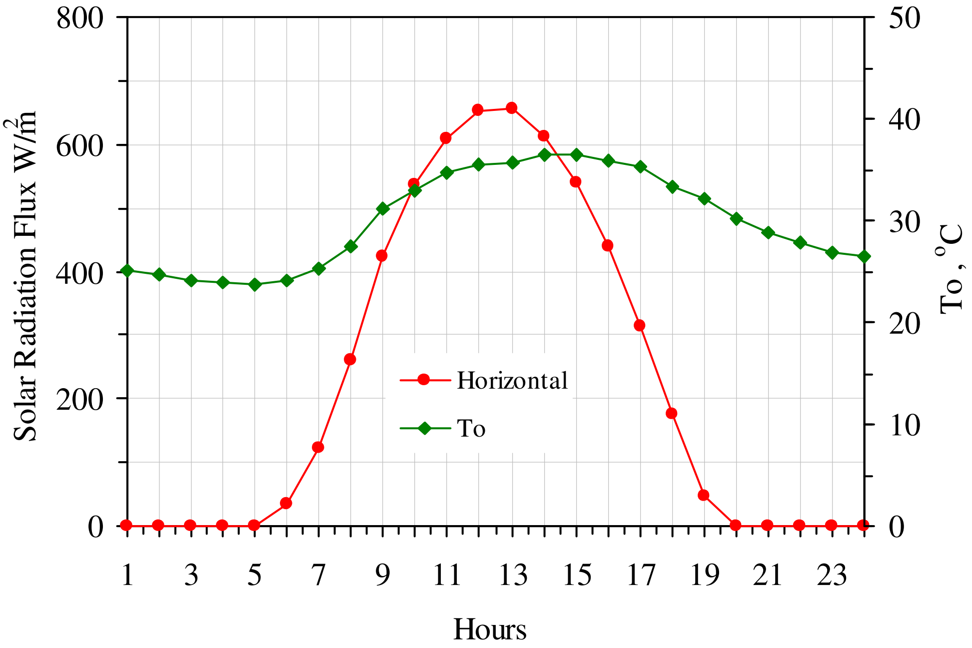

Fig.6.1. Measured values of solar radiation on horizontal surface and outside air temperature for 23 July

Firstly, the solar radiation flux results of in this study and Kaşka at al.[61] for main directions were compared with each other. As the results of solar radiation flux in Kaşka et al.[61] are shown in Fig.6.2, the results of solar radiation flux in this study are shown in Fig.6.3. It is seen from the figures that approximately same results are obtained.

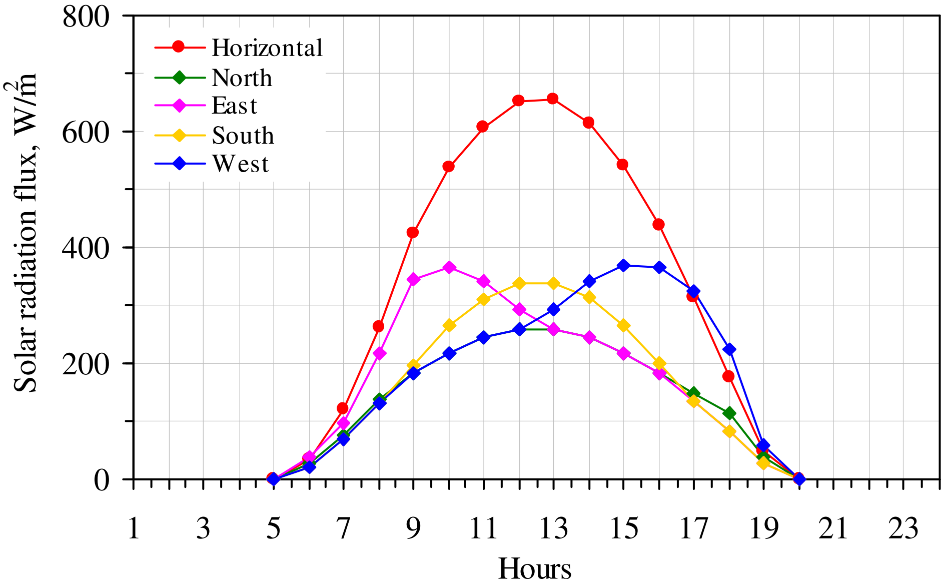

Fig.6.2. Mean values of hourly ambient air temperature and incident solar radiation flux in Kaşka et.al.[61]

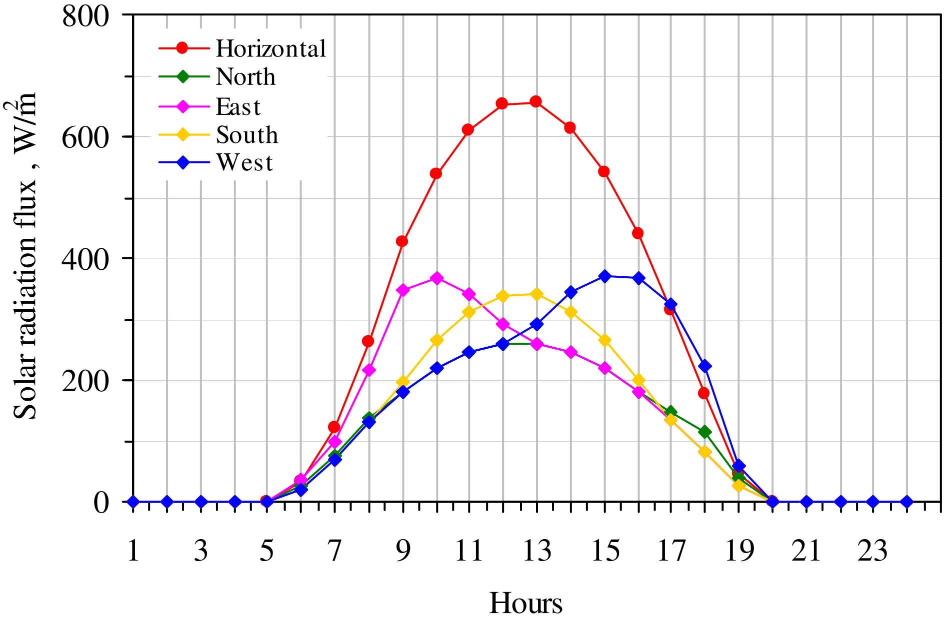

Fig.6.3. Incident solar radiation flux in this study

Then, the sol-air temperature results of gray color surface in this study and Kaşka et al.[61] were compared with each other. Fig.6.4 shows the sol-air temperature results in Kaşka et al.[61] and Fig.6.5 shows the sol-air temperature results in this study. Comparison of sol-air temperature results show that the sol-air temperature results of this study for main directions and the sol-air temperature results of Kaşka et al.[61] for main directions are approximately same.

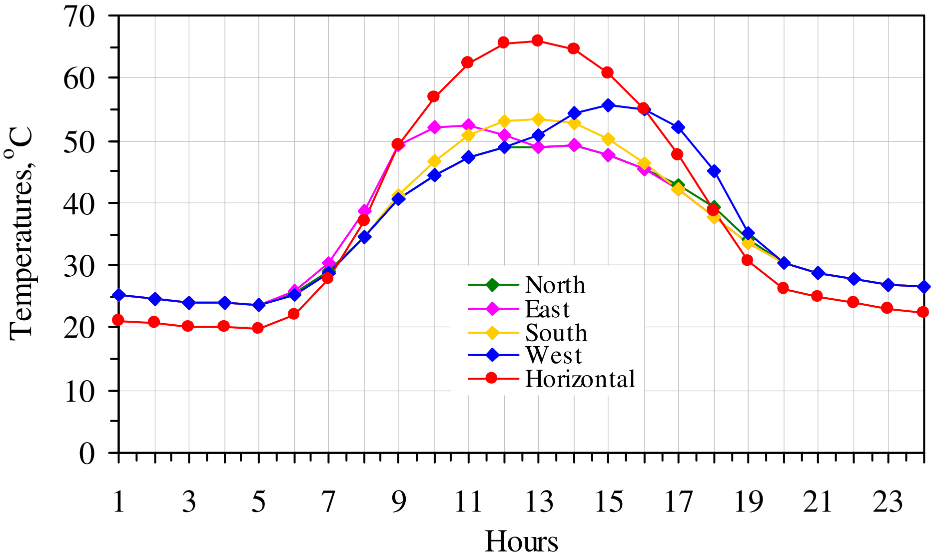

Fig.6.4. Hourly ambient air and sol-air temperatures for gray walls in Kaşka et.al.[61]

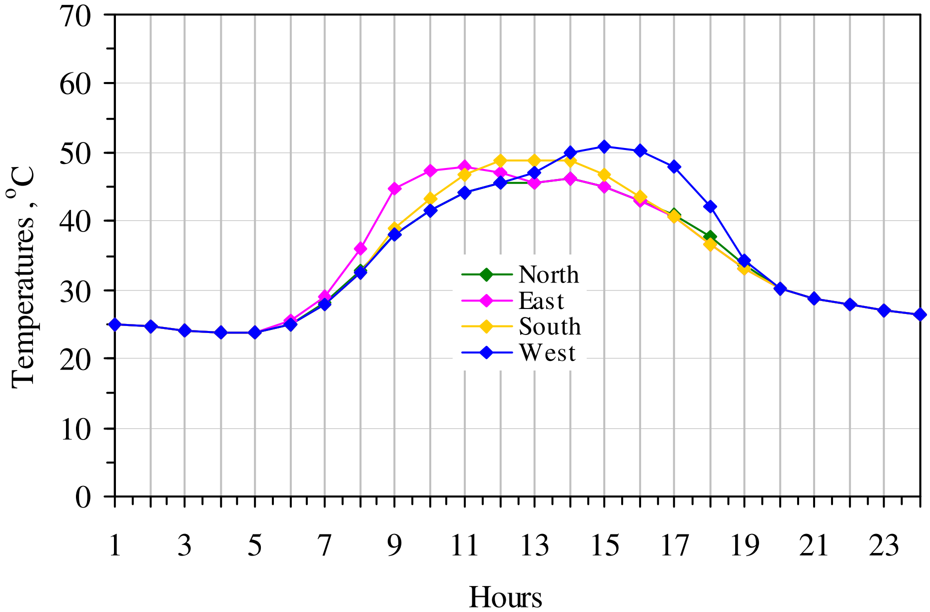

Fig.6.5. Hourly sol-air temperatures for gray walls in this study

Finaly, the TETD results are compared with each other. The theoretical results of TETD values of briquette wall in Kaşka et al.[61] are indicated in Fig.6.6 while the results of TETD values of briquette wall in this study are indicated in Fig.6.7. It is seen from figures that the results are approximately same.

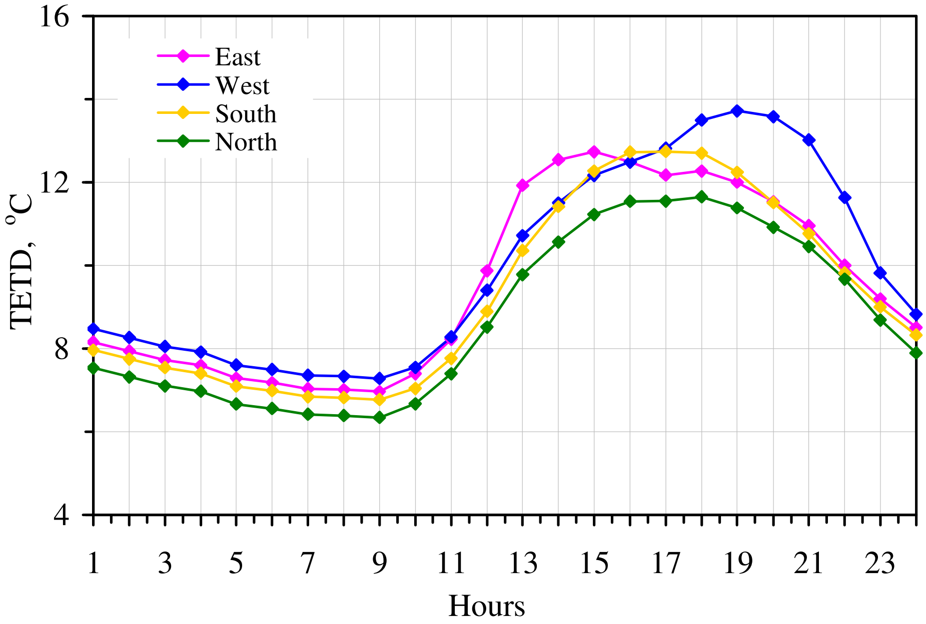

Fig.6.6. Theoretical and experimental values of TETD values of briquette wall for main directions in Kaşka et.al.[61]

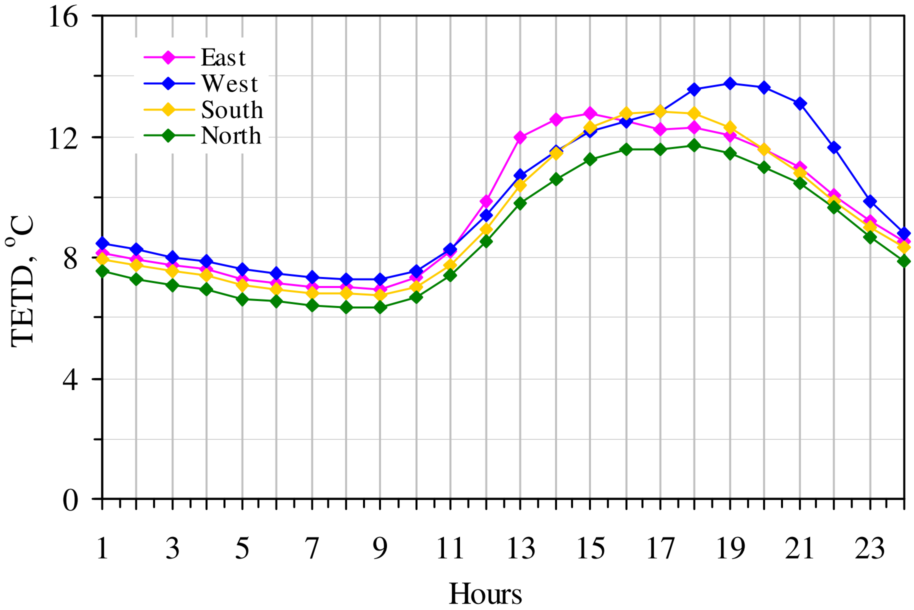

Fig.6.7. The TETD values of briquette wall for main directions in this study

6.3. Results for Heat Gain Calculations

In this study, a theoretical method is used to find total heat gain during cooling season by using Total Equivalent Temperature Difference (TETD) values of each building wall. The TETD values are computed by using an expression based on solution of one-dimensional transient heat transfer problem. The TETD values depending essentially on time lag (TL) decrement factor (DF) and sol-air temperature (Tsol-air). The sol-air temperature was calculated using a methodology given in Duffie and Beckman(1992). In order to obtain theoretical values of TETD for different types of walls, a computer program prepared in Fortran is used utilizing TL, DF and sol-air temperature. Four types of commonly used walls are selected, which are briquette, brick, blokbims, autoclaved aerated concentrate (AAC). Thickness of the plaster for both sides and walls, and design inside air temperature are taken as 2 cm, 20cm and 25°C for the base calculations unless they are defined. Schematic representation of these walls is shown in Fig.6.8. Values of the TL, and DF, Tsol-air and TETD values are obtained by using measured values of hourly solar radiation on horizontal surface and outside air temperatures. In order to obtain more reliable and realistic results for TETD values of walls, the hourly outside air temperatures and the solar radiation flux on horizontal surfaces which were measured by meteorological station in Gaziantep in Turkey from 1997 to 2007, are used. The mean values of hourly outside air temperature and solar radiation on horizontal surface for design day of 21 July are given in Fig.6.9 for the city of Gaziantep in Turkey. Daily average values of hourly outside air temperature and daily average total solar radiation on horizontal surface for cooling season are given in Fig.6.10 for the city of Gaziantep in Turkey.

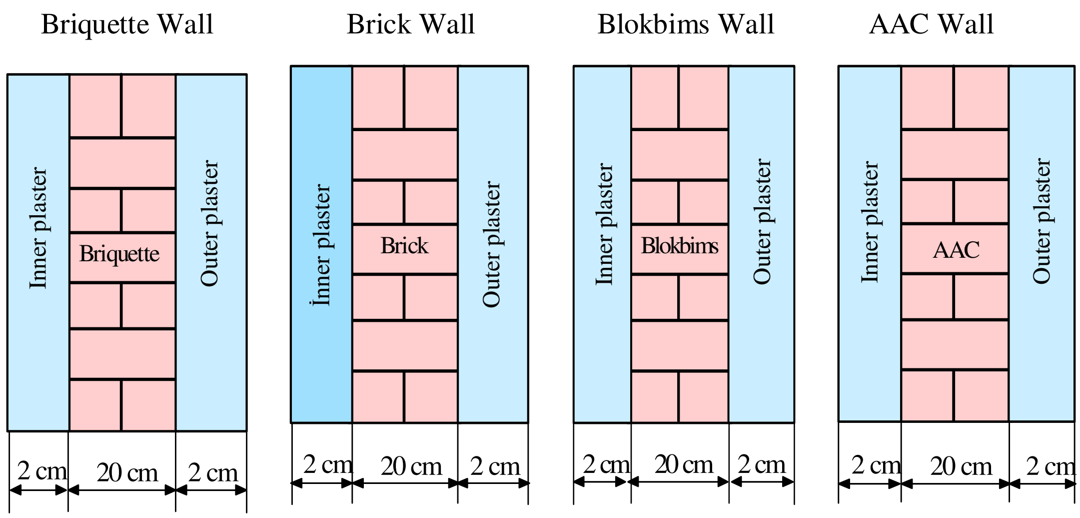

Fig.6.8. Schematic representation of these walls

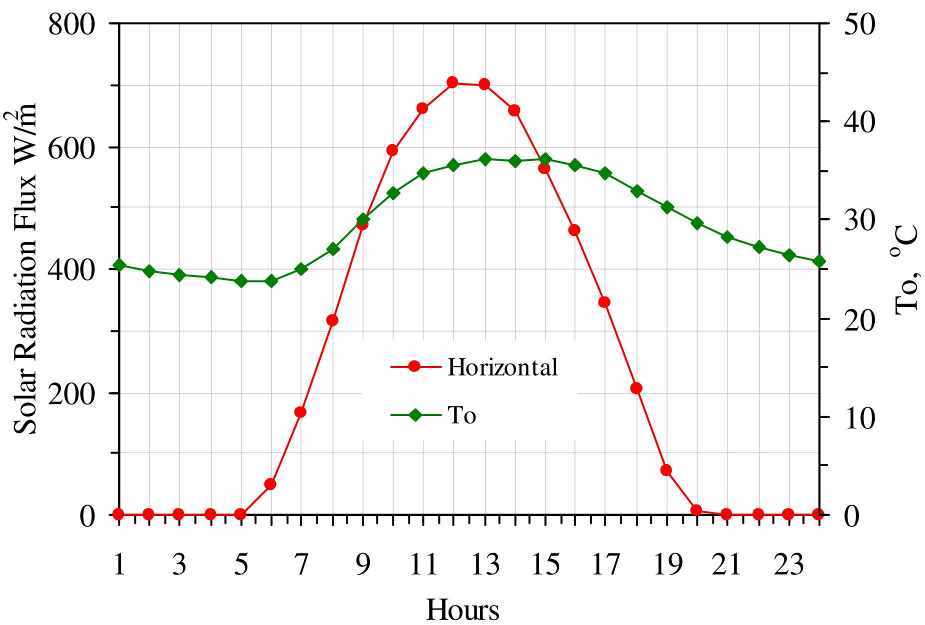

Fig.6.9. Measured values of solar radiation on horizontal surface and outside air temperature for design day of 21 July.

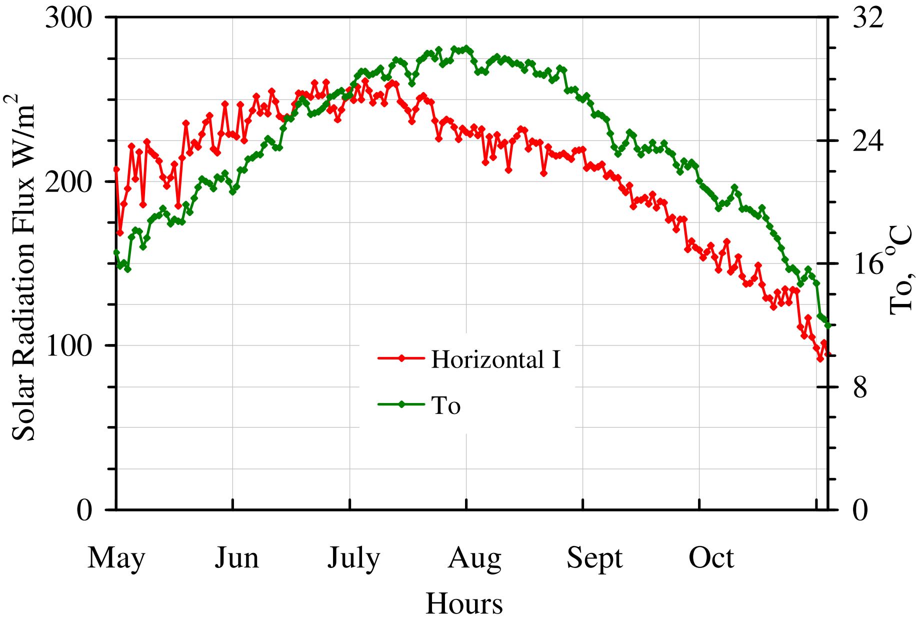

Fig.6.10. Measured values of daily average outside air temperature and total solar radiation on horizontal surface during cooling season

Values of the TL and DF for these walls with different thicknesses are given in Appendix C and Fig.6.11. It is seen from the table that the thickness of walls affect the values of TL and DF. The highest TL and the lowest DF are obtained by increasing wall thickness, and the lowest TL and the highest DF are obtained by decreasing wall thickness. As the TL increases for a wall, the DF decreases or vice versa. Different wall materials give different TL and DF, and thickness of the wall is very deterministic from the TL and DF point of view. The higher TL and the lower DF values give better comfort conditions for people.

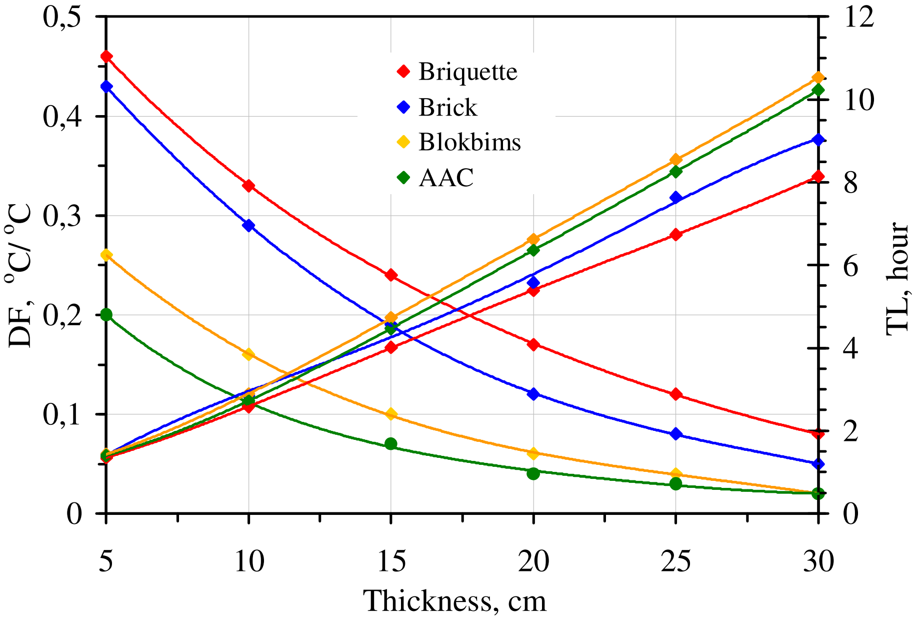

Fig.6.11. TL and DF values of the walls for different wall thicknesses

The results of hourly incident solar radiation flux on the walls change with direction of walls. Figure 6.12. indicates the hourly incident solar radiation flux on the walls for main directions for 21 July. The values of incident solar radiation flux for the south and north directions are seen as symmetric but they are not exactly symmetric for the east and west directions. The results which are compared and controlled with values in Kaşka[21]. The values of solar radiation flux on tilted surface during cooling season are shown in Fig.6.13. The values of minimum incident solar radiation flux on walls take place during October for all of the main directions whereas the maximums are obtained during July except south direction. Peak incident solar radiation flux on walls is obtained for west direction and during July. But, the total incident solar radiation flux values for the east direction are higher than those for west direction during cooling season. The results given in Fig.6.12 and Fig.6.13 are obtained using Liu and Jordon model.

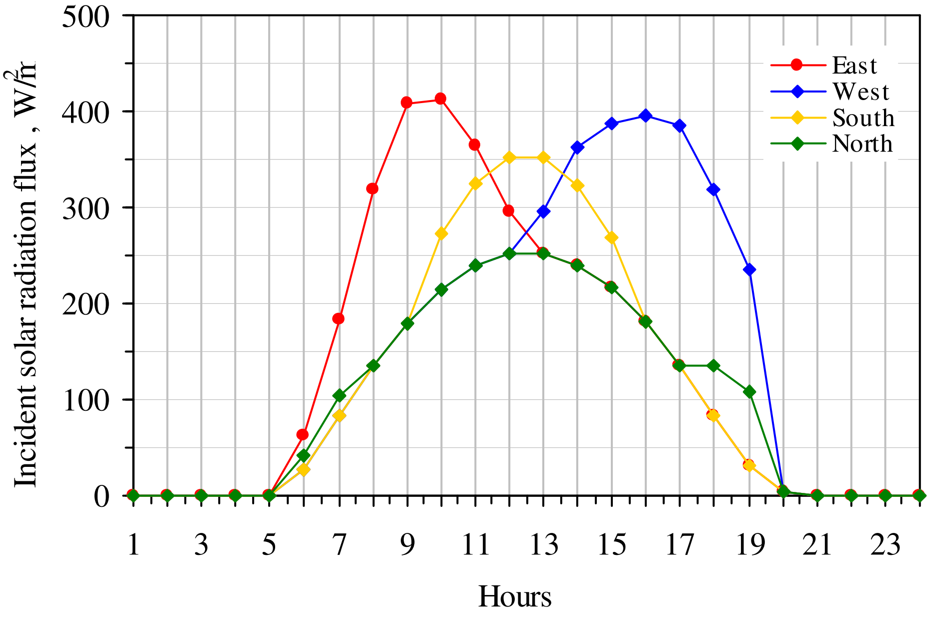

Fig.6.12. The values of hourly incident solar radiation flux for design day of 21 July .

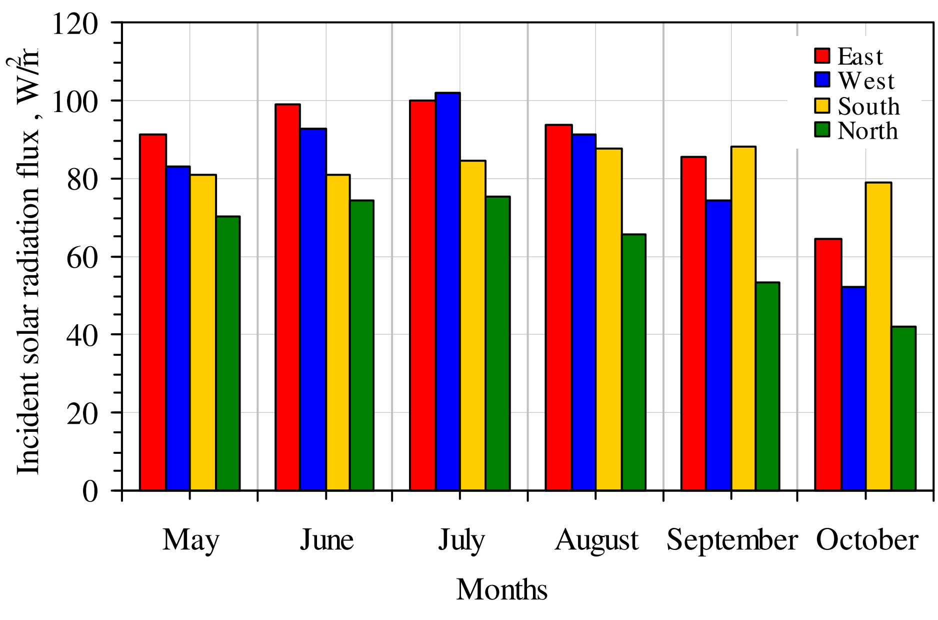

Fig.6.13 The values of solar radiation flux on tilted surfaces during cooling season

In order to find TETD values for the structures, the sol-air temperatures are calculated. The values of sol-air temperatures are affected by directions of walls and color of surfaces. Fig.6.14 shows that the hourly sol-air temperatures of gray surface walls for main directions for 21 July. The general form of Fig.6.14 is seen as similar to the Fig.6.12. But, the sol-air temperatures for west walls are higher than for the east walls. The reason of this difference is hourly outside air temperatures which have high values during afternoon hours. The highest value of sol-air temperature is obtained for west wall at 15pm. Fig.6.15 denotes the average sol-air temperatures of gray surface walls for main directions during cooling season. The highest average sol-air temperatures are obtained in July for all of main directions during cooling season. The sol-air temperatures in Fig.6.14 and Fig.6.15 are used for determining TETD values of walls.

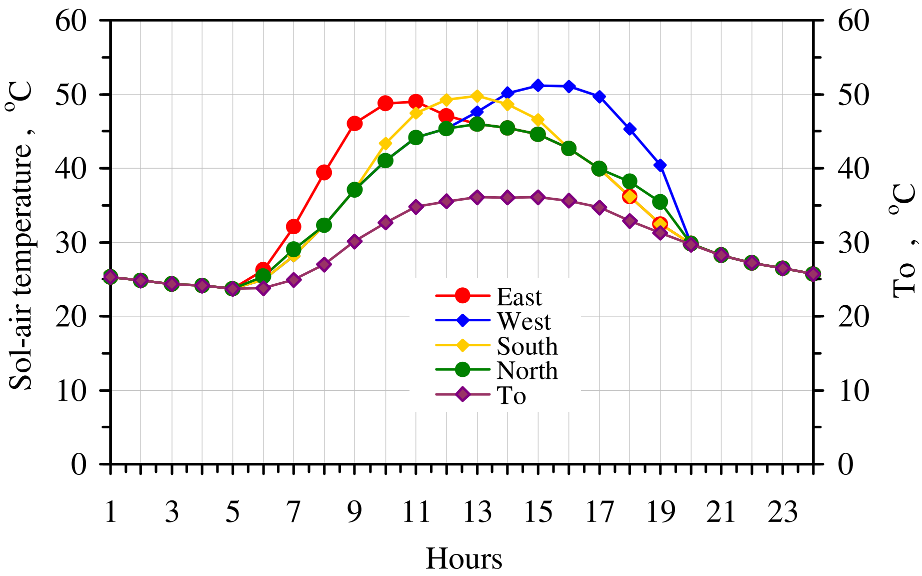

Fig.6.14 Hourly outside air and sol-air temperatures for gray surface for design day of 21 July .

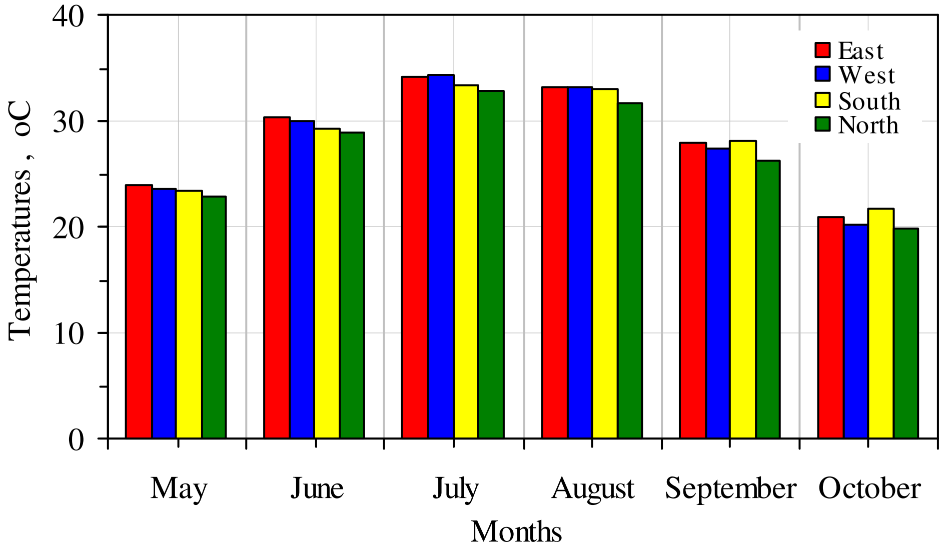

Fig.6.15 Average of sol-air temperatures for gray surface during cooling season

The direction and thickness of walls, color of surfaces and type of walls are important for the calculation of TETD values and heat gain. The hourly variation of the TETD values of blokbims wall for main directions is given in Fig.6.16. The heat gain is obtained by multiplying TETD values with overall heat transfer coefficient of wall, U. Therefore, these figures have the approximately same form. The hourly variation of the TETD values in Fig.6.16 is necessary to determine the highest heat gain through the wall. The highest TETD values give the highest heat gain through the walls. The lowest TETD values are obtained at the hour of 12 for all of main directions whereas the time of highest TETD values are different for each direction. When the lowest TETD value is obtained for the north wall with a value of 8.01°C, the highest TETD value is obtained for the west wall at hour of 22 with a value of 11.31°C. The highest TETD values take place at times 18, 20 and 20 for the east, south and north directions, respectively. At this time, the highest TETD values are obtained as 10.68°C, 10.05°C, 9.35°C. Because of TL whose value is 4.73, the highest TETD value occurs in later hours.

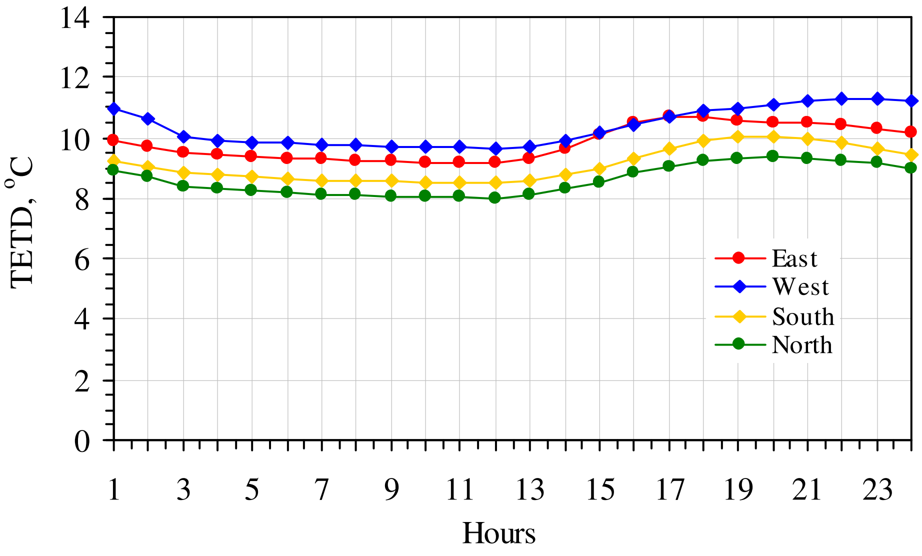

Fig.6.16. Hourly variation of TETD from gray colored blokbims wall for four main directions for design day of 21 July (20cm)

Monthly variation of heat gain from gray colored blokbims surface during cooling season with respect to four main directions are shown in Fig.6.17. The highest TETD values lead the highest heat gain. It is seen from the figure that the highest heat gain is obtained for the wall directed due to East during May, June, August and the lowest heat gain is obtained for the wall directed due to North. But, the highest heat gains for all directions are obtained during July, and also for the wall directed due to West during July. Effect of solar radiation flux is the highest during this month which is seen from the Fig.6.10. At the same time, maximum sol-air temperature and TETD value, which are a function of solar radiation, are obtained for the west direction.

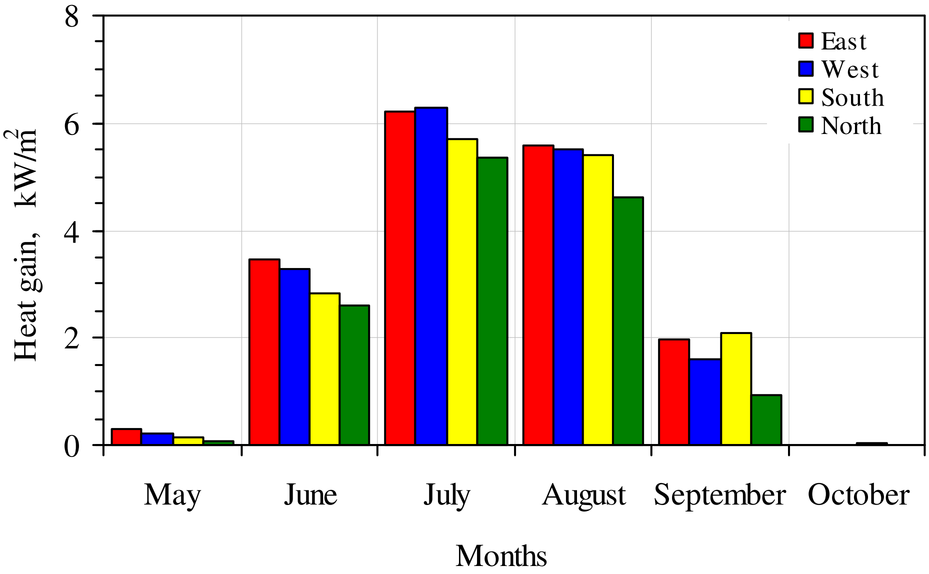

Fig.6.17. Monthly variation of heat gain from gray colored blokbims wall due to four main directions (20cm)

Effect of wall colors on heat gain for the blokbims wall with 20cm thickness due to south direction are indicated in Fig.6.18 and Fig.6.19. When Fig.6.18 shows the effect of absorptivity of wall surface on hourly heat gain, Fig.6.19 shows the effect of absorptivity of wall surface on total heat gain during cooling season. Fig.6.18 is considered, lower minimum heat gain through wall takes place during morning whereas higher maximum heat gain through wall takes place during afternoon which shows that the effect of solar radiation on external surface become more dominant than ambient air temperature as surface absorptivity increase. In Fig.6.19, therefore external walls absorb the most solar radiation in July with increasing surface absorptivity, the highest total heat gain takes place in July during cooling season. As a consequence of these figures, the total heat gain obtained from the highest to lowest one are black, green, brown, gray and light surface, respectively. The values of absorptivity of these surfaces, α_s , are taken as 0.884, 0.8, 0.75, 0.663 and 0.442, respectively. It is seen from the figures that, the solar energy transferred through the wall is directly related to the surface absorptivity, thus the absorptivity of the wall has profound effect on TETD and heat gain values. The absorptivity of the walls depend on the colors of the walls. The absorptivity of dark surfaces are higher than that of the light surfaces. The dark surfaces absorb more solar radiation than the light surfaces.

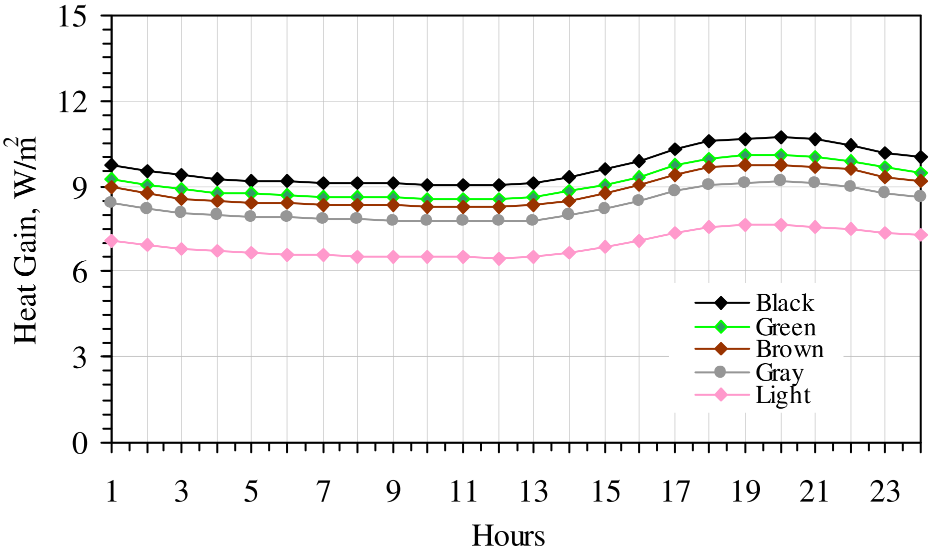

Fig.6.18. Hourly variation of heat gain from three different colored blokbims wall due to south direction for design day of 21 July .(20cm)

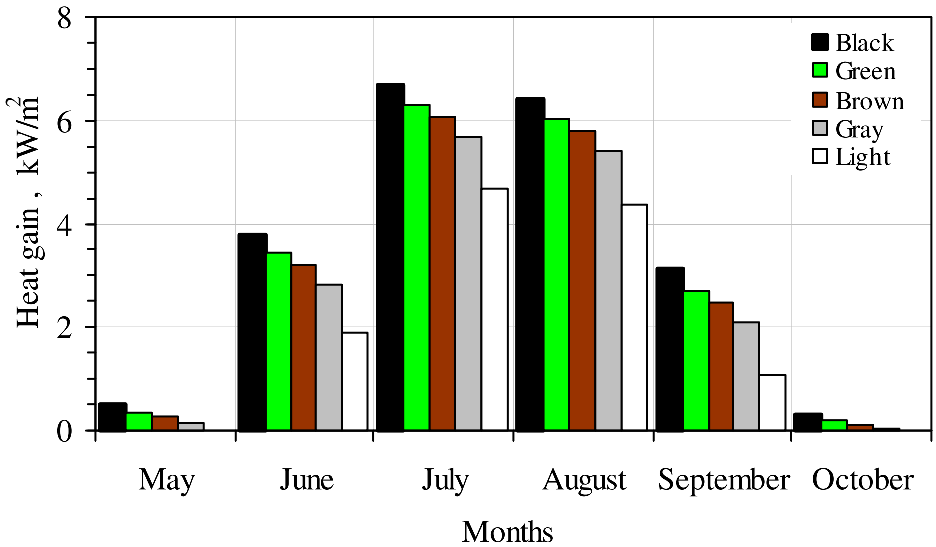

Fig.6.19. Effect of colors on total heat gain for the blockbims wall for South.(20cm)

All of these calculations which are solar radiation on tilted surfaces, sol-air temperature, TL and DF are expressed in order to find TETD values and heat gain during cooling season which are used to determine suitable building wall materials. For the purpose of determining the most suitable building wall material, four different types of walls which are briquette, brick, blokbims and AAC are selected since they are commonly used in building constructions in Turkey. Fig.6.20 and Fig.6.21 indicate daily variations of TETD and heat gain values for the walls of briquette, brick, blokbims and AAC during July 21. Minimum and maximum values of TETD and heat gain are obtained during morning and afternoon hours for all of wall types, respectively. While the lowest TETD value and heat gain take place at the hour of 11 for AAC wall with a value of 8.70 and 5.57W/m2 , respectively, the highest TETD value and heat gain take place at the hour of 18 for briquette wall with a value of 11.78 and 26.51W/m2 , respectively. The highest hourly variation in the TETD values and heat gain occur for the briquette wall and this is followed by brick, blokbims and AAC, respectively. Daily average values of TETD and consequently heat gains for both walls are close to each other. It is clear that cooling load of a building will be very high when exterior walls of the building are constructed by the briquette and brick. As a result, cooling capacity of the selected air conditioning system will increase, and also energy requirement and operation cost of the system will increase. It is desirable to use the minimum capacity provided that comfort conditions are satisfied.

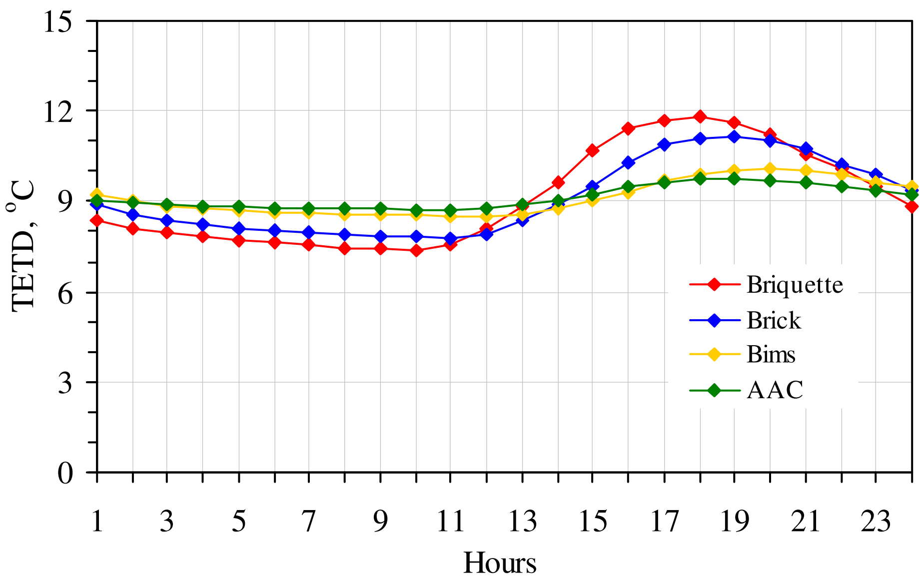

Fig.6.20. Hourly variation of TETD of four different walls for design day of 21 July.(20cm)

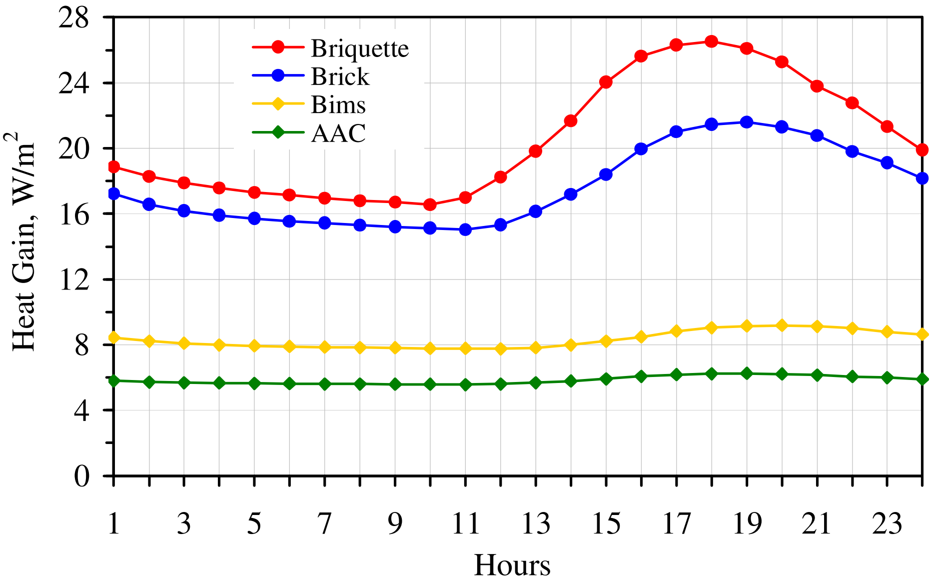

Fig.6.21. Hourly variation of heat gain of four different walls for design day of 21 July .(20cm)

Fig.6.22 and Fig.6.23 indicate hourly variations of TETD and heat gain values for the walls of briquette, brick, blokbims and AAC during cooling season. It is seen from the figures that briquette wall has the highest amplitude of the TETD and heat gain values, and this is followed by brick, blokbims and AAC, respectively. The amplitudes of the TETD values for the blokbims and AAC walls are very small, which indicate that daily variations of heat gain through these walls are very small. Reason of this condition is directly related to decrement factor and time lag. The amplitude is a function of decrement factor and time lag. As the decrement factor increases, respectively the time lag decreases. As a result, higher decrement factor gives lower time lag and higher TETD and heat gain amplitude. In consequence, blokbims and AAC walls give better comfort conditions than the others for people because it has minimum amplitude than the others.

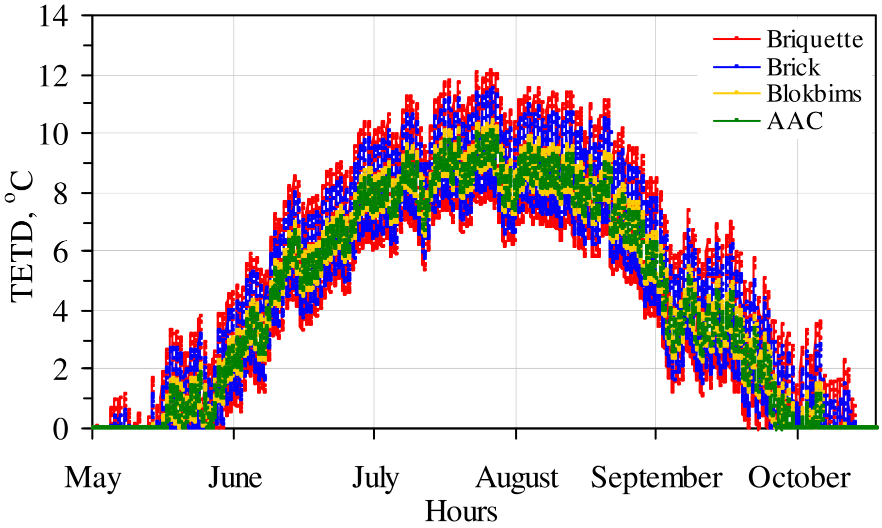

Fig.6.22. Hourly variation of TETD values gray surfaces for south direction for different wall during cooling season.(20cm)

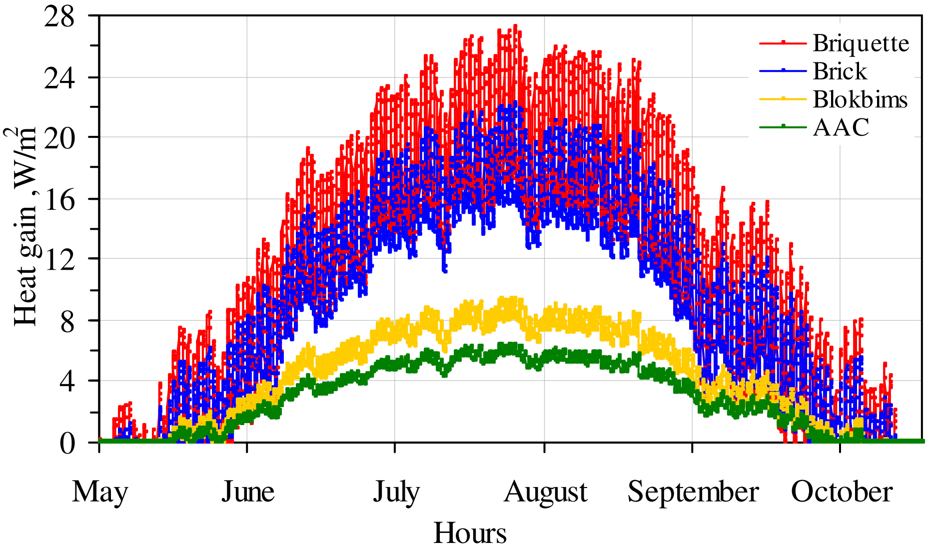

Fig.6.23. Hourly variation of heat gain of gray surfaces for south direction for different wall during cooling season.(20cm)

The thermophysical properties of wall materials which are conductivity, density, specific heat, heat capacitance and thermal diffusivity, are important factors to determine the TETD values and heat gain. The properties of the materials are measure of transient heat flow. In thermal behavior, thermal capacitance, which is the ability of a material to absorb and store heat later use, is the more effective parameter. Because the higher capacitance gives the higher TETD values and heat gain. Also the thermophysical properties of wall structures have a profound effect on decrement factor and time lag which effect TETD values and heat gain. Higher thermal resistance or lower thermal conductivity of structure gives higher time lag and lower decrement factor. The lower decrement factor results in lower TETD values and heat gain. It is seen from the Fig.6.21 and Fig.6.23 that cooling load due to wall decreases when the wall is constructed with AAC. Since, AAC wall has the smallest heat capacity and thermal conductivity. It is observed that the briquette wall has the highest heat capacity and thermal conductivity. If the cooling load increases, cooling capacity of the selected air conditioning will increase. Consequently, the use of walls having lower heat capacity and thermal conductivity leads to stable room temperature or comfortable condition in the room.

Another important thermal property is the thermal diffusivity of wall material which is a measure of transient heat flow. It affects directly diffusion of heat in a material. The thermal diffusivity is defined as It is defined as the thermal conductivity divided by the product of specific heat and density. Only thermal diffusivities are considered, the blokbims wall gives the lowest TETD values and heat gain since blokbims have the lowest thermal diffusivity value. It is seen from the Fig.6.21 and Fig.6.23 that heat gain of blokbims and AAC are close to each other. AAC is generally known construction material whereas the blokbims is not well known construction material. Blokbims are produced from local natural volcanic materials in Kayseri and Nevşehir cities located in central Anatolian region of Turkey. It is considered that formation of blokbims material is similar to the industrial production of the AAC. The cost of blokbims is lower than AAC. Because of its favorable thermal behavior, using blokbims in building constructions allow the use of smaller capacity air conditioning units.

Variation of seasonal heat gain values for gray colored briquette, brick, blokbims and AAC is indicated in Fig. 6.24. It is seen from the figure that the highest monthly variation in the heat gain and TETD values occur for the briquette wall and this is followed by brick, blokbims and AAC, respectively. While the highest heat gain is obtained for the briquette, the lowest heat gain through the walls is obtained for the AAC wall. Also the highest heat gains through briquette wall carry out in July during cooling season. Since the maximum effects of solar radiation flux on the wall are observed during July. Most of the buildings and houses are constructed with the briquette in Turkey. The briquette is an undesirable wall type. Since, it increases heating and cooling loads. It is known that capacity of an air-conditioning system increases with the cooling load. As the capacity increases, energy requirement and operation cost of the system increase.

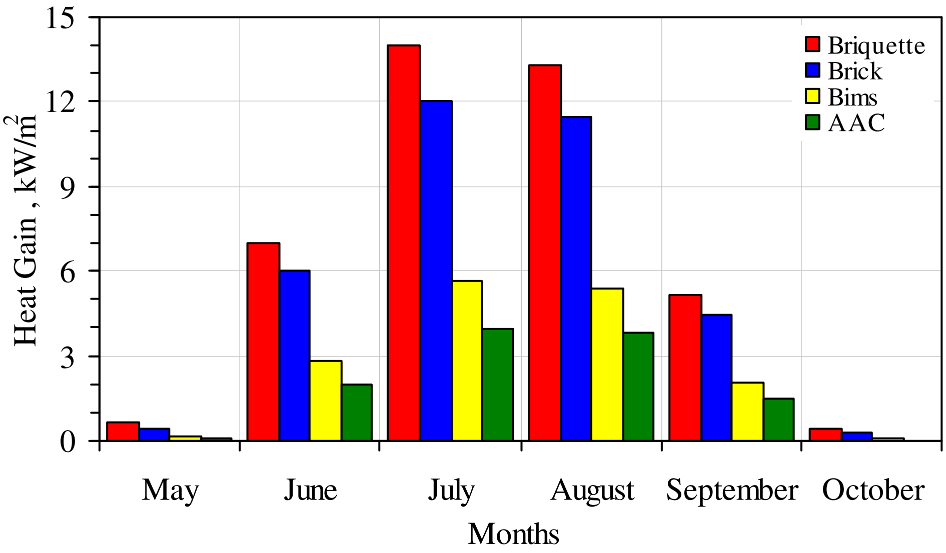

Fig.6.24. Variation of heat gain of four different walls during cooling months(20cm)

The thickness of wall materials has a profound effect on TETD values linked to heat gain which is depicted in Fig.6.25 and Fig.6.26. It is observed that the time of the highest TETD value and heat gain occurs in different hours depending on thickness of the wall material. The highest TETD value and heat gain are obtained with 5cm wall thickness. If the thickness of wall increases, the values of TETD and heat gain decrease. But, the cost of building construction increases with increasing thickness of material. There must be a limit in the thickness of wall material. Therefore, an economical analysis is required to determine the optimum wall thickness. Furthermore, the value of wall thickness affects the amplitude of TETD value and heat gain. The amplitude of TETD and heat gain decrease with increasing thickness of wall material. The lower amplitude gives better comfort conditions for people than the higher amplitude.

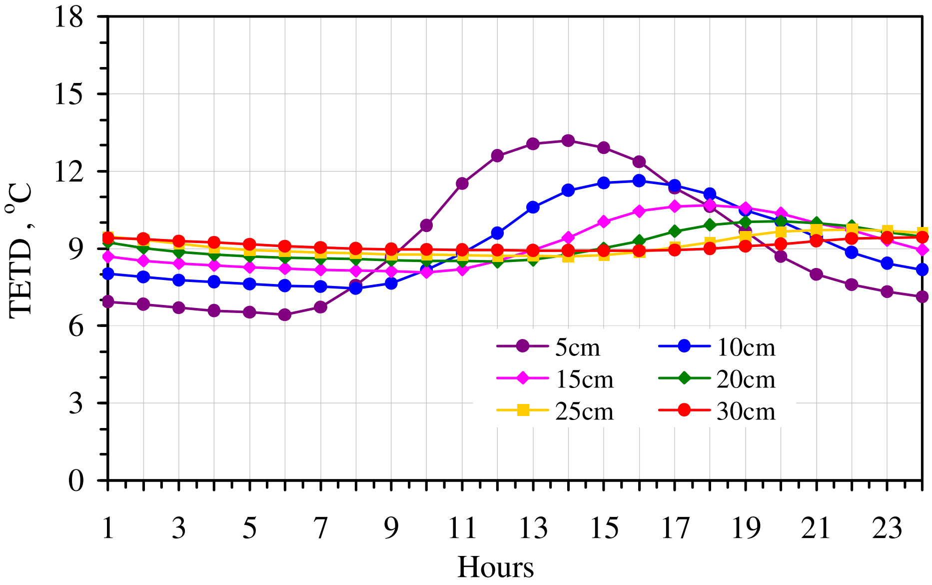

Fig.6.25. Hourly variation of TETD values of blokbims wall of gray surface due to south direction for different thicknesses for design day of 21.

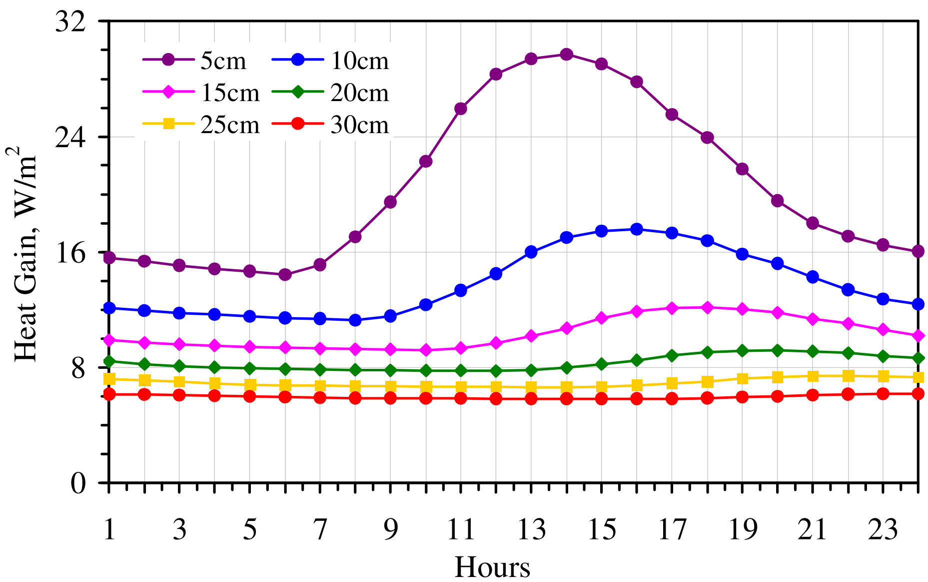

Fig.6.26. Hourly variation of heat gain of blokbims wall of gray surface due to south direction for different thicknesses for design day of 21.

Fig.6.27 is depicted for comparing the total heat gain with respect to wall thickness for gray colored walls of briquette, brick , blokbims and AAC during July. The value of highest heat gain during July is different for each wall depending on heat storage capabilities and thermophysical properties of the wall material. Heat capacity and thermal conductivity are the dominant properties. It is observed that the briquette wall has the highest heat capacity and thermal conductivity while AAC wall has the lowest heat capacity and thermal conductivity. The total heat gain for each wall decreases as the wall thickness increases. As the highest heat gain occurs for the briquette wall with minimum thickness, the lowest heat gain takes place for the AAC with maximum thickness. This figure gives an idea which one of thickness for the walls constructed with briquette or brick corresponds to the AAC or blokbims. It indicates that how much total heat gain with which wall thickness occurs for each walls. It is seen from the figure that amount of heat gain through the blokbims wall with a thickness of 5cm is equal to the same amount of heat gain through brick and briquette wall thickness of 15cm and 20cm , respectively. It is observed from the figure that blokbims gives approximate results with AAC. When it is used in building wall construction in Turkey, it provides stable temperature in the rooms and comfortable condition for the people living in the buildings. Also, size of air conditioner and initial operation costs of conditioner and building construction will decreased.

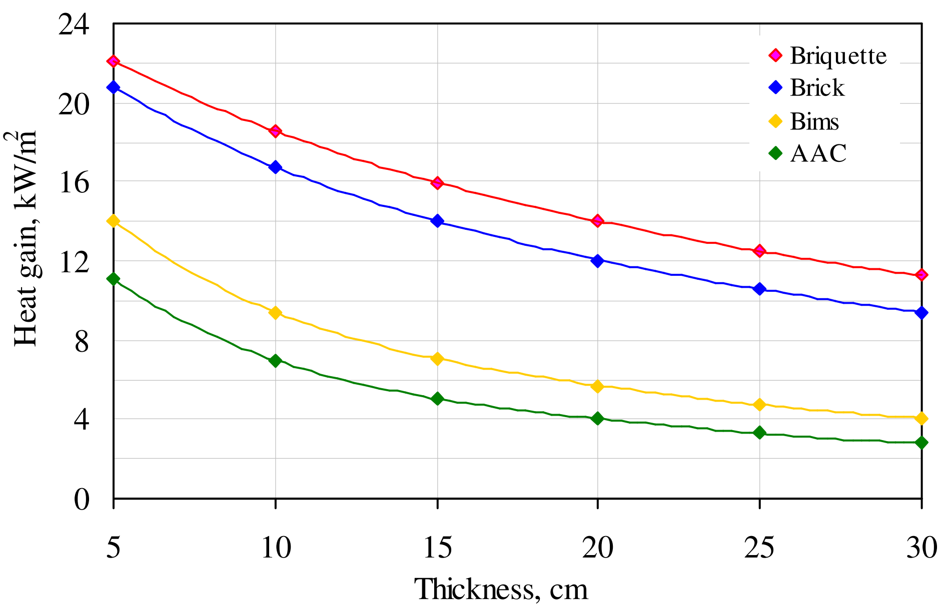

Fig.6.27. Variation of the highest heat gains with thickness for four south-facing wall constructions. (for July)

Fig.6.28 depicts the variation of the highest heat gains of four walls for three color surfaces due to south direction and Fig.6.29 indicates the variation of the highest heat gains of four walls for main directions and gray surface wall constructions during July. It is seen from the Fig. 6.28 that the highest difference between the surface colors takes place for briquette wall and it is followed by brick, blokbims and AAC, respectively. Figure 6.29 shows that the briquette wall has the highest heat gain difference between the directions of walls, while the AAC wall has the lowest heat gain difference between the directions of walls. Because all of the walls have the different thermal and physical properties which are heat capacity, thermal conductivity, thermal diffusivity, specific heat, density, layer thickness and number of layer. As the heat gain differences between briquette and brick are close to each other, the heat gain differences between blokbims and AAC are close to each other. The thermophysical properties of the blokbims and AAC are close to each other and the cost of blokbims is lower than AAC because of natural existence of its material in Turkey. As a consequence, the using of blokbims wall is more desirable than AAC in building construction. The using of briquette wall is undesirable because of increased heating and cooling loads. Increasing cooling load affects the air-conditioning system capacity. If the capacity increases, energy requirement and operation cost of system increase.

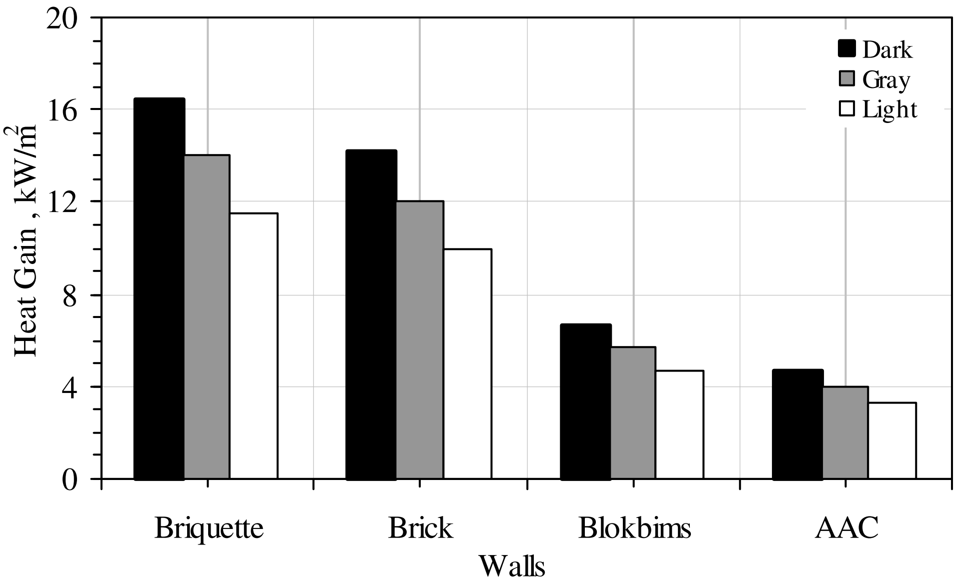

Fig.6.28. Variation of the highest heat gains of four walls for three color surfaces and south-facing wall constructions (for july-20cm)

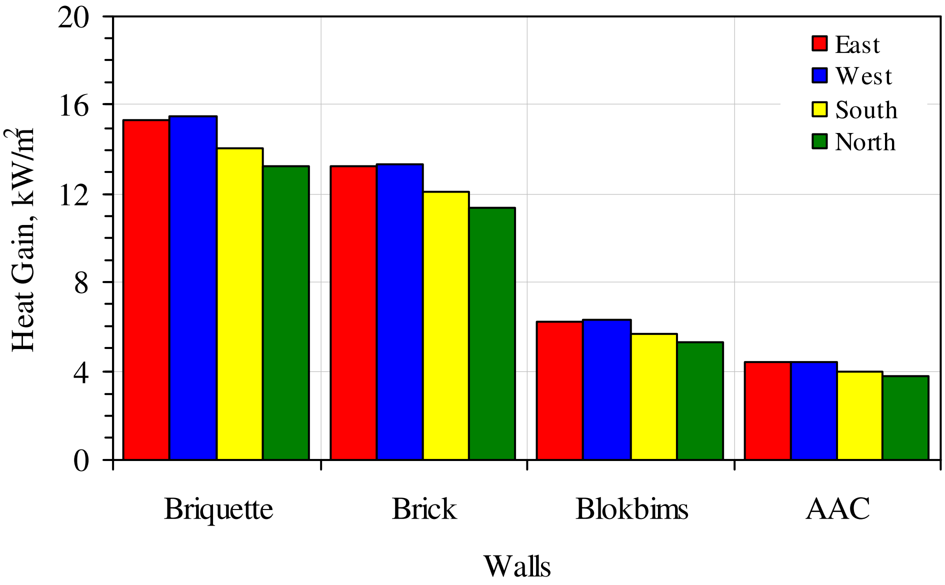

Fig.6.29. Variation of the highest heat gains of four walls for main directions and gray surface wall constructions (for july-20cm)

The inside design air temperature is another parameter in the calculation of cooling loads. Fig.6.30 is shows that the annual cooling heat gains of four different walls with 20cm thickness due to south direction with various Ti temperature for Gaziantep. The inside design air temperature is used in the calculation of TETD values linked to heat gain. When the inside design air temperature is decreased, the total heat gain is increased during cooling season. Because more amount of energy is consumed to cool the inside of building. As a consequence, the lower inside design air temperature requires the higher cooling load.

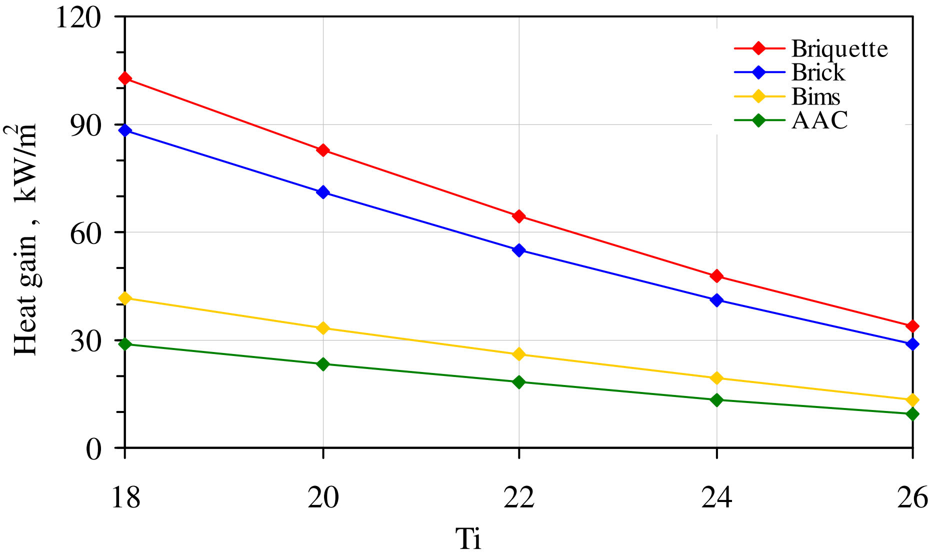

Fig.6.30. The annual cooling heat gains of four different walls with 20 cm thickness due to south direction with various Ti temperature for Gaziantep

6.4. Results for Economical Analysis

In order to obtain optimum wall and insulation thickness, an economical analysis is required. All of the numerical calculations were realized to obtain economical analysis which is obtained by using the heat gain results. The TETD method was used for determination of the building energy consumption for cooling load. The economical analysis is based on life cycle cost analysis. As a result of the economical analysis, energy cost, total cost and optimum wall and insulation thickness of different wall types were obtained. The effects of directions, color of surfaces, types of walls and wall thickness on economical analysis were investigated.

The energy cost of gray colored blokbims wall for four main directions with different wall thickness during cooling season is depicted in Fig.6.31. The highest heat gain leads the highest energy cost. It is seen from the figure that the highest energy cost is obtained for the wall directed due to East direction with 5cm wall thickness and the lowest energy cost is obtained for the wall directed due to North with 5cm wall thickness. If the wall thickness is increased, the cost of energy is decreased. But, there is a limit for the thickness of wall. Because increasing wall thickness causes the increasing wall and total cost. Therefore, the economical analysis is carried out to find optimum wall thickness. Fig.6.32 shows that the energy cost of gray colored blokbims wall for four main directions during cooling season with 20cm. It is observed from the figure that the highest energy cost is obtained for the wall directed due to East during May, June, August and the lowest energy cost is obtained for the wall directed due to North. But, the highest energy cost for all directions are obtained during July, and also for the wall directed due to West during July. As a result of these figures, the west directed wall with 5cm blokbims wall during July has the maximum energy cost.

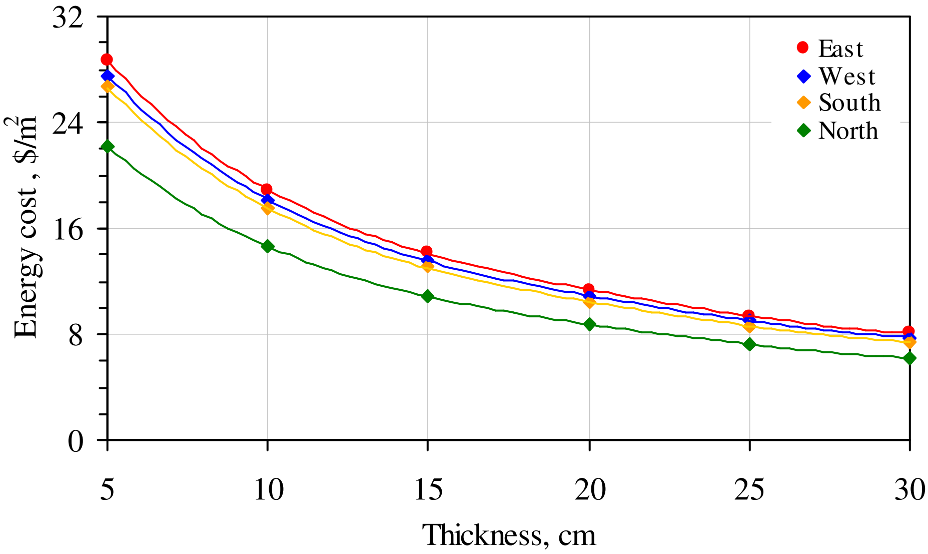

Fig.6.31. The annual cooling energy cost of gray colored blokbims wall for four main directions with different wall directions

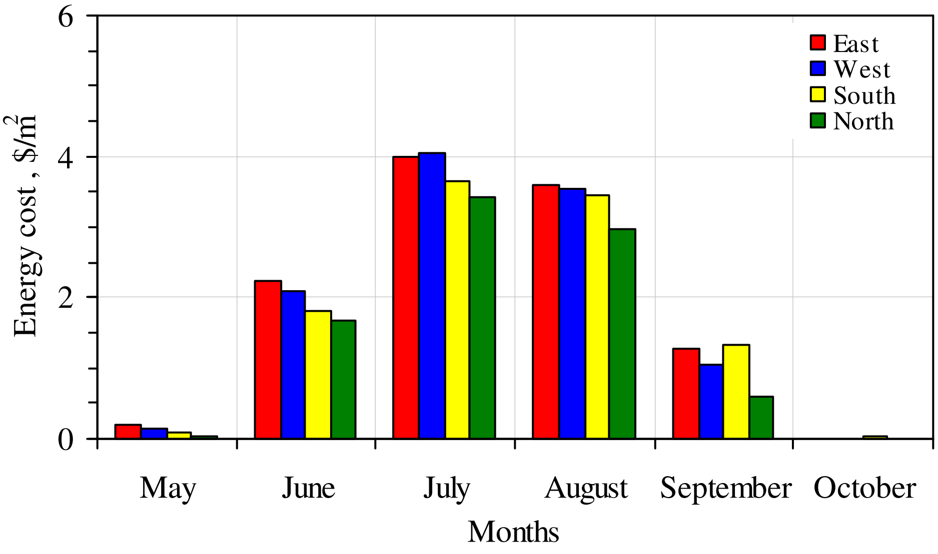

Fig.6.32. The energy cost of gray colored blokbims wall for four main directions during cooling season with 20cm

Fig.6.33 and Fig.6.34 show the effects of surface absorptivity on energy cost. The effect of surface colors with respect to wall thickness on the annual cooling energy cost for the blokbims wall which is directed South direction is shown in Fig.6.33. The energy cost increases with the increasing surface absorptivity due to heat gain. But the effect of absorptivity decreases with increasing wall thickness. Because dark surface walls with small thickness absorb more solar radiation. Therefore, the building walls constructed with higher absorptivity and small thickness are required more energy cost in order to cool the inside of building. Fig.6.34 shows that the effects of surface colors on energy cost for the blokbims wall directed to south direction during cooling season. Because of more solar radiation and absorption, the maximum energy cost is obtained for dark surface during July. The surface absorptivity which changes with surface color is profound effect on energy cost.

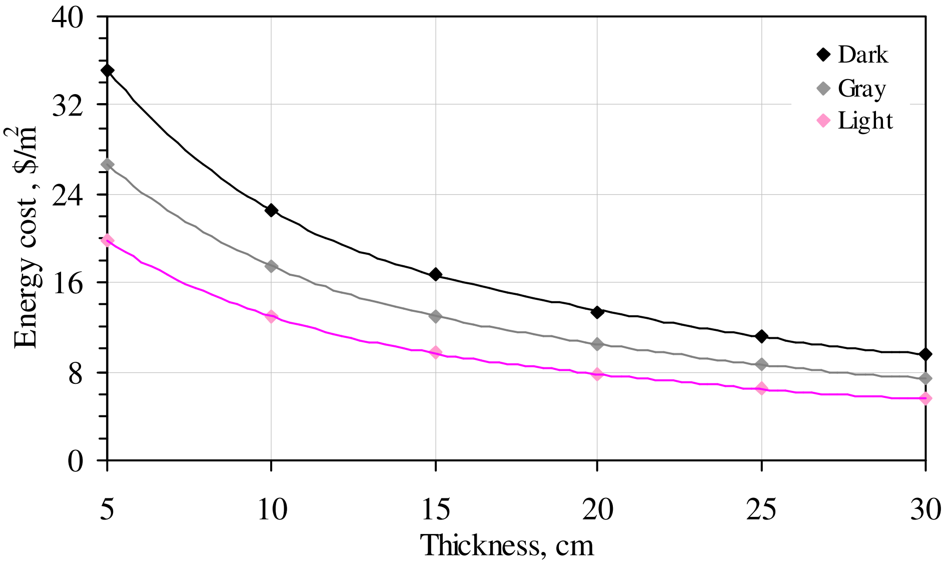

Fig.6.33. Effect of surface colors on the annual cooling energy cost for the blokbims wall due to South with different thickness

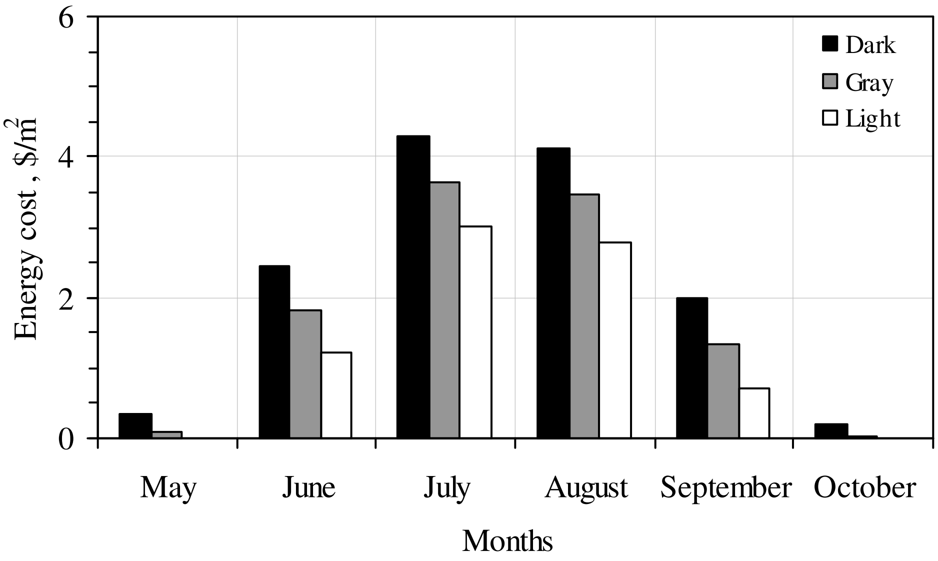

Fig.6.34. Effect of surface colors on energy cost for the blokbims wall due to South during cooling season

Different types of walls have the different thermophysical properties which are thermal conductivity, density, specific heat, thermal diffusivity and heat capacity. The variation of energy costs with respect to wall types are depicted in Fig.6.35 and Fig.6.36. The total cooling energy cost during year with respect to wall thickness of four different walls which directed to south and colored gray surface is shown in Fig.6.35. As the highest energy cost is obtained for briquette wall with minimum thickness, the lowest energy cost is taken for AAC wall with maximum thickness. The briquette wall has the maximum heat gain because of the highest heat capacity and thermal conductivity. Therefore, the briquette wall has the highest energy cost. The lower energy cost is obtained with increasing thickness of wall because of decreasing heat gain. Fig.6.36 depicts the monthly variation of energy cost with respect to different wall types. It is seen from the figure that all of wall types have the maximum energy cost during July, due to the highest solar radiation. As a consequence, the briquette wall with small thickness is undesirable construction wall material. The capacity and energy cost of air conditioning system increases owing to using of briquette wall with small thickness in construction.

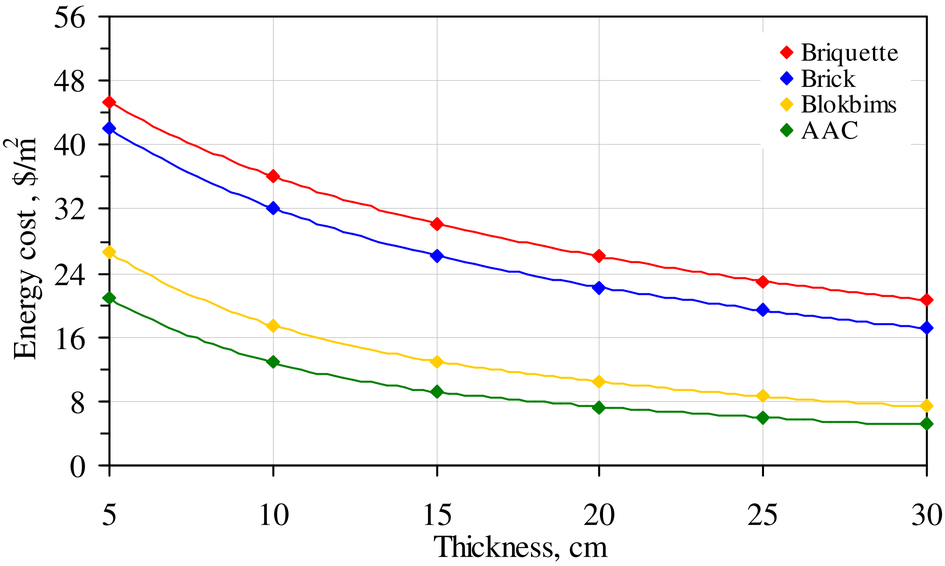

Fig.6.35. The annual cooling energy cost with respect to wall thickness of four different walls which directed to south and colored gray surface.

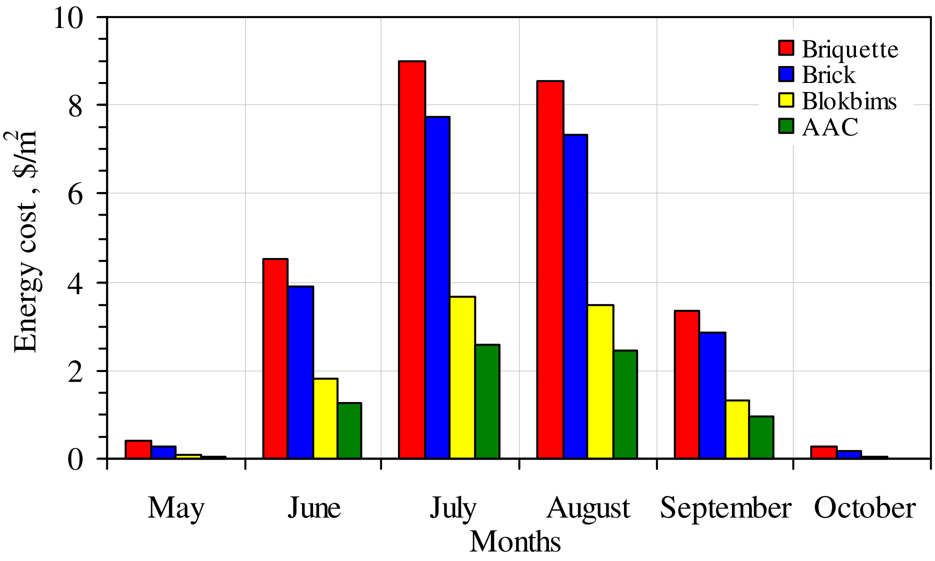

Fig.6.36. Monthly variation of the energy cost of four different walls which directed to south and colored gray surface during cooling season. (20cm)

The main purpose of economical analysis is determination of the optimum thickness of wall and insulation material with respect to cooling loads. In this study, the optimum thickness of four different wall materials are calculated for cooling loads at Gaziantep of Turkey. The energy cost, the wall cost and the total cost are ploted versus wall thickness in Figures.6.37-6.40. In buildings, with an increased wall thickness, heat gains decrease. If the wall thikness is increased, the cooling load and energy cost decrease. However, increasing the thickness means increasing the cost of wall. On the other hand, the wall cost increases linearly with wall thickness and is independent of energy cost. The total cost is obtained when the cost of energy is added to the wall material cost with respect to wall thickness for cooling loads. As expected, the total cost curve shows a minimum that corresponds to the optimum wall thickness. It is noted that, the optimum wall thickness results obtained from formulation is approximately same from the Figures.6.37-6.40. The optimum thickness of briquette, brick, blokbims and AAC is 29.21 , 25.61 , 15.74 and 9.84cm , respectively. When the optimum thickness of briquette and brick are close to each other, the optimum thickness of blokbims and AAC are close to each other.

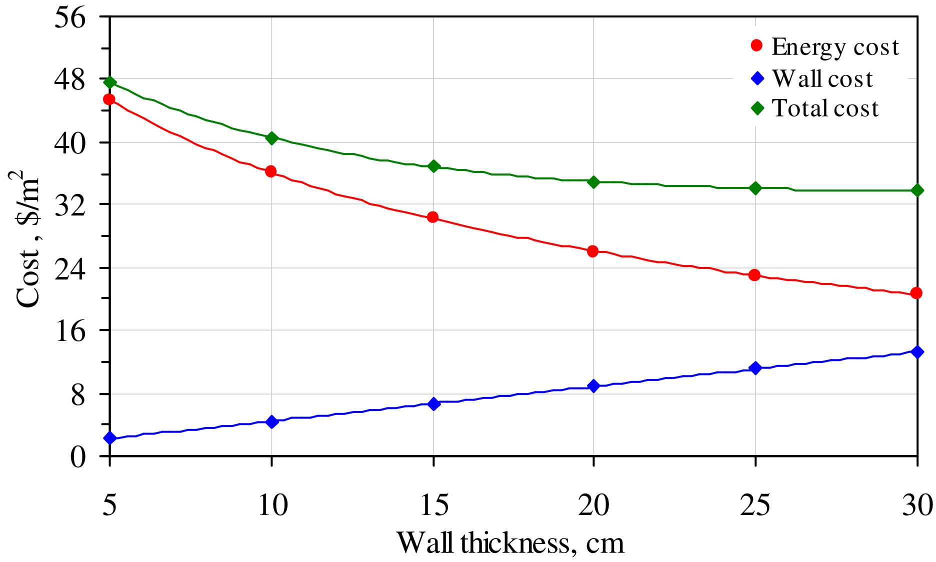

Fig.6.37. Variation of wall cost, energy cost and total cost with wall thickness of briquette wall

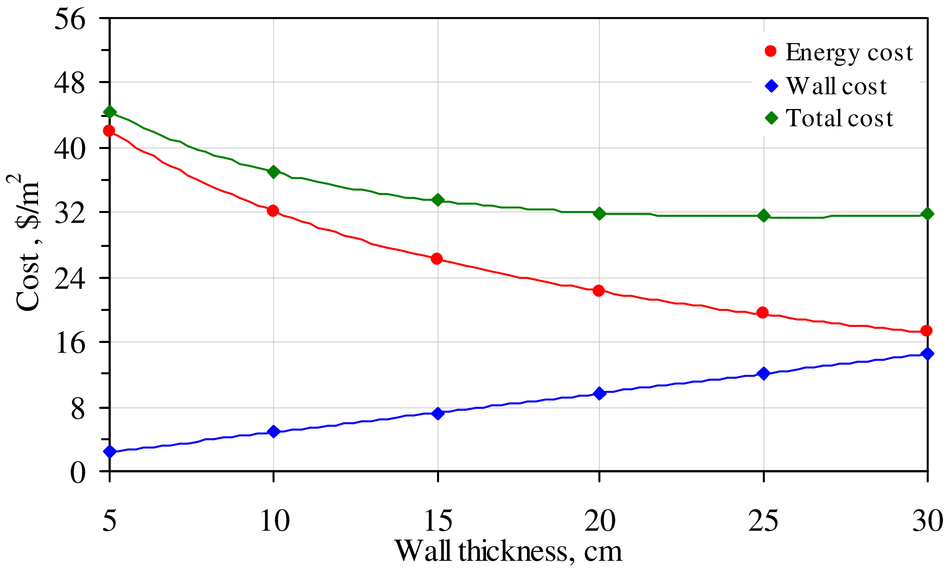

Fig.6.38. Variation of wall cost, energy cost and total cost with wall thickness of brick wall

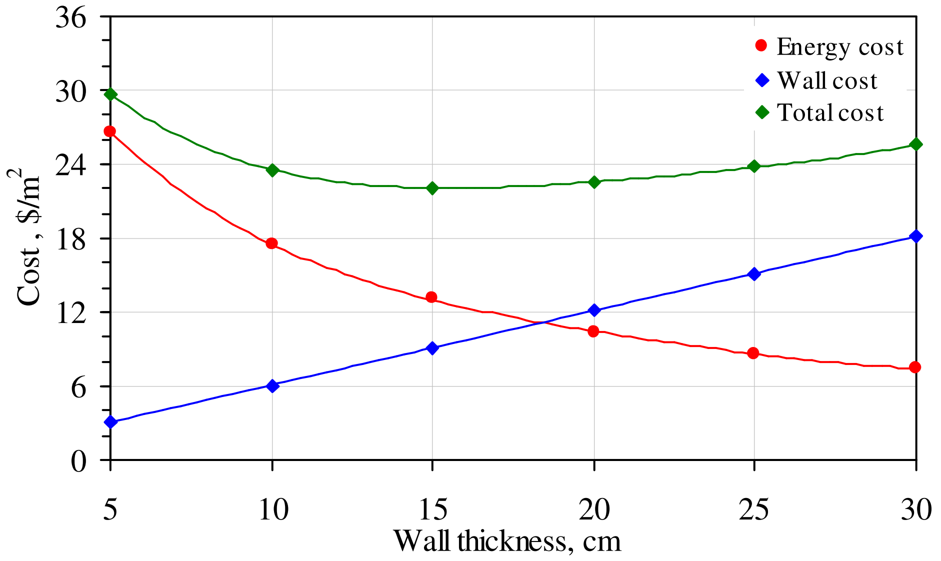

Fig.6.39. Variation of wall cost, energy cost and total cost with wall thickness of blokbims wall

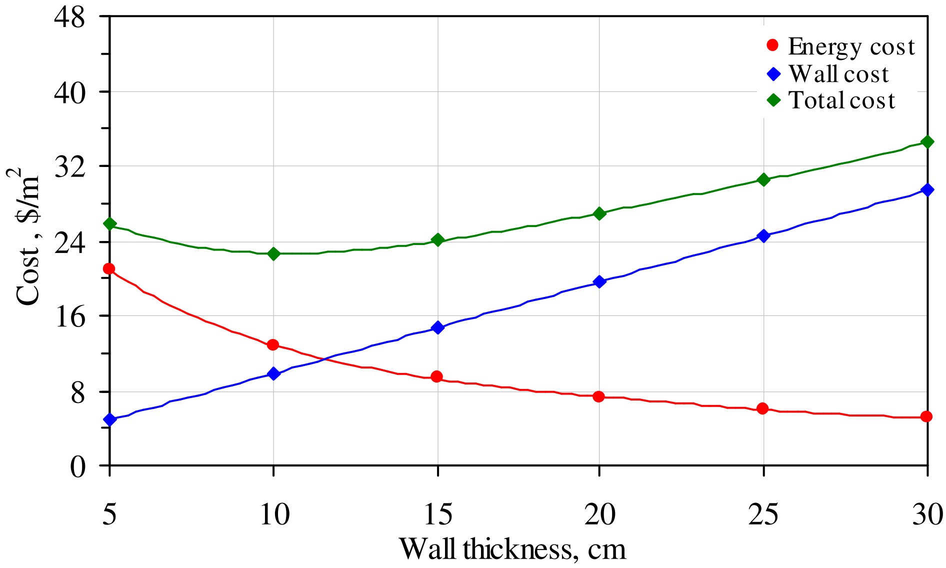

Fig.6.40. Variation of wall cost, energy cost and total cost with wall thickness of AAC wall

The total cost of four wall types are depicted in Fig.6.41. It is seen from the figure that the cost of briquette, brick, blokbims and AAC which have optimum thickness are 33.94 , 31.46 , 22.13 and 22.63$/m2 , respectively. Consequently, the using of brick wall in construction is better than the briquette wall. Because, the total cost of brick is cheaper than the briquette. Also, the using of blokbims wall in construction is better than the AAC wall. Since total cost of blokbims is cheaper than AAC.

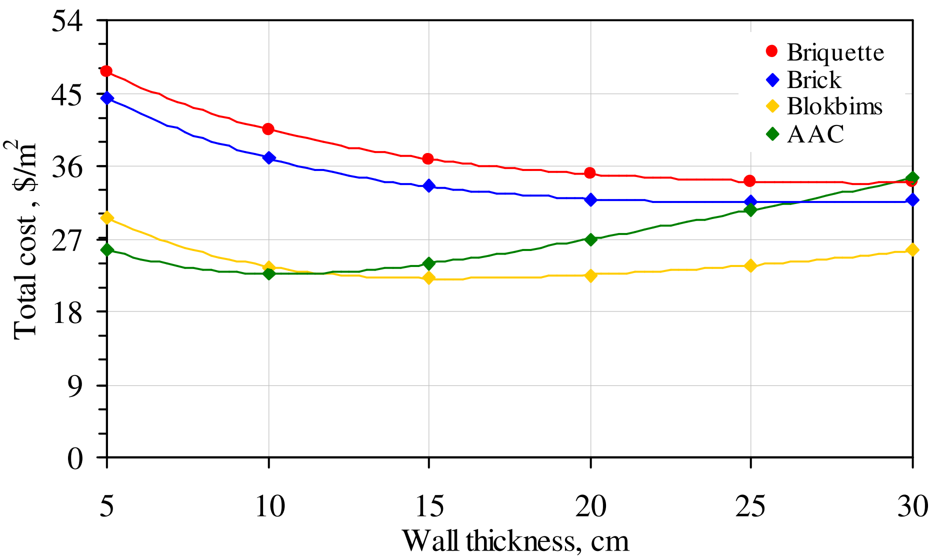

Fig.6.41. Variation of total cost of four different wall types with wall thickness

Figures.6.43-6.46 show that the variation of insulation cost, energy cost and total cost with respect to insulation thickness. The walls are insulated with xps. The thickness of all wall types are considered 15cm. Schematic representation of these walls is shown in Fig.6.42. In order to find optimum insulation thickness of these structures, xps insulation material is used. The optimum insulation thickness of briquette, brick, blokbims and AAC is 0.06 , 0.06 , 0.04 and 0.03m , respectively. While the briquette and brick wall are required the highest insulation thickness, AAC is required the lowest insulation.

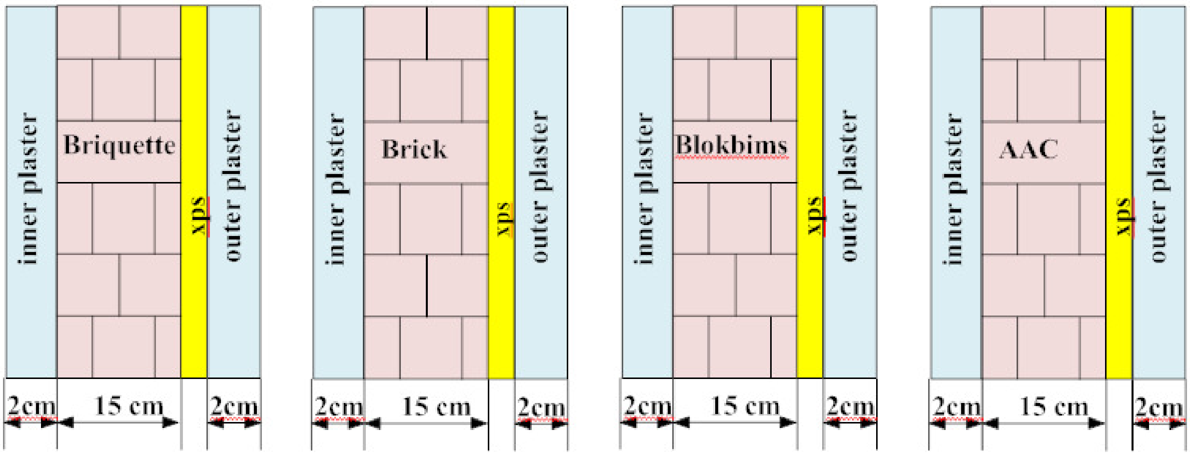

Fig.6.42. Schematic representation of these walls

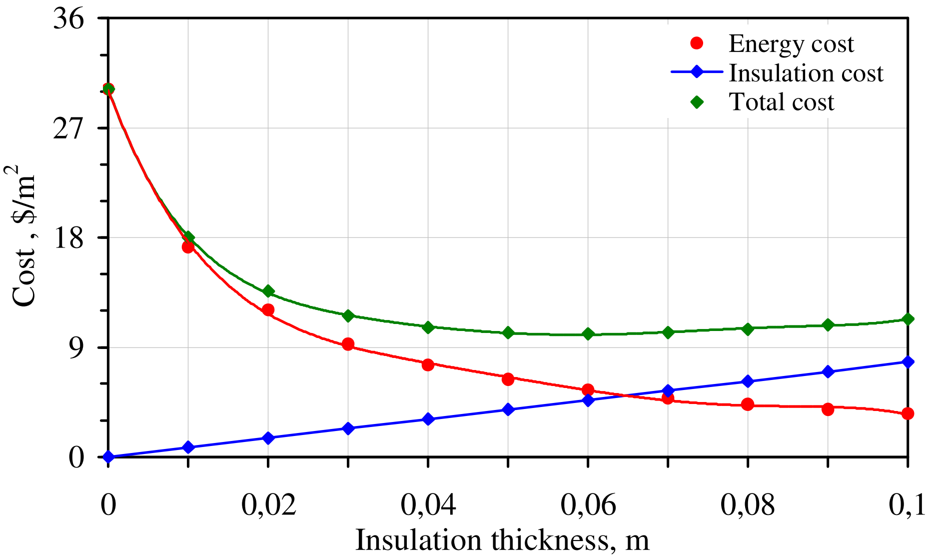

Fig.6.43. Variation of insulation cost, energy cost and total cost with insulation thickness of briquette wall

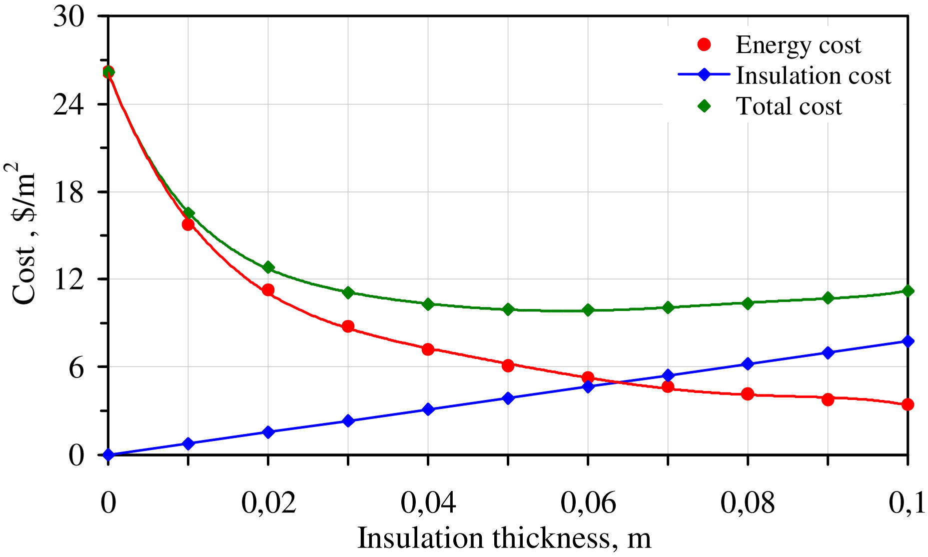

Fig.6.44. Variation of insulation cost, energy cost and total cost with insulation thickness of brick wall

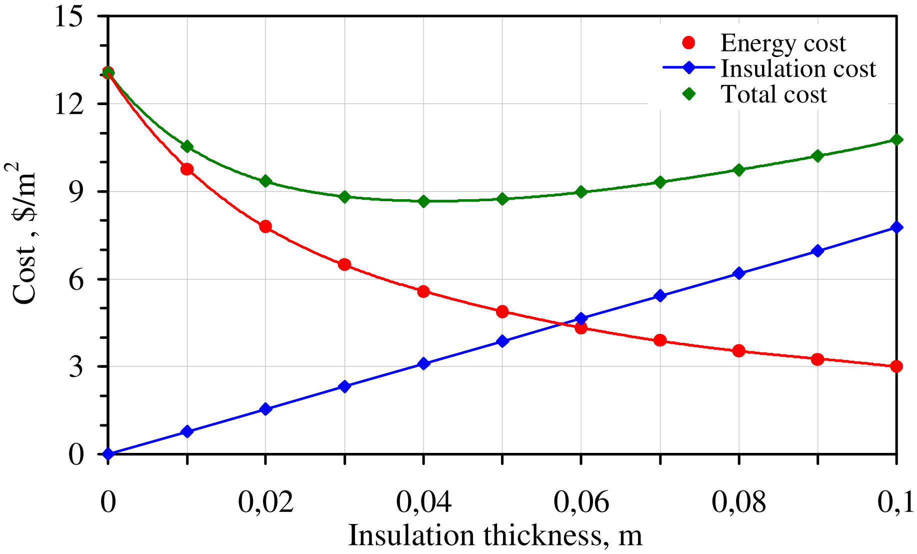

Fig.6.45. Variation of insulation cost, energy cost and total cost with insulation thickness of blokbims wall

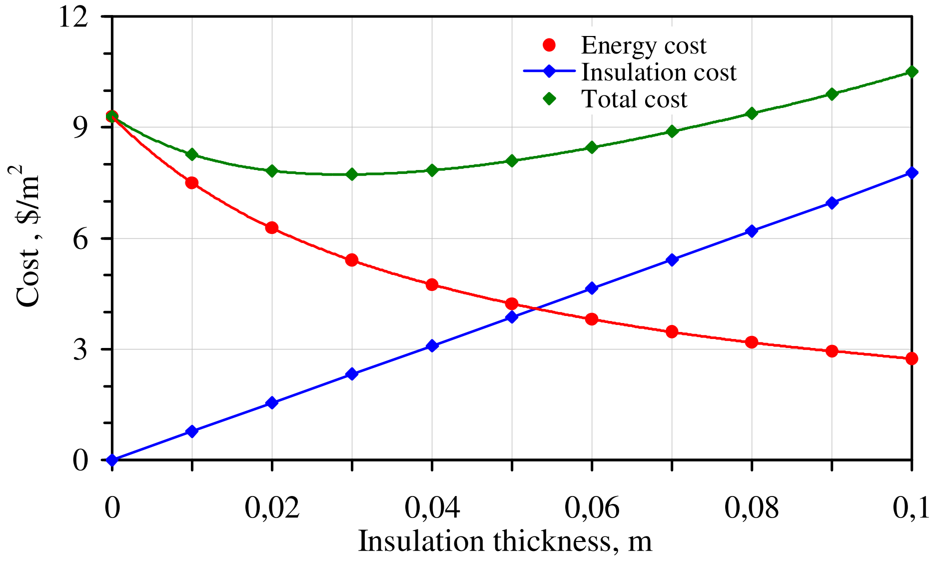

Fig.6.46. Variation of insulation cost, energy cost and total cost with insulation thickness of AAC wall

Energy savings of walls are indicated in Fig.6.47. It is seen from the figure that maximum savings can not be obtained with increasing insulation thickness. The energy saving is maximum at optimum insulation thickness. The highest energy saving is obtained for briquette wall and it follows brick, blokbims and AAC, respectively. The values of energy savings are 20.08, 16.26 , 4.35 and 1.56 $/m2.

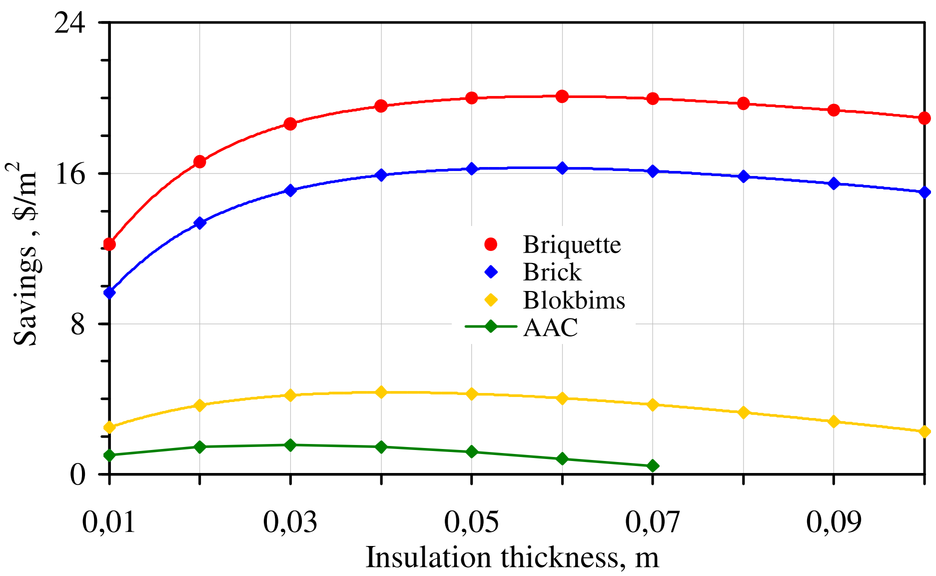

Fig.6.47. Variation of savings of four different wall types with respect to insulation thickness

Figures.6.49-6.52 show that the variation of insulation cost, energy cost and total cost with respect to insulation thickness considering optimum wall thickness. Xps is used for the insulation material. The thickness of briquette, brick, blokbims and AAC are considered 30cm, 25cm, 15cm and 10cm, respectively. Schematic representation of these walls is shown in Fig.6.48. It is observed from the figure that the optimum insulation thickness of briquette, brick, blokbims and AAC are obtained 0.05 , 0.05, 0.04 and 0.04cm , respectively. Considering overall total cost of walls which is summation of insulated total cost and wall cost, the following results are obtained. The overall total cost of briquette, brick, blokbims and AAC are obtained 22.998 , 21.613 , 17.73 and 18.41$/m2 , respectively. The blokbims has the lowest overall total cost. Therefore it is desirable construction wall material.

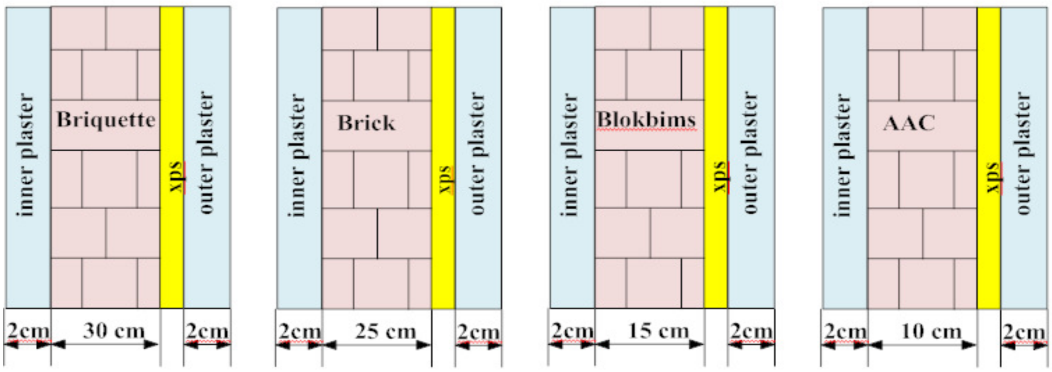

Fig.6.48. Schematic representation of these walls

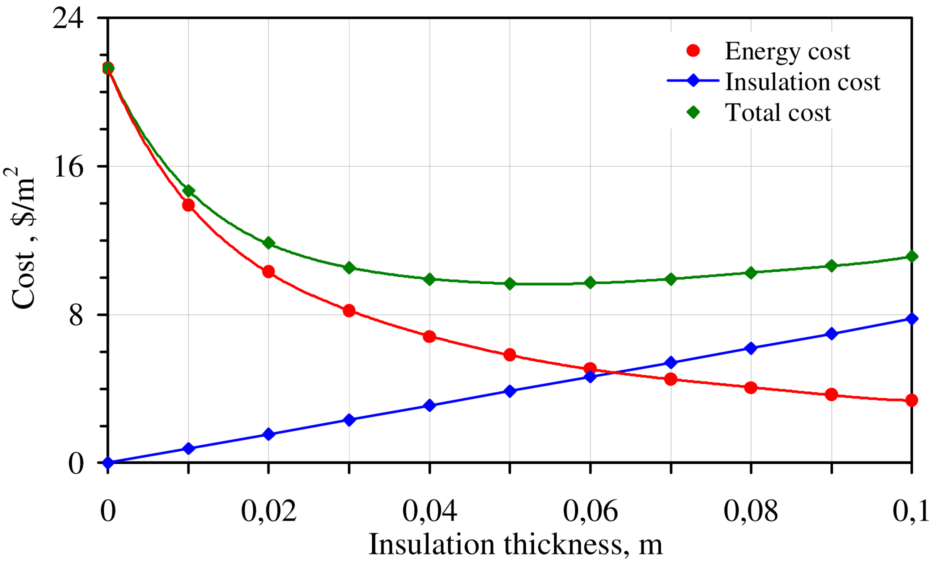

Fig.6.49. Variation of insulation cost, energy cost and total cost with insulation thickness considering optimum wall thickness of briquette wall with 30cm

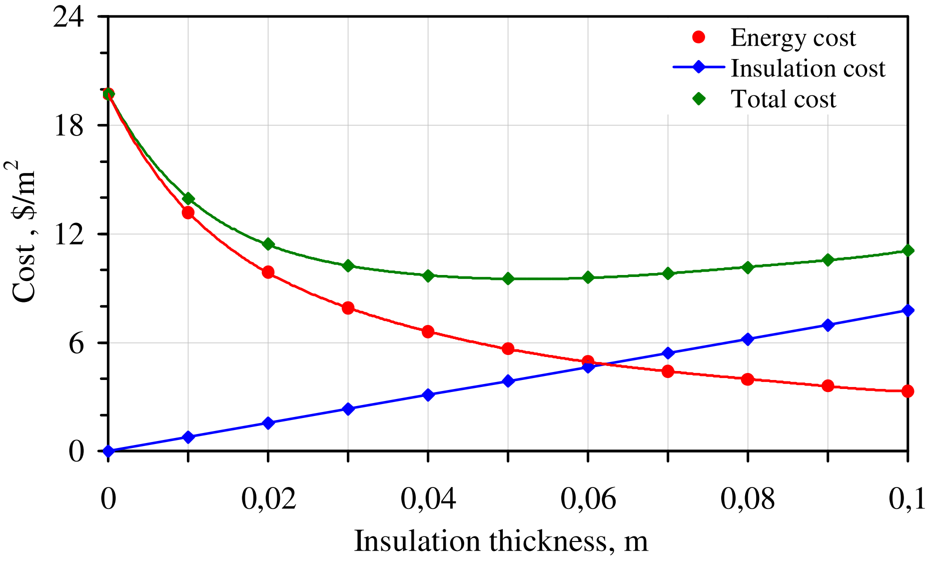

Fig.6.50. Variation of insulation cost, energy cost and total cost with insulation thickness considering optimum wall thickness of brick wall with 25cm

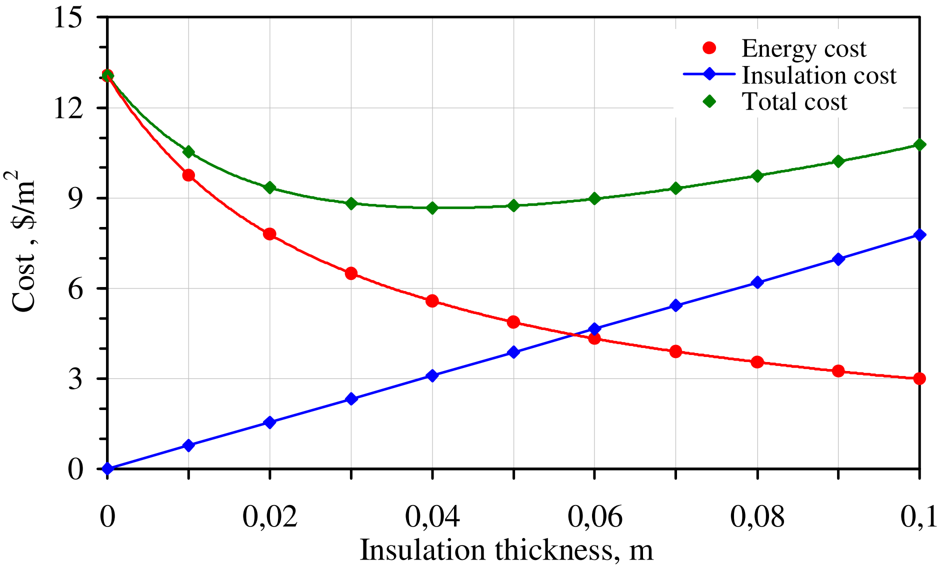

Fig.6.51. Variation of insulation cost, energy cost and total cost with insulation thickness considering optimum wall thickness of blokbims wall with 15cm

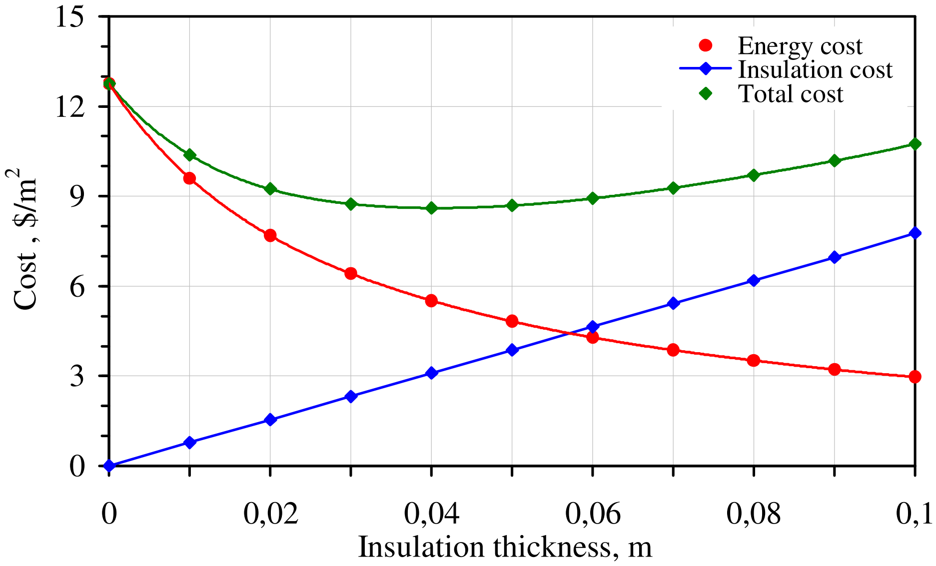

Fig.6.52. Variation of insulation cost, energy cost and total cost with insulation thickness considering optimum wall thickness of AAC wall with 10cm

6.4. Results for Energy Cost of Commonly Used Different Walls

In order to obtain a present value of the cost of energy consumption of walls over a lifetime of n years, the economical analysis is required. The economical analysis consists of a present worth factor, PWF, is function of the inflation rate (d), and the interest rate(i). The economical analysis was realized by using cooling loads of structures. The heat gains through the walls were obtained by using Total Equivalent Temperature Difference, TETD, method. The TETD values consist of TL, DF and sol-air temperatures. The sol-air temperatures are functions of hourly outside air temperature and solar radiation flux on horizontal surface which were taken from meteorological station. As a result of the economical analysis, the present values of energy costs of eight walls were obtained. Many constructions in Turkey have standard wall types. Therefore, eight walls were selected which are commonly used walls in Turkey. These walls consist of briquette, brick, blokbims, AAC and xps. The first four types of the walls have no insulation materials and last three ones have insulation material. Schematic representation of walls is shown in Fig.6.53.

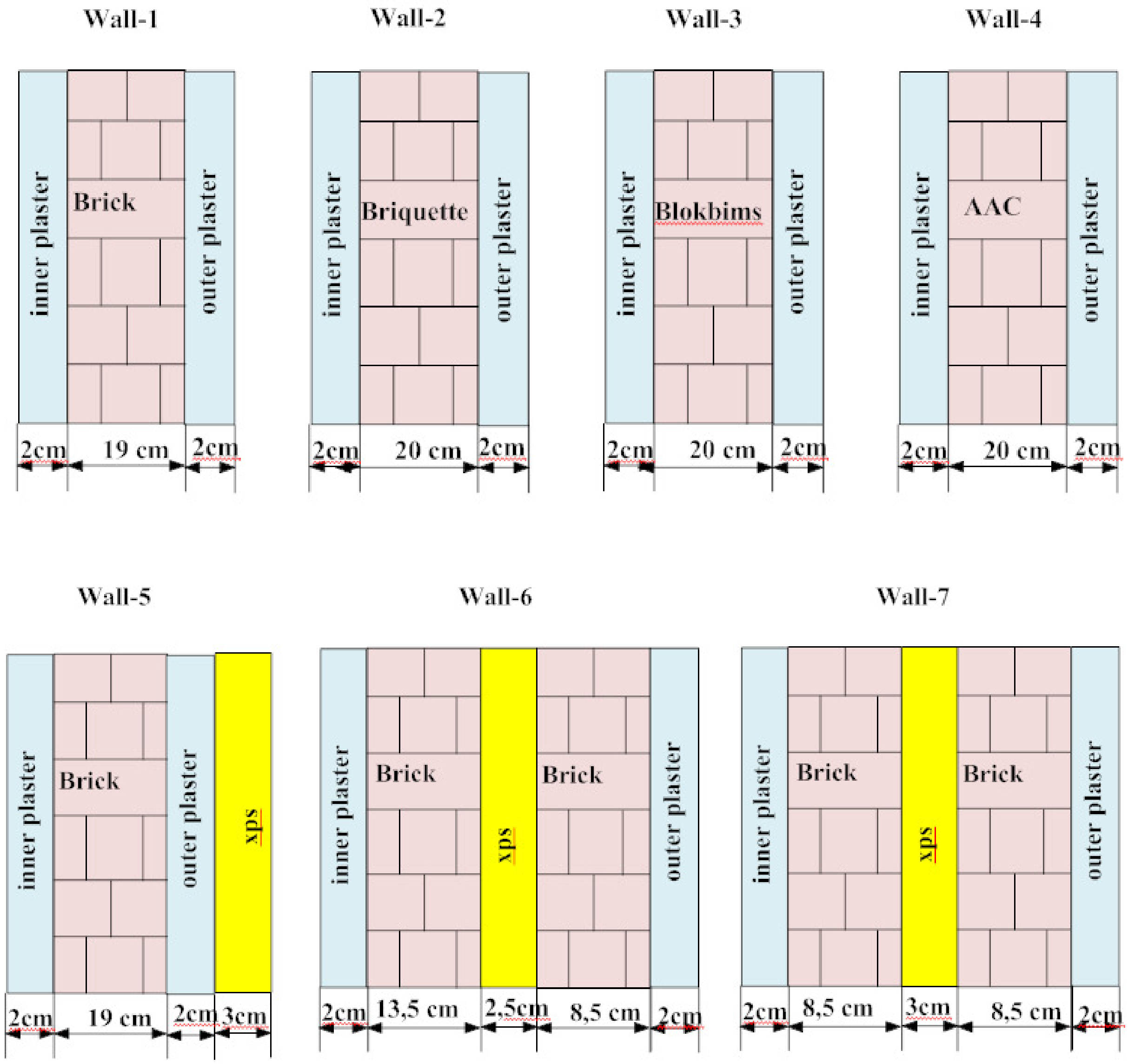

Fig.6.53. Schematic representation of walls

The energy costs of gray colored eight walls for south direction during cooling season is shown in Fig.6.54. It is seen from the figure that the highest energy cost for all wall types are obtained during July. Since more solar radiation is obtained in July during cooling season. Fig.6.55. shows that the total energy cost of eight walls during cooling season. It is observed from the figure that the higher energy costs are obtained from no insulated walls and the lower energy costs are obtained from insulated walls. As the highest energy cost is obtained from Wall-2 and the lowest energy cost is obtained from Wall-4. Since the briquette wall has the highest heat gain and absorbs more solar radiation than the others and The AAC wall the lowest heat gain than the others. The wall-5, wall-6 and wall-7 have the same construction materials but have different thicknesses. The wall-5 and wall-7 have the same insulation material thickness but have different wall thickness. When the wall thickness increases, the energy cost decreases. The thickness of wall material and insulation material is important factor for energy cost.

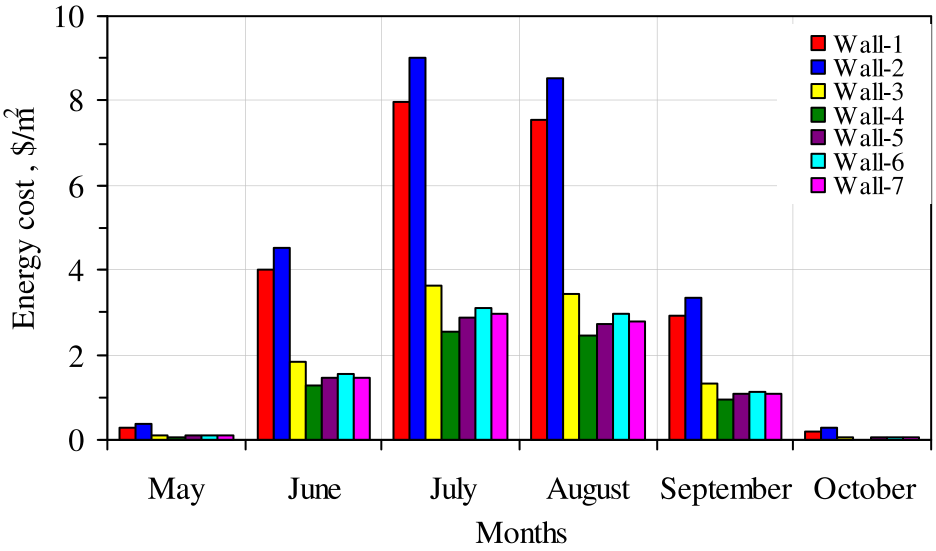

Fig.6.54. The energy costs of gray colored eight walls for south direction during cooling season

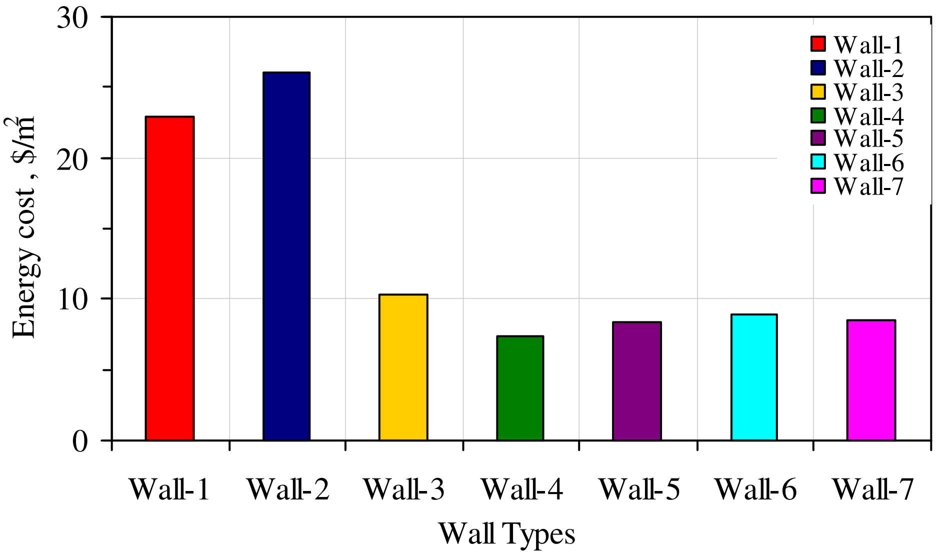

Fig.6.55. The total energy cost of eight walls for south direction during cooling season

CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS

7.1. Conclusions

In the present work, daily and monthly TETD and heat gain values for Gaziantep in Turkey are obtained by using hourly outside air temperature and solar radiation on horizontal surface for four types of walls commonly used, which are briquette, brick, blokbims and AAC in order to obtain annual cooling load. Then the results of cooling loads are used as input parameters to obtain economical analysis. The economical analysis is required to decide which one wall type is better in construction and how much optimum wall and insulation thickness is used in construction. Also, it gives the energy cost, wall cost and total cost of each wall types. Therefore a computer program in Fortran is prepared to calculate, solar radiation on tilted surface, temperature distribution within the walls, sol-air temperatures, overall heat transfer coefficients, TETD values, heat gains, energy cost, wall cost, total cost and finally the optimum wall and insulation thickness.

The results show that higher solar radiation and ambient air temperatures give higher TETD values, leading higher heat gains and higher energy consumption to keep a space at a given temperature. Meteorological values, absorbtivity of surfaces, thermophysical properties, directions of the walls and type of walls have important effects on the heat gain linked to optimum wall and insulation thickness. All of these effects can be summarized as follows :

1. The directions of walls have important affect on the TETD values and heat gain leads to economical analysis. The lowest TETD, heat gain and energy cost are obtained for north direction during October but the highest TETD, heat gain and energy cost are obtained for west direction during July. Generally, east directed

walls have higher TETD, heat gain and energy cost than west directed walls during cooling season except of July. The north directed walls always have the lower TETD, heat gain and energy cost during cooling season. The highest annual cooling TETD, heat gain and energy cost are obtained for east directed walls and it follows that west, south and north directed walls, respectively.

2. Absorptivity of surfaces has profound effect on the TETD, heat gain and energy cost. The values of absorptivity change with color of surfaces. The absorptivity of dark surface is higher than light surface. Therefore dark surfaces absorb more solar radiation than the light surfaces.

3. Thermophysical properties of the wall materials have profound effects on TL and DF which affect TETD, heat gain and energy cost. That is, the highest thermal resistance or lowest thermal conductivity gives the highest time lag but it gives the lowest decrement factor. The lowest decrement factor causes the lowest TETD, heat gain and energy cost.

4. The amplitude is a function of decrement factor and time lag. The highest decrement factor and the lowest time lag give the highest amplitude of TETD and heat gain. The briquette wall has the highest amplitude and it follows brick, blokbims and AAC. Also the amplitude of TETD and heat gain change with wall thickness. The amplitude decreases with increasing thickness of wall material. The lower amplitude gives better comfort conditions for people than the higher amplitude. When the briquette wall with small thickness has the highest amplitude, the AAC wall with high thickness has the lowest amplitude. As a consequence, blokbims and AAC walls give better comfort conditions than the others for people because of minimum amplitude.

5. The building construction is important factor for the calculation of TETD, heat gain and economical analysis in order to determine the most suitable building wall material. Four types of wall materials which are briquette, brick, blokbims and AAC are selected since they are commonly used in building construction in Gaziantep. All of the wall types have different heat capacity and thermal conductivity from each other. The higher heat capacity and thermal conductivity

give the higher TETD, heat gain and energy cost. Because of the highest heat capacity and thermal conductivity , the briquette wall has the highest TETD, heat gain and energy cost and it follows brick, blokbims and AAC.

6. The thickness of wall is significant factor in the construction of buildings. Therefore, the optimum thickness of each wall is calculated. Each wall has different optimum thickness. As the briquette wall has the highest optimum thickness, the AAC wall has the lowest optimum thickness.

7. Another important factor in the construction of buildings is the optimum insulation thickness. Each type of wall has different optimum insulation thickness.

8. The maximum energy savings are obtained at optimum insulation thickness. Energy savings increase with increasing cooling load. The briquette wall has the highest saving because of the highest cooling load.

7.2. Recommendations

The primary purpose of this study was determination of the optimum external wall and insulation thickness by economical analysis. The economical analysis was carried out using cooling loads as input parameters for commonly used wall types which are briquette, brick, blokbims and AAC. The heat gains were obtained by using Total Equivalent Temperature Difference, TETD, Method. The TETD values are functions of TL, DF and Sol-air Temperatures. Sol-air temperatures were calculated by using hourly outside air temperatures and solar radiation on horizontal surface for Gaziantep in Turkey. The following recommendations omitted in this study are given for further study:

1. The TETD values, heat gains and economical analysis for all of the cities may be obtained for all building structures constructed in Turkey.
2. The TETD values, heat gains and economical analysis may be carried ot during heating season.

3. In the economical analysis, different insulation materials may be used. The optimum insulation thickness of walls may be obtained for different insulation materials.
4. Cost of building site area may be considered in the economical analysis.

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APPENDICES

APPENDIX A

Solar Radiation on Horizontal Plane for Gaziantep [unit of data in tables, (cal/cm2)/100]

	JANUARY															
	DAYS															
HOURS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	205,5	167,14	273,33	145,71	76,88	90	135	97,5	108	84,38	112,5	95	180	116,25	214	148,75
9	852	590	852	468	326,67	390	705	570	702	486	653,33	630	766,67	558	714	786
10	1644	1194	1422	1146	474	942	1333,33	1176	1560	1260	1458	1620	1608	1260	1518	1680
11	2118	1674	1896	1608	696	1434	1644	1680	2238	1704	1998	2352	2268	1848	2118	2226
12	2274	1878	1860	1662	996	1680	1674	1986	2634	2052	2214	2802	2592	1974	2298	2508
13	2112	1806	2172	1686	1206	1740	1776	2040	2622	1830	2184	2658	2460	1998	2538	2652
14	1938	1530	1884	1566	1056	1776	1554	1800	2358	1638	1818	2358	2328	1968	2166	2586
15	1500	1272	1350	1254	822	1368	1248	1272	1722	1200	1500	1650	1650	1446	1758	2136
16	840	714	672	576	516	813	660	666	948	760	783	1026	762	798	1188	1333,33
17	163	176,67	130,11	198,75	217,14	344,29	155	144,5	252	277,5	238,13	316,67	195	270	271	381,67
18	15	0	0	60	60	90	180	30	0	45	0	0	15	60	30	60
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	JANUARY														
	DAYS														
HOURS	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	158,57	144,38	196,67	150	228,33	105	176,25	140	150	222,5	201,67	105	200	166,67	200
9	744	636	804	660	833,33	420	420	620	768	930	946,67	624	822	738	858
10	1578	1254	1506	1386,67	1380	794	846	1392	1506	1824	1482	1374	1614	1596	1686
11	2340	1938	2112	1704	1854	1134	1242	2010	2040	2580	1950	1920	2292	1974	2226
12	2670	2340	2490	1788	2196	1296	1506	2274	2316	3024	2322	2556	2568	2322	2610
13	3132	2154	2460	1632	1938	1332	1626	2238	2292	2784	2430	2652	2838	2406	2808
14	2688	1926	2184	1614	1848	1253,33	1674	2052	1896	2466	2154	2370	2472	2094	2484
15	2130	1452	1950	1398	1518	1033,33	1350	1578	1536	1974	1596	2028	1980	1632	2082
16	1242	858	1182	888	804	600	810	1110	1017	1206	918	1170	1326	972	1212
17	288	287,14	343,89	363,6	330	213,33	250	354	233,33	427	390	427,5	444	349	426,67
18	30	60	30	70	30	60	30	30	20	101,25	75	82,5	70	70	30
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	FEBRUARY															
	DAYS															
HOURS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	15	0	0	0	0	20	0	15	15	50	50	45	22,5	30	37,5	40
8	216,67	141,11	176,25	262	226	262,22	210	376,67	348	390	460	467	96,67	221	367,78	373,33
9	913,33	786,67	597	918	834	993,33	834	1116	1254	1296	1400	1272	526,67	924	1200	1020
10	1728	1284	1146	1620	1554	1578	1572	1854	2028	2166	2413,33	1992	1194	1614	2088	1704
11	2394	1998	1770	2256	2082	2376	2100	2772	3006	2880	2874	2898	1842	2232	2754	2670
12	2772	2430	1896	2622	2412	2778	2658	3192	3432	3270	3174	2922	1806	2136	2802	2880
13	3000	2424	2106	2568	2190	2418	2784	3480	3486	3078	3162	2718	2094	1896	3006	2886
14	2778	2244	1992	2238	1668	2082	2430	3084	3318	2952	2970	2421	2046	1824	2598	2628
15	2256	1860	1758	1938	1332	1674	2022	2604	2544	2448	2508	2026,67	1614	1470	2448	1992
16	1524	1176	1296	1236	1014	1194	1338	1900	1818	1692	1698	1353,33	1122	960	1428	1440
17	510	383,33	523,33	438	468,75	526,67	618	633,33	588	648	680	558,75	528	474	637	646,67
18	99	75	115	73,33	97,5	52	231	66,67	74,38	91,43	77,5	86	76,67	85	126	95
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	MARCH															
	DAYS															
HOURS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	112,5	99,29	50	127,14	78,75	99	161,43	92,86	114,29	174,38	245	103,75	301,88	138,75	158,33	195
8	586,67	672	498	642	612	639	852	696	942	1026	846	700	1110	798	672	886,67
9	1407	2022	1434	1650	1884	1614	1944	1896	2202	2208	1998	2172	2268	2142	1680	2082
10	2334	3054	2316	2778	2880	2646	2766	2898	3078	3150	2934	2976	3378	3144	3198	3324
11	3036	3600	2940	3672	3522	3360	3264	3330	3576	3768	3438	3702	3966	3804	3684	3912
12	3606	4110	3402	4092	3702	3390	3702	3696	4236	4200	3942	3876	4632	4224	3402	3996
13	3672	3822	3462	3978	3576	3462	3594	3750	4338	4032	3996	3984	4524	4032	3486	4248
14	3516	3114	3330	3912	3510	3300	2916	3294	3630	3330	3918	3618	3876	3618	3570	4218
15	3066	2760	2436	3342	2820	3108	2610	2592	3000	2904	2982	3060	2778	3096	3468	3354
16	1836	2202	1650	2400	1878	2286	1938	1767	2208	2082	2268	2178	1938	2250	2700	2412
17	768	1128	876	1110	850,5	1146	1008	1066,67	1278	1176	1212	1146	1104	1176	1590	1405,5
18	192	159	129	139,5	138,33	318,33	230,56	343,13	333,75	190	305	215	223,33	260,56	383,33	457,5
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	MARCH														
	DAYS														
HOURS	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	213,33	174,44	201,67	249,38	237	188,89	205	226,67	253,33	268	289	276	402	322,5	348
8	1008	786	780	882	804	804	906	954	885	1140	990	954	1338	1170	1332
9	2694	1836	1962	2154	1770	2220	2328	2208	2430	2232	2214	2154	2610	2532	2580
10	3870	3180	2994	3492	2580	3054	3348	3528	3804	3366	3378	3378	3504	3546	3456
11	4314	3660	3810	4074	3204	3756	3504	4002	4602	3960	4308	3738	3876	4050	3936
12	4806	3594	3636	4344	3552	4254	4116	3696	4548	4212	4260	4056	4398	4470	4272
13	4380	3870	3300	4332	3036	3792	3720	4218	4380	4308	4440	4140	4008	4476	4236
14	4050	3234	3282	3936	2568	3426	3450	3402	3864	3990	4116	3342	3558	3696	3804
15	3306	2748	2922	3546	2166	3174	3030	3000	3288	3330	3198	2922	3228	2832	3180
16	2346	1848	2064	2586	1740	2508	2160	2484	2238	2664	2196	2352	2598	2316	2010
17	1260	1230	1242	1566	1062	1482	1260	1380	1606,67	1878	1560	1392	1338	1254	1248
18	334,44	319	325,5	390	295,5	507	366	461,11	573,33	654	596,67	566,67	441	461	402
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

HOURS	APRIL															
	DAYS															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	90	0	0	0	0	0	0	0	0	0	0
6	15	20	90	70	115,83	150	48,75	56,25	73,33	95,83	76	52,5	70	126,67	80	86,43
7	290	288	180	403,5	366	450	522	390	435	678	732	609	492	502,5	576	696
8	1080	864	666	1434	1098	1362	1518	1350	1374	1872	1938	1626	1590	1692	1656	1878
9	2454	1842	1782	2826	2496	2874	2556	2700	2766	3522	3618	3138	2586	3102	2946	3204
10	3222	2586	2646	3846	3120	3792	3558	3516	3534	4644	4542	4200	3756	3828	3990	3840
11	4086	2790	3504	4350	3510	4332	4194	4284	4044	5232	5226	4926	4404	4788	4146	4584
12	4356	2892	3768	4566	4200	4200	3930	4398	4296	5544	5418	5070	4650	4926	4860	4668
13	4056	3012	4242	4092	4284	4152	3942	4224	4884	5568	5226	5124	4626	4680	4272	4194
14	3528	2712	3960	3378	4392	3828	3942	3990	4518	5106	4506	4608	4470	4092	3876	4128
15	2736	1998	3486	3000	3246	3372	3318	3444	3840	4296	3558	3858	3888	3564	3330	3702
16	2148	1350	2646	2250	2526	2628	2412	2808	3306	3228	3048	2880	2904	2718	2634	2556
17	1350	793,33	1746	1284	1818	2106,67	1866,67	1830	2190	1878	1770	1908	1872	1722	1650	1380
18	484,5	385,71	646,67	546,67	594	701,11	553,33	594	816	690	546	690	774	636	786	648
19	120	50	29	60	60	76,67	45	55	110	33,33	110	72,5	140	61,67	185	35,63
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	APRIL														
	DAYS														
HOURS	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
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3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
6	78	73,33	90	96,25	78,57	91,25	154,29	106,88	147,78	127,78	254,5	165	205		
7	582	450	504	606	600	498	498	654	648	852	696	1224	744	1056	
8	1842	1566	1668	1788	1830	1896	1644	1356	1842	2130	2268	2562	2310	2352	
9	3312	2796	3072	2904	3252	3024	2838	2286	3120	3318	3888	3750	3654	3696	
10	4464	3324	3846	3522	4008	3672	3276	3204	3636	4200	4746	4584	4332	4668	
11	5094	4134	4752	4290	4464	3714	3816	3852	4080	5058	5160	5166	5412	5220	
12	4824	4428	4776	4740	4176	3780	4572	4014	4146	5166	5502	5022	5352	5562	
13	4410	3672	4932	4452	3714	3822	4512	3588	4050	4794	5184	4956	5130	5208	
14	4644	3288	4320	4464	3408	3822	3966	3306	4068	4224	4824	4596	4560	4620	
15	3792	2964	3594	3780	2556	3144	3114	2802	3270	3714	3714	4026	3696	3870	
16	2838	2394	2784	3120	2496	2394	2310	2412	2598	2886	2880	2964	2622	3060	
17	1956	1464	1956	1926	1602	1380	1614	1638	1932	1980	1902	2266,67	1806	2310	
18	912	570	876	648	513,33	516	819	588	926,67	860	840	860	768	930	
19	102,5	58	115,71	54,29	60	85,71	91,88	88,13	165	68,75	129,29	88	108,89	96,5	
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

	MAY															
	DAYS															
HOURS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	90	0	0	15	20	15
6	192	132	185,56	213,33	223	282,22	224	224	304,44	313,33	309,5	214	242,5	235	255	306
7	1032	822	942	1026	1122	1040	1050	960	1286,67	1140	1014	894	978	798	930	1068
8	2508	1902	2400	2280	2472	2148	2388	2160	2706	2544	2526	2310	2082	1932	2370	2490
9	4068	3204	3738	3450	3912	3348	4008	3366	3930	4008	3936	3978	3480	3582	3846	4014
10	4800	3846	4308	4068	4974	4374	4932	4026	4680	4830	4866	4848	4302	4518	4704	4884
11	5286	4458	4920	5046	5508	5106	5328	4422	5190	5436	5388	5628	4926	4860	5256	5460
12	4878	4374	4926	5328	5718	5238	5862	4602	5478	5718	5772	5604	4950	5196	5640	5730
13	5178	3924	4620	5448	5226	5232	5592	4596	5628	5508	5472	5598	5172	5184	5160	5166
14	4236	3876	3864	4332	4776	4488	4782	4206	5046	4824	4584	4728	4668	4218	4416	4362
15	4290	3198	3270	3822	4338	3966	4074	3762	4068	4086	3810	3630	4134	3840	3252	3702
16	3234	2340	2520	2934	3570	3180	3372	3048	3612	3186	3114	2796	3330	3018	2622	2845
17	1938	1836	1752	1662	2442	2016	2190	1890	2442	2238	2376	2202	2322	2160	2104	2186,67
18	948	776	876	666	1164	954	954	936	1176	972	1098	1164	1002	948	1033,33	1000
19	150	165	133,89	124,44	195,56	174,44	178,33	145	502,5	220	193,33	189,44	195,63	198,75	153,75	183,75
20	0	0	0	0	0	0	0	0	150	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	MAY														
	DAYS														
HOURS	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	30	15	22,5	17,5	15	60	105	35	22,5	82,5	90	60	46,67	75	61,25
6	213	286,5	328,5	277,5	353,5	324	427,5	393,33	363	444	456	388,5	504	402	529,5
7	714	1152	1230	1158	1260	1050	1218	1080	1380	1344	1428	1332	1434	1194	1464
8	1974	2412	2790	2544	2400	2358	2418	2274	2856	2466	2532	2550	2820	2508	2892
9	3510	4092	4326	4038	3990	4020	3954	4110	4398	4068	3900	4170	4374	4194	4242
10	4146	4818	5364	5226	4842	4896	5136	5028	5400	5088	4776	5124	5424	5100	4866
11	4452	5202	5910	5196	5598	5694	5904	5694	5934	5298	5220	5730	5748	5670	5304
12	4368	5418	5946	5178	5850	5784	5820	6162	5910	5658	5520	5682	6018	5658	5328
13	4572	5676	5610	5040	5580	5166	5400	5916	5790	5310	5022	5430	5964	5388	5220
14	3936	4746	5232	4830	4980	4734	4962	5148	5160	4854	4854	4896	5322	4896	4842
15	3930	3804	4440	3996	4290	4224	4362	4578	4482	3906	4140	4386	4818	4296	4464
16	3180	3180	3432	3402	3366	3396	3606	3774	3558	3114	3102	3414	3894	3720	3594
17	1896	2232	2310	2286	2364	2439	2436	2652	2598	2082	2196	2448	2820	2556	2490
18	981	978	1332	1350	1020	1200	1146	1470	1362	1248	1212	1410	1458	1218	1362
19	300	195	285	351	203,13	213,75	268,33	363,33	325,5	297	323,33	291	333,33	283,13	420
20	0	0	0	0	0	0	0	0	0	60	52,5	0	0	0	120
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	JUNE															
	DAYS															
HOURS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	50	86,67	30	45	53,33	90	0	116,67	40	36,25	135	30	45	105	60	0
6	458	552	364,5	468	504	516	504	534	438	591	576	441	435	516	434	420
7	1332	1680	1296	1536	1512	1638	1542	1440	1446	1782	1650	1506	1356	1602	1626	1548
8	2802	3036	2322	2952	2736	3030	2880	2886	2838	3204	3012	2892	2670	3036	3018	2760
9	4278	4470	4002	4248	4164	4446	4446	4458	4158	4596	4356	4242	4128	4410	4308	4338
10	5106	5292	5184	5178	5358	5334	5328	5424	5088	5334	5340	5184	5250	5142	5262	5238
11	5460	5610	5574	5610	5868	5904	5736	5922	5718	5874	5814	5634	5850	5640	5838	5730
12	5430	5850	5538	5496	5958	6012	5844	5958	5952	6222	6000	5730	5898	5586	5772	6066
13	5298	5586	5652	5472	5700	5742	5706	5904	5892	5958	5910	5772	5502	5700	5388	6018
14	4908	5544	5328	5370	5316	5574	5340	5232	5160	5346	5448	5268	5088	5238	4788	5580
15	4446	4716	4002	4638	4752	5028	4614	4320	4566	4740	4638	4830	4464	4506	4458	4728
16	3348	3876	3162	3540	3834	3900	3624	3726	3756	3852	3648	3600	3738	3414	3594	3930
17	2466	2682	2052	2514	2586	2856	2610	2802	2844	2868	2802	2580	2796	2376	2628	2736
18	1188	1470	1460	1344	1452	1506	1338	1530	1560	1680	1548	1368	1494	1464	1548	1464
19	279	486	376,67	440	348	363	352,5	465	330	507	466,67	343,33	354	486	426	399
20	10	0	60	0	30	0	10	55	40	45	15	45	60	200	20	30
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	JUNE														
	DAYS														
HOURS	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
5	90	60	0	22,5	120	30	120	172,5	0	30	22,5	30	20	120	
6	486	516	414	583,5	546	414	468	606	477	522	384	543	429	585	
7	1596	1602	1260	1734	1698	1404	1530	1884	1332	1632	1374	1608	1440	1782	
8	2940	2928	2484	3138	3060	2736	2904	3246	2322	2928	2616	2736	2718	3216	
9	4230	4362	4356	4296	4398	4290	4212	4518	3930	4254	4152	4122	4182	4512	
10	5178	5196	5352	5202	5274	5340	5082	5322	5280	4950	5166	5184	5304	5370	
11	5808	5808	5934	5802	5958	5958	5694	5976	5634	5484	5694	5772	5976	5886	
12	6018	6126	6000	6048	6282	6144	5838	6252	6072	5862	5982	5940	6258	6270	
13	6006	6102	6072	6042	6288	6144	5802	6066	5910	5796	5916	5982	6012	6144	
14	5556	5580	5760	5436	5754	5700	5214	5598	5658	5538	5010	5130	5478	5274	
15	4938	5010	5124	4686	5004	4926	5070	4800	4794	4380	4344	4542	4554	4644	
16	4116	4026	4086	3906	3864	4092	4314	4074	3816	3702	3570	3756	3960	3828	
17	3042	2880	2976	2802	2850	2778	3222	2946	2970	2790	2676	2718	3006	2748	
18	1812	1614	1638	1644	1722	1548	1902	1644	1572	1848	1530	1704	1698	1710	
19	582	427,5	580	525	653,33	513,33	654	504	432	693	468	513	558	555	
20	0	90	150	0	150	60	135	90	15	95	105	0	105	90	
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

	JULY															
	DAYS															
HOURS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	25	67,5	0	67,5	30	67,5	30	90	30	105	15	120	0	30	90	0
6	453	570	420	492	444	486	528	465	528	543	558	522	408	438	431	381
7	1572	1698	1476	1716	1524	1554	1608	1530	1584	1698	1710	1662	1266	1530	1428	1458
8	3078	3048	2880	3072	2970	2832	2958	2874	2820	3066	3060	3042	2652	2868	2700	2826
9	4578	4326	4302	4476	4362	4374	4356	4266	4146	4476	4362	4338	4224	4296	4080	4236
10	5442	5328	5238	5370	5226	5184	5256	5196	5094	5364	5298	5310	5148	5154	5130	5118
11	5994	5904	5838	5934	5856	5784	5856	5790	5760	5928	5910	5892	5754	5760	5742	5538
12	6156	6168	5970	6246	6072	5802	6114	5874	6018	6144	6210	6120	6102	6090	6000	5862
13	5784	6204	5832	6198	6072	5766	6000	5820	5928	5838	6192	6048	6030	5838	5598	5676
14	5208	5652	5304	5796	5736	5322	5448	5478	5406	5406	5778	5736	5532	5352	5442	5058
15	4548	4884	4824	4968	4812	4788	4734	4998	4596	4860	5064	5028	4986	4560	4614	4404
16	3708	3882	3990	4056	3924	3894	3858	4188	3936	4170	4146	4146	3876	3810	3786	3504
17	2742	2922	3066	2964	3114	2976	2874	3000	2886	3126	2982	3024	2904	2784	2850	2568
18	1608	1770	1872	1770	1836	1632	1764	1812	1740	1890	1728	1764	1734	1596	1740	1536
19	534	648	530	600	597	630	567	678	567	588	537	606	582	582	552	552
20	20	135	60	150	80	100	135	150	55	90	67,5	112,5	120	120	60	56,67
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	JULY														
	DAYS														
HOURS	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0
6	456	401	453	432	432	429	294,57	423	366	348	366	192	394	360	360
7	1494	1476	1494	1356	1428	1488	1047,54	1302	1254	1332	1332	954	1350	1350	1284
8	2712	2844	2688	2694	2706	2736	2241,51	2598	2502	2556	2526	2070	2478	2628	2400
9	4056	4224	4074	4080	4044	4050	3654,18	4176	3966	3966	3888	3552	3870	3864	3678
10	4890	5112	5070	5118	5076	4884	4611,99	4974	4980	4878	4854	4584	4848	4782	4602
11	5538	5736	5712	5712	5688	5484	5231,91	5568	5580	5628	5496	5316	5502	5460	5292
12	5940	6030	6024	6054	6036	5736	5612,8	5916	5922	5886	5826	5640	5742	5778	5718
13	5736	5898	6060	6054	6000	5568	5624,84	5802	5730	5832	5832	5742	5820	5712	5796
14	5334	5526	5748	5682	5646	5208	5263,72	5154	5316	5328	5256	5352	5202	5190	5478
15	4782	4998	5028	4818	4836	4410	4644,66	4476	4512	4686	4500	4632	4428	4350	4392
16	3948	4092	4176	4032	3972	3906	3777,12	3522	3732	3714	3450	3756	3624	3594	3582
17	2892	2970	3096	2934	2958	2796	2704,94	2694	2916	2598	2694	2706	2634	2550	2574
18	1824	1722	1788	1692	1764	1608	1521,85	1470	1686	1518	1548	1500	1554	1422	1530
19	672	594	537	577,8	624	528	403,68	484,5	537	492	468	477	472	393	477
20	60	135	65	135	60	75	0	90	60	90	0	90	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	AUGUST															
	DAYS															
HOURS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	504	396	313	387	322,5	309	369	345	271	319,5	325,5	240	401,67	346,5	227,5	240
7	1362	1338	1158	1320	1296	1176	1206	1176	1134	1182	1320	1050	1278	1356	978	1104
8	2718	2592	2538	2466	2610	2406	2418	2454	2586	2460	2664	2496	2628	2586	2280	2442
9	4086	3834	4056	3612	3888	3666	3654	3660	3876	3654	3780	3732	3882	3708	3798	3744
10	4932	4782	4932	4452	4908	4518	4566	4686	4710	4494	4782	4692	4806	4806	4704	4578
11	5484	5430	5550	5118	5586	5178	5292	5292	5424	5046	5436	5322	5358	5424	5316	5334
12	5556	5838	5838	5490	5814	5430	5568	5670	5658	5286	5592	5694	5766	5736	5658	5700
13	5400	5724	5748	5430	5376	5394	5472	5616	5562	4980	5466	5706	5790	5802	5604	5520
14	5196	4734	5322	4788	5004	4698	5346	4878	4884	4356	4824	5310	5358	5310	4902	5214
15	4662	4482	4686	3714	4158	4188	4656	4332	4386	3756	4224	4662	4506	4632	4332	4554
16	3672	3564	3750	3042	3510	3336	3822	3408	3606	3258	3594	3582	3636	3582	3474	3696
17	2580	2436	2376	2256	2526	2394	2658	2430	2406	2292	2550	2598	2634	2592	2562	2544
18	1338	1440	1146	1242	1374	1296	1518	1416	1296	1278	1386	1458	1398	1440	1290	1326
19	414	429	323	342	444	343,5	504	418,5	333	343	364,5	364,5	337,5	315	230,5	273
20	20	0	90	15	60	0	60	0	0	0	0	30	30	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	AUGUST														
	DAYS														
HOURS	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	330	275	243,33	268,33	216,67	309,38	298,33	212,5	246,67	193,13	176,25	266,67	217,5	140	121,67
7	1170	1134	1134	1050	1050	1164	1110	1032	1086	1008	1068	1140	990	960	960
8	2460	2520	2400	2370	2334	2502	2376	2340	2418	2274	2394	2358	2238	2286	2184
9	3696	3816	3666	3678	3708	3768	3618	3654	3744	3516	3714	3696	3636	3504	3486
10	4692	4770	4434	4608	4698	4668	4602	4674	4554	4536	4680	4596	4584	4500	4452
11	5358	5358	4974	5268	5238	5358	5250	5322	5172	5256	5352	5226	5274	5178	5160
12	5652	5676	5148	5568	5544	5688	5562	5580	5532	5562	5658	5664	5652	5478	5340
13	5622	5616	4740	5598	5508	5610	5382	5502	5514	5646	5706	5628	5640	5352	5544
14	5118	5028	4398	5190	5058	4698	4854	5082	4770	4860	5112	5220	5178	4890	5070
15	4212	4488	3996	4410	4206	3960	4266	4350	4116	4170	4356	4188	4572	4062	4326
16	3366	3528	3318	3570	3342	3186	3330	3420	3390	3378	3366	3318	3462	3180	3252
17	2598	2412	2370	2400	2298	2220	2388	2316	2298	2322	2238	2394	2274	2238	2226
18	1428	1230	1206	1284	1200	1104	1242	1080	1188	1122	1098	1260	1104	1026	1005
19	381	270	282	355,5	283,33	237	265,5	238,13	326,67	243,75	217,5	210	226,5	142,5	188,33
20	0	0	0	0	0	0	0	0	0	0	0	0	240	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	SEPTEMBER															
	DAYS															
HOURS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	150	0	0	0	0	0	0	0	0	0
6	130	105	139,29	107,14	90	95,63	272,5	97,22	50,83	87,5	207,5	75	67,5	30	100	90
7	906	924	930	840	870	906	1032	906	720	816	870	738	768	744	673	732
8	2328	2244	2244	2136	2202	2292	2328	2088	1986	2046	2220	2028	2136	1998	1848	2010
9	3690	3612	3612	3480	3540	3594	3600	3420	3120	3354	3426	3336	3444	3348	3108	3414
10	4668	4566	4518	4452	4542	4560	4494	4290	3984	4254	4236	4260	4230	4164	4068	4260
11	5166	5238	5166	5082	5184	5034	5076	5028	4872	4938	4758	4830	4746	4824	4860	4818
12	5376	5526	5526	5244	5388	5256	5334	5130	5352	5334	4968	5208	4884	5202	5112	5166
13	5256	5208	5460	5184	5328	5076	5286	5016	5064	5214	4566	4938	4794	5058	4872	5082
14	4884	4854	5016	4932	4884	4716	4662	4674	4710	4584	4230	4386	4362	4380	4398	4656
15	4218	4200	4206	4050	4182	4134	3876	4002	4110	3888	3642	3612	3834	3858	3822	3912
16	3252	3348	3270	3162	3240	3132	2784	3084	3108	3174	2628	2820	3012	2814	2934	2850
17	2040	2106	2208	2172	1956	2022	1842	1854	1950	2058	1638	1908	1806	1890	1788	1703
18	912	936	942	912	777	777	793,33	716	734	825	597	657	678	702	628	633,33
19	150	208,75	187,22	136,25	89,44	156,67	167,14	140	116	190	112,5	120	195	225	243,75	300
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	SEPTEMBER														
	DAYS														
HOURS	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
6	66	82,5	67,5	70	52,5	37,5	45	0	90	30	35	0	0	22,5	
7	678	639	684	648	678	594	556,5	528	646,5	427,5	447	495	385,5	398	
8	1806	1854	1932	1824	1944	1740	1686	1656	1836	1482	1416	1614	1422	1470	
9	3048	3180	3162	3216	3228	2940	2928	3072	3090	2694	2808	2736	2688	2784	
10	4098	4236	4068	4068	4116	3698	3792	4068	3888	3846	3678	3834	3474	3624	
11	4824	4914	4764	4656	4734	4494	4674	4752	4506	4326	4428	4506	3720	4488	
12	5106	5154	5118	5064	5004	4428	4932	4914	4302	4512	4632	4440	4242	4830	
13	4992	5082	5034	4728	4806	4794	4668	4842	3696	4632	4344	4392	4380	4470	
14	4386	4656	4608	4278	4182	4230	4578	4278	3540	4050	3624	3738	3864	3594	
15	3690	3798	3834	3264	3384	3336	3516	3534	2934	3348	3168	2802	3294	2976	
16	2760	2808	2856	2436	2634	2688	2718	2694	2298	2412	2346	2100	2406	2154	
17	1560	1704	1674	1377	1368	1488	1608	1548	1338	1440	1356	1302	1434	1236	
18	537	472	526	495,56	417	424,5	579	424,5	480	451,5	367,5	396	319	320	
19	420	180	240	300	240	360	210	210	120	120	300	300	0	90	
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

	OCTOBER															
	DAYS															
HOURS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	30	30	0	30	30	0	15	0	0	0	90	0	0	0
7	467	401	331	448	460	302	399	274,5	299	247	342,22	259	353,5	314,5	283	236,5
8	1596	1476	1416	1512	1500	1242	1398	1326	1338	1104	1092	1188	1326	1224	1320	1242
9	2766	2574	2586	2766	2748	2424	2490	2622	2544	2238	2292	2430	2538	2346	2388	2304
10	3648	3702	3372	3768	3804	3438	3438	3678	3588	3450	3210	3336	3378	3288	3096	3126
11	4452	4554	4104	4506	4482	4026	4122	4350	3900	4062	3864	3840	4122	3876	3762	3630
12	4704	4716	4026	4650	4866	4290	4452	4602	4290	4074	3930	4236	4476	4128	4068	3786
13	4494	4254	4158	4344	4602	4062	4350	4458	4110	3948	4056	4074	4404	3816	3816	3540
14	4032	3624	3726	3648	4074	3558	3798	3840	3594	3426	3588	3732	3792	3492	3240	3306
15	3060	3096	2976	2970	3318	3108	2934	3186	2748	2772	3054	2922	3066	2760	2460	2724
16	2142	2220	2136	2136	2370	2112	1962	2214	1800	1926	2106	2004	2076	1932	1584	1764
17	1236	960	987	1086	1194	1074	906	1074	936	936	780	900	882	848	498	786
18	370	190	286,25	315,56	313,5	219,5	195,56	186	178,13	146,67	161,67	141,88	194,29	240	67,14	134,17
19	240	0	30	90	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	OCTOBER														
	DAYS														
HOURS	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	310	234,44	191,11	297	264,5	215,5	174,44	164	216,25	186	228,75	128,57	105	147,5	133,75
8	1122	930	984	1176	1044	1146	1398	942	804	948	792	606	504	828	624
9	2400	2100	2148	2130	2178	2124	2352	1920	1716	1950	1722	1476	1506	1728	1374
10	3096	2916	3006	3168	2958	2988	3210	2646	2598	2970	2616	2124	2478	2556	2190
11	3648	3768	3576	3804	3528	3618	3636	3252	2868	3432	3066	2862	2844	2994	2580
12	3756	4218	3798	4086	3816	3966	4194	3474	3324	3642	3018	3102	2928	3198	2790
13	3408	4026	3504	4032	3684	4062	4080	3216	3270	3432	3216	2856	2748	3156	3018
14	2988	3462	3288	3246	3144	3630	3396	2910	2922	3078	2880	2826	2340	2652	2760
15	2262	2682	2682	2688	2502	2892	2790	2232	2136	2400	2262	2304	1866	2070	2202
16	1560	1896	1890	1740	1650	2046	1632	1524	1398	1476	1332	1374	1128	1200	1254
17	738	876	720	764	690	810	576	582	490	540	507	593,33	432	358,5	478,89
18	200	240,83	149,17	232,14	298	135,63	26,67	136	147,5	85	75	105	130	55	96,67
19	0	0	0	360	300	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	NOVEMBER															
	DAYS															
HOURS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	165	145	105	88,57	114,17	100,71	112,86	80	80	81,43	152,5	75	106,25	91,43	56	70
8	846	636	597	519	738	594	642	828	630	414	624	654	762	573,33	580	435
9	1878	1602	1284	1422	1794	1674	1596	1710	1470	1212	1518	1572	1794	1326	1416	1338
10	2748	2436	1974	2166	2592	2424	2166	2676	2244	2178	2394	2442	2664	2232	2244	2064
11	3372	3138	2652	2508	3396	2580	2724	3330	2898	2832	3036	2892	3204	2910	2628	2916
12	3546	3354	2934	2676	3402	2886	2934	3504	3090	3102	3288	3258	3216	3114	2898	3324
13	3420	3246	2808	2754	3222	2736	2658	3252	2790	2742	3072	3228	3228	2928	2814	3114
14	2994	2820	2502	2382	2856	2388	2244	2712	2418	2430	2556	2760	2700	2640	2490	2778
15	2094	2334	2112	1902	2142	1836	1776	1986	1740	2046	1794	2160	1950	1938	1938	2088
16	1296	1392	1248	1188	1182	1113,33	960	1074	966	1098	924	1176	945	1086	1044	1080
17	396,67	381	507	368	291	255	273	325,56	288,75	236,67	270	195	220	240	246,67	180
18	120	105	630	720	60	0	60	120	0	0	0	0	0	240	90	60
19	0	0	210	210	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	NOVEMBER														
	DAYS														
HOURS	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
7	61,43	45	105	57	42	66,67	63,75	80	65	95	212	48	22,5	90	
8	462	360	345	396	408	534	375	486	313,33	483,33	597	306	333,75	333	
9	1428	1122	1128	1254	1026	1452	1272	1230	1026,67	1286,67	1350	1140	900	798	
10	2076	1974	2022	2064	1680	2178	2022	1758	1410	1662	2130	1866	1602	1218	
11	2628	2484	2568	2622	2064	2532	2730	2142	1842	2244	2718	2298	2118	1836	
12	2760	2760	2808	2772	2310	2682	3216	2280	2256	2436	2970	2532	2280	2010	
13	2730	2640	2868	2550	2496	2442	2904	2364	1878	2292	2766	2724	2358	1884	
14	2310	2364	2394	2076	2274	2112	2586	2184	1608	1968	2442	2358	1956	1680	
15	1686	1782	1812	1596	1710	1626	1974	1626	1302	1368	1848	1812	1428	1308	
16	978	990	996	920	846	918	954	768	620	750	909	816	756	594	
17	183	232,5	241,5	180	157,5	166,67	179	195	150	223,75	145,71	161,25	156,67	163,13	
18	0	0	90	0	0	60	180	0	0	240	0	0	60	0	
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

	DECEMBER															
	DAYS															
HOURS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	40	40	35	30	45	60	10	0	0	45	20	0	127,5	30	0	0
8	327	258	310	234	220	136,67	183	109	155	288	223,33	163,33	218,57	140	243,33	207
9	1134	852	864	876	792	624	666	450	510	918	840	780	600	666	926,67	726
10	1974	1614	1410	1506	1542	1380	1248	1020	1002	1794	1632	1320	1176	1452	1370	1206
11	2526	2166	1902	2022	2226	1854	1830	1308	1392	2358	2268	1956	1794	2034	1674	1782
12	2688	2250	2100	2166	2352	1926	1884	1398	1578	2376	2526	2256	1770	1824	1764	1944
13	2640	2268	2112	2280	2298	2016	1812	1452	1848	2472	2304	2076	1932	1854	1980	2202
14	2154	2058	1872	2100	2262	1836	1662	1368	1758	2196	2118	1794	1788	1836	1638	1920
15	1656	1578	1548	1524	1632	1224	1254	1200	1380	1662	1500	1398	1266	1332	1386	1308
16	894	750	846	702	840	576	642	572	618	822	696	684	630	618	820	654
17	170	195	134,44	163,5	170	124,5	183,75	165	190	150	107,78	196,67	154,44	150	162,22	150
18	0	0	0	0	0	90	0	0	0	0	0	240	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	DECEMBER														
	DAYS														
HOURS	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	15	17,5	0	0	0	15	0	0	0	30	0	0	0	0	0
8	270	184,29	202,78	168,75	177	165	131,25	146,25	125,83	125	148,13	92,86	111	216,11	103,13
9	813,33	529,5	726	603	762	720	477	697,5	606,67	593,33	666,67	594	582	853,33	564
10	1440	1020	1236	1254	1554	1242	942	1153,33	1071	1236	1314	1224	1170	1494	1332
11	1866	1428	1596	1830	2094	1806	1302	1373,33	1746	1596	1830	1890	1716	1968	1830
12	1956	1512	1728	1860	2268	2076	1428	1453,33	1908	1458	1896	2094	1812	2244	1980
13	1986	1650	1920	1974	2502	2382	1446	1332	1710	1692	2004	1980	1710	2310	1992
14	1752	1590	1608	1992	2280	2058	1368	1386	1500	2022	2112	1962	1428	1926	1770
15	1158	1062	1212	1458	1602	1410	942	1008	1290	1386	1660	1362	1092	1452	1482
16	570	666	696	714	834	666	495	750	720	642	956,67	740	630	746,67	906,67
17	96,67	178,89	126,43	132	189	117,5	150,56	150	180	164,44	266,25	370	134,67	238,57	202,78
18	0	0	0	0	0	0	0	0	30	0	45	0	15	0	30
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

APPENDIX B

Ambient Air Temperature Data for Gaziantep [unit of data in tables, ^oC]

	JANUARY															
	DAYS															
HOURS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	3,46	3,96	3,72	3,21	3,72	4,57	4,28	3,4	2,36	2,65	2,87	2,75	3,2	3,39	3,25	2,78
2	3,27	3,77	3,55	3,09	3,52	4,47	3,99	3,23	1,9	2,41	2,61	2,61	3,03	3,12	3,13	2,48
3	3,12	3,72	3,22	3	3,49	4,21	3,9	3,09	1,76	2,08	2,43	2,54	2,67	2,86	3,08	2,21
4	3,01	3,59	3	2,83	3,47	4,1	3,72	2,88	1,62	1,85	2,27	2,5	2,42	2,73	2,93	1,94
5	2,74	3,63	2,81	2,72	3,51	3,84	3,6	2,67	1,36	1,5	2,03	2,54	2,46	2,55	2,7	1,73
6	2,29	3,61	2,62	2,67	3,56	3,83	3,63	2,35	1,28	1,2	1,94	2,5	2,38	2,33	2,66	1,47
7	2,01	3,38	2,56	2,63	3,48	3,88	3,4	1,99	1,12	1,29	1,67	2,5	2,29	2,13	2,46	1,34
8	2,15	3,45	2,84	2,95	3,47	4,23	3,55	2,18	1,56	1,65	2,08	2,62	2,46	2,41	2,83	1,83
9	3,91	4,61	4,12	4,19	3,95	5,45	4,86	3,79	3,54	3,33	3,51	4,01	4,32	4,38	3,73	3,95
10	6,48	5,89	6,03	5,4	4,24	6,4	6,3	5,16	5,39	5,29	4,93	6,1	6,43	6,01	5,03	5,79
11	8,04	6,99	7,3	6,63	4,61	7,02	6,98	6,4	6,76	6,4	5,88	7,48	7,78	7,2	6	7,05
12	8,6	7,56	7,75	7	4,93	7,74	7,35	7,03	7,57	7,03	6,42	8,56	8,84	7,99	6,94	7,94
13	8,91	8,13	8,34	7,32	5,32	8,18	7,52	7,48	8,19	7,28	7,06	9,03	9,08	8,39	7,64	8,74
14	9,49	8,23	8,66	7,4	5,74	8,23	7,61	7,99	8,35	7,33	7,24	9,31	9,48	8,59	8,06	9,26
15	9,37	8,14	8,4	7,3	5,8	8,09	7,64	7,73	8,2	7,23	7,13	9,04	9,35	8,27	8,14	9,2
16	8,95	7,84	7,74	6,65	5,64	7,85	7,33	7,27	7,8	6,79	6,56	8,47	8,76	7,83	7,68	8,6
17	7,57	6,79	6,86	5,6	5,23	7,08	6,44	6,11	6,33	6,03	5,72	7,24	7,55	6,67	6,63	7,16
18	6,4	5,95	6,02	5,19	4,86	6,34	5,67	5,25	5,86	5,27	4,92	6,3	6,52	5,82	5,58	5,77
19	5,68	5,34	5,19	4,73	4,65	5,78	5,08	4,55	4,5	4,9	4,4	5,38	5,47	5,07	5,07	4,71
20	5,18	5,08	4,68	4,54	4,56	5,49	4,71	4,09	3,97	4,52	4,05	4,84	5,06	4,53	4,42	4,12
21	4,93	4,82	4,46	4,41	4,6	5,19	4,44	3,5	3,63	4,25	3,56	4,32	4,56	4,23	3,98	3,65
22	4,6	4,44	4,11	4,1	4,69	4,81	4,16	3,31	3,32	3,82	3,34	4,07	4,11	3,95	3,64	2,92
23	4,39	4,17	3,8	3,78	4,6	4,57	3,83	3,13	2,99	3,45	3,15	3,89	3,75	3,6	3,27	2,48
24	4,21	3,95	3,46	3,65	4,7	4,39	3,52	2,71	2,77	3,08	2,92	3,46	3,48	3,43	3,07	2,21

	JANUARY														
	DAYS														
HOURS	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1	1,92	2,05	1,93	2,37	1,29	2,24	2,77	2,16	1,39	2,4	1,12	0,82	1,29	1,59	2,3
2	1,65	1,69	1,65	2,21	1,12	2,39	2,76	1,99	1,33	2,14	1,01	0,72	1,15	1,44	2,13
3	1,31	1,43	1,42	2,12	0,98	2,49	2,8	1,61	1,3	1,81	0,89	0,71	1,01	1,3	1,92
4	1,36	1,13	1,12	2,05	0,68	2,35	2,45	1,53	1,13	1,49	0,66	0,44	0,81	1,09	1,73
5	1,37	1,03	0,81	1,94	0,69	2,2	2,17	1,43	1,03	1,21	0,59	0,33	0,74	0,89	1,69
6	1,1	0,78	0,72	1,83	0,62	2,01	2,1	1,28	0,85	1,07	0,38	0,34	0,53	0,57	1,6
7	1,09	0,76	0,53	1,76	0,43	1,94	2,11	1,2	0,94	0,76	0,26	0,42	0,59	0,61	1,48
8	1,48	1,2	1,02	1,85	0,75	1,94	2,21	1,45	1,39	1,04	0,41	0,72	1,78	1,34	1,46
9	3,61	2,58	3,21	3,27	2,29	2,59	2,7	2,98	3,27	3,31	2,46	2,01	3,4	3,47	3,28
10	5,82	4,02	5,08	4,5	4,07	3,5	3,42	4,28	4,85	5,53	3,82	3,29	5,23	5,24	4,72
11	7,5	5,33	5,98	5,22	5,22	4,07	3,98	5,08	6,16	6,9	4,68	4,47	6,31	6,15	6,05
12	8,3	6,05	6,88	5,87	5,69	4,25	4,48	5,53	6,71	7,61	5,09	5,43	7,14	6,86	6,95
13	9,21	6,34	7,21	5,99	5,97	4,51	4,77	6,07	7,04	7,98	5,64	5,91	7,83	7,25	7,61
14	9,58	6,77	7,52	6,14	6,29	4,63	5,03	6,37	7,22	8,16	5,96	6,27	8,08	7,56	8,07
15	9,59	6,79	7,67	6,01	6,46	4,56	5,4	6,33	7,31	7,79	5,8	6,43	7,83	7,34	8,27
16	8,83	6,36	7,31	5,97	6,17	4,29	5,21	6	7,08	7,56	5,43	5,98	7,62	7,12	7,9
17	7,09	5,24	5,95	5,26	5,31	4,02	4,45	5,18	5,93	6,5	4,67	5,05	6,51	6,27	6,76
18	5,87	4,27	4,86	4,28	4,48	3,74	3,92	4,38	5,03	5,08	3,46	4,18	5,37	5,47	5,79
19	4,86	3,68	3,85	3,67	3,72	3,56	3,46	3,75	4,41	4,17	2,61	3,31	4,11	4,61	4,94
20	4,1	3,39	3,4	3,04	3,34	3,3	3,21	3,24	3,88	3,44	2,18	2,66	3,37	4,06	4,46
21	3,59	3,21	3,2	2,45	3,01	3,21	3,04	2,76	3,61	2,68	1,77	2,16	3,08	3,69	3,7
22	2,88	2,87	2,62	1,96	2,69	3,03	2,72	2,34	3,14	2,08	1,48	1,94	2,34	3,18	2,98
23	2,64	2,51	2,45	1,73	2,43	2,95	2,45	1,92	2,71	1,59	1,27	1,63	2,15	3,05	2,56
24	2,43	2,16	2,43	1,56	2,28	2,91	2,3	1,67	2,43	1,36	1,07	1,49	2,01	2,67	2,45

	FEBRUARY															
	DAYS															
HOURS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	2,08	2,43	2,63	2,05	2,42	2,54	3,27	2,95	2,28	1,79	2,63	2,02	3,45	4,07	1,91	1,76
2	1,6	2,32	2,25	1,83	1,88	2,36	3,05	2,78	1,94	1,6	2,09	1,62	3,39	3,86	1,54	1,59
3	1,37	2,12	2,12	1,53	1,83	2,21	2,76	2,45	1,62	1,08	1,85	1,38	3,37	3,58	1,34	1,48
4	1,29	1,91	2,08	1,14	2,03	2,18	2,63	2,35	1,4	0,98	1,82	1,16	3,29	3,42	1,38	1,27
5	1,02	1,72	1,63	0,85	1,71	2,08	2,31	2,29	1,26	0,85	1,61	1,03	3,17	3,26	0,98	1,23
6	0,95	1,72	1,65	0,68	1,61	1,93	2,1	1,99	0,97	0,63	1,44	0,95	3,03	3,19	1,09	1,15
7	0,88	1,64	1,69	0,45	1,46	2,05	1,96	1,63	0,76	0,61	1,35	0,85	3,08	3,03	0,71	1,15
8	1,27	2,07	2,01	0,76	2,03	2,97	2,39	2,25	1,31	1,29	1,87	1,48	3,6	3,24	1,69	1,58
9	2,8	4,09	3,69	2,86	3,52	4,16	4,53	3,98	3,77	4,73	4,33	4,16	4,72	5,09	3,43	3,11
10	4,76	5,11	4,76	4,85	4,66	5,67	5,92	5,61	5,89	6,54	6,01	5,98	5,87	6,4	5,04	4,61
11	5,95	5,99	5,49	5,97	5,66	6,82	7,98	7,08	7,48	7,94	7,25	7,04	6,79	7	5,77	5,63
12	7,07	6,86	5,89	6,63	6,24	7,43	8,44	8,02	8,46	8,57	7,92	7,93	7,29	7,16	6,18	6,12
13	8,01	7,14	6,27	7,14	6,48	7,68	8,8	9,05	9,11	9,09	8,33	8,52	7,67	7,16	6,48	6,81
14	8,55	7,45	6,6	7,57	6,58	8,22	8,63	9,57	9,34	9,36	8,73	8,7	7,89	7,24	6,81	7,19
15	8,71	8,43	6,77	7,63	6,26	8,09	8,45	9,72	9,38	9,29	8,84	8,51	7,92	6,74	6,76	6,99
16	8,41	7,91	6,68	7,13	6,17	7,89	8,3	9,38	8,7	8,98	8,57	8,07	7,72	6,22	6,3	6,67
17	7,2	7,15	5,71	6,19	5,44	7,23	7,22	8,08	7,45	7,88	7,45	7,21	7,08	5,49	5,21	5,86
18	6,03	6,46	4,78	5,23	4,6	6,33	6,27	6,33	6,21	6,63	6,29	6,38	6,25	4,75	4,21	5,1
19	4,89	5,66	4,08	4,25	4,1	5,7	5,38	5,13	5,03	5,68	4,9	5,64	5,88	3,89	3,46	4,41
20	4,3	5,34	3,62	3,72	3,64	5,09	5,04	4,38	4,28	4,96	4,31	4,96	5,3	3,45	3,08	3,65
21	4,07	4,03	3,2	3,27	3,43	4,47	4,85	3,91	3,51	4,33	3,69	4,74	4,88	3,16	2,84	3,17
22	3,47	3,4	2,86	2,83	3,29	3,96	4,22	3,1	2,89	3,55	3,21	4,31	4,36	2,65	2,42	2,62
23	2,68	3,03	2,64	2,62	3,07	3,65	3,82	2,85	2,52	3,21	2,76	4	4,08	2,35	2,16	2,43
24	2,64	2,82	2,38	2,38	2,85	3,41	3,28	2,54	2,31	2,93	2,42	3,6	3,99	2,15	1,96	2,2

	FEBRUARY														
	DAYS														
HOURS	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1	1,98	3,01	3,13	2,36	2,35	2,08	1,95	2,12	3,34	4,01	3,39	3,56	2,9		
2	1,38	2,78	2,97	2,18	2,14	1,87	1,81	1,88	3,12	3,71	3,06	3,12	2,85		
3	0,81	2,57	2,8	1,97	1,97	1,6	1,52	1,81	2,93	3,42	2,87	2,68	2,6		
4	0,54	2,28	2,81	1,85	1,74	1,49	1,15	1,68	2,82	3,02	2,84	2,52	2,45		
5	0,42	2,23	2,69	1,35	1,85	0,94	1,04	1,66	2,73	3,02	2,64	2,35	2,45		
6	0,31	2,28	2,54	1,02	1,84	0,83	0,85	1,51	2,76	2,57	2,39	2,4	2,2		
7	0,18	2,35	2,35	0,94	1,6	0,56	0,71	1,5	2,69	2,48	2,11	2,6	2,1		
8	1,31	3,18	3,29	2,33	2,53	2,02	1,72	2,47	3,55	3,55	3,22	3,99	3,8		
9	3,56	4,58	5,08	4,79	4,35	4,17	3,87	4,38	5,01	5,33	5,93	6,74	6,5		
10	5,19	5,79	6,37	6,57	6,03	6,09	5,66	5,75	6,99	7,07	8,03	8,57	8		
11	6,53	6,87	7,24	7,7	7,12	7,11	7,09	6,63	8,32	8,19	9,28	9,95	9,4		
12	7,52	7,55	8	8,51	7,63	7,83	8,34	7,57	8,74	9,04	10,2	10,68	10,35		
13	8,13	7,92	8,59	9,11	7,9	8,24	9,12	7,87	9,09	9,87	10,78	11,08	11		
14	8,61	8,01	8,8	9,48	8,26	8,17	9,69	8,05	9,3	10,41	11,69	11,47	12		
15	8,43	8,08	8,73	9,16	8,32	7,93	9,77	8,15	9,33	10,48	11,47	11,57	12		
16	8,01	7,95	8,42	8,58	8,38	7,52	9,23	8,06	9,09	10,12	10,97	11,34	12		
17	7,25	7,59	7,21	7,44	7,11	6,6	7,89	7,32	8,27	9,1	9,46	10,47	10,9		
18	6,72	6,64	6,4	6,42	6,15	5,75	6,7	6,79	7,34	8,04	8,42	9,31	9,55		
19	5,85	5,88	5,05	5,39	5,33	4,69	5,59	6,11	6,55	6,93	7,24	8,17	8,5		
20	5,22	5,24	4,52	4,78	4,47	4,17	4,82	5,59	6,04	5,96	6,43	7,45	8		
21	4,64	4,77	4,26	4,1	3,89	3,55	4,04	4,8	5,6	5,37	5,43	7	7,75		
22	4,3	4,22	3,8	3,38	3,53	3,24	3,46	4,59	5,25	4,69	4,93	6,47	7,65		
23	3,89	3,83	3,48	2,99	2,98	2,76	2,87	4,12	4,86	4,08	4,33	6,16	7,7		
24	3,5	3,5	3,09	2,69	2,38	2,32	2,37	3,67	4,58	3,72	3,99	5,65	7,45		

	MARCH															
	DAYS															
HOURS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	6,24	5,62	6,81	7,2	6,21	7,37	5,81	5,86	5,81	4,97	5,91	6,29	6,23	6,1	6,67	5,91
2	6,01	5,44	6,67	6,88	5,92	6,86	5,46	5,59	5,44	4,63	5,58	5,93	5,77	5,73	5,9	5,58
3	5,69	5,13	6,87	6,31	5,58	6,47	5,09	5,39	5,16	3,96	5,38	5,89	5,27	5,16	5,51	5,38
4	5,33	4,81	6,64	5,98	5,13	6,23	4,82	5,17	4,96	3,57	5,06	5,6	4,91	5,05	5,17	5,09
5	4,97	4,56	6,32	5,8	4,83	6,19	4,46	4,92	4,73	3,13	4,8	5,47	4,69	4,78	4,86	4,77
6	4,63	4,32	6,25	5,37	4,58	5,95	4,24	4,81	4,62	2,87	4,6	5,26	4,34	4,76	4,59	4,56
7	4,33	4,61	6,11	5,38	4,77	5,87	4,19	4,8	4,7	2,99	4,49	5,31	4,28	4,96	4,87	4,67
8	5,38	6,22	7,07	6,52	6,38	6,98	5,82	6,74	5,78	4,34	5,82	6,16	6,22	6,53	5,91	5,95
9	7,95	9,22	9,04	8,83	10,56	9,85	8,71	8,68	9,12	7,15	8,34	8,79	9,39	9,6	7,81	8,53
10	10,03	11,07	10,7	11,3	12,9	11,58	10,46	10,68	10,67	9,83	10,47	10,42	11,26	11,11	9,76	10,37
11	11,43	12,19	11,72	12,72	14,43	12,71	11,46	11,59	11,7	10,91	11,64	11,47	12,48	12,24	10,5	11,56
12	12,25	13,1	12,5	13,55	15,16	13,2	12,27	12,41	12,32	11,51	12,54	12,43	13,38	13,05	11,03	12,13
13	13,03	13,76	13,14	14,26	15,72	13,5	12,76	12,89	12,97	12,43	13,09	12,86	13,95	13,23	11,18	12,91
14	13,54	14,12	13,42	14,75	16,02	13,7	13,03	13,13	13,32	12,56	13,79	13,18	14,47	13,55	11,25	13,27
15	13,57	14,01	13,3	14,84	16,14	13,9	13,1	12,76	13,09	12,37	13,95	13,25	14,23	13,56	12,05	13,45
16	13,2	13,97	12,94	14,31	15,63	13,59	12,73	12,29	12,29	11,87	13,52	12,91	13,68	13,01	12,15	12,86
17	12,09	12,76	12,23	13,45	14,44	12,38	12,07	11,57	11,28	11,21	12,56	12,34	13,45	12,32	11,58	12,33
18	10,85	11,24	11,3	12,02	13,12	10,91	11,05	10,55	10,28	10,05	11,47	11,29	12,39	11,05	10,48	11,14
19	9,48	9,89	10,12	10,45	11,76	9,7	9,8	9,27	9,12	9,03	10,53	10,19	10,94	9,98	9,49	9,87
20	8,76	9,13	9,37	9,36	10,41	8,84	8,9	8,49	8,11	8,35	9,56	9,66	9,84	9,36	8,94	8,92
21	8,16	8,62	9,14	8,54	9,69	7,78	8,18	7,77	7,19	7,87	8,86	8,37	8,7	8,59	8,17	8,06
22	7,41	8	8,53	7,7	8,79	7,04	7,57	7,09	6,34	7,31	8,07	7,67	8,04	8,07	7,43	7,12
23	6,9	7,65	8,06	7,13	8,26	6,55	7,01	6,72	5,77	6,76	7,31	6,99	7,49	7,44	6,83	6,88
24	6,27	7,32	7,56	6,61	7,82	6,26	6,34	6,25	5,42	6,36	6,86	6,35	6,88	7,13	6,35	6,39

	MARCH														
	DAYS														
HOURS	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1	6	6,72	5,95	5,02	5,85	6,37	6	5,14	6,74	6,23	6,26	7,12	6,94	7,79	7,94
2	5,55	6,44	5,59	4,78	5,62	5,97	5,61	4,81	6,54	5,49	5,97	6,67	6,51	7,37	7,51
3	5,21	5,83	5,31	4,53	5,44	5,57	5,45	4,56	6,01	4,91	5,45	6,34	6,02	7,26	7,28
4	4,61	5,55	5,14	4,42	5,13	5,26	5,35	4,5	5,81	4,62	5,27	5,95	5,84	6,93	7,12
5	4,2	5,2	4,84	4,12	4,99	5,04	5,06	4,37	5,38	4,63	5,02	5,73	5,59	6,81	6,86
6	3,78	5,16	4,6	4,07	4,8	4,92	4,85	4,16	5,28	4,49	4,81	5,67	5,68	6,66	6,62
7	4,23	5,62	4,81	4,54	4,98	5,27	5,26	4,43	5,72	5,07	5,14	6,03	6,2	7,35	7,2
8	6,25	6,79	6,18	6,04	6,77	6,62	6,76	5,9	7,03	6,45	6,85	7,87	7,71	8,9	9,43
9	9,28	9,28	7,94	8,23	8,72	9,22	8,81	8,33	9,12	8,58	9,65	10,42	10,11	11,8	11,9
10	11,34	11,05	9,16	9,61	9,89	10,71	10,21	9,86	10,56	10,09	11,36	12,5	12,46	13,35	13,47
11	12,54	11,97	10,16	10,55	10,71	11,38	10,76	10,83	11,56	11,08	12,99	13,57	13,23	14,28	14,67
12	13,19	11,65	10,26	11,51	11,19	12,39	11,4	11,3	12,01	11,82	13,78	14,24	14,36	14,92	15,63
13	13,68	12,27	10,29	11,8	11,32	12,72	11,64	12,04	12,52	12,39	14,23	14,69	14,65	15,57	16,24
14	13,91	11,96	10,89	12,09	11,38	12,58	12,08	12,1	12,67	12,77	14,9	14,78	15,03	15,93	16,59
15	14,06	11,83	10,9	12,14	11,12	12,85	12,18	12,07	12,69	12,7	14,64	14,45	15,18	15,22	16,56
16	13,88	11,54	10,67	12,16	10,83	12,52	11,77	11,91	12,53	12,67	13,85	14,25	15,09	15,07	16,21
17	12,74	11,04	9,89	11,36	10,54	12	11,16	11,35	11,89	11,85	13,47	13,47	14,38	14,22	15,54
18	11,78	10,17	8,8	10,09	9,61	10,68	10,01	10,3	10,41	10,79	12,34	12,65	13,27	13,31	14,62
19	10,29	8,96	7,82	8,81	8,72	9,27	8,96	9,48	9,25	9,64	11,3	11,32	11,85	12,03	13,57
20	9,53	8,21	7,34	8,1	8,27	8,45	7,93	8,69	8,6	8,95	10,36	10,13	10,91	11,12	12,93
21	8,91	7,57	7,08	7,57	7,79	8,07	7,28	8,09	8,34	8,22	9,63	9,41	10,22	10,53	12,23
22	8,03	6,99	6,24	6,88	7,26	7,34	6,67	7,71	7,77	7,62	8,8	8,66	9,33	9,63	11,22
23	7,49	6,47	5,71	6,33	6,77	6,9	6,27	7,19	7,31	7,12	8,28	8,08	8,82	8,95	10,65
24	6,9	6,29	5,37	6,08	6,49	6,47	5,62	7,15	6,79	6,64	7,57	7,72	8,22	8,44	10,07

	APRIL															
	DAYS															
HOURS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	9,54	10,73	9,67	8,05	8,1	8,66	8,2	8,68	9,93	9,32	10,02	10,64	11,19	12,72	11,97	11,32
2	9,43	10,33	9,35	7,84	7,8	8,14	8	8,42	9,46	8,98	9,58	10,35	10,83	12,14	11,63	10,89
3	9,13	9,83	9,19	7,45	7,65	7,84	7,77	7,91	9,22	8,59	9,14	10	10,53	11,56	11,31	10,31
4	9,08	9,27	8,92	7,26	7,31	7,64	7,41	7,73	8,88	8,16	8,92	9,91	10,26	11,32	11,07	10,06
5	8,84	9	8,64	7,06	7,01	7,5	7,18	7,48	8,67	7,76	8,6	9,89	10,08	10,95	10,8	9,73
6	8,59	8,83	8,52	7,1	6,88	7,28	7,03	7,56	8,54	8,06	8,52	9,92	10,13	10,92	10,61	9,72
7	8,96	9,03	8,83	7,66	7,91	7,92	7,96	8,19	9,28	9,03	9,71	10,47	11,3	11,66	11,85	10,89
8	10,92	9,91	9,67	9,04	9,6	10,25	9,7	10,38	10,98	11,05	12,26	13,07	13,88	14,23	13,85	13,17
9	12,83	11,64	10,88	11,34	11,95	12,79	11,85	13,08	13,3	13,84	15,14	15,83	16,11	17,45	15,74	15,31
10	14,31	12,61	11,74	12,95	13,13	14,45	13,37	14,56	14,38	15,72	17,01	17,66	18,27	19,04	16,89	16,24
11	15,32	13,27	12,93	13,92	13,91	15,26	14,34	15,65	15,42	16,78	18,59	19,03	19,53	20,18	17,48	17,33
12	15,9	13,59	13,79	14,39	14,65	15,54	14,33	16,33	16,07	17,87	19,05	19,58	20,32	20,8	18,01	17,76
13	16,24	13,88	14,67	14,57	15,58	16,1	15,65	16,74	17,06	18,74	19,56	20,19	20,55	21,12	18,81	18,05
14	16,46	14,07	15,22	14,69	16,16	16,14	16,34	16,97	17,71	19,27	19,74	20,46	21,3	21,33	18,73	18,45
15	16,03	13,89	15,33	14,54	15,84	16,19	16,31	16,72	17,56	19,21	19,52	20,22	21,55	21,15	18,42	18,3
16	15,77	13,59	15,07	14,17	15,81	15,89	15,88	16,96	17,71	18,9	19,27	19,83	21,25	20,6	18,41	17,85
17	15,39	12,7	14,4	13,49	15,1	15,65	15,23	16,32	17,04	18,14	18,81	19,15	20,61	19,93	17,58	17,23
18	14,39	12,11	13,02	12,23	14,17	14,18	13,78	15	15,47	16,72	17,45	17,75	19,3	18,54	16,07	16,37
19	13,31	11,55	11,75	11,03	12,89	12,98	12,64	13,62	14,13	14,97	15,49	16,18	17,71	17,04	14,88	15,19
20	12,77	11,12	10,84	10,3	12,08	12,05	11,78	12,8	12,83	13,7	14,27	14,76	16,72	15,74	14,08	14,41
21	12,17	11,16	10,11	9,64	11,31	11,35	10,86	11,74	12,13	12,69	13,17	14,1	15,83	14,91	13,39	13,52
22	11,6	10,76	9,25	9,1	10,51	10,3	10,05	11,31	11,03	11,86	12,14	12,92	15,12	14,1	12,88	12,76
23	11,55	10,46	8,74	8,71	10,01	9,29	9,64	10,73	10,37	11,15	11,54	12,48	14,05	13,15	12,54	12,16
24	11,04	10,1	8,34	8,47	9,33	8,68	9,12	10,18	9,71	10,67	10,98	11,95	13,37	12,52	12,11	11,76

	APRIL														
	DAYS														
HOURS	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1	11,26	12,02	12,34	11,15	10,45	10,85	11,05	11,82	11,42	11,12	11,09	10,74	11,45	11,15	
2	10,68	11,63	12,04	10,8	9,75	10,52	10,75	11,3	10,9	10,74	10,75	10,63	11,23	10,7	
3	10,34	11,27	11,48	10,42	9,42	10,52	10,4	11,08	10,42	10,24	10,52	10,17	10,76	10,15	
4	10,01	10,71	11,13	9,99	9,23	10,36	10,2	10,7	10,29	9,93	10,14	9,75	10,49	9,82	
5	10,03	10,6	10,89	9,7	9,04	10,18	10,02	10,55	9,95	9,49	9,8	9,63	10,21	9,9	
6	10,14	10,61	10,81	9,8	9,12	10,3	10,04	10,46	10,11	9,5	10,05	9,69	10,35	10,23	
7	11,14	11,73	11,69	10,63	10,4	11,08	10,95	11,37	11,14	10,67	11,06	11,35	11,83	11,98	
8	13,8	13,62	13,63	12,31	13,09	12,96	12,59	12,61	12,8	12,93	13,22	14,01	14,25	14,52	
9	16	16,09	15,95	14,21	15,28	14,92	14,77	14,45	15,62	15,41	16,14	16,68	17,1	17,21	
10	17,33	17,33	17,26	15,27	16,84	16,2	15,78	15,59	16,55	17,4	17,83	17,91	18,41	18,92	
11	19,01	18,04	17,97	16,29	17,76	16,51	16,6	16,72	17,59	18,35	18,5	18,96	19,66	19,8	
12	19,34	18,74	19,11	16,62	17,96	17,1	17,75	17,23	17,95	18,91	19,28	19,34	20,3	20,29	
13	19,4	19,02	19,74	17,42	18,07	18,08	18,27	17,59	18,28	19,34	19,91	19,95	20,42	20,97	
14	19,71	19,07	20,2	17,55	18,12	18,3	18,47	17,76	18,66	19,21	20,28	20,17	20,45	21,6	
15	19,77	18,99	20,14	18,03	17,21	18,3	18,31	17,63	18,37	19,56	20,35	20,24	19,49	21,57	
16	19,63	18,84	19,81	18,25	17,15	18,16	18,18	17,51	18,38	19,2	20,15	19,94	19,31	21,35	
17	18,99	18,33	18,38	17,29	16,91	17,39	17,71	16,91	18,33	18,49	19,33	19	18,43	20,83	
18	17,58	17,51	16,93	16,14	15,75	16,26	16,71	15,8	17,13	17,27	17,85	17,68	17,44	19,25	
19	16,19	16,43	15,52	14,76	14,34	14,86	15,6	14,69	15,74	15,53	16,52	16,23	16,62	17,57	
20	15,15	15,57	14,64	13,82	13,51	14,56	14,71	13,91	14,46	14,35	15,36	14,84	15,31	16,27	
21	14,49	14,82	13,63	13,23	13	13,36	13,88	13,24	13,66	13,6	14,46	14,1	14,32	15,17	
22	13,73	14,06	12,91	12,28	12,34	12,65	12,94	12,57	12,76	12,76	13,3	13,16	13,29	14,27	
23	13,18	13,58	12,35	11,72	11,71	12,17	12,54	12,18	12,05	12,08	12,5	12,57	12,58	13,64	
24	12,5	12,93	11,66	11,21	11,21	11,75	12,22	11,86	11,51	11,57	11,73	12,12	11,79	13,2	

	MAY															
	DAYS															
HOURS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	12,97	13,13	12,04	12,26	13,02	14,3	14,39	14,21	12,97	14,32	14,38	14,23	15,27	15,8	15,4	14,51
2	12,63	12,78	11,95	11,68	12,54	13,91	13,9	13,66	12,57	13,82	13,88	13,82	14,87	15,46	14,86	13,99
3	12,21	12,41	11,68	11,18	12,43	13,32	13,41	13,06	12,28	13,47	13,63	13,33	14,39	15,1	14,46	13,69
4	11,87	12,05	11,65	11,02	12,16	12,82	12,92	12,98	11,92	13,06	13,33	13,25	14,07	14,97	14,16	13,4
5	11,67	11,59	11,27	10,95	11,96	12,3	12,63	12,74	11,64	12,84	12,97	12,93	13,81	14,72	13,87	13,24
6	11,88	11,69	11,59	11,14	12,19	12,79	12,86	13,14	12,01	13,26	13,34	13,17	14,37	14,96	14,12	13,45
7	13,3	13,34	13,3	12,26	13,79	14,35	14,42	14,31	13,72	15,06	15,21	14,85	16,02	16,2	15,75	15,32
8	15,28	15	15,25	13,79	15,96	16,34	16,7	16,06	16,1	17,12	17,84	17,6	18,23	18	17,62	17,83
9	18,05	17,42	17,57	16,2	18,88	18,96	19,72	18,25	19,34	20,39	21,07	21,41	21,53	20,38	20,55	20,58
10	19,32	18,66	18,88	17,52	20,59	20,56	21,17	19,71	20,69	22,12	22,71	23,06	22,65	21,78	21,93	21,91
11	20,19	19,62	19,82	18,69	21,7	21,45	22,08	20,83	21,6	23,09	23,78	24,21	23,35	22,66	22,86	22,84
12	20,72	20	20,44	19,61	22,52	22,53	22,82	21,45	22,23	23,46	24,5	24,73	24,19	23,1	23,46	23,58
13	21,08	20,29	20,6	19,78	23,02	23,18	23,52	21,58	23,03	24,05	24,69	25,16	24,8	23,94	23,43	24,11
14	21,61	20,02	20,51	19,99	23,2	23,73	23,73	22,04	23,51	24,45	24,71	25,02	24,95	24,39	23,95	25,02
15	21,79	19,47	20,71	20,42	23,57	23,59	23,35	22,08	23,48	24,67	24,75	23,67	25,54	24,56	22,7	24,7
16	21,83	19,88	20,38	20,21	23,62	23,64	22,94	21,76	23,52	24,77	24,57	24,07	25,39	24,12	22,61	24,05
17	21,24	19,09	19,73	19,67	22,81	23	22,31	20,94	22,49	24,16	24,09	23,67	24,17	23,4	21,72	22,94
18	19,63	17,77	18,49	18,54	21,72	21,77	20,75	19,45	20,78	22,58	22,77	22,7	22,67	22,07	20,56	21,63
19	18,19	16,63	16,99	17,26	19,54	20,29	19,21	17,99	19,39	20,88	20,87	21,01	21,14	20,21	19,24	20,35
20	17,04	15,18	15,81	16,04	17,85	18,62	18,11	16,74	17,96	18,92	19,19	19,52	19,64	18,9	18,14	19,13
21	16,01	14,23	14,92	14,97	16,7	17,56	16,95	15,76	16,79	17,65	17,7	18,14	18,35	17,58	17,43	17,87
22	14,92	13,56	14,08	14,33	15,84	16,5	15,97	14,6	15,88	16,47	16,61	17,11	17,53	16,83	16,55	17,03
23	14,41	13,03	13,68	13,93	15,13	15,7	15,4	13,75	15,14	15,64	15,7	16,38	16,83	16,2	15,62	16,35
24	13,8	12,49	12,95	13,56	14,68	14,99	14,74	13,27	14,58	14,91	14,96	15,8	16,51	15,73	14,87	15,77

	MAY														
	DAYS														
HOURS	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1	15,24	14,98	15,18	15,31	16,31	16,58	16,77	16,87	16,9	16,02	17,02	17,33	17,41	17,66	16,82
2	14,69	14,41	14,89	14,7	15,66	16,21	16,39	16,26	16,33	15,47	16,49	16,86	17,27	17,33	16,4
3	14,33	13,79	14,57	14,41	15,31	15,69	15,93	15,81	15,98	15,03	16,13	16,3	16,71	16,61	15,89
4	13,98	13,38	14,51	14	15,11	15,31	15,7	15,36	15,43	14,59	15,78	16,01	16,48	16,16	15,61
5	13,61	13,19	14,35	13,66	14,81	14,67	15,57	15,07	15,05	14,49	15,32	15,55	16,36	15,71	15,24
6	13,88	13,55	14,81	13,99	14,94	15,19	15,96	15,53	15,53	15,01	15,71	16,11	16,76	16,06	15,71
7	15,35	15,44	16,59	15,84	16,7	17,1	17,75	17,49	17,55	17,04	18,03	18,05	18,38	17,85	17,54
8	17,82	17,7	18,67	17,9	18,66	19,8	20,55	20,62	20,11	20,04	20,34	20,42	20,57	20,07	19,65
9	20,62	20,12	20,9	20,14	20,66	22,48	23,27	23,23	22,91	22,72	23,31	22,94	23,07	22,9	22,21
10	22,24	21,43	22,63	22,07	22,48	24,29	25,14	24,6	24,65	24,33	24,62	24,35	24,6	24,35	23,73
11	22,83	22,1	23,79	22,94	23,67	25,63	26,23	25,53	25,54	25,44	25,79	25,46	25,7	25,4	24,73
12	23,18	22,75	24,48	23,45	24,61	25,91	26,87	26,41	26,2	25,98	26,46	26,14	26,61	25,9	25,08
13	23,82	23,74	25,34	23,92	25,15	26,19	27,41	27,04	26,81	26,44	26,99	27,03	27,46	26,5	25,38
14	23,86	24,28	25,73	23,97	25,67	26,59	27,71	27,29	27,2	27,08	27,6	26,82	27,77	26,75	25,91
15	23,77	24,11	25,77	24,51	25,86	26,73	27,64	27,33	27,47	26,76	27,82	27,28	27,91	26,73	26,15
16	23,8	23,99	25,69	24,35	25,6	26,66	27,3	27,14	27,09	26,89	27,08	27,13	27,44	26,51	25,78
17	22,96	23,01	25,05	23,76	24,91	25,66	26,34	26,4	26,35	25,46	26,27	26,26	26,71	25,63	24,92
18	20,86	21,79	23,28	22,59	23,78	24,15	24,19	24,9	24,7	24,27	25,15	24,78	24,69	24,46	23,26
19	19,23	20,02	21,63	21,23	22,38	22,46	22,63	22,99	22,93	22,12	23,56	23,13	23,33	22,77	21,82
20	18,08	18,71	19,67	19,94	20,77	21,13	21,23	21,58	21,18	21,04	21,99	21,19	21,93	21,24	20,56
21	17,37	17,88	18,25	18,64	19,59	20,25	20,14	19,97	19,73	19,93	20,76	20,22	20,65	20,24	19,45
22	16,61	16,51	17,59	17,84	18,57	18,56	19,07	19,05	18,59	18,68	19,71	19,39	19,69	19,19	18,46
23	16,09	15,94	16,8	17,47	17,75	17,88	18,37	18,26	17,6	18,02	18,94	18,87	18,8	18,27	17,75
24	15,55	15,8	15,91	16,98	16,99	17,36	17,63	17,43	16,71	17,51	18,14	18,37	18,22	17,61	17,37

	JUNE															
	DAYS															
HOURS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	16,52	17,61	17,95	17,94	19,02	18,91	18,66	19	19,98	19,37	19,43	19,13	19,87	20,61	21,14	20,82
2	15,96	17,23	17,57	17,8	18,44	18,29	18,11	18,55	19,6	18,74	18,52	18,88	19,46	20,4	20,73	20,71
3	15,59	16,76	17,25	17,41	17,97	17,77	17,99	18,22	19,3	18,47	18,08	18,65	19,01	20,01	20,29	20,2
4	15,35	16,39	16,78	17,24	17,48	17,38	17,39	17,7	18,74	18,09	17,71	18,32	18,75	19,83	19,82	19,56
5	15,08	15,98	16,48	16,97	17,05	17,12	16,35	17,59	18,13	17,56	17,56	18,06	18,52	19,58	19,54	19,27
6	15,64	16,42	16,87	17,46	17,51	17,52	16,81	17,67	18,54	17,79	17,97	18,23	19,35	20,15	19,83	19,67
7	17,36	18,01	18,64	18,69	19,18	19,09	18,92	19,92	20,7	19,78	19,72	20,1	21,14	22,11	21,55	21,8
8	19,7	20,26	20,76	21,54	21,54	22,09	22,08	21,97	22,38	22,26	22,21	22,35	23,58	24,44	24,42	24,08
9	22,64	23,67	24,07	24,59	23,95	24,64	24,66	24,73	25,12	25,24	25,23	24,94	26,25	27,81	27,06	27,17
10	23,87	25,17	25,57	25,97	25,88	26,18	26,12	26,64	26,9	26,97	26,74	26,63	27,74	29,06	28,55	28,74
11	25,03	26,24	26,54	27,18	26,96	27,26	26,94	27,88	28,17	28,18	27,72	27,7	28,88	29,85	29,78	30,09
12	25,42	26,89	27,05	27,83	27,65	27,86	27,6	29,06	28,9	29,01	28,61	28,35	29,51	30,51	30,44	30,63
13	26,26	27,61	27,87	28,54	28,01	28,09	28,24	29,52	29,52	29,73	29,22	29,19	30,21	31,08	30,72	31,45
14	26,63	28,13	28,14	28,92	28,92	28,61	28,9	29,78	29,72	30,06	29,54	29,5	30,61	31,32	31,02	32,08
15	26,94	27,97	27,73	28,78	28,66	28,94	29	29,67	29,88	30,29	29,66	29,58	30,53	31,51	31,42	32,14
16	26,43	27,76	27,35	28,56	28,41	28,89	28,85	29,49	29,74	30,05	29,39	28,64	30,61	30,88	31,36	31,88
17	25,38	26,7	26,11	27,62	27,23	27,98	28,07	28,67	29,03	28,89	27,95	27,67	29,64	29,38	29,99	30,67
18	24,1	25,12	24,64	26,35	25,93	26,63	26,81	27,5	27,72	27,31	26,95	26,28	28,33	28,58	29,07	29,28
19	22,53	23,85	23,12	23,67	24,32	24,84	25	25,74	26,07	26,24	25,28	24,44	26,93	26,94	27,27	27,78
20	21,2	22,59	21,81	22,34	22,65	23	22,96	24,04	24,45	24,06	23,42	23,2	25,1	25,45	25,36	26,14
21	20,15	21,27	20,51	21,37	21,45	21,83	22,15	22,49	22,94	22,6	22,08	22,12	23,66	24,31	23,95	25,02
22	19,31	20,2	19,81	20,56	20,49	20,91	21,29	21,41	21,91	21,54	21	21,31	22,89	23,09	23,03	24,07
23	18,74	19,33	19	19,99	19,94	20,13	20,56	20,84	20,95	20,79	20,47	20,66	22,06	22,26	22,01	23,26
24	18,08	18,59	18,36	19,75	19,5	19,24	19,7	20,31	20,03	20,07	19,78	20,4	21,4	21,69	21,36	22,63

	JUNE														
	DAYS														
HOURS	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1	21,9	21,81	22,6	21,43	21,57	21,16	21,85	21,81	22,2	22,52	22,64	23,51	22,74	22,59	
2	21,39	21,47	22,18	21,17	21,14	20,92	21,52	21,24	21,98	22,34	22,29	23,02	22,23	21,95	
3	20,94	21,26	21,61	20,72	20,72	20,39	21,19	20,82	21,51	22,04	22,2	22,88	21,92	21,32	
4	20,77	20,82	21,11	20,28	20,29	20,05	20,72	20,55	20,95	21,59	21,88	23,05	21,71	20,98	
5	20,53	20,63	20,68	19,51	19,68	19,83	20,37	20,2	20,49	21,33	21,55	22,34	21,23	20,49	
6	20,9	21,22	20,79	20,13	20,12	20,23	20,76	20,6	20,89	21,8	21,91	22,72	21,46	21,03	
7	22,39	23,05	22,25	22,14	21,95	22,56	22,3	22,3	22,71	23,32	23,5	24,1	22,86	22,82	
8	24,71	25,18	24,54	24,45	24,05	24,98	24,55	24,34	25,14	25,5	25,71	25,99	25,25	25,36	
9	27,6	27,83	27,17	26,94	26,76	27,6	26,81	27,37	27,7	28,49	28,42	28,45	27,92	28,04	
10	29,69	29,51	29,64	29,12	28,51	29,17	28,67	29,07	29,86	30,08	30	29,96	29,64	29,58	
11	30,73	30,47	30,79	30,18	29,93	30,36	30	30,31	31,28	30,27	31,17	30,99	30,66	30,87	
12	31,33	31,67	31,69	30,88	30,79	30,97	30,7	31,14	31,91	32,08	31,85	31,67	31,48	31,6	
13	31,89	32,21	32,41	31,6	31,38	31,78	31,58	31,8	32,53	32,72	32,8	32,45	32,34	32,57	
14	32,34	32,48	32,47	31,91	31,91	32,12	31,94	32,31	33,08	33,04	32,99	32,85	32,66	33,16	
15	32,43	32,69	32,57	31,71	32,06	31,99	32,14	32,49	33,27	32,92	33,1	32,82	32,63	33,52	
16	32,34	32,66	32,29	31,13	31,75	31,78	32,05	32,51	32,79	32,69	32,74	32,56	32,47	33,22	
17	31,09	31,86	31,09	30,02	30,55	30,36	30,93	31,67	31,91	31,25	31,85	31,55	31,8	32,25	
18	29,75	30,46	29,79	28,66	29,31	29,01	29,61	30,36	30,56	30	30,29	29,97	30,16	30,31	
19	27,91	28,51	28,04	26,89	27,59	27,21	27,62	28,65	28,92	28,16	28,56	28,36	28,31	28,75	
20	26,94	26,82	26,39	25,35	26	25,57	26,02	26,82	27,09	26,66	27,08	26,67	26,71	27,17	
21	25,08	25,65	25,09	24,12	24,67	24,37	24,93	25,33	25,54	25,15	25,9	26,06	25,67	25,72	
22	24,15	24,77	23,89	23,46	23,53	23,48	23,86	24,38	24,52	24,48	24,76	24,79	24,51	25,01	
23	23,33	24,09	22,72	22,86	22,67	22,81	23,04	23,47	23,75	23,74	24,11	23,94	23,78	24,39	
24	22,59	23,33	22,09	22,11	21,88	22,16	22,34	22,79	23,11	23,09	23,74	23,42	23,27	23,73	

	JULY															
	DAYS															
HOURS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	23,18	23,85	24,04	24,3	24,53	24,55	23,95	24,65	24,7	23,82	24,14	24,63	24,63	24,67	24,62	23,41
2	23,27	23,6	23,51	23,9	24,13	24,17	23,79	24,34	23,99	23,68	23,57	24,27	24,35	24,3	24,26	23,16
3	22,6	23,21	23,02	23,58	23,79	23,8	23,37	23,9	23,57	23,35	23,46	24,04	24	23,99	23,91	22,91
4	22,35	22,85	22,73	23,44	23,5	23,48	23,01	23,33	23,15	23,05	23,27	23,88	23,61	23,62	23,75	22,45
5	22,08	22,59	22,43	23,02	22,92	23,03	22,53	23,08	22,68	22,51	23,09	23,67	23,31	23,34	23,38	21,92
6	22,56	22,64	22,99	23,15	22,98	23,17	22,68	23,3	22,67	22,7	23,49	23,69	23,36	23,57	23,55	22,23
7	24,19	24,01	24,49	24,5	24,13	24,78	24,53	24,48	24,17	24,07	24,78	24,92	24,75	24,87	25,1	23,86
8	26,55	26,41	26,92	26,68	26,09	26,87	26,69	26,7	26,28	26,25	26,99	26,64	27,46	27,18	26,96	26,19
9	29,42	28,98	29,47	29,1	28,92	29,34	29,28	29,04	29,04	29,02	29,85	29,32	30,61	29,97	29,65	28,87
10	31,13	30,86	31,54	30,79	30,59	31,02	31,25	31,23	30,68	30,58	31,52	31,38	31,57	32,2	31,47	30,75
11	32,1	31,97	32,82	32,14	32,03	32,29	32,57	32,68	32,08	31,85	32,6	33,01	34,04	33,76	32,4	32,12
12	33,23	32,96	33,73	32,96	32,86	33,26	33,39	33,44	32,78	32,73	33,55	34,16	34,84	34,41	33,29	33,01
13	33,79	33,65	34,27	33,81	33,55	33,81	33,96	34,96	33,55	33,47	34,22	35	35,49	35,17	34,02	33,43
14	33,86	34,03	34,81	34,41	34,09	34,21	34,54	34,42	34,04	34	34,98	35,66	35,85	35,48	34,35	33,73
15	33,1	34,11	34,8	34,52	34,25	34,46	34,98	34,55	34,03	34,02	35,23	35,99	35,88	35,51	34,42	33,49
16	32,92	34,03	34,77	34,38	33,76	34,14	34,71	34,38	33,76	33,81	35	35,95	35,49	35,18	33,41	33,23
17	31,4	33,34	33,56	33,72	32,88	32,76	33,36	33,62	32,74	32,97	33,9	35,12	33,42	33,92	32,41	31,69
18	30,02	31,97	31,8	31,99	31,44	31,22	31,9	32,17	31,2	31,44	32,52	33,45	32,56	32,14	30,94	30,38
19	28,63	30,13	30,18	30,18	29,65	29,42	30,74	30,5	29,27	29,56	30,68	31,22	30,46	30,28	29,1	28,77
20	26,97	28,4	28,48	28,39	28,31	28,43	28,63	28,75	27,95	28,03	29,11	29,71	28,77	28,56	27,84	27,51
21	26,23	27,03	27,1	27,23	26,98	26,58	27,07	27,45	26,61	26,92	27,93	27,99	27,48	27,13	26,65	26,28
22	25,43	25,97	26,02	26,43	25,96	25,73	26	26,34	25,65	26,14	26,95	26,88	26,44	26,19	25,5	25,47
23	24,72	25,31	25,49	25,63	25,38	25,04	25,26	25,77	24,99	25,47	26,17	25,95	25,81	25,58	24,77	25,47
24	24,23	24,71	24,76	25,09	25,06	24,4	24,84	25,24	24,22	25	25,55	25,33	25,33	24,95	24,09	24,77

	JULY														
	DAYS														
HOURS	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1	24,4	24,6	24,93	25,3	25,31	25,08	25,1	24,69	25,26	24,54	25,25	25,5	25,61	26,19	25,11
2	23,43	24,39	24,65	24,99	24,82	24,58	24,65	24,22	24,62	24,19	24,98	25,3	25,34	25,05	24,83
3	23,07	24,24	24,34	24,51	24,38	24,25	24,05	23,85	24,28	23,78	24,89	24,95	24,85	24,51	24,47
4	22,92	23,71	24,13	23,96	24,13	23,7	23,95	23,42	23,93	23,51	24,52	24,63	24,34	24,1	24,47
5	22,65	23,21	23,71	23,66	23,73	23,4	23,75	23,25	23,55	23,24	24,37	24,34	24,21	23,97	23,57
6	22,85	23,59	23,91	23,75	23,81	23,61	24,1	23,76	23,6	23,47	24,63	24,41	24,3	24,06	24
7	23,99	24,91	25,27	25,26	24,93	24,75	25,25	24,51	25,1	24,57	25,7	25,66	25,6	25,35	25,26
8	26,36	27,2	27,38	27,6	26,98	26,57	27,5	26,57	27,07	26,84	28,3	27,83	27,59	27,74	28,03
9	29,27	29,87	29,47	30,72	30,11	29,71	31,1	29,71	30,39	30,28	31,44	30,76	30,67	31,04	30,69
10	31,22	31,96	31,56	32,76	32,71	32,03	32,95	31,64	32,41	32,2	33,35	33,19	32,87	33,31	33,15
11	32,42	33,23	33,14	34,1	34,81	33,76	34,7	33,02	33,74	33,43	34,78	34,86	34,25	34,68	34,49
12	33,29	34,07	34,13	34,88	35,53	34,64	35,55	33,91	34,55	34,43	35,55	35,48	35,02	35,63	35,58
13	34,01	34,74	34,9	35,52	36,1	35,44	35,6	34,69	35,18	35,2	36,16	35,79	35,93	36,21	36,2
14	34,39	35,21	35,42	35,9	36,07	35,77	36,5	35,29	35,38	35,72	36,22	36,38	36,36	36,68	36,59
15	34,68	35,47	35,66	36,21	36,11	35,36	36,4	35,29	35,46	35,99	36,43	36,42	36,19	36,46	36,58
16	33,87	35,38	35,37	35,97	35,64	35,48	35,9	34,98	35,23	35,63	35,72	35,82	35,7	35,92	36,02
17	33,26	34,26	34,46	35,07	34,72	34,75	35,25	33,99	34,1	34,42	34,75	34,19	34,63	35,33	35,1
18	31,53	32,78	32,87	33,4	32,92	32,99	33,3	32,14	32,16	32,53	32,85	32,23	33,08	33,47	33,08
19	30,16	30,94	31,31	31,59	31,26	31,25	32,1	30,34	30,17	30,48	31,04	30,98	31,15	31,4	31,11
20	28,35	29,49	29,63	29,82	29,66	29,58	30,25	28,88	28,5	29,5	29,51	29,21	29,78	29,88	29,29
21	27,15	28,15	28,25	28,2	28,27	28,24	28,75	27,87	27,47	27,95	28,3	28,08	28,56	28,55	28,02
22	26,14	27,12	27,22	26,96	27,23	27,21	27,85	26,73	26,41	26,96	27,23	27,06	27,36	27,44	26,87
23	25,64	26,26	26,55	26,15	26,46	25,92	26,95	26,2	25,59	26,29	26,65	26,44	26,87	26,67	26,32
24	25,02	25,56	25,77	25,49	25,72	25,15	26,4	25,72	25,14	25,58	26,13	25,95	26,12	25,86	25,45

	AUGUST															
	DAYS															
HOURS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	24,85	24,33	23,95	24,9	24,59	24,98	25,68	25,13	24,62	24,92	24,85	24,81	24,76	24,35	24,32	24,84
2	24,4	23,79	23,67	24,76	24,26	24,55	25,2	24,74	24,28	24,67	24,55	24,21	24,43	23,9	23,83	24,48
3	23,98	23,51	23,36	24,38	23,89	24,31	24,91	24,37	23,97	24,49	24,15	23,94	23,95	23,38	23,14	24,17
4	23,76	22,98	23,13	24,18	23,59	23,8	24,42	24,04	23,8	24,04	23,82	23,56	23,6	22,99	22,93	23,84
5	23,47	22,6	22,68	23,83	23,57	23,61	23,91	23,61	23,61	23,89	23,68	23,04	23,23	22,41	22,75	23,65
6	23,39	22,54	22,64	23,65	23,82	23,46	23,94	23,61	23,62	23,66	23,76	22,99	23,03	22,38	22,58	23,43
7	24,75	24,01	24,21	24,79	24,91	24,37	24,97	24,51	24,68	24,59	24,65	24,31	24,18	23,52	23,83	24,34
8	27,18	26,49	26,25	26,22	26,87	26,75	27,11	26,69	27,1	27,08	26,69	26,37	26,7	25,94	26,69	26,77
9	30,14	29,45	29,13	28,91	29,58	29,75	30,38	29,75	30,56	30,27	29,75	29,74	28,53	29,31	30,08	29,96
10	32,86	32,08	31,56	31,04	31,53	32,06	32,38	32,2	32,58	32,51	32,18	32,31	31,79	31,62	32,7	32,31
11	34,14	33,31	32,98	32,82	33,05	33,55	33,89	33,89	33,93	33,83	33,43	33,77	33,4	32,98	34,21	33,85
12	34,67	34,24	33,85	33,71	34,18	34,47	34,71	34,77	34,71	34,94	34,49	34,37	34,31	33,95	35	35,05
13	35,21	34,92	34,37	34,38	34,93	35,18	35,23	35,21	35,6	35,49	35,22	35,24	35,11	34,67	35,26	35,37
14	35,64	35,41	35,1	34,96	35,32	35,58	35,66	35,53	36,16	35,54	35,45	35,75	35,34	35,34	36,21	35,89
15	35,68	35,3	35	33,8	35,44	35,73	35,79	35,64	36,16	35,46	35,32	35,69	35,62	35,41	36,08	35,65
16	35,32	34,63	34,84	33,24	35,18	35,38	35,55	35,18	35,51	35,21	35,09	35,46	35,35	35,02	35,97	35,33
17	34,28	32,88	33,46	32,12	34,27	34,54	34,68	34,02	34,32	34,26	33,96	34,42	34,76	34,03	34,64	34,12
18	32,24	31,09	31,68	30,2	32,54	32,74	32,76	32,21	32,37	32,29	31,89	32,41	32,36	32,03	32,39	31,83
19	30,44	29,11	30,06	28,81	30,52	30,55	30,4	30,5	30,64	30,13	30,09	30,41	30,21	30,09	30,55	29,65
20	28,8	27,89	28,98	27,63	29,13	29,27	28,89	28,96	29,07	28,67	28,38	28,82	28,2	28,5	28,76	27,92
21	27,41	26,81	27,16	26,97	27,86	28,22	27,82	27,32	28,06	27,55	27,41	27,47	27,16	27,17	27,52	26,76
22	26,3	25,63	26,5	26,21	26,97	27,18	26,88	26,29	26,76	26,64	26,11	26,53	26,3	26,08	26,52	26,05
23	25,59	24,88	25,72	25,62	26,25	26,69	26,11	25,62	26,05	25,88	25,62	25,73	25,69	25,29	25,89	25,23
24	24,95	24,34	25,35	25,11	25,68	26,13	25,66	25,04	25,42	25,31	25,19	25,19	25,06	24,76	25,38	24,74

	AUGUST														
	DAYS														
HOURS	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1	24,21	23,53	24,28	24,4	24,06	23,46	24,11	24,42	23,47	23,27	23,15	22,79	22,47	22,66	22,34
2	23,79	23,18	23,95	24,13	23,56	23,11	23,87	24,13	22,93	22,88	22,67	22,36	22,19	22,42	21,8
3	23,53	22,66	23,45	23,78	23,03	22,91	23,57	23,68	22,75	22,46	22,36	21,93	21,91	22,03	21,2
4	23,23	22,36	22,9	23,34	22,8	22,57	23,14	23,53	22,38	22,09	22,02	21,81	21,53	21,68	20,8
5	22,59	22,14	22,51	23,05	22,51	21,92	22,7	23,18	21,9	22,02	21,77	21,55	21,18	21,37	20,39
6	22,39	21,81	22,5	22,91	22,5	21,81	22,64	22,93	21,8	21,92	21,65	21,42	20,99	21,3	20,36
7	23,31	23,04	23,54	23,52	23,72	22,78	23,76	23,7	22,68	22,9	22,73	22,32	21,79	22,12	21,47
8	25,62	25,71	25,28	25,91	25,89	25,1	25,53	25,96	24,89	25,09	25,36	24,53	23,85	24,12	23,72
9	29,29	28,99	28,85	29,01	29,15	28,79	29,77	29,51	28,33	28,1	28,11	27,5	27,41	27,73	27,35
10	31,8	31,91	31,01	31,57	31,25	31,08	32,4	31,72	30,57	30,07	30,53	29,69	29,89	30,1	29,75
11	33,15	33,4	32,51	33,14	32,63	32,54	33,91	33,32	31,78	31,53	31,9	30,9	31,07	31,66	31,34
12	34,01	34,21	33,29	34,04	33,3	33,75	34,67	34,1	32,61	32,73	32,86	31,92	31,72	32,54	32,06
13	34,73	34,86	33,86	34,81	33,82	34,48	35,31	34,82	33,21	33,61	33,56	32,94	32,72	33,29	32,9
14	34,94	35,16	34,32	35,4	34,23	34,87	35,53	35,17	33,38	33,68	33,97	33,51	32,86	33,53	33,34
15	34,62	35,24	34,71	35,19	34,23	34,74	35,63	35,3	33,38	33,7	34,05	33,6	33,17	33,27	33,15
16	34,24	35,07	34,69	34,78	33,52	34,53	35,29	34,93	32,75	33,09	33,72	32,88	32,86	32,96	32,85
17	33,45	33,76	33,66	33,21	32,64	33,58	34,18	33,63	31,76	32,09	32,65	31,97	31,81	32,16	31,72
18	31,22	31,68	31,52	31,36	30,53	31,46	31,92	31,67	29,99	30,22	30,37	29,63	29,66	29,88	29,67
19	29,41	29,6	29,14	29,74	28,86	29,48	29,53	29,57	27,86	28,24	28,38	27,71	27,7	27,97	27,5
20	27,9	28	28,04	28,38	27,48	27,4	28,08	28,18	26,74	26,81	26,79	26,28	26,39	26,44	26,16
21	26,68	26,95	26,96	27,11	26,22	26,93	26,96	26,9	25,94	25,8	25,64	25,17	25,29	25,27	25,01
22	25,68	26,23	26,14	26,13	25,16	26,03	26,18	25,92	24,9	24,83	24,56	24,26	24,47	24,35	23,73
23	25,05	25,54	25,41	25,25	24,36	25,36	25,47	25,07	24,26	24,15	23,8	23,5	23,67	23,58	23
24	24,28	24,84	24,84	24,54	23,82	24,75	24,83	24,34	23,62	23,66	23,4	22,95	23,22	23,13	22,36

	SEPTEMBER															
	DAYS															
HOURS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	21,89	21,26	21,44	21,53	20,65	20,03	19,37	19,4	19,01	19,99	20,29	20,27	19,26	19,54	18,84	19
2	21,38	20,75	21,16	21,06	20,45	19,6	18,72	18,89	18,61	19,73	20,01	19,83	18,91	19,12	18,42	18,64
3	20,76	20,29	20,71	20,54	19,99	19,07	18,17	18,45	17,84	19,36	19,3	19,47	18,46	18,47	18,02	18,3
4	20,38	20,04	20,33	20,22	19,5	18,67	17,76	17,87	17,46	18,78	18,95	19,06	18,13	18,24	17,68	18,05
5	19,85	19,73	19,82	19,91	19,45	18,12	17,37	17,58	17,02	18,69	18,82	18,63	17,6	17,87	17,5	17,86
6	19,68	19,65	19,65	19,67	19,6	18	17,14	17,29	16,96	18,4	18,63	18,45	17,15	17,66	17,25	17,69
7	20,48	20,75	20,42	20,58	19,82	18,7	18	18,5	18,22	19,1	19,26	19	18,11	18,02	18,12	18,34
8	23,02	23,14	23,06	23,11	21,81	20,97	20,51	20,74	20,86	21,72	21,53	21,31	20,27	20,42	20,76	20,91
9	26,16	26,62	26,2	26,32	25,08	24,73	24,17	24,05	24,98	25,57	25,59	25,29	23,9	24,09	24,37	24,81
10	29,12	28,68	28,68	28,72	26,9	26,59	25,99	26,32	27,55	27,94	28,22	26,42	25,45	26,67	26,93	27,1
11	30,23	30,17	30,36	30,35	28,89	27,94	27,38	27,69	28,66	29,4	29,61	27,59	27,22	28,37	28,31	28,55
12	31,17	31,19	31,08	31,05	29,5	28,83	28,25	28,44	29,63	30,38	30,22	28,53	28,18	29,24	29,08	29,68
13	32,03	32,07	31,77	31,51	30,23	29,4	29,05	29,11	30,49	31,12	30,74	29,25	29	29,99	29,79	30,61
14	32,29	32,52	32,2	31,8	30,53	29,79	29,57	29,9	31,05	31,29	30,88	29,47	29,39	30,36	30,31	31,09
15	32,47	32,54	32,34	31,76	30,75	29,97	29,41	30,24	31	31,41	30,86	29,41	29,58	30,51	30,39	31,04
16	31,94	32,08	31,95	31,16	30,4	29,51	29,03	30,03	30,6	31,07	30,05	28,63	29,24	30,1	29,9	30,53
17	30,73	31,24	30,79	30,49	29,39	28,58	28,48	29,14	29,77	29,83	28,91	27,48	28,31	29,1	28,87	29,51
18	28,52	28,92	28,67	28,31	27,05	26,32	26,63	27,35	27,62	27,49	26,88	25,58	26,4	26,97	26,43	27,26
19	26,74	27,04	26,66	26,16	25,25	24,13	24,67	25,12	25,17	25,38	24,75	23,84	24,34	24,59	24,38	25,44
20	25,32	25,88	25,37	24,72	23,78	22,97	23,23	23,63	23,58	24,1	23,54	22,98	22,57	22,96	22,93	23,64
21	24,18	24,68	24,18	23,58	22,96	22,07	21,99	22,33	22,53	23,11	22,55	21,59	21,47	22,05	21,79	22,47
22	23,23	23,73	23,26	22,74	22,17	21,12	20,42	21,23	21,59	22,27	21,86	20,91	20,73	20,91	20,75	21,49
23	22,45	22,83	22,69	21,93	21,3	20,36	19,68	20,38	20,89	21,35	21,24	20,26	20,37	19,99	20,09	20,85
24	21,86	21,98	22,02	21,21	20,64	19,92	19,28	19,82	20,51	20,86	20,8	19,7	20,01	19,58	19,41	20,1

	SEPTEMBER														
	DAYS														
HOURS	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1	19,65	19,07	18,9	19,66	19,13	18,82	17,43	17,86	18,58	18,6	18,31	17,66	17,5	16,89	
2	19,31	18,45	18,65	19,31	18,69	18,24	17,14	17,42	18,07	18,18	18,15	17,21	17,13	16,53	
3	18,83	18,1	18,44	18,78	18,39	17,86	16,63	16,95	17,52	17,84	17,61	16,94	16,63	16,3	
4	18,36	17,65	18,27	18,41	18,12	17,45	15,89	16,69	17,14	17,5	17,13	16,58	16,33	15,85	
5	17,81	17,25	17,79	17,84	17,88	16,99	15,51	16,55	16,86	17,02	16,64	16,22	16,3	15,34	
6	17,46	16,98	17,61	17,49	17,51	16,58	15,38	16,32	16,61	16,88	16,08	16,1	16,34	15,23	
7	17,97	17,41	18,22	18,34	18,11	17,12	16,02	16,37	17,29	17,42	17,19	16,69	16,74	15,61	
8	20,12	20,1	20,76	20,86	20,21	19,24	18,33	19,2	19,66	19,77	19,66	18,76	18,57	18,06	
9	24,12	24,72	24,85	24,94	24,27	23,56	23,36	23,99	23,91	23,48	23,62	22,62	22,09	22,22	
10	26,55	27,24	27,48	27,07	26,65	25,86	25,7	26,61	26,61	26,05	25,84	25,36	24,62	24,69	
11	28,05	28,53	29,17	28,47	27,97	27,25	27,12	28,08	27,97	27,41	27,26	26,62	25,4	26,15	
12	29,1	29,44	29,92	29,09	28,97	27,89	27,98	28,82	28,49	28,27	27,98	27,37	26,39	27,25	
13	29,77	30,05	30,76	29,54	29,55	28,61	28,74	29,5	28,09	29,17	28,65	27,79	27,02	26,79	
14	30,15	30,49	31,01	29,84	29,83	29,03	29,26	29,95	28,12	29,43	28,77	28,18	27,22	26,85	
15	29,86	30,54	31,17	29,61	29,7	28,72	29,21	29,89	27,9	29,18	28,72	27,57	26,96	26,86	
16	29,65	30,14	30,45	28,94	28,92	28,3	28,92	29,45	27,61	28,69	28,28	26,8	26,34	26,28	
17	28,6	29,07	29,49	27,6	27,62	27,41	27,54	28,03	26,41	27,3	26,99	25,13	24,89	24,89	
18	26,81	26,56	27,04	25,26	25,7	25,24	25,24	25,83	24,38	25,1	24,95	23,13	22,97	22,99	
19	24,66	24,48	24,77	23,54	23,76	23,85	22,81	23,7	22,74	23,13	22,99	21,34	21,16	21,25	
20	22,99	22,92	23,32	21,94	22,46	21,62	21,39	22,27	21,54	21,85	21,79	20,27	20,09	20,03	
21	21,44	22,06	21,92	21,35	21,33	20,77	20,28	21,08	20,67	20,87	20,88	19,43	19,28	19,35	
22	20,45	20,85	21,08	20,56	20,4	19,65	19,47	20,19	19,99	19,96	19,91	18,81	18,29	18,38	
23	19,87	20,03	20,71	20,06	19,73	18,98	18,75	19,64	19,34	19,42	19,27	18,34	17,79	17,83	
24	19,32	19,53	20,17	19,71	19,32	18,19	18,15	19,21	19,01	18,79	18,55	17,93	17,27	17,46	

	OCTOBER															
	DAYS															
HOURS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	16,91	16,79	16,45	15,87	15,49	15,48	16,93	17,05	15,71	15,47	15,61	15,58	14,24	15,01	15,72	14,98
2	16,6	16,29	16,16	15,46	14,93	15,06	16,49	16,61	15,16	14,91	15,16	15,26	13,88	14,71	15,1	14,71
3	16,03	15,73	15,74	15,16	14,66	14,84	16,13	16,13	14,49	14,33	14,85	14,59	13,58	14,33	14,71	14,19
4	15,64	15,45	15,62	15,07	14,29	14,34	15,78	15,79	14,16	14,11	14,49	14,35	12,97	14,07	14,31	13,75
5	15,27	15,26	15,55	14,7	13,9	14,07	15,35	15,27	13,74	13,79	14,15	13,91	12,79	13,72	13,78	13,43
6	15,18	15	15,63	14,4	13,59	13,79	14,86	14,76	13,55	13,63	14,09	13,74	12,67	13,53	13,41	13,14
7	15,61	15,48	15,83	14,89	14,13	14,35	15,12	14,84	13,87	14,25	14,33	14,26	12,96	13,96	13,38	13,33
8	17,31	17,49	17,72	17,16	16,61	16,73	17,61	17,52	16,06	15,93	16,66	16,71	15,6	16,19	15,4	15,49
9	20,98	21,12	21,17	21,04	21,26	20,42	21,14	21,73	19,84	19,71	20,32	20,32	20,3	20,13	19,89	19,15
10	23,69	23,5	22,94	23,87	23,66	23,97	24,34	24,23	22,92	22,77	22,96	23,42	23,17	23,1	22,3	21,15
11	25,19	25,13	24,1	25,28	25,55	25,4	26	26,23	24,53	24,68	24,65	24,57	24,67	24,83	23,9	22,66
12	26,06	25,63	24,52	26,23	26,42	26,52	27,18	26,88	25,41	25,75	25,05	25,48	25,7	26,22	24,91	23,42
13	26,7	26,27	25,49	26,72	27,08	27,08	27,92	27,51	26,24	26,59	25,94	26,12	26,42	26,83	25,48	24,06
14	27,06	26,4	25,76	26,82	27,14	27,45	28,25	27,58	26,62	27,23	26,31	26,36	26,94	26,97	25,81	24,88
15	26,88	26,38	24,95	26,15	27,06	27,5	28,02	27,28	26,34	26,91	26,55	26,21	26,63	26,78	25,48	24,34
16	26,23	25,78	24,05	25,46	26,71	26,91	27,31	26,68	26,63	26,21	25,81	25,02	25,83	26,16	24,12	23,64
17	24,79	24,03	23	23,87	24,77	25,36	25,25	24,59	24,04	23,69	23,54	23,1	23,73	24,1	22,75	22,06
18	22,94	22,31	20,66	22,06	22,48	22,98	23,19	22,52	22,27	22,13	21,63	21,12	21,83	22,09	20,75	20,35
19	21,1	20,74	19,01	20,41	20,47	21,6	21,49	20,88	20,5	20,2	19,87	19,42	19,58	20,42	19,39	18,88
20	20,15	19,66	18,29	19,11	19,29	20,44	20,46	19,64	19,24	18,94	18,68	18,21	18,38	19,05	18,27	18,01
21	19,27	18,92	17,68	18,1	18,26	19	19,57	18,44	18,06	18,23	17,78	17,3	17,57	18,27	17,38	17,57
22	18,35	18,18	17,07	17,08	17,38	18,15	18,85	17,39	17,1	17,14	17,01	16,22	16,72	17,07	16,66	16,91
23	17,62	17,58	16,47	16,56	16,87	17,6	18,2	16,57	16,33	16,63	16,34	15,53	16,18	16,71	16	16,46
24	17,22	17,08	16,15	16,19	16,16	17,23	17,57	16,19	15,84	16,2	15,87	14,87	15,55	16,21	15,61	15,85

	OCTOBER														
	DAYS														
HOURS	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1	15,22	14,8	14,31	13,2	12,44	12,63	11,97	10,91	11,56	12,09	12,65	11,9	11,31	9,99	10,19
2	14,85	14,48	13,95	12,94	11,86	12,09	11,49	10,49	11,18	11,56	12,33	11,49	10,97	9,72	9,86
3	14,43	14,14	13,67	12,36	11,83	11,52	11,03	10,13	10,95	11,11	12,03	11,34	10,76	9,44	9,76
4	14,18	13,76	13,02	11,89	11,54	11,23	10,7	9,75	10,67	10,7	11,68	11,06	10,61	9,18	9,52
5	13,98	13,54	12,58	11,89	11,3	11,01	10,23	9,61	10,54	10,41	11,21	11,04	10,32	9,13	9,12
6	13,73	13,37	12,37	11,8	11,08	10,73	10,01	9,61	10,47	10,19	10,95	11,06	10,2	8,97	8,9
7	13,9	13,56	12,6	12,2	11,41	10,5	10,08	9,62	10,55	10,44	11,08	11,13	10,3	8,93	8,71
8	15,73	15,4	14,61	13,91	13,35	13,3	13,34	11,76	11,98	12,34	13,14	12,38	11,76	10,48	9,98
9	18,54	18,57	18,07	17,06	16,13	16,87	17,06	15,4	15,38	16,13	15,77	14,86	13,67	12,55	12,29
10	21	20,37	20,38	19,11	18,56	18,98	19,56	18,06	17,65	18,67	17,73	17,12	15	14,04	13,65
11	22,27	21,43	21,47	20,73	19,76	20,22	20,74	19,27	19,11	20,31	19,13	18,78	15,96	15,2	14,74
12	22,97	22,48	22,21	21,5	20,64	20,88	21,61	20,25	19,97	21,23	19,84	19,78	16,28	16,12	15,62
13	22,97	23,22	22,66	21,98	21,33	21,72	22,05	20,8	20,36	21,99	20,35	20,03	16,23	16,6	16,19
14	22,95	23,5	23,02	22,39	21,45	22,27	22,51	21,06	21,02	22,17	20,66	20,16	16,01	16,73	16,43
15	22,99	23,1	22,98	21,82	21,27	22,04	21,99	20,92	20,92	21,99	20,61	19,87	15,61	16,76	16,56
16	22,31	22,3	21,95	20,68	20,44	21,18	21,06	20,09	20,26	21,1	19,8	18,95	14,82	16,02	15,73
17	20,81	20,82	20,03	19,16	18,96	19,17	19,09	18,06	18,77	19,48	18,16	17,36	13,7	14,77	14,43
18	19,38	19,04	18,22	17,5	17,14	17,04	17	16,53	16,98	17,35	16,47	15,93	12,9	13,7	12,99
19	18,15	17,43	16,93	16,28	15,82	15,56	15,43	15,2	15,38	15,98	15,11	14,6	12,01	12,85	11,97
20	17,32	16,68	15,75	15,5	15,08	14,65	14,31	14,12	14,56	15,12	14,19	13,81	11,64	12,1	11,35
21	16,66	16,27	15,14	14,83	14,22	14,04	13,53	13,42	13,85	14,58	13,49	13,25	11,07	11,47	10,67
22	16,02	15,48	14,44	14,17	13,48	13,35	12,65	12,83	13,07	13,85	12,94	12,68	10,68	10,96	10,04
23	15,62	15,03	13,82	13,64	13,07	12,89	11,93	12,35	12,98	13,36	12,41	12,15	10,38	10,78	9,62
24	15,18	14,64	13,54	13,2	12,86	12,47	11,5	11,96	12,55	13	12,09	11,7	10,29	10,46	9,2

	NOVEMBER															
	DAYS															
HOURS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	8,89	9,51	9,82	10,11	9,54	9,23	9,51	8,82	9,57	9,44	9,56	8,33	8,14	7,6	7,21	7,65
2	8,67	9,2	9,61	9,77	9,24	8,9	9,12	8,55	9,23	9,33	9,42	8,05	7,6	7,18	7,04	7,27
3	8,52	8,92	9,4	9,52	8,96	8,45	8,51	8,34	9,16	9,12	9,28	7,6	7,27	7	6,99	7,06
4	8,29	8,69	9,26	9,27	8,73	8,31	8,6	8,25	9	8,98	9	7,39	6,99	6,78	6,85	6,72
5	8,04	8,56	9,01	9,19	8,59	8,03	8,66	8,04	8,87	8,89	8,85	7,02	6,69	6,68	6,65	6,65
6	7,83	8,24	8,83	8,95	8,35	7,67	8,54	7,9	8,83	8,71	8,61	6,88	6,4	6,47	6,58	6,54
7	8,08	8,24	8,95	8,82	8,44	7,27	8,28	8,06	8,92	8,67	8,33	6,88	6,54	6,2	6,45	6,46
8	10,21	10,18	10,88	10,45	10,03	8,81	10,41	10,7	10,59	9,94	9,66	8,72	8,29	7,94	7,97	8,48
9	13,69	13,53	13,45	13,73	13,23	12,31	13,3	13,48	13,35	12,49	12,61	11,98	12,01	11,03	11,08	11,55
10	15,5	15,77	15,79	16,09	15,48	14,59	14,94	15,58	15,34	14,26	14,83	14,34	14,73	13,65	13,42	13,88
11	17,1	17,35	17,26	17,55	17,01	15,52	16,28	17,26	16,63	15,65	16,44	15,62	16,27	15,14	14,66	15,31
12	17,83	18,2	18,07	18,31	17,97	16,06	16,91	17,75	17,46	16,47	16,87	16,61	17,12	16,09	15,44	16,13
13	18,59	18,77	18,53	18,67	18,32	16,33	17,19	18,35	17,72	16,83	17,61	17,58	17,76	16,54	16,08	16,64
14	18,48	18,82	18,83	18,32	18,55	16,58	17,45	18,45	17,86	17,08	17,76	17,93	17,95	16,74	16,14	16,71
15	18,28	18,75	18,67	17,86	18,1	16,47	17,13	18,3	17,58	16,83	17,27	17,57	17,47	16,66	15,95	16,37
16	16,76	17,76	17,85	17,03	17	15,55	16,09	17,27	16,66	16,09	16,14	16,34	16,49	15,45	14,97	15,27
17	14,99	15,8	16,06	15,46	15,12	13,96	14,49	15,47	14,79	14,37	14,49	14,46	14,12	13,39	13,05	13,2
18	13,7	14,22	14,62	13,97	13,12	12,91	13,05	13,73	13,34	12,84	12,79	12,76	12,17	11,47	11,58	11,84
19	12,74	12,82	13,32	12,74	11,96	11,98	11,9	12,58	12,43	11,86	11,68	11,69	10,81	10,29	10,41	10,52
20	12,01	11,98	12,48	11,91	11,25	11,52	11,04	11,81	11,86	11,3	10,7	10,68	9,99	9,66	9,79	9,9
21	11,7	11,44	12,06	11,51	10,66	11,01	10,56	11,41	11,23	10,82	10,15	9,93	9,51	9,03	9,2	9,28
22	10,83	10,74	11,41	10,81	10,05	10,47	9,96	10,94	10,64	10,43	9,53	9,22	8,67	8,38	8,61	8,77
23	10,42	10,36	10,99	10,3	9,7	10,06	9,49	10,47	10,43	10,16	9,19	8,74	8,3	7,82	8,15	8,44
24	9,98	10,07	10,61	9,98	9,43	9,81	9,09	9,98	9,86	9,88	8,9	8,42	7,83	7,48	7,94	8,07

	NOVEMBER														
	DAYS														
HOURS	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1	7,61	8,32	8,05	7,11	7,75	7,66	5,06	5,34	6,05	5,24	5,1	5,11	5,17	5,52	
2	7,38	7,95	7,67	6,8	7,49	7,16	4,75	5,03	5,74	5,07	4,89	4,96	4,73	5,33	
3	7,33	7,6	7,57	6,56	7,2	6,64	4,54	4,72	5,64	4,84	4,8	4,76	4,54	5,1	
4	7,2	7,25	7,45	6,47	6,9	6,16	4,3	4,58	5,21	4,52	4,68	4,46	4,44	5,05	
5	7,2	7,26	7,32	6,27	6,69	5,52	4,01	4,34	4,9	4,29	4,48	4,27	4,3	5,08	
6	7,26	7,06	7,07	6,07	6,59	5,03	3,78	4,19	4,57	4,08	4,18	4,04	4,32	5,04	
7	7,32	7,04	6,85	5,97	6,57	5,42	3,5	4,08	4,37	4,14	4,09	3,83	4,28	4,9	
8	8,31	8,42	8,21	7,25	7,73	6,15	5,13	5,5	5,03	4,89	5,13	4,92	4,95	5,43	
9	11,58	10,82	10,48	10,29	9,95	8,71	8,38	8,55	7,4	7,65	7,75	7,65	7,59	7,16	
10	14,06	12,79	12,34	12,03	11,92	11,3	10,47	10,27	9,17	9,42	9,78	9,77	9,59	8,57	
11	15,21	13,79	13,54	13,53	13,38	12,08	12,25	11,51	10,62	10,66	11,14	11,31	10,8	10,03	
12	16,25	14,69	14,67	14,27	14,03	12,96	13,2	12,24	11,33	11,64	12,22	12,28	11,35	10,76	
13	16,55	14,98	15,35	14,72	14,43	13,44	13,76	13,01	11,57	12,08	12,87	13,04	11,75	10,96	
14	16,71	15,23	15,38	14,83	14,78	13,62	13,93	13,03	11,72	12,56	13,36	13,37	11,67	11,07	
15	16,4	14,94	15,22	14,65	14,33	13,25	13,59	12,63	11,44	12,14	13,09	13,36	11,37	11	
16	15,33	14,05	14,25	13,66	13,19	12,09	12,39	11,57	10,69	11,08	11,68	12,3	10,56	10,38	
17	13,54	12,44	12,31	12,11	11,56	10,51	10,35	9,81	9,36	9,43	10,24	10,43	9,37	9,06	
18	12,15	11,2	10,96	11,07	10,59	9,03	8,89	8,85	8,38	8,23	8,9	9,09	8,34	8,03	
19	10,97	10,53	9,91	10,01	9,8	7,97	7,86	8,02	7,53	7,45	7,92	8,01	7,58	7,37	
20	10,43	9,95	9,28	9,37	9,31	7,2	7,25	7,65	6,94	7,11	7,09	7,39	7,08	6,83	
21	9,88	9,74	8,69	9,12	9,14	6,62	6,76	7,42	6,61	6,78	6,57	6,9	6,71	6,45	
22	9,22	8,95	7,9	8,54	8,5	6,05	6,19	7	6,21	6,24	6,12	6,32	6,22	6	
23	9,09	8,67	7,53	8,24	8,22	5,67	5,76	6,71	5,94	5,79	5,71	6	6,1	5,61	
24	8,76	8,36	7,36	7,95	7,94	5,42	5,62	6,27	5,49	5,44	5,5	5,48	5,83	5,3	

	DECEMBER															
	DAYS															
HOURS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	5,02	4,76	5,81	5,51	4,8	5,61	5,6	5,73	6,15	5,25	3,66	3,13	3,87	3,31	4,33	2,83
2	4,78	4,75	5,55	5,15	4,45	5,49	5,32	5,57	5,95	5,01	3,36	2,86	3,64	2,83	4,08	2,46
3	4,58	4,56	5,26	4,92	4,09	5,23	5,08	5,42	5,79	4,94	3	2,66	3,39	2,59	4,03	2,36
4	4,22	4,46	4,92	4,56	3,93	4,89	4,95	5,25	5,49	4,57	2,75	2,48	3,06	2,41	3,86	2,14
5	3,97	4,41	4,67	4,1	3,73	4,58	4,78	5,08	5,33	4,27	2,54	2,35	2,87	2,07	3,88	2,14
6	3,72	4,31	4,46	3,83	3,52	4,4	4,65	5	5,24	4,29	2,45	2,4	2,61	2,04	3,68	2,1
7	3,54	4,24	4,48	3,73	3,4	4,51	4,61	5,06	5,25	4,26	2,29	2,26	2,5	2,01	3,56	2,13
8	4,87	5,63	5,33	4,4	4,35	5,12	5,05	5,34	5,55	4,85	2,82	2,66	3,05	2,6	3,72	2,58
9	8,03	8,03	7,93	7,01	6,83	7,32	6,6	6,89	7,08	7,57	5,85	5,56	4,66	5,38	4,91	4,24
10	10,27	10,17	9,8	9,76	9,64	9,24	8,43	7,99	8,77	9,43	8,63	7,51	7,13	7,46	5,81	5,57
11	11,59	11,31	11,32	11,23	11,53	10,39	9,79	8,95	9,69	10,79	10,1	9,02	8,31	8,69	6,67	6,82
12	12,48	12,55	12,04	11,91	12,29	10,8	10,42	9,41	10,41	11,61	10,74	9,97	8,93	9,3	7,04	7,49
13	12,79	13,07	12,28	12,65	12,78	11,54	10,8	9,99	10,83	12,24	10,96	10,52	9,41	9,64	7,51	8,25
14	12,95	13,23	12,67	12,73	13,16	11,4	11,07	10,31	11,08	12,18	11,26	10,58	9,52	9,8	7,7	8,45
15	12,54	12,95	12,3	12,54	12,73	10,82	10,68	10,23	10,8	11,97	10,91	10,19	9,26	9,57	7,49	8,4
16	11,54	11,78	11,19	11,54	11,54	9,92	10,05	9,76	10,16	11,06	10,01	8,86	8,36	8,87	6,87	7,76
17	9,41	10,16	9,97	9,84	9,9	8,93	8,67	8,61	9,05	8,69	8,15	7,72	7,02	7,97	5,82	6,51
18	8,11	8,95	8,81	8,58	8,84	8,1	7,87	7,99	7,93	7,22	6,94	6,91	5,96	7,11	4,94	5,63
19	7,27	8,28	7,68	7,55	7,88	7,52	7,34	7,45	7,09	6,07	5,82	6,13	5,42	6,42	4,56	5,14
20	6,71	7,72	7,2	6,71	7,3	6,97	6,9	7,04	6,84	5,59	5,29	5,52	4,95	5,92	4,23	4,66
21	6,2	7,32	6,87	6,2	6,88	6,67	6,58	6,75	6,66	5,19	4,98	5,19	4,72	5,56	4,01	4,15
22	5,46	6,85	6,31	5,72	6,49	6,36	6,28	6,5	6,2	4,71	4,27	4,91	4,19	4,95	3,66	3,77
23	5,13	6,49	6,05	5,52	6,19	6,07	6,07	6,39	5,87	4,35	3,76	4,51	3,81	4,84	3,47	3,58
24	4,9	6,35	5,79	5,2	5,86	5,87	5,88	6,25	5,58	4	3,46	4,21	3,56	4,55	3,1	3,35

	DECEMBER														
	DAYS														
HOURS	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1	3,34	4,31	3,63	2,18	1,6	1,75	3,11	2,06	2,3	2,27	1,41	1,47	2,49	2,1	2,92
2	3,32	4,11	3,45	2,02	1,39	1,46	2,91	2,06	2,12	2,01	1,06	1,34	2,07	1,71	2,71
3	3,16	4,02	3,23	1,83	1,08	1,24	2,84	2,13	1,93	1,8	0,75	1,31	1,84	1,52	2,57
4	3,07	3,88	3,04	1,66	0,85	0,96	2,62	1,92	1,9	1,57	0,44	1,19	1,51	0,97	2,53
5	2,88	3,77	2,89	1,65	0,38	0,9	2,61	1,69	1,72	1,41	0,19	1,15	1,36	0,76	2,5
6	2,83	3,6	2,76	1,55	0,25	0,72	2,51	1,57	1,56	1,21	-0,03	1,27	1,21	0,83	2,46
7	2,75	3,51	2,67	1,6	0,2	0,92	2,37	1,73	1,56	0,96	-0,18	1,22	1,12	0,67	2,48
8	3,15	3,64	2,84	1,8	0,53	1,07	2,37	1,83	1,78	0,99	-0,08	1,59	1,38	0,95	2,72
9	5,24	5,2	3,84	3,35	2,35	2,74	3,33	3,17	3,17	2,94	1,94	3,2	3,11	3,02	3,77
10	7,31	6,69	4,82	4,93	4,95	4,72	4,08	4,01	4,66	3,93	4,27	4,97	4,87	5,15	5,82
11	8,23	7,93	6,15	6,09	6,23	6,05	4,9	4,73	5,27	4,79	5,09	6,22	5,69	6,33	6,81
12	9,08	8,38	6,65	6,69	7,27	6,9	5,37	5,14	6,08	5,6	5,81	7,22	6,04	7,34	7,63
13	9,58	8,85	7,37	7,17	8,15	7,64	5,68	5,56	6,35	6,1	6,25	8,1	6,12	8,35	8,44
14	9,68	9,02	7,38	7,36	8,43	7,82	5,89	5,95	6,57	6,45	6,59	8,49	6,2	8,56	8,74
15	9,65	8,89	6,97	7,21	8,24	7,53	5,68	5,93	6,41	6,4	6,3	8,09	6,2	8,62	8,94
16	9,02	8,37	6,53	6,63	7,44	6,67	5,31	5,4	5,87	5,97	5,55	7,3	5,75	7,77	8,45
17	7,56	7,43	5,73	5,47	6	5,72	4,59	5,09	4,92	4,96	4,59	6,03	4,95	6,52	7,04
18	6,77	6,21	4,94	4,5	4,98	4,83	3,96	4,35	4,26	4,07	3,77	5,11	4,4	5,73	5,76
19	6,19	5,4	4,3	3,55	4,3	4,5	3,36	3,97	3,65	3,33	3,23	4,31	3,86	5,14	5,12
20	5,81	5,01	3,88	3,05	3,43	4,07	2,99	3,68	3,29	3,07	2,64	3,88	3,43	4,83	4,41
21	5,48	4,74	3,69	2,97	2,85	3,87	2,66	3,33	3,04	2,74	2,4	3,62	3,15	4,3	3,94
22	4,95	4,5	3,2	2,48	2,55	3,69	2,63	2,96	2,87	2,34	1,93	3,16	2,77	3,94	3,53
23	4,71	4,16	2,85	2,22	2,27	3,42	2,38	2,81	2,65	2,08	1,78	3	2,53	3,59	3,27
24	4,61	3,89	2,38	1,99	1,89	3,24	2,17	2,68	2,54	1,78	1,7	2,75	2,29	3,18	2,98

APPENDIX C

TL and DF Values of the Walls for Different Wall Thicknesses

Wall Types	5 cm		10 cm		15 cm		20 cm		25 cm		30 cm	
	TL	DF	TL	DF	TL	DF	TL	DF	TL	DF	TL	DF
Briquette	1.35	0.46	2.58	0.33	4.01	0.24	5.39	0.17	6.74	0.12	8.14	0.08
Brick	1.42	0.43	2.85	0.29	4.47	0.19	5.57	0.12	7.63	0.08	9.03	0.05
Blokbims	1.43	0.26	2.89	0.16	4.73	0.10	6.62	0.06	8.54	0.04	10.53	0.02
AAC	1.4	0.20	2.72	0.11	4.47	0.07	6.36	0.04	8.26	0.03	10.23	0.02

APPENDIX D

TETD Values of Walls [unit of data in tables °C]

Briquette wall – Dark surface – 10cm

Hours	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
East	8,48	8,23	7,98	7,85	7,69	7,54	7,46	7,33	8,43	10,87	13,88	16,45	17,38	17,24	16,30	15,75	15,52	15,14	14,35	13,27	11,81	10,35	9,35	8,83
West	8,95	8,70	8,45	8,32	8,16	8,01	7,93	7,80	8,30	9,62	11,21	12,98	14,42	15,56	16,02	16,95	18,09	18,54	18,53	18,02	16,29	14,31	9,82	9,29
South	7,84	7,59	7,35	7,21	7,05	6,90	6,82	6,69	7,20	8,51	10,10	11,87	14,34	15,92	16,63	16,80	16,31	15,37	13,71	12,63	11,17	9,71	8,72	8,19
North	7,39	7,14	6,89	6,76	6,60	6,45	6,37	6,24	6,97	8,44	9,65	11,42	12,86	14,00	14,46	14,66	14,43	14,05	13,26	12,17	11,60	10,58	8,26	7,73

Briquette wall – Light surface – 10cm

Hours	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
East	8,48	8,23	7,98	7,85	7,69	7,54	7,46	7,33	8,43	10,87	13,88	16,45	17,38	17,24	16,30	15,75	15,52	15,14	14,35	13,27	11,81	10,35	9,35	8,83
West	8,95	8,70	8,45	8,32	8,16	8,01	7,93	7,80	8,30	9,62	11,21	12,98	14,42	15,56	16,02	16,95	18,09	18,54	18,53	18,02	16,29	14,31	9,82	9,29
South	7,84	7,59	7,35	7,21	7,05	6,90	6,82	6,69	7,20	8,51	10,10	11,87	14,34	15,92	16,63	16,80	16,31	15,37	13,71	12,63	11,17	9,71	8,72	8,19
North	7,39	7,14	6,89	6,76	6,60	6,45	6,37	6,24	6,97	8,44	9,65	11,42	12,86	14,00	14,46	14,66	14,43	14,05	13,26	12,17	11,60	10,58	8,26	7,73

Briquette wall – Dark surface – 20cm

Hours	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
East	10,42	10,15	9,98	9,84	9,72	9,65	9,57	9,49	9,45	9,38	9,95	11,20	12,76	14,08	14,56	14,49	14,00	13,72	13,60	13,40	13,00	12,44	11,69	10,94
West	11,01	10,73	10,56	10,43	10,30	10,23	10,15	10,07	10,03	9,96	10,22	10,90	11,72	12,63	13,38	13,96	14,20	14,68	15,26	15,50	15,49	15,23	14,34	13,32
South	9,63	9,36	9,19	9,05	8,93	8,86	8,78	8,70	8,66	8,59	8,85	9,53	10,35	11,26	12,53	13,34	13,71	13,80	13,55	13,06	12,21	11,65	10,90	10,15
North	9,07	8,80	8,62	8,49	8,37	8,30	8,21	8,14	8,10	8,03	8,41	9,16	9,79	10,70	11,44	12,03	12,27	12,37	12,25	12,05	11,65	11,09	10,79	10,27

Briquette wall – Light surface – 20cm

Hours	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
East	7,53	7,28	7,10	6,97	6,85	6,78	6,69	6,62	6,58	6,51	6,80	7,52	8,47	9,40	9,86	10,00	9,82	9,73	9,67	9,57	9,33	8,97	8,44	7,93
West	7,83	7,57	7,39	7,26	7,14	7,07	6,98	6,91	6,87	6,80	6,94	7,37	7,95	8,68	9,27	9,74	9,92	10,21	10,50	10,62	10,58	10,37	9,77	9,12
South	7,14	6,89	6,71	6,58	6,45	6,38	6,30	6,22	6,18	6,11	6,25	6,68	7,27	7,99	8,85	9,43	9,68	9,77	9,64	9,40	8,94	8,58	8,05	7,53
North	6,86	6,60	6,43	6,30	6,17	6,10	6,02	5,94	5,90	5,83	6,03	6,50	6,99	7,71	8,30	8,77	8,95	9,05	8,99	8,90	8,65	8,30	8,00	7,59

Briquette wall – Dark surface – 30cm																								
Hours	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
East	11,97	11,62	11,27	11,03	10,90	10,81	10,75	10,69	10,66	10,62	10,59	10,57	10,53	10,80	11,39	12,12	12,75	12,97	12,94	12,71	12,58	12,52	12,43	12,24
West	13,66	13,24	12,76	11,67	11,54	11,46	11,40	11,34	11,31	11,27	11,23	11,21	11,18	11,30	11,62	12,01	12,44	12,79	13,06	13,17	13,40	13,68	13,78	13,78
South	11,10	10,75	10,39	10,15	10,02	9,94	9,88	9,82	9,79	9,75	9,71	9,69	9,66	9,78	10,10	10,49	10,92	11,51	11,90	12,07	12,11	11,99	11,76	11,36
North	10,48	10,34	10,09	9,53	9,40	9,32	9,25	9,20	9,16	9,12	9,09	9,07	9,04	9,21	9,57	9,86	10,29	10,64	10,92	11,03	11,08	11,02	10,93	10,74

Briquette wall – Light surface – 30cm																								
Hours	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
East	8,51	8,26	8,02	7,83	7,72	7,63	7,57	7,51	7,48	7,44	7,40	7,38	7,35	7,49	7,83	8,28	8,71	8,93	9,00	8,91	8,87	8,84	8,79	8,68
West	9,35	9,07	8,76	8,16	8,04	7,95	7,89	7,83	7,80	7,76	7,73	7,71	7,67	7,74	7,94	8,22	8,56	8,84	9,06	9,14	9,28	9,42	9,47	9,45
South	8,07	7,82	7,58	7,40	7,28	7,19	7,13	7,07	7,04	7,00	6,97	6,95	6,91	6,98	7,18	7,46	7,80	8,20	8,48	8,59	8,63	8,57	8,46	8,24
North	7,76	7,62	7,43	7,09	6,97	6,88	6,82	6,76	6,73	6,69	6,65	6,63	6,60	6,69	6,92	7,15	7,49	7,77	7,99	8,07	8,12	8,09	8,04	7,93

Brick wall – Dark surface – 10cm																								
Hours	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
East	8,86	8,63	8,42	8,30	8,16	8,03	7,96	7,84	8,81	10,95	13,60	15,86	16,68	16,55	15,72	15,24	15,04	14,71	14,01	13,06	11,78	10,49	9,62	9,16
West	9,35	9,13	8,91	8,80	8,65	8,53	8,45	8,34	8,78	9,94	11,34	12,89	14,16	15,16	15,57	16,38	17,38	17,78	17,77	17,33	15,80	14,06	10,12	9,65
South	8,18	7,96	7,74	7,62	7,48	7,35	7,28	7,16	7,61	8,76	10,16	11,72	13,89	15,27	15,90	16,05	15,62	14,80	13,34	12,38	11,10	9,82	8,95	8,48
North	7,70	7,48	7,26	7,14	7,00	6,87	6,80	6,68	7,33	8,62	9,68	11,24	12,51	13,51	13,91	14,09	13,89	13,55	12,86	11,90	11,40	10,50	8,47	8,00

Brick wall – Light surface – 10cm																								
Hours	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
East	6,40	6,18	5,96	5,84	5,70	5,57	5,50	5,38	5,88	7,11	8,74	10,32	11,10	11,35	11,04	10,88	10,77	10,61	10,20	9,59	8,68	7,80	7,13	6,70
West	6,65	6,42	6,21	6,09	5,95	5,82	5,75	5,63	5,87	6,61	7,60	8,84	9,85	10,65	10,96	11,45	11,95	12,15	12,08	11,72	10,70	9,59	7,38	6,95
South	6,06	5,84	5,62	5,50	5,36	5,23	5,16	5,05	5,28	6,02	7,02	8,25	9,71	10,71	11,13	11,28	11,06	10,66	9,86	9,25	8,35	7,46	6,80	6,36
North	5,82	5,60	5,38	5,26	5,12	4,99	4,92	4,81	5,14	5,95	6,78	8,01	9,02	9,83	10,13	10,30	10,20	10,03	9,62	9,01	8,50	7,81	6,56	6,12

Brick wall – Dark surface – 20cm

Hours	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
East	11,08	10,69	10,48	10,35	10,25	10,15	10,10	10,03	9,98	9,95	9,89	10,33	11,29	12,48	13,49	13,85	13,80	13,43	13,21	13,12	12,97	12,66	12,23	11,66
West	13,07	11,30	11,09	10,96	10,86	10,76	10,71	10,64	10,59	10,55	10,50	10,70	11,22	11,85	12,55	13,11	13,56	13,74	14,11	14,56	14,73	14,73	14,53	13,85
South	10,25	9,86	9,66	9,52	9,42	9,32	9,27	9,21	9,15	9,12	9,07	9,27	9,78	10,41	11,11	12,08	12,70	12,98	13,05	12,86	12,49	11,83	11,40	10,83
North	10,19	9,27	9,07	8,93	8,83	8,73	8,68	8,62	8,56	8,53	8,48	8,76	9,34	9,82	10,52	11,09	11,54	11,72	11,79	11,70	11,55	11,24	10,82	10,59

Brick wall – Light surface – 20cm

Hours	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
East	7,97	7,67	7,47	7,34	7,24	7,14	7,09	7,03	6,97	6,94	6,88	7,11	7,66	8,39	9,10	9,45	9,56	9,42	9,35	9,30	9,23	9,04	8,77	8,36
West	8,96	7,97	7,78	7,64	7,54	7,45	7,39	7,33	7,27	7,24	7,19	7,29	7,62	8,07	8,62	9,08	9,44	9,58	9,80	10,02	10,11	10,08	9,92	9,46
South	7,55	7,25	7,06	6,92	6,82	6,73	6,67	6,61	6,55	6,52	6,47	6,57	6,91	7,35	7,91	8,56	9,01	9,19	9,26	9,17	8,98	8,63	8,35	7,95
North	7,52	6,96	6,76	6,63	6,53	6,43	6,38	6,32	6,26	6,23	6,17	6,32	6,69	7,06	7,61	8,06	8,42	8,56	8,64	8,59	8,52	8,33	8,06	7,83

Brick wall – Dark surface – 30cm

Hours	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
East	11,98	11,82	11,60	11,38	11,23	11,15	11,09	11,06	11,02	11,00	10,97	10,95	10,94	10,92	11,09	11,46	11,91	12,30	12,44	12,42	12,28	12,20	12,16	12,10
West	13,21	13,14	12,87	12,57	11,89	11,81	11,76	11,72	11,68	11,66	11,64	11,62	11,61	11,59	11,66	11,86	12,10	12,37	12,59	12,76	12,83	12,97	13,15	13,21
South	11,08	10,92	10,69	10,47	10,32	10,24	10,19	10,15	10,12	10,09	10,07	10,05	10,04	10,02	10,09	10,29	10,53	10,80	11,17	11,41	11,52	11,55	11,47	11,33
North	10,44	10,27	10,18	10,03	9,68	9,60	9,55	9,51	9,47	9,45	9,43	9,40	9,39	9,37	9,48	9,71	9,89	10,16	10,38	10,55	10,62	10,65	10,61	10,56

Brick wall – Light surface – 30cm

Hours	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
East	8,46	8,36	8,20	8,05	7,94	7,86	7,81	7,77	7,73	7,71	7,69	7,67	7,65	7,63	7,72	7,93	8,21	8,48	8,62	8,66	8,61	8,58	8,56	8,53
West	9,08	9,02	8,84	8,65	8,27	8,19	8,14	8,10	8,07	8,04	8,02	8,00	7,99	7,97	8,01	8,13	8,31	8,52	8,69	8,83	8,88	8,97	9,05	9,09
South	8,01	7,91	7,75	7,60	7,48	7,41	7,36	7,32	7,28	7,26	7,24	7,21	7,20	7,18	7,22	7,35	7,52	7,73	7,99	8,16	8,23	8,26	8,22	8,15
North	7,69	7,58	7,50	7,38	7,16	7,09	7,03	7,00	6,96	6,94	6,91	6,89	6,88	6,86	6,92	7,06	7,20	7,41	7,59	7,72	7,78	7,81	7,79	7,76

Blokbims wall – Dark surface – 10cm																								
Hours	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
East	10,07	9,95	9,83	9,76	9,68	9,61	9,57	9,51	10,04	11,22	12,69	13,93	14,38	14,32	13,86	13,59	13,48	13,30	12,91	12,39	11,68	10,97	10,49	10,23
West	10,66	10,53	10,42	10,35	10,27	10,20	10,16	10,10	10,34	10,98	11,75	12,61	13,31	13,86	14,09	14,54	15,09	15,31	15,30	15,06	14,21	13,25	11,08	10,82
South	9,27	9,15	9,03	8,96	8,88	8,81	8,77	8,71	8,95	9,59	10,36	11,22	12,42	13,18	13,53	13,61	13,37	12,92	12,12	11,59	10,88	10,17	9,69	9,44
North	8,70	8,58	8,46	8,39	8,31	8,24	8,20	8,14	8,50	9,21	9,79	10,65	11,35	11,91	12,13	12,22	12,11	11,93	11,55	11,02	10,74	10,25	9,12	8,87

Blokbims wall – Light surface – 10cm																								
Hours	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
East	7,16	7,04	6,92	6,86	6,78	6,71	6,67	6,60	6,88	7,56	8,45	9,32	9,76	9,89	9,72	9,63	9,58	9,49	9,26	8,92	8,42	7,94	7,57	7,33
West	7,46	7,33	7,21	7,15	7,07	7,00	6,96	6,90	7,03	7,43	7,98	8,66	9,22	9,67	9,83	10,11	10,38	10,49	10,45	10,26	9,69	9,08	7,86	7,62
South	6,76	6,64	6,52	6,46	6,38	6,31	6,27	6,20	6,33	6,74	7,29	7,97	8,78	9,33	9,56	9,64	9,52	9,30	8,86	8,52	8,02	7,54	7,17	6,93
North	6,48	6,35	6,24	6,17	6,09	6,02	5,98	5,92	6,10	6,55	7,00	7,69	8,24	8,69	8,86	8,95	8,89	8,80	8,57	8,24	7,95	7,57	6,88	6,64

Blokbims wall – Dark surface – 20cm																								
Hours	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
East	11,61	11,34	11,16	11,06	11,00	10,96	10,91	10,89	10,86	10,83	10,82	10,79	10,99	11,44	11,98	12,45	12,62	12,59	12,42	12,32	12,28	12,21	12,07	11,87
West	12,99	12,63	11,82	11,72	11,66	11,61	11,57	11,54	11,52	11,49	11,47	11,45	11,54	11,78	12,07	12,39	12,66	12,86	12,95	13,11	13,32	13,40	13,40	13,31
South	10,71	10,45	10,27	10,17	10,11	10,06	10,02	9,99	9,96	9,94	9,92	9,90	9,99	10,23	10,52	10,84	11,29	11,57	11,70	11,73	11,65	11,48	11,17	10,98
North	10,24	10,05	9,63	9,53	9,47	9,42	9,38	9,35	9,33	9,30	9,28	9,26	9,39	9,66	9,88	10,20	10,47	10,67	10,76	10,79	10,75	10,68	10,54	10,34

Blokbims wall – Light surface – 20cm																								
Hours	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
East	8,22	8,04	7,90	7,81	7,75	7,70	7,66	7,63	7,60	7,58	7,56	7,54	7,64	7,90	8,23	8,56	8,72	8,77	8,71	8,68	8,65	8,62	8,54	8,41
West	8,92	8,69	8,23	8,14	8,08	8,03	7,99	7,96	7,93	7,91	7,89	7,87	7,92	8,07	8,28	8,53	8,74	8,91	8,97	9,07	9,17	9,22	9,20	9,13
South	7,78	7,59	7,45	7,36	7,30	7,26	7,21	7,19	7,16	7,13	7,12	7,09	7,14	7,29	7,50	7,75	8,06	8,26	8,35	8,38	8,34	8,25	8,09	7,96
North	7,54	7,39	7,14	7,05	6,98	6,94	6,89	6,87	6,84	6,81	6,80	6,77	6,84	7,01	7,18	7,44	7,65	7,81	7,88	7,91	7,89	7,86	7,77	7,64

Blokbims wall – Dark surface – 30cm																								
Hours	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
East	11,80	11,78	11,73	11,66	11,58	11,49	11,43	11,40	11,37	11,36	11,34	11,34	11,33	11,32	11,31	11,30	11,37	11,52	11,70	11,86	11,91	11,91	11,85	11,82
West	12,62	12,64	12,64	12,61	12,51	12,39	12,11	12,08	12,06	12,05	12,03	12,02	12,01	12,00	12,00	11,99	12,02	12,10	12,20	12,31	12,39	12,46	12,49	12,55
South	10,96	10,90	10,80	10,73	10,64	10,56	10,49	10,46	10,44	10,43	10,41	10,40	10,39	10,38	10,38	10,37	10,40	10,48	10,58	10,69	10,84	10,93	10,97	10,98
North	10,20	10,18	10,13	10,07	10,03	9,97	9,83	9,80	9,78	9,76	9,75	9,74	9,73	9,72	9,72	9,71	9,75	9,84	9,91	10,02	10,11	10,18	10,21	10,22

Blokbims wall – Light surface – 30cm																								
Hours	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
East	8,29	8,29	8,27	8,25	8,20	8,14	8,08	8,04	8,01	7,98	7,97	7,95	7,95	7,94	7,93	7,92	7,91	7,95	8,03	8,15	8,25	8,31	8,33	8,30
West	8,69	8,71	8,70	8,68	8,61	8,53	8,38	8,35	8,33	8,31	8,30	8,29	8,28	8,27	8,27	8,26	8,27	8,32	8,39	8,48	8,55	8,60	8,62	8,66
South	6,87	6,84	6,81	6,80	6,77	6,84	7,01	7,18	7,44	7,65	7,81	7,88	7,91	7,89	7,86	7,77	7,64	7,54	7,39	7,14	7,05	6,98	6,94	6,89
North	7,49	7,48	7,45	7,41	7,37	7,32	7,24	7,21	7,19	7,17	7,16	7,15	7,14	7,13	7,12	7,12	7,14	7,19	7,25	7,34	7,41	7,46	7,48	7,50

AAC wall – Dark surface – 10cm																								
Hours	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
East	10,53	10,45	10,37	10,32	10,27	10,22	10,19	10,15	10,52	11,33	12,33	13,19	13,50	13,46	13,14	12,96	12,88	12,75	12,49	12,13	11,64	11,16	10,83	10,65
West	11,16	11,07	10,99	10,95	10,89	10,85	10,82	10,77	10,94	11,38	11,91	12,50	12,98	13,36	13,52	13,83	14,21	14,35	14,35	14,18	13,60	12,94	11,45	11,27
South	9,69	9,60	9,52	9,48	9,42	9,37	9,35	9,30	9,47	9,91	10,44	11,03	11,85	12,38	12,62	12,67	12,51	12,20	11,64	11,28	10,80	10,31	9,98	9,80
North	9,09	9,00	8,92	8,87	8,82	8,77	8,74	8,70	8,94	9,43	9,84	10,43	10,91	11,29	11,44	11,51	11,43	11,30	11,04	10,68	10,49	10,15	9,38	9,20

AAC wall – Light surface – 10cm																								
Hours	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
East	7,46	7,37	7,29	7,24	7,19	7,14	7,11	7,07	7,26	7,73	8,34	8,94	9,24	9,33	9,21	9,16	9,12	9,05	8,90	8,66	8,32	7,99	7,73	7,57
West	7,77	7,68	7,60	7,56	7,50	7,45	7,43	7,38	7,47	7,75	8,13	8,60	8,98	9,29	9,40	9,59	9,78	9,85	9,83	9,69	9,30	8,88	8,05	7,88
South	7,03	6,95	6,87	6,82	6,77	6,72	6,69	6,65	6,74	7,02	7,39	7,86	8,42	8,79	8,95	9,01	8,93	8,78	8,47	8,24	7,90	7,56	7,31	7,15
North	6,73	6,65	6,56	6,52	6,47	6,42	6,39	6,35	6,47	6,78	7,09	7,56	7,94	8,25	8,37	8,43	8,39	8,33	8,17	7,94	7,75	7,48	7,01	6,85

AAC wall – Dark surface – 20cm

Hours	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
East	11,41	11,29	11,23	11,19	11,16	11,13	11,11	11,09	11,07	11,06	11,05	11,18	11,48	11,84	12,15	12,27	12,25	12,14	12,07	12,04	12,00	11,90	11,77	11,59
West	12,51	11,97	11,90	11,86	11,83	11,80	11,78	11,76	11,75	11,74	11,72	11,78	11,94	12,13	12,35	12,52	12,66	12,72	12,83	12,97	13,02	13,02	12,96	12,75
South	10,50	10,38	10,32	10,27	10,24	10,21	10,20	10,18	10,16	10,15	10,13	10,20	10,36	10,55	10,76	11,06	11,25	11,34	11,36	11,30	11,19	10,99	10,85	10,68
North	10,01	9,73	9,67	9,62	9,59	9,56	9,55	9,53	9,51	9,50	9,48	9,57	9,75	9,90	10,11	10,29	10,43	10,48	10,51	10,48	10,43	10,34	10,20	10,13

AAC wall – Light surface – 20cm

Hours	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
East	8,06	7,97	7,91	7,87	7,84	7,81	7,79	7,77	7,75	7,74	7,73	7,80	7,97	8,19	8,41	8,52	8,55	8,51	8,48	8,47	8,45	8,39	8,31	8,18
West	8,61	8,30	8,24	8,20	8,17	8,14	8,13	8,11	8,09	8,08	8,06	8,10	8,20	8,33	8,51	8,64	8,76	8,80	8,87	8,93	8,96	8,95	8,90	8,76
South	7,60	7,51	7,45	7,41	7,38	7,35	7,33	7,31	7,30	7,29	7,27	7,30	7,40	7,54	7,71	7,91	8,05	8,11	8,13	8,10	8,04	7,93	7,85	7,73
North	7,36	7,19	7,13	7,08	7,05	7,02	7,01	6,99	6,97	6,96	6,94	6,99	7,10	7,22	7,39	7,53	7,64	7,68	7,70	7,69	7,67	7,61	7,52	7,45

AAC wall – Dark surface – 30cm

Hours	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
East	11,78	11,73	11,66	11,58	11,49	11,43	11,40	11,37	11,36	11,34	11,34	11,33	11,32	11,31	11,30	11,37	11,52	11,70	11,86	11,91	11,91	11,85	11,82	11,80
West	12,64	12,64	12,61	12,51	12,39	12,11	12,08	12,06	12,05	12,03	12,02	12,01	12,00	12,00	11,99	12,02	12,10	12,20	12,31	12,39	12,46	12,49	12,55	12,62
South	10,90	10,80	10,73	10,64	10,56	10,49	10,46	10,44	10,43	10,41	10,40	10,39	10,38	10,38	10,37	10,40	10,48	10,58	10,69	10,84	10,93	10,97	10,98	10,96
North	10,18	10,13	10,07	10,03	9,97	9,83	9,80	9,78	9,76	9,75	9,74	9,73	9,72	9,72	9,71	9,75	9,84	9,91	10,02	10,11	10,18	10,21	10,22	10,20

AAC wall – Light surface – 30cm

Hours	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
East	8,27	8,25	8,20	8,14	8,08	8,04	8,01	7,98	7,97	7,95	7,95	7,94	7,93	7,92	7,91	7,95	8,03	8,15	8,25	8,31	8,33	8,30	8,29	8,29
West	8,71	8,70	8,68	8,61	8,53	8,38	8,35	8,33	8,31	8,30	8,29	8,28	8,27	8,27	8,26	8,27	8,32	8,39	8,48	8,55	8,60	8,62	8,66	8,69
South	7,84	7,87	7,88	7,86	7,83	7,78	7,74	7,68	7,61	7,57	7,54	7,52	7,50	7,49	7,48	7,47	7,46	7,46	7,45	7,46	7,52	7,58	7,67	7,77
North	7,48	7,45	7,41	7,37	7,32	7,24	7,21	7,19	7,17	7,16	7,15	7,14	7,13	7,12	7,12	7,14	7,19	7,25	7,34	7,41	7,46	7,48	7,50	7,49

APPENDIX E

Optimum Thicknesses [unit of data in tables cm]

Optimum Thickness of Uninsulated Walls				
Wall Types	Briquette	Brick	Blokbims	AAC
Optimum Thickness(cm)	29,21	25,61	15,74	9,84

Optimum Insulation Thickness of Walls				
Wall Types	Briquette-15cm	Brick-15cm	Blokbims-15cm	AAC-15cm
Optimum Insulation Thickness(cm)	6	6	4	3

Optimum Insulation Thickness of Walls				
Wall Types	Briquette-30cm	Brick-25cm	Blokbims-15cm	AAC-10cm
Optimum Insulation Thickness(cm)	5	5	4	4