THE IMPACT OF DOUBLE SKIN FACADES ON THERMAL PERFORMANCE OF BUILDINGS

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

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ABSTRACT

THE IMPACT OF DOUBLE SKIN FACADES ON
THERMAL PERFORMANCE OF BUILDINGS

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Human comfort and satisfaction are of utmost importance that should be considered in design of a buildings. Providing occupants with high level of comfort is notably affected by thermal performance of building. In the case of invalid thermal behavior, health, productivity and performance of occupants will be affected negatively. Therefore, in this study it is intended to find out that if double skin facades are fundamental factors in thermal performance of the buildings or not. The study will concentrate on thermal behavior of the space within the double skin façade. Moreover, it discusses the disadvantages of non- ventilated double skin façade cavity.

In this research, the south façade of Akman Medicorium Health Center in Ankara were investigated. Accordingly, the investigation was done through collecting temperature and relative humidity data by data loggers in cavity of south- east and south- west façade, the atrium and exterior. It is indicated that, the glass type in the façade of the building does not prevent inside to become hot through letting direct sunlight in to the building. Therefore, in order to decrease high heating loads of interior space, central cooling can be utilized in the building. It is recommended to apply ventilated double skin façade to the building which contributes to the thermal comfort of the space.

Keywords: Human Comfort, Thermal Performance, Double Skin Façade, Relative Humidity, Cavity, Central Cooling, Non- Ventilated DSF, Ventilated DSF.

ÖZ

ÇİFT KABUKLU CEPHELERİN BİNALARIN
TERMAL PERFORMANSİ ÜZERİNDEKİ ETKİSİ

Daneshkadeh, Samia
Yüksek Lisans, Yapı Bilimleri, Mimarlık Bölümü
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Binaların tasarımında insan konforu ve tatmini dikkate alınması gereken önemli hususlardır. Bina sakinlerinin konforunun en iyi şekilde sağlanabilmesi binanın termal performansının seviyesine bağlıdır. Yetersiz temal oluşum, sağlik ve üretkenliği olumsuz yönde etkilemektedir. Dolayısı ile, bu çalısmanın amacı çift kabuk cephelerinın binaların termal performansı üzerindeki termal etkilerinin araştırılmasıdır. Bu çalışma, çift kabuk cephelerinin arasındaki boşluğun termal davranışı üzerinde yoğunlaşmaktadır. Ayrıca çift kabuk cephelerinde havalandırılmış hava koridorunun dezavantajlarını da tartışmaktadır.

Bu araştırmada; Ankara'da bulunan Akman Medicorium sağlik merkezinin güney cephesı çalışılmıştşr. Bu çalışma, sıcaklık ve bağıl nem verilerinin güney-doğu ve güney-batı cepheleri, atrium ve diş ortamdan veri kaydedicisine toplanması vasıtası ile yapılmıştır. Bu çalışmada, bina cephesinde kulanılan cam türünün, iceriye direk olarak giren güneş ışığının sebep olduğu ısınmayı engellemediği gözlenmiğtir. Dolayısı ile, kapalı alanda oluşan yüksek ısının azaltılması icin binada merkezi soğutma kulanılabilir. Kapalı alandaki termal konfora katkıda bulunması amacı ile havalandırılmış çift kabuk cephe uygulanması tavsiye edilir.

Anahtar Kelimeler: İnsan konforu, Termal performans, çift kabuk cephe, Sıcaklık, Bağıl nem, Hava koridoru, Merkezi soğutma, Havalandırılmış ÇKC, Havalandırılmamış ÇKC.

To my parents and my lovely sister Salva

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LIST OF ABBREVIATIONS

DSF	Double Skin Façade
BBRI	Belgian Building Research Institute
HVAC	Heating, Ventilating and Air Conditioning
VDF	Ventilated Double Skin Façade
DL	Data Logger
SHGC	Solar Heat Gain Coefficiency

CHAPTER 1

INTRODUCTION

This study will consider the impact of double skin facades on thermal performance of buildings. In this chapter background information, problem, aim and objective accompanied by contribution will be presented.

1.1 Argument

The environmental impacts of buildings and the demand of applying new facade technologies in architecture have increased considerably in the last few years. Double skin facades started to be applied in many tall buildings since they can provide energy efficient design. These types of facades originated in European countries because of their awareness in ecological and environmental fields together with climatical comfort subjects. The rapid growth of double skin facades dates back to 1970's which is called as "oil crisis era". Double skin facades are commonly used in high rise buildings as they can provide opportunities such as thermal comfort, sound insulation and energy consumption.

The idea of a building envelope which can adapt to internal and external environment is not new. The improvement in utilizing glass in skin of the buildings resulted in the evolution in the design of double skin facades; thus in 19 centuries architectures were provided to come up with new design in building exterior by development of greenhouse construction and skeleton frame.

This study will consider the impact of double skin facades on thermal performance of the buildings since it is believed that double skin facades can be described as one of the remarkable factors which play a role in sufficient thermal performance of buildings.

The problem addressed by this study is poor thermal comfort in buildings which have a potential of resulting in excessive heat gain and loss during seasons since architects generally do not realize the difference in the performance of the ventilated double skin facades versus the non- ventilated double skin facades. As a result most buildings are seemed to have a fixed non- ventilated external skin.

1.2 Objective

Most percent of heat losses and gains happen through the glass in buildings' facades; thus, total glass surface is a significant factor in affecting the thermal behavior of the building. Therefore, the fundamental aim of this study it is to find out whether double skin facades are substantial elements in thermal performance of buildings or not. As a result this study will survey the impact of double skin facades on thermal behavior of the space within the DSF and its impact on the building energy loads and the drawback of a non- ventilated DSF cavity.

As a result the objective of the study will be presented through investigating the air condition system of the indoor space in Akman Medicorium Center on the basis of temperature.

1.3 Methodology

The study focused on double skin facades effect on thermal behavior of building which was carried out on Akman Medicorium Center. As a result in order for evaluation, thermal data in the spaces between south- east and south- west DSF, the atrium and external were collected for investigation.

In this study firstly, the temperature and relative humidity were recorded at 15 minute intervals in selected four spaces of the building through data loggers. These data were collected during the hottest season from 14 May 2013 until 23 July 2013.

Secondly, the raw data were downloaded to the computer from the data loggers and were imported to the Excel software. As a result, the data could be reached both in tabular and graphical forms. Thus, the overall obtained data examined and analyzed. Afterwards, the comparison was made between collected data from building and relevant standards at hand.

1.4 Disposition

The thesis is presented in five chapters:

The first chapter describes the topic of the thesis consisted of the problem statement and aims of study accompanied by procedure of the research namely overall methodology.

In the second chapter the literature review will be described. In this chapter general description of double skin facades will be presented consisted of their history and systems. Afterwards, goals of utilizing double skin facades and their classification will be discussed. Finally, thermal performance of double skin facades will be described including information about solar heat gain/loss and natural and mechanical ventilation through double skin facades.

In the third chapter the materials which utilized in the study will be explained. Afterwards, the case study building which is Akman Medicorium Center and data loggers which were utilized for data collection are introduced. Moreover, Ankara weather data which was obtained through http://www.eurometeo.com are also presented in this chapter. At the end, the methodology of the study is described in detail.

In the fourth chapter evaluation of data is done by having graphs and tables at hand. Therefore, discussions and outcomes of the study are presented in this part.

Finally, the fifth chapter will present the conclusions and recommendations.

CHAPTER 2

LITERATURE REVIEW

2.1 Double Skin facades

Andreotti (2001) states that “A building becomes a chameleon which adapts a properly equipped and responsively clothed building would monitor all internal and external variables, temperature, hygrometry and light levels, solar radiation and its internal systems accordingly. It is too much to ask of a building to incorporate, in its fabric and its nervous system, the very basic vestiges of an adaptive capability”.

Campogno (2002) describes the term double skin facades as “an arrangement with a glass skin in front of the actual building façade. Solar control devices are placed in the cavity between these two skins, which protects them from the influences of weather and air pollution, a factor of particular importance in high-rise buildings or ones situated in the vicinity of busy roads.”

Based on Aydin (2005) and Oestrele et al (2001) double skin facades have multilayer principles which are composed of exterior skin, interior skin and intermediate space. He states that in these types of facades weather protection and noise control is provided through exterior layer. Moreover, the ventilation of the intermediate and interior space is provided through openings which were installed to the skin; and solar induced thermal buoyancy and wind effect leads airflow in intermediate space.

Streicher (2005) points out some of the characteristics of double skin facades as their capability in providing buffer zone, wind and sound protection, energy consumption, pollutant protection and appropriate heating/cooling systems.

According to Ismail and Salinas (2006) and Oesterle (2001) double skin facades date back to utilizing box-type windows in most of European houses in order to increase thermal insulation. Oesterle et al (2001) state 1903 as the appearance time of curtain double skin wall in Steiff factory in Giengen, Germany. He mentions the attitudes of the double skin façade in Steiff factory as its capability in macimizing daylight with regard to high wind rate and cold weather of the Giengen. According to these studies double skin facades provide us with approximately 25 percent reduction in amount of utilized energy and external noise and natural ventilation not only in low- rise building but also in multistory constructions. In addition , double skin facades are most commonly used in tall buildings in order for providing natural ventilation because of lower pressure of the façade cavity and shading device protection because of extreme wind pressure apart from aesthetic purposes.

2.2 Goals of double skin facades

According to Aronas (2000a and 2000b) double skin facades have five the main goals which are discussed below.

a) Energy consumption and ecological responsibility: According to this study reducing solar energy factor on envelope of the building will lead to energy consumption. Therefore, reduced solar loads and low U- value will decrease the loads of the building in respect. In addition double skin façade are considered as their capability in saving natural resources, thus their priority in providing energy consumption along building performance life.
b) Economical issues: Depending on this research applying double skin facades in to the building will require higher cost in comparison to applying a conventional façade despite the additional costs which differ between 20%- 30%. Aronas states that in installation of double skin façade cost rate of the process should be considered and compared along with advantageous and life-cycle basics of the project while maintenance and operational costs also should be taken in to account. However, decreasing the size of HVAC system will lead to reduction of heating and cooling loads on building skin.
c) Natural ventilation: Based on Aronas study double skin facades are considered as suitable solution for areas with high wind rate because of their capability in providing buffering zone through placement of level of glass on exterior of the operable glass. Of course, mechanical ventilation of the double skin façade is demanded to be regarded as natural ventilation of double skin facades do not seem to be efficient and desirable for the areas with hot climate.
d) Noise reduction: A database was developed to store essential information of retrieved studies. It included information such as name of authors, name of journals, country of origin, year of publish, employed research models, statistical analysis methods and statistical analysis tools.
e) Safety: According to this study supplemental external layer of façade provides security of the building by acting as physical obstacle. Moreover, additional skin of façade provides windows to be opened in to the interior space which lead to come up with more secure building compared to the buildings with directly exposed glazings.
f) Aesthetics: Aronas implies that depth, layering and transparency attitude of double skin facades provides architectures to come up with various and alternative designs compared to buildings which stay as massive volume with traditional brickwork façade

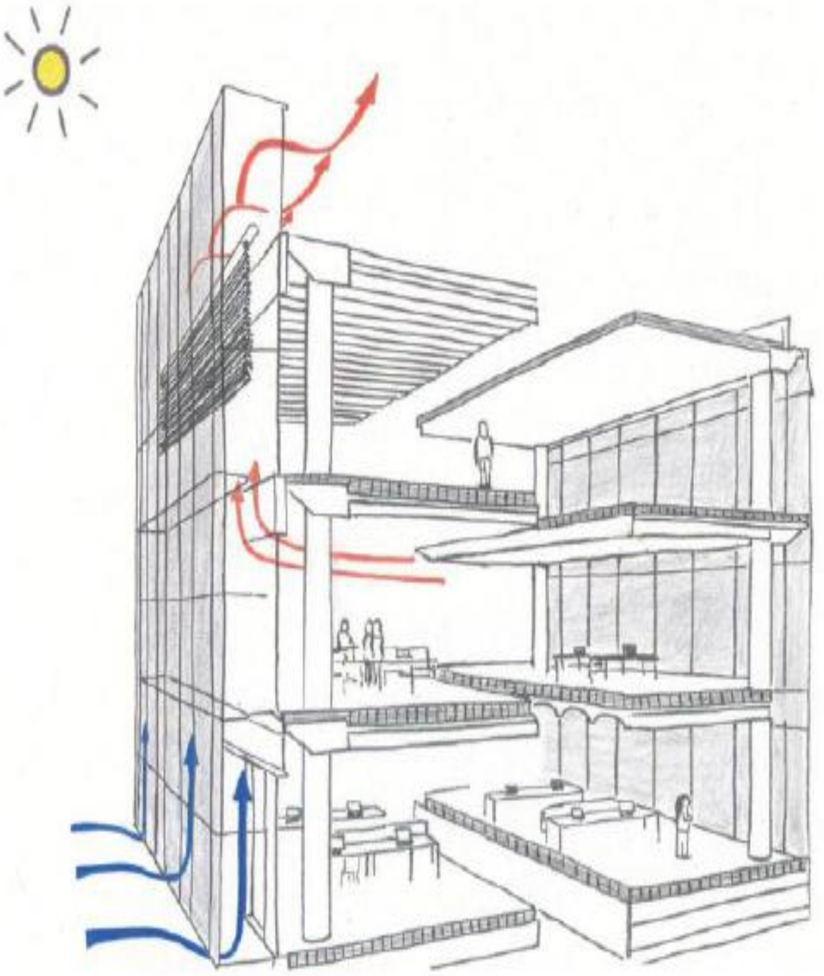


Figure 2.1 Typical double skin façade (Source: Angus, 2001)

2.3 Classification of double skin facades

Belgian Building Research Institute- BBRI (2004) indicates that "A double skin façade can be defined as a traditional single façade doubled inside or outside by a second, essentially glazed façade. Each of these two facades is commonly called a skin".

Table 2.1 Classification of double skin façade systems (Source: Gelesz & Reith, 2011)

<table>
<tr><td colspan="2">Ventilation mode</td><td>Non- ventilated buffer systems</td><td>Partly or fully ventilated (naturally or mechanically)</td></tr>
<tr><td colspan="2">Operation mode/ Construction type</td><td>Buffer zone</td><td>Outdoor air curtain
Indoor air curtain
Air supply
Air exhaust</td></tr>
<tr><td colspan="2">Window type systems</td><td>Compound window</td><td>Box- type window</td></tr>
<tr><td rowspan="4">Double skin facadess</td><td>Vertically and horizontally partitioned</td><td rowspan="3">Buffer Facade</td><td>Box- type window</td></tr>
<tr><td>Horizontally partitioned</td><td>Corridor facade</td></tr>
<tr><td>Multi- story</td><td>Multi- story facade</td></tr>
<tr><td>Mixed partitioning mode</td><td>–</td><td>Shaft- box type facade</td></tr>
</table>

2.3.1 Non-ventilated double skin facade

According to BBRI (2004) the intentional and possibly controlled ventilation of the ventilated double façade is the main difference between a non- ventilated and ventilated double kin façades, whether or not integrating a shading device in the cavity separating the glazing.

- **Buffer façade:** According to Pollard (2000) in this type of ventilation each of the skins of double skin façade is airtight and therefore no ventilation of the cavity is occurred, thus the cavity acts as a buffer zone between the inside and outside. In addition, the cavity of buffer DSF mainly functions as insulation layer.

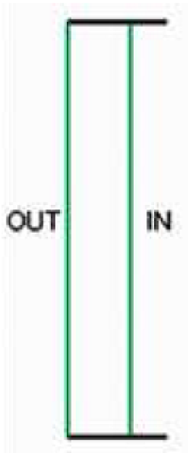


Figure 2.2 Buffer type façade **(**Source: Berezovska, 2011)

2.3.2 Ventilated double skin façade

According to the research done by Loncour, Deyener and Wouters (2004) in ventilated façade concepts ventilation of the cavity is controllable by means of fans, openings which are the remarkable characteristic of Ventilated double skin facades (VDF). A ventilated cavity- having a width can range from several centimeters to several meters- is located between two skins. Automated equipment, such as devices, motorized openings or fans, are often integrated into the façade.

Based on the Loncour, Deyener and Wouters (2004) the classification of ventilated double skin facades are generally done according to the geometric shapes of facades while their working modes are ignored. However, in this report the classification of double skin facades will be considered depending on their working mode, including:

- Ventilation type
- Partitioning type of façade
- Ventilation of the cavity

a) Ventilation type: According to the Loncour, Deyener and Wouters (2004) the impelling pressure of ventilation of the cavity which is located between two cover of glass is defined as type of ventilation, incuding:

(i) Natural ventilation: As Wong (2008) states fresh air for interior spaces can be supplied by natural ventilation. In his point of view number of factors that result in natural ventilation include: 1) differences in temperature which lead to air changes 2) pressure differences which lead to air movement or flow and 3) stack effect which Berezovska (2011) describes it as the “movement of the air in to and out of buildings, chimneys, flue gas stacks, or other containers, and is driven by buoyancy"; Of course, however air movement which result from stack effect seems efficient in order for cooling interior space by convection but in order to produce demanded air movement, these forces do not seem too much adequate for thermal comfort in hot places. In addition Berezovska (2011) indicates that natural ventilation decreases the need for mechanical ventilation, thus improve the environmentally friendly ventilation and energy consumption.

(ii) **Mechanical ventilation:** According to Gruner (2012) refers to Hegger (2008) mechanical ventilation systems concentrate on improving efficiency of transported volume and scattering of the air inside the system. Belgian Building Research Instituton (2004) describes the mechanical ventilation as: "Ventilation with the aid of powered air movement components".

(iii) **Hybrid ventilation:** Based on the study by Eggers, Matthes, Panaskova and Mukker (2009) hybrid ventilation system is the combination of the integrated ventilation unit and automated glasses. They state that in these systems motors which joined into window frame help windows to be opened continuously. They also add that mechanical ventilation system which is composed of controlled compromise of both natural and mechanical ventilation. Additionally, based on this study mechanical ventilation system can both supply the fresh air and take it out from the interior space.

b) **Partitioning type of cavity:** Based on Alibaba and Ozdeniz (2011) multiple skin facades are composed of two transparent surfaces which are partitioned by a cavity and need for cooling during summer or heating during winter can be decreased by utilizing additional skin. In their point of view these types of facades can be classified depending on the arrangement of the cavity as it is mentioned below.

(i) **Box type window:** According to Louver, Deyener and Wouter (2004) these types of facades are divided into independent boxes through vertical and horizontal partitioning. They state that these types of facades have special frame that hold the glass pane which is called fish-mouth; therefore the outside air which was built in the stories, is exhausted through fish- mouth.

Figure 2.3 The box type window **(**Source: Berezovska, 2011)

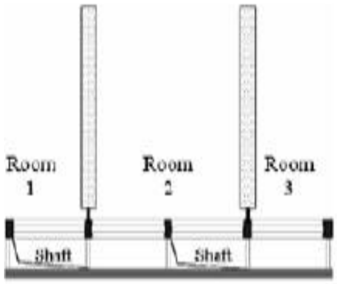
(ii) **The multistory DSF:** Berezovska (2011) points out that multistory ventilated double façades are composed of cavity which is not dived horizontally nor often vertically; additionally these types of facades can take advantage of stack effect which provides natural ventilation by installing suitable openings. Based on this research chimney effect influences the use of natural ventilation remarkably. The author adds that multistory double skin facades sometimes equipped with HVAC systems; and atrium space can be created through undivided space.

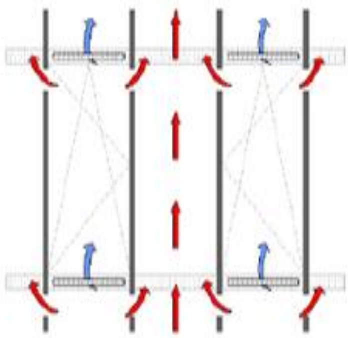
Figure 2.4 The multistory double skin façade (Source: Berezovska, 2011)

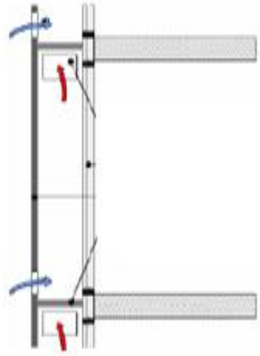
(iii) **The corridor type DSF:** According to Berezovska (2011) these types of double skin facades are composed of spacious cavity which is partitioned at each floor height horizontally and form corridors along the façade. The author states that in some types of double skin facades, story separating elements are utilized for cleaning and maintenance purposes. Berezovska emphasizes that cavity dividing decreases the overheating rate remarkably in levels above; moreover, corridor facades provide natural ventilation of the cavity without allowing hot air to move upward since they are equipped with air intakes and outlet at each story.

Figure 2.5 The corridor type façade (Source: Berezovska, 2011)

(iv) **The shaft- box DSF:** Berezovska (2011) indicates that shaft-box ventilated double skin facades are only applicable to the naturally ventilated facades since the partition takes advantage of natural ventilation and increases the stack effect. Berezovska adds that vertical shafts are installed among vertical components of façade and thus through stack effect trapped warm air in varied parts of façade can move upper to extract by outlets. In addition Alibaba and ozdeniz (2011) state that the air space is divided vertically along façade in shaft-box window; and box window are joined to tall ventilation shaft on the façade. They also emphasize some of the disadvantages of shaft-box facades including noise transmission and fire protection.


Room 1
Room 2
Room 3
Shaft
Shaft





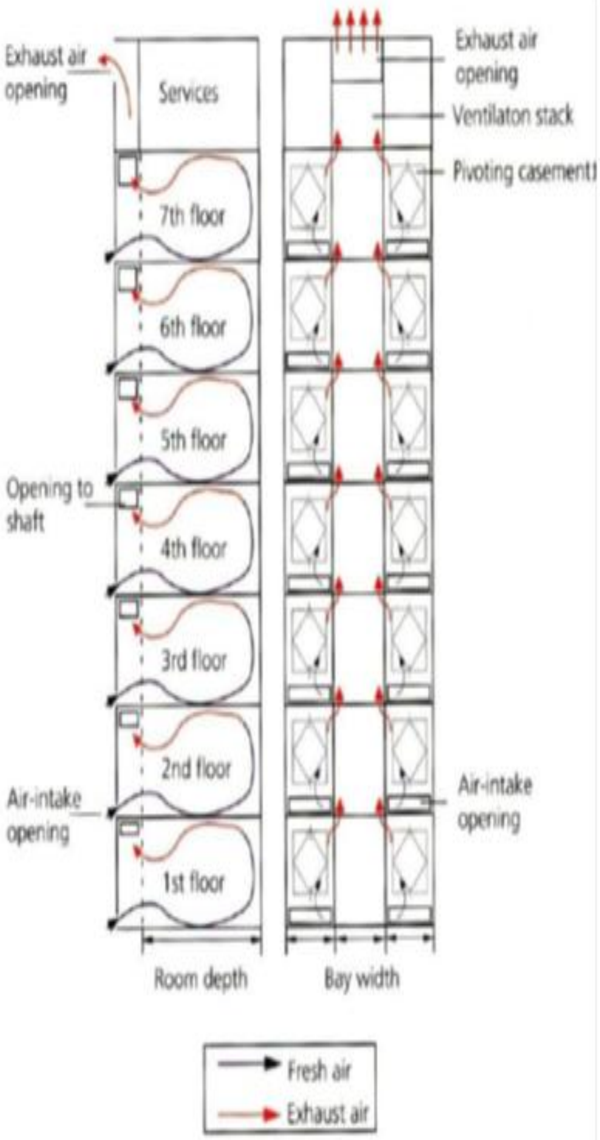

Exhaust air opening
Services
7th floor
6th floor
5th floor
Opening to shaft
4th floor
3rd floor
2nd floor
Air-intake opening
1st floor
Room depth
Exhaust air opening
Ventilaton stack
Pivoting casement
Air-intake opening
Bay width
Fresh air
Exhaust air

Figure 2.6 The shaft-box ventilated double skin façade (Source: Berezovska, 2011; Oesterle, 2001)

c) **Ventilation of the cavity:** According to Raffnsoe (2007) windows and ventilation are generally composed of individual systems; fresh air valves are located in window frames while in airflow windows, the cavity which is located among glass panes draw the fresh air before reaching interior space and cause integration of window and ventilation systems. It is possible to identify five ventilation modes in DSF. According to Louver, Deyener and Wouter (2004) "The ventilation mode refers to the origin and the destination of the air circulating in the ventilated cavity. The ventilation mode is independent of the type of ventilation applied". The author indicates the five ventilation modes, including:

- Outdoor air curtain
- Indoor air curtain
- Air supply
- Air exhaust
- Buffer zone

In addition, Coexistence of several ventilation modes in DSFs are also possible. As Alessi (2008) states " A number of ventilation modes can operate in an existing double skin façade and natural ventilated system with the help of motorized ventilation openings offers the most possibilities. These motorized ventilations openings can switch from one ventilation mode to another and bring the indoor comfort to an ideal level".

2.4 Thermal performance of double skin façade

Based on the Heinberg et al (2007) energy efficient building envelope is composed of thermal and air barrier elements. According to this study by installing suitable insulation products, effective thermal barrier will be provided; otherwise installing inappropriate insulation products will decrease energy performance of buildings nearly 30 percent; therefore, in order to come up with energy efficient design layer of insulation materials should be applied to the entire envelope.

According to EREC and NREL (2000) elements of energy efficient building are composed of walls, roofs, windows, insulation, air/vapor retarders and caulking. The study implies that the thermal envelope of the building attempts to protect indoor spaces from the outside. Additionally, dependent upon this study amount of R-value is too high in energy efficient buildings which described as ability of material that resists heat transformation. For example, the low R-value will cause quick heat loss. Figure below displays the amount of recommended R- values on building envelope:

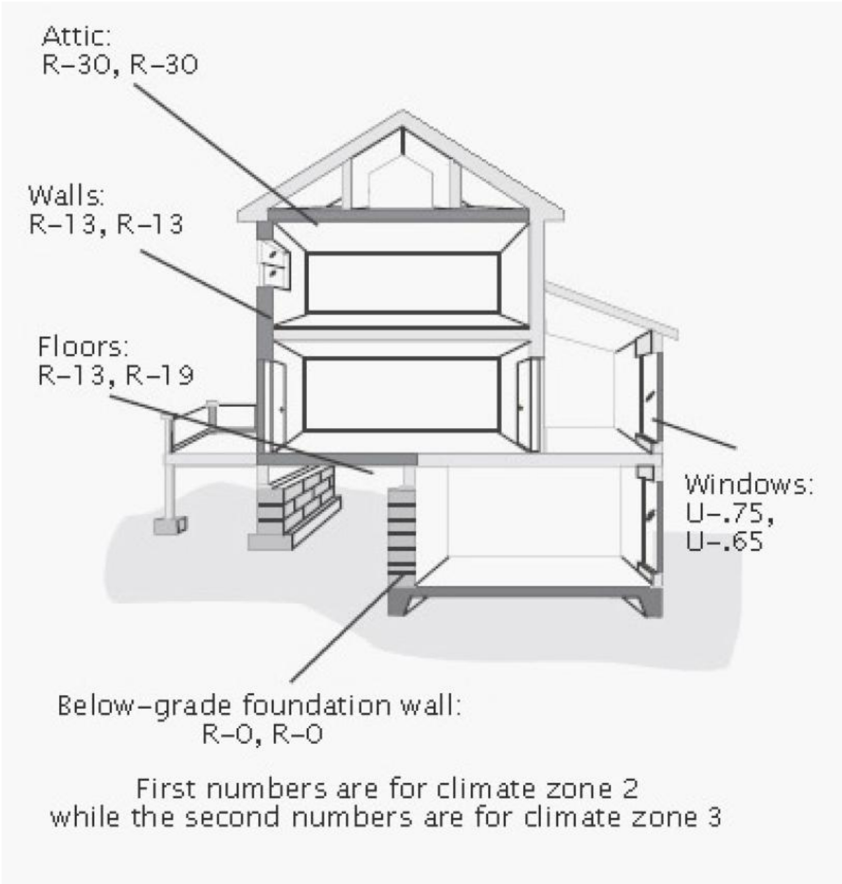


Figure 2.7 Insulating the Building Envelope- Recommended R-values
(Source:Heinberg 2007)

Depending on Ismail, Salinas and Henriquez (2008) approximately 90 percent of radiation can be transferred through simple glass windows. The study explains that amount of energy consumption can be remarkably decreased by taking advantage of new strategies and technologies. Additionally the study implies that windows with solar effective attributes are called thermally efficient windows since selective properties inside glass results remarkable changes in transmission, reflection and absorption; Therefore according to this research high performance glass can be achieved through applying deposited films.

2.4.1 Quality of indoor space

According to Heinberg et al (2007) our living environment should not be considered completely independent from outside world around. In this study some of the general remarkable problems of our living environments including homes, office, Hospital and etc are described as below:

- Extreme heating and cooling bills

- High humid range
- Excessive rate of fromaldehyde, radon and carbonmonxide

Therefore, Heinbergg et al (2007) states that in order to solve these kinds of problems it is demanded to come up with a design in which the living space is appropriately able to react to the interior and exterior environment; thus in order to reach this level of design the house should be able to act excellent in humidity levels, fluctuating temperatures and air pressures. Heinberg et al (2007) explains that the quality of the living environment can be provided through keeping following factors in pleasant levels.

- Moisture levels
- Temperature
- Air quality
- Air movement
- Structural integirity

2.4.2 Solar heat gain and loss

In this section the performance of double skin facades in hot and cold climate will be described based on Yilmaz and cetintas (2005) and Oesterle et al (2001):

- In winter time, exterior heat transfer resistance can be increased through qualified insulation which is provided by exterior supplemental skin. In addition despite the low U- value of constantly ventilated double skin façade in thermal transmission equivalent in comparison to the single skin façade, the outcomes will increase in quality while partly or totally there is not opening in the cavity during heating process. Moreover, heat loss rate will be reduced as a result of reduction in heat transfer amount through raised temperature and decreased air-flow speed in the cavity.
- In summer time, building envelope takes in the emitted energy which reaches the building, thus re- scattered waves of infrared energy can not transport to the exterior though the glass. Therefore, the trapped air inside the cavity will be increased in temperature through convection. In addition the transferring of the heated air inside the cavity occurs by means of conduction through glazing. According to Oesterle's study applying double skin facades in to the buildings will decrease the heat transfer amount from exterior to the interior and thus the amount of energy which is demanded in order for cooling purposes of the building. Depending on this research the heat transfer amount in constant condition is described as U-value; therefore heat flow through the building components is pretended by U- value (in W/m^2K) in constant condition with one degree of temperature difference among varied components. Moreover, low U-value rate implies to the high thermal resistance of the building components.

$$u = \frac{1}{\frac{1}{he} + \frac{1}{hi} + \frac{1}{ht}}$$

Where U= W/m^2K

- he= External heat transfer coefficient (W/m^2K)
- hi= Internal heat transfer coefficient (W/m^2K)
- ht= Conduction of multiple glazing units (W/m^2K)

The exterior heat transfer coefficient is indicated as he which is reflected on the exterior glazing of the building based on the outside condition. The hi indicates heat transfer coefficient of the cavity space in which convection and conduction of the cavity is the result of the transfer of remained radiation through the glass lead to reflection of the interior glazing and walls of the cavity. Finally, ht is indicator of the accumulated and remained heat through conduction and radiation that reaches the room. Heat transfer mechanism through single skin glass is illustrated in Figure 2.2. In addition figure 2.3 displays the heat transfer mechanism through double skin façade. Furthermore, figure 3.3 indicates the impact of conduction, convection and solar radiation on movement of the air inside the cavity. Figure 2.8 also describe the factors that affect heat transfer through building skin.

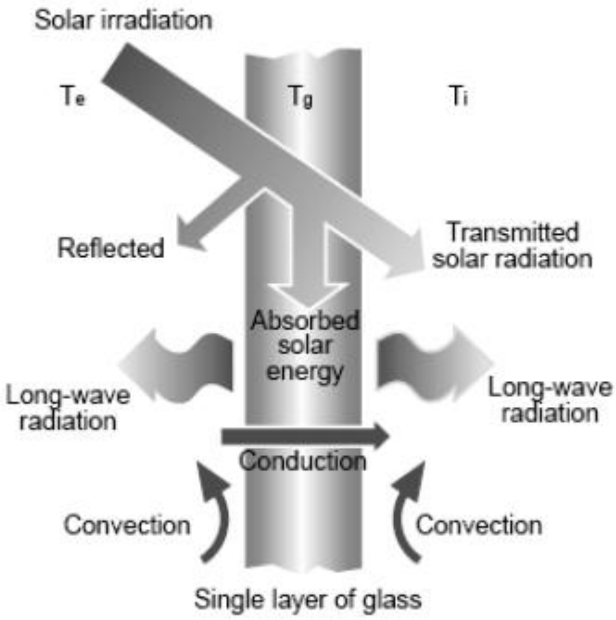


Figure 2.8 Heat transfer through single skin glazing (Source: Yellamraju, 2004)

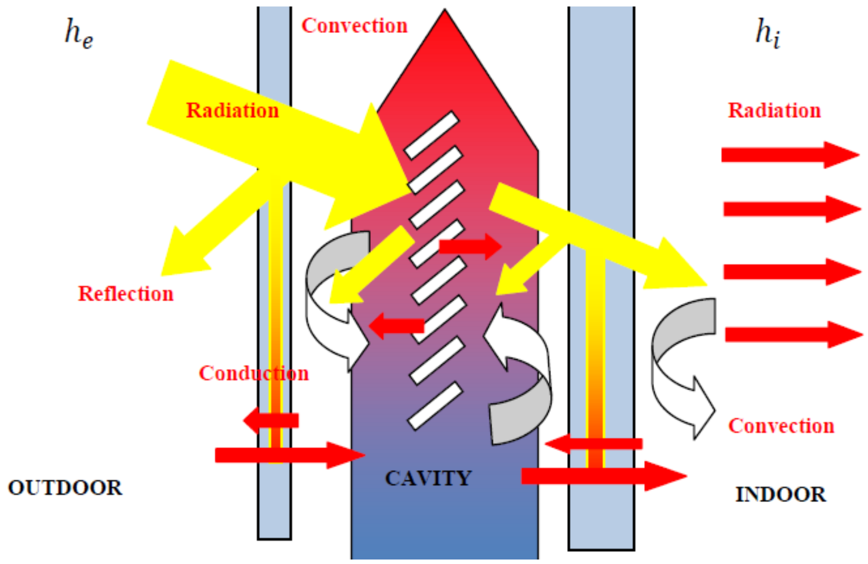


Figure 2.9 Heat transfer through single skin glazing (Source: Yellamraju, 2004)

2.4.3 Natural ventilation and double skin façade

According to Azarbayjani (2010) however the optimization of mechanical ventilation has been increased in last half century, natural ventilation also can be considered as well ventilating solution and cost effective system in comparison to air conditioning system. Based on this study in natural ventilation in it is intended to reduce the amount of energy which is consumed for cooling by taking advantage of natural driving forces as well as possible.

Azarbayjani (2010) states that increased interior heat loads and deeper plans of highly populated buildings lead to come up with mechanically ventilated construction in which introduced air in to the building can be controlled. Therefore, in order to reach satisfactory and comfort of occupants through having uniform interior space temperature, it has been required to control the introduced air in to the building.

According to Gratia and Herde (2004b) and Azarbayjani (2010) building velocity is increased in respect to its height. Therefore, healthy solution of building ventilation should be taken in to account. She states that in order to solve the velocity problem, façade of the building was sealed and so mechanical ventilation was utilized as ventilating system, conventionally. As a result, in traditional solution, façade of the building was closed and introduced air in to the building could be controlled. Moreover, because of flapping risk of shading devices in high rise buildings, the shading devices were suggested to be eliminated; thus these lead to come up with the façade which was closed with second skin.

Azarbayjani (2010) mentions that it has been claimed that considerable amount energy can be saved through by taking advantage of natural ventilation through utilizing double skin façade. She also states that according to the Grabe et al (2002) study on temperature performance and air flow attitudes of naturally ventilated double skin facades, heat sources which are close to window panes lead to increase of temperature.

Based on the study done by Gratia and Herde (2004a,b,c) and (2007a,b,c) on strategies of natural ventilation on double skin facades it has been explained that in order to provide appropriate ventilation during day and night, window opening should be applied to the building despite inadequate wind attitudes. In addition, in their point of view, utilizing cavity air for ventilation in south facing double skin façade during winter is not adequate while air moves downward in the openings as a result of high pressure of the wind. As a result building cooling load is increased because of the warmed cavity air that reached the building interior. Moreover, because of high temperature of the cavity air than outside temperature along the day it should be taken in to account to provide louver control system in order to prevent increase of cooling loads through natural ventilation in south facing double skin façade.

Finally, based on Azarbayjani (2010) study, natural ventilation of the building can be driven in two ways including stack/buoyancy driven and wind driven ventilation. She explains that in both stack and wind driven ventilation outside fresh air can reach interior space of the building and unfavorable heat can be driven to the outside.

2.4.4 Mechanical ventilation and HVAC systems

Oesterle (2001) states that it has been believed most commonly that with appearance of double skin façade there is no need for applying mechanical ventilation in to the building. In his point of view, such a subject should not be generalized while it should also not be ignored depending on the applied constraints on each distinct case. For example, absence of mechanical ventilation in to the building in high temperature conditions will lead to thermal discomfort, though occupant dissatisfaction.

Oesterle (2001) describes that satisfaction evaluation of the habitants in entire naturally ventilated building differs from high to low. He gives an example of Gladbacher bank in Monchengladbach in Germany which provides high occupants satisfaction by increasing thermal comfort quality through utilizing scope in window ventilation. On the other side, the study also explains displeasure of occupants where air- conditioning system is not planted in to the building because of economical issues and lack of adequate space for such a system; in which occupants were unsatisfied due to overheating problems and insufficient fresh air supply in the absence of mechanical ventilation.

As a result, based on Oesterle (2001) in spite of wind flow problems and extreme noise, facilitating of natural ventilation by double skin facades throughout the year is considerably appreciable. On the other hand, according to this study by utilizing air-conditioning in building ventilation system high satisfaction of thermal comfort can also be reached inside the building.

According to the Oesterle (2001) double skin facades provide scope for decreasing installation dimension of the mechanical air- conditioning due to more qualified association of building physics with these types of construction. Therefore, Oesterle mentions that during winter more improved seal and U- value is provided through utilizing double skin façade that single ones.

Oesterle (2001) explains that in the case of sealed windows it is required to take advantages of mechanical ventilation. He adds that interior skin of façade in the case of having double skin façade can be opened in order for natural ventilation ; thus in such a situation partial mechanical ventilation can be installed in place of using systems which supply cooling, heating, humidification and dehumidification. Oesterle states that partial and full air conditioning systems are separated from each other in the case of humidification and dehumidification and also through decreasing of cooling capacity. Moreover, depending on this study partial air conditioning system can also be called "supporting ventilation system with cooling".

Based on Oesterle (2001) in supporting ventilation system, mechanical air conditioning system is utilized in high temperature of the summer and low temperature during winter; thus due to low heating and cooling loads during other seasons the building have to be managed in the absence of this system in other seasons.

According to Streicher (2005) by utilizing HVAC (Heating, Ventilating and Air Conditioning) systems desired and demanded environmental condition can be provided in a space. Based on this study certain performance demands' including energy consumption, thermal comfort and air quality should be provided in a building.

Based on Saelens, Carmeliet and Hens (2003) and Streicher (2005) energy consumption demands' means that the energy which is required to heat and cool the building and the energy which is required for building operation should be as effective as possible through utilizing free cooling and heat recovery based on climatic conditions. In addition indoor air quality demands' means that particular ventilation efficiency and indoor air flow should be reached. Moreover, in order to reach thermal comfort demands' comfortable level of interior space should be provided which means that it is not valuable to have too much cool or warm environment. As a result in order to have valuable interior space air quality and reduced energy consumption, energy efficient and properly controlled ventilation system is required.

Streicher (2005) presents two approaches for the building with HVAC systems:

- "A building with its own separate heating, cooling and ventilating system, where a second skin is added to the façade. The cavity of the double skin façade is only ventilated to the outside and is built to reduce noise, contain solar shading and light redirection devices".

- “A building where the heating, cooling and ventilating system of the building is integrated in to the double skin façade e.g. by ventilating the building using the cavity of double skin façade”.

Streicher (2005) describes some of the benefits of double skin facades which are effective on HVAC system as it is cited at below:

Firstly, cooling loads can be reduced through double skin facades by mounting daylight enhancing and solar shading devices in to the space inside the air gap.

Secondly, electricity consumption for ventilating can be reduced through double skin facades as they provide natural ventilation.

Thirdly, heat losses and heat loads can be reduced during winter through the cavity in double skin façade since the cavity offers thermal buffer zone and provides passive solar gain.

CHAPTER 3

MATERIALS AND METHODS

The details of the research study will be explained in this chapter. The details are composed of two parts: the material and the method. The □ Material □ section includes the introduction of the case study which is Medicorium Building in Ankara and the data loggers which are utilized in order for collecting data. Afterwards, in □ Method □ section, collection, measurement and evaluation of the data will be presented.

3.1 Materials

In this research the Akman Medicorium Medicine center is selected as a case study in order to conduct research on the impact of double skin facades on thermal performance of the buildings. Along this research, in order to record temperature and relative humidity six data loggers were utilized which were located in four different spaces of the building. Accordingly, the case study building which is the Akman Medicorium center, data loggers which are used for collection and measurement of data will be described in this section.

3.1.1 Case study building

In the case study the effect of double skin facades on thermal performance of building was examined through evaluating and comparing outdoor and indoor air quality in Akman Medicorium building.

a) **General description:** The case study □ Akman Condominium Business Center-Medicorium Medicine Center □ is located in Balgat region in Ankara. The building is designed and constructed by Mustafa Yuce in 1997. The Akman Condominium Center is constructed as three distinct building in which the Medicorium center is connected to the main body through a laminated glass bridge which is supported by a steel structure. Hence, the building is composed of the main body which is the hotel with the height of 110 meter and 31 stories, the Medicorium health center and the Emporium which is the shopping center. The main entrance of the Medicorium building in which the survey is conducted is in south façade.

Figure 3.1 Akman Condominium Business Center- Medicorium Center

(Source: http://wowturkey.com/forum/viewtopic.php?t=21, 6.2.2013)

Figure 3.2 Entrance of Akman Condominium Business Center- Medicorium Center

(Source: www.akmanmedicorium.com, 6.2.2013)

Figure 3.3Top view from Akman Medicorium health center

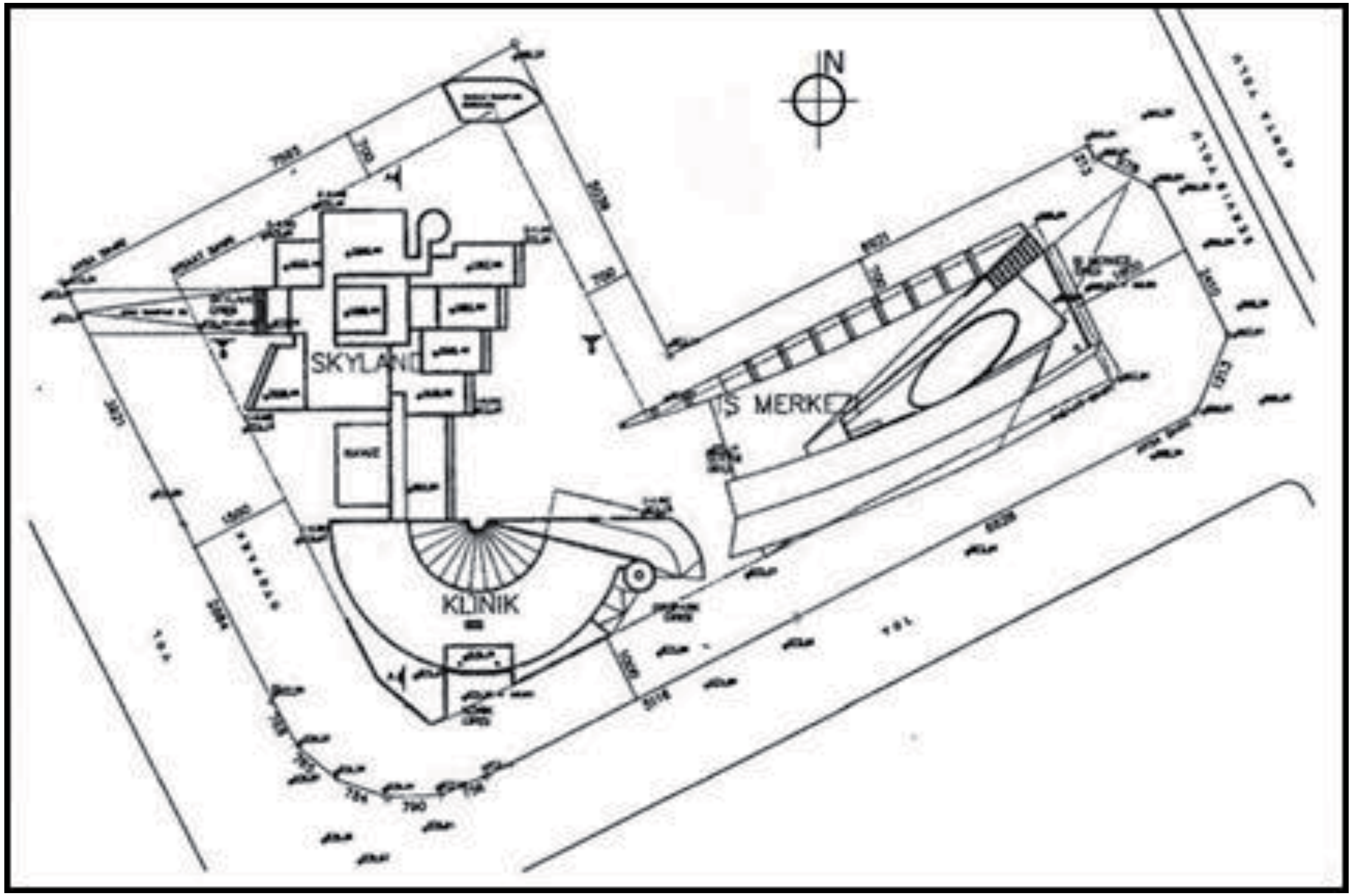


Figure 3.4 Site plan of Medicorium Center

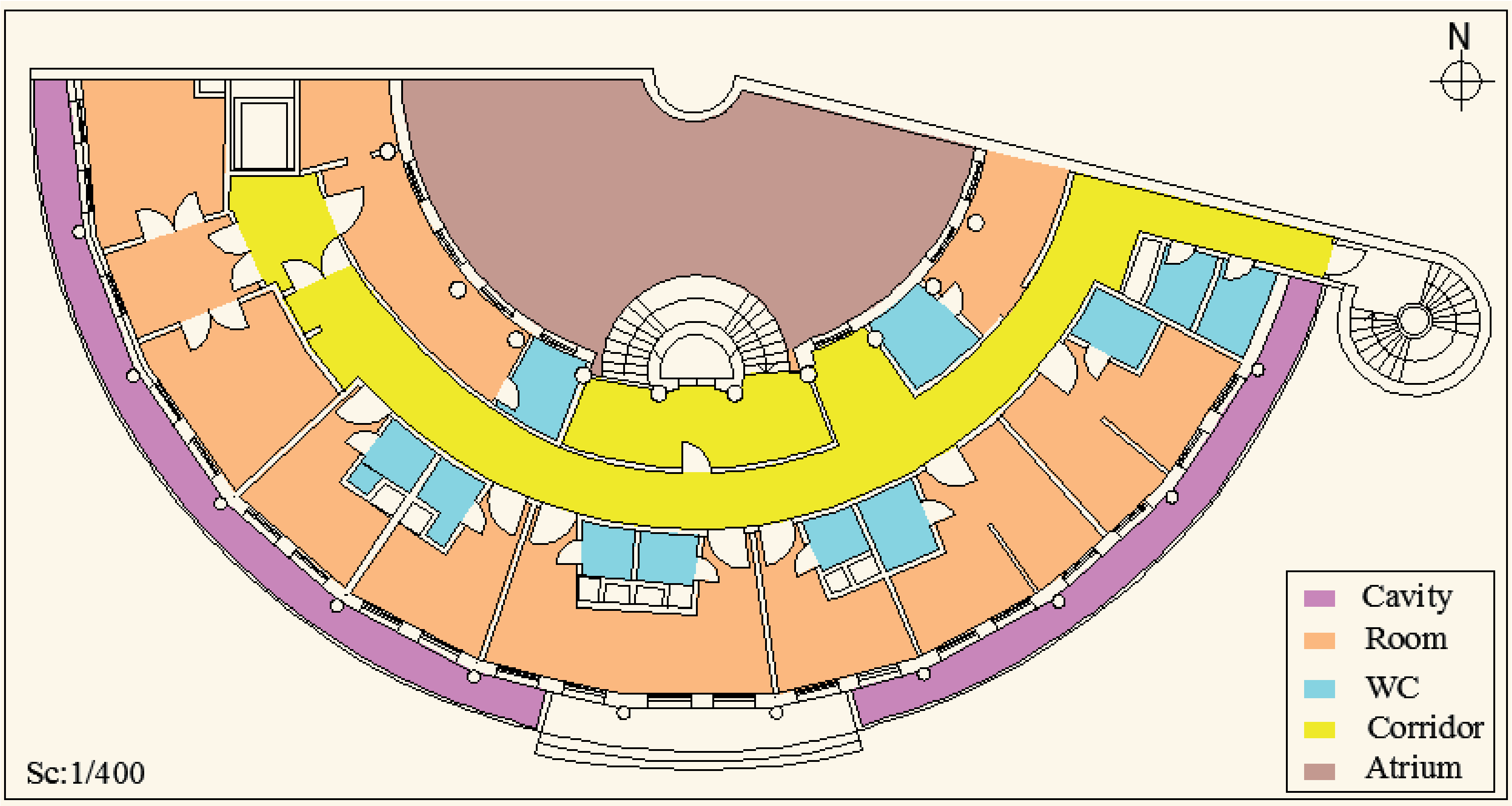


Figure 3.5 The plan of medicorium center

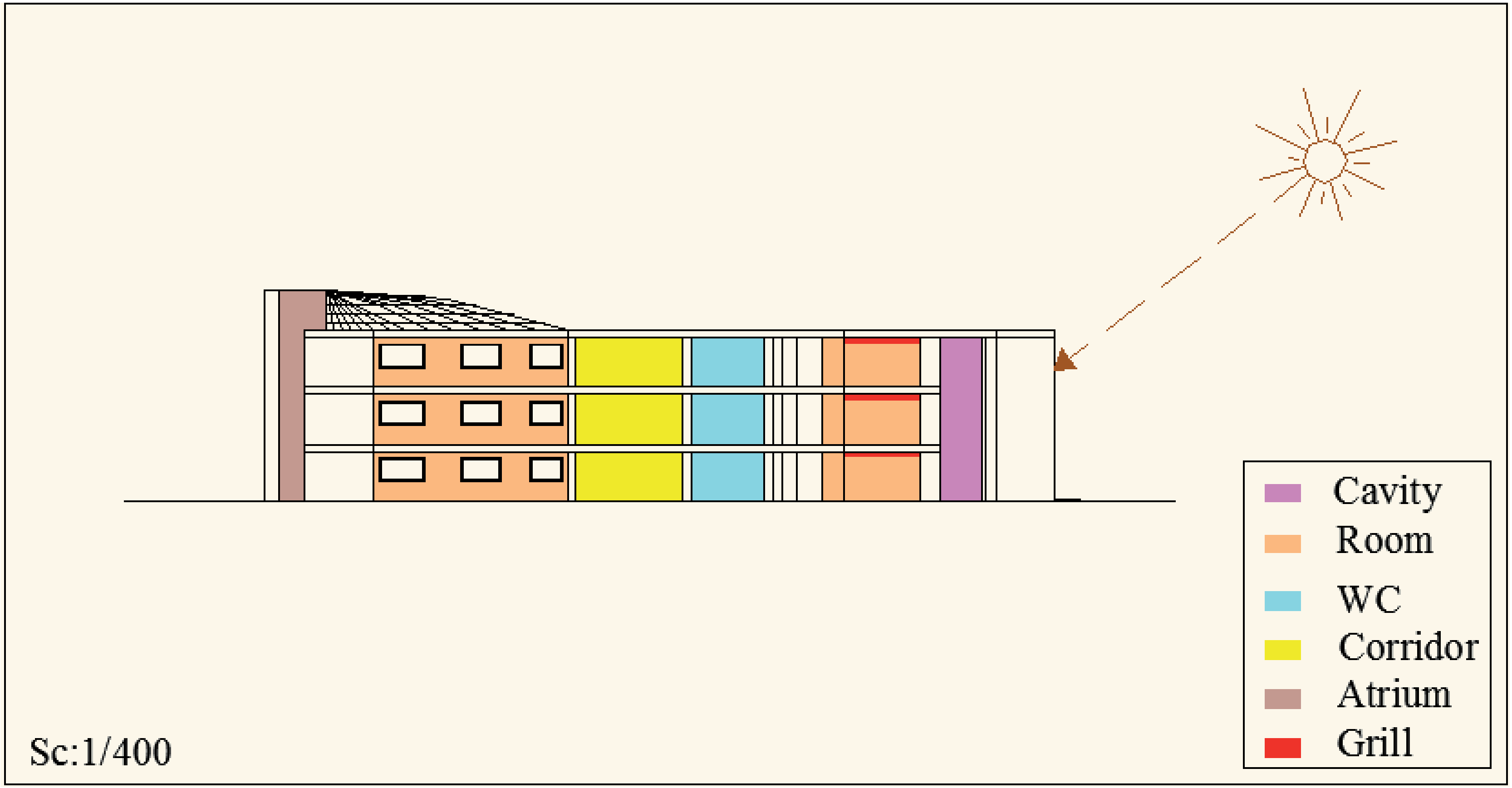


Figure 3.6 Section from Akman Medicorium health center

b) **Ventilation system:** Based on the research and interviews with staff of the Medicorium medicine center it is understood that the building ventilation is done mechanically through air conditioning system. In Medicorium health center both heating and cooling is done solely by central air conditioning system throughout the year in which for taking advantage of heating through mechanical system natural gas is utilized.

Additionally through the interview with ventilation system responsible staff of Medicorium health center it has been discovered that there is no exact date for starting heating and cooling ventilation in the building. Therefore, heating and cooling of the building depends on the weather condition of the Ankara in which heating of the building starts when it is less than 10 degree and cooling starts when it is more than 22 degrees centigrade.

Moreover, amount of electricity consumption in Medicorium building by considering only mechanical based ventilation (heating and cooling) is approximately about 29, 440 KW for each month (2013) which provides monthly electricity costs between 9.500 and 10.000 Turkish Lira (2013).

As it is stated further in this study the south façade of the building will be examined in which two grills are located in the empty space between regular wall and glass facade of the building. According to the examination it is discovered that cool air is emitted through the grills which located in empty space between glass and wall. Figure below shows the location of the grills on the plan.

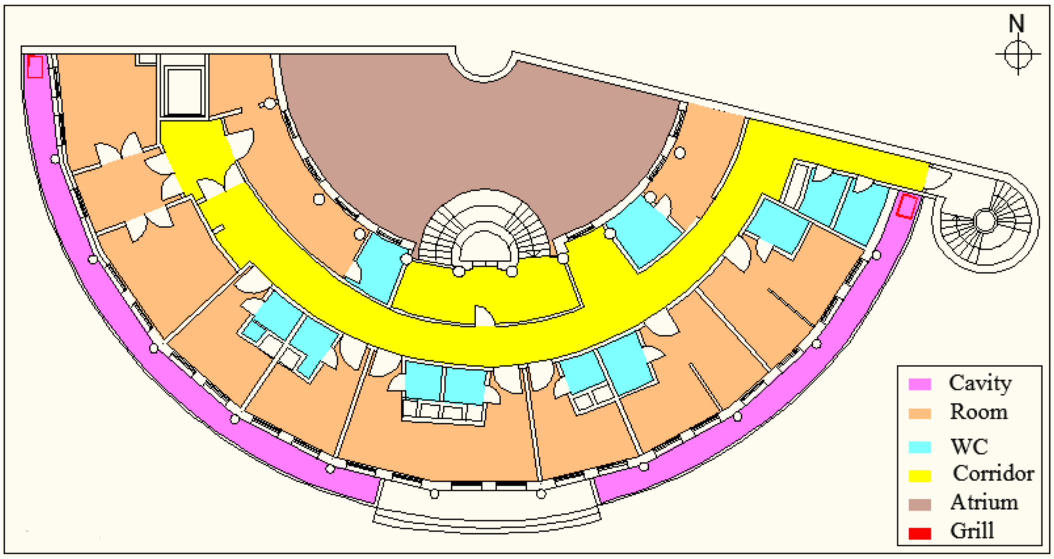


Figure 3.7 Grills location at south façade of the building

Figure 3.8 Grills location in south façade of Medicorium health center

Figure 3.9 Grills location in rooms of Akman Medicorium health center

c) **Glass facade information:** The east and west façade of the building is composed of three storied curvilinear glass walls in front of regular walls of the building. Moreover, as shown in the figure 2.19 the east and west articulated glass façade of the building with 30 meter height is supported through glass wall systems which afford view over street.

Figure 3.10 The South facade of Akman Medicorium Center

(Source: www.akmanmedicorium.com, 6.2.2013)

Figure 3.11 The entrance and south facade of Akman Medicorium Center

Through the interview with the architect of the building it is found out that the security glass type was utilized in facade of the building. Therefore, according to the www.trakyacam.com in order to reduce the risks of injuries as result of possible glass breakage and additionally in order to provide security against external attack the glass type has to be laminated glazing. Moreover, based on Trakya Cam Sanayi laminated security glazing is manufactured with clear or opaque PVB (Poly Vinyl Butyral) film layers and these types of glazing is proper recommendation to be utilized in hospitals. Furthermore, depending on the http://www.aisglass.com "Laminated glass is a sandwich made of one piece of plastic Poly Vinyl Butyral between two or more glasses. The PVB sticks with the glass, forms chemical as well as mechanical bonds. When laminated with annealed glass, the layer maintains the geometric integrity of the pane in case of breakage. Also it gives acoustic insulation as well as gives protection against damage caused due to UV radiation because it cuts almost 97% of UV radiation present in the sunlight. A Laminated glass is regarded as a safety glass by most of the standards". The each glass pair in the façade of the case study building has 1.24 widths and 2.42 length. Table 3.1 displays some of the properties of laminated security glass.

Table 3.1 Properties of laminated security glass (source: www.trakyacam.com)

	PVB Thickness (mm)	Glass Thickness (mm)	Standard Dimensions (mm)	Thickness Tolerance (mm)
Clear	0.38 0.76	3+3 4+4	3210 x 2250 3210 x 2500 3210 x 6000	± 0.4
Clear	0.38 0.76	5+5 6+6	3210 x 2250 3210 x 2500 3210 x 6000	± 0.4
Opaque	0.38	4+4 5+5	3210 x 2500 3210 x 6000	± 0.4

Therefore, according to the data at hand it can be realized that the each glass pair is divided in to the smaller parts and so the glass type in façade of the building should be categorized among glass with the thickness of 3+ 3 which has the minimum standard dimensions. As a result, depending on Table 3.2 which achieved from www.nationalglass.com it is found out that the U- value of the glass in the façade of the building is approximately about 5.8 or 5.7 with SHGC of 0.79. Thus, it is realized that the non- ventilated laminated security glazing (Glass with PVB film layers) with high U- value and SHGC has been utilized in the façade of the building.

Table 3.2 SHGC and U- value of laminated glass (source: www.national glass.com)

Laminated Glass	SHGC	U- value (W/m^2K)
6.38mm	0.79	5.8
6.76mm	0.79	5.7
8.38mm	0.75	5.7
8.76mm	0.75	5.6
10.38mm	0.72	5.6
10.76mm	0.72	5.6
12.38mm	0.70	5.6
12.76mm	0.70	5.5

In this study in order to examine the impact of double skin facades on thermal performance of buildings the spaces between regular walls and the East- South and West- South façade of building was selected for data collection as the façade of building is composed of curvilinear glass wall in front of regular wall. Moreover, it is also decided to select some data from attic and atrium. Table 3.2 describes the features of the locations where the were selected for data collection. In this study cleaning staff in Medicorium building helped in finding information about the cleaning of the selected four spaces which data loggers were located. According to the cleaning staff since cavity of the South-East and South-West facade, atrium and attic are not used in the building, thus cleaning issues in these spaces are not happened frequently but occasionally and once in a month for about 10 or 15 minutes.

Figure 3.12 The interior view from south facade of Akman Medicorium Center

Figure 3.12 The interior view from south facade of Akman Medicorium Center

Table 3.3 Features of selected locations for data collection

	Space Between East – South Façade and Regular Wall	**Space Between West – South Façade and Regular Wall**	**Atrium**	**Fire Exit**
Floor	-1	-1	+1	+2
Facing Facade	East- South	West- South	West- North	West
Purpose of Use	Empty Space between regular wall and glass wall	Empty Space between regular wall and glass wall	Atrium	Fire exit
Floor Material	Mosaic tiles	Mosaic tiles	Mosaic tiles	Stone
Ventilation System	Air conditioner	Air conditioner	Air conditioner	Air conditioner
Heating System	Air conditioner	Air conditioner	Air conditioner	Air conditioner

In this study cleaning staff in Medicorium building helped in finding information about the cleaning of the selected four spaces which data loggers were located.

According to the cleaning staff since cavity of the South-East and South-West facade, atrium and attic are not used in the building, thus cleaning issues in these spaces are not happened frequently but occasionally and once in a month for about 10 or 15 minutes.

3.1.2 Data loggers

In this study Onset HOBO U12 data loggers were utilized in order for collection and measurement of data. Onset HOBO U12 data loggers are located in selected locations of the building and they can record and measure the temperature and relative humidity themselves.

Onset HOBO U12 data loggers are utilized in indoor spaces. In addition, HOBOware pro software is required in order to readout and launch data loggers. The collected and recorded data can be downloaded to the computer both in tabular and graphical manner through utilizing HOBOware software.

Figure 3.13 Onset HOBO U12 data logger

(Source: http://www.onsetcomp.com/products/data-loggers/u12-012, 6.2.2013)

3.1.3 Weather data for Ankara

In this research Ankara weather data were acquired from http://www.eurometeo.com. Afterwards, all data were imported to the Excel and thus temperature graph for Ankara weather data could be reached between 14 May and 23 July. Figure 3.8 displays temperature chart for Ankara between 14 May and 23 July.

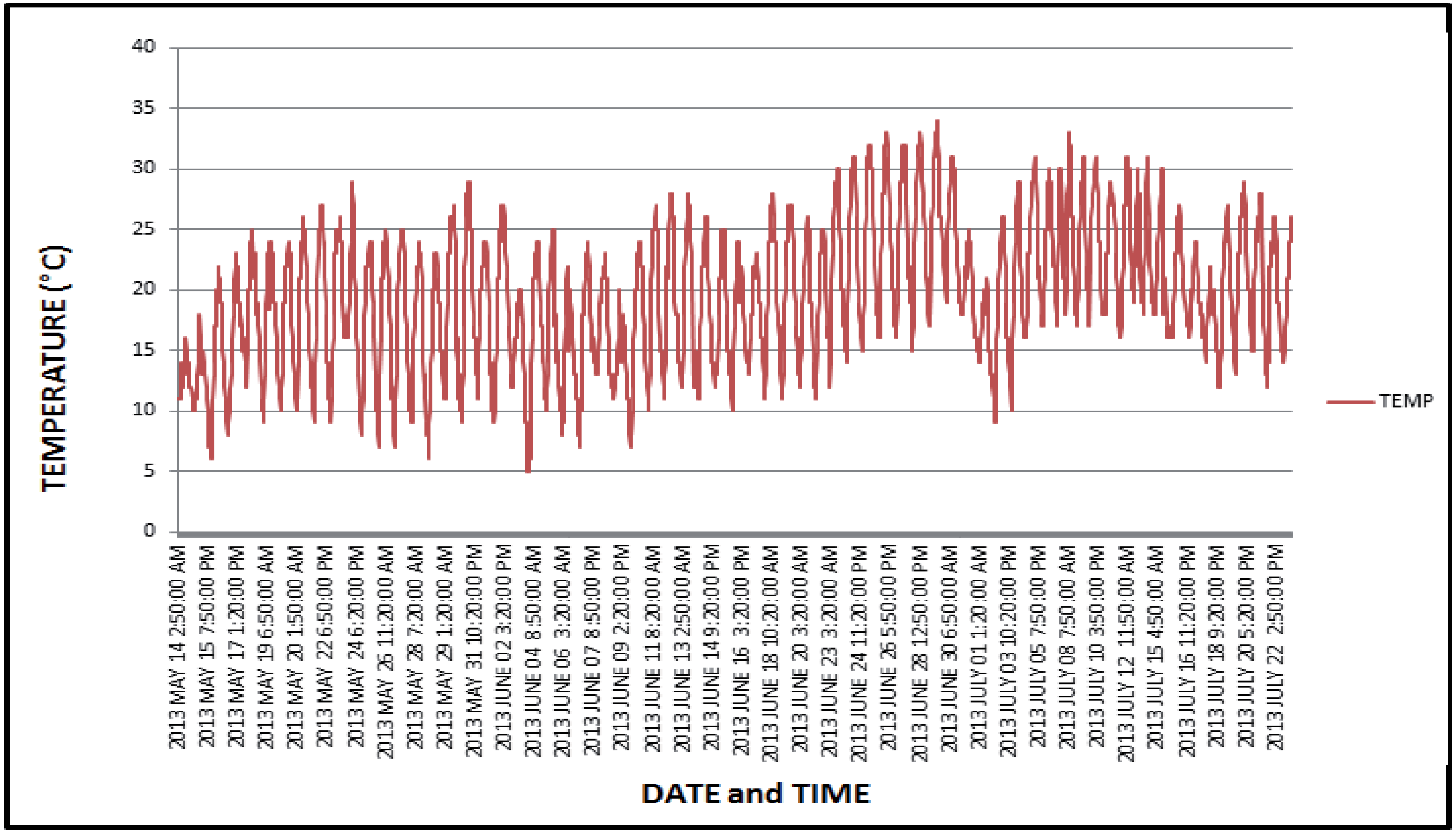


Figure 3.14 Temperature chart for Ankara (14 May 2013 to 23 July 2013)

3.2 Method

The study was conducted in two sections. Firstly, as a field study in order to achieve temperature and relative humidity, data collection through data loggers were done by recording data in selected locations of the case study. Afterwards, in order to perceive existing condition and its possible causes the evaluation and interpretation of data was done. In the following chapter the evolution of the study will be presented gradually and more in detail.

3.2.1 Data collection

In this study in order to reach temperature and relative humidity, data were collected in four different spaces of the Medicorium building through utilizing six data loggers. The data is recorded with 15 minute intervals at each selected location.

The collected data can be affected negatively by locating data loggers in inappropriate spaces; for instance placement of data loggers in spaces which are exposed to the direct sunlight, additional heat amount or humidity and air movement will result to come up with incorrect and unreliable recorded values. Thus, it is seriously significant and influential to notice in placement of the data loggers in suitable and proper places. Table 3.3 describes the location of the data loggers and sensors.

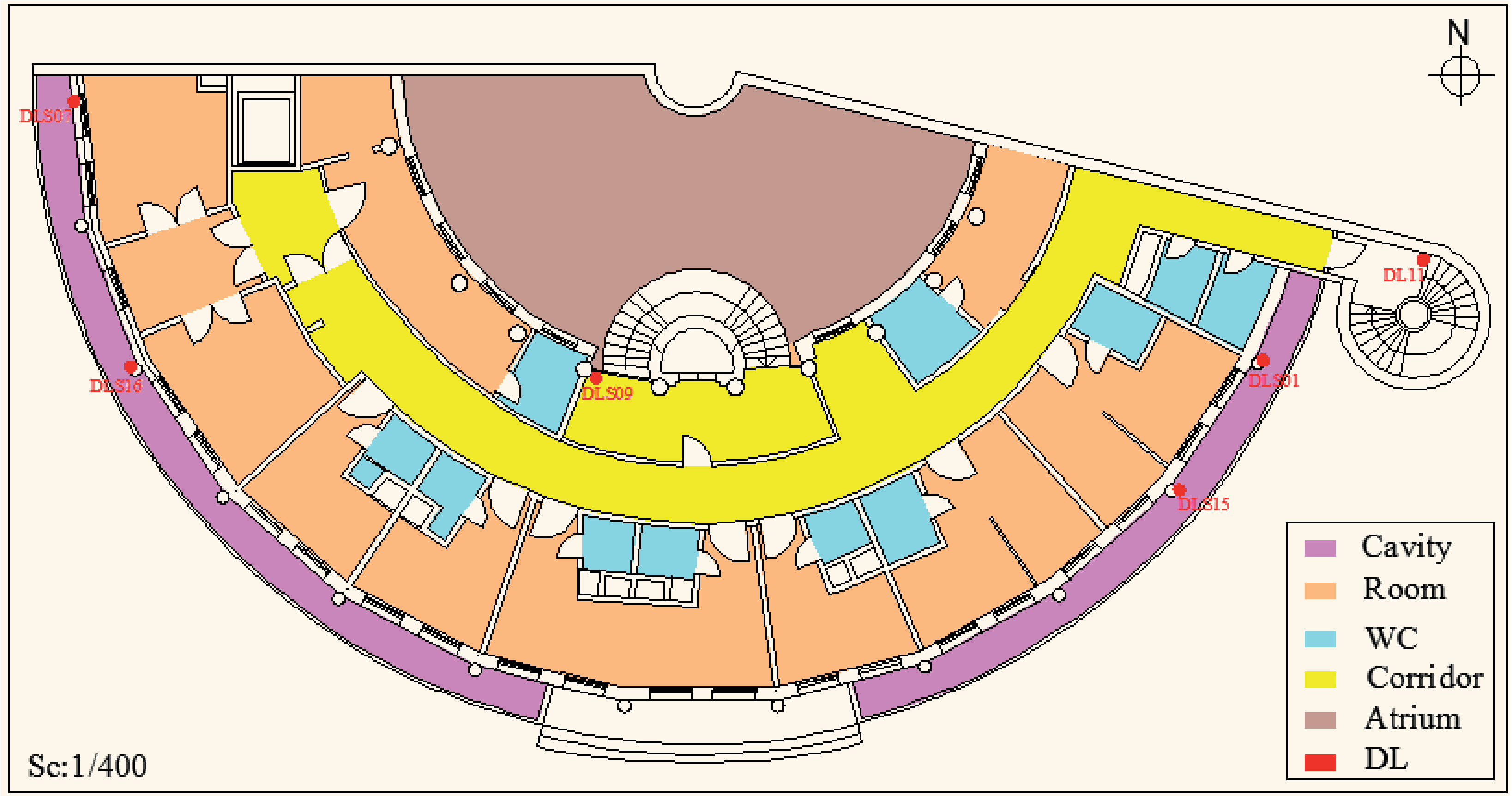


Figure 3.15 Data loggers' location on the plan

Table 3.4 locations of Data loggers

	Data Logger Location	**Data Logger Height from Floor**	**Numbe r of Sensors**	**Sensor Location**	**Sensor Height from Floor**	**Number of Data Loggers Outputs**
DL01	South.East façade- Inside-On the column	210 m	1	Outside- On the glass	206 m	2
DL07	South.West Façade- Inside- On the windowsill	84 m	1	Outside- On the glass	126 m	1
DL09	Atrium- Inside- On the step bar	66 m	1	Inside- On the wall	193 m	1
DL11	Fire exit- Outside- On the step bar	58 m	0	–	–	1
DL15	South.East façade- Inside- On the column	210 m	1	Inside- On the glass	140 m	1
DL16	South.West façade- Inside- On the column	210 m	1	Inside- On the glass	193 m	2

In this study the temperature and relative humidity were taken between 14 May 2013 and 23 July 2013. In addition all selected four spaces were empty during the data recording except for cleaning purposes once in a month.

Figure 3.16 Data logger DL 01- South.East facade

Figure 3.17 Data logger DL 07- South.West facade

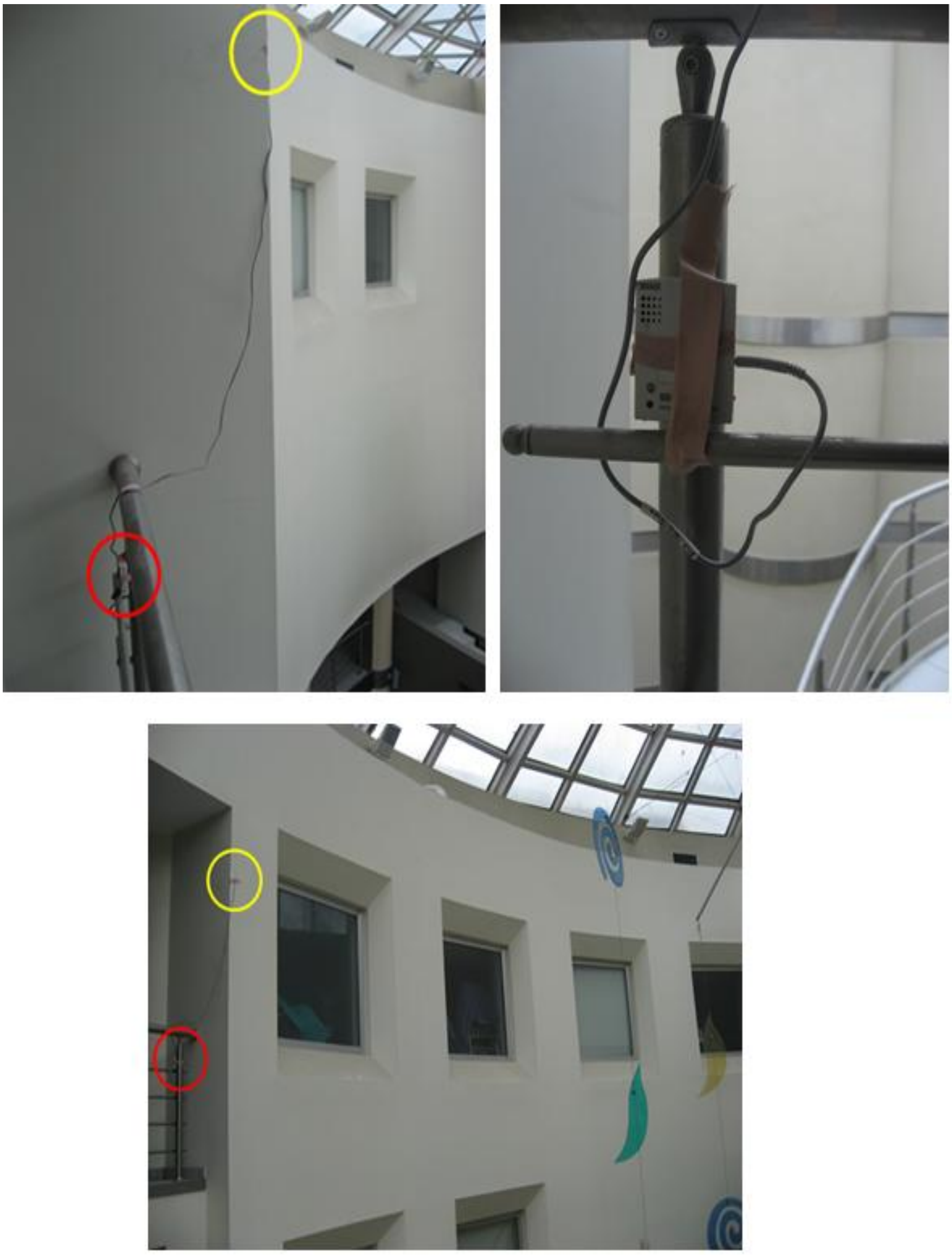


Figure 3.18 Data logger DL 09- Atrium

Figure 3.19 Data logger DL 11- Fire exit

Figure 3.20 Data logger DL 15- South.East facade

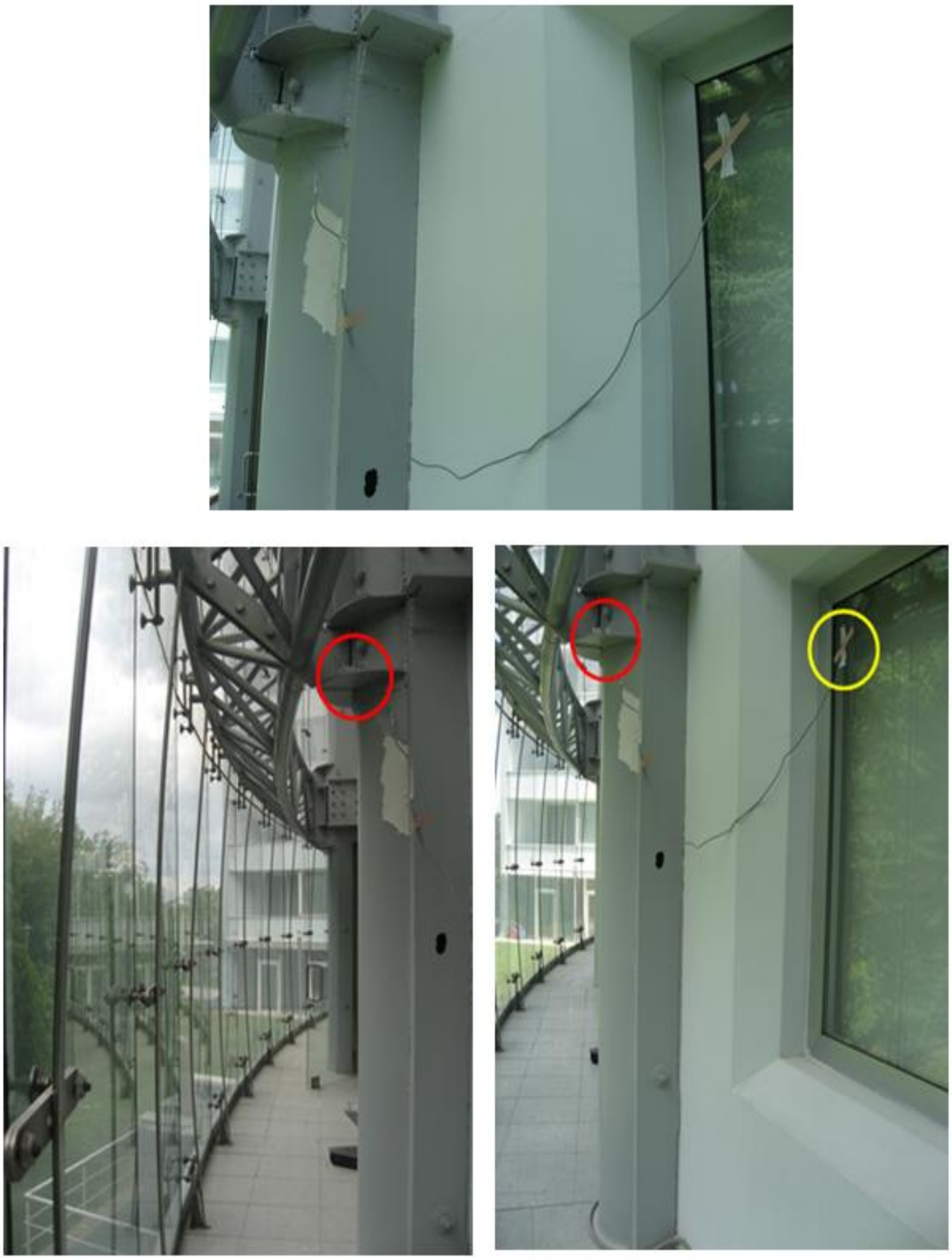


Figure 3.21 Data logger DL 16- South.West façade

3.2.2 Data evaluation

In this research all data which recorded from south east and south west façade, attic and fire exit between 14 May and 23 July were downloaded through data loggers to the computer with the HOBOware pro software. Afterward, all collected data were imported in to the excel software which provides data in both tabular and graphical presentation. Therefore, the overall data which recorded at each location could be examined.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Temperature data

In this section the recorded data will be displayed both in graphical and tabular forms and accordingly the evaluation of temperature data which were collected from south façade, atrium and fire exit in Akman Medicorium Center will be done.

Data loggers were placed at the locations shown in Figure 3.12 on the 14th May 2013. They collected temperature data at 15 minutes interval until the 23rd of July 2013; however, one data logger (DL01) was removed on the 11th of July 2013. Moreover, 5 of data loggers had sensors attached to record the surface temperature of the glazing.

As it is described in previous chapter, DL11 was located at the fire exit of the building on the staircase at the height of 58cm above from the floor to collect the exterior data.

The outdoor temperature data is displayed in Figure 4.1. These data were downloaded and graphs were produced. Accordingly, for these graphs the day that data logger has the hottest and coolest period was selected and thus evaluations were done for 3 days in the selected area.

As it is displayed in Figure 4.1 the temperature reaches high values between 30 May 2013 to 1 June 2013.

Furthermore, as can be seen on the graph the temperature has lowest values from 14 May 2013 to 16 May 2013. Therefore, the evaluations were done for indicated days with highest and lowest temperature values.

The minimum and maximum temperature values recorded by data loggers and sensors are displayed in Table 4.1 where in the first column data loggers and sensors identity, in the second column location of data loggers, in the third column minimum temperature value, in the fourth column the date and time for minimum temperature, in the fifth column maximum temperature value and in the sixth column the date and time for maximum temperature value are displayed.

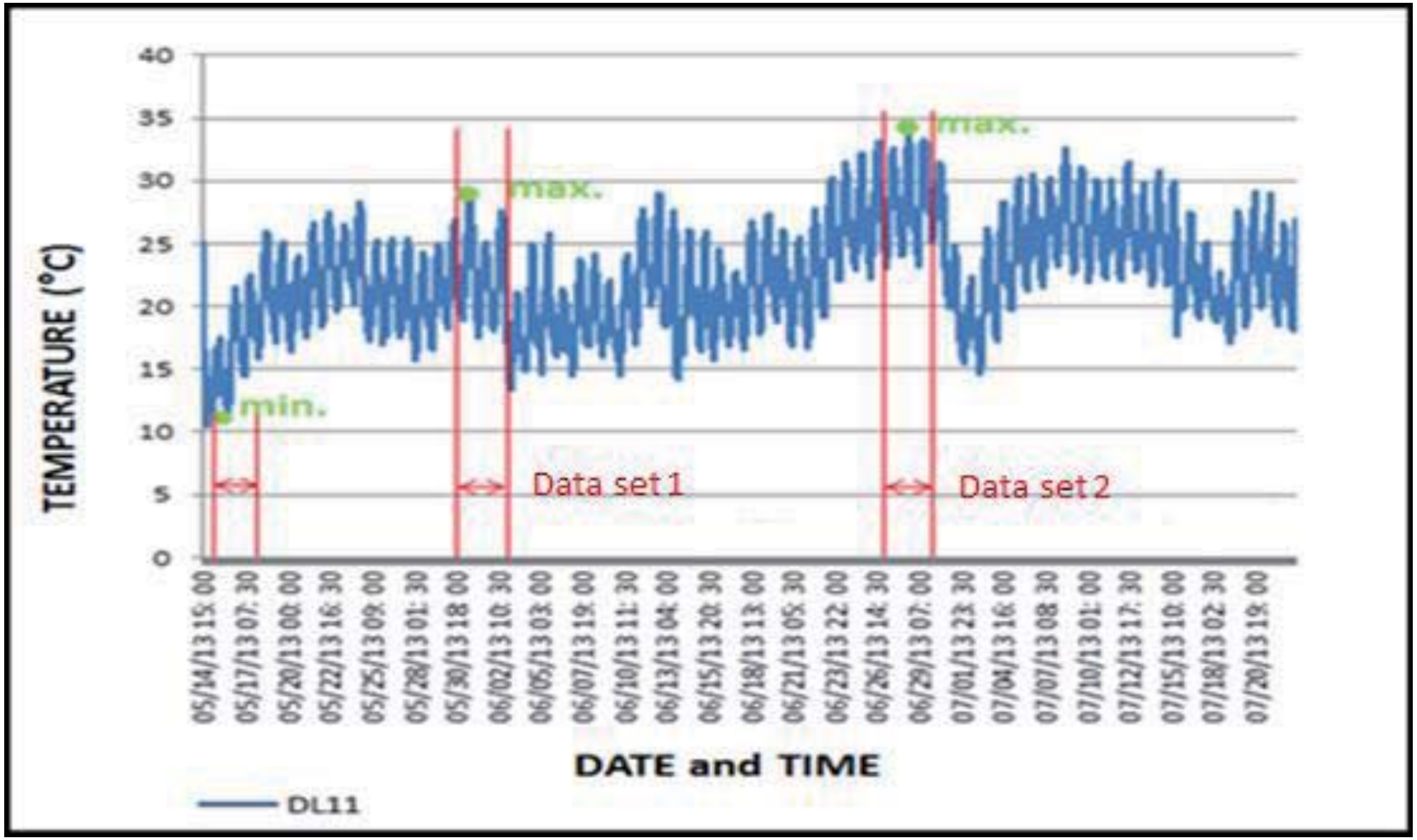


Figure 4.1 Temperature data collected from the exterior (DL11)

Table 4.1 The minimum and maximum temperature values recorded by data loggers and sensors for selected 3 days

Tempertaure (°C)					
DL#	Location	Min	Date and Time of Min	Max	Date and time of Max
DL01	On the column	15.91	16 May 2013, 4:15 AM	34.09	31 May 2013, 2:30 PM
DL01- Sensor	Exterior glass	14.85	16 May 2013, 4:15 AM	25.21	31 May 2013, 2:30 PM
DL07	on the windowsill	17.17	16 May 2013, 6:45 AM	49.58	1 June 2013, 4:45 PM
DL07- Sensor	exterior glass	15.27	16 May 2013, 6:45 AM	27.53	1 June 2013, 4:45 PM
DL09	Atrium	19.84	16 May 2013, 5:45 AM	34.28	31 May 2013, 3:30 PM
DL09- Sensor	On the staircase	17.46	16 May 2013, 5:45 AM	25.73	31 May 2013, 3:30 PM
DL11	Fire exit- Exterior	11.56	16 May 2013, 6:00 AM	28.89	31 May 2013, 5:30 PM
DL15	On the column	16.15	16 May 2013, 6:30 AM	36.52	31 May 2013, 12:30 PM
DL16	On the column	17.05	16 May 2013, 6:45 AM	41.56	1 June 2013, 4:15 PM
DL16- Sensor	window pane	16.07	16 May 2013, 6:45 AM	28.47	1 June 2013, 4:15 PM

4.1.1 Temperature comparison for hottest days

In this section the temperature data comparison and evaluation will be done in both tabular and graphical forms for selected 3 days. The Figure 4.2 presents a comparative graph for peak temperature in the south- west and south- east DSF cavity and the exterior as well as the atrium. Data loggers which located inside also had sensors attached to the glass as shown in Figure 3.12.

As it is displayed in Figure 4.2 it can be realized that the external temperature ranges from 17 (°C) to 28 (°C). In addition, the space temperature ranges from 22 (°C) to 50 (°C) where glass façade temperature ranges from 17 (°C) to 27 (°C) and the window pane temperature ranges from 18 (°C) to 27 (°C).

In addition, the space temperature of 3 data loggers is higher than the exterior and interior surface temperatures in which the highest space temperature values is for space at the south- west façade because of exposure to the direct sunlight from the west. Therefore, according to the data at hand it can be concluded that the there is a remarkable difference between space and outside temperature while exterior glass temperature does not reach too much high values; which means that space inside becomes too hot as a result of exposure to the direct sunlight.

As it is explained in previous chapter, the building is fully air- conditioned in which the windows openings are completely sealed. Additionally, according to the interviews to the staff of the building it was found out that the DSF cavity is an unoccupied space except once in a month when the staff cleans it.

The data logger 01 was located at the south-east façade cavity, placed on the column at the height of 210cm from the floor and one sensor attached to the external surface of the glass façade at the height of 206cm from the floor.

According to the Table 4.1, the maximum temperature value recorded by data logger 01 is 34.09 °C for 31 May 2013 at 2:30 PM. Moreover, the maximum surface temperature value is 25.21 °C for the same day.

It is indicated that however the outdoor temperature is about 28.39 °C based on the recorded data by data logger 11 at 2:30 PM on 31 May, the space temperature is increased to 34.09 °C. Therefore, by finding the difference between space and surface temperature it is found out that the space has 8.88 °C higher temperature in comparison to the glass façade.

The data logger 07 was located at the south-west façade cavity, placed on the windowsill at the height of 84cm from the floor and one sensor attached to the internal surface of the glass façade at the height of 126cm from the floor.

According to the Table 4.1, the maximum temperature value recorded by data logger 07 is 49.58 °C for 1 June 2013 at 4:45 PM. Moreover, the maximum surface temperature value is 27.53 °C for the same day.

It is indicated that however the outdoor temperature is about 24.72 °C based on the recorded data by Data logger 11 at 4:45 PM on 1 June, the space temperature is increased to 49.58 °C. Therefore, by finding the difference between space and surface temperature it is found out that the space has 23.05 °C higher temperature in comparison to the glass façade.

The data logger 09 was located at the atrium of the building at the height of 66cm above from the floor at the second floor of the building and one sensor attached to the internal envelope (wall) of the building at the height of 193cm from the floor.

According to the Table 4.1, the maximum temperature value recorded by data logger 09 is 34.28 °C for 31 May 2013 at 3:30 PM. Moreover, the maximum interior surface temperature value is 25.73 °C for the same day.

It is indicated that however the outdoor temperature is about 28.76 °C based on the recorded data by Data logger 11 at 3:30 PM on 31 May, the space temperature is increased to 34:28 °C. Therefore, by finding the difference between space and interior surface temperature it is found out that the space has 8.55 °C higher temperature in comparison to the glass façade.

The data logger 16 was located at the south-west façade of the building at the height of 210cm from the floor at DSF cavity and one sensor attached to window pane at the height of 193cm from the floor.

According to the Table 4.1, the maximum temperature value recorded by data logger 16 is 41.56 °C for 31 May 2013 at 12:30 PM. Moreover, the maximum interior surface temperature value is 28.47 °C f0r the same day.

It is indicated that however the outdoor temperature is about 26.28 °C at 12:30 PM on 31 May, the space temperature is increased remarkably to 41.56 °C. Therefore, by finding the difference between interior space and interior glass temperature it is found out that the space has 13.09 °C higher temperature in comparison to the interior glass.

Based on the data at hand in pervious analysis on DL01, DL07, DL09 and DL16 it is indicated that the glass surface whether glass façade or interior glass at regular wall does not absorb the heat but allows sunlight to pass through the glass. Therefore, here also it can be concluded that however exposure of direct sunlight in to the space does not increase the interior glass temperature in a high degree but causes heat to accumulate in the space considerably.

The low temperature of the interior glass in comparison to the space temperature is also indicator of the fact that the interior glass also adds to the heating loads of the space. In addition by referring to the figure 4.2 it is realized that there is a remarkable difference between space and sensor temperatures in which space temperature displays high values. Moreover, the space temperature of 3 data loggers is higher than the exterior and interior surface temperatures; which means that the building has high heating loads inside.

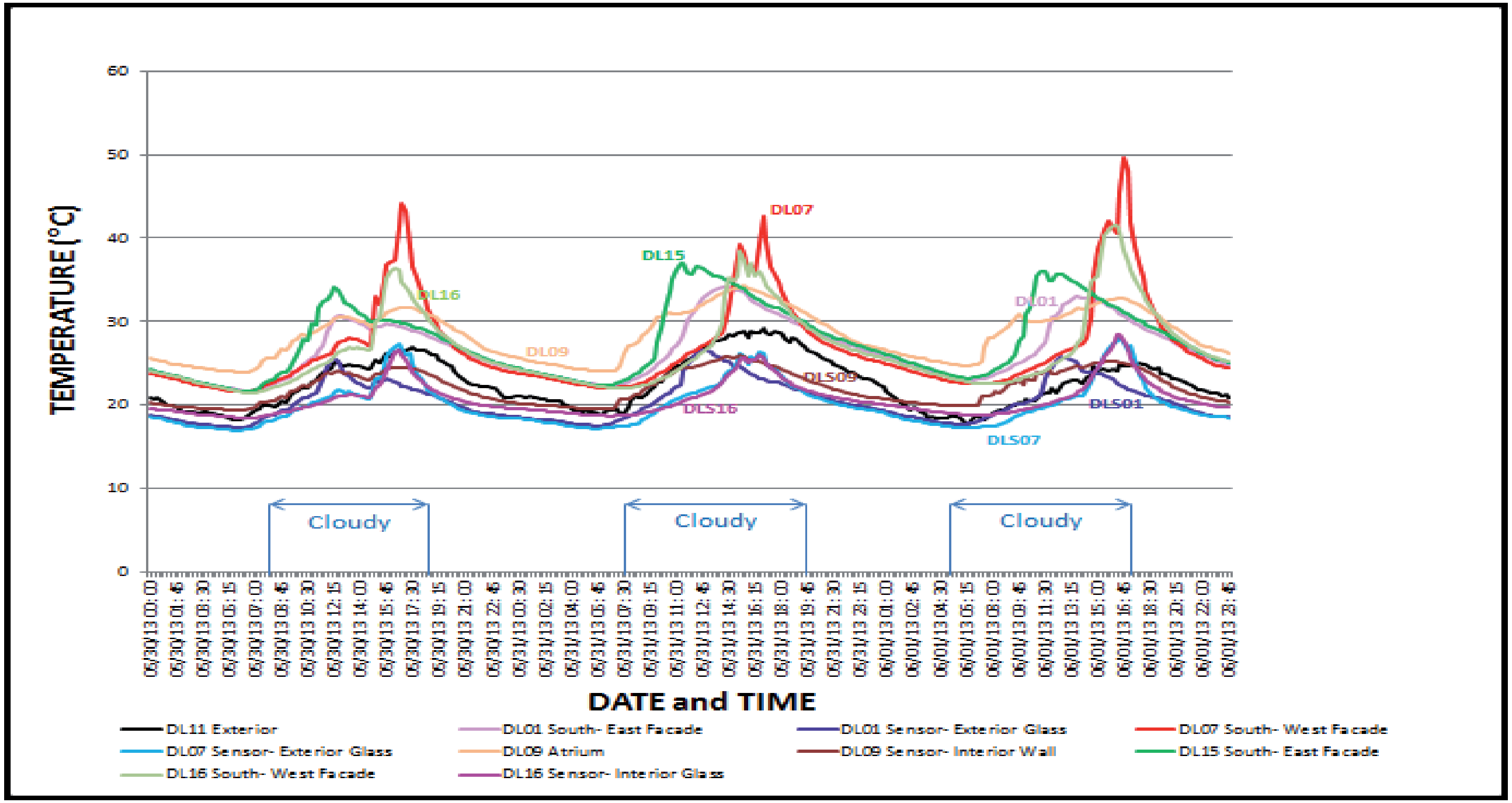


Figure 4.2 Temperature data comparison for hottest days from 30 May to 1 June 2013

4.1.2 Temperature comparison for coolest days

In this section the temperature data comparison and evaluation will be done in both tabular and graphical forms for selected 3 days. The Figure 4.3 presents a comparative graph for coolest days in the south- west and south- east DSF cavity and the exterior as well as the atrium. Data loggers which located inside also had sensors attached to the glass as shown in Figure 3.12.

As it is displayed in Figure 4.3 it can be realized that the external temperature ranges from 13 (°C) to 23 (°C). In addition, the space temperature ranges from 17 (°C) to 43 (°C) where glass façade temperature ranges from 14 (°C) to 26 (°C) and the window pane temperature ranges from 18 (°C) to 26 (°C).

In addition, the space temperature of 3 data loggers is higher than the exterior and interior surface temperatures in which the highest space temperature values is for space at the south- west façade because of exposure to the direct sunlight from the west. Therefore, according to the data at hand it can be concluded that the there is a remarkable difference between space and outside temperature even in the coolest days.

Additionally, according to the Figure 4.3 the surface temperature does not reach much low values even in coolest days because excessive heat builds up in the cavity during the day and thus the glass temperature does not drop as low as the external temperature.

Therefore, according to the data at hand it can be concluded that the space inside becomes too hot as a result of exposure to the direct sunlight passes through the glass and so the glass façade does not prevent space to become hot.

As it is explained in previous chapter, the building is fully air- conditioned in which the windows openings are completely sealed. Additionally, according to the interviews to the staff of the building it was found out that the DSF cavity is an unoccupied space except once in a month when the staff cleans it.

According to the Table 4.1 the minimum space temperature value recorded by data logger 01 is 15.91 °C for 16 May 2013 at 6:15 AM and 14.85 °C for exterior surface temperature at the same day.

Additionally, according to the Table 4.1 the minimum space temperature value recorded by data logger 07 is 17:17 °C for 16 May 2013 at 6:45 AM and 15:27 °C for glass façade temperature on 16 May 2013 at 6:45 AM. Therefore, it can be concluded that the glass façade is cooler than the interior space while there is no occupancy loads; which means that the glass does not absorb the heat considerably and thus space temperature increases because of solar heat gain passes through the glass and makes space to become hot.

Moreover, according to the Table 4.1 the minimum space temperature value recorded by data logger 09 is 19.84 °C for 16 May 2013 at 5:45 AM and 17.46 °C for interior space temperature on 16 May 2013 at 5:45 AM. Therefore, it can be concluded that as result of direct sunlight through glass roof of the building the space temperature increases notably even though the interior surface is not too much warm. Additionally, according to the Table 4.1 the minimum space temperature value recorded by data logger 16 is 17.05 °C for 16 May 2013 at 6:45 AM and 16.70 °C for interior glass temperature on 16 May 2013 at 6:45 AM. As a result through comparing minimum space temperature and minimum interior surface temperature it can be realized that interior space temperature is also higher than interior glass temperature in the building.

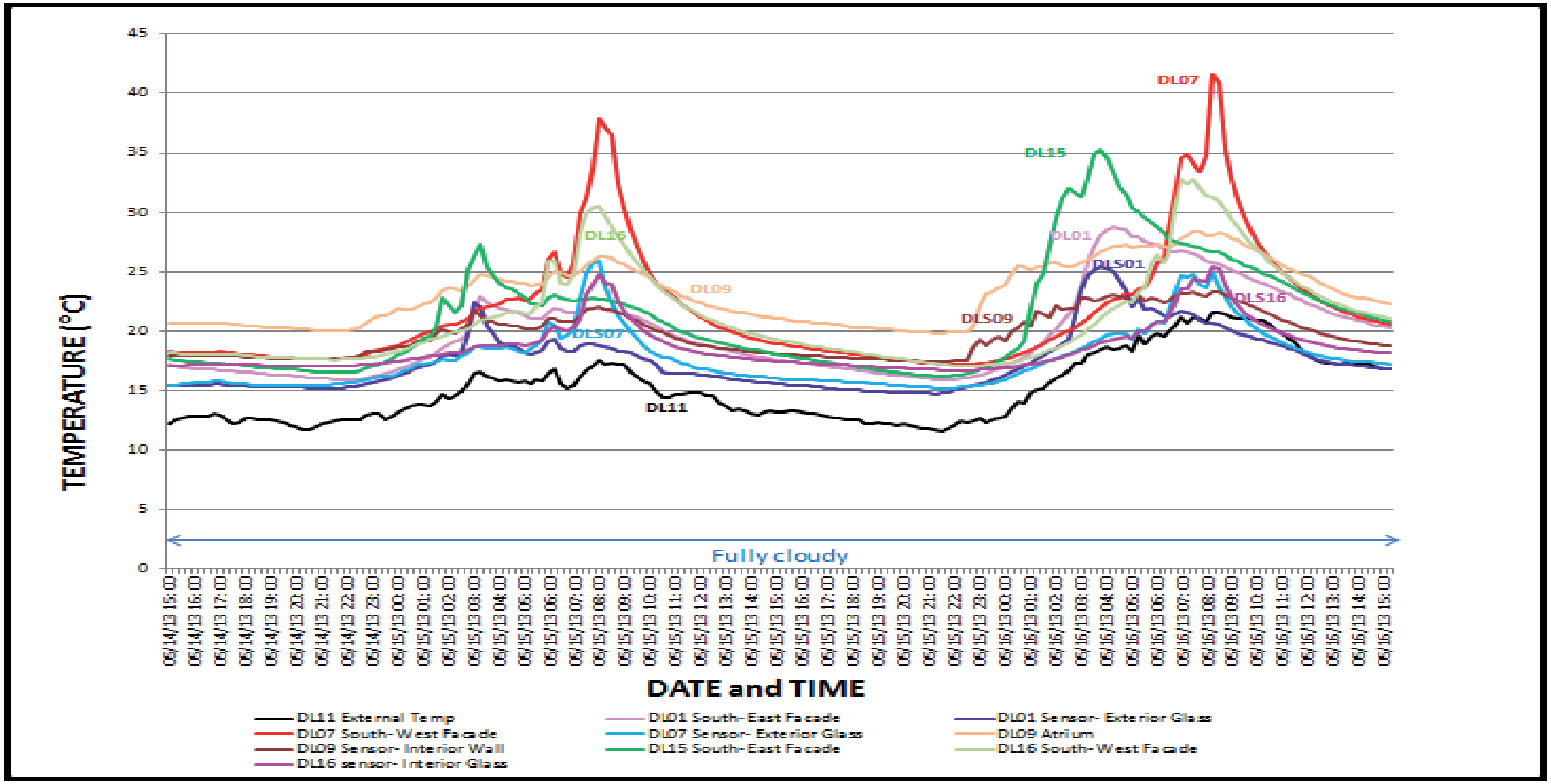


Figure 4.3 Temperature data comparison for coolest days from 30 May to 1 June 2013

4.2 Humidity data

The humidity data which collected between 14 may 2013 to 23 July 2013 through data logger 11 at fire exit of the building are displayed in Figure 4.3. In addition in order to evaluate humidity data, the maximum exterior relative humidity was selected through the representative graph of exterior humidity and thus evaluations were done for 3 days in the selected area. As it is displayed in Figure 4.3 the humidity reaches high values from 8 to 10 June 2013. Therefore, these dates were used to compare humidity data for the cavity, atrium and outdoor.

The maximum relative humidity values recorded by data loggers are displayed in Table 4.3 where in the first column data loggers and sensors identity, in the second column location of data loggers, in the third column maximum humidity value and in the fourth column the date and time for maximum humidity value are displayed.

Table 4.2 The maximum humidity values recorded by data loggers for selected 3 days

Relative humidity (%)			
DL#	Location	Max	Date and Time of Min
DL01	On the column	48.85	10 June 2013, 7:00 AM
DL07	on the windowsill	57.15	10 June 2013, 8:15 AM
DL09	Atrium	43.99	10 June 2013, 5:45 AM
DL11	Fire exit- Exterior	66.26	8 June 2013, 10:45 PM
DL15	On the column	51.43	10 June 2013, 6:30 AM
DL16	On the column	50.04	10 June 2013, 8.15 AM

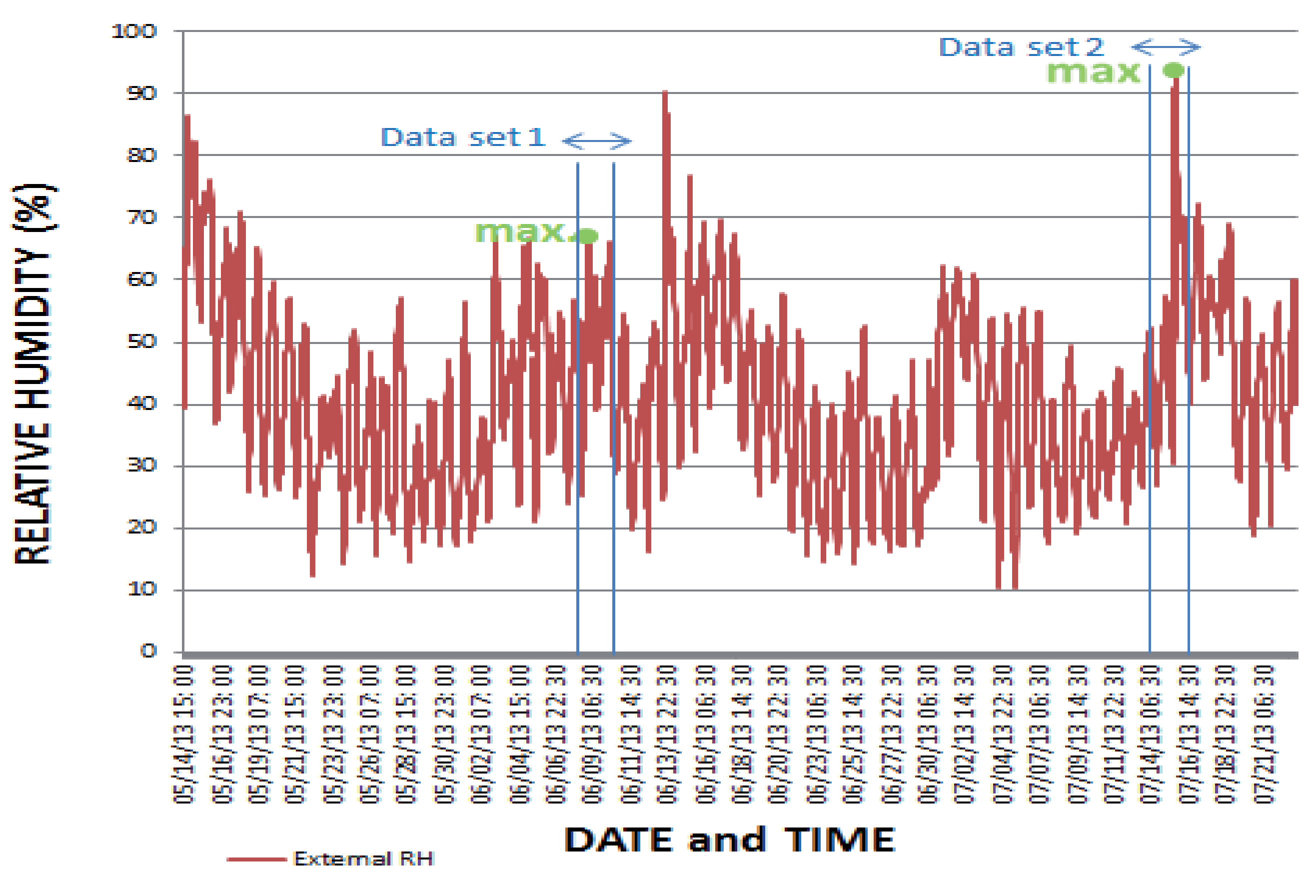


Figure 4.4 relative humidity data collected from the exterior location (DL11)

In this section the humidity data comparison and evaluation will be done in both tabular and graphical forms for selected 3 days. The Figure 4.4 presents a comparative graph for peak humidity in the south- west and south- east DSF cavity and the exterior as well as the atrium. As it is displayed in Figure 4.4 it can be realized that the external humidity ranges from 25 % to 66 %. In addition, the space humidity ranges from 20 % to 58 %. In addition, as it is seen in the graph the outside humidity is higher than the relative humidity for all data loggers. Moreover, the highest humidity value is for data logger 07..Therefore, according to the data at hand it can be concluded that the there is a remarkable difference between space and outside humidity in which space humidity shows lower values than the outside; which means that space inside becomes too hot as a result of exposure to the direct sunlight.

According to the Table 4.2 the Maximum space humidity value recorded by data logger 01 at south- east façade cavity is 48.85 % for 10 June 2013 at 7:00 AM and 65.99 % for exterior humidity at the same day. Therefore, by finding the difference between space and outdoor humidity value it is found out that the relative humidity of the space decreases considerably about 17.14 %; which means that inside temperature increases and building bears high heat loads. The temperature inside is 27.89°C and surface temperature displays 20.45°C for the same day and same time.

The Table 4.2 displays that the Maximum space humidity value recorded by data logger 07at south- west façade cavity is 57.15 % for 10 June 2013 at 8:15 AM and 69.01 % for exterior humidity at the same day. Therefore, by finding the difference between space and outdoor humidity value it is found out that the relative humidity of the space decreases considerably about 11.86 %; which means that inside temperature increases and building inside becomes too hot. The temperature inside is 20.61°C and surface temperature displays 15.73°C for the same day and same time.

The Table 4.2 displays that the Maximum space humidity value recorded by data logger 09 at the atrium is 43.99 % for 10 June 2013 at 5:45 AM and 61.86 % for exterior humidity at the same day. Therefore, by finding the difference between space and outdoor humidity value it is found out that the relative humidity of the space decreases considerably about 17.87 %; which means that temperature inside reaches high values and thus building inside becomes too hot. The temperature inside is 22.51°C and surface temperature displays 17.73°C for the same day and same time.

The Table 4.2 displays that the Maximum space humidity value recorded by data logger 15 at the south- east façade cavity is 51.43 % for 10 June 2013 at 6:30 AM and 62.59 % for exterior humidity at the same day. Therefore, by finding the difference between space and outdoor humidity value it is found out that the relative humidity of the space decreases considerably about 11.16 %; which means that here also temperature inside reaches high values and thus building inside becomes too hot. The temperature inside is 19.96°C for the same day and same time.

The Table 4.2 displays that the Maximum space humidity value recorded by data logger 16 at the south- west façade cavity is 50.04 % for 10 June 2013 at 8.15 AM and 69.01 % for exterior humidity at the same day. Therefore, by finding the difference between space and outdoor humidity value it is found out that the relative humidity of the space decreases considerably about 18.97 %; which means that here also temperature inside reaches high values and thus building inside becomes too hot. The temperature inside is 19.93°C and surface temperature displays 17.96°C for the same day and same time.

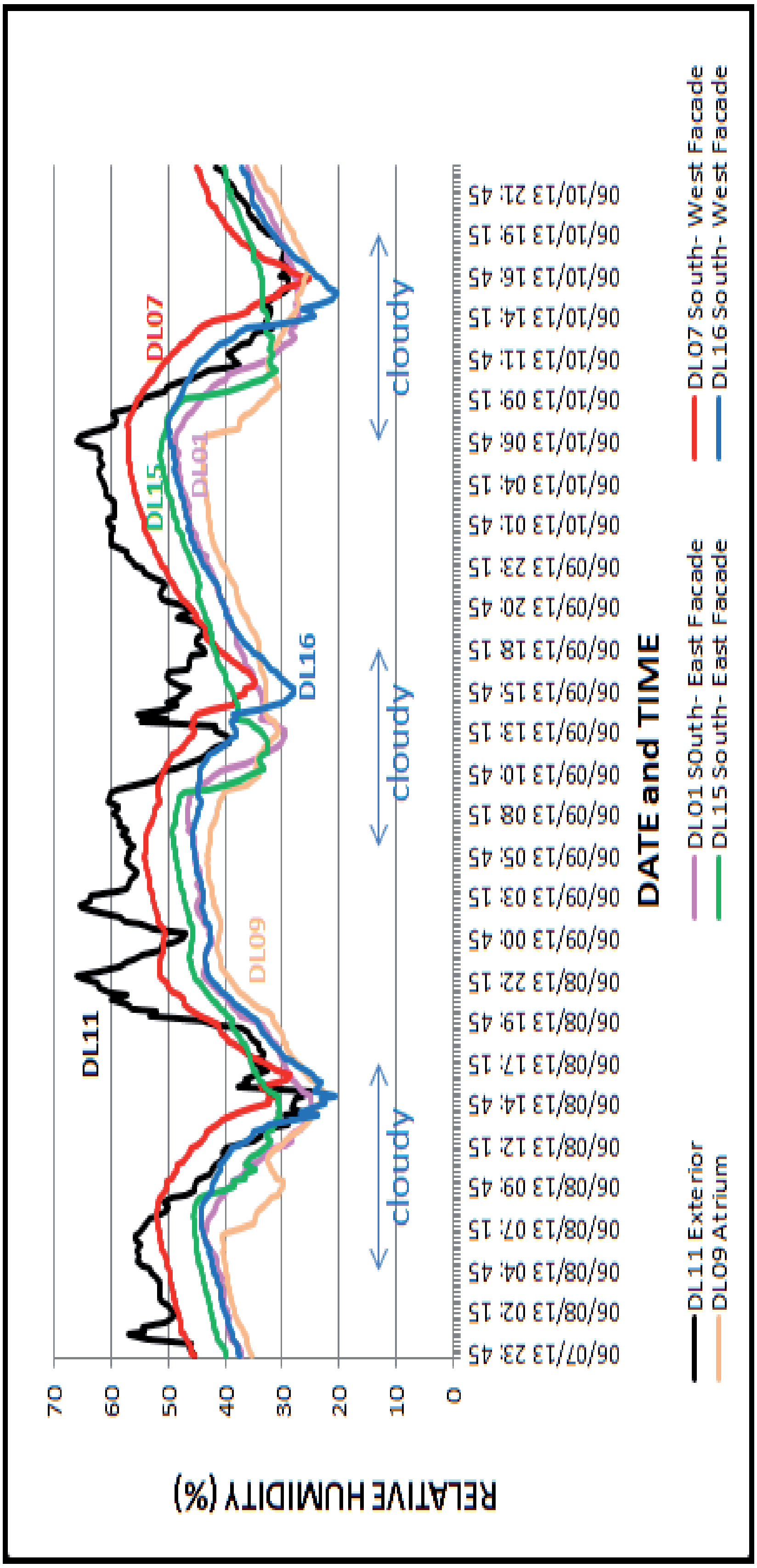


Figure 4.5 Humidity data comparison for hottest days from 8 June to 10 June 2013

4.3 Features of space and glass in relation to the results

As presented in pervious sections it is indicated that the space temperature reaches high level in comparison to the glass façade of the building. The glass façade does not absorb the heat and thus becomes cooler than interior space which becomes too hot because of direct sunlight that passes through the glass façade and so in spite of the low temperature of the glass surface, the space temperature rises remarkably as a result of direct solar heat gain through the glass façade. In addition, DSF glazing can only be laminated glass because for double or triple glazing, framing is necessary therefore it is not preferred; while the laminated glass has higher u- values and SHGC than the latter types and so this leads to high heat gain. So it is realized that contrary to the common belief, the glass type does not affect the thermal behavior of the DSF cavity if the space is not ventilated any way.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

Human comfort and satisfaction are essential elements that should be taken in to account in design of the buildings. Thermal behavior of buildings is highly influential factor in providing occupants with high level of comfort and less environmental disturbance. Invalid thermal performance and air condition of the space will affect occupants' performance, productivity and health which will be a result of excessive heating and cooling loads inside the building.

Double skin facades play significant role in thermal performance of buildings due to their impact on heating and cooling loads of indoor spaces. The high rate of heat loss and gain is done through the glass in building surface. Therefore, the study concentrates on the impact of double skin facades on thermal performance of buildings.

In this study, through collected temperature and relative humidity data it is realized that the interior temperature increases remarkably as a result of accumulated heating loads inside the building. In addition, high U- value and SHGC of the laminated glass also adds to the heating loads of the space. Therefore, not only the glass type in façade of the building does not prevent interior space from reaching high temperature values but adds to the heating loads of the building through letting direct sunlight in to the space.

In this investigation, providing high comfort level for occupants is of utmost importance because in hospital buildings sufficient and qualified thermal performance has to be presented for patients' health and comfort. As a result, in order to reduce excessive heating loads it is demanded to cool the building. It is recommended to utilize natural ventilation that creates stack effect in the cavity and dissipate the heat built- up in the cavity of DSF during summer and reduces the total energy consumption. Hence, non-ventilated double skin façade of the building impact cooling loads of the space. These types of facades could only harvest solar heat and thus create the greenhouse effect. It is recommended to apply ventilated double skin façade in to the building which contribute to the thermal comfort of the space throughout the year because these types of facades are able to regulate thermal exchange between the exterior and interior. For example according to the Figure 2.6 shaft- box type can be applied to the building which takes advantage of natural ventilation and increases the stack effect in the cavity. Therefore, the trapped heat in different parts of the cavity moves up and is extracted through the outlets on the upside.

Additionally, in order to provide thermal comfort it can be suggested to utilize shading devices during the summer. Moreover, for the winter time it can be proposed to use open windows and grills in order to take pre- heated air from the cavity.

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APPENDIX A

TEMPERATURE DATA FOR THREE HOTEST DAYS

Table A Temperature data for three hottest days

	DL01		DL07		DL09		DL11	DL15		DL16	
Date	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**
5/30/2013 1:30	23.545	18.312	22.992	17.826	24.944	19.904	19.936	23.376	44.157	23.304	19.191
5/30/2013 1:45	23.424	18.217	22.872	17.71	24.871	19.872	19.817	23.232	44.292	23.184	19.138
5/30/2013 2:00	23.328	18.111	22.753	17.604	24.823	19.829	19.365	23.112	44.247	23.04	19.075
5/30/2013 2:15	23.208	17.995	22.657	17.53	24.75	19.787	19.175	23.016	44.247	22.92	19.022
5/30/2013 2:30	23.064	17.921	22.513	17.446	24.677	19.755	19.27	22.896	44.113	22.8	18.958
5/30/2013 2:45	22.944	17.857	22.417	17.382	24.629	19.733	19.246	22.776	44.307	22.681	18.905
5/30/2013 3:00	22.848	17.805	22.321	17.393	24.557	19.691	19.222	22.657	44.068	22.585	18.862
5/30/2013 3:15	22.729	17.762	22.226	17.361	24.508	19.67	19.103	22.561	44.262	22.465	18.831
5/30/2013 3:30	22.633	17.741	22.154	17.288	24.436	19.638	19.222	22.441	44.262	22.369	18.788
5/30/2013 3:45	22.537	17.688	22.058	17.245	24.388	19.606	19.151	22.345	44.277	22.274	18.746
5/30/2013 4:00	22.465	17.646	21.987	17.172	24.315	19.584	19.103	22.25	44.277	22.154	18.714
5/30/2013 4:15	22.369	17.593	21.891	17.172	24.267	19.553	19.032	22.154	44.247	22.058	18.672
5/30/2013 4:30	22.298	17.562	21.819	17.108	24.219	19.531	18.889	22.034	44.247	21.963	18.629
5/30/2013 4:45	22.226	17.52	21.748	17.056	24.171	19.51	18.771	21.963	44.277	21.867	18.598
5/30/2013 5:00	22.13	17.477	21.7	17.035	24.122	19.489	18.723	21.867	44.187	21.772	18.566
5/30/2013 5:15	22.034	17.425	21.652	17.014	24.074	19.457	18.461	21.795	44.068	21.676	18.534
5/30/2013 5:30	21.987	17.382	21.604	17.014	24.05	19.446	18.247	21.724	43.8	21.604	18.502
5/30/2013 5:45	21.867	17.33	21.581	17.045	24.002	19.436	18.295	21.7	43.637	21.533	18.492
5/30/2013 6:00	21.795	17.351	21.604	17.077	24.002	19.446	18.319	21.7	43.299	21.485	18.481
5/30/2013 6:15	21.724	17.393	21.652	17.14	24.002	19.457	18.485	21.748	42.831	21.485	18.502

Table A (Continued)

	DL01		DL07		DL09		DL11	DL15		DL16	
Date	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**
5/30/2013 6:30	21.7	17.467	21.772	17.288	24.002	19.499	18.747	21.891	41.953	21.509	18.545
5/30/2013 6:45	21.724	17.583	21.939	17.488	24.074	19.584	18.937	22.13	41.061	21.581	18.619
5/30/2013 7:00	21.772	17.847	22.202	17.815	24.243	19.744	19.389	22.489	40.309	21.724	18.714
5/30/2013 7:15	21.939	18.153	22.417	18.005	24.653	20.288	19.674	22.753	41.033	21.891	18.82
5/30/2013 7:30	22.13	18.471	22.657	18.153	25.307	20.384	19.984	23.04	41.896	22.058	18.915
5/30/2013 7:45	22.298	18.661	22.753	18.217	25.623	20.362	19.936	23.112	39.255	22.178	18.979
5/30/2013 8:00	22.465	18.799	22.992	18.439	25.72	20.512	19.936	23.497	39.35	22.298	19.064
5/30/2013 8:15	22.561	18.82	23.232	18.661	25.623	20.48	19.817	23.954	39.623	22.513	19.17
5/30/2013 8:30	22.753	19.085	23.352	18.735	26.036	20.812	20.055	24.026	40.075	22.609	19.213
5/30/2013 8:45	23.04	19.425	23.593	19.011	26.695	21.165	20.507	24.484	36.005	22.776	19.297
5/30/2013 9:00	23.184	19.351	23.905	19.319	26.622	20.951	20.412	25.137	35.356	23.04	19.425
5/30/2013 9:15	23.4	19.68	24.122	19.489	27.186	21.714	21.032	25.963	32.269	23.256	19.521
5/30/2013 9:30	23.713	19.957	24.436	19.744	27.702	21.617	21.39	27.186	28.004	23.521	19.648
5/30/2013 9:45	24.05	20.256	24.726	19.861	27.974	21.94	21.676	27.875	22.979	23.785	19.765
5/30/2013 10:00	24.484	20.726	24.847	19.851	28.394	22.242	22.011	27.727	20.79	23.93	19.819
5/30/2013 10:15	24.895	20.962	25.404	20.362	28.468	22.383	22.034	29.79	20.106	24.315	20.021
5/30/2013 10:30	25.186	20.908	25.428	20.373	28.369	22.199	22.082	29.665	8.143	24.436	20.096
5/30/2013 10:45	25.623	21.359	25.598	20.555	28.692	22.621	22.824	31.689	25.605	24.629	20.213
5/30/2013 11:00	25.987	21.552	25.793	20.779	28.766	22.903	22.968	32.484	16.814	24.847	20.352
5/30/2013 11:15	26.573	22.015	26.012	20.983	29.065	23.077	23.4	32.665	8.132	25.089	20.512

Table A (Continued)

	DL01		DL07		DL09		DL11	DL15		DL16	
Date	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**
5/30/2013 11:30	27.186	23.262	26.28	21.133	29.34	23.545	23.905	33.391	8.132	25.38	20.694
5/30/2013 11:45	28.891	24.686	26.842	21.509	29.665	23.961	24.219	34.176	8.153	25.841	20.929
5/30/2013 12:00	29.865	25.527	27.456	21.81	29.941	23.841	24.557	33.73	25.461	26.304	21.133
5/30/2013 12:15	30.419	25.728	27.677	21.714	30.268	23.983	25.089	32.898	35.98	26.524	21.176
5/30/2013 12:30	30.697	25.283	27.677	21.509	30.495	24.071	25.137	32.278	32.656	26.622	21.198
5/30/2013 12:45	30.646	24.213	28.048	21.638	30.621	23.884	24.726	32.098	33.659	26.891	21.294
5/30/2013 13:00	30.419	23.687	27.85	21.294	30.495	23.808	24.75	31.663	39.432	26.842	21.219
5/30/2013 13:15	30.419	23.644	27.949	21.316	30.571	23.873	24.968	31.204	39.147	26.867	21.198
5/30/2013 13:30	30.243	23.033	27.776	21.122	30.394	23.589	24.605	30.9	38.169	26.818	21.144
5/30/2013 13:45	29.941	22.708	27.579	20.951	30.192	23.48	24.605	30.646	39.746	26.744	21.058
5/30/2013 14:00	29.74	22.556	27.21	20.726	30.066	23.404	24.629	30.117	39.554	26.549	20.929
5/30/2013 14:15	29.515	22.307	27.407	21.058	29.916	23.262	24.46	29.89	36.416	26.744	21.015
5/30/2013 14:30	29.165	21.983	32.949	23.131	29.665	23.033	24.243	30.192	38.368	29.89	22.059
5/30/2013 14:45	28.965	22.091	31.97	23.11	29.49	23.142	24.436	30.117	39.759	30.394	22.458
5/30/2013 15:00	29.389	23.033	34.836	24.598	30.016	23.83	25.477	30.192	40.462	33.678	23.458
5/30/2013 15:15	29.414	22.794	36.742	25.739	30.293	23.731	25.065	30.167	41.216	35.182	24.202
5/30/2013 15:30	29.64	23.055	37.069	26.499	30.697	24.125	25.841	30.091	41.484	36.012	25.328
5/30/2013 15:45	29.715	23.099	37.398	27.05	31.052	24.323	26.134	30.041	41.682	36.444	26.432
5/30/2013 16:00	29.69	22.946	41.268	27.322	31.281	24.444	25.89	29.941	41.824	36.227	26.51
5/30/2013 16:15	29.59	22.74	44.226	26.802	31.51	24.532	26.426	29.84	41.924	34.73	25.973
5/30/2013 16:30	29.49	22.534	43.163	25.995	31.612	24.565	26.549	29.715	42.039	34.097	25.427

Table A (Continued)

	DL01		DL07		DL09		DL11	DL15		DL16	
Date	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**
5/30/2013 16:45	29.34	22.329	38.812	26.196	31.714	24.576	26.475	29.59	42.225	33.443	24.576
5/30/2013 17:00	29.215	22.156	36.688	24.94	31.714	24.554	26.573	29.439	42.383	32.742	23.906
5/30/2013 17:15	29.065	22.005	35.262	23.797	31.765	24.499	26.695	29.29	42.542	32.15	23.371
5/30/2013 17:30	28.916	21.875	33.809	23.197	31.714	24.389	26.891	29.14	42.628	31.484	22.903
5/30/2013 17:45	28.791	21.767	32.536	22.404	31.51	24.235	26.646	28.965	42.701	30.874	22.513
5/30/2013 18:00	28.642	21.627	31.408	21.854	31.204	24.071	26.549	28.791	42.992	30.268	22.177
5/30/2013 18:15	28.468	21.498	30.52	21.445	31.026	23.906	26.549	28.617	43.196	29.765	21.907
5/30/2013 18:30	28.32	21.369	29.765	21.165	30.874	23.764	26.402	28.419	43.328	29.265	21.67
5/30/2013 18:45	28.122	21.23	29.115	20.897	30.748	23.567	25.987	28.221	43.534	28.841	21.477
5/30/2013 19:00	27.949	21.08	28.543	20.651	30.495	23.327	26.061	27.998	43.637	28.444	21.283
5/30/2013 19:15	27.751	20.929	27.998	20.384	30.192	23.099	25.501	27.776	43.934	28.072	21.122
5/30/2013 19:30	27.579	20.779	27.481	20.128	29.916	22.892	25.283	27.53	44.142	27.727	20.951
5/30/2013 19:45	27.358	20.608	27.014	19.904	29.64	22.675	24.919	27.284	44.157	27.407	20.801
5/30/2013 20:00	27.161	20.437	26.622	19.67	29.365	22.469	24.677	27.038	44.202	27.087	20.651
5/30/2013 20:15	26.965	20.224	26.28	19.468	29.09	22.264	24.219	26.818	44.217	26.818	20.533
5/30/2013 20:30	26.744	19.957	25.987	19.287	28.841	22.069	23.617	26.573	44.202	26.549	20.416
5/30/2013 20:45	26.524	19.733	25.72	19.159	28.593	21.886	23.136	26.378	44.217	26.28	20.298
5/30/2013 21:00	26.304	19.553	25.477	19.075	28.32	21.703	22.776	26.158	44.187	26.036	20.202
5/30/2013 21:15	26.085	19.414	25.258	19.011	28.023	21.52	22.633	25.939	44.232	25.841	20.128
5/30/2013 21:30	25.89	19.287	25.065	18.926	27.702	21.359	22.513	25.768	44.202	25.647	20.053

Table A (Continued)

	DL01		DL07		DL09		DL11	DL15		DL16	
Date	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**
5/30/2013 21:45	25.72	19.202	24.895	18.841	27.431	21.219	22.441	25.598	44.217	25.477	19.989
5/30/2013 22:00	25.55	19.117	24.726	18.714	27.112	21.069	22.321	25.453	44.232	25.307	19.925
5/30/2013 22:15	25.38	19.043	24.581	18.651	26.842	20.94	22.274	25.307	44.217	25.137	19.861
5/30/2013 22:30	25.234	18.99	24.436	18.587	26.622	20.833	22.178	25.162	44.247	24.992	19.808
5/30/2013 22:45	25.089	18.947	24.291	18.545	26.451	20.726	22.058	25.04	44.262	24.847	19.765
5/30/2013 23:00	24.944	18.905	24.195	18.534	26.329	20.651	21.963	24.871	44.232	24.702	19.712
5/30/2013 23:15	24.823	18.831	24.074	18.502	26.207	20.566	21.533	24.75	44.217	24.605	19.67
5/30/2013 23:30	24.702	18.756	23.978	18.492	26.085	20.48	20.96	24.629	44.232	24.484	19.616
5/30/2013 23:45	24.581	18.703	23.905	18.492	26.012	20.416	20.96	24.508	44.217	24.388	19.595
5/31/2013 0:00	24.484	18.672	23.833	18.439	25.89	20.352	20.889	24.412	44.247	24.267	19.563
5/31/2013 0:15	24.363	18.651	23.785	18.386	25.768	20.298	21.056	24.315	44.202	24.195	19.531
5/31/2013 0:30	24.267	18.608	23.713	18.344	25.72	20.245	21.175	24.219	44.217	24.098	19.499
5/31/2013 0:45	24.171	18.545	23.641	18.259	25.55	20.202	21.127	24.122	44.202	24.002	19.468
5/31/2013 1:00	24.074	18.471	23.569	18.217	25.453	20.16	21.008	24.026	44.202	23.905	19.436
5/31/2013 1:15	23.978	18.407	23.472	18.132	25.331	20.117	21.032	23.905	44.262	23.809	19.393
5/31/2013 1:30	23.881	18.354	23.376	18.026	25.258	20.074	20.96	23.809	44.277	23.713	19.351
5/31/2013 1:45	23.785	18.301	23.28	17.974	25.137	20.042	20.865	23.713	44.247	23.617	19.319
5/31/2013 2:00	23.689	18.269	23.184	17.91	25.065	20	20.77	23.617	44.262	23.521	19.276
5/31/2013 2:15	23.641	18.259	23.112	17.889	25.016	19.968	20.77	23.521	44.217	23.424	19.244
5/31/2013 2:30	23.569	18.217	23.04	17.836	24.968	19.946	20.555	23.448	44.262	23.352	19.223
5/31/2013 2:45	23.497	18.185	22.944	17.741	24.895	19.904	20.603	23.352	44.262	23.256	19.181

Table A (Continued)

	DL01		DL07		DL09		DL11	DL15		DL16	
Date	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**
5/31/2013 3:00	23.376	18.111	22.872	17.688	24.847	19.883	20.46	23.256	44.232	23.16	19.138
5/31/2013 3:15	23.304	18.069	22.776	17.593	24.726	19.84	20.507	23.16	44.217	23.064	19.096
5/31/2013 3:30	23.208	18.016	22.705	17.541	24.653	19.808	20.246	23.064	44.247	22.968	19.053
5/31/2013 3:45	23.112	17.931	22.609	17.456	24.557	19.765	19.888	22.968	44.068	22.872	19.011
5/31/2013 4:00	23.04	17.836	22.513	17.404	24.484	19.744	19.627	22.872	44.247	22.776	18.979
5/31/2013 4:15	22.944	17.773	22.441	17.351	24.388	19.702	19.46	22.776	44.232	22.681	18.926
5/31/2013 4:30	22.848	17.752	22.345	17.309	24.339	19.68	19.413	22.681	44.217	22.585	18.894
5/31/2013 4:45	22.776	17.699	22.274	17.256	24.291	19.638	19.27	22.585	44.247	22.489	18.862
5/31/2013 5:00	22.681	17.667	22.202	17.193	24.243	19.616	19.318	22.513	44.142	22.393	18.82
5/31/2013 5:15	22.585	17.636	22.13	17.182	24.195	19.584	19.294	22.417	43.978	22.321	18.788
5/31/2013 5:30	22.537	17.583	22.082	17.235	24.122	19.563	19.246	22.369	43.711	22.226	18.756
5/31/2013 5:45	22.465	17.541	22.082	17.288	24.098	19.563	19.103	22.345	43.446	22.178	18.746
5/31/2013 6:00	22.393	17.562	22.082	17.298	24.098	19.563	18.889	22.369	43.211	22.106	18.735
5/31/2013 6:15	22.345	17.646	22.106	17.34	24.098	19.574	19.175	22.465	42.962	22.082	18.735
5/31/2013 6:30	22.345	17.783	22.106	17.456	24.098	19.606	19.413	22.561	42.686	22.058	18.746
5/31/2013 6:45	22.345	17.921	22.178	17.498	24.171	19.659	19.318	22.729	42.369	22.058	18.778
5/31/2013 7:00	22.393	18.1	22.226	17.509	24.195	19.712	19.817	22.92	42.325	22.058	18.799
5/31/2013 7:15	22.489	18.269	22.274	17.541	24.726	20.726	19.056	23.136	42.21	22.058	18.831
5/31/2013 7:30	22.609	18.407	22.321	17.636	26.158	20.779	19.103	23.4	41.91	22.106	18.862
5/31/2013 7:45	22.753	18.598	22.393	17.762	27.21	20.705	19.793	23.665	41.782	22.154	18.915
5/31/2013 8:00	22.944	18.82	22.537	17.984	27.21	20.994	20.555	23.93	41.498	22.25	18.968

Table A (Continued)

	DL01		DL07		DL09		DL11	DL15		DL16	
Date	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**
5/31/2013 8:15	23.112	19.053	22.705	18.195	27.358	21.273	21.079	24.267	41.117	22.345	19.053
5/31/2013 8:30	23.304	19.297	22.896	18.502	27.702	21.294	20.841	24.653	40.6	22.441	19.128
5/31/2013 8:45	23.521	19.531	23.136	18.82	28.245	21.638	20.913	25.065	39.787	22.609	19.223
5/31/2013 9:00	23.785	19.776	23.4	19.096	28.667	22.091	21.199	25.671	36.674	22.776	19.329
5/31/2013 9:15	24.074	20.042	23.665	19.393	29.215	22.48	21.772	27.505	30.482	22.968	19.446
5/31/2013 9:30	24.412	20.32	23.93	19.765	30.066	22.415	22.226	29.19	29.152	23.184	19.563
5/31/2013 9:45	24.798	20.619	24.219	20.01	30.52	23.012	22.753	31.714	15.006	23.4	19.702
5/31/2013 10:00	25.21	20.865	24.508	20.277	30.621	22.979	22.729	33.574	8.132	23.617	19.851
5/31/2013 10:15	25.671	21.208	24.823	20.501	30.849	23.578	23.545	35.022	8.111	23.881	20.01
5/31/2013 10:30	26.158	21.52	25.137	20.705	31.077	23.786	23.978	36.227	8.1	24.146	20.181
5/31/2013 10:45	26.695	21.843	25.428	20.887	31.001	23.666	24.315	36.987	18.894	24.436	20.352
5/31/2013 11:00	27.21	22.156	25.72	21.058	30.925	24.334	24.702	36.933	19.446	24.75	20.512
5/31/2013 11:15	27.825	22.502	26.134	21.273	30.95	24.246	24.605	35.823	8.121	25.137	20.683
5/31/2013 11:30	28.518	24.158	26.353	21.391	31.026	24.686	25.089	35.582	8.132	25.428	20.833
5/31/2013 11:45	30.167	24.94	26.573	21.509	31.204	24.554	25.525	36.525	8.111	25.72	20.983
5/31/2013 12:00	30.849	25.472	26.842	21.757	31.306	24.521	25.671	36.606	8.132	26.061	21.144
5/31/2013 12:15	31.408	26.219	27.087	21.951	31.586	24.62	26.036	36.362	8.132	26.426	21.294
5/31/2013 12:30	32.073	26.544	27.358	22.102	31.791	24.774	26.28	36.119	32.778	26.769	21.477
5/31/2013 12:45	32.82	26.589	27.653	22.264	32.124	24.973	26.891	35.743	35.268	27.161	21.703
5/31/2013 13:00	33.235	26.6	27.875	22.285	32.433	25.15	26.989	35.475	36.687	27.801	21.94
5/31/2013 13:15	33.548	26.342	28.245	22.502	32.691	25.272	27.358	35.422	37.653	28.518	22.318

Table A (Continued)

	DL01		DL07		DL09		DL11	DL15		DL16	
Date	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**
5/31/2013 13:30	33.704	26.062	28.692	22.892	32.768	25.35	27.628	35.262	38.689	29.74	22.751
5/31/2013 13:45	33.94	25.895	29.615	23.491	33.105	25.494	27.751	35.075	39.31	32.924	23.262
5/31/2013 14:00	34.071	25.661	31.765	24.18	33.313	25.594	27.998	34.889	39.12	35.235	23.83
5/31/2013 14:15	34.097	25.35	34.677	24.301	33.574	25.739	27.998	34.572	41.668	34.863	24.18
5/31/2013 14:30	34.097	25.217	37.7	25.305	33.783	25.884	28.394	34.308	39.924	35.395	24.73
5/31/2013 14:45	33.887	24.653	39.149	26.196	33.914	25.616	28.27	34.124	40.448	38.421	25.361
5/31/2013 15:00	33.783	24.763	38.17	25.806	33.966	25.872	28.593	33.861	40.157	37.425	25.572
5/31/2013 15:15	33.73	24.741	36.039	24.852	34.176	26.006	28.617	33.391	39.582	35.502	25.018
5/31/2013 15:30	33.521	24.378	36.715	25.817	34.281	25.739	28.766	33.157	41.033	36.933	25.483
5/31/2013 15:45	33.001	23.851	35.85	25.416	33.966	25.383	28.147	32.794	41.498	35.555	25.361
5/31/2013 16:00	32.691	23.775	39.177	26.443	33.887	25.505	28.816	32.536	41.385	36.092	25.995
5/31/2013 16:15	32.33	23.469	42.654	26.275	33.704	25.25	28.568	32.33	42.484	35.128	25.716
5/31/2013 16:30	31.996	23.251	39.545	25.062	33.521	25.239	28.617	32.073	41.711	34.255	24.984
5/31/2013 16:45	31.765	23.11	36.688	24.543	33.417	25.106	29.19	31.868	41.019	33.678	24.422
5/31/2013 17:00	31.484	22.925	35.609	24.466	33.235	24.819	28.593	31.74	40.24	33.235	24.038
5/31/2013 17:15	31.255	22.892	34.624	23.83	32.949	24.664	28.419	31.663	40.977	32.846	23.666
5/31/2013 17:30	31.077	22.892	33.704	23.48	32.794	24.73	28.891	31.433	43.167	32.304	23.327
5/31/2013 17:45	30.95	22.816	32.562	22.957	32.742	24.543	28.617	31.128	41.824	31.791	23.012
5/31/2013 18:00	30.748	22.588	31.74	22.513	32.51	24.334	28.568	30.874	42.977	31.281	22.74
5/31/2013 18:15	30.52	22.404	31.077	22.231	32.175	24.082	27.875	30.646	43.138	30.798	22.502
5/31/2013 18:30	30.293	22.21	30.52	22.037	31.996	23.928	27.604	30.419	43.505	30.394	22.296

Table A (Continued)

	DL01		DL07		DL09		DL11	DL15		DL16	
Date	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**
5/31/2013 18:45	30.066	22.069	29.865	21.789	31.842	23.83	28.023	30.167	43.46	29.966	22.091
5/31/2013 19:00	29.865	21.94	29.315	21.52	31.612	23.622	27.924	29.916	43.815	29.59	21.907
5/31/2013 19:15	29.64	21.821	28.841	21.294	31.331	23.425	27.358	29.64	44.023	29.24	21.735
5/31/2013 19:30	29.414	21.638	28.493	21.144	31.077	23.229	26.94	29.365	44.098	28.965	21.595
5/31/2013 19:45	29.165	21.466	28.147	20.962	30.874	23.066	26.524	29.115	44.113	28.642	21.445
5/31/2013 20:00	28.941	21.316	27.825	20.822	30.621	22.881	26.402	28.891	44.217	28.394	21.337
5/31/2013 20:15	28.717	21.165	27.579	20.651	30.318	22.697	26.182	28.692	44.232	28.147	21.23
5/31/2013 20:30	28.518	21.047	27.333	20.533	30.041	22.523	25.963	28.493	44.232	27.924	21.144
5/31/2013 20:45	28.345	20.929	27.112	20.405	29.79	22.372	25.671	28.345	44.202	27.727	21.047
5/31/2013 21:00	28.171	20.79	26.916	20.288	29.515	22.199	25.453	28.147	44.232	27.53	20.962
5/31/2013 21:15	27.998	20.672	26.72	20.16	29.265	22.059	25.258	27.974	44.247	27.333	20.876
5/31/2013 21:30	27.825	20.544	26.549	20.064	28.99	21.907	24.895	27.825	44.217	27.186	20.801
5/31/2013 21:45	27.653	20.437	26.402	19.946	28.717	21.767	24.677	27.677	44.247	27.014	20.726
5/31/2013 22:00	27.481	20.341	26.231	19.84	28.444	21.638	24.508	27.505	44.217	26.842	20.651
5/31/2013 22:15	27.333	20.234	26.085	19.744	28.171	21.52	24.171	27.358	44.202	26.671	20.576
5/31/2013 22:30	27.186	20.128	25.939	19.68	27.899	21.412	24.002	27.21	44.247	26.524	20.501
5/31/2013 22:45	27.063	20.032	25.793	19.584	27.702	21.305	23.857	27.063	44.262	26.378	20.437
5/31/2013 23:00	26.916	19.946	25.647	19.531	27.505	21.208	23.641	26.916	44.232	26.231	20.373
5/31/2013 23:15	26.769	19.883	25.525	19.446	27.333	21.133	23.424	26.769	44.232	26.109	20.309
5/31/2013 23:30	26.622	19.797	25.404	19.404	27.21	21.069	23.208	26.646	44.247	25.987	20.256
5/31/2013 23:45	26.475	19.733	25.307	19.319	27.112	20.994	23.088	26.524	44.217	25.866	20.202

Table A (Continued)

	DL01		DL07		DL09		DL11	DL15		DL16	
Date	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**
6/1/2013 0:00	26.353	19.659	25.186	19.276	27.014	20.929	22.944	26.378	44.232	25.744	20.149
6/1/2013 0:15	26.256	19.584	25.065	19.159	26.916	20.887	22.729	26.231	44.217	25.598	20.085
6/1/2013 0:30	26.109	19.489	24.944	18.958	26.793	20.833	22.369	26.085	44.217	25.477	20.021
6/1/2013 0:45	25.987	19.404	24.823	18.852	26.695	20.769	22.274	25.939	44.217	25.355	19.957
6/1/2013 1:00	25.866	19.287	24.677	18.725	26.573	20.705	21.7	25.793	44.232	25.234	19.893
6/1/2013 1:15	25.744	19.191	24.557	18.598	26.475	20.651	21.27	25.623	44.262	25.089	19.829
6/1/2013 1:30	25.574	19.053	24.436	18.439	26.378	20.598	20.984	25.453	44.247	24.944	19.755
6/1/2013 1:45	25.404	18.926	24.291	18.354	26.231	20.544	20.627	25.307	44.247	24.774	19.702
6/1/2013 2:00	25.234	18.799	24.146	18.238	26.109	20.491	20.317	25.162	44.232	24.629	19.627
6/1/2013 2:15	25.089	18.714	24.002	18.164	25.987	20.437	19.912	25.016	44.113	24.484	19.563
6/1/2013 2:30	24.919	18.619	23.881	18.111	25.866	20.395	19.436	24.847	44.247	24.339	19.51
6/1/2013 2:45	24.774	18.555	23.761	18.026	25.793	20.352	19.77	24.702	44.232	24.243	19.457
6/1/2013 3:00	24.653	18.492	23.617	17.963	25.671	20.288	19.603	24.557	44.232	24.098	19.404
6/1/2013 3:15	24.508	18.396	23.521	17.868	25.574	20.245	19.246	24.412	44.292	23.954	19.351
6/1/2013 3:30	24.388	18.312	23.4	17.794	25.55	20.202	18.985	24.267	44.292	23.833	19.308
6/1/2013 3:45	24.219	18.227	23.28	17.699	25.428	20.17	18.414	24.146	44.232	23.713	19.255
6/1/2013 4:00	24.098	18.153	23.184	17.625	25.331	20.128	18.652	24.002	44.277	23.593	19.202
6/1/2013 4:15	23.954	18.069	23.064	17.572	25.307	20.096	18.461	23.881	44.217	23.497	19.159
6/1/2013 4:30	23.833	17.984	22.992	17.509	25.21	20.053	18.366	23.737	44.187	23.376	19.106
6/1/2013 4:45	23.737	17.921	22.896	17.467	25.065	20.01	18.509	23.617	44.217	23.232	19.053
6/1/2013 5:00	23.617	17.857	22.8	17.382	25.016	19.968	18.485	23.497	44.202	23.136	19.011

Table A (Continued)

	DL01		DL07		DL09		DL11	DL15		DL16	
Date	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**
6/1/2013 5:15	23.497	17.805	22.729	17.34	24.968	19.946	18.818	23.376	43.904	23.016	18.968
6/1/2013 5:30	23.376	17.762	22.681	17.351	24.871	19.904	18.652	23.304	43.682	22.944	18.926
6/1/2013 5:45	23.28	17.752	22.657	17.382	24.823	19.893	18.604	23.256	43.475	22.824	18.905
6/1/2013 6:00	23.184	17.741	22.609	17.372	24.774	19.883	18.319	23.256	43.196	22.753	18.873
6/1/2013 6:15	23.112	17.773	22.609	17.404	24.702	19.904	17.558	23.28	42.962	22.681	18.862
6/1/2013 6:30	23.088	17.847	22.609	17.404	24.75	19.925	17.915	23.352	42.831	22.633	18.852
6/1/2013 6:45	23.04	17.942	22.633	17.425	24.823	19.957	18.461	23.472	42.571	22.609	18.862
6/1/2013 7:00	23.088	18.079	22.657	17.446	24.798	20	18.866	23.617	42.426	22.585	18.873
6/1/2013 7:15	23.136	18.259	22.657	17.467	25.307	21.187	18.2	23.833	42.225	22.561	18.894
6/1/2013 7:30	23.256	18.439	22.681	17.498	26.94	21.155	18.319	24.074	41.924	22.537	18.915
6/1/2013 7:45	23.4	18.619	22.753	17.562	28.097	21.09	18.699	24.339	41.824	22.561	18.947
6/1/2013 8:00	23.545	18.788	22.824	17.678	28.097	21.326	18.961	24.581	41.796	22.585	19
6/1/2013 8:15	23.689	19	22.944	17.868	28.345	21.595	19.27	24.847	41.54	22.657	19.043
6/1/2013 8:30	23.881	19.191	23.04	18.037	28.692	21.563	19.413	25.137	41.23	22.729	19.096
6/1/2013 8:45	24.074	19.361	23.232	18.301	29.09	21.918	19.389	25.501	38.931	22.848	19.159
6/1/2013 9:00	24.267	19.542	23.472	18.64	29.365	22.415	19.698	26.012	35.47	22.968	19.266
6/1/2013 9:15	24.532	19.776	23.713	18.915	29.765	22.534	20.007	27.653	30.142	23.064	19.34
6/1/2013 9:30	24.823	20.106	23.978	18.937	30.419	22.621	19.984	28.369	35.369	23.28	19.425
6/1/2013 9:45	25.089	20.16	24.219	19.213	30.874	23.175	20.293	30.925	9.503	23.4	19.531
6/1/2013 10:00	25.331	20.224	24.388	19.234	30.369	22.502	20.246	31.765	38.636	23.569	19.606
6/1/2013 10:15	25.525	20.437	24.532	19.393	30.243	23.393	20.77	33.914	8.111	23.689	19.702

Table A (Continued)

	DL01		DL07		DL09		DL11	DL15		DL16	
Date	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**
6/1/2013 10:30	25.817	20.533	24.677	19.531	30.016	23.001	20.555	35.368	8.111	23.833	19.808
6/1/2013 10:45	26.085	20.683	24.847	19.68	29.966	23.077	20.531	36.092	20.662	24.002	19.925
6/1/2013 11:00	26.475	20.908	25.089	19.861	29.991	23.862	20.722	36.039	21.692	24.219	20.074
6/1/2013 11:15	26.965	21.219	25.428	20.064	29.991	23.709	21.223	34.969	8.1	24.557	20.245
6/1/2013 11:30	27.554	23.088	25.647	20.01	30.091	24.147	21.461	34.836	36.095	24.823	20.341
6/1/2013 11:45	29.665	24.598	25.939	20.213	30.192	24.301	21.437	35.609	37.851	25.065	20.501
6/1/2013 12:00	30.469	24.598	26.231	20.533	30.268	23.72	21.987	35.743	8.143	25.38	20.683
6/1/2013 12:15	30.697	25.228	26.426	20.683	30.293	23.83	21.461	35.609	8.089	25.671	20.801
6/1/2013 12:30	31.281	25.739	26.549	20.737	30.52	24.103	22.25	35.182	33.77	25.866	20.887
6/1/2013 12:45	32.073	25.639	26.842	20.876	30.798	24.213	22.633	34.863	36.377	26.256	21.08
6/1/2013 13:00	32.33	25.594	27.014	21.037	30.976	24.356	22.776	34.783	37.6	26.965	21.348
6/1/2013 13:15	32.639	25.516	27.186	21.198	31.204	24.521	22.992	34.572	40.963	27.53	21.724
6/1/2013 13:30	32.949	25.294	27.382	21.026	31.459	24.653	22.92	34.176	37.443	28.147	21.897
6/1/2013 13:45	33.079	24.808	28.097	21.789	31.663	24.741	23.04	33.809	40.185	31.791	22.415
6/1/2013 14:00	32.872	24.18	30.545	22.729	31.586	24.587	22.633	33.521	40.642	34.783	23.088
6/1/2013 14:15	32.82	23.972	35.182	23.633	31.714	24.741	23.424	33.209	41.174	35.049	23.797
6/1/2013 14:30	32.742	23.851	38.588	24.532	31.919	24.907	23.641	32.898	41.413	35.475	24.521
6/1/2013 14:45	32.613	23.819	39.971	25.328	32.124	24.984	24.726	32.639	41.456	38.868	25.172
6/1/2013 15:00	32.51	23.72	40.92	26.096	32.304	25.084	24.05	32.355	41.512	40.314	25.861
6/1/2013 15:15	32.381	23.655	42.001	26.724	32.355	25.128	24.315	32.124	41.696	40.978	26.308
6/1/2013 15:30	32.201	23.469	41.152	27.378	32.484	25.172	24.267	31.919	41.753	41.443	27.209

Table A (Continued)

	DL01		DL07		DL09		DL11	DL15		DL16	
Date	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C
6/1/2013 15:45	31.944	23.306	40.516	27.673	32.613	25.195	24.195	31.663	41.896	41.56	28.473
6/1/2013 16:00	31.689	23.12	45.499	28.312	32.691	25.217	24.315	31.408	42.139	40.717	28.553
6/1/2013 16:15	31.331	22.708	49.581	27.537	32.794	25.195	24.219	31.153	42.282	38.421	27.628
6/1/2013 16:30	30.976	22.437	48.106	26.488	32.768	25.117	24.968	30.9	42.484	37.178	26.701
6/1/2013 16:45	30.672	22.188	41.825	27.209	32.742	25.073	24.726	30.646	42.643	36.146	25.594
6/1/2013 17:00	30.369	21.929	39.036	25.383	32.562	24.918	24.774	30.394	42.686	35.128	24.708
6/1/2013 17:15	30.091	21.778	36.96	23.841	32.433	24.797	24.798	30.142	42.846	34.176	23.994
6/1/2013 17:30	29.815	21.584	35.182	23.023	32.278	24.653	24.726	29.916	42.992	33.313	23.436
6/1/2013 17:45	29.565	21.445	33.521	22.037	31.97	24.444	25.137	29.69	42.992	32.562	22.968
6/1/2013 18:00	29.315	21.316	32.201	21.434	31.689	24.246	24.871	29.464	43.094	31.868	22.588
6/1/2013 18:15	29.09	21.187	31.103	21.004	31.408	24.049	24.847	29.24	43.269	31.179	22.253
6/1/2013 18:30	28.866	21.112	30.243	20.694	31.153	23.862	24.581	29.015	43.343	30.571	21.961
6/1/2013 18:45	28.667	20.972	29.49	20.437	30.925	23.633	24.267	28.791	43.519	30.041	21.724
6/1/2013 19:00	28.468	20.865	28.891	20.288	30.646	23.327	24.557	28.568	43.593	29.565	21.509
6/1/2013 19:15	28.27	20.737	28.369	20.064	30.293	23.044	23.809	28.369	43.785	29.115	21.316
6/1/2013 19:30	28.048	20.63	27.875	19.84	29.966	22.794	23.785	28.147	44.023	28.667	21.133
6/1/2013 19:45	27.85	20.501	27.456	19.702	29.69	22.556	23.545	27.899	44.187	28.27	20.962
6/1/2013 20:00	27.653	20.341	27.063	19.553	29.439	22.329	23.256	27.653	44.187	27.924	20.812
6/1/2013 20:15	27.407	20.138	26.744	19.446	29.165	22.134	23.088	27.431	44.262	27.579	20.694
6/1/2013 20:30	27.186	19.957	26.451	19.351	28.891	21.929	22.968	27.186	44.277	27.308	20.576
6/1/2013 20:45	26.965	19.744	26.207	19.244	28.543	21.735	22.848	26.94	44.202	27.038	20.48

Table A (Continued)

	DL01		DL07		DL09		DL11	DL15		DL16	
Date	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**
6/1/2013 21:00	26.769	19.563	25.963	19.106	28.245	21.552	22.585	26.72	44.202	26.793	20.384
6/1/2013 21:15	26.549	19.393	25.744	18.947	27.924	21.38	22.417	26.475	44.262	26.549	20.266
6/1/2013 21:30	26.329	19.255	25.55	18.841	27.628	21.23	22.13	26.231	44.232	26.329	20.17
6/1/2013 21:45	26.134	19.128	25.331	18.767	27.382	21.09	21.939	26.036	44.232	26.109	20.085
6/1/2013 22:00	25.939	19.011	25.137	18.661	27.21	20.972	21.819	25.866	44.202	25.914	20
6/1/2013 22:15	25.768	18.915	24.944	18.587	26.989	20.865	21.7	25.671	44.247	25.744	19.936
6/1/2013 22:30	25.574	18.809	24.774	18.566	26.916	20.758	21.485	25.501	44.232	25.55	19.872
6/1/2013 22:45	25.404	18.725	24.629	18.555	26.818	20.683	21.39	25.355	44.232	25.428	19.819
6/1/2013 23:00	25.234	18.672	24.532	18.566	26.646	20.598	21.509	25.234	44.232	25.307	19.776
6/1/2013 23:15	25.089	18.64	24.412	18.46	26.5	20.523	21.127	25.089	44.262	25.186	19.744
6/1/2013 23:30	24.944	18.598	24.291	18.396	26.304	20.448	21.27	24.944	44.262	25.04	19.691
6/1/2013 23:45	24.823	18.576	24.195	18.291	26.134	20.384	20.984	24.823	44.232	24.895	19.648

APPENDIX B

TEMPERATURE DATA FOR THREE COOLEST DAYS

Table B Temperature data for three coolest days

	DL01		DL07		DL09		DL11	DL15		DL16	
Date	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**
5/15/2013 1:30	16.725	15.52	18.247	15.751	20.65	17.921	12.968	17.272	43.652	18.081	17.224
5/15/2013 1:45	16.677	15.489	18.224	15.678	20.627	17.9	12.534	17.225	44.127	18.081	17.224
5/15/2013 2:00	16.63	15.447	18.176	15.615	20.603	17.889	12.147	17.153	43.756	18.057	17.203
5/15/2013 2:15	16.582	15.405	18.105	15.541	20.555	17.868	12.34	17.13	43.593	18.01	17.193
5/15/2013 2:30	16.558	15.384	18.057	15.531	20.484	17.826	12.678	17.082	43.83	17.986	17.172
5/15/2013 2:45	16.511	15.373	18.033	15.489	20.436	17.815	12.703	17.034	44.247	17.915	17.151
5/15/2013 3:00	16.463	15.363	17.962	15.457	20.412	17.783	12.582	16.987	44.068	17.867	17.13
5/15/2013 3:15	16.415	15.331	17.938	15.457	20.341	17.762	12.509	16.939	44.247	17.843	17.119
5/15/2013 3:30	16.368	15.331	17.867	15.426	20.293	17.731	12.582	16.892	44.083	17.819	17.108
5/15/2013 3:45	16.32	15.342	17.819	15.436	20.246	17.72	12.485	16.868	44.262	17.796	17.098
5/15/2013 4:00	16.272	15.331	17.772	15.447	20.269	17.72	12.316	16.82	44.232	17.772	17.098
5/15/2013 4:15	16.249	15.3	17.748	15.447	20.246	17.71	12.122	16.796	44.068	17.748	17.098
5/15/2013 4:30	16.201	15.268	17.724	15.478	20.222	17.688	11.929	16.749	44.068	17.724	17.098
5/15/2013 4:45	16.153	15.268	17.701	15.468	20.15	17.678	11.734	16.701	43.682	17.701	17.098
5/15/2013 5:00	16.106	15.247	17.701	15.436	20.126	17.678	11.637	16.654	44.038	17.677	17.098
5/15/2013 5:15	16.058	15.226	17.653	15.415	20.103	17.678	11.929	16.606	44.113	17.653	17.087

Table B (Continued)

	DL01		DL07		DL09		DL11	DL15		DL16	
Date	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**
5/15/2013 6:45	15.939	15.342	17.843	15.73	20.174	17.762	12.63	16.582	42.556	17.653	17.119
5/15/2013 7:00	15.963	15.384	17.938	15.804	20.246	17.878	12.63	16.677	41.3	17.701	17.14
5/15/2013 7:15	16.058	15.562	18.081	15.93	20.627	18.248	12.92	16.892	41.033	17.748	17.182
5/15/2013 7:30	16.177	15.72	18.247	16.098	21.103	18.301	13.064	17.082	41.47	17.867	17.235
5/15/2013 7:45	16.296	15.857	18.414	16.182	21.318	18.301	13.016	17.225	41.16	17.962	17.298
5/15/2013 8:00	16.415	15.962	18.509	16.193	21.318	18.375	12.509	17.439	40.74	18.057	17.33
5/15/2013 8:15	16.582	16.119	18.628	16.245	21.533	18.587	12.823	17.701	39.8	18.152	17.372
5/15/2013 8:30	16.82	16.351	18.842	16.445	21.867	18.703	13.137	18.081	39.093	18.319	17.456
5/15/2013 8:45	16.963	16.445	19.08	16.635	21.748	18.693	13.401	18.224	39.896	18.485	17.541
5/15/2013 9:00	17.13	16.645	19.318	16.866	21.843	18.831	13.666	18.509	38.783	18.699	17.646
5/15/2013 9:15	17.391	16.919	19.603	17.14	22.082	19.159	13.81	18.937	35.167	18.913	17.741
5/15/2013 9:30	17.629	17.098	19.793	17.214	22.321	19.138	13.81	19.389	37.286	19.103	17.815
5/15/2013 9:45	17.843	17.224	19.96	17.267	22.417	19.223	13.714	19.555	34.965	19.246	17.868
5/15/2013 10:00	18.129	17.488	20.174	17.467	22.729	19.744	14.074	20.341	32.39	19.436	17.963
5/15/2013 10:15	18.533	17.974	20.412	17.741	23.424	20.192	14.745	22.776	23.306	19.603	18.069
5/15/2013 10:30	18.985	18.026	20.555	17.583	23.665	19.893	14.361	22.226	36.947	19.841	18.121
5/15/2013 10:45	19.151	17.942	20.579	17.583	23.521	19.84	14.577	21.581	37.377	19.912	18.153
5/15/2013 11:00	19.341	18.195	20.841	17.878	23.448	20.16	14.936	22.106	18.026	20.031	18.238
5/15/2013 11:15	19.936	19.808	21.079	18.185	23.809	20.598	15.557	25.137	18.248	20.198	18.375
5/15/2013 11:30	21.581	22.394	21.533	18.703	24.291	21.843	16.487	26.231	8.143	20.531	18.619
5/15/2013 11:45	22.968	21.983	21.963	18.735	24.774	21.24	16.511	27.284	40.545	20.96	18.767

Table B (Continued)

	DL01		DL07		DL09		DL11	DL15		DL16	
Date	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**
5/15/2013 12:00	22.393	20.362	22.058	18.534	24.653	20.854	16.129	25.355	40.573	21.056	18.767
5/15/2013 12:15	22.202	19.744	22.178	18.523	24.557	20.801	16.106	24.653	37.43	21.175	18.788
5/15/2013 12:30	21.939	19.032	22.298	18.502	24.363	20.544	15.796	24.026	41.583	21.246	18.809
5/15/2013 12:45	21.748	18.862	22.705	18.64	24.219	20.555	15.891	23.617	38.155	21.533	18.905
5/15/2013 13:00	21.724	18.799	22.705	18.566	24.146	20.469	15.843	23.545	40.254	21.604	18.905
5/15/2013 13:15	21.557	18.545	22.776	18.365	24.098	20.373	15.748	23.136	39.053	21.628	18.884
5/15/2013 13:30	21.342	18.206	22.489	18.238	24.002	20.16	15.796	22.824	42.599	21.413	18.809
5/15/2013 13:45	21.056	18.005	22.753	18.555	23.833	20.117	15.581	22.345	41.216	21.604	18.894
5/15/2013 14:00	21.032	18.195	23.112	18.852	23.857	20.224	15.915	22.274	41.427	21.987	19.075
5/15/2013 14:15	21.032	18.449	23.497	19.329	23.905	20.459	15.843	22.226	35.306	22.393	19.244
5/15/2013 14:30	21.557	19.213	26.061	20.779	24.508	21.101	16.439	22.753	38.864	25.89	20.042
5/15/2013 14:45	21.939	19.287	26.695	20.437	25.089	21.101	16.868	22.992	40.157	25.89	20.469
5/15/2013 15:00	21.748	18.598	24.847	19.404	24.919	20.769	15.509	22.776	39.992	24.098	20.128
5/15/2013 15:15	21.509	18.259	24.581	19.627	24.702	20.758	15.247	22.609	38.288	23.93	20.042
5/15/2013 15:30	21.485	18.291	25.72	20.064	24.702	20.833	15.438	22.585	39.732	24.75	20.277
5/15/2013 15:45	21.676	18.788	29.84	22.805	25.016	21.348	16.177	22.609	40.365	28.221	21.069
5/15/2013 16:00	21.867	18.979	31.204	24.763	25.55	21.778	16.654	22.705	41.3	29.941	22.979
5/15/2013 16:15	21.915	18.958	33.678	25.839	25.939	21.929	17.082	22.729	41.796	30.394	23.862
5/15/2013 16:30	21.891	18.852	37.838	25.85	26.231	21.994	17.582	22.705	41.924	30.469	24.808
5/15/2013 16:45	21.795	18.651	37.151	23.633	26.256	21.757	17.153	22.657	42.039	29.665	23.983
5/15/2013 17:00	21.676	18.513	36.444	22.404	26.109	21.789	17.249	22.537	42.802	28.816	23.884

Table B (Continued)

	DL01		DL07		DL09		DL11	DL15		DL16	
Date	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**
5/15/2013 17:15	21.557	18.344	32.33	21.294	25.841	21.509	17.201	22.369	42.977	27.949	22.491
5/15/2013 17:30	21.437	18.291	30.268	20.672	25.647	21.359	17.13	22.274	42.182	27.235	21.66
5/15/2013 17:45	21.294	18.143	28.543	19.925	25.331	21.09	16.582	22.082	43.006	26.451	21.037
5/15/2013 18:00	21.127	17.952	27.186	19.382	25.065	20.865	16.177	21.891	42.904	25.793	20.544
5/15/2013 18:15	20.936	17.741	25.914	18.756	24.774	20.576	15.796	21.652	43.431	25.137	20.085
5/15/2013 18:30	20.674	17.498	24.847	18.269	24.484	20.288	15.533	21.366	43.904	24.508	19.691
5/15/2013 18:45	20.412	17.172	24.074	18.026	24.098	20.074	14.984	21.103	43.505	23.954	19.372
5/15/2013 19:00	20.103	16.529	23.569	17.847	23.785	19.883	14.409	20.77	42.672	23.472	19.117
5/15/2013 19:15	19.817	16.403	23.208	17.773	23.521	19.68	14.481	20.507	43.475	23.088	18.926
5/15/2013 19:30	19.603	16.424	22.729	17.498	23.232	19.446	14.697	20.222	43.771	22.681	18.725
5/15/2013 19:45	19.365	16.424	22.274	17.33	22.968	19.244	14.673	19.984	43.978	22.274	18.545
5/15/2013 20:00	19.199	16.414	21.891	17.151	22.753	19.096	14.792	19.793	44.232	21.939	18.396
5/15/2013 20:15	19.032	16.372	21.509	16.993	22.561	18.947	14.84	19.603	44.202	21.628	18.269
5/15/2013 20:30	18.889	16.319	21.151	16.856	22.369	18.841	14.84	19.46	44.232	21.318	18.164
5/15/2013 20:45	18.747	16.298	20.865	16.761	22.226	18.756	14.601	19.318	44.262	21.056	18.09
5/15/2013 21:00	18.628	16.245	20.603	16.656	22.082	18.672	14.553	19.222	44.247	20.865	18.026
5/15/2013 21:15	18.533	16.161	20.341	16.54	21.963	18.587	13.906	19.08	44.247	20.65	17.963
5/15/2013 21:30	18.414	16.077	20.126	16.424	21.843	18.513	13.642	18.961	44.247	20.46	17.9
5/15/2013 21:45	18.295	15.983	19.912	16.372	21.724	18.449	13.353	18.818	44.247	20.293	17.836
5/15/2013 22:00	18.176	15.909	19.746	16.319	21.581	18.375	13.497	18.699	44.262	20.103	17.773
5/15/2013 22:15	18.081	15.846	19.603	16.256	21.485	18.322	13.353	18.604	44.172	19.96	17.71

Table B (Continued)

	DL01		DL07		DL09		DL11	DL15		DL16	
Date	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**
5/15/2013 22:30	17.962	15.772	19.436	16.182	21.39	18.28	13.016	18.461	44.247	19.817	17.657
5/15/2013 22:45	17.843	15.72	19.341	16.172	21.294	18.227	12.92	18.366	44.277	19.674	17.604
5/15/2013 23:00	17.772	15.678	19.222	16.151	21.199	18.185	13.161	18.271	44.068	19.555	17.551
5/15/2013 23:15	17.677	15.636	19.103	16.119	21.151	18.143	13.377	18.176	43.696	19.436	17.52
5/15/2013 23:30	17.605	15.615	18.985	16.035	21.079	18.1	13.209	18.081	44.068	19.318	17.477
5/15/2013 23:45	17.534	15.573	18.889	15.993	21.008	18.058	13.233	17.986	44.262	19.222	17.446
5/16/2013 0:00	17.439	15.457	18.794	15.962	20.936	18.016	13.353	17.891	43.608	19.127	17.414
5/16/2013 0:15	17.391	15.426	18.699	15.899	20.841	17.995	13.305	17.819	44.217	19.032	17.372
5/16/2013 0:30	17.32	15.384	18.628	15.941	20.793	17.963	13.137	17.724	43.608	18.913	17.34
5/16/2013 0:45	17.249	15.384	18.557	15.888	20.746	17.931	13.04	17.653	43.874	18.818	17.298
5/16/2013 1:00	17.201	15.331	18.485	15.888	20.698	17.91	13.112	17.582	44.202	18.723	17.277
5/16/2013 1:15	17.106	15.258	18.414	15.857	20.674	17.868	12.992	17.486	43.859	18.628	17.235
5/16/2013 1:30	17.058	15.247	18.343	15.804	20.65	17.857	12.823	17.391	44.068	18.557	17.203
5/16/2013 1:45	16.987	15.205	18.271	15.783	20.555	17.826	12.654	17.32	43.8	18.461	17.182
5/16/2013 2:00	16.892	15.1	18.224	15.751	20.531	17.794	12.678	17.225	44.247	18.39	17.161
5/16/2013 2:15	16.82	15.069	18.152	15.741	20.412	17.762	12.582	17.13	43.815	18.319	17.13
5/16/2013 2:30	16.749	15.037	18.081	15.709	20.341	17.741	12.582	17.058	43.845	18.247	17.108
5/16/2013 2:45	16.701	15.027	18.01	15.688	20.317	17.72	12.534	16.987	43.623	18.152	17.077
5/16/2013 3:00	16.63	14.974	17.938	15.636	20.293	17.71	12.147	16.892	44.068	18.105	17.045
5/16/2013 3:15	16.558	14.922	17.891	15.573	20.246	17.678	12.195	16.82	43.387	18.01	17.024
5/16/2013 3:30	16.487	14.922	17.819	15.552	20.222	17.657	12.268	16.725	43.904	17.938	16.993

Table B (Continued)

	DL01		DL07		DL09		DL11	DL15		DL16	
Date	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**
5/16/2013 3:45	16.415	14.88	17.772	15.51	20.15	17.636	12.195	16.654	44.247	17.867	16.961
5/16/2013 4:00	16.344	14.827	17.701	15.468	20.15	17.604	12.171	16.606	44.008	17.772	16.929
5/16/2013 4:15	16.296	14.838	17.629	15.447	20.103	17.583	12.074	16.534	44.038	17.724	16.908
5/16/2013 4:30	16.249	14.848	17.582	15.405	20.031	17.572	12.147	16.463	44.008	17.629	16.877
5/16/2013 4:45	16.201	14.827	17.51	15.321	19.984	17.541	12.05	16.415	43.446	17.558	16.856
5/16/2013 5:00	16.129	14.775	17.439	15.321	19.936	17.52	11.953	16.344	44.262	17.486	16.835
5/16/2013 5:15	16.082	14.775	17.368	15.3	19.888	17.488	11.856	16.296	44.142	17.415	16.803
5/16/2013 5:30	16.058	14.775	17.32	15.268	19.865	17.477	11.856	16.249	44.083	17.344	16.782
5/16/2013 5:45	15.986	14.744	17.249	15.237	19.841	17.467	11.734	16.201	43.652	17.272	16.75
5/16/2013 6:00	15.939	14.775	17.225	15.205	19.841	17.477	11.565	16.153	43.652	17.225	16.729
5/16/2013 6:15	15.915	14.859	17.177	15.195	19.865	17.488	11.832	16.177	43.299	17.153	16.708
5/16/2013 6:30	15.939	15.006	17.177	15.226	19.865	17.509	12.025	16.249	42.919	17.106	16.708
5/16/2013 6:45	16.01	15.163	17.177	15.279	19.888	17.53	12.389	16.344	42.643	17.058	16.708
5/16/2013 7:00	16.082	15.279	17.177	15.321	19.936	17.572	12.364	16.463	42.585	17.058	16.719
5/16/2013 7:15	16.201	15.405	17.225	15.384	20.412	18.735	12.413	16.582	42.788	17.058	16.74
5/16/2013 7:30	16.32	15.573	17.272	15.447	22.226	19.351	12.678	16.773	42.455	17.082	16.771
5/16/2013 7:45	16.463	15.741	17.32	15.51	23.184	18.767	12.316	16.987	42.167	17.13	16.814
5/16/2013 8:00	16.63	15.899	17.415	15.604	23.256	19.329	12.509	17.225	41.597	17.153	16.845
5/16/2013 8:15	16.82	16.098	17.534	15.751	23.665	19.542	12.727	17.51	41.682	17.225	16.887
5/16/2013 8:30	17.058	16.309	17.677	15.93	23.954	19.223	12.799	17.819	41.019	17.272	16.94
5/16/2013 8:45	17.296	16.54	17.819	16.14	24.726	19.883	13.425	18.152	41.188	17.368	16.993

Table B (Continued)

	DL01		DL07		DL09		DL11	DL15		DL16	
Date	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**
5/16/2013 9:00	17.582	16.803	18.033	16.382	25.55	20.288	14.05	18.557	40.517	17.463	17.045
5/16/2013 9:15	17.867	17.056	18.224	16.624	25.453	20.769	13.978	19.175	35.003	17.629	17.13
5/16/2013 9:30	18.224	17.351	18.461	16.866	25.21	20.384	14.768	21.891	8.164	17.772	17.224
5/16/2013 9:45	18.628	17.657	18.723	17.108	25.404	21.66	15.055	24.098	28.668	17.962	17.319
5/16/2013 10:00	19.103	17.974	18.985	17.34	25.355	21.445	15.247	24.726	29.5	18.152	17.435
5/16/2013 10:15	19.651	18.291	19.246	17.562	25.744	21.112	15.724	27.186	27.912	18.366	17.562
5/16/2013 10:30	20.198	18.576	19.508	17.688	25.744	22.199	16.034	29.464	8.089	18.58	17.688
5/16/2013 10:45	20.793	18.905	19.77	17.878	25.501	21.757	16.249	31.153	8.089	18.818	17.836
5/16/2013 11:00	21.437	19.308	20.031	18.047	25.453	21.897	16.701	32.047	20.341	19.08	17.995
5/16/2013 11:15	22.178	21.305	20.341	18.365	25.55	21.918	17.296	31.612	16.645	19.365	18.195
5/16/2013 11:30	23.833	23.545	20.674	18.555	25.793	22.827	17.368	31.306	8.089	19.698	18.386
5/16/2013 11:45	25.744	24.631	21.056	18.82	26.036	22.849	18.105	32.872	8.1	20.126	18.598
5/16/2013 12:00	27.186	25.139	21.509	19.191	26.304	22.523	18.176	34.836	8.1	20.603	18.831
5/16/2013 12:15	28.072	25.394	21.891	19.34	26.598	22.686	18.366	35.235	8.121	21.056	19.032
5/16/2013 12:30	28.493	25.283	22.417	19.627	26.867	22.881	18.628	34.624	8.089	21.533	19.202
5/16/2013 12:45	28.816	25.018	22.657	19.808	27.136	23.033	18.414	33.365	24.466	21.891	19.361
5/16/2013 13:00	28.692	24.312	22.848	19.797	27.21	22.946	18.509	32.15	32.293	22.154	19.446
5/16/2013 13:15	28.543	23.393	23.136	19.819	27.284	22.838	18.842	31.459	37.22	22.489	19.584
5/16/2013 13:30	27.949	22.015	23.04	19.329	27.014	22.437	18.295	30.394	40.226	22.465	19.478
5/16/2013 13:45	27.899	22.784	23.569	20.181	27.112	23.023	19.698	30.041	36.069	23.232	19.968
5/16/2013 14:00	27.579	21.8	23.713	19.797	27.136	22.567	18.985	29.54	39.405	23.665	20

Table B (Continued)

	DL01		DL07		DL09		DL11	DL15		DL16	
Date	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**
5/16/2013 14:15	27.358	21.864	24.581	20.576	27.136	22.74	19.579	29.09	37.851	25.72	20.395
5/16/2013 14:30	27.284	21.67	25.744	20.844	27.308	22.686	19.793	28.816	39.066	26.353	20.737
5/16/2013 14:45	26.916	21.251	26.036	20.672	27.136	22.448	19.603	28.295	40.656	25.817	20.79
5/16/2013 15:00	26.646	21.176	28.345	21.498	27.063	22.545	19.888	27.801	41.047	26.451	21.155
5/16/2013 15:15	26.646	21.445	31.255	23.12	27.308	22.936	20.484	27.505	41.033	30.268	22.275
5/16/2013 15:30	26.72	21.638	34.545	24.631	27.751	23.197	21.127	27.382	41.371	32.794	23.6
5/16/2013 15:45	26.622	21.498	34.942	24.587	28.072	23.186	20.674	27.235	40.531	32.355	23.6
5/16/2013 16:00	26.524	21.402	34.176	24.752	28.345	23.295	21.199	27.186	40.185	32.768	24.422
5/16/2013 16:15	26.256	20.94	33.417	23.873	28.369	23.012	20.984	27.014	42.571	32.047	24.323
5/16/2013 16:30	25.963	20.683	34.783	23.655	28.048	22.892	20.77	26.793	41.64	31.433	24.169
5/16/2013 16:45	25.768	20.705	41.56	24.863	28.048	23.24	21.557	26.695	40.67	31.281	25.372
5/16/2013 17:00	25.647	20.608	40.833	23.644	28.221	23.229	21.533	26.671	41.64	30.925	25.25
5/16/2013 17:15	25.404	20.266	35.288	22.903	28.147	23.001	21.366	26.426	42.239	30.217	23.961
5/16/2013 17:30	25.137	20	32.82	22.069	27.801	22.74	21.223	26.085	42.441	29.439	22.838
5/16/2013 17:45	24.895	19.787	31.052	21.38	27.604	22.491	21.056	25.866	43.152	28.742	22.113
5/16/2013 18:00	24.653	19.627	29.64	21.198	27.308	22.361	21.079	25.574	42.846	28.072	21.606
5/16/2013 18:15	24.412	19.489	28.493	20.598	27.063	22.188	21.056	25.355	43.006	27.456	21.187
5/16/2013 18:30	24.195	19.361	27.53	20.17	26.793	21.972	20.96	25.113	43.181	26.891	20.833
5/16/2013 18:45	23.978	19.244	26.72	19.84	26.475	21.724	20.936	24.847	43.299	26.353	20.533
5/16/2013 19:00	23.785	19.106	26.085	19.553	26.134	21.455	20.579	24.605	43.431	25.841	20.266
5/16/2013 19:15	23.569	18.968	25.501	19.287	25.866	21.219	20.103	24.388	43.608	25.404	20.032

Table B (Continued)

	DL01		DL07		DL09		DL11	DL15		DL16	
Date	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**
5/16/2013 19:30	23.328	18.799	24.968	19.096	25.574	20.983	19.793	24.146	43.652	24.968	19.819
5/16/2013 19:45	23.112	18.598	24.484	18.831	25.258	20.747	19.365	23.857	44.053	24.581	19.616
5/16/2013 20:00	22.848	18.396	24.026	18.587	25.016	20.533	19.008	23.569	44.127	24.195	19.436
5/16/2013 20:15	22.609	18.132	23.593	18.396	24.823	20.352	18.461	23.28	44.172	23.833	19.276
5/16/2013 20:30	22.345	17.91	23.232	18.185	24.605	20.181	18.01	23.064	44.157	23.497	19.128
5/16/2013 20:45	22.106	17.71	22.872	18.037	24.363	20	17.677	22.824	44.217	23.208	19
5/16/2013 21:00	21.867	17.541	22.537	17.91	24.098	19.829	17.463	22.585	44.232	22.92	18.873
5/16/2013 21:15	21.676	17.425	22.25	17.815	23.833	19.68	17.344	22.345	44.232	22.657	18.767
5/16/2013 21:30	21.461	17.309	22.011	17.731	23.569	19.531	17.32	22.154	44.187	22.441	18.661
5/16/2013 21:45	21.27	17.214	21.772	17.657	23.328	19.404	17.225	21.963	44.172	22.25	18.576
5/16/2013 22:00	21.151	17.182	21.557	17.551	23.088	19.287	17.272	21.772	44.187	22.034	18.513
5/16/2013 22:15	21.032	17.161	21.366	17.456	22.944	19.202	17.344	21.652	44.217	21.843	18.449
5/16/2013 22:30	20.889	17.098	21.199	17.467	22.848	19.117	17.249	21.509	44.172	21.7	18.386
5/16/2013 22:45	20.746	17.024	21.056	17.425	22.753	19.043	17.272	21.342	44.217	21.533	18.322
5/16/2013 23:00	20.603	16.95	20.936	17.404	22.609	18.979	17.225	21.223	44.232	21.39	18.28
5/16/2013 23:15	20.484	16.877	20.841	17.34	22.489	18.915	16.915	21.079	44.232	21.27	18.238
5/16/2013 23:30	20.365	16.866	20.722	17.288	22.369	18.852	16.749	20.936	44.187	21.127	18.185
5/16/2013 23:45	20.269	16.835	20.603	17.224	22.274	18.799	16.773	20.841	44.172	21.008	18.143
5/17/2013 0:00	20.198	21.67	25.744	20.844	27.308	22.686	19.793	28.816	39.066	26.353	20.737
5/17/2013 0:15	20.103	21.251	26.036	20.672	27.136	22.448	19.603	28.295	40.656	25.817	20.79
5/17/2013 0:30	20.007	21.176	28.345	21.498	27.063	22.545	19.888	27.801	41.047	26.451	21.155

Table B (Continued)

	DL01		DL07		DL09		DL11	DL15		DL16	
Date	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**
5/17/2013 0:45	19.912	21.445	31.255	23.12	27.308	22.936	20.484	27.505	41.033	30.268	22.275
5/17/2013 1:00	19.817	21.638	34.545	24.631	27.751	23.197	21.127	27.382	41.371	32.794	23.6
5/17/2013 1:15	19.746	21.498	34.942	24.587	28.072	23.186	20.674	27.235	40.531	32.355	23.6
5/17/2013 1:30	19.651	21.402	34.176	24.752	28.345	23.295	21.199	27.186	40.185	32.768	24.422
5/17/2013 1:45	19.579	20.94	33.417	23.873	28.369	23.012	20.984	27.014	42.571	32.047	24.323
5/17/2013 2:00	19.508	20.683	34.783	23.655	28.048	22.892	20.77	26.793	41.64	31.433	24.169
5/17/2013 2:15	19.413	20.705	41.56	24.863	28.048	23.24	21.557	26.695	40.67	31.281	25.372
5/17/2013 2:30	19.341	20.608	40.833	23.644	28.221	23.229	21.533	26.671	41.64	30.925	25.25
5/17/2013 2:45	19.27	20.266	35.288	22.903	28.147	23.001	21.366	26.426	42.239	30.217	23.961
5/17/2013 3:00	19.199	20	32.82	22.069	27.801	22.74	21.223	26.085	42.441	29.439	22.838
5/17/2013 3:15	19.151	19.787	31.052	21.38	27.604	22.491	21.056	25.866	43.152	28.742	22.113
5/17/2013 3:30	19.103	19.627	29.64	21.198	27.308	22.361	21.079	25.574	42.846	28.072	21.606
5/17/2013 3:45	19.08	19.489	28.493	20.598	27.063	22.188	21.056	25.355	43.006	27.456	21.187
5/17/2013 4:00	19.032	19.361	27.53	20.17	26.793	21.972	20.96	25.113	43.181	26.891	20.833
5/17/2013 4:15	19.008	19.244	26.72	19.84	26.475	21.724	20.936	24.847	43.299	26.353	20.533
5/17/2013 4:30	18.961	19.106	26.085	19.553	26.134	21.455	20.579	24.605	43.431	25.841	20.266
5/17/2013 4:45	18.937	18.968	25.501	19.287	25.866	21.219	20.103	24.388	43.608	25.404	20.032
5/17/2013 5:00	18.913	18.799	24.968	19.096	25.574	20.983	19.793	24.146	43.652	24.968	19.819
5/17/2013 5:15	18.889	18.598	24.484	18.831	25.258	20.747	19.365	23.857	44.053	24.581	19.616
5/17/2013 5:30	18.866	18.396	24.026	18.587	25.016	20.533	19.008	23.569	44.127	24.195	19.436

Table B (Continued)

	DL01		DL07		DL09		DL11	DL15		DL16	
Date	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**
5/17/2013 5:45	18.818	18.132	23.593	18.396	24.823	20.352	18.461	23.28	44.172	23.833	19.276
5/17/2013 6:00	18.771	17.91	23.232	18.185	24.605	20.181	18.01	23.064	44.157	23.497	19.128
5/17/2013 6:15	18.723	17.71	22.872	18.037	24.363	20	17.677	22.824	44.217	23.208	19
5/17/2013 6:30	18.675	17.541	22.537	17.91	24.098	19.829	17.463	22.585	44.232	22.92	18.873
5/17/2013 6:45	18.652	17.425	22.25	17.815	23.833	19.68	17.344	22.345	44.232	22.657	18.767
5/17/2013 7:00	18.675	17.309	22.011	17.731	23.569	19.531	17.32	22.154	44.187	22.441	18.661
5/17/2013 7:15	18.723	17.214	21.772	17.657	23.328	19.404	17.225	21.963	44.172	22.25	18.576
5/17/2013 7:30	18.818	17.182	21.557	17.551	23.088	19.287	17.272	21.772	44.187	22.034	18.513
5/17/2013 7:45	18.961	17.161	21.366	17.456	22.944	19.202	17.344	21.652	44.217	21.843	18.449
5/17/2013 8:00	19.103	17.098	21.199	17.467	22.848	19.117	17.249	21.509	44.172	21.7	18.386
5/17/2013 8:15	19.27	17.024	21.056	17.425	22.753	19.043	17.272	21.342	44.217	21.533	18.322
5/17/2013 8:30	19.436	16.95	20.936	17.404	22.609	18.979	17.225	21.223	44.232	21.39	18.28
5/17/2013 8:45	19.627	16.877	20.841	17.34	22.489	18.915	16.915	21.079	44.232	21.27	18.238
5/17/2013 9:00	19.793	16.866	20.722	17.288	22.369	18.852	16.749	20.936	44.187	21.127	18.185
5/17/2013 9:15	19.912	16.835	20.603	17.224	22.274	18.799	16.773	20.841	44.172	21.008	18.143
5/17/2013 9:30	20.031	16.792	20.507	17.214	22.154	18.756	16.725	20.746	44.217	20.889	18.1
5/17/2013 9:45	20.079	16.761	20.412	17.193	22.082	18.714	16.177	20.65	44.232	20.793	18.069
5/17/2013 10:00	20.198	16.677	20.317	17.119	21.987	18.661	16.201	20.531	44.202	20.698	18.026
5/17/2013 10:15	20.388	16.656	20.222	17.13	21.915	18.629	16.344	20.436	44.262	20.579	17.984
5/17/2013 10:30	20.722	16.593	20.15	17.066	21.819	18.587	16.272	20.317	44.202	20.484	17.952
5/17/2013 10:45	20.984	16.561	20.055	17.024	21.748	18.555	16.249	20.222	44.202	20.388	17.91

Table B (Continued)

	DL01		DL07		DL09		DL11	DL15		DL16	
Date	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**
5/17/2013 11:00	21.413	16.498	19.96	16.908	21.724	18.523	16.01	20.126	44.247	20.293	17.868
5/17/2013 11:15	21.891	16.456	19.865	16.898	21.652	18.492	15.915	20.031	44.262	20.174	17.826
5/17/2013 11:30	22.537	16.424	19.77	16.792	21.604	18.46	15.819	19.936	44.262	20.079	17.783
5/17/2013 11:45	23.689	16.372	19.674	16.75	21.557	18.428	15.772	19.841	44.202	19.984	17.752
5/17/2013 12:00	25.137	16.361	19.603	16.708	21.509	18.407	15.7	19.746	44.247	19.888	17.71
5/17/2013 12:15	25.817	16.298	19.508	16.687	21.485	18.375	15.652	19.651	44.202	19.817	17.678
5/17/2013 12:30	25.647	16.298	19.46	16.666	21.461	18.365	15.7	19.579	44.187	19.722	17.667
5/17/2013 12:45	25.671	16.319	19.413	16.708	21.413	18.354	15.867	19.508	44.202	19.674	17.657
5/17/2013 13:00	25.914	16.361	19.389	16.74	21.39	18.344	15.772	19.436	44.262	19.627	17.646
5/17/2013 13:15	26.451	16.372	19.365	16.803	21.342	18.333	15.891	19.389	44.187	19.579	17.657
5/17/2013 13:30	27.038	16.382	19.365	16.824	21.318	18.333	15.796	19.341	44.187	19.555	17.657
5/17/2013 13:45	27.505	16.403	19.365	16.856	21.294	18.322	15.915	19.294	44.202	19.532	17.667
5/17/2013 14:00	27.825	16.414	19.365	16.835	21.27	18.322	15.605	19.27	44.232	19.508	17.678
5/17/2013 14:15	27.825	16.445	19.341	16.866	21.246	18.322	15.652	19.222	44.217	19.508	17.678
5/17/2013 14:30	27.974	16.445	19.341	16.856	21.223	18.312	15.843	19.222	44.262	19.484	17.678
5/17/2013 14:45	28.097	16.424	19.341	16.835	21.246	18.312	15.915	19.175	44.217	19.436	17.667
5/17/2013 15:00	28.097	16.414	19.318	16.803	21.199	18.291	15.796	19.151	44.232	19.436	17.657
5/17/2013 15:15	27.85	16.351	19.27	16.761	21.175	18.28	14.888	19.103	44.127	19.389	17.636
5/17/2013 15:30	27.358	16.34	19.246	16.729	21.175	18.269	15.008	19.056	44.127	19.318	17.615
5/17/2013 15:45	27.087	16.33	19.222	16.719	21.151	18.269	15.461	19.008	43.874	19.27	17.593
5/17/2013 16:00	26.769	16.319	19.222	16.698	21.127	18.28	14.553	18.985	43.741	19.222	17.572

Table B (Continued)

	DL01		DL07		DL09		DL11	DL15		DL16	
Date	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**
5/17/2013 16:15	26.5	16.424	19.294	16.803	21.175	18.365	14.553	19.032	42.268	19.246	17.604
5/17/2013 16:30	26.28	16.561	19.46	16.961	21.342	18.513	14.84	19.151	41.924	19.294	17.657
5/17/2013 16:45	26.158	16.687	19.579	17.066	21.461	18.587	15.652	19.294	42.268	19.365	17.688
5/17/2013 17:00	25.914	16.866	19.77	17.256	21.581	18.672	15.986	19.413	40.907	19.46	17.773
5/17/2013 17:15	25.695	17.077	19.984	17.425	21.676	18.735	16.058	19.651	41.244	19.603	17.847
5/17/2013 17:30	25.477	17.267	20.174	17.572	21.867	18.926	16.082	19.841	40.02	19.746	17.931
5/17/2013 17:45	25.234	17.446	20.365	17.72	22.178	19.011	16.01	20.079	40.879	19.936	18.026
5/17/2013 18:00	24.968	17.593	20.627	17.868	22.321	19.149	16.082	20.293	40.034	20.126	18.111
5/17/2013 18:15	24.726	17.762	20.841	18.09	22.561	19.414	16.487	20.555	38.945	20.317	18.206
5/17/2013 18:30	24.484	17.847	21.008	18.153	22.729	19.329	16.511	20.698	38.985	20.46	18.28
5/17/2013 18:45	24.243	17.868	21.151	18.217	22.776	19.351	16.558	20.817	41.033	20.603	18.344
5/17/2013 19:00	24.026	17.868	21.294	18.248	22.824	19.372	16.892	20.865	41.089	20.722	18.386
5/17/2013 19:15	23.809	17.847	21.318	18.259	22.8	19.361	16.773	20.841	41.357	20.793	18.418
5/17/2013 19:30	23.617	18.037	21.557	18.418	22.872	19.499	17.011	21.008	38.609	20.984	18.502
5/17/2013 19:45	23.4	18.269	21.891	18.672	23.04	19.67	16.915	21.294	38.235	21.223	18.619
5/17/2013 20:00	23.208	18.735	22.25	19.022	23.376	19.989	17.582	22.011	34.664	21.509	18.767
5/17/2013 20:15	23.064	18.82	22.465	19.096	23.593	19.978	17.677	22.13	38.235	21.7	18.873
5/17/2013 20:30	22.92	19.425	22.896	19.499	23.93	20.427	18.2	23.232	32.729	22.034	19.064
5/17/2013 20:45	22.8	19.861	23.28	19.765	24.267	20.619	18.747	23.737	29.187	22.345	19.244
5/17/2013 21:00	22.681	20.576	23.689	19.936	24.629	20.972	19.127	24.557	25.572	22.681	19.425
5/17/2013 21:15	22.561	21.864	23.809	19.957	25.065	21.391	19.318	26.182	8.153	22.896	19.563

Table B (Continued)

	DL01		DL07		DL09		DL11	DL15		DL16	
Date	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**	**°C**
5/17/2013 21:30	22.441	23.24	23.93	20.138	25.428	21.606	19.912	28.617	8.132	23.136	19.723
5/17/2013 21:45	22.321	23.033	24.363	20.373	25.841	21.789	20.293	28.742	30.931	23.521	19.893
5/17/2013 22:00	22.226	22.134	24.847	20.512	26.061	21.8	20.222	27.628	33.486	23.881	20.032
5/17/2013 22:15	22.13	21.94	25.162	20.619	26.207	21.918	20.126	27.456	33.609	24.171	20.17
5/17/2013 22:30	22.034	22.339	25.355	20.683	26.378	22.08	20.507	27.628	33.253	24.46	20.298
5/17/2013 22:45	21.915	23.023	25.477	21.037	26.671	22.437	20.984	27.974	32.511	24.823	20.533
5/17/2013 23:00	21.843	23.229	25.647	21.122	27.014	22.664	21.175	28.394	34.414	25.453	20.79
5/17/2013 23:15	21.748	23.371	25.963	21.412	27.382	22.903	21.748	28.742	35.865	26.061	21.122
5/17/2013 23:30	21.652	23.142	26.475	21.531	27.702	22.99	22.082	28.965	38.235	27.087	21.423
5/17/2013 23:45	21.581	22.632	26.916	21.574	27.875	22.892	21.772	28.891	36.674	27.579	21.563

APPENDIX C

HUMIDITY DATA FOR THREE HOTTEST DAYS

Table C Humidity data for three hottest days

	DL01	**DL07**	**DL09**	**DL11**	**DL15**	**DL16**
Date	**%**	**%**	**%**	**%**	**%**	**%**
6/8/2013 1:45	39.558	47.92	37.305	50.498	41.926	39.384
6/8/2013 2:00	39.452	47.976	37.64	49.45	42.084	39.508
6/8/2013 2:15	39.409	48.125	37.97	48.922	42.209	39.693
6/8/2013 2:30	39.532	48.25	38.301	49.431	42.398	40.045
6/8/2013 2:45	39.72	48.402	38.498	50.008	42.556	40.137
6/8/2013 3:00	40.134	48.621	38.765	51.219	42.747	40.458
6/8/2013 3:15	40.158	48.708	38.93	51.394	42.935	40.613
6/8/2013 3:30	40.116	48.926	39.092	51.561	43.09	40.705
6/8/2013 3:45	40.14	49.077	39.288	51.447	43.28	40.73
6/8/2013 4:00	40.653	49.231	39.419	51.353	43.437	40.854
6/8/2013 4:15	40.613	49.289	39.481	51.422	43.594	41.009
6/8/2013 4:30	40.705	49.538	39.547	52.201	43.75	41.458
6/8/2013 4:45	40.602	49.592	39.674	53.016	43.94	41.515
6/8/2013 5:00	41.146	49.679	39.841	53.255	44.096	41.928
6/8/2013 5:15	41.335	49.953	39.838	54.496	44.254	42.146
6/8/2013 5:30	41.521	50.166	40.002	55.48	44.443	42.332

Table C (Continued)

	DL01	DL07	DL09	DL11	DL15	DL16
Date	**%**	**%**	**%**	**%**	**%**	**%**
6/8/2013 7:00	43.452	51.482	40.383	55.838	45.177	43.621
6/8/2013 7:15	43.46	51.482	40.383	55.231	45.387	43.84
6/8/2013 7:30	43.439	51.601	39.927	54.475	45.44	43.963
6/8/2013 7:45	43.356	51.762	37.109	53.869	45.4	44.153
6/8/2013 8:00	43.306	51.922	35.135	53.409	45.259	44.22
6/8/2013 8:15	43	52.086	34.712	52.027	45.415	44.316
6/8/2013 8:30	42.57	52.193	34.726	50.714	45.771	44.322
6/8/2013 8:45	42.138	52.062	34.342	50.107	45.54	44.106
6/8/2013 9:00	41.773	51.867	33.413	50.749	45.345	44.243
6/8/2013 9:15	41.381	51.675	32.651	49.465	45.053	43.839
6/8/2013 9:30	40.859	51.486	31.93	46.876	44.444	43.303
6/8/2013 9:45	40.308	51.202	30.8	45.325	43.56	42.933
6/8/2013 10:00	39.794	50.709	30.595	45.528	40.34	42.411
6/8/2013 10:15	38.959	50.24	29.929	44.981	38.503	42.211
6/8/2013 10:30	38.581	50.128	29.763	44.425	38.83	42.16
6/8/2013 10:45	37.896	49.502	30.973	42.627	36.563	41.862
6/8/2013 11:00	36.934	49.109	31.32	42.201	36.644	41.559
6/8/2013 11:15	36.373	48.46	32.072	41.718	34.803	40.94
6/8/2013 11:30	35.917	48.374	32.212	41.107	36.417	41.133

Table C (Continued)

	DL01	DL07	DL09	DL11	DL15	DL16
Date	%	%	%	%	%	%
6/8/2013 12:15	32.498	46.215	31.891	39.999	34.23	39.279
6/8/2013 12:30	31.581	45.894	30.989	38.231	33.314	38.885
6/8/2013 12:45	29.687	45.224	30.121	34.902	32.46	37.873
6/8/2013 13:00	28.467	44.188	29.395	33.905	32.088	36.148
6/8/2013 13:15	28.536	43.625	28.577	33.942	32.749	35.285
6/8/2013 13:30	27.796	43.313	27.529	32.767	32.598	35.107
6/8/2013 13:45	26.828	42.519	26.855	28.842	31.691	33.464
6/8/2013 14:00	26.125	41.303	25.977	29.201	31.415	32.26
6/8/2013 14:15	25.656	40.666	25.199	29.636	31.134	27.716
6/8/2013 14:30	25.04	38.832	24.562	26.364	30.483	23.838
6/8/2013 14:45	24.935	37.857	23.918	28.339	30.653	26.819
6/8/2013 15:00	24.685	35.271	23.973	27.925	30.491	24.51
6/8/2013 15:15	24.852	32.421	23.529	27.61	30.688	22.444
6/8/2013 15:30	24.951	32.641	23.084	26.457	30.895	23.19
6/8/2013 15:45	24.904	31.135	22.8	25.032	30.88	20.813
6/8/2013 16:00	26.362	32.665	22.802	37.636	32.345	24.344
6/8/2013 16:15	27.098	33.853	23.298	35.882	33.106	23.66
6/8/2013 16:30	27.601	30.659	24.099	36.537	33.597	23.179
6/8/2013 16:45	28.266	29.17	24.847	34.594	34.134	24
6/8/2013 17:00	28.688	28.686	25.656	32.679	34.527	24.793
6/8/2013 17:15	29.215	30.995	26.379	34.007	34.927	25.922

Table C (Continued)

	DL01	**DL07**	**DL09**	**DL11**	**DL15**	**DL16**
Date	**%**	**%**	**%**	**%**	**%**	**%**
6/8/2013 17:30	29.568	32.414	26.944	35.358	35.252	27.309
6/8/2013 17:45	29.954	33.749	27.712	33.628	35.504	28.428
6/8/2013 18:00	30.138	35.121	28.264	33.064	35.755	29.411
6/8/2013 18:15	30.495	36.17	28.746	34.005	36.082	30.056
6/8/2013 18:30	30.75	37.242	29.123	34.091	36.341	30.836
6/8/2013 18:45	31.171	38.346	29.357	34.626	36.666	31.547
6/8/2013 19:00	31.594	39.228	29.701	35.489	37.163	31.993
6/8/2013 19:15	32.152	39.771	29.826	35.937	37.557	32.443
6/8/2013 19:30	32.607	40.74	30.242	37.135	37.951	33.421
6/8/2013 19:45	33.192	40.995	30.797	41.456	38.543	33.793
6/8/2013 20:00	33.641	41.086	31.208	43.953	38.895	33.97
6/8/2013 20:15	35.025	42.529	31.549	53.198	38.806	34.278
6/8/2013 20:30	37.33	44.572	31.526	51.975	39.735	35.512
6/8/2013 20:45	37.631	45.64	32.657	56.361	40.32	36.439
6/8/2013 21:00	38.269	46.351	33.776	57.309	40.767	37.234
6/8/2013 21:15	39.004	47.099	35.032	60.106	41.549	38.3
6/8/2013 21:30	39.474	47.36	35.878	57.309	42.26	39.13
6/8/2013 21:45	40.305	48.234	36.792	60.301	42.906	39.797
6/8/2013 22:00	41.267	48.986	37.429	62.205	43.284	40.594
6/8/2013 22:15	41.834	49.863	38.106	62.483	43.859	41.196

Table C (Continued)

	DL01	DL07	DL09	DL11	DL15	DL16
Date	**%**	**%**	**%**	**%**	**%**	**%**
6/8/2013 22:30	42.593	50.391	38.538	65.218	44.463	42.027
6/8/2013 22:45	43.442	51.107	39.176	66.265	45.296	42.536
6/8/2013 23:00	43.778	51.411	39.671	61.917	45.536	42.976
6/8/2013 23:15	43.826	51.37	40.232	58.614	45.813	43.289
6/8/2013 23:30	43.648	51.36	40.689	57.421	45.897	43.407
6/8/2013 23:45	43.602	51.379	40.884	56.127	46.043	43.523
6/9/2013 0:00	43.523	51.461	40.941	54.56	46.29	43.579
6/9/2013 0:15	43.48	51.164	41.156	50.764	46.246	43.565
6/9/2013 0:30	43.284	50.964	41.339	51.136	46.139	43.266
6/9/2013 0:45	42.723	50.862	41.363	49.304	46.131	43.031
6/9/2013 1:00	42.43	50.761	41.316	47.419	45.995	42.7
6/9/2013 1:15	42.198	50.821	41.215	46.831	45.826	42.697
6/9/2013 1:30	42.844	50.72	41.014	52.684	45.722	42.559
6/9/2013 1:45	42.774	50.904	40.807	54.942	45.847	42.716
6/9/2013 2:00	43.611	51.369	40.869	57.637	46.069	43.063
6/9/2013 2:15	43.895	51.707	40.964	58.498	46.227	43.445
6/9/2013 2:30	44.308	51.921	41.13	62.195	46.413	43.692
6/9/2013 2:45	44.717	52.254	41.424	65.091	46.629	43.938
6/9/2013 3:00	44.994	52.37	41.718	65.641	46.844	44.056
6/9/2013 3:15	44.985	52.458	42.044	63.71	47.027	44.045
6/9/2013 3:30	44.817	52.577	42.173	63.678	47.145	43.972

Table C (Continued)

	DL01	**DL07**	**DL09**	**DL11**	**DL15**	**DL16**
Date	**%**	**%**	**%**	**%**	**%**	**%**
6/9/2013 3:45	44.032	52.758	42.365	58.917	47.362	43.864
6/9/2013 4:00	44.377	52.877	42.493	57.245	47.512	43.949
6/9/2013 4:15	44.403	53.183	42.495	56.872	47.732	44.134
6/9/2013 4:30	45.001	53.173	42.685	56.758	47.819	44.155
6/9/2013 4:45	44.482	53.475	42.815	55.86	48.001	44.532
6/9/2013 5:00	44.541	53.624	42.812	55.454	48.123	44.747
6/9/2013 5:15	44.631	53.711	43.006	56.428	48.275	44.995
6/9/2013 5:30	44.786	53.922	43.037	57.379	48.49	45.115
6/9/2013 5:45	45.318	53.981	43.134	57.349	48.548	45.173
6/9/2013 6:00	45.054	54.136	43.098	57.049	48.67	45.391
6/9/2013 6:15	45.208	54.198	43.164	56.939	48.67	45.417
6/9/2013 6:30	45.336	54.084	43.065	56.011	48.798	45.545
6/9/2013 6:45	45.4	54.032	42.94	57.314	48.932	45.673
6/9/2013 7:00	45.405	53.918	42.782	57.054	48.971	45.644
6/9/2013 7:15	45.342	53.862	42.751	58.302	49.13	45.742
6/9/2013 7:30	45.699	53.782	42.751	57.414	49.258	45.716
6/9/2013 7:45	46.499	53.646	42.593	58.835	49.27	45.629
6/9/2013 8:00	45.937	53.364	42.47	58.526	48.975	45.388
6/9/2013 8:15	46.589	53.025	42.124	58.909	48.781	45.248
6/9/2013 8:30	46.74	52.747	41.875	59.667	48.68	45.047
6/9/2013 8:45	46.694	52.494	41.567	58.77	48.736	44.813

Table C (Continued)

	DL01	DL07	DL09	DL11	DL15	DL16
Date	**%**	**%**	**%**	**%**	**%**	**%**
6/9/2013 9:00	46.521	52.268	41.484	58.673	48.477	44.734
6/9/2013 9:15	46.538	51.953	41.135	60.576	48.434	44.534
6/9/2013 9:30	46.339	51.608	41.052	60.393	48.224	44.3
6/9/2013 9:45	46.225	51.744	40.447	60.004	48.025	44.677
6/9/2013 10:00	45.827	51.811	40.364	59.146	47.141	44.712
6/9/2013 10:15	44.966	51.725	39.513	55.672	42.91	44.847
6/9/2013 10:30	44.08	51.675	36.258	52.547	39.802	44.823
6/9/2013 10:45	43.071	51.443	35.207	51.521	37.586	44.615
6/9/2013 11:00	42.154	51.243	34.217	50.929	36.046	44.6
6/9/2013 11:15	40.907	50.941	34.419	48.741	34.211	44.585
6/9/2013 11:30	39.693	50.583	34.583	46.594	33.124	44.382
6/9/2013 11:45	36.647	50.224	34.515	44.521	33.84	43.958
6/9/2013 12:00	34.713	49.716	34.377	43.219	34.241	43.404
6/9/2013 12:15	33.647	49.264	34.043	42.963	33.423	42.915
6/9/2013 12:30	32.486	48.566	33.603	41.704	32.609	41.945
6/9/2013 12:45	30.985	47.594	33.097	39.415	32.542	40.792
6/9/2013 13:00	30.262	46.933	32.42	39.19	32.676	39.66
6/9/2013 13:15	29.718	46.305	31.597	39.797	32.889	38.968
6/9/2013 13:30	29.51	45.628	31.109	41.818	33.275	38.093
6/9/2013 13:45	29.481	45.453	30.823	41.758	33.714	38.007
6/9/2013 14:00	30.926	45.927	30.947	54.792	35.147	38.765

Table C (Continued)

	DL01	DL07	DL09	DL11	DL15	DL16
Date	%	%	%	%	%	%
6/9/2013 14:15	31.757	45.493	31.473	50.248	35.961	39.075
6/9/2013 14:30	33.851	45.745	32.318	55.558	37.929	38.064
6/9/2013 14:45	33.582	45.098	32.97	50.494	37.823	38.548
6/9/2013 15:00	33.438	42.276	33.25	48.538	37.872	34.079
6/9/2013 15:15	33.181	38.642	33.332	50.283	37.746	31.401
6/9/2013 15:30	33.539	38.461	32.947	48.378	38.201	29.721
6/9/2013 15:45	33.479	38.383	32.82	47.573	38.306	28.917
6/9/2013 16:00	33.86	36.677	32.816	46.34	38.618	28.067
6/9/2013 16:15	34.035	36.683	32.849	48.162	38.966	28
6/9/2013 16:30	34.643	34.878	32.812	49.77	39.374	28.578
6/9/2013 16:45	34.976	34.804	32.803	50.419	39.845	29.538
6/9/2013 17:00	35.078	35.27	33.066	49.891	39.912	30.504
6/9/2013 17:15	35.381	35.898	33.396	46.75	40.286	31.079
6/9/2013 17:30	35.751	36.942	33.66	46.376	40.558	32.042
6/9/2013 17:45	36.453	37.758	33.781	46.341	41.037	32.741
6/9/2013 18:00	36.7	39.144	34.04	46.024	41.356	33.276
6/9/2013 18:15	36.882	39.771	34.172	43.559	41.54	34.015
6/9/2013 18:30	37.063	40.456	34.099	43.778	41.653	34.985
6/9/2013 18:45	37.577	41.386	34.16	44.992	42.04	35.749
6/9/2013 19:00	37.928	42.054	34.219	45.027	42.259	36.411
6/9/2013 19:15	38.144	43.133	34.416	44.205	42.479	37.104

Table C (Continued)

	DL01	**DL07**	**DL09**	**DL11**	**DL15**	**DL16**
Date	**%**	**%**	**%**	**%**	**%**	**%**
6/9/2013 19:30	37.995	43.64	34.781	43.208	42.458	37.662
6/9/2013 19:45	38.208	43.618	35.144	44.309	42.512	38.126
6/9/2013 20:00	38.585	43.635	35.535	44.909	42.754	38.718
6/9/2013 20:15	39.158	44.617	35.859	48.523	43.063	38.918
6/9/2013 20:30	39.599	45.302	36.208	47.825	43.537	39.383
6/9/2013 20:45	39.485	45.131	36.629	45.692	43.578	39.915
6/9/2013 21:00	39.666	45.719	37.081	47.256	43.727	39.99
6/9/2013 21:15	40.146	46.373	37.467	50.293	44.105	40.133
6/9/2013 21:30	40.557	47.094	37.72	51.332	44.418	40.572
6/9/2013 21:45	40.937	47.847	37.844	51.59	44.859	40.815
6/9/2013 22:00	41.251	48.277	37.976	51.136	44.746	41.057
6/9/2013 22:15	41.468	48.706	38.135	50.654	44.667	41.172
6/9/2013 22:30	41.29	49.009	38.294	50.801	44.527	41.481
6/9/2013 22:45	41.671	49.313	38.688	52.716	44.644	41.727
6/9/2013 23:00	42.014	49.872	39.173	54.098	44.83	42.459
6/9/2013 23:15	42.359	50.14	39.534	54.421	45.045	42.866
6/9/2013 23:30	42.572	50.724	39.761	55.911	45.358	43.372
6/9/2013 23:45	42.981	51.151	40.149	56.384	45.736	43.971
6/10/2013 0:00	43.614	51.456	40.768	57.258	46.113	44.249
6/10/2013 0:15	43.342	51.755	41.156	57.235	46.264	44.431
6/10/2013 0:30	44.427	52.307	41.485	58.159	46.706	44.676

Table C (Continued)

	DL01	**DL07**	**DL09**	**DL11**	**DL15**	**DL16**
Date	**%**	**%**	**%**	**%**	**%**	**%**
6/10/2013 0:45	44.608	52.514	41.678	60.063	46.918	45.274
6/10/2013 1:00	44.725	52.845	42.066	60.165	47.23	45.356
6/10/2013 1:15	45.126	53.271	42.197	60.073	47.412	45.856
6/10/2013 1:30	45.214	53.6	42.389	59.919	47.626	46.007
6/10/2013 1:45	45.49	53.832	42.586	59.875	47.874	46.123
6/10/2013 2:00	46.026	54.101	42.683	60.583	48.344	46.494
6/10/2013 2:15	46.24	54.245	42.65	60.517	48.521	46.45
6/10/2013 2:30	46.359	54.386	42.808	59.296	48.704	46.629
6/10/2013 2:45	46.414	54.682	42.971	59.395	48.919	46.776
6/10/2013 3:00	46.497	54.976	43.096	59.421	49.069	46.926
6/10/2013 3:15	46.425	55.181	43.027	59.542	49.28	47.169
6/10/2013 3:30	46.511	55.385	43.124	60.365	49.494	47.284
6/10/2013 3:45	46.918	55.559	43.151	60.927	49.707	47.623
6/10/2013 4:00	47.065	55.732	43.309	60.917	49.92	47.706
6/10/2013 4:15	47.405	55.967	43.469	61.131	50.133	47.919
6/10/2013 4:30	47.778	56.139	43.563	61.403	50.279	48.128
6/10/2013 4:45	47.772	56.254	43.56	61.719	50.522	48.407
6/10/2013 5:00	47.985	56.427	43.72	62.317	50.544	48.426
6/10/2013 5:15	48.099	56.541	43.783	62.086	50.819	48.638
6/10/2013 5:30	48.279	56.683	43.907	61.551	51.027	48.915
6/10/2013 5:45	48.02	56.74	43.904	61.86	51.112	48.714

Table C (Continued)

	DL01	DL07	DL09	DL11	DL15	DL16
Date	**%**	**%**	**%**	**%**	**%**	**%**
6/10/2013 6:00	48.358	56.858	43.997	62.124	51.297	48.859
6/10/2013 6:15	48.547	56.922	43.931	61.92	51.426	49.073
6/10/2013 6:30	48.175	57.024	43.901	62.596	51.435	49.193
6/10/2013 6:45	48.686	56.967	43.934	64.678	51.291	49.19
6/10/2013 7:00	48.856	56.909	43.871	65.99	51.181	49.63
6/10/2013 7:15	48.837	56.883	43.871	65.404	51.043	49.658
6/10/2013 7:30	48.729	57.068	43.56	62.989	50.813	49.941
6/10/2013 7:45	48.495	57.045	40.166	61.137	50.556	49.784
6/10/2013 8:00	48.011	56.995	37.867	59.429	50.331	49.941
6/10/2013 8:15	47.589	57.157	37.413	59.014	50.331	50.044
6/10/2013 8:30	47.2	56.932	37.364	59.813	50.238	49.865
6/10/2013 8:45	46.747	56.747	36.638	59.765	49.894	49.592
6/10/2013 9:00	46.14	56.471	35.69	56.512	49.42	49.227
6/10/2013 9:15	45.303	56.2	34.693	54.818	48.623	49.019
6/10/2013 9:30	44.787	55.745	34.117	54.927	48.215	48.498
6/10/2013 9:45	44.243	55.321	32.763	53.235	47.236	48.198
6/10/2013 10:00	43.832	54.831	32.557	50.673	43.923	47.966
6/10/2013 10:15	43.034	54.431	31.899	50.196	39.721	47.639
6/10/2013 10:30	42.4	53.784	30.89	48.205	37.191	47.184
6/10/2013 10:45	41.121	53.353	31.097	46.226	34.896	46.89
6/10/2013 11:00	39.993	52.734	30.941	44.504	33.561	46.346

Table C (Continued)

	DL01	**DL07**	**DL09**	**DL11**	**DL15**	**DL16**
Date	**%**	**%**	**%**	**%**	**%**	**%**
6/10/2013 11:15	39.525	52.179	31.693	42.977	32.387	45.928
6/10/2013 11:30	37.838	51.829	32.34	37.404	31.139	45.705
6/10/2013 11:45	34.905	51.1	32.573	38.418	31.968	45.218
6/10/2013 12:00	32.855	50.53	32.502	38.736	32.316	44.482
6/10/2013 12:15	32.281	49.867	32.222	39.704	32.071	43.583
6/10/2013 12:30	31.301	49.236	31.882	38.236	31.589	42.846
6/10/2013 12:45	30.438	48.475	31.607	37.237	32.137	41.946
6/10/2013 13:00	29.586	47.83	31.32	35.789	31.939	41.019
6/10/2013 13:15	28.658	47.018	30.845	35.48	31.938	39.77
6/10/2013 13:30	27.7	46.098	30.448	34.856	31.686	38.405
6/10/2013 13:45	28.545	45.503	29.813	31.617	32.782	37.825
6/10/2013 14:00	28.18	44.602	29.485	33.22	32.911	36.194
6/10/2013 14:15	27.637	43.972	29.333	32.755	32.687	31.993
6/10/2013 14:30	27.541	41.923	28.927	32.181	32.618	26.975
6/10/2013 14:45	27.166	37.973	28.338	32.115	32.458	24.473
6/10/2013 15:00	27.233	35.917	27.747	32.064	33.043	25.099
6/10/2013 15:15	27.547	35.892	27.255	33.14	33.393	26.474
6/10/2013 15:30	27.664	34.829	27.17	31.981	33.577	23.463
6/10/2013 15:45	27.381	32.65	27.305	31.162	33.389	21.414
6/10/2013 16:00	27.505	30.56	27.278	29.795	33.484	20.672
6/10/2013 16:15	27.49	30.879	26.851	28.873	33.4	20.541

Table C (Continued)

	DL01	DL07	DL09	DL11	DL15	DL16
Date	**%**	**%**	**%**	**%**	**%**	**%**
6/10/2013 16:30	27.536	29.644	26.387	28.929	33.519	21.927
6/10/2013 16:45	27.517	26.392	26.235	29.082	33.497	22.447
6/10/2013 17:00	27.773	25.222	26.079	30.322	33.656	23.175
6/10/2013 17:15	28.064	26.717	25.82	29.113	33.812	23.905
6/10/2013 17:30	28.079	28.481	25.482	29.441	33.931	24.652
6/10/2013 17:45	28.402	29.516	25.468	28.886	34.26	25.639
6/10/2013 18:00	28.587	31.657	25.666	30.084	34.448	26.521
6/10/2013 18:15	29.117	33.119	26.006	29.868	34.917	27.445
6/10/2013 18:30	29.272	34.24	26.319	29.257	35.011	28.296
6/10/2013 18:45	29.364	35.318	26.708	29.823	35.102	29.083
6/10/2013 19:00	29.622	36.183	27.13	30.873	35.328	29.861
6/10/2013 19:15	29.782	37.019	27.546	30.889	35.49	30.504
6/10/2013 19:30	30.211	37.796	27.884	32.536	35.963	31.049
6/10/2013 19:45	30.603	38.537	28.153	33.55	36.291	31.661
6/10/2013 20:00	30.995	39.207	28.493	34.087	36.547	32.173
6/10/2013 20:15	31.115	39.776	28.978	34.479	36.869	32.615
6/10/2013 20:30	31.569	40.208	29.316	35.356	37.192	33.19
6/10/2013 20:45	32.059	40.85	29.868	35.894	37.554	33.502
6/10/2013 21:00	32.414	41.291	30.243	36.09	37.88	34.084
6/10/2013 21:15	32.804	41.865	30.513	36.393	38.135	34.563
6/10/2013 21:30	33.195	42.272	30.744	36.749	38.494	34.979

Table C (Continued)

	DL01	DL07	DL09	DL11	DL15	DL16
Date	**%**	**%**	**%**	**%**	**%**	**%**
6/10/2013 21:45	33.649	42.816	31.114	37.83	38.82	35.429
6/10/2013 22:00	34.105	42.928	31.518	38.325	39.146	35.378
6/10/2013 22:15	34.425	43.37	31.886	38.508	39.061	35.395
6/10/2013 22:30	34.612	43.378	32.778	38.974	39.519	35.609
6/10/2013 22:45	35.064	43.721	33.25	39.935	39.741	35.892
6/10/2013 23:00	35.451	44.064	33.655	40.256	39.76	36.077
6/10/2013 23:15	35.568	44.341	34.232	40.344	39.812	36.328
6/10/2013 23:30	35.888	44.553	34.467	41.717	39.966	36.909
6/10/2013 23:45	36.307	45.098	34.802	43.693	40.221	37.096

APPENDIX D

TEMPERATURE DATA COMPARISON GRAPH FOR THREE HOTTEST DAY (WITHOUT DL01)

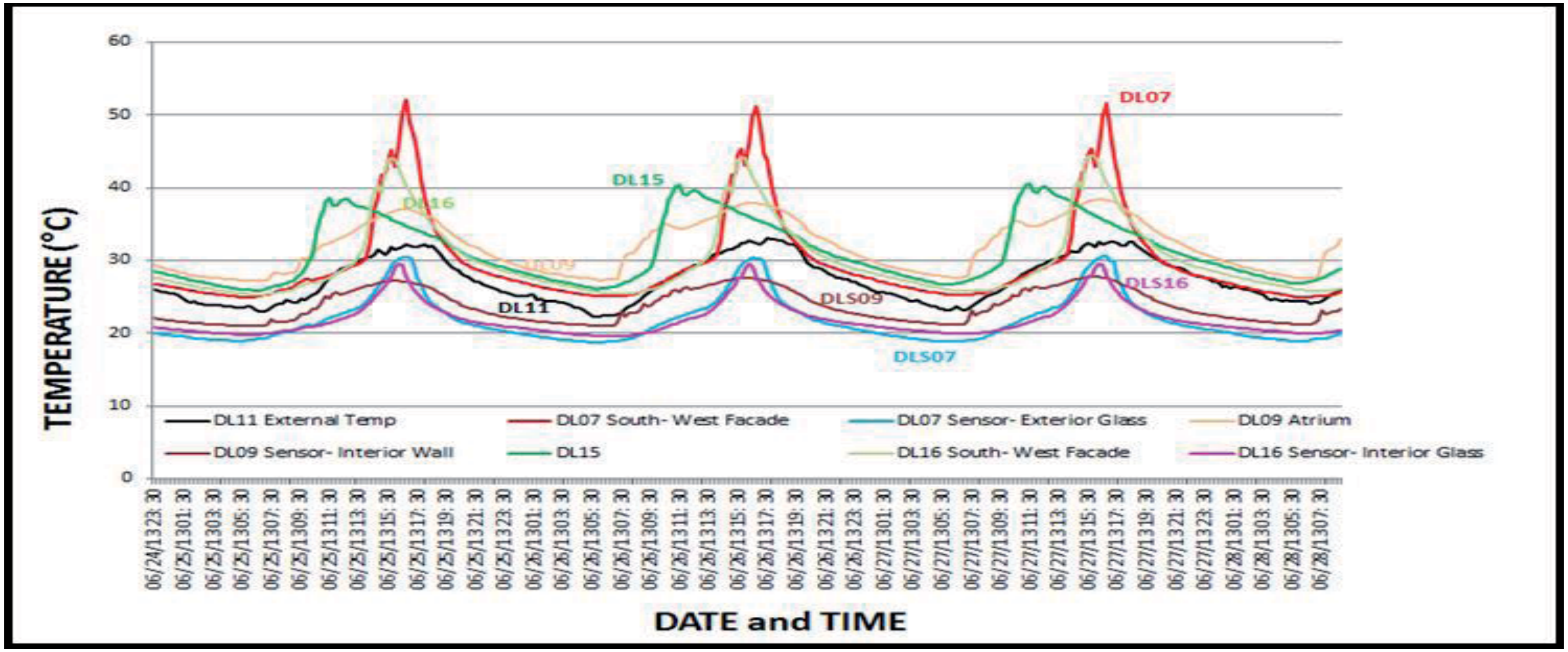

Figure D Temperature data comparison graph for three hottest days (Without DL01)

APPENDIX E

HUMIDITY DATA COMPARISON GRAPH FOR THREE HOTTEST DAYS (WITHOUT DL01)

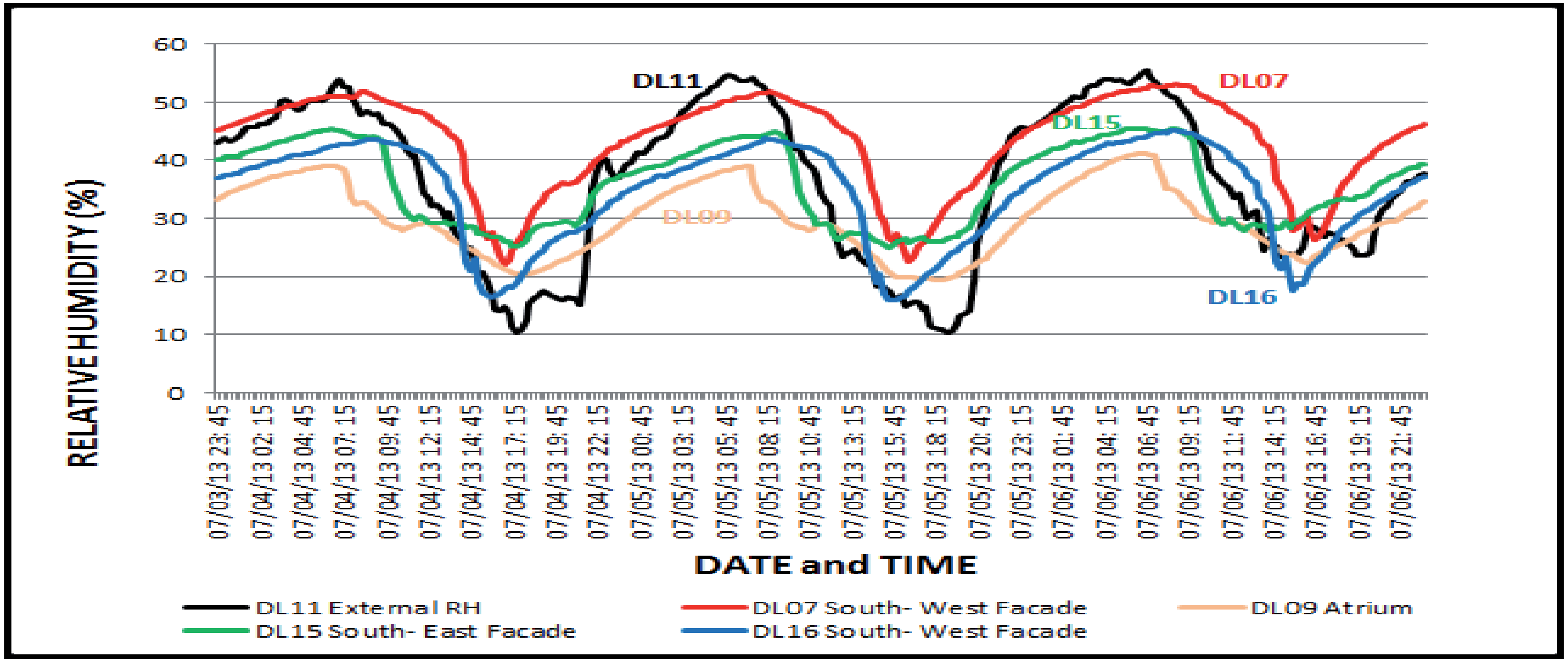

Figure E Humidity data comparison graph for three hottest days (Without DL01)