ASSESSING THERMAL COMFORT CONDITIONS;
A CASE STUDY ON THE METU FACULTY OF ARCHITECTURE BUILDING

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ABSTRACT

ASSESSING THERMAL COMFORT CONDITIONS;
A CASE STUDY ON THE METU FACULTY OF ARCHITECTURE BUILDING

Çakır, Çağrı

M.S., Department of Architecture

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The aim of this study was to evaluate the effects of environmental design parameters on thermal comfort conditions in the METU Faculty of Architecture Building located in Ankara.

The building had some problems in terms of indoor climatic conditions, both in winter and in summer. It was evident that some design parameters caused this undesirable situation. The study therefore focused on understanding and evaluating the effects of design-dependent elements such as thermal mass, the size and orientation of windows, shading and vegetation on thermal comfort conditions in the case study building. While conducting this study, data loggers were used to record temperature and humidity data in predetermined rooms. Data was collected during certain periods in July, August, and September 2006.

The data collected was analyzed statistically and hypotheses were tested using ANOVA. This study showed that the effect of thermal mass was almost the same for the rooms investigated owing to the fact that the entire building had been constructed with concrete curtain walls. In terms of thermal performance the number and orientation of the exterior walls, orientation and size of windows, room heights and also sun shading with surrounding vegetation were most effective design parameters for the rooms investigated.

Keywords: Thermal Mass, Building Orientation, Thermal Comfort, Data Logger, METU Faculty of Architecture.

ÖZ

ORTA DOĞU TEKNİK ÜNİVERSİTESİ MİMARLIK FAKÜLTESİ BİNASINDAKİ ISIL KONFOR KOŞULLARININ DEĞERLENDİRİLMESİ

Çakır, Çağrı
Yüksek Lisans, Mimarlık Bölümü
Tez Yöneticisi: Doç. Dr. Soofia Tahira Elias Özkan

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Bu çalışmanın amacı, çevresel tasarım parametrelerinin Ankara'da bulunan Orta Doğu Teknik Üniversitesi Mimarlık Fakültesi binasındaki ısıl konfor koşulları üzerine etkilerini değerlendirmektir.

Hem yaz hem de kış, mevcut bina iç iklim şartları açısından bazı problemleri bünyesinde barındırmaktaydı. Sorunun bazı tasarım parametrelerinden kaynaklandığı açıktı. Bundan dolayı bu çalışma, ısıl kütle, pencerelerin yönü ve büyüklüğü, gölgeleme ve bitki örtüsü gibi tasarıma bağlı parametrelerin mevcut binanın ısıl konfor koşullarına etkisini anlamaya ve değerlendirmeye yoğunlaştı. Bu çalışmayı yürütürken, sıcaklık ve nem değerlerini kaydedebilen data logger adındaki aletler önceden belirlenen odalara konuldu ve Temmuz, Ağustos, Eylül ayları içinde belli zaman aralıkları boyunca sıcaklık ve nem değerleri kaydedildi.

Sonuç olarak, toplanan bilgiler istatistiki olarak analiz edildi ve ANOVA kullanılarak hipotezler test edildi. Bu çalışma, ısıl kütlenin etkisinin tüm odalar için yaklaşık olarak aynı olduğunu gösterdi çünkü mevcut bina betonarme perde duvarlarla inşa edilmişti. Isıl performans açısından bakıldığında dış duvarların sayısı ve yönü, pencerelerin büyüklüğü ve yönü, oda yükseklikleri ve etraftaki bitkilerin gölgeleme etkisi etkin tasarım parametreleri olarak yer almaktaydı.

Anahtar Kelimeler: Isıl Kütle, Bina Yönü, Isıl Konfor, Data Logger, Orta Doğu Teknik Üniversitesi Mimarlık Fakültesi.

to my family...

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LIST OF ABBREVIATIONS

AH	Absolute Humidity
ANOVA	Analysis of Variance
ASHRAE	American Society of Heating Refrigerating and Air Conditioning Engineers
A / V	Ratio of Area to Building Volume
BS 566	Building Science 566
ET	Effective Temperature
HMV	High Mass with Night time Ventilation
HT	High Thermal Mass
METU	Middle East Technical University
NVM	Natural Ventilation and Mechanical Ventilation
PMV	Predicted Mean Vote
PPD	Predicted Percentage of Dissatisfied
SC	Shading Coefficient
SGHC	Solar Heat Gain Coefficient
S.W.S.	South Window Size
TSE	Turkish Standards Institute
U.S.	United States

LIST OF SYMBOLS

A_{Du}	Dubois Surface Area of Body
H_0	Null Hypothesis
E_{sw}	Heat Loss from the Body by Evaporation of Regulatory Sweat Secretion from Skin
f_{cl}	Ratio of Clothed Surface of Body to Nude Body Surface Area
H	Height
h_c	Convection Coefficient
I_{cl}	Insulation of Clothing in Clo Units
M	Metabolic Rate
t_a	Air Temperature
t_{cl}	Temperature of Clothing Surface
T_m	Mean Temperature
t_{mrt}	Mean Radiant Temperature
T_n	Thermal Neutrality
t_s	Surface Temperature
V	Air Flow Rate
η	Efficiency

LIST OF UNITS

Btu / ft^2	British thermal unit per square foot
^{o}C	degrees Celsius
clo	clothing insulation unit
^{o}F	degrees Fahrenheit
ft	foot
g / kg	gram per kilogram
g / m^3	gram per cubic meter
met	metabolic rate
m^{2}K/W	square meter Kelvin per watt
mm Hg	millimeters of mercury
mm	millimeter
W/m^2	watts per square meter

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CHAPTER 1

INTRODUCTION

In this chapter the argument for the study, its objectives, the procedure followed and the disposition of the various chapters within the thesis, are presented.

1.1. Argument

The human body has a certain thermal balance and in order to preserve this balance it should be protected from effects of severe outdoor conditions. On the other hand, a building is an envelope which separates its occupants from outdoor climatic conditions and provides adequate thermal comfort for them. In general, buildings fulfill this requirement with the help of air conditioning and heating units. Unfortunately, there is a reluctance to apply existing knowledge regarding design solutions which provide thermal comfort conditions in a building. These conditions depend on how good the thermal performance of a building is. Especially in Turkey, builders and designers usually do not pay attention to the thermal performance of their buildings.

In recent years, depletion of conventional energy resources has forced people to explore alternative energy resources. This situation is worsening for buildings and their occupants, since more than half of the total energy consumption is used up by buildings. An excessive use of fossil fuels is costly and causes air pollution. In view of these problems, architects should understand that they must design buildings which not only have minimum heating and cooling loads but also provide thermal comfort for their occupants. Moreover, it will be a logical approach for architects to pay attention to local climatic conditions during the design process.

As stated above, buildings should be thermally comfortable for their occupants. Factors affecting thermal comfort in buildings can be classified into two groups. The first group of factors include local climatic conditions, which are outdoor temperature, relative humidity, solar radiation, geographical location and the effect of neighbouring buildings *etc*. The second group of factors comprise materials of the building envelope, glazing type and size, orientation, thermal mass, surrounding vegetation, thermal insulation, ratio of transparent and opaque components, shading tools, building form *etc*. As can be realized, architects have a chance to control and regulate the second group of factors in achieving better thermal comfort in their designs. Thermal comfort mostly depends on making the right design decisions related to these factors during preliminary design stages.

1.2. Objectives

The aim of this study was to analyse the effects of design-dependent elements on thermal comfort conditions in the METU Faculty of Architecture building located in Ankara. In performing this study, data loggers were used to record temperature and humidity data in predetermined rooms of the case study building.

The Architecture Faculty building had some problems in terms of indoor climatic conditions, both in winter and summer. Hence, the first objective of this study was to investigate the thermal behaviour of office spaces in this building. To analyse this behaviour, temperature and humidity data had to be collected. On the other hand, it was clear that some design parameters had influenced the thermal conditions in the case study building. For this reason, the second objective was to determine which design variables were most effective on the thermal performance of the building. These variables were thermal mass, size and orientation of windows, orientation of rooms, sun control device or shading, and surrounding vegetation respectively.

1.3. Procedure

This study focused on design-dependent elements and their possible effects on thermal performance of the METU Faculty of Architecture building in Ankara.

In the first stage of the study, real data (temperature and humidity) were collected from a predetermined set eleven rooms by using data loggers during certain periods in July, August, and September 2006. Sizes of the windows were measured. Meanwhile, exterior photos of the rooms investigated were taken and architectural drawings of these rooms were obtained. Furthermore, data related to exterior weather conditions were recorded during the study and, also, the temperature data for Ankara was obtained from Turkish State Meteorological Service.

In the final stage of the study, raw data collected by data loggers were compiled into charts and statistical tests (ANOVA) were applied to the raw data. Analysis and discussions were conducted by using temperature and humidity graphs, and ANOVA test results.

1.4. Disposition

The study is presented in five chapters. This first chapter is composed of the argument, objectives, and an overview of general methodology. It concludes with the disposition of subject matter that follows in the remaining chapters.

The second chapter is composed of a literature review including general aspects of thermal comfort, climatic and design dependent elements affecting thermal performance of buildings, and recent thermal comfort studies in buildings.

Chapter 3 presents study material and method used to conduct the research.

Chapter 4 comprises of analysis and discussions in the light of temperature and humidity graphs, and statistical test (ANOVA) results.

Chapter 5 concludes the study by summarizing its findings.

CHAPTER 2

LITERATURE REVIEW

This literature review is based on information taken from 27 published sources and 3 websites. It covers topics related to thermal comfort including bioclimatic charts, thermal comfort models, climate responsive building design, design-dependent elements and thermal performance studies in buildings.

2.1. Thermal Comfort

Fanger (1970) states that wherever artificial climates are built for occupants, the aim is that the thermal environment created provide thermal comfort for each occupant. ASHRAE standards 55-66 define thermal comfort for a person as, “that state of mind which expresses satisfaction with the thermal environment”. Fanger (1970) claims that if a group of people are exposed to the climatic conditions of the same room, satisfying everyone at the same time will not be possible because of physical variance. Accordingly, this means that thermal comfort for the highest percentage of the group should be aimed at, if one wants to create optimal thermal comfort for the group.

Fanger (1970) also reports that the first aim of the heating and air conditioning industry is to create thermal comfort for occupants. This approach produced a radical effect on the construction sector, the choice of materials and on the whole building industry. The same author also says that viewed from a wider perspective, the main function of buildings is to create comfortable shelters for their occupants which depend on these thermal surroundings. Today, most of the feasibility studies aim at creating thermal comfort in these shelters with artificial climates; therefore, one should have knowledge of the conditions providing thermal comfort. The variables affecting the condition of thermal comfort, as defined by Fanger (1970), are:

- Activity level of occupants
- Thermal resistance of the clothing
- Air temperature
- Mean radiant temperature
- Relative air velocity
- Humidity

Considering any of these factors affecting thermal comfort independently is not possible. Thermal comfort can be achieved by combination of these variables and use of many different technical systems.

2.1.1. Comfort Zone

According to Panchyk (1984), thermal comfort in an interior space can be considered as the sum-total of heat or cold sensations experienced by occupants. Further, if the interior space has neither excessive heat nor cold conditions, it is then considered to be thermally comfortable. This reveals that the space is within an occupant's comfort zone. Thus, the comfort zone may be defined as a thermal condition in which little or no effort is required by occupants to adjust their bodies to surrounding environmental conditions.

Panchyk (1984) also states that the temperature perceived by a person results from temperature of the air, relative humidity, and air movement, since these three thermal elements are related to each other, a change in one should be compensated by an adjustment in another. The author states that high air temperature together with increased air movement can be beneficial in terms of thermal comfort, while a space having high relative humidity should have lower air temperature. The term effective temperature (ET) has been developed to show the combined effects of air temperature, relative humidity, and air motion.

Meanwhile, Panchyk (1984) determines age, sex, activity level, type of clothing, and climatic origin as the factors which affect a person's comfort level. Therefore, he states that, effective comfort zone temperatures have certain restrictions about an individual from any gender which will be considered as an average person at seated rest, wearing ordinary indoor clothing, effective temperatures also will be applicable to the climate someone is familiar with. The author points out that people from tropical climates, for instance, will be comfortable at temperatures by 30 F (16.7 C) which is higher than the temperature in which people from cold climate feel comfortable, persons engaged in a physical activity feel more comfortable at lower temperatures than they are at rest, and people above forty years of age generally want to be in warmer temperatures due to metabolic variations, and women need a bit higher temperatures than men.

2.1.2. Bioclimatic Charts

Sayigh and Marafia (1998) evaluated several studies which attempted to develop a methodology on adapting building design to human needs and climatic conditions. According to them, these kind of studies comprise the development of the building bioclimatic charts and Mahony tables. Bioclimatic charts help the analysis of climate characteristics of a given location in terms of human thermal comfort. They can give an insight concerning building design strategies to maximize indoor comfort conditions when the building is free running. These charts refer to the comfort zone, these are explained in more detail below:

a. Olgyay's Bioclimatic Chart: Olgyay (1969), puts the comfort zone in the center of this chart. The climatic elements are represented by curves around it. This chart indicates the relationships of various climatic elements. On the chart, it can be seen that dry-bulb temperature is at the ordinate and relative humidity on the abscissa. The summer comfort zone is in the middle and divided into the desirable and practicable parts. The winter comfort zone is at a bit lower. Any climatic condition in relation to dry-bulb temperature and relative humidity can be plotted. One feels comfortable in shade when plotted point is in comfort zone. If plotted point is out of comfort zone, then corrective measures are required. Winds are required when plotted point is higher than the upper boundary of the comfort zone. Winds are needed in the situation which the temperature is high and the relative humidity is low. The dotted lines show the moisture percentage needed to decrease temperatures to the comfort level. The line above which shading is required is at the lower limit of the comfort zone. In contrast, radiation is essential below the line to block lower dry-bulb temperatures. Mean radiant temperatures, at the left, are necessary to regulate comfort by either radiant heating or cooling.

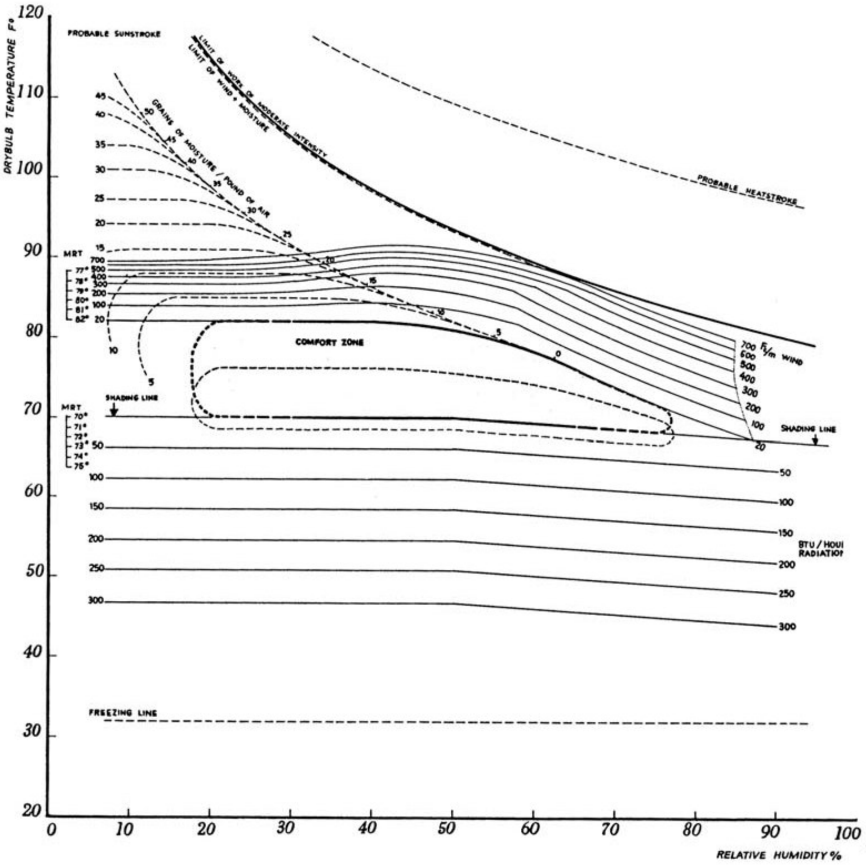


Figure 2.1. Bioclimatic chart for U.S. moderate zone inhabitants. (Xu, 2003.)

Sayigh and Marafia (1998) claim that there are some restrictions in analysing the indoor environmental conditions of buildings, because the chart is based on outdoor climatic conditions. The chart is therefore more suitable for a hot humid climate because there is no high range fluctuation between internal and external conditions.

b. Givoni's Bioclimatic Chart: According to Sayigh and Marafia (1998), this climatic chart's aim is to predict the indoor conditions of the building as regards to prevailing outdoor conditions. Givoni focused on the linear relationship between the temperature amplitude and vapour pressure of the outdoor air in several regions. In light of this relationship, appropriate passive cooling strategies are defined in compliance with the prevailing outside climatic conditions. The chart assemble temperature amplitude and vapour pressure of the ambient air plotted on the psychometric chart and correlated with specific lines of the passive cooling techniques overlaid on the chart. These techniques are evaporative cooling, thermal mass, cooling with natural ventilation and passive heating.

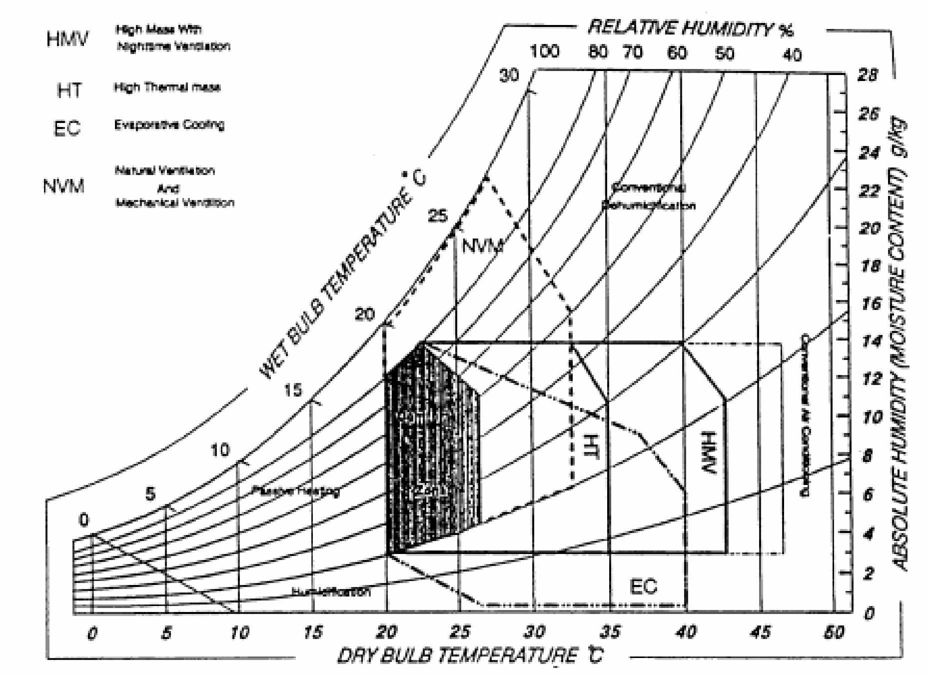


Figure 2.2. Givoni's bioclimatic chart. (Sayigh and Marafia, 1998.)

Sayigh and Marafia (1998) also state that there are some limitations about Givoni's bioclimatic chart defined by Watson in 1981 which are as follows:

- It is applicable to residential scale structures having no internal heat gains.
- Ventilation is based on the assumption that indoor mean radiant temperature and vapour pressure are nearly the same as those of outdoor environment. This requires a building having low mass and exterior structure with high thermal resistance provided by white external paint.
- Thermal mass effectiveness depends on that all windows are closed during day, a still indoor air and the indoor vapour pressure is 2 mm higher than outdoor.

c. Szokolay's Bioclimatic Chart: Sayigh and Marafia (1998) also have a discussion on the Szokolay's bioclimatic chart. According to them, Szokolay have developed a concept, which depends on the location and the people of that location, by combining the index of thermal stress and thermal neutrality equations. There are two comfort zones which are based on thermal neutrality in relation to the outdoor mean temperature (Tm) by equation:

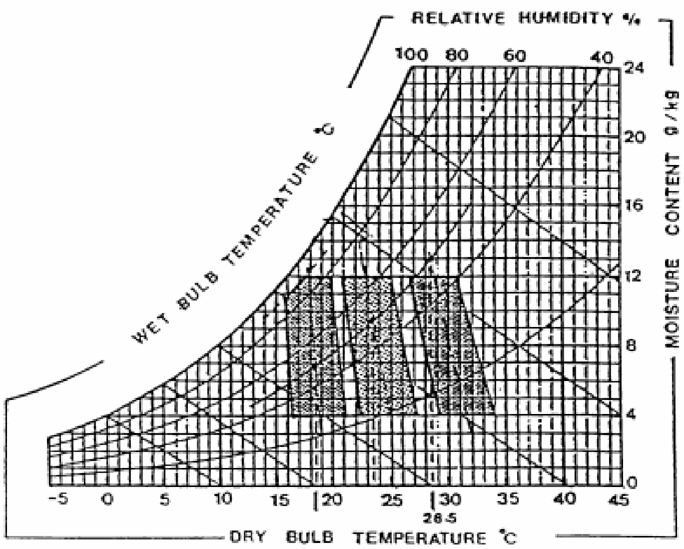


Figure 2.3. Szokolay's bioclimatic chart. (Sayigh and Marafia, 1998.)

$Tn = 17.6 + 0.31Tm$

Equation is valid under the conditions given below:

- $18.5 < Tn < 28.5$
- At 50 % relative humidity, the comfort zone's width is 2 K
- Lower and upper humidity limits are between 4-12 g/kg moisture content (AH), and based on ASHRAE standard 55-81.
- Relative humidity mustn't be higher than 90 % RH curve.

2.1.3. Comfort Equation

Sayigh and Marafia (1998) evaluate the Fanger comfort equation which is based on a research carried on American college going age persons exposed to a uniform environment under steady state conditions. The equation correlates among the environment variables, clothing type, and activity levels. It formulates the heat balance of human body regarding net heat exchange resulting from six factors which include air temperature, mean radiant temperature, air velocity, humidity, metabolic rate, and clothing level. The necessary condition for optimal comfort depends on satisfaction of this equation, given below:

$$(M/A_{Du})(1-\eta) - 0{,}35[1{,}92t_s - 25{,}3 - P_a] - (E_{sw}/A_{Du}) - 0{,}0023(M/A_{Du})(44-P_a) -$$
$$0.0014(M/A_{Du})(34-t_a) = 3.4 \times 10^{-8} f_{cl}\,[(t_{cl}+273)^4 - (t_{mrt}+273)^4] + f_{cl}h_c(t_{cl} - t_a)$$

Sayigh and Marafia (1998) state that the equation includes three variables which the heat loss, skin temperature, and metabolic rate. Fanger produced following equations for these variables as functions of the internal heat production per surface area:

$$t_s = 35.7 - 0.032(H/A_{Du})$$
$$E_{sw} = 0.42A_{Du}\,[(H/A_{Du}) - 50]$$

Fanger derived the general comfort equation based on these three equations. In this equation, it is obvious that the human thermal comfort is a function of the type of clothing (t_{cl}, f_{cl}), the type of activity (η,V, M/A_{Du}), and environmental variables (V, t_a, t_{mrt}, P_a). This equation is given as below:

$$(M/A_{Du})(1-\eta) - 0.35\,[43 - 0.061(M/A_{Du})\,(1-\eta) - P_a] - 0.42\,[(M/A_{Du})(1-\eta) - 50] - 0.0023(M/A_{Du})(44 - P_a) - 0.0014(M/A_{Du})(34 - t_a) = 3.4 \times 10^{-8} f_{cl}\,[(t_{cl}+273)^4 - (t_{mrt}+273)^4] + f_{cl} h_c\,(t_{cl} - t_a)$$

2.1.4. Thermal Comfort Models

Fanger (1970) discussed the question that how can one, in light of measurements in practice, determine if a given indoor climate is satisfactory or not, determining such a method, has a great importance to reach any meaningful results from practical measurements. It is also a essential prerequisite for the establishment of the standards in the field. The author points out that a lot of thermal indices have been established to enable making prediction of man’s thermal environment or thermal state. Three of these indices are explained in more detail in the following paragraphs.

a. Predicted Mean Vote (PMV): As previously stated, the comfort equation’s satisfaction is a requirement for optimal thermal comfort. Fanger (1970), however, states that the equation gives information on how to combine the variables in order to provide optimal thermal comfort. It can not be used to understand the thermal sensation of people in an arbitrary climate since the variables may not be expected to satisfy the equation. In light of comfort equation, an index has been developed to make thermal sensation predictions for any combination of environmental parameters, activity level, clothing value. Psycho-physical ASHRAE scale with seven levels has been used as a measure for the thermal sensation:

←-----------I-----------I------------I-----------I-----------I-----------I-----------I---------→

-3	-2	-1	0	+1	+2	+3
cold	cool	slightly cool	neutral	slightly warm	warm	hot

Sayigh and Marafia (1998) report that predicted mean vote (PMV) is the mean vote expected to result from average of the thermal sensation vote of a large group of people in a given environment. PMV is a complex equation making a connection among environmental variables, thermal sensation, activity and clothing level. This equation is as below:

$$PMV = (0.352e^{-0,042\,(M/A_{Du})} + 0.032)\,[M/A_{Du})(1-\eta) - 0.35\,[43 - 0.061(M/A_{Du})(1-\eta) - P_a] - 0.42\,[M/A_{Du})(1-\eta) - 50] - 0.0023(M/A_{Du})(44 - P_a) - 0.0014(M/A_{Du})(34 - t_a) - 3.4x10^{-8} f_{cl}\,[(t_{cl}+273)^4 - (t_{mrt}+273)^4] + f_{cl}h_c(t_{cl} - t_a)$$

Some conclusions about Predicted Mean Vote can be summarized as following (http://www.esru.strath.ac.uk/Courseware/Class-16387, 15.06.2006):

- PMV is suitable for steady state conditions but also applicable during minor fluctuations of one or more variables.
- It is calculated for situations when the person is in thermal balance which means that heat loss is compensated by the metabolic heat production.
- PMV index can be used in situation that PMV values are between -2 and 2
- Use of PMV is recommended for only those conditions below:
  M = 46 to 232 W/m^2 (0.8 to 4 met)
  I_{cl} = 0 to 0.310 m^2K/W (0 to 2 clo)
  t_a = 10 to 30°C; t_r = 10 to 40°C
  v_{ar} = 0 to 1m/s (or less if draughts are important)
  p_a = 0 to 2700 P_a. (also relative humidity should be between 30 and 70%)

b. Predicted Percentage of Dissatisfied (PPD): Butera (1998) states that the mean thermal votes of a large group of person exposed to the same condition can be extracted from PMV index. Individual votes, however, can be spread around the mean value. The author further points out that, Predicted Percentage of Dissatisfied (PPD) index has been developed to predict the number of people which are not satisfied in terms of thermal comfort. In brief, PPD help predicting the number of dissatisfied people. When the PMV value is known, the PPD can be found from the equation below:

$$PPD = 100 - 95 \times \exp[-(0.03353 \times PMV^4 + 0.2179 \times PMV^2)]$$

As can be realized from Figure 2.4, even if the PMV is zero, percentage of dissatisfied person is 5%. According to ISO 7730 standard, PPD should be lower than 10%.

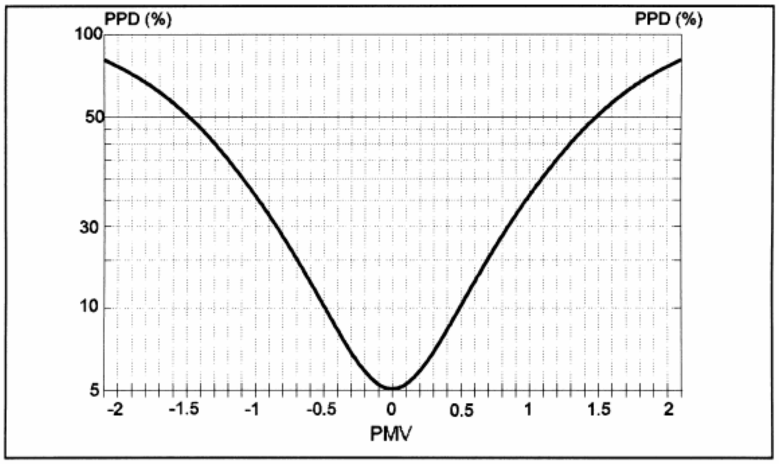


Figure 2.4. PPD as a function of predicted mean vote. (Butera, 1998.)

c. Adaptive Model: According to course notes on environmental engineering science published on the http://www.esru.strath.ac.uk, website, the adaptive principle states that "If a change occurs in the thermal environment which tends to produce discomfort, people will respond in ways that tend to restore their comfort"

As can be understood from the statement above, adaptive principle claims that comfort can be achieved by occupants fitting to the building environment or by adjusting the building to improve their comfort sensation. According to the same source, in previous models, comfort predictions were based on heat exchange between people and their environment. The response is only that people change their clothing levels resulting from preferred temperatures in summer or winter. People in warmer climatic zones prefer warmer conditions and vice versa because of expectations and preferences. There are many studies on adapting behaviour to improve thermal comfort. A recent one has revealed that occupants of naturally ventilated buildings are more comfortable than occupants of air conditioned buildings (http://www.esru.strath.ac.uk/Courseware/Class-16387, 15.06.2006).

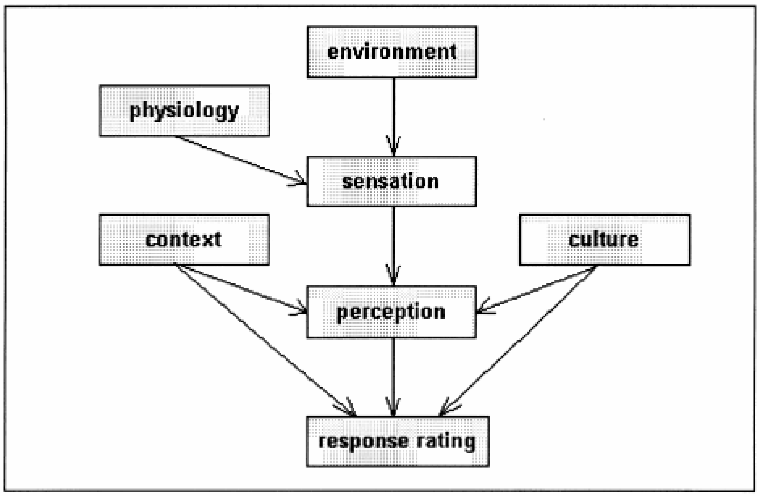


Figure 2.5. The adaptation model. (Butera, 1998.)

According to Butera (1998), there is no significant difference of people's thermal sensation who usually live in a too cold, hot or temperate climate when they are exposed to same thermal environment. On the other hand, differences have been observed on neutral temperatures of people living in buildings, especially in free running buildings, it has been realized that comfortable indoor temperatures were related to outdoor temperature. Butera (1998) claims that his situation is not related to physiological differences but to differences of expectation. In light of such factors, the adaptation model (Figure 2.5) suggests an alternative approach in comfort prediction of free running buildings. People adapt to thermal environment by changing the physical parameters (environment), their physiology, activity level, clothing, their expectations and their method in rating scales.

2.2. Climate Responsive Building Design

According to Olgyay (1969), the adaptation of a building to environment has been a problem for centuries; and Le Corbusier, for example, underlines this situation with the following words:

> "The symphony of climate…has not been understood…The sun differs along the curvature of the meridian, its intensity varies on the crust of the earth according to its incidence…In this play many conditions are created which await adequate solutions. It is at this point that an authentic regionalism has its rightful place".

Olgyay (1969) also claims that the use of nature's force is the desirable procedure in terms of achieving better living conditions. The structure, which utilizes natural resources for people, may be called "climate balanced". It is hard to reach perfect balance in normal environmental circumstances. On the other hand it is possible for a house to achieve great comfort at lowered cost within minimizing of mechanical conditioning. The same author examines the process of building a climate-balanced house in four stages:

- *Climate data* of a specific region should be investigated considering annual characteristics of their sub elements, such as temperature, relative humidity, radiation, and wind effects.
- *Biological evaluation* should be based on human sensations. Within collaboration of climate data and bioclimatic chart, a diagnosis showing relative importance of the various climatic elements in the region is deduced. The results can be tabulated on a yearly timetable including necessary measures for revision of comfort conditions.
- *Technological solutions* comprise some calculative methods, such as site selection, orientation, shading calculations, housing forms, air movements, and indoor temperature balance.
- *Architectural application* of the results from first three steps should be improved and adjusted in compliance with the importance of the different elements.

Straaten (1967) asserts that there should be three aspects concerning thermal design of structures. First of all, it has to be evaluated about indoor environmental conditions. Secondly representative or typical weather conditions must be described. As last step, it has to be shown how to utilize design procedures and physical properties of structural materials to achieve best solution for living and working environments.

Straaten (1967) also states that, asymmetric radiation conditions, for instance, resulting from the high temperatures of un-insulated ceilings or roofs and also from direct solar radiation through unprotected windows, have a certain impact in warm climates. The author emphasizes that the selection of design weather data for thermal evaluations must be based on combined effect of weather parameters on the thermal performance of a building, for example, assessing design wind speed data for natural ventilation purposes, all the factors including speed of wind, its direction and frequency, shape of the building have to be taken into account. In addition, effect of microclimatic variations on building design should also be accounted for.

Roulet (2001) claims that a well-adapted building to climate protects its occupants from extreme outdoor conditions creating comfortable indoor conditions. A well-adapted building (curve A in Figure 2.6) has good thermal insulation, appropriate passive solar gains and ventilation devices. Hence, it protects itself from solar radiation in summer, but uses solar radiation in winter to increase indoor temperatures. The author points out that in most temperate climates, a well-adapted building creates comfort for its occupants without any other energy sources than the sun, the energy use for heating is decreased and for cooling is not required if the internal heat load is within reasonable limits. On the contrary, a poorly adapted building (curve B in Figure 2.6) does not have good insulation and efficiency design for solar energy. Roulet further notes that in free running situation, indoor temperature is too low in winter and too high in summer. That is why, extra mechanical systems have to be installed to adjust indoor thermal comfort.

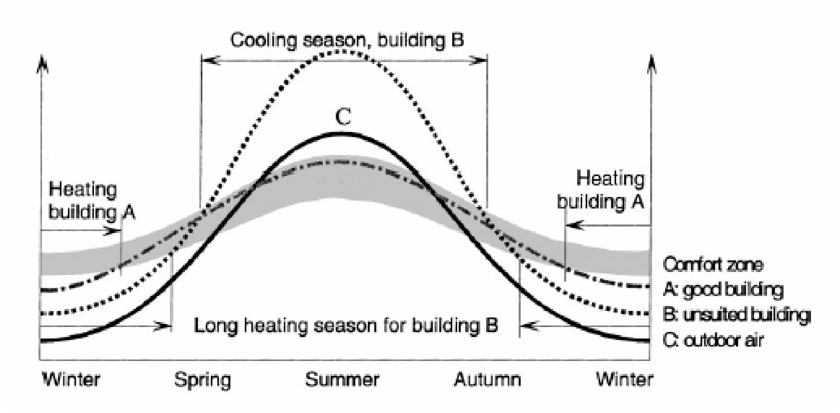


Figure 2.6. Evolution of temperatures in a free floating building and its environment throughout the year, Northern hemisphere. (Roulet, 2001.)

2.2.1. Climatic Elements

Olgyay (1969) evaluates weather as a combination of meteorological conditions. Since they show their effects in combination, it is really difficult to define the effects of each of those different meteorological conditions separately. Therefore, a proper architectural approach needs a methodology which makes an evaluation of each meteorological (or climatic) condition and its effect on buildings, and on comfort of individuals at the same time. Olgyay (1969) argues effects of climatic elements -air temperature, solar radiation, and wind basically- and their relationship for this purpose. On the other hand, Givoni (1976) also adds humidity, condensation and precipitation (rain, snow, etc), and examines relations among all of these elements.

According to McMullan (1998), climatic elements can vary by the hour, by the day or by the season, some of them have a cycle in a predictable period like the sun, however others such as wind and cloud are less predictable in the short term. After collecting data about these climatic elements over time, a variety of data forms are deduced. According to the author these forms include:

- Maximum or minimum values.
- Average values.

- Probabilities or frequencies.

Mc Mullan (1998) also states that, acquired climatic data are used for design requirements. For example in sizing heating plant or designing wind loads, maximum or minimum peak values are needed. Longer term averages, such as seasonal data, are used for prediction of energy consumption. Following paragraphs explain the five important variables in a climatic data.

a. Air Temperature: Olgyay (1969) and Givoni (1976) mention air temperature, which depends on the clearness or cloudiness of the sky, as the most important climatic element. However, this situation changes according to the seasons. Clear days in summer are warmer, but clear days in winter are cooler. This condition can be explained by solar energy transfer principles of different surfaces. Olgyay (1969) explains the reason of this situation in relation to solar radiation; more solar energy is received in a clear day in summer; however, long night period causes heat loss easily through clear atmosphere in a clear day in winter. Therefore, as Givoni (1976) supports, solar radiation has an indirect effect on air temperature. Since annual and daily patterns of air temperature depends on the variations of surface temperature, architectural design process can definitely use local seasonal, daily, and annual meteorological data to get enough information about air temperature.

Givoni (1976) argues that, wind characteristics of a region are also significant variables which affect the air temperature. Those characteristics are affected by global distribution of air pressure, the rotation of earth, the daily variations in heating and cooling of land and sea and the topography of the given area.

b. Solar Radiation: Givoni (1976) describes solar radiation as an electromagnetic radiation emitted from the sun. According to Olgyay (1969), some part of the solar radiation is absorbed and some part of is reflected by the surface. Most of the energy of solar radiation is absorbed by the surfaces and shows itself as heat within the structures. The temperature of the air also changes according to the amount of the absorbed radiation.

Solar radiation rate also changes according to different seasons. Heat exchange and radiation rates differ from winter to summer. Summer values of mean daily temperature are much higher than winter values. Apart from atmospheric diffusion of solar radiation, radiant heat transfer also affects buildings. Olgyay (1969) determines the ways of this effect as below:

- direct short-wave radiation from the sun;
- diffuse short wave radiation from the sky vault;
- short-wave radiation reflected from the surrounding terrain;
- long-wave radiation from the heated ground and nearby objects;
- outgoing long-wave radiation exchange from building to sky.

c. Humidity: Humidity is another climatic element. McMullan (1998) defines humidity as the amount of moisture in the atmosphere. In other words, Givoni (1976) defines humidity as the water vapour content of the atmosphere, and uses several terms such as absolute humidity (vapour amount rate by g/m^3), specific humidity (vapour amount rate by g/kg), vapour pressure (vapour amount rate by mm Hg), and relative humidity (vapour amount rate by 100 % of the absolute saturation humidity). Saturation is a key term in the problem of humidity, and McMullan (1998) defines saturation point of the air as the point when the maximum amount of water vapour is contained at given temperature.

Givoni (1976) discusses about differents sources of water vapour and rate of water vapour. According to him, water vapour comes into the air from different sources such as oceans, vegetation, water bodies in varying sizes, by evaporation, which is carried and also distributed by the winds. The rate of the water vapour in the air depends on different factors. The main factor is air temperature. Vapour distribution is highest in warm climates and lowest in cold climates.

McMullan (1998) states that natural humidity of a particular place depends on weather conditions of that place. He underlines that, interior humidity of a building is also affected by the thermal conditions and the use type of that building. According to Goulding, Lewis, and Steemers, humidity of the air can be regulated by the presence of water and vegetation. Pools, fountains, water jets, and vegetation next to buildings bring about humidification of the air. These tools have also evaporative cooling effect on the air.

d. Wind: Givoni (1976) talks about different kinds of wind systems and explains their occurrence by local topographic features (such as mountains and valleys), and differences between day and night temperatures as climatology does. Similarly Olgyay (1969) describes wind speed by using local topographic features, and he also claims that wind speed close to the ground, operative wind pattern by the local topography and surroundings, and evaluation of the comfort that wind provides should definitely be considered in order to calculate wind effect on buildings.

Olgyay (1969) asserts that wind effect on housing have to be considered both outside and inside of the building itself. Both positive and negative effects of the wind on thermal comfort conditions have to be considered. According to Olgyay (1969), effect of the wind should be used properly by architectural designers; strong and negative wind effects should be blocked during underheated periods, however, designer should utilize wind effect at overheated times; because wind is an essential cooling tool for buildings.

e. Condensation and Precipitation: Condensation in the open air is explained by Givoni (1976) as a dew-point dependent event, and he defines dew-point as the temperature at which air becomes saturated. However, dew-point is not a constant value; any cooling below the dew point causes the condensation of the water vapour in excess of the air capacity at the new lower dew-point. Since being a dew-point dependent event, condensation is also in a direct relation with cooling levels. The author also points out that the cooling level of air is affected by several factors such as contact with cooler surfaces, mixing with cooler air and expansion associated with raising air currents.

Discussion by McMullan (1998) on condensation focuses on the problematic side of condensation in buildings. In buildings, condensation results in dampness caused by water vapour in the air. He points out that, misting of windows, beads of water on non-absorbent surfaces, dampness of absorbent materials, and mould growth are some of the effects of condensation. The author claims that condensation is not a problematic situation for every kind of space in the building, for example it does not create a problem for bathrooms or indoor swimming pools. On the other hand, unwanted condensation creates problems because of causing unhealthy living conditions or damaging to structural or decoration materials. Therefore, problems that are caused by condensation should definitely be considered in the design process of buildings; also in terms of designing heating, cooling or ventilation functions of the building.

McMullan (1998) also states that, condensation in buildings generally shows itself in two ways; surface condensation and interstitial condensation. Surface condensation is shown on the walls, windows, ceilings, and floors. Surface condensation may be shown even on absorbent surfaces when condensation occurs continuously. Interstitial condensation occurs inside the structure when the air that containing moisture cools while passing through the structure. This process may cause serious damage to structural materials such as corrosion of iron parts.

Generally, condensation happens when most air and cold surface comes together. There are also other factors which cause condensation in buildings. McMullan (1998) defines those factors as several indoor moisture sources (indoor plants, number of living people, etc.), air temperatures, structural temperature, ventilation, and use of buildings. Also, Givoni (1976) considers indoor vapour pressure level and absorptivity level of the internal surfaces as important condensation factors. McMullan (1998) proposes a proper combination of ventilation, heating, and insulation techniques in order to prevent condensation in buildings. Suitable material choice is also another way of preventing condensation.

2.2.2. Design-Dependent Elements

Even though the whole features of the climate are out of our control, the design of a building can affect its climatic performance significantly. McMullan (1998) suggests the following actions in order to increase climatic performance of buildings:

- Site selection to avoid heights and cavities.
- Orientation of buildings to increase or decrease solar gains.
- Arranging spaces between buildings to avoid unwanted wind and shade effects.
- Design of windows to allow maximum daylight in buildings.
- Design of shading devices to prevent solar overheating.
- Choice of trees and wall surfaces to shelter buildings from rain and snow.
- Selection of ground surfaces for dryness.

According to Bouchlaghem (1999), there are two types of parameters affecting a building's thermal performance. The first type relates to unsteady climatic conditions such as solar radiation, relative humidity, air temperature and wind direction. The second types are design variables which can be controlled by architects. These design parameters can be listed as below:

- General layout and siting
- Thermophysical properties of the building materials
- Fenestration of windows and their sizes
- Shading of windows and the building's envelope
- Thermal insulation
- Surface behaviour of the envelope
- Mass and surface area of partitions

Bouchlaghem (1999) also claims that these variables do not affect the thermal performance of buildings in the same way or at the same rate; some are more effectiveness than others. Changing window area, for example, has more effect on the building thermal performance than changing the thickness of a wall. Whereas some variables including orientation are independent, others are interrelated such as floor to ceiling height and the volume of a room.

a. Building Form: Oral and Yilmaz (2002) report that building form has a significant influence on total heat loss of buildings. On the other hand, overall heat transfer coefficient (U-value) determines heat loss through the building envelope. Therefore, heat loss for different building forms should be determined in relation to U-value of the building envelope. The authors say that the shape factor (the ratio of building length to building depth), height and roof type are the parameters defining building form. Many buildings may have same volume, but different facade area; thus, the ratio of total facade area to building volume (A/V) is commonly used in describing the building form. Hence, U-value of building envelope should be determined as regards the ratio of A/V. While floor area and volume is constant, building facade area can change depending on change in building form. Then again, bigger facade area may contain bigger window area in terms of daylighting requirements; consequently heat loss through glazing increase. Thus, building form is an important factor which affects total heat loss and thermal comfort in cold climates.

Rassam (2004) also points out that heat loss or save from the building envelope is related the rate of exposed surface area to the building volume. Therefore, compact building forms save energy better than other forms. From a thermal point of view, the cube is the optimum building form which can be stretched to form a rectangle. Heat loss and gain through the surface is higher in rectangle forms. Buildings having high surface/volume ratio receive more solar radiation on their walls, windows and roof. Rassam (2004) underlines that, if the building's long side is on the east-west axis, this may be an advantage in winter, but not in the summer. Heat loss and gain from the building also depend on the ratio of building surface to floor area. For example, comparing two buildings with the same mass proportion, the small buildings have more surface area exposed, more heat gain and loss than large buildings.

Rassam (2004) reports a computer simulation study to emphasize the advantages of cubic forms in terms of thermal performance. In this study, a heat loss comparison between three forms of buildings with the same floor areas; a square, a rectangle with ratio of 4:1, and a triangle. In rectangle and triangle forms, south facing facades were assumed as major facades to take advantages of solar gains. The simulation have revealed that building with square plan has a heat loss coefficient which was 26.6 % more than the rectangle and triangle building forms.

Olgyay (1969), however, has a bit different arguments in terms of building form and optimum shape. According to the author, it can be considered as a rule that optimum building shape losses minimum heat in winter and also gains minimum heat in summer. It is widely accepted that a square building shows better performance about keeping the heat in winter and preventing the overheating in summer. This assumption is based on the fact that a square building has largest volume with the smallest exterior surface. The author also says that this assumption may be valid for older buildings with small openings exposed to negligible radiation effect, but this concept is not valid for the contemporary buildings with the large openings. To investigate the shaping effect, a hypothetical house, which has frame construction with insulation (U = 0.13), with 40% glass on the south side, and with 20% glass surfaces on all other sides, was chosen. After that, it was analyzed for four regional climates. Results from the house with square plan were compared to the houses with the same construction , characteristics, same square – foot area, but with different forms. According to the author, following conclusions can be drawn from the study:

- The square house is not the optimum form in any location.
- All shapes elongated on the north – south direction have less thermal efficiency than the cubic one.
- All shapes elongated on the east – west direction show better thermal performance than the square one

b. Orientation: Panchyk (1984) states that solar analysis for new projects is useful in site selection and building orientation. Generally, buildings facing south orientation take the maximum radiant heat during the winter in the northern hemisphere. In terms of passive solar design principles, heat storing potential of buildings depends on an increase of south facing windows. Orientation can be investigated under four different categories and daily solar radiation with respect to orientation is presented in Figure 2.7:

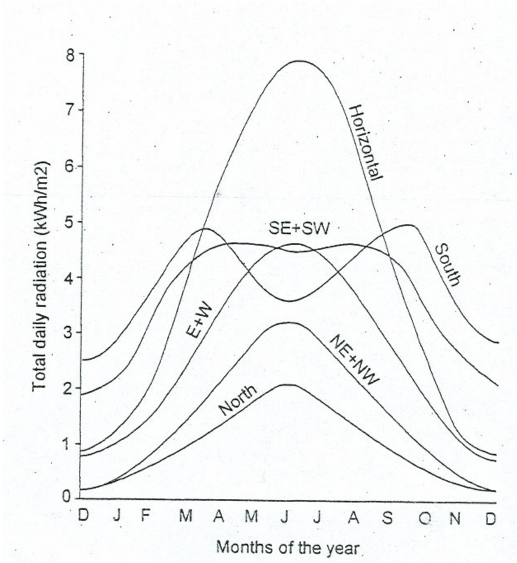


Figure 2.7. Total daily solar radiation on various surface orientations for a clear day at 51.5 ^{0}N latitude. (Karagüzel, 2003.)

SW-SOUTH-SE: it is the best for winter heat gain and living spaces requiring direct solar radiation in winter.

EAST: significant heat gain and solar radiation in summer mornings. Adjustable shading is suggested for summer.

WEST: significant heat gain and solar radiation is observed in summer afternoons. Therefore, exposed openings need efficient shading. Heat gain is at minimum in winter.

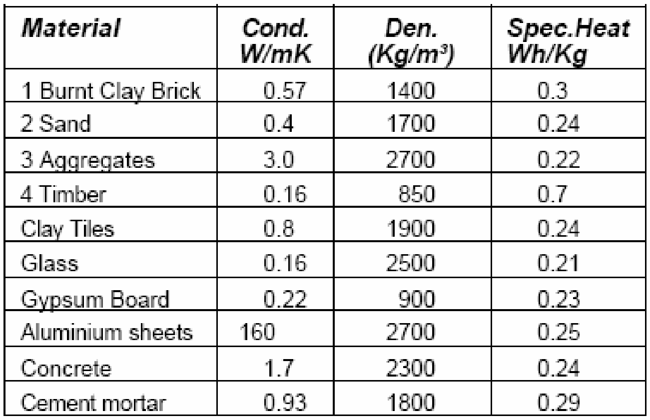
NW-NORTH-NE: it is generally sunless and windy in winter. Building parts exposed need wind shelter or windbreak.

According to Givoni (1976), effect of building orientation on indoor climate can be understood taking account two distinct climatic factors. Firstly, solar radiation and its heating effect on walls and rooms facing different directions. Secondly, ventilation problems resulting from the relation between prevailing winds and the building orientation. For example, in a building with insulated walls of light external colour, and effectively shaded windows, indoor temperature distinction depending on orientation may be ignored. Under these conditions, indoor climate greatly depends on ventilation and thus orientation of prevailing winds is more important than solar radiation patterns. This is particularly acceptable for humid regions where physiological comfort requirement is closely related to air motion. On the other hand, if external wall is dark and windows are not effectively shaded, orientation may have a vital effect on thermal conditions. In climatic regions where indoor temperature has more impact on occupants than ventilation and humidity is low, orientation in compliance with the sun is a significant consideration for human comfort. Under these conditions, facing of major facades to north-south orientation is preferred. In buildings with square plans, the term orientation is valid for the building's different rooms not for the building as a whole.

c. Thermal Mass: Thermal mass materials have some properties determining their heat storage capabilities. Thomas (1999) gives definition about these thermal properties in his study. According to the author, the amount of heat transfer per unit of thickness for a given temperature difference is the thermal conductivity of a material. Wood, plastic, aerated materials (foam, glass fibre quilt or feathers) are poor conductors but are good insulators because of their low thermal conductivities. In addition, the specific heat capacity is the amount of heat which a material will able to store in its per unit of mass and per unit of temperature change. Thermal mass of a material is a variable which depends on multiplying its mass, its specific heat capacity, and the increase in temperature. Table 2.1 shows the thermal properties of some building materials.

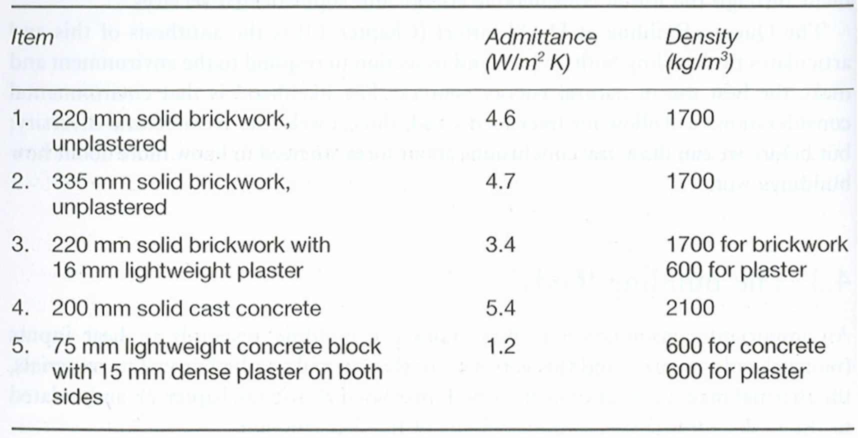
Other thermal properties related to thermal mass are U-value and thermal admittance parameters. According to Thomas (1999), the heat loss from any building element is related to its U- value. The U-value is the heat flow rate per unit area from the air on warm side of the material to the air on the cold side. The admittance, Y, is the amount of energy entering the material's surface for each degree of temperature change occurring just outside the surface. It also has the same units as the U-value (W/m^2K). A material's admittance depends on its thickness, conductivity, density, specific heat and the frequency at which heat is put into it. Acording to Table 2.2, dense constructions have higher admittance value. In multi layered slabs, the admittance is determined by the surface layer.

Table 2.1. Thermal properties of commonly used building materials. (Muitta, 1998)



Material	*Cond. W/mK*	*Den. (Kg/m³)*	*Spec.Heat Wh/Kg*
1 Burnt Clay Brick	0.57	1400	0.3
2 Sand	0.4	1700	0.24
3 Aggregates	3.0	2700	0.22
4 Timber	0.16	850	0.7
Clay Tiles	0.8	1900	0.24
Glass	0.16	2500	0.21
Gypsum Board	0.22	900	0.23
Aluminium sheets	160	2700	0.25
Concrete	1.7	2300	0.24
Cement mortar	0.93	1800	0.29

Table 2.2. Admittance and density of selected construction materials.
(Thomas, 1999.)



Item	*Admittance (W/m^2 K)*	*Density (kg/m^3)*
1. 220 mm solid brickwork, unplastered	4.6	1700
2. 335 mm solid brickwork, unplastered	4.7	1700
3. 220 mm solid brickwork with 16 mm lightweight plaster	3.4	1700 for brickwork 600 for plaster
4. 200 mm solid cast concrete	5.4	2100
5. 75 mm lightweight concrete block with 15 mm dense plaster on both sides	1.2	600 for concrete 600 for plaster

According to Anderson and Wells (1994), it is possible to store sun’s energy and then use it whenever it is needed. Thick adobe walls, for instance, act like a sponge to absorb large amounts of solar heat. Because their external surfaces are warm during the day, the heat slowly moves into interior spaces, which are protected from overheating. When external walls lose their heat at night, the adobe is ready to absorb heat again the next day, keeping the buildings cool. On the other hand, in

New England colonial houses, massive central masonry chimneys absorb and store any excessive heat, and release stored heat to keep buildings warm at night.

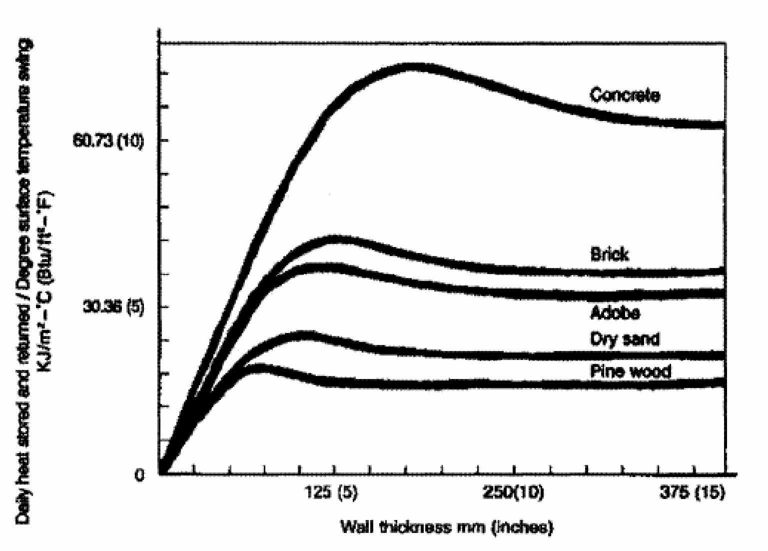


Figure 2.8. Daily heat stored and emitted for walls of different thickness materials. (Rassam, 2004.)

In a free-running lightweight structure, drops in temperature are relatively quick as compared to heavy structure. On the contrary, a heavy, massive, well insulated structure built of concrete, brick or stone keep its temperature longer. The most effective way is that the heavy materials should be on the inside of insulated building. Rassam (2004) supports this explanation with help of a figure showing daily heat storage capacity for walls of different thickness and material. According to Figure 2.8 above, the performance of a concrete wall of 125 mm thickness is the maximum.

Moore (1993) mentions that buildings having mass effect employ their thermal storage capabilities in four ways: by dampening interior daily temperature fluctuations; by delaying daily temperature extremes, by ventilating the building at night; and by earth contact to provide seasonal storage. In first situation, if interior walls and floors are built up of massive constructions such as concrete, masonry which have thermal storage capacity, these materials are bound to absorb the heat and afterwards release it at night when indoor temperature is low. If the building is well insulated, the thermal mass is completely within the insulation envelope. There is no appreciable time delay for this situation but even if so, this moderation has a significant advantage in hot-arid climates which have substantial daily temperature changes. In second situation, if external building materials are conductive massive construction such as concrete, masonry or water storage containers, these envelopes offset indoor temperatures in desirable level by preventing overheating in daytime and by warming up at night. There is a significant time delay or lag. This behaviour can be observed in traditional and contemporary massive constructions such as adobe and trombe walls.

Moore (1993) further states that in hot climates where daytime temperature is often too high, ventilation cooling could be not only ineffective but also result in discomfort increasing the cooling load. If the building interior is of massive materials, night ventilation having air temperatures below the comfort zone can be used to cool the building exposed heat absorption during the day. To be effective this strategy, the ventilating airflow should directly contact with the thermal mass. Moreover additional cooling utilizing fans enhance effect of this strategy and may be cost effective. The author further emphasises that night flushing is especially effective in buildings occupied only during the daytime. In final situation concerning thermal mass, heat storage capacity of the earth helps us to use it for seasonal storage. At depths below 20 ft, the soil temperature is almost stable and equal to the average yearly surface temperature which is two or three degrees warmer than the average annual temperature. There is a time lag depending on increase of depth. Soil type, compaction, humidity, surface conditions (shade, insulating ground cover, air temperature) affect soil temperatures. Earth contact are utilized for building cooling in two ways: direct contact that the building is completely or partially buried underground or indirect contact that the building is cooled by buried pipes or air tubes. In similar manner, Hyde (2000) draws attention to heavy weight floor slabs in terms of cooling effect by using thermal mass. According to author, cooler temperatures at night can cool the floor and keep the building cooler during the day.

Figure 2.9 shows the cooling effect of the ground floor slabs with respect to thermal mass.

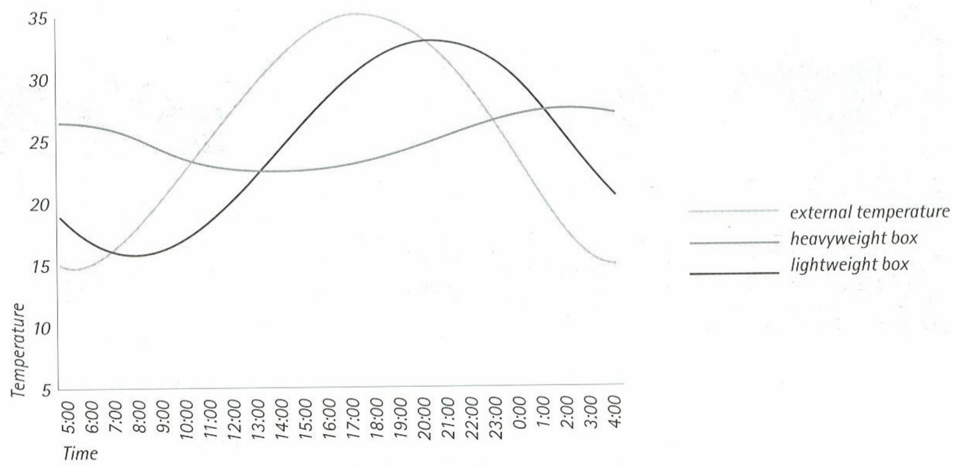


Figure 2.9. The thermal performance of lightweight and mass construction. (Hyde, 2000.)

Goulding, Lewis, and Streemers (1994) consider that, the main issue is to maximize the convective heat transfer between the thermal mass and the air. Unfortunately, this parameter is generally considered by an empirical value. This difficulty becomes more crucial when dealt with an optimization concerning both winter and summer. Another difficulty is because of the thermal inertia of thermal mass compared to the external layers having relatively rapid processes. Thermal mass has a particularly influence in regulation of required comfort conditions for continuous building occupation. For optimum thermal design, thermal mass should take place in center of heating and cooling controls to be installed.

Panchyk (1984) reports that effectiveness of solar heat for indoor temperature depends on relationship between the living space, the south facing glass and the thermal mass. If sun penetrates through windows to warm the space and the mass, the passive solar design is referred to as a direct gain system. In case of unwanted unlimited direct sun, the thermal mass is installed between the living space and the south facing glass. This system is called as an indirect heat gain system. Sizing the thermal mass and the south facing glass is interdependent on each other to provide a good thermal balance between day and night.

d. Windows: Goulding *et al.* (1994) discuss that, in northern part of the Europe, most of the glazing is placed on south facade to gain more solar energy. On the other hand smaller windows are located on the other facades. Use of glazing materials having good insulation can prevent draughts resulting from cold north air flow to glazed south façade. The challenge is to allow efficient conduction of solar energy and to reduce heat loss. The authors claim that some installations may improve thermal and solar capabilities of the glazing in the following manner.

- Adding one or more layers improves insulation of glazing whereas it slightly diminishes the solar conductivity. A heavy gas can be filled into the gap between the layers to reduce convective heat losses. Moreover, a selective surface on the glass helps not only solar radiation gain (short-wave) but also reflect thermal radiation (long-wave) from the occupied space.
- Low iron content glass with a higher solar conductivity can be used.
- Glazing with reflective surfaces may not be suitable for the sake of maximizing passive solar gains to allow less sunshine during heating season. Glazing is developed to correct this disadvantage.
- Other surface materials covering glass are several types of transparent polymer sheets; some of them have very high solar transmittances so that they can offer good thermal and solar performances. However, most are open to unwanted effects of thermal radiation.
- Heat losses because of thermal radiation to exterior can be reduced by using glazing with a low emissivity layer.

Goulding *et al.* (1994) also point out that the window frame plays an important role in the thermal losses. On the other hand, a few parameters, such as stability, ease of cleaning, colour etc., affect the selection of frame. Wood and pvc frames have good thermal features. Aluminium frames with a thermal barrier have comparatively higher heat losses than pvc and wood frames, but less than aluminium frames having no thermal barrier, or steel frames. Serious condensation problems are connected with steel frames.

According to Givoni (1976), the effect of window orientation on the indoor temperatures is largely dependent on the ventilation conditions and efficiency of the window shading. To understand this effect better, an experimental study was carried out at the building research station in Haifa under different ventilation and shading conditions. The results of the study have revealed that, both the shading and ventilation of rooms have an effect on performance of window orientation. In ventilated volumes with effectively shaded windows, the indoor temperatures are almost independent from orientation. If shading is absent or ineffective, but rooms are ventilated, small variations are observed in the indoor temperature depending on window orientation. In this situation, penetrating radiation causes heating of internal surfaces. When there is no shading and no ventilation, the differences in solar heating owing to window orientation are the maximum.

According to Givoni (1976), heat gain through a window is much higher than that through an identical area of ordinary wall, and its effect is felt rapidly without any time lag. This can be observed particularly in buildings with lightweight materials. On the other hand, the combination of shading devices and glass can optimize the thermal effect of windows. Another way of controlling the thermal effect of windows is to use of special glasses or glass treatments. Shading devices can be applicable externally, internally or between double glazing. They may be fixed, adjustable or retractable. Internal shading devices consist of Venetian blinds, roller blinds, curtains etc. and usually are retractable. External shading devices include shutters, awnings, overhangs and variety of louvers. Shading between double glazing includes venetian blinds, pleated paper and roller shades, which are usually adjustable or retractable from the inside. Shading devices control heat gain by diminishing the sun in overheated periods and allowing it in under-heated periods. They can influence daylight, glare, view and ventilation. Givoni (1976) evaluates that, the thermal effects of windows and shading devices depend on the size of the windows, but also other factors such as ventilation conditions, thickness, the thermophysical properties of the materials play role in the thermal effect of windows and shading devices.

Table 2.3. Shading coefficients and solar heat gain coefficients for various glazing and shading devices. (Rassam, 2004.)

Device	SC	SHGC
Single glazing		
Clear glass, 1/8-inch thick	1.0	0.86
Clear glass, 1/4-inch thick	0.94	0.81
Heat absorbing or tinted	0.6-0.8	0.5-0.7
Reflective	0.2-0.5	0.2-04
Double glazing		
Clear	0.84	0.73
Bronze	0.5-0.7	0.4-0.6
Low-e clear	0.6-0.8	0.5-0.7
Spectrally selective	0.4-0.5	0.3-0.4
Triple-clear	0.7-0.8	0.6-0.7
Glass block	0.1-0.7	
Interior shading		
Venetian blinds	0.4-0.7	
Roller shades	0.2-0.6	
Curtains	0.4-0.8	
External shading		
Egg-crate	0.1-0.3	
Horizontal overhang	0.1-0.6	
Vertical fins	0.1-0.6	
Trees	0.2-0.6	

Rassam (2004) claims that, a window’s solar heat gain coefficient (SHGC) and shading coefficient (SC) determine the total heat gain transmittance of the window. Utilized for solar gains, south facing windows in commercial and institutional buildings may have high SHGC value. Overheating potential, however, depends on appropriate window sizing or thermal storage. The windows need to be shaded during the overheated period with external shading devices. Windows with a low SHGC, on the other hand, is compatible for un-shaded north orientations in buildings. North facing windows can allow significant heat gain in summer. Shading coefficient values for various type of shading devices are listed in Table 2.3 above.

e. Thermal Insulation: According to Straaten (1967), thermal insulator for buildings can be defined as any material blocking heat transfer and having a thermal conductivity value not exceeding 0.5 Btu/ft^2.h deg. F. per in. thickness. Thermal conductivity value alone is not enough in choosing of an insulation material. There are other properties that should be taken into account such as density, specific heat, thermal expansion coefficient, resistance to excessive temperature and vapour, durability, mechanical strength, convenient for moisture absorption, resistance to insects, influence of dust and air movement on its efficiency and appearance.

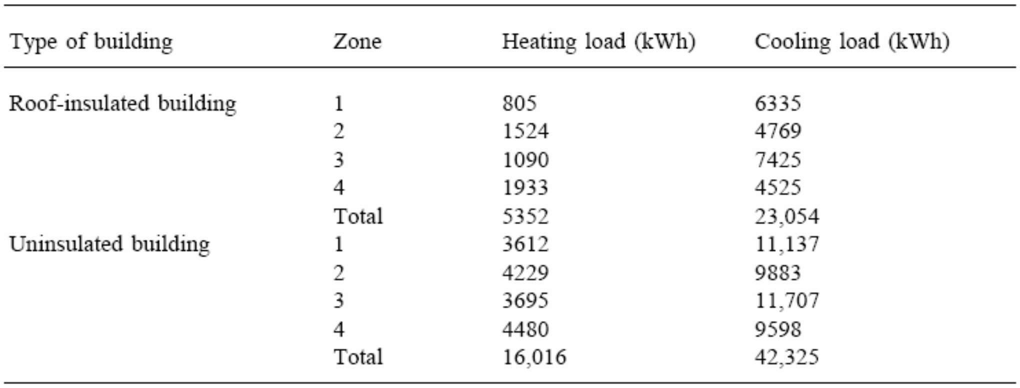
Straaten (1967) indicates that, some applications of thermal insulation can be observed whereas its main use is for preventing heat flow:

- To conserve heat or cold by providing temperature differences between indoor and outdoor.
- To reduce the effect of high solar radiation from roof or ceiling.
- To protect occupants or workers from radiation resulting from high temperature sources.
- To control thermal movements in structural components.
- To give a quick response to intermittent heating and cooling of heavy weight structures
- To control visible condensation

Straaten (1967) further explain that thermal insulation alone does not mean much unless heat losses and gains from windows and doors are restricted. Heat losses or gains through large glass areas, which have high thermal conductivity, cannot be compensated by increasing thermal resistance of the remaining wall area. It is a common approach that walls and windows are carefully planned with respect to sun. However, effects of the sun on the roof have been ignored although roofs are directly exposed to solar heat most of the day. In this context, for instance, maximum heat gain through a galvanized steel roof with an uninsulated plasterboard ceiling can be up to three times as much as that through an east or west facing 9 inch brick wall.

Kalogirou, Florides and Tassou (2002) define the roofs as two types including light-weight and heavy-weight roofs. Lightweight roofs include all forms of conventional roofs and the roof material is steel, asbestos cement or tiles. Heavy-weight roofs are usually of concrete. In general, there are some methods to reduce heat gain or losses from roofs: insulation, painting the lightest possible colour, evaporative cooling (water spray), using tiles or crushed stone. Studies in United States showed that the degree of the temperature changes of roof surfaces depends not only on the mass, density and specific heat of the substrate but also on the colour and texture of the surface.

Table 2.4. Heating and cooling loads of typical building with insulated and uninsulated roofs. (Kalogirou *et al*., 2002.)



Type of building	Zone	Heating load (kWh)	Cooling load (kWh)
Roof-insulated building	1	805	6335
	2	1524	4769
	3	1090	7425
	4	1933	4525
	Total	5352	23,054
Uninsulated building	1	3612	11,137
	2	4229	9883
	3	3695	11,707
	4	4480	9598
	Total	16,016	42,325

In a simulation study conducted by Kalogirou *et al.,* (2002), effects of building thermal mass on heating and cooling loads are examined. A typical four zone building having heavy-weight roof is subject of the study. This study also includes a comparison between insulated and uninsulated roofs in terms of heating and cooling loads. Table 2.4 shows these comparison results from simulation studies.

Panchyk (1984) mentions that insulating value and height of a ceiling may have a great effect on the heat used in an interior space. If the ceiling without insulation has a function as a roof or a floor, it is responsible for heat losses from the space. An interior ceiling having another space above does not lose heat directly, but the ceiling height has an indirect thermal effect on occupants in this situation. The extra air space resulting from excessive ceiling height needs to additional heat, therefore, in particularly winter, high ceilings create the living spaces with thermal inefficiency. In existing high-ceiling interiors, a suspended ceiling with thermal insulation feature can reduce undesirable thermal effects.

McMullan (1998) underlines that, thermal insulation is the main factor in reducing the heat loss from the buildings. It reduces the heat flow into a building, while outdoor temperature is bigger than the indoor temperature. Use of thermal insulation also minimizes surface condensation risk due to the warmer internal surfaces. According to McMullan (1998), thermal insulators used in building sector are made of several raw materials, and can be divided into five sections in terms of their formation:

- Rigid performed materials; aerated concrete blocks
- Flexible materials; fibreglass quilts
- Loose fill materials; polystyrene granules
- Materials formed on site; foamed polyurethane
- Reflective materials; aluminium foil

McMullan (1998) lists the essential features of thermal insulation materials as below:

- Suitable of thermal insulation for the purpose
- Suitable of strength or rigidity for the purpose
- Resistance to moisture
- Resistance to fire
- Resistance to insects and fungi
- Compatibility with adjacent materials
- Harmless to the environment

f. Shading: According to Anderson and Wells (1994):

> “Usually the easiest, most inexpensive and effective way to ‘solar’ cool your house is to shade it – keep the sun from hitting your windows, walls and roof. In fact, where summer temperatures average less than 80^0 F, shading may be all you need to stay cool".

To understand shading effect on buildings one should be aware of sun’s movement in a day. According to Egan (1975) the sun’s position with respect to geographic location, season, and time of day can be determined by geometric techniques. The sun's movement differs in azimuth and altitude angles with the seasons. These sun angles in relation to the north-south axis can be used to predict shadows for a particular time at a specific latitude. There is a formula, $d = x (\tan\alpha / \cos\beta)$, between the depth of shade and the overhang width. Sun angle geometry and sun path at 40^0 north latitude can be shown as below:

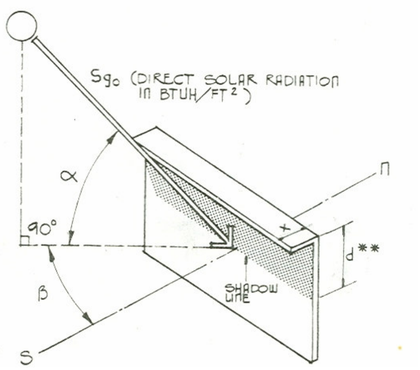


Figure 2.10. Sun angles. (Egan, 1975.)

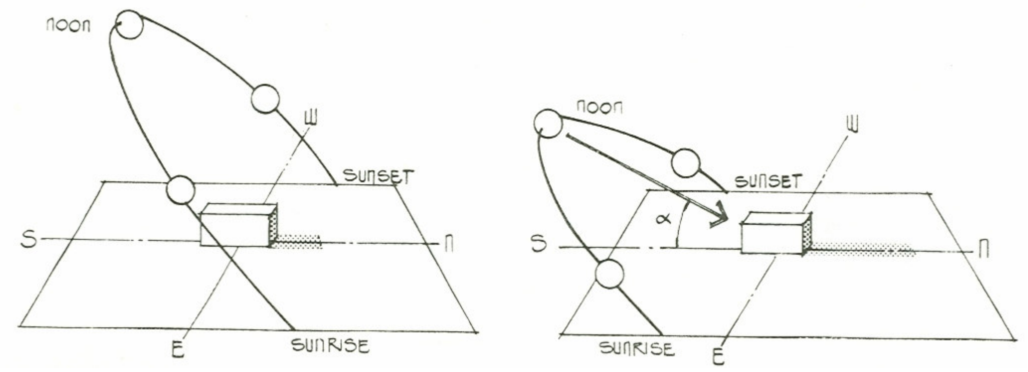


Figure 2.11. Summer and winter sun path diagrams at 40^0 north latitude. (Egan, 1975.)

According to Anderson and Wells (1994), major point in shading is to reduce heat loss in winter, and also reduce summer heat gain. For instance, shading poor insulated walls is a requirement while not required for well insulated walls keeping out summer heat. In hot climates, un-insulated walls, roofs and also windows should be shaded. Overhangs and awnings are good shading devices. On the other hand, the shading provided by fixed overhangs coincides with the seasons of the sun rather than with the climate. In other words, fixed overhangs show best performance in the longest day-June 21 when the sun is highest in the sky, however hottest days are in August when the sun is lower in the sky.

Anderson and Wells (1994) further report that shading with vegetation is closely concerned with the climatic seasons. On March 21, for instance, there are no leaves on most plants in northern hemisphere that's why sunlight easily reaches to buildings through naked branches. In contrast, on September 21, for example, the same plants have still leaves providing required shading. Operable shades are most adaptable to human comfort and generally mounted on the outside of a building. However, these shades do not exist very long due to nesting animals, climbing children and wind. Inside shades are not as effective as outside shades. The sunlight hitting the window is responsible for the lost of half the cooling load. Shading east and west windows is difficult because the sun in these directions is low in the sky in both summer and winter. Amount of sunlight through these directions, which overhangs cannot prevent, is much more in summer than in winter. The method of shading such windows is to install vertical louvers or other vertical extensions.

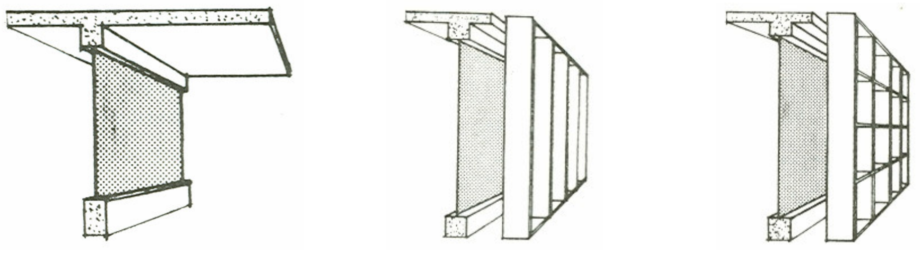


Figure 2.12. Horizontal, vertical and egg-crate shading devices. (Egan, 1975.)

The horizontal shading devices are useful for south facing facades. East and west facades need excessive width of overhang for effective shading. On the other hand the vertical exterior louver and egg-crate solar shading devices are primarily useful for east and west exposures. These devices increase the insulation resistance of windows in winter by behaving like a windbreak. The egg-crate solar shading device is a combination of horizontal and vertical elements. These devices are commonly used in hot climates due to its high shading efficiency (≤ 0.10). These three type shading device are illustrated in Figure 2.12 above.

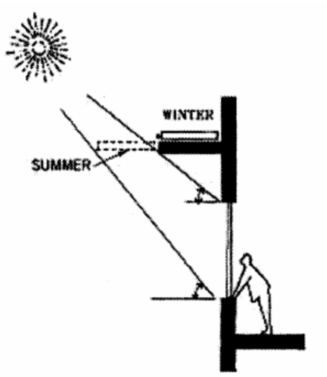


Figure 2.13. Adjustable overhang for solar penetration in winter. (Rassam, 2004.)

According to Rassam (2004), to design effective shading, one needs to determine the periods when the sun is to be allowed or to be prevented. For example, two dates with similar sun angles, such as March 21 and September 21, may need different shading solutions. For instance fixed shading devices provide shading for the glazing not only in warmer months but also in cooler months when solar radiation may be required. Sun angles are not completely in relation to air temperatures. Daily weather patterns greatly change, especially in spring and fall when too hot or too cold days might be occurred. Adjustable shading devices (Figure 2.13) are suitable for seasonal variations and daily weather patterns. Shading devices should be detached from the building in order to minimize the transfer of any heat absorbed by the device to the building. Another aim here is to let the air flow towards the occupants in summer.

Rassam (2004) also emphasises that, plants are effective shading devices for windows facing east and west directions. Leaves absorb 60-90% of incident sunlight. The shading coefficient of plants varies 0.2-0.6 depending on the density, age, seasonal growth, and the angle of incident. Vines might be good shading devices because they have a dense leaf structure growing faster than trees and provide filtered dynamic light. Vines can block almost 60% of the solar radiation on walls. East and west facades are suitable for best performance of a vertical vine covered trellis. On the other hand, a horizontal trellis performs well on southern façade. The major disadvantage of plants is that naked branches of most trees still have shading effect and can block about 30-60% of the sunlight. They can also prevent wind for cross ventilation and the exterior view unless they are right located.

2.3. Thermal Performance Studies in Buildings

Inanıcı and Demirbilek (2000) have conducted simulative study in order to optimize the thermal performance of building aspect ratio and south window size (S.W.S.) in five cities having different climatic characteristics of Turkey. The effects of six different building aspect ratios and eight different S.W.S.'s for each building aspect ratio are analyzed for apartments in five cities of Turkey: Erzurum, Ankara, Diyarbakır, İzmir, and Antalya by using simulation thermal analysis program named SUNCODE-PC. A three-storey building model was developed for the purpose of simulation. It is a three-storey building with single zones in each floor. The middle floor has four units, each having a 100m^2 floor area and 3m height which is a common apartment storey height type in Turkey. Independent, independent, and control variables were used in the study. The results of the study on building aspect ratio shows that maximum elongation in east-west axis is preferable in hot climates including Diyarbakır, İzmir, and Antalya. On the other hand, building having a compact form is the optimum case for cold climates such as Ankara and Erzurum. Window's effect on heat gain and loss is a factor in determining S.W.S. of residential buildings. While a building with 25 % S.W.S is suitable for hot climates because of the requirement in decreasing heat gain in summer; in cold climates larger S.W.S. are recommended due to the need for increasing heat gains in winters. The results can be applied to buildings without roof or ground contact.

Flippin, Larsen, Beascochea, and Lesino (2005) performed a study to analyze the effect of design and human dependent factors on conventional and energy-saving buildings. In this context, energy efficient buildings were constructed for low income students at La Pampa University during the year 2000. Buildings are located in a temperate semi-arid region of Central Argentina. The main strategies focus on energy conservation devices, passive solar heating, natural ventilation, and solar protection. The buildings consist of two blocks of apartments with a net floor are of 700 m^2 and main spaces including two bedrooms, a dining room, and essential services. All main spaces have solar windows and there are northern shading devices and metallic pergolas to protect windows in summer. The study which especially focuses on the results of the thermal energy behaviour of the buildings has also a monitoring plan which was prepared after the construction of the buildings. The results of the study show that the evolution of internal temperature was different in each apartment. The natural gas consumption was different among occupants; however, gas consumption of new constructed buildings was lower than that of conventional buildings. Occupants have good living conditions at 50 % of the auxiliary energy consumed by conventional buildings without extra cost.

In a study by Kalogirou *et al.,* (2001), effects of thermal mass on heating and cooling load is demonstrated. Modelling and simulation studies have been done with a computer program named TRNSYS. A typical four-zone building with an insulated roof was used, and a thermal wall was installed in place of the south facing wall of one of the zones. Surprisingly no thermal mass application is available, even though daily temperature variations in Cyprus are suitable for this type application. Hence, to investigate the benefits of such construction has determined the major aim of this study. According to results, a reduction is observed in the heating load requirement by almost 47% whereas at the same time there is slight increase in the cooling load. Various construction materials have been optimized with the study. For instance, it was found that optimum overhang size is 1.2 m and wall thickness is 25cm. the air gap effect between the glazing and the thermal wall is significant. Results also reveal that roof insulation is a requirement for better comfort conditions.

The study by Krüger and Zannin (2004) aims to discuss the results environmental performance in classrooms situated in the State Parana, Brazil. Thermal measurements are made in several buildings according to the construction year within classrooms in the oldest and the newest blocks. In this context, choice of classrooms is based on primarily the façade orientation and the construction materials of the corresponding walls and ceilings. Evaluation of thermal comfort in the classrooms includes some steps, such as, choice of classrooms, definition of analysis period, temperature measurements with data loggers, estimation of air humidity of the classrooms, bioclimatic analysis of the results by ANALYSIS software, comparison of thermal comfort results with thermophysical properties of the classrooms.

Krüger and Zannin (2004) evaluates the results that the solar orientation effect on the facades is significant both in winter and summer if no shading for all windows. During winter, the ceiling transmittances affect the comfort degree only on the sun exposed facades within a limit. This is because of the integrated effect of solar orientation and thermophysical properties of the materials. When less wall transmittance has supposed, thermal discomfort increases due to cold. The higher thermal inertia of old buildings has no positive effect. In summer, however, smaller wall transmittance and bigger thermal inertia cause to greater heat storage in the older classrooms. The orientation is still important whereas the ceiling effect is low for the monitored period. Nevertheless, reduction on the indoor temperatures is evident.

Karaguzel (2003) has a study in which effects of glazing type and shading of south facing windows and thermal mass of building envelope on the thermal performance of residential buildings, located in Ankara, have been investigated. Two thermal analysis softwares called ECOTECT 5.0 and ENERGY-10 are used for this research. The hypothetical building model for simulations is based on sample residential building in TSE 825 (Turkish Standards Institute). Simulations were first conducted with ECOTECT 5.0 and then with ENERGY-10; due to in consistency of ECOTECT 5.0. According to results, building envelope materials having high thermal storage and high glazing performance provide substantial energy savings when the size of south facing windows is increased to a certain extent. The research also shows that fixed overhangs above south facing windows do not have significant effect in reducing of cooling loads.

Another study has been conducted by Gezer (2003), gives information about the effects of construction materials on thermal comfort in residential buildings by using ECOTECT 5.0. This research uses three residential buildings in the province of Yozgat, each have different construction. It is concluded that construction materials in naturally ventilated buildings have an influence on thermal comfort and thermal performance. Additionally, buildings having traditional construction materials show better thermal performance while minimizing energy costs.

CHAPTER 3

MATERIAL AND METHOD

This chapter includes details about the material and research method used in this study. The research material consists of the case study building, data collected from the building, and the data loggers used to collect the temperature and humidity data. Data collection and data evaluation procedures are presented in the sections concerning the methodology.

3.1. Material

The study was carried out on the Faculty of Architecture building in the METU campus in Ankara. Materials were the case study building, temperature and humidity data collected from certain offices, and data logger used for this data collection. Measurements of the windows and photos from exterior were other related materials in the study. In addition to all, monthly temperature data for Ankara in July, August, and September 2006 was obtained from Turkish State Meteorological Service because exterior data could not be recorded during whole study. This data is given below:

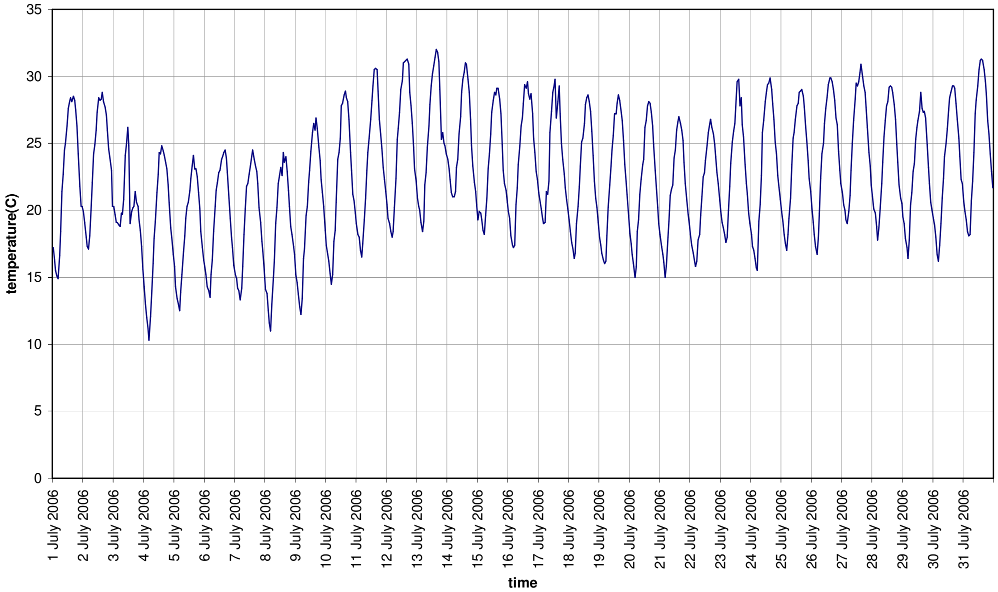


Figure 3.1a. Temperature chart for Ankara, July 2006.

(Turkish State Meteorological Service)

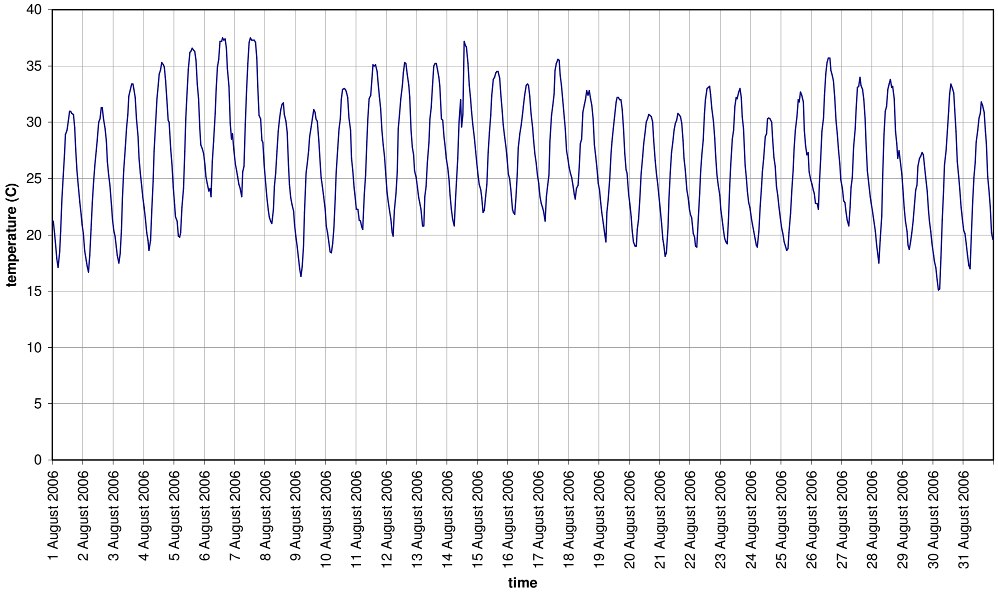


Figure 3.1b. Temperature chart for Ankara, August 2006.

(Turkish State Meteorological Service)

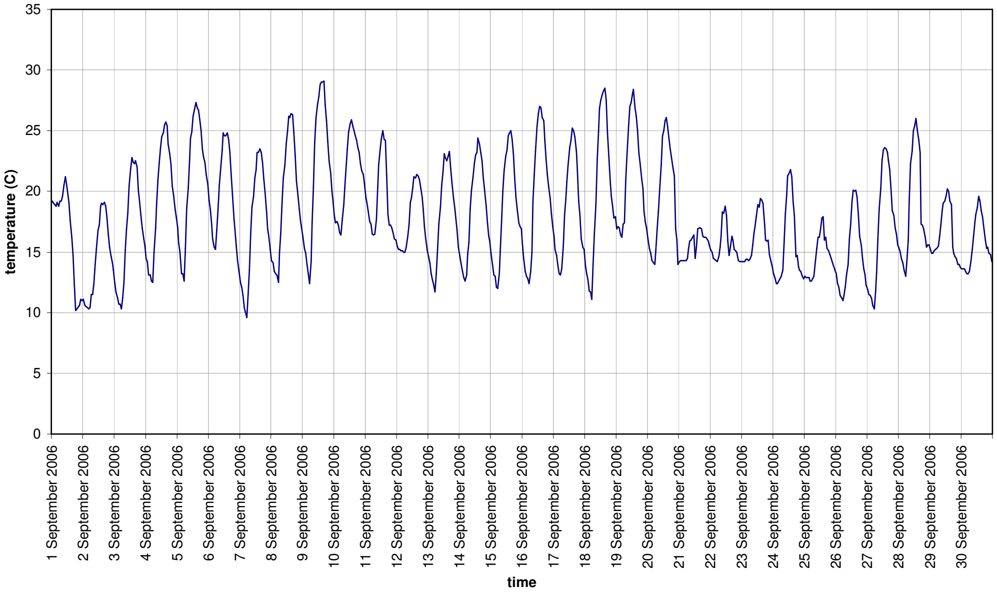


Figure 3.1c. Temperature chart for Ankara, September 2006.
(Turkish State Meteorological Service)

3.1.1. Data Loggers

Tiny Tag data loggers (Figure 3.2) were used to record temperature and humidity data at predetermined intervals through certain periods of time. Data loggers can be located both inside and outside. Certain precautions have to be taken while using this sensitive tool; for example, interior data loggers should not be located close to walls or openings, in the path of direct sunlight and frequent air movements, near heat or moisture producing sources. On the other hand, exterior data loggers should not be located in direct sunlight or on the path of prevailing winds. These also should be kept away from heat sources and moisture producing sources. Data loggers are launched and offloaded by the software called Gemini Data Logger Manager. The tabular data can be exported to spread sheet documents to develop the comparison graphs.

At first two, and later three, loggers were used for this study. Since, at first stages of the research, two data loggers had to be used due to shortage of data loggers. Therefore, outdoor data for the first stages could not be recorded. Later on, two data loggers were located inside the building whereas the third one was outside.

Figure 3.2. Tinytag data logger. (www.tinytag.info)

3.1.2. Data Collected

Relative humidity and temperature data were collected from certain rooms of the case building which are being used as offices. The data were collected several times during the summer months of 2006. The data on air temperature and relative humidity were collected at 15-minute intervals at certain periods during the months of July, August, and September. The monthly temperature data for Ankara, which was obtained from Turkish State Meteorological Service , is given in Appendix A. The temperature and humidity data collected in the selected rooms is presented in Appendix B and C respectively.

3.1.3. Case Study Building

In this study, effects of design dependent parameters, such as thermal mass; window sizes and orientation; and shading, on indoor thermal comfort were examined. The METU faculty of architecture building was the case study building, which is situated in Ankara. This building is a low-rise structure, and was constructed in 1963. It includes class-rooms and studios as well as academic and administrative offices. It is a three storey building and has a floor area of 12,675 m^2. The building is elongated on the north-south axis. It has concrete curtain walls having 250 mm thickness. All the windows are double glazed. It has a flat roof with heat and water insulation and its interior floors are covered with natural stone tiling. Figures 3.3, 3.4, and 3.5 shows floor plans, in which rooms investigated are also marked.

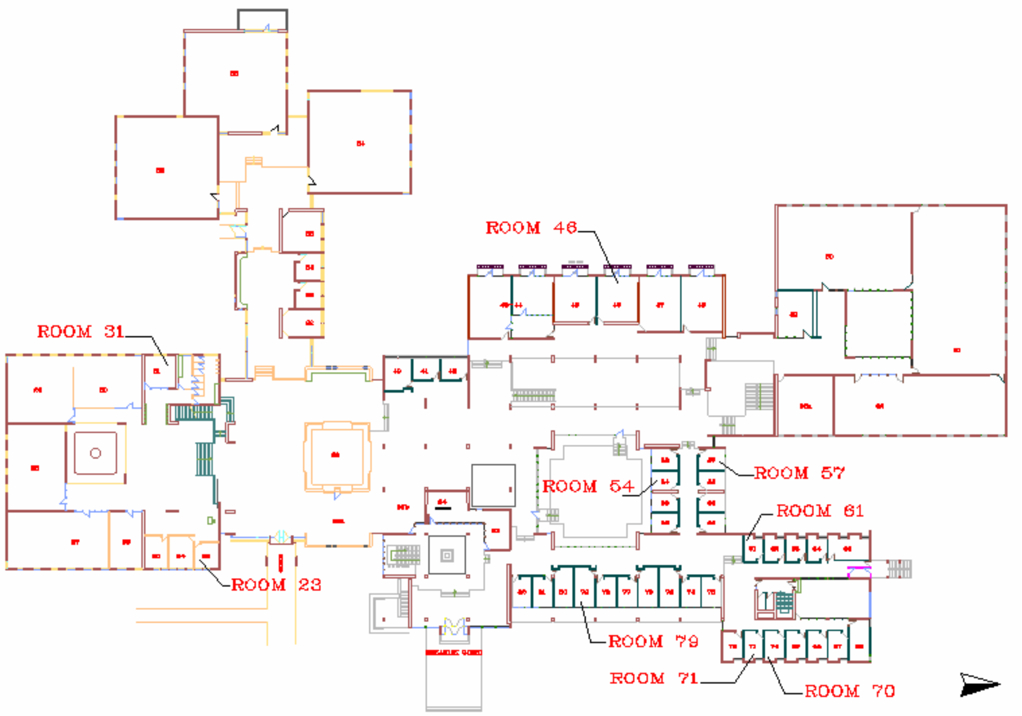


Figure 3.3. Ground floor plan of the case-study building: METU Faculty of Architecture. (the course of building science 566)

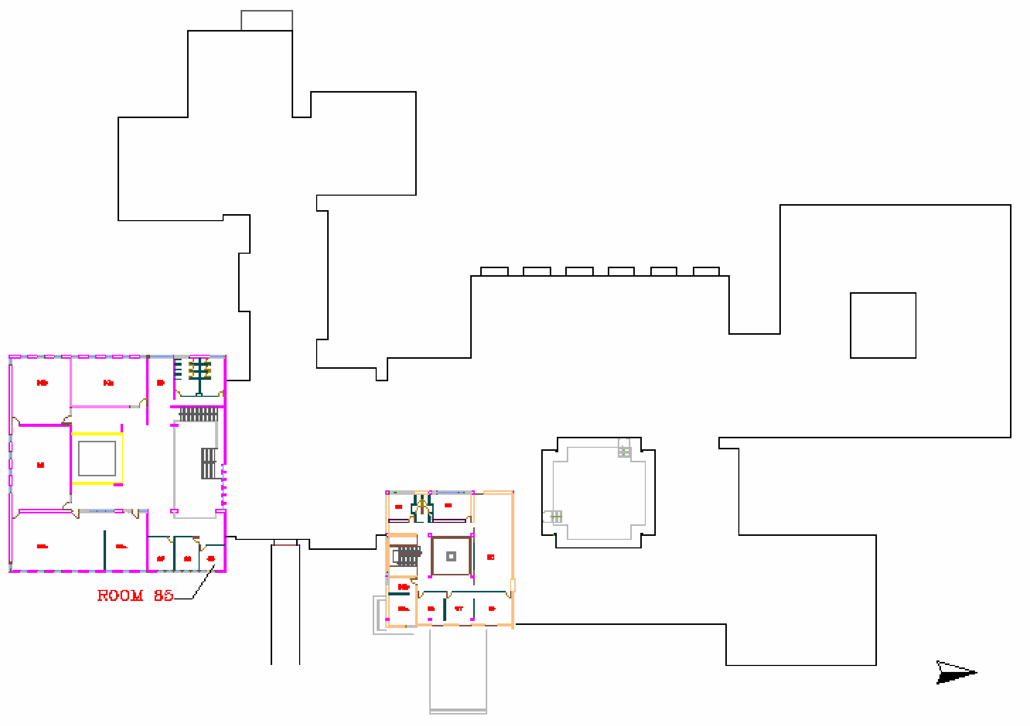


Figure 3.4. First floor plan of the case-study building. (the course of building science 566)

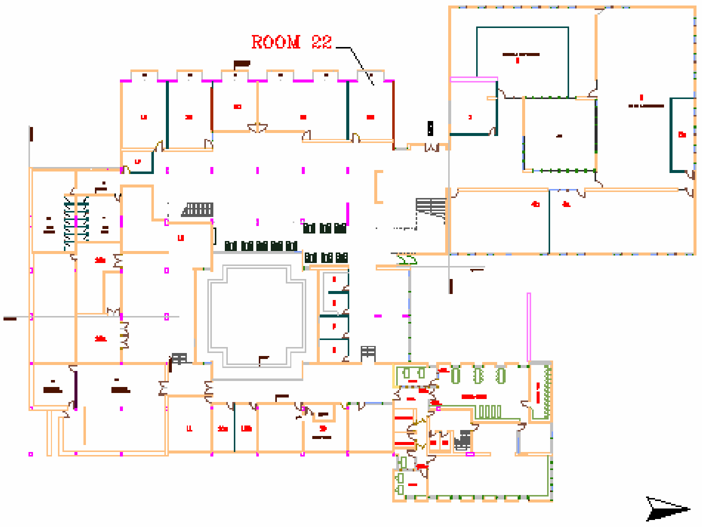


Figure 3.5. Basement floor plan of the case-study building. (the course of building science 566)

3.2. Method

The method in this research mainly comprised two main steps. First temperature and humidity data were collected with the help of data loggers and then the data were evaluated statistically and hypotheses tested. These two steps are explained in more detail in the following sections. The floor plans of the case study building were obtained from archives of the BS566 course, the photographs of the windows were taken from outside and their measurements were recorded. The temperature data for Ankara was obtained from Turkish State Meteorological Service, for the period when temperature and humidity readings were recorded. Details of data collection and data evaluation are given in the following sections.

3.2.1. Data Collection

It should be noted that collecting data concurrently for whole building was impossible due to shortage of data loggers. In order to exclude external microclimatic influences, the study had to be performed under unheated and unoccupied conditions. This meant that no one was able to enter the rooms and open or close the windows. Therefore, suitable unoccupied offices were selected to record humidity and temperature data during the months of July, August, and September 2006. Vacation dates of occupants were the most important criteria in selecting the suitable offices and the time-period of recording data. Data collection was conducted consecutively in the faculty building. At first, there were only two data loggers available for recording data in two rooms at a time; later on, when the third one became available, it was located outside of the building to record external data. Table 3.1 shows the data sets collected for certain days in July, August, and September 2006. These datasets are listed in the first column of Table 3.1, while dates for data recordings, Room numbers and data logger identity are given in the 2nd, 3rd and 4th columns respectively.

Table 3.1. Data sets collected in July, August, and September, 2006.

	Date	*Room no*	*Data logger*
Data set 1	7 – 14 July 2006	54	dc4
		57	dc1
Data set 2	14 – 18 July 2006	85	dc4
		outside	dc1
Data set 3	18 – 21 August 2006	79	dc1
		outside	dc4
Data set 4	22 – 28 August 2006	61	dc4
		70	dc1
Data set 5	28 – 31 August 2006	23	dc4
		31	dc1
Data set 6	1 – 5 September 2006	46	dc2
		22	dc4
		outside	dc1
Data set 7	20 –25 September2006	85	dc2
		71	dc4
		outside	dc1

3.2.2. Data Evaluation

Hypotheses were formulated and then tested by conducting ANOVA to show if there is a significant difference between the temperatures of the rooms; and their levels of humidity. If a significant difference was determined then the reasons behind this difference were investigated in terms of the design-dependent parameters influencing the thermal conditions within. Since the data were collected for only one room in Data set 2 and Data set 3, these data sets were combined with Data set 1 and Data set 4 respectively, so as to constitute the comparison groups for ANOVA. This was possible because during these periods the external climatic conditions were seen to be similar according to the Ankara weather data. Data collected for the same number of days, was considered for this analysis.

In this context, the ANOVA at a 5 % level of significance was applied and the following Null hypotheses were tested for Data Sets 1 and 2; 3 and 4; 5, 6, and 7:

H_{01}: There is no difference between the temperatures of the rooms,.
H_{02}: There is no difference between the humidity of the rooms.

CHAPTER 4

RESULTS AND DISCUSSION

In this chapter, temperature and humidity data and results obtained from the analysis of variance are presented. Firstly floor plans , sections and elevations of the rooms, along with the temperature and humidity charts are presented for each data set. Following this description of the data collected and hypotheses tested for each data set are presented along with the results of ANOVA and the discussion related.

4.1. Temperature and Humidity Data

In this section, all seven data sets are presented, according to chronological order, for each room. Combining the graphs of indoor and outdoor data on one chart made possible the comparison between these data in question. In the temperature graphs the abscissa shows the date of recording period and the ordinate shows the temperature in degrees C. In humidity graphs, the abscissa shows the date of recording period and the ordinate shows the relative humidity as percentage. The summary tables for each data set present information on the rooms in which the data were recorded, the floor area, ceiling heights and window sizes and orientation of these rooms; sky conditions on the days data were recorded, as well as position of curtains or blinds.

4.1.1. Data Set 1

This data set was recorded in Room 54 and Room 57 concurrently. These rooms are located opposite to each other in the corridor to the north of the atrium. Room 54 (Figure 4.2) has south-facing floor-to-ceiling windows overlooking the atrium. Room

57, on the other hand has north facing floor-to-ceiling windows to the exterior (Figure 4.1). These windows were fitted with Venetian blinds.

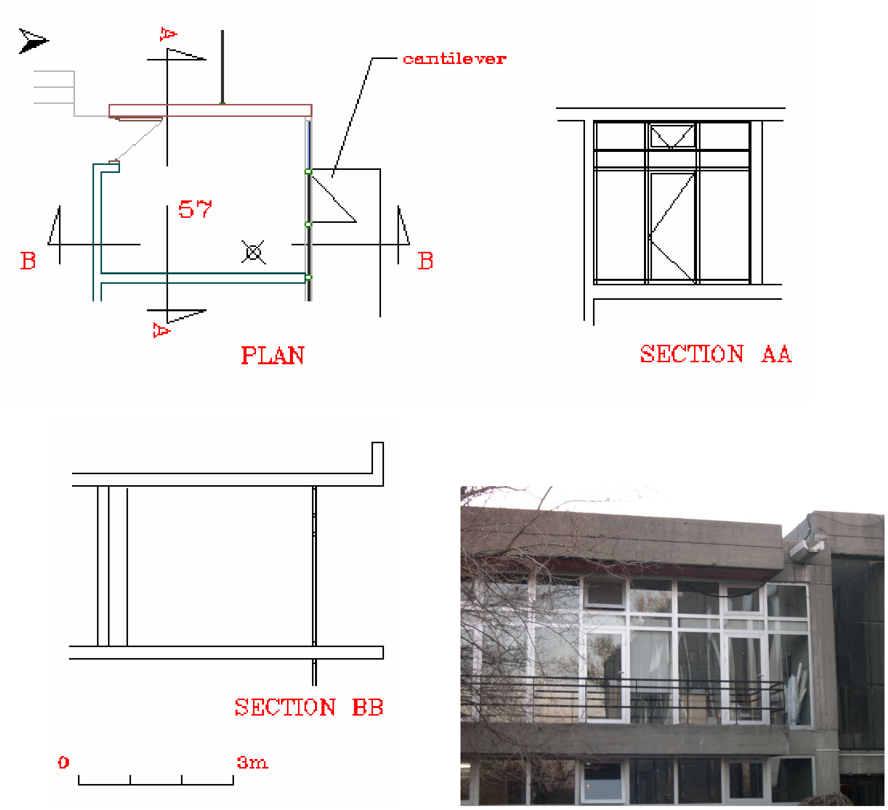


Figure 4.1. Floor plan, section BB (showing sunshade device), section AA and exterior view of Room57. (photo by the author.)

Relevant data (Table 4.1) and temperature and humidity charts for these rooms are given below (Figure 4.3a) and (Figure 4.3b). Table 4.1 gives relevant information on these rooms and exterior weather conditions *etc*. as explained above.

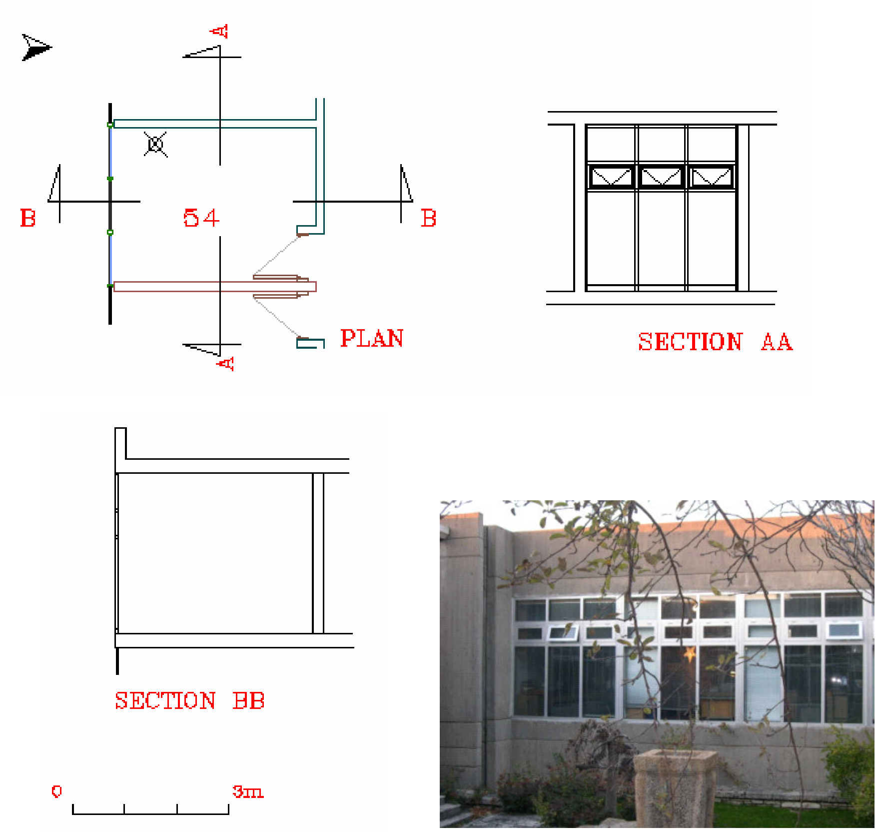


Figure 4.2. Floor plan, section AA, section BB and exterior view of Room 54. (photo by the author.)

Table 4.1. Information regarding rooms and weather conditions for Data Set 1.

BUILDING	METU Faculty of Architecture Building					
ROOM NO	R54				R57	
FLOOR AREA	10,48 M²				10,99 M²	
WINDOWS AREA	8,8 M²				9,1 M²	
HEIGHT	3,09 M				3,09 M	
ORIENTATION	South				North	
DATALOGGER	dc4				dc1	
RECORD	07.07.2006-16:50-------14.07.2006-15:10				07.07.2006-16:53--------14.07.2006-15:13	
DATE	CLOUDINESS		WIND			OTHER
dd / mm / yy	9:00 AM	3:00 PM	9:00 AM	3:00 PM	9:00 PM	CONDITIONS
07.07.2006	partial around 4.50 pm		calm around 4.50 pm		light breeze	<day, hot and sunny>, <night cool>
08.07.2006	clear	partial	light breeze	light breeze	calm	<morning, cool>
09.07.2006	clear	clear	calm	calm	calm	
10.07.2006	clear	clear	calm	calm	calm	
11.07.2006	clear	clear	calm	calm	calm	
12.07.2006	clear	clear	calm	calm	calm	
13.07.2006	clear	clear	calm	calm	calm	
14.07.2006	partial	clear	calm	calm		<morning, cool>
Notes:						
I opened the venetian blinds in room 54 at 16:30, 12 July 2006. Until that time venetian blind on the left was open while others were closed. Whole venetian blinds were open during the recording time in room 57.						

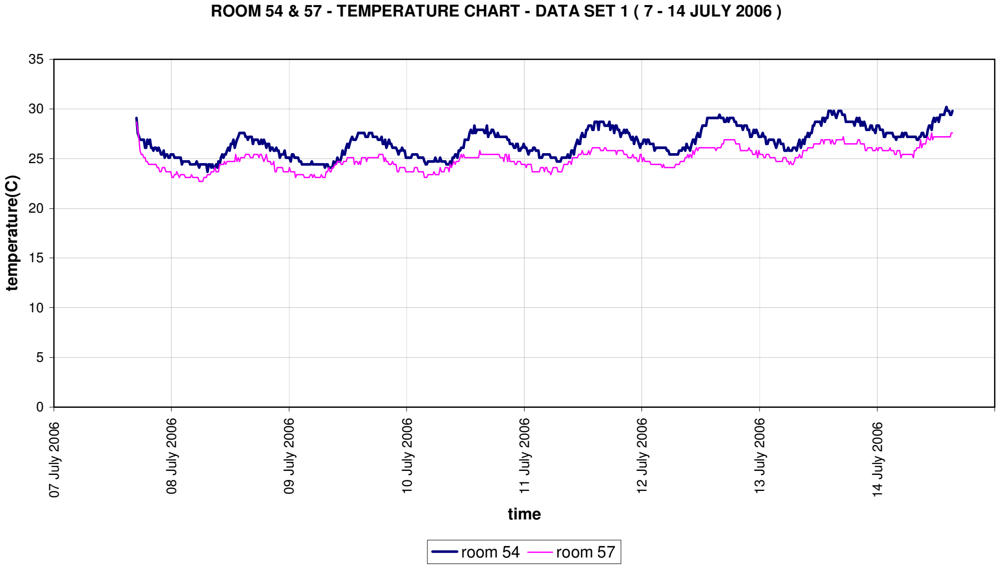


Figure 4.3a. Temperature chart for Data Set 1.

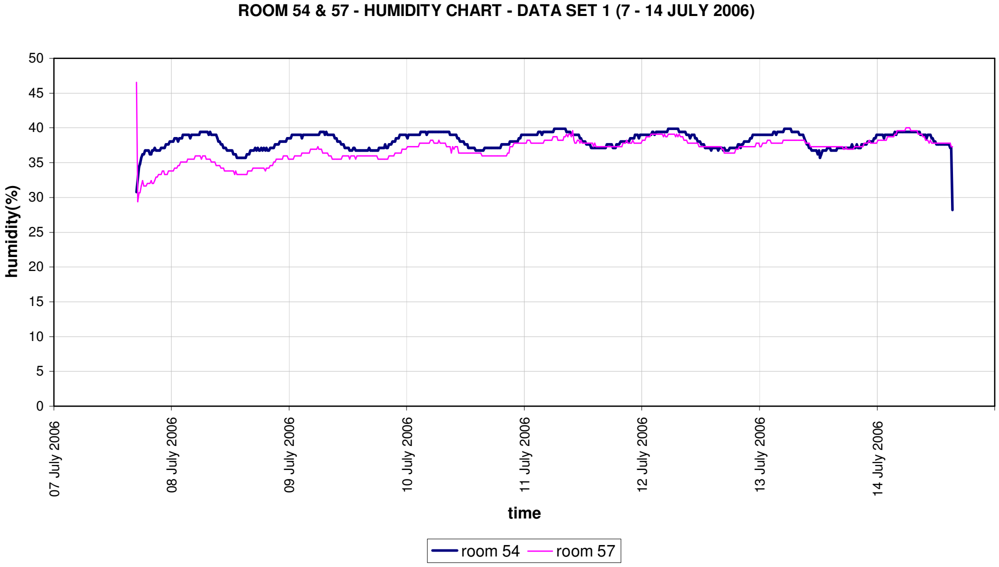


Figure 4.3b. Humidity data chart for Data Set 2.

4.1.2. Data Set 2

This data set includes the temperature and humidity data of Room 85 (Figure 4.4) and outdoor concurrently. Room 85 has east facing windows of sizes 95 x 95 cm. Its exterior walls are covered with vines. The condensed data (Table 4.2) and temperature and humidity charts for this room are given below (Figure 4.4a) and (Figure 4.4b).

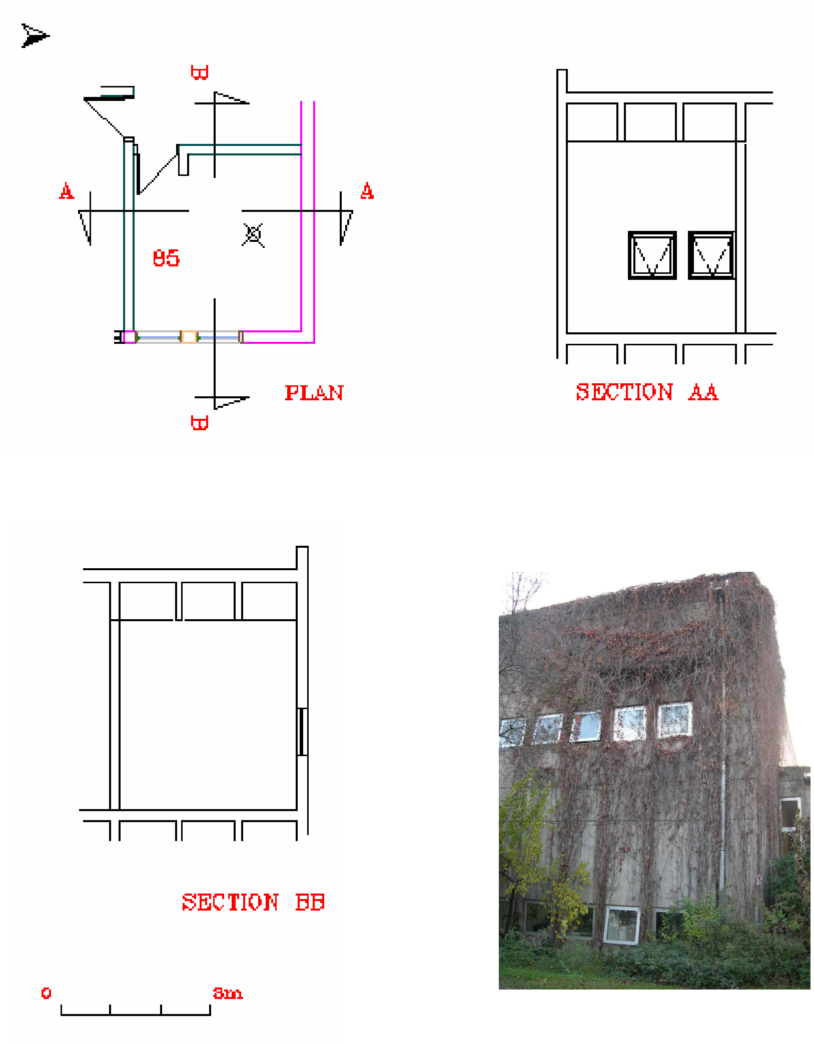


Figure 4.4. Floor plan, section AA, section BB, and exterior view of Room 85. (photo by the author.)

Table 4.2. Information regarding rooms and weather conditions for Data Set 2.

BUILDING	METU Faculty of Architecture Building					
ROOM NO	R85			Outdoor		
FLOOR AREA	11,97 M²					
WINDOWS AREA	1,8 M²					
HEIGHT	4,61 M					
ORIENTATION	East					
DATALOGGER	dc4			dc1		
RECORD	14.07.2006-15:45------18.07.2006-10.05					
DATE	CLOUDINESS		WIND			OTHER
dd / mm / yy	9:00 AM	3:00 PM	9:00 AM	3:00 PM	9:00 PM	CONDITIONS
14.07.2006		clear		calm	calm	
15.07.2006	clear	partial	calm	calm	calm	
16.07.2006	clear	clear	calm	calm	calm	
17.07.2006	clear	partial	calm	calm	calm	
18.07.2006	clear		calm			
Notes:						
Roller blinds were open in room 85. The room might be occupied for an uncertain period on July 17.						

ROOM 85 - TEMPERATURE CHART - DATA SET 2 (14 - 18 JULY 2006)

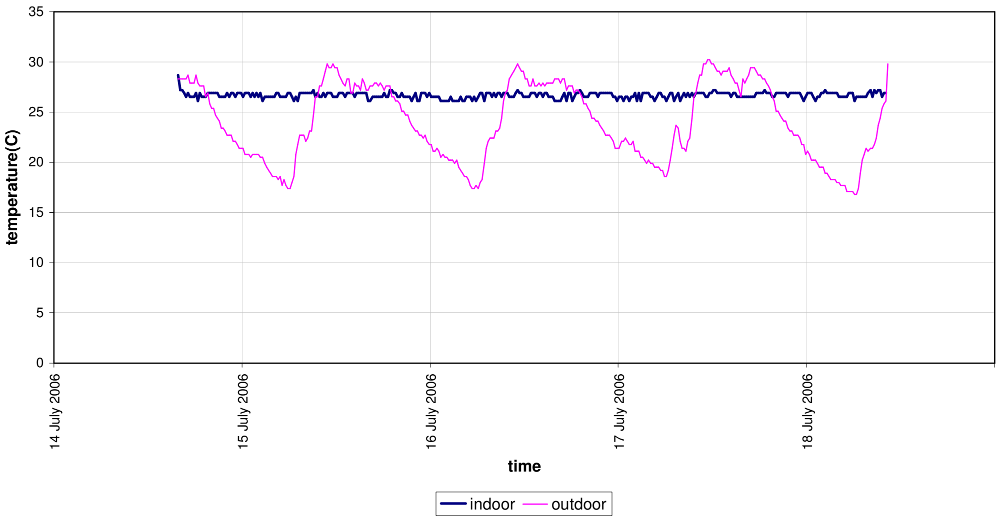


Figure 4.4a. Temperature data chart for Data Set 2

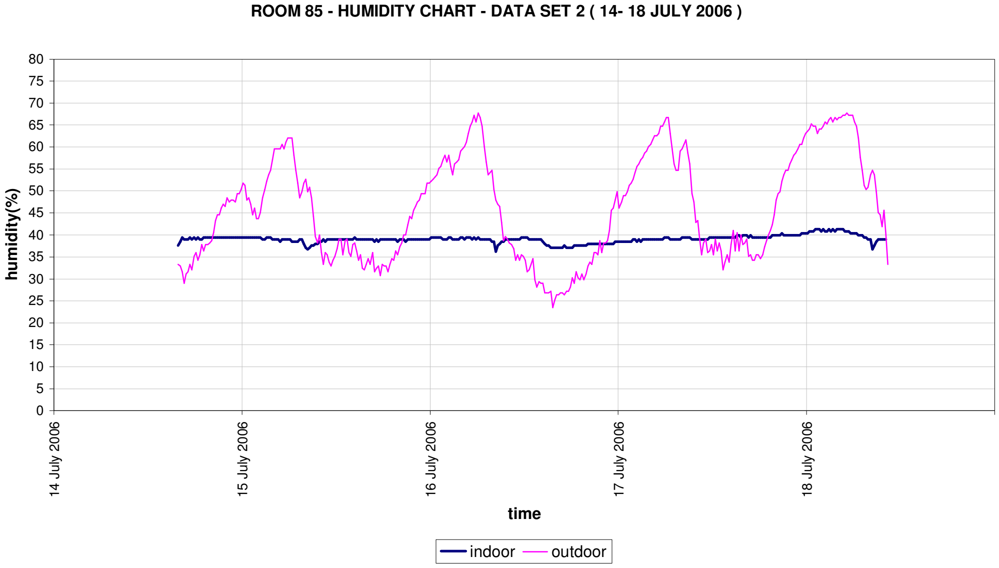


Figure 4.4b. Humidity data chart for Data Set 2.

4.1.3. Data Set 3

This data set includes the temperature and humidity data of Room 79 (Figure 4.5) and outdoor concurrently. Room 79 has east facing floor-to-ceiling windows of area overlooking a garden covered with the bushes. Room 79 has the balcony and the cantilever above it. The cantilever performs as a sun shading device. The condensed data (Table 4.3) and temperature and humidity charts for the Room 79 are given below (Figure 4.5a) and (Figure 4.5b).

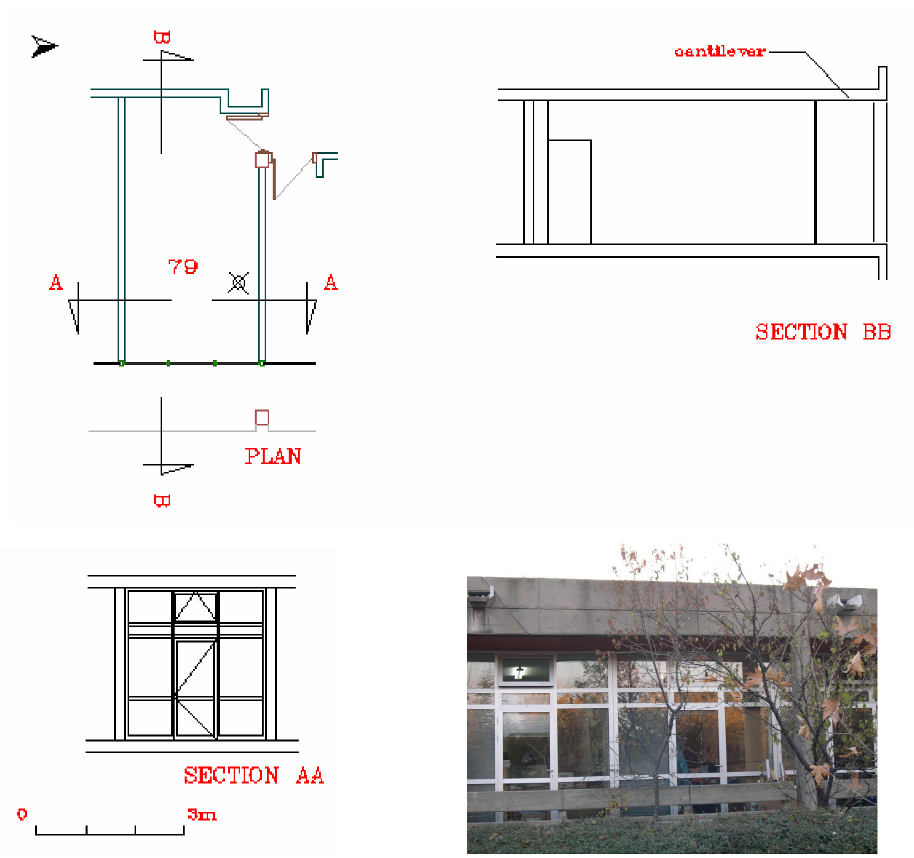


Figure 4.5. Floor plan, section AA, section BB and exterior view of Room 79. (photo by the author.)

Table 4.3. Information regarding rooms and weather conditions for Data Set 3.

BUILDING	METU Faculty of Architecture Building					
ROOM NO	R79				Outdoor	
FLOOR AREA	16,9 M²					
WINDOWS AREA	8,83 M²					
HEIGHT	3,09 M					
ORIENTATION	East					
DATALOGGER	dc1				dc4	
RECORD	18.08.2006-17:20-----21.08.2006-08:34					
DATE	CLOUDINESS		WIND			OTHER
dd / mm / yy	9:00 AM	3:00 PM	9:00 AM	3:00 PM	9:00 PM	CONDITIONS
18.08.2006	clear around 5.20 pm		calm around 5.20 pm		calm	
19.08.2006	clear	clear	calm	calm	light breeze	
20.08.2006	clear	clear	calm	light breeze	mild	
21.08.2006	clear		calm			
Notes:						
End of the recording time for outdoor logger was 9:30 am. Venetian blinds were closed during the record						

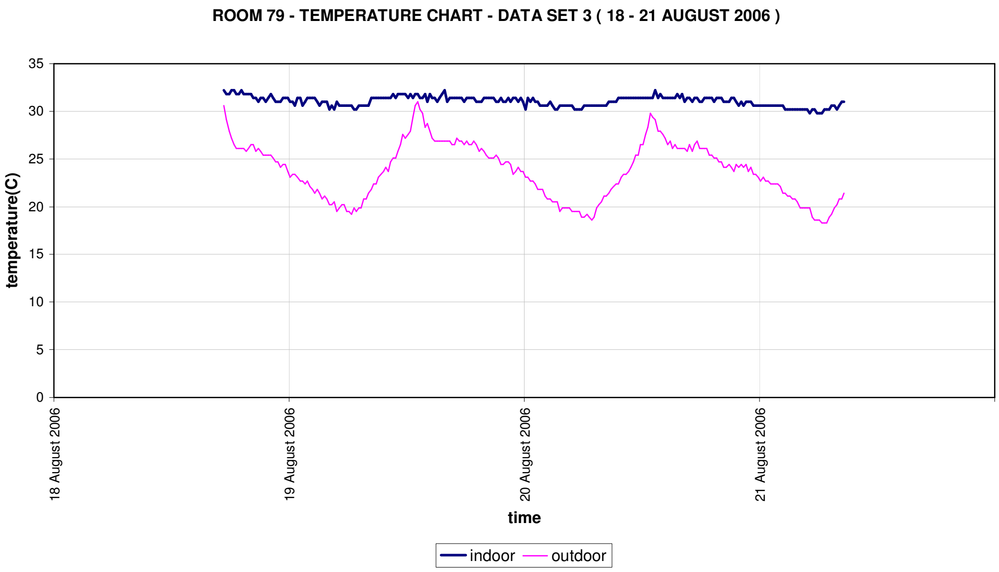


Figure 4.5a. Temperature chart for Data Set 3.

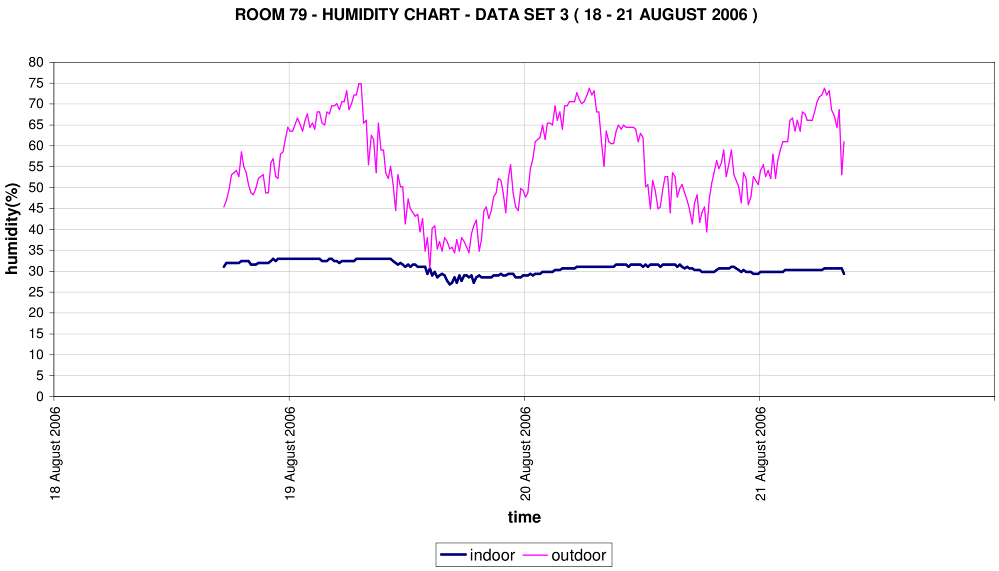


Figure 4.5b. Humidity chart for Data Set 3.

4.1.4. Data Set 4

This data set was recorded in Room 61 and Room 70 concurrently. These rooms are located opposite to each other. Room 61 (Figure 4.6) has west-facing floor-to-ceiling windows. Room 70 (Figure 4.7), on the other hand has east facing floor-to-ceiling windows to the exterior.

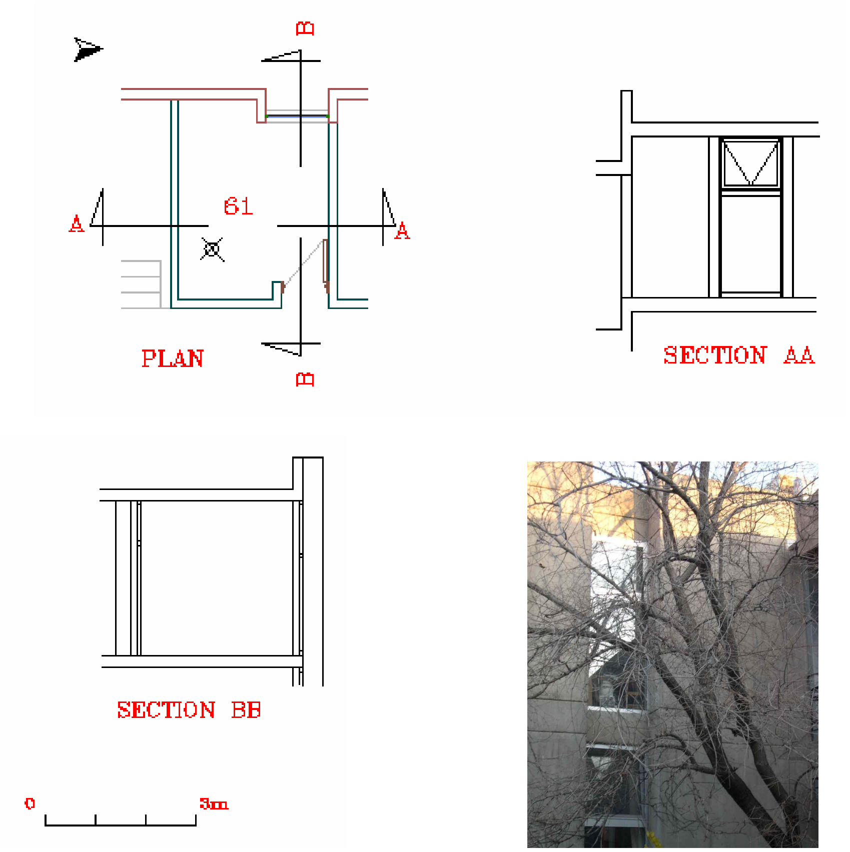


Figure 4.6. Floor plan, section AA, section BB and exterior view of Room 61. (photo by the author.)

The condensed data (Table 4.4) and temperature and humidity charts for these rooms are given below (Figure 4.8a) and (Figure 4.8b).

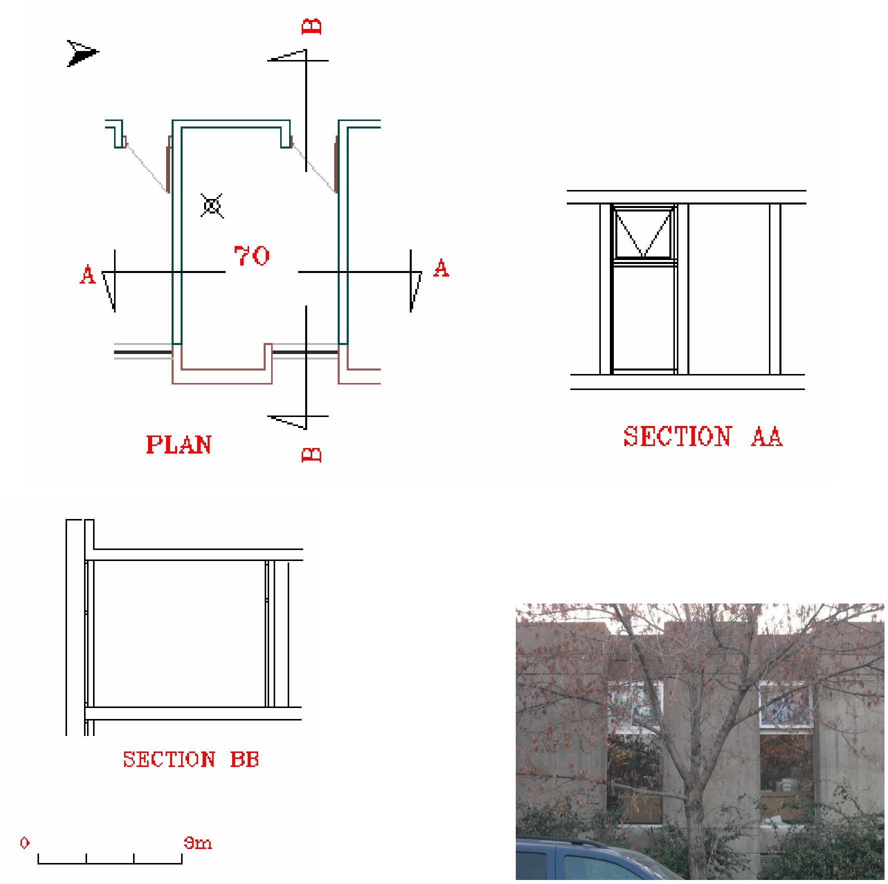
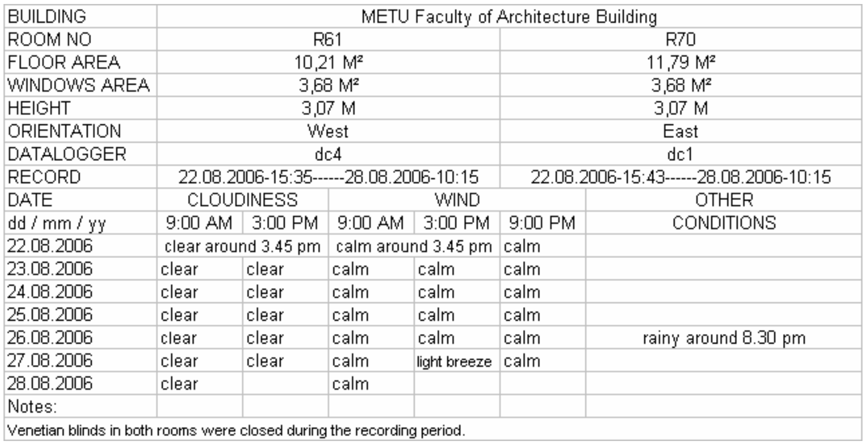


Figure 4.7. Floor plan, section AA, section BB and exterior view of Room 70. (photo by the author.)

Table 4.4. Information regarding rooms and weather conditions for Data Set 4.



BUILDING	METU Faculty of Architecture Building					
ROOM NO	R61				R70	
FLOOR AREA	10,21 M²				11,79 M²	
WINDOWS AREA	3,68 M²				3,68 M²	
HEIGHT	3,07 M				3,07 M	
ORIENTATION	West				East	
DATALOGGER	dc4				dc1	
RECORD	22.08.2006-15:35------28.08.2006-10:15				22.08.2006-15:43------28.08.2006-10:15	
DATE	CLOUDINESS		WIND			OTHER CONDITIONS
dd / mm / yy	9:00 AM	3:00 PM	9:00 AM	3:00 PM	9:00 PM	
22.08.2006	clear around 3.45 pm		calm around 3.45 pm		calm	
23.08.2006	clear	clear	calm	calm	calm	
24.08.2006	clear	clear	calm	calm	calm	
25.08.2006	clear	clear	calm	calm	calm	
26.08.2006	clear	clear	calm	calm	calm	rainy around 8.30 pm
27.08.2006	clear	clear	calm	light breeze	calm	
28.08.2006	clear		calm			
Notes:						
Venetian blinds in both rooms were closed during the recording period.						

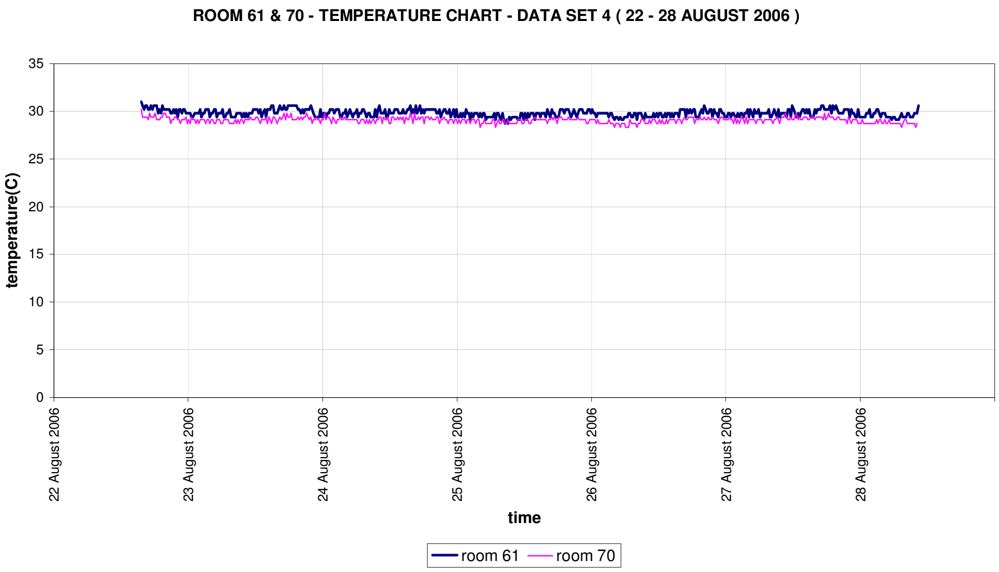


Figure 4.8a. Temperature chart for Data Set 4.

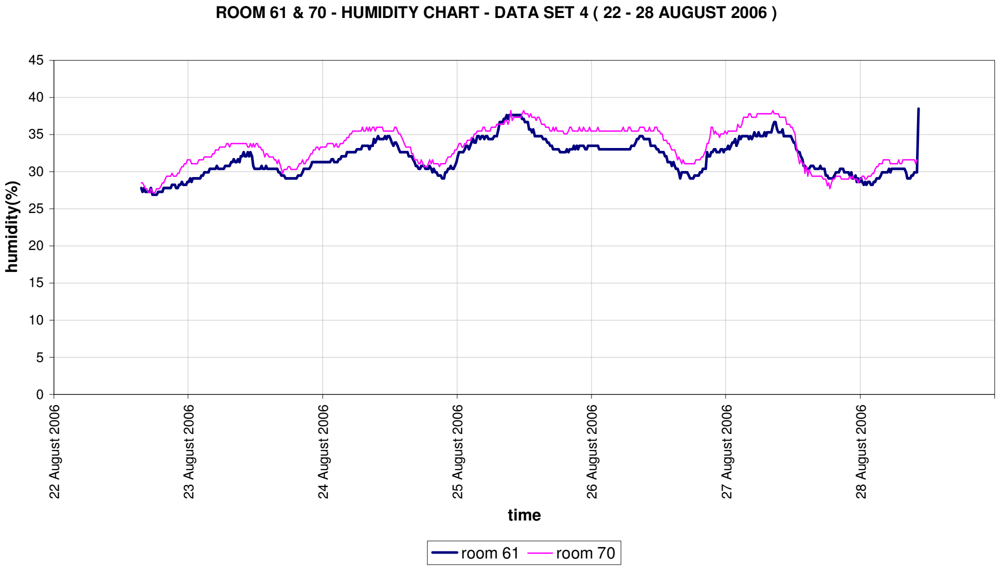


Figure 4.8b. Humidity chart for Data Set 4.

4.1.5. Data Set 5

This data set was recorded in Room 23 and Room 31 concurrently. These rooms are located opposite to each other. Room 23 (Figure 4.9) has east-facing windows. Room 31 (Figure 4.10), on the other hand has west facing floor-to-ceiling windows to the exterior.

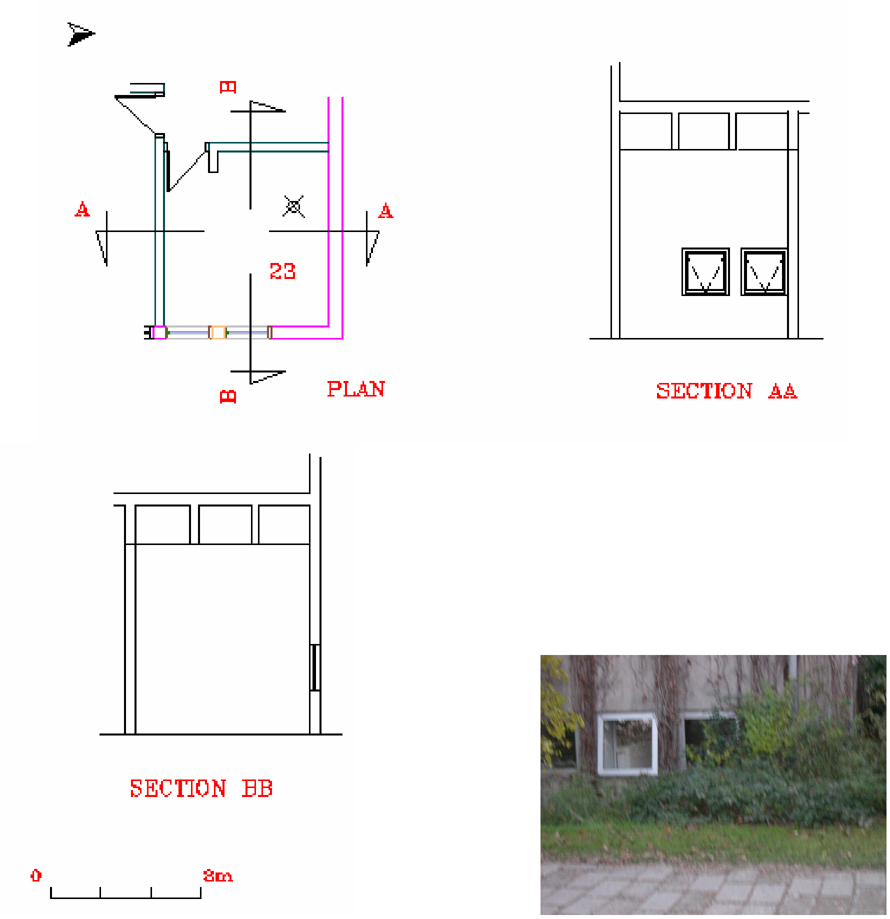


Figure 4.9. Floor plan, section AA, section BB and exterior view of Room 23. (photo by the author.)

There is dense vegetation in front of these rooms. Room 31 also has a mezzanine. The condensed data (Table 4.5) and temperature and humidity charts for these rooms are given below (Figure 4.11a) and (Figure 4.11b).

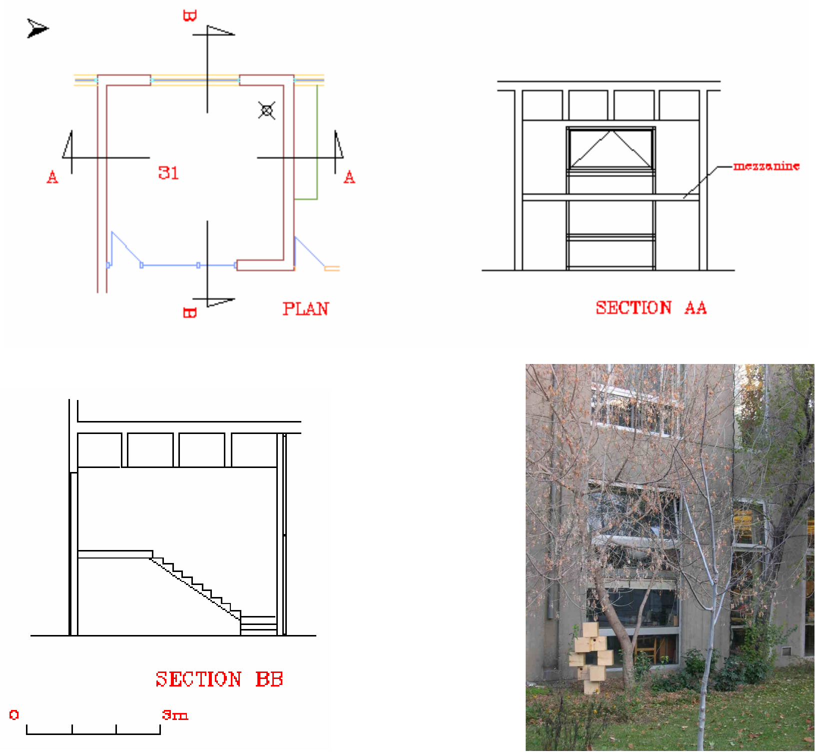


Figure 4.10. Floor plan, section AA, section BB and exterior view of Room 31. (photo by the author.)

Table 4.5. Information regarding rooms and weather conditions for Data Set 5.

BUILDING	METU Faculty of Architecture Building					
ROOM NO	R23				R31	
FLOOR AREA	11,9 M²				20,4 M²	
WINDOWS AREA	1,76 M²				8,48 M²	
HEIGHT	4,6 M				4,6 M	
ORIENTATION	East				West	
DATALOGGER	dc4				dc1	
RECORD	28.08.2006-10:25------31.08.2006-13:56				28.08.2006-10:30------31.08.2006-13:56	
DATE	CLOUDINESS		WIND			OTHER
dd / mm / yy	9:00 AM	3:00 PM	9:00 AM	3:00 PM	9:00 PM	CONDITIONS
28.08.2006	clear	clear	calm	calm	light breeze	
29.08.2006	clear	clear	mild	mild	calm	
30.08.2006	clear	clear	calm	light breeze	light breeze	
31.08.2006	clear	clear	calm	calm		
Notes:						
Roller blinds in room 23 were closed. In room 31, roller blinds were closed on ground floor while roller blinds in mezzanine were open.						

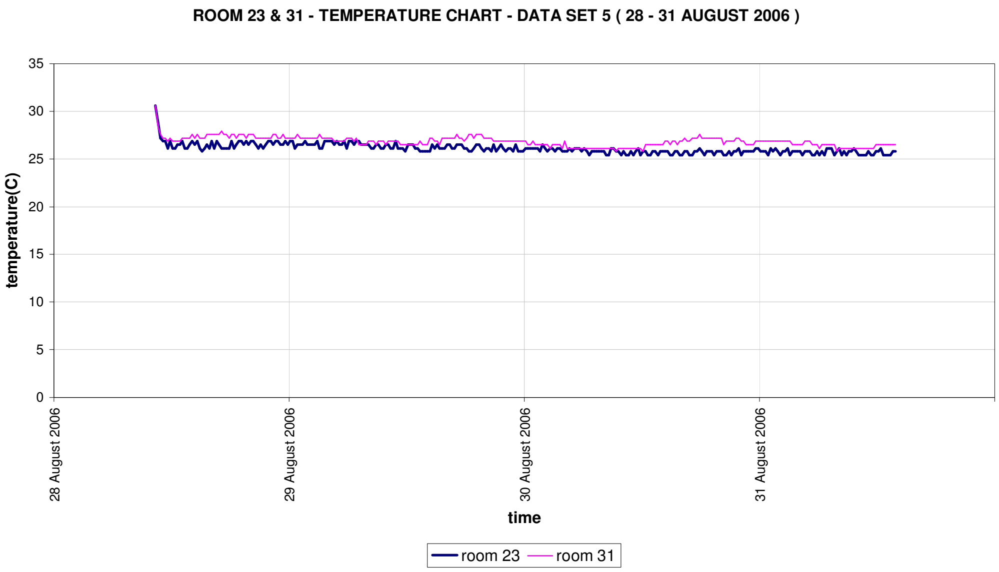


Figure 4.11a. Temperature chart for Data Set 5.

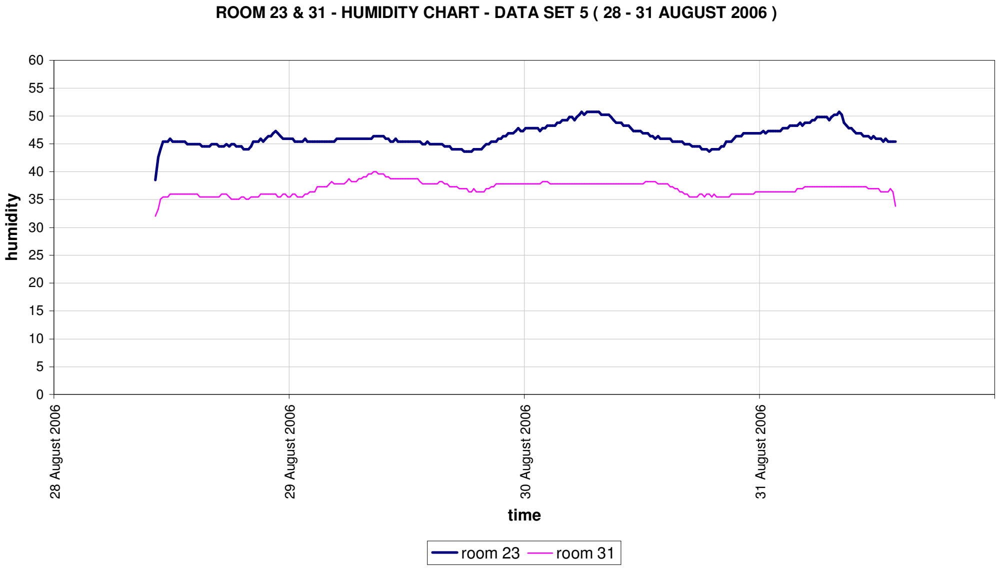


Figure 4.11b. Humidity chart for Data Set 5.

4.1.6. Data Set 6

This data set includes the temperature and humidity data of Room 46, Room 22, and building exterior, concurrently. Room 46 is located on the floor above Room 22. Room 46 (Figure 4.12) and Room 22 (Figure 4.13) have west-facing floor-to-ceiling windows overlooking the same garden. Furthermore, both of these rooms have the sun shading devices such as egg-crate concrete grill and covered balcony. The condensed data (Table 4.6) and temperature and humidity charts for these rooms are given below (Figure 4.14a) and (Figure 4.14b).

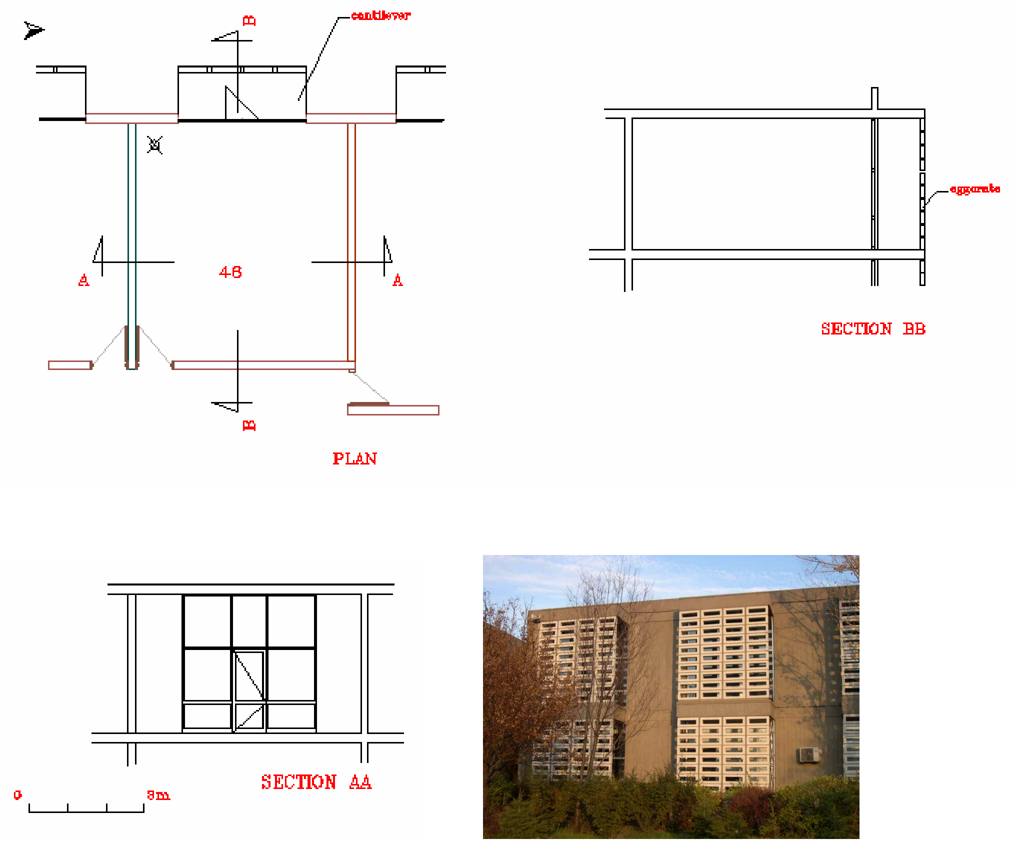


Figure 4.12. Floor plan, section AA, section BB and exterior view of Room 46. (photo by the author.)

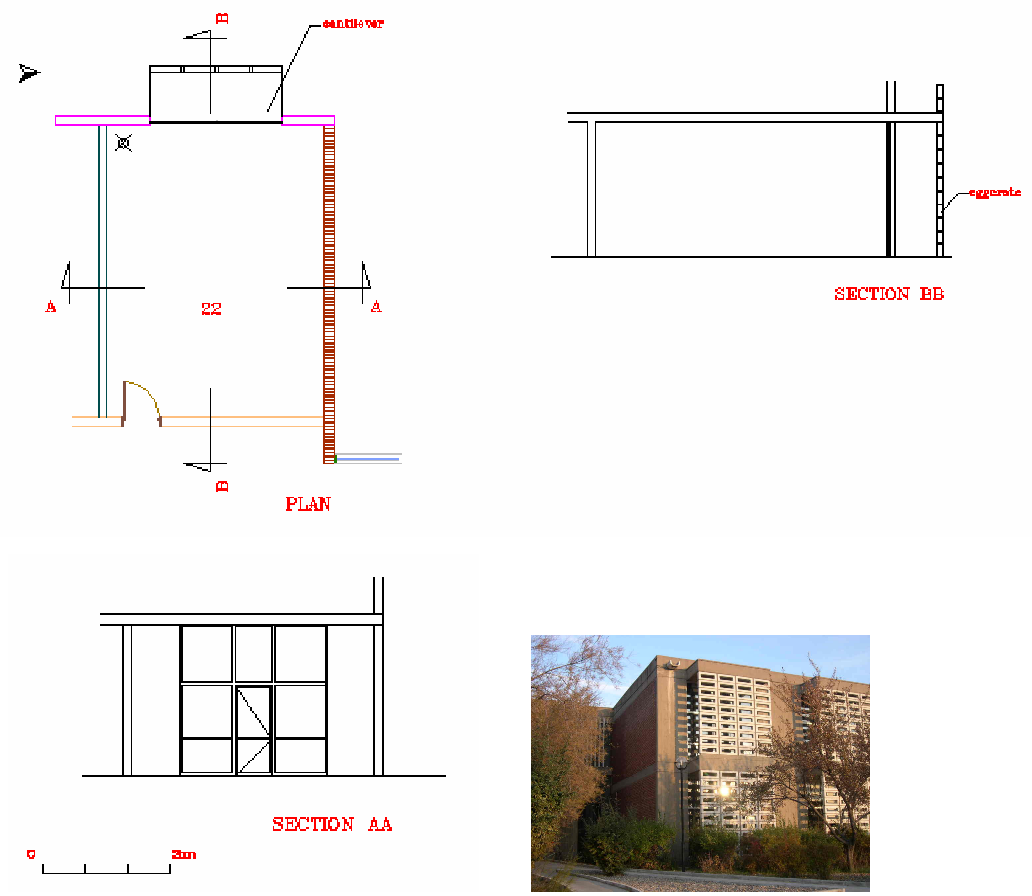


Figure 4.13. Floor plan, section AA, section BB and exterior view of Room 22. (photo by the author.)

Table 4.6. Information regarding rooms and weather conditions for Data Set 6.

BUILDING	METU Faculty of Architecture Building					
ROOM NO	R46		R22			Outdoor
FLOOR AREA	37,7 M²		44,95 M²			
WINDOWS AREA	12,6 M²		12,6 M²			
HEIGHT	3,59 M		3,6 M			
ORIENTATION	West		West			
DATALOGGER	dc2		dc4			dc1
RECORD	1.9.2006-11:45--5.9.2006-9~10:00		1.9.2006-11:42--5.9.2006-9~10:00			1.9.2006-12:10
DATE	CLOUDINESS		WIND			OTHER
dd / mm / yy	9:00 AM	3:00 PM	9:00 AM	3:00 PM	9:00 PM	CONDITIONS
01.09.2006	overcast	overcast	mild	mild	mild	in september 1, storm and rain around 18:20 and still goes on at 19:45.
02.09.2006	partial	partial	calm	calm	calm	
03.09.2006	clear	partial	calm	calm	calm	
04.09.2006	clear	clear	calm	calm	calm	
05.09.2006	clear		calm			
Notes:						
Black curtains in both rooms were open during the record.						

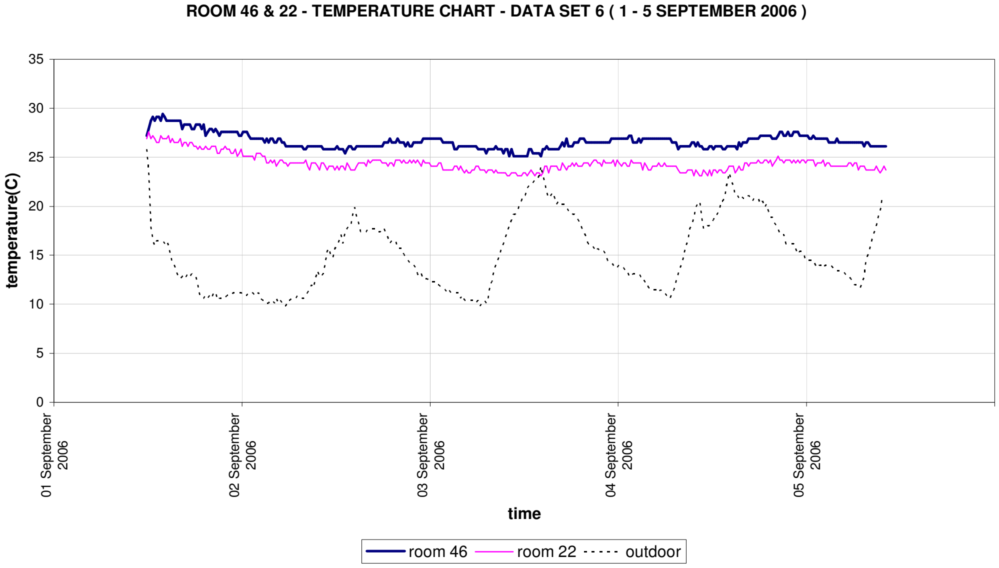


Figure 4.14a. Temperature chart for Data Set 6.

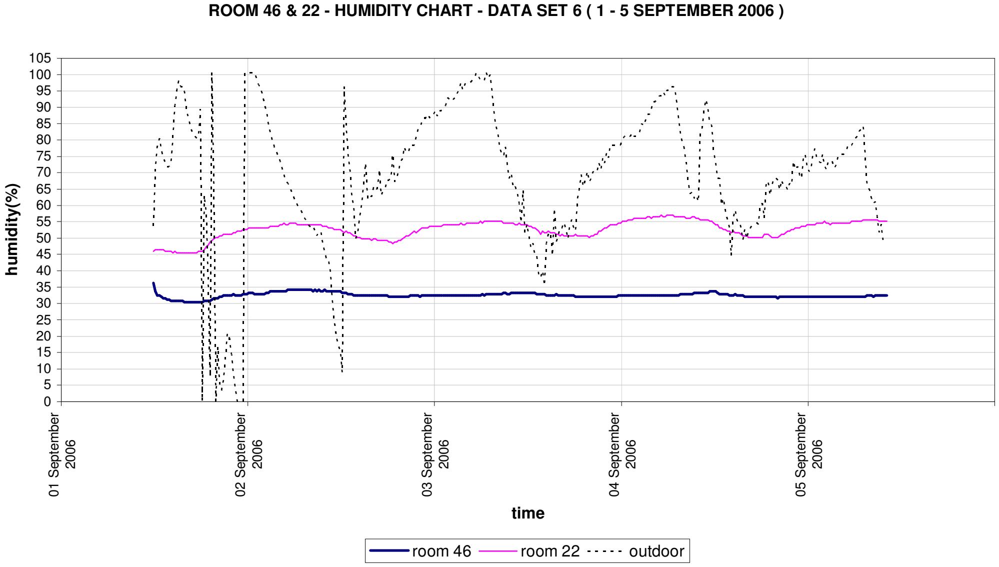


Figure 4.14b. Humidity chart for Data Set 6.

4.1.7. Data Set 7

This data set includes the temperature and humidity data of room 85 (Figure 4.15), Room 71, and the exterior of the building, concurrently. Room 85 has two small east-facing windows, while the east-facing windows of Room 71 (Figure 4.16) are floor-to-ceiling windows. The ceiling heights of the two rooms are also very different, as can be seen from the sections given below; Room 85 is 4.61m high and Room 71 is 3.07m high. The condensed data (Table 4.7) and temperature and humidity charts for these rooms are given below (Figure 4.17a) and (Figure 4.17b).

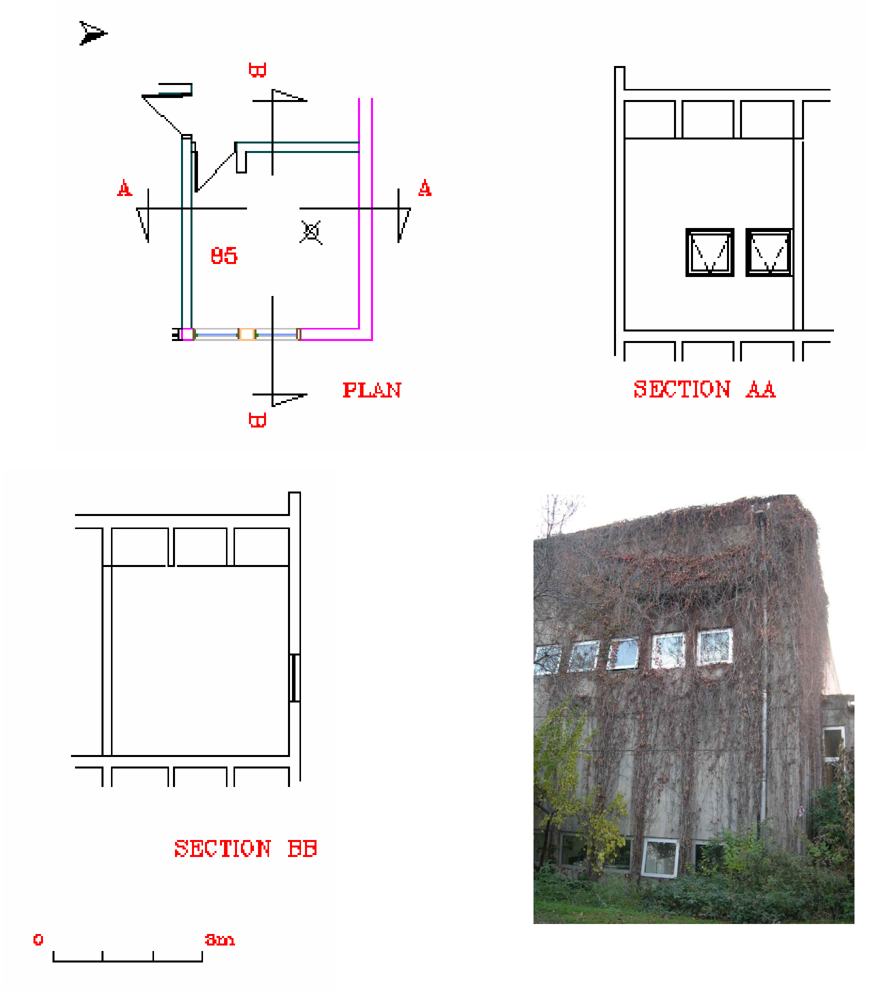


Figure 4.15. Floor plan, section AA, section BB and exterior view of Room 85. (photo by the author.)

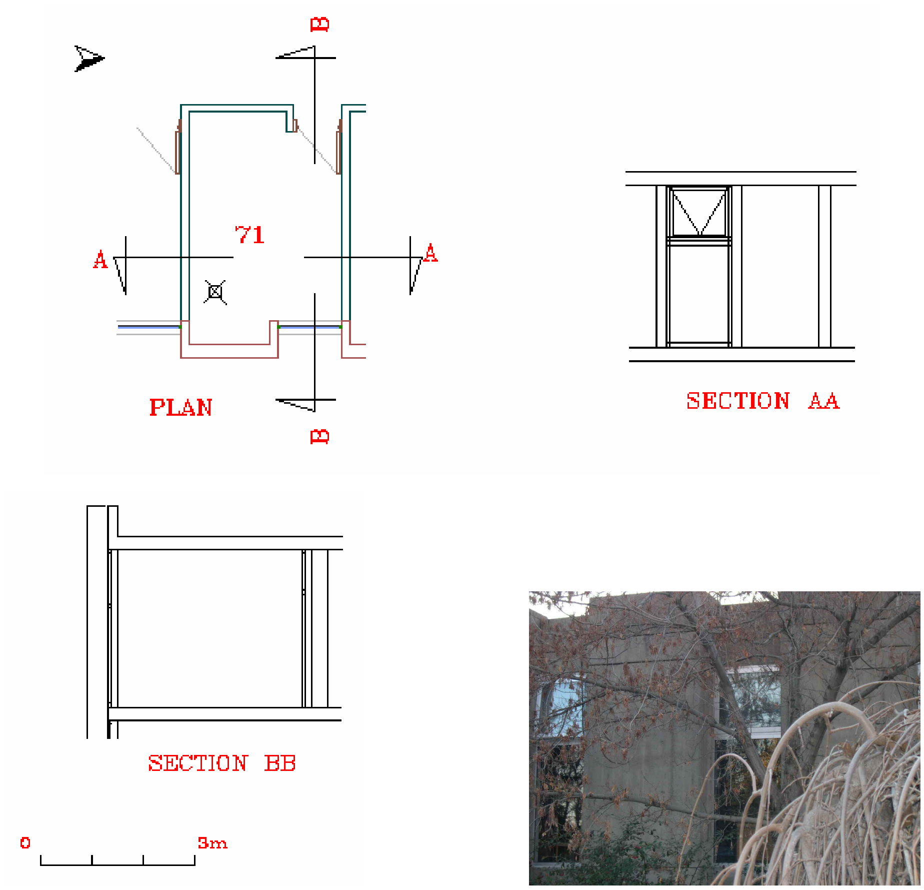
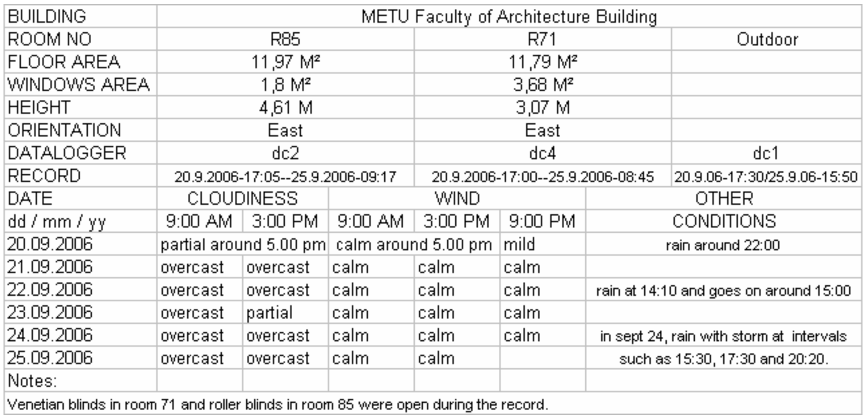


Figure 4.16. Floor plan, section AA, section BB and exterior view of Room 71. (photo by the author.)

Table 4.7. Information regarding rooms and weather conditions for Data Set 7.



<table>
<tr><td>BUILDING</td><td colspan="6">METU Faculty of Architecture Building</td></tr>
<tr><td>ROOM NO</td><td colspan="2">R85</td><td colspan="3">R71</td><td>Outdoor</td></tr>
<tr><td>FLOOR AREA</td><td colspan="2">11,97 M²</td><td colspan="3">11,79 M²</td><td></td></tr>
<tr><td>WINDOWS AREA</td><td colspan="2">1,8 M²</td><td colspan="3">3,68 M²</td><td></td></tr>
<tr><td>HEIGHT</td><td colspan="2">4,61 M</td><td colspan="3">3,07 M</td><td></td></tr>
<tr><td>ORIENTATION</td><td colspan="2">East</td><td colspan="3">East</td><td></td></tr>
<tr><td>DATALOGGER</td><td colspan="2">dc2</td><td colspan="3">dc4</td><td>dc1</td></tr>
<tr><td>RECORD</td><td colspan="2">20.9.2006-17:05--25.9.2006-09:17</td><td colspan="3">20.9.2006-17:00--25.9.2006-08:45</td><td>20.9.06-17:30/25.9.06-15:50</td></tr>
<tr><td>DATE</td><td colspan="2">CLOUDINESS</td><td colspan="3">WIND</td><td>OTHER</td></tr>
<tr><td>dd / mm / yy</td><td>9:00 AM</td><td>3:00 PM</td><td>9:00 AM</td><td>3:00 PM</td><td>9:00 PM</td><td>CONDITIONS</td></tr>
<tr><td>20.09.2006</td><td colspan="2">partial around 5.00 pm</td><td colspan="2">calm around 5.00 pm</td><td>mild</td><td>rain around 22:00</td></tr>
<tr><td>21.09.2006</td><td>overcast</td><td>overcast</td><td>calm</td><td>calm</td><td>calm</td><td></td></tr>
<tr><td>22.09.2006</td><td>overcast</td><td>overcast</td><td>calm</td><td>calm</td><td>calm</td><td>rain at 14:10 and goes on around 15:00</td></tr>
<tr><td>23.09.2006</td><td>overcast</td><td>partial</td><td>calm</td><td>calm</td><td>calm</td><td></td></tr>
<tr><td>24.09.2006</td><td>overcast</td><td>overcast</td><td>calm</td><td>calm</td><td>calm</td><td>in sept 24, rain with storm at intervals</td></tr>
<tr><td>25.09.2006</td><td>overcast</td><td>overcast</td><td>calm</td><td>calm</td><td></td><td>such as 15:30, 17:30 and 20:20.</td></tr>
<tr><td>Notes:</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="7">Venetian blinds in room 71 and roller blinds in room 85 were open during the record.</td></tr>
</table>

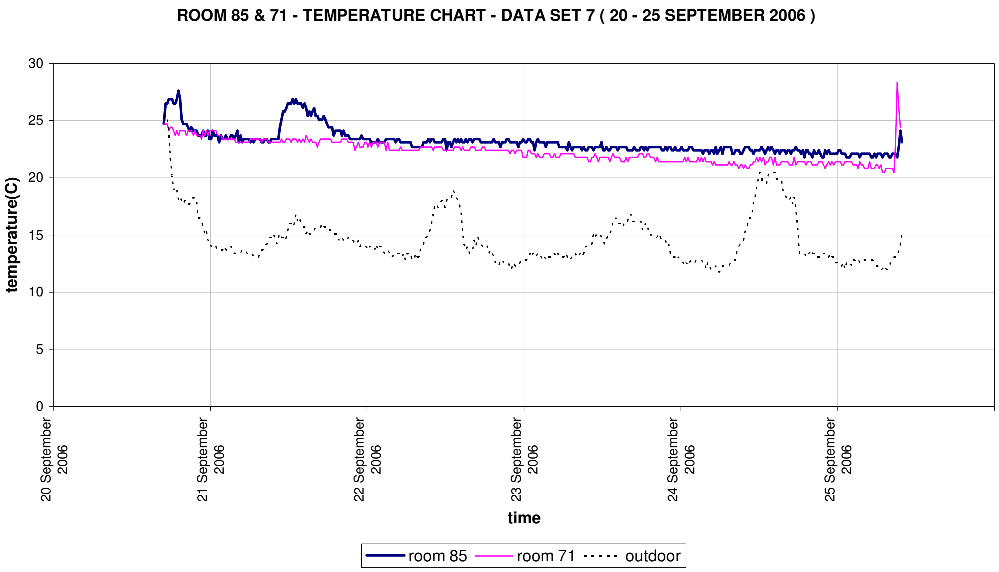


Figure 4.17a. Temperature chart for Data Set 7.

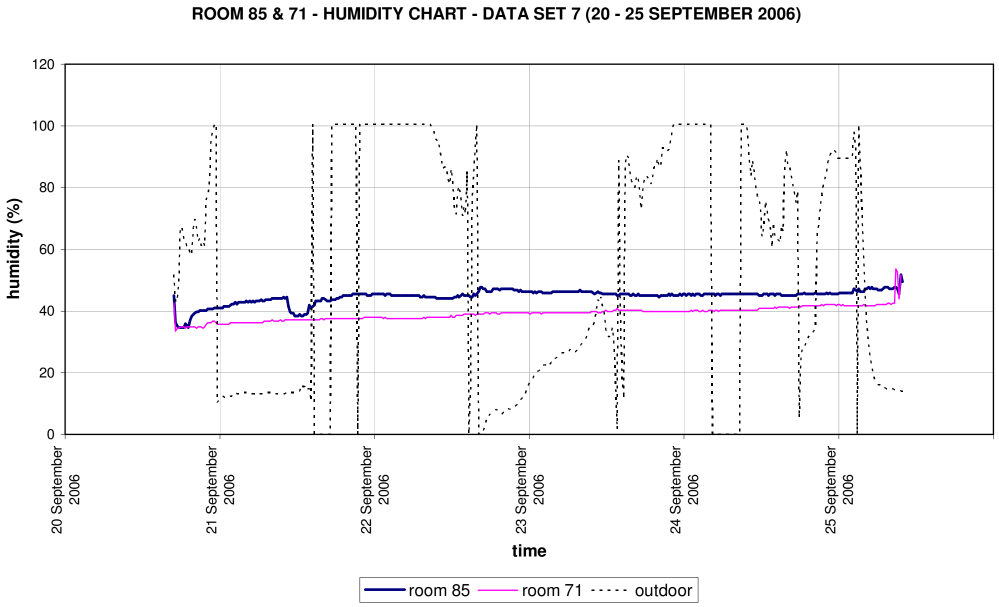


Figure 4.17b. Humidity chart for Data Set 7.

4.2. Hypotheses Tested

Null hypotheses (H_{01} and H_{02}) were tested with the help of ANOVA for the temperature and humidity data.

4.2.1. ANOVA for Data Set 1 and 2

Making a comparison or an evaluation for Data Set 2 was not possible because the data were collected for only Room 85 in this data set. Therefore, this data set was combined with Data Set 1 to create the comparison groups for ANOVA (see Table 4.8). These data sets were recorded in different periods during July 2006. However, similar external climatic conditions made this combination possible. Temperature in Rooms 54, 57 and 85 and outdoor temperature for July 2006 are presented in Figure 4.18 below.

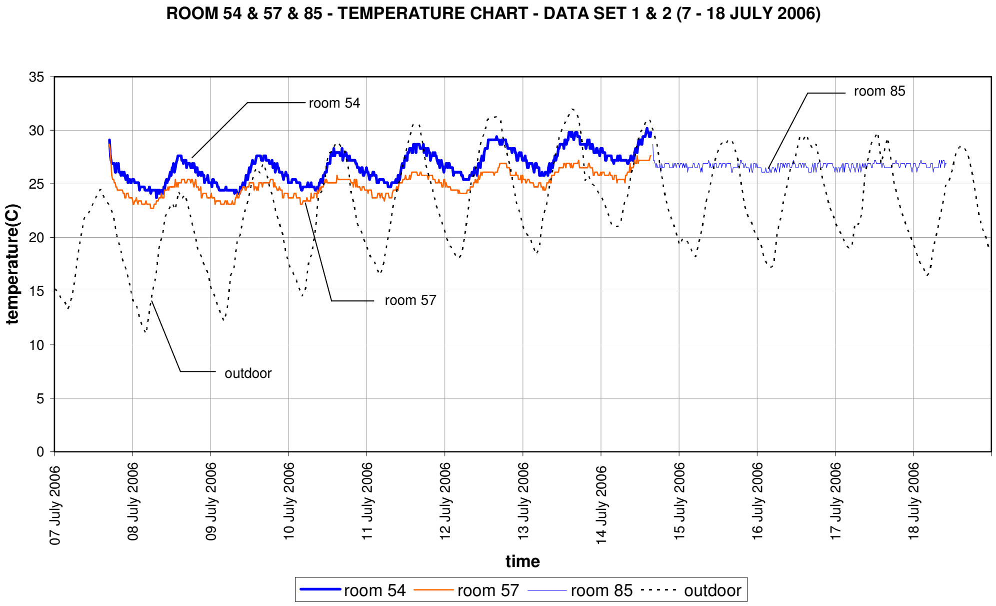
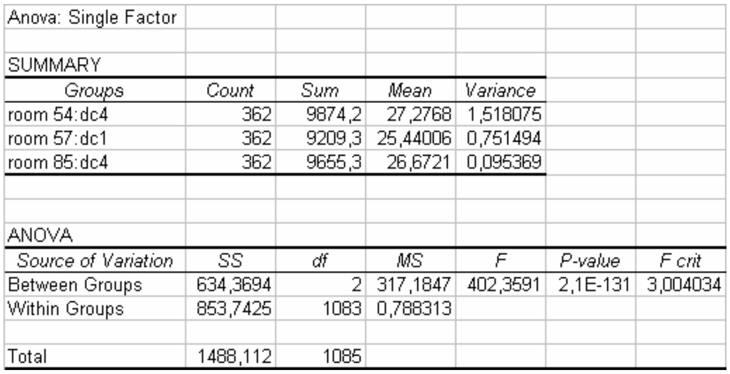


Figure 4.18. Temperature chart for Data Set 1 & 2.

$H_{01:}$ There is no difference between the temperatures in Room 54, Room 57 and Room 85.

Table 4.8. ANOVA for temperature data of rooms 54, 57 and 85.

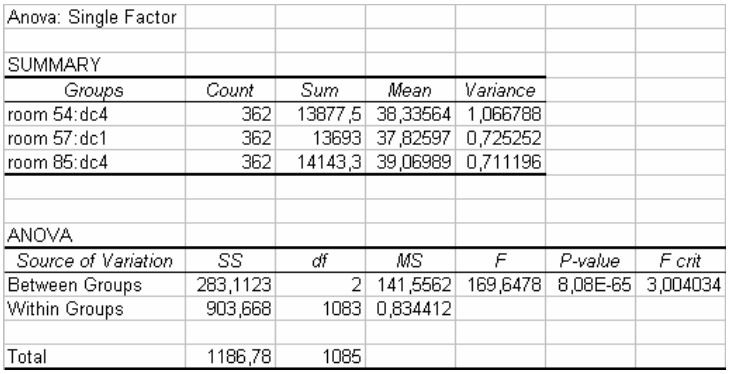


Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Mean*	*Variance*		
room 54:dc4	362	9874,2	27,2768	1,518075		
room 57:dc1	362	9209,3	25,44006	0,751494		
room 85:dc4	362	9655,3	26,6721	0,095369		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	634,3694	2	317,1847	402,3591	2,1E-131	3,004034
Within Groups	853,7425	1083	0,788313			
Total	1488,112	1085				

According to Table 4.8, value of F_{calc}> F_{crit}, therefore, H_{01} is rejected (i.e. there is a significant difference between the temperatures in the three rooms). Average temperatures in these rooms are expected values when the orientation of the windows and the rooms are considered. As seen in the temperature charts in section 4.1, there are strong fluctuations in Room 54 and Room 57 as compared to Room 85. These fluctuations confirm the thermal mass effect in this building. Changing of temperature is faster in these rooms because of floor-to-ceiling windows. On the contrary, Room 85 has more stable temperature because it has small windows and more exterior concrete walls. These walls prevent excessive warming in Room 85 and keep the indoor temperature at a certain level. Another point is that, Room 54 is expected to be much hotter than the other two rooms because of the south-orientation of its floor to ceiling window. On the other hand, average temperature of this room might have been affected from closed blinds until certain period and cooling effect of vegetation in the atrium.

H_{02}: There is no difference between the humidity in rooms 54, 57 and 85.

Table 4.9. ANOVA for humidity data of rooms 54, 57 and 85.



Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Mean*	*Variance*
room 54:dc4	362	13877,5	38,33564	1,066788
room 57:dc1	362	13693	37,82597	0,725252
room 85:dc4	362	14143,3	39,06989	0,711196

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	283,1123	2	141,5562	169,6478	8,08E-65	3,004034
Within Groups	903,668	1083	0,834412			
Total	1186,78	1085				

According to Table 4.9, there is a significant difference between the humidity in these rooms. It is expected that Room 57 facing north orientation show larger humidity values than the other two rooms. However, Room 54 and Room 85 had more humidity because of the effect of vegetation next to their windows; Room 54 overlooks the interior garden and Room 85 is covered with vines on its two exterior walls. We can say that microclimatic weather conditions increased the humidity levels for Room 85 and Room 54. At first stages of the recording period, certain part of the Venetian blinds in Room 54 were closed, this may have caused higher humidity levels in this room compared to Room 57. On the other hand, humidity level of Room 57 reached the humidity level of Room 54 at a point on the humidity chart when the Venetian blinds in Room 54 were opened (July 12); thereafter, these two humidity level were almost equal.

4.2.2. ANOVA for Data Set 3 and 4

Making a comparison or an evaluation for Data Set 3 was not possible because the data was collected for Room 79 only. Therefore, this data set was combined with Data Set 4 to create comparison groups for ANOVA (see Table 4.10). These data sets were recorded in different periods during August 2006. However, similar external climatic conditions made this combination possible. Rooms 79, 61 and 70 and outdoor temperature for August 2006 are presented in Figure 4.19:

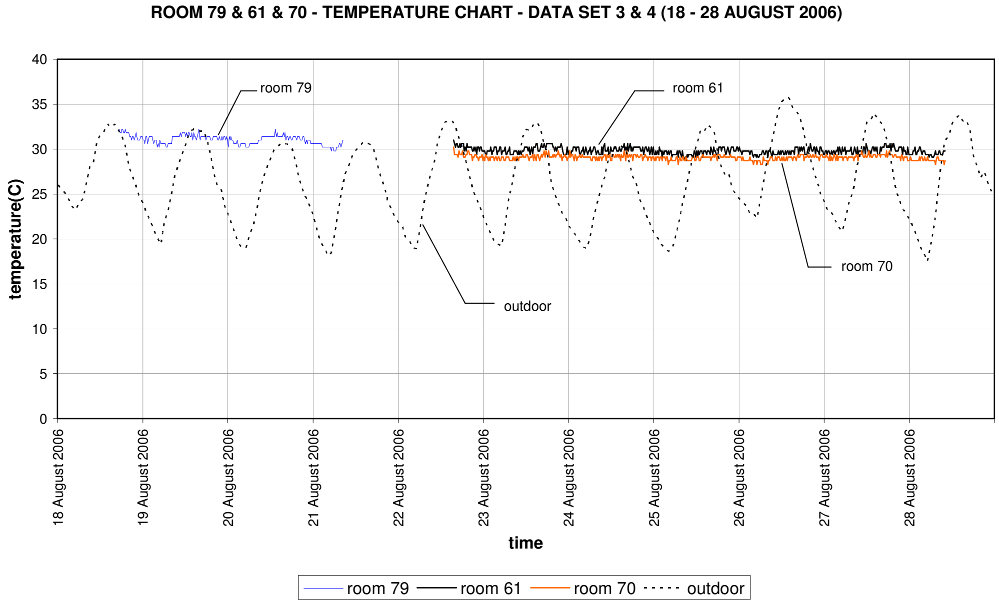
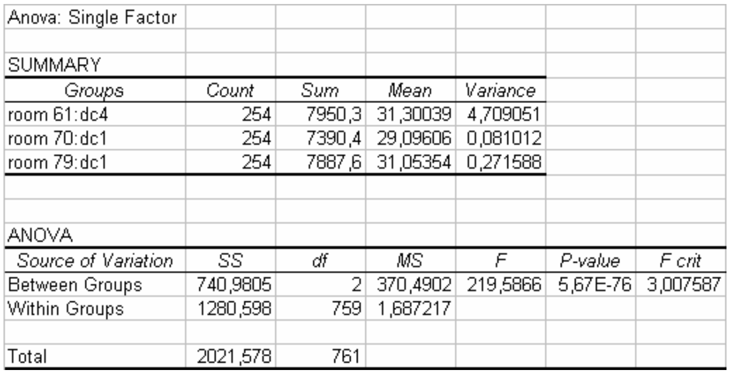


Figure 4.19. Temperature chart for Data Set 3 & 4.

H_{01}: There is no difference between the temperatures in the rooms 61, 70 and 79.

Table 4.10. ANOVA for temperature data of rooms 61, 70 and 79.

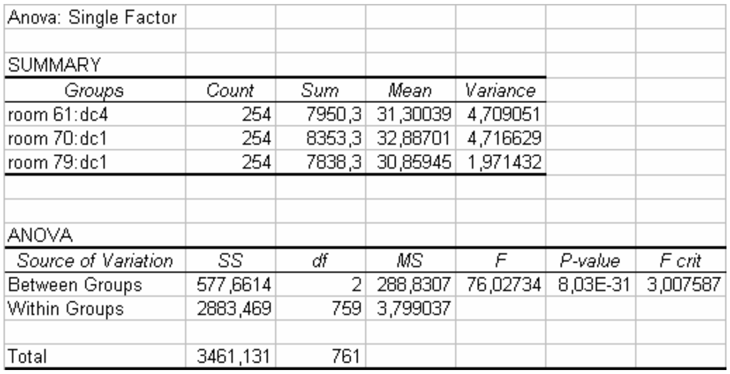


Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Mean*	*Variance*		
room 61:dc4	254	7950,3	31,30039	4,709051		
room 70:dc1	254	7390,4	29,09606	0,081012		
room 79:dc1	254	7887,6	31,05354	0,271588		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	740,9805	2	370,4902	219,5866	5,67E-76	3,007587
Within Groups	1280,598	759	1,687217			
Total	2021,578	761				

$F_{calc} > F_{crit}$ as seen in table 4.10 H_{01} is rejected. Hence, it can be said that there is a significant difference between the temperatures in the rooms. Room 61 is expected to have higher temperature than others, due to its west orientation, however the average temperature value of Room 79 is very close to that of Room 61. In the temperature chart (Figure 4.5a), temperature curve of Room 79 is seen to be stable, however its average temperature is higher than that in Room 70, which has the same orientation but much smaller window area. Larger windows and larger indoor surfaces having heat storage capacity might be the reason of this situation. Horizontal shading device to the east of Room 79 is not very effective since the sun is low in both summer and winter for east and west directions. Furthermore, in front of Room 61, there is a tree which partly prevents sunlight from entering the west-oriented window and keeps the temperature at lower level.

H_{02}: There is no difference between the humidity in the rooms 61, 70 and 79.

Table 4.11. ANOVA for humidity data of rooms 61, 70 and 79.



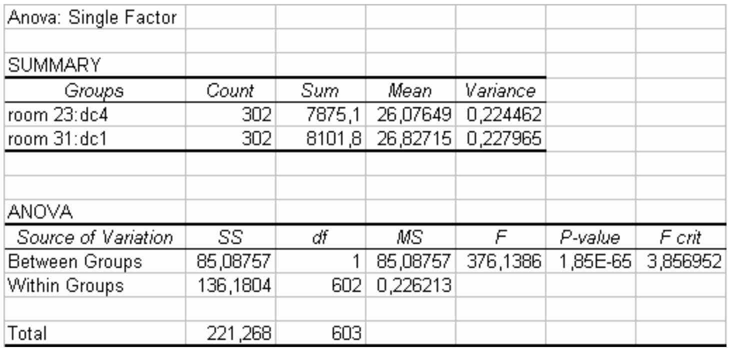
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Mean*	*Variance*		
room 61:dc4	254	7950,3	31,30039	4,709051		
room 70:dc1	254	8353,3	32,88701	4,716629		
room 79:dc1	254	7838,3	30,85945	1,971432		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	577,6614	2	288,8307	76,02734	8,03E-31	3,007587
Within Groups	2883,469	759	3,799037			
Total	3461,131	761				

Since the table 4.11 shows the $F_{calc}>F_{crit}$, there is a significant difference between the humidity in the rooms. Temperature curves for each room are stable. However, humidity values for Room 61 and Room 70 show fluctuations whereas humidity values of Room 79 are steady. While looking at average humidity values Room 70, which was cooler, was expected to have higher values compared to other rooms. Despite the fact that temperature values of Room 61 and Room 79 were closer to each other, Room 61 had higher average humidity value than that of Room 79. All the Venetian blinds were closed during the recording period. Exterior concrete wall of Room 61 might have caused more humidity than the humidity of Room 79 having no exterior wall. Room 61 overlooks an open courtyard, but is always shaded because of the surrounding building and the tree next to its window; this may be the reason for more humidity in this room.

4.2.3. ANOVA for Data Set 5

H_{01}: There is no difference between the temperatures in the two rooms (23 and 31).

Table 4.12. ANOVA for temperature data of rooms 23 and 31.

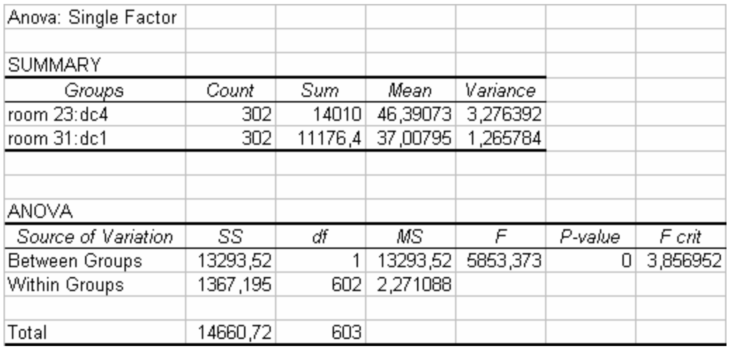


Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Mean*	*Variance*		
room 23:dc4	302	7875,1	26,07649	0,224462		
room 31:dc1	302	8101,8	26,82715	0,227965		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	85,08757	1	85,08757	376,1386	1,85E-65	3,856952
Within Groups	136,1804	602	0,226213			
Total	221,268	603				

Since the table 4.12 shows the $F_{calc}>F_{crit}$, there is a significant difference between the temperatures in the two rooms. Temperature values for these rooms were close to each other although Room 31 faces west and Room 23 faces east. This situation may be explained by the fact that Room 31 has floor-to-ceiling window and a garden next to it, which creates cooling microclimatic effects. On the other hand, Room 23 has smaller windows and more exterior wall area , which creates more thermal mass effect.

H_{02}: There is no difference between the humidity in the two rooms (23 and 31).

Table 4.13. ANOVA for humidity data of rooms 23 and 31.



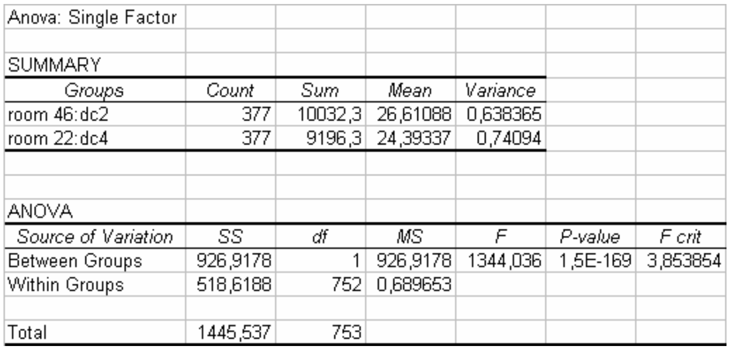
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Mean*	*Variance*		
room 23:dc4	302	14010	46,39073	3,276392		
room 31:dc1	302	11176,4	37,00795	1,265784		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	13293,52	1	13293,52	5853,373	0	3,856952
Within Groups	1367,195	602	2,271088			
Total	14660,72	603				

According to Table 4.13, there is a significant difference between the humidity in the two rooms. Room 23 is cooler than Room 31 because of the orientation of its windows. Moreover, it has exterior wall surfaces facing east and north directions, which are also covered with vines. These vines are known to prevent direct effect of sun light and retain humidity.

4.2.4. ANOVA for Data Set 6

H_{01}: There is no difference between the temperatures in the two rooms (46 and 22).

Table 4.14. ANOVA for temperature data of rooms 46 and 22.

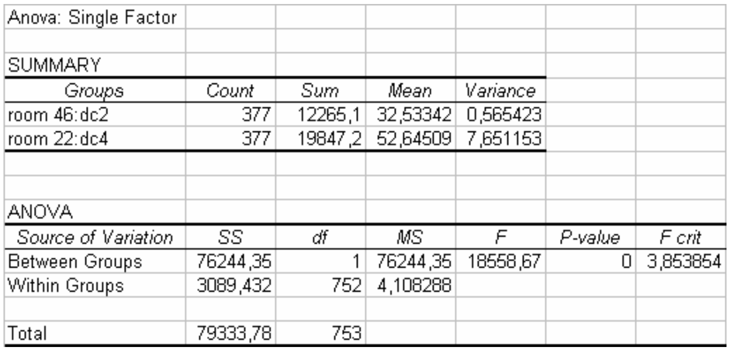


Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Mean*	*Variance*		
room 46:dc2	377	10032,3	26,61088	0,638365		
room 22:dc4	377	9196,3	24,39337	0,74094		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	926,9178	1	926,9178	1344,036	1,5E-169	3,853854
Within Groups	518,6188	752	0,689653			
Total	1445,537	753				

Since the table 4.14 shows the $F_{calc} > F_{crit}$, there is a significant difference between the temperatures in Room 46 and Room 22. Windows of these rooms face the west orientation. However, temperature values of Room 46 are higher than that in Room 22 according to average values in Table 4.14 and temperature curve in Figure 4.14a. Stable values belonging to each room indicated the effect of thermal mass. Room 22 is cooler than Room 46 because it has more exterior walls exposed to climatic effects, and larger interior volume as compared to Room 46. Room 22 also had an exterior wall facing the north direction and this wall was always shaded. Furthermore, cooling effect of vegetation around this room might be more effective in lowering its temperature.

H_{02}: There is no difference between the humidity in rooms 46 and 22.

Table 4.15. ANOVA for humidity data of rooms 46 and 22.



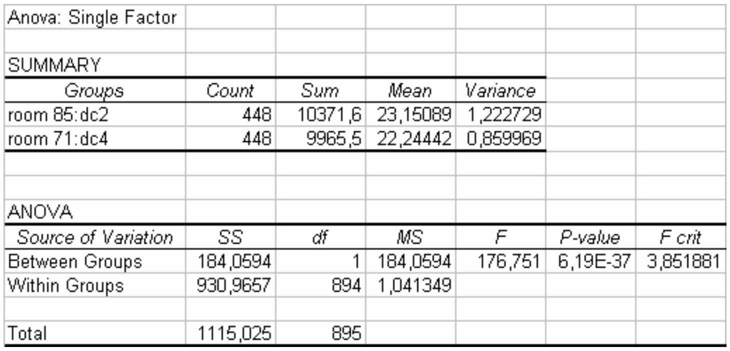
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Mean*	*Variance*		
room 46:dc2	377	12265,1	32,53342	0,565423		
room 22:dc4	377	19847,2	52,64509	7,651153		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	76244,35	1	76244,35	18558,67	0	3,853854
Within Groups	3089,432	752	4,108288			
Total	79333,78	753				

According to ANOVA Table 4.15, there is a significant difference between the humidity in Room 46 and Room 22. As noted in the discussions related to temperatures of these two rooms, Room 22 was much cooler than Room 46, consequently, humidity level of Room 22 was higher than that in Room 46. According to the humidity chart of Room 22, it should be noted that there were periodic fluctuations also; daily exterior temperature variations may have caused this fluctuations.

4.2.5. ANOVA for Data Set 7

H_{01}: There is no difference between the temperatures in rooms 85 and 71.

Table 4.16. ANOVA for temperature data of rooms 85 and 71.

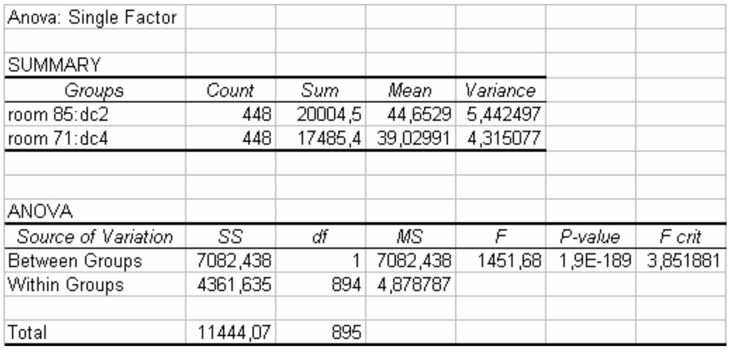


Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Mean*	*Variance*		
room 85:dc2	448	10371,6	23,15089	1,222729		
room 71:dc4	448	9965,5	22,24442	0,859969		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	184,0594	1	184,0594	176,751	6,19E-37	3,851881
Within Groups	930,9657	894	1,041349			
Total	1115,025	895				

According to Table 4.16, since $F_{calc}>F_{crit}$, there is a significant difference between the temperatures in Room 85 and Room 71. Average temperature values in Table 4.16 and temperature curve in Figure 17.a confirmed that the temperature values in Room 85 were higher than those in Room 71, even though these two rooms face the east orientation. It was surprising that temperatures in Room 85 were higher than those in Room 71 because Room 85 had more exterior wall surfaces, which included a wall facing the north direction, and also had much smaller windows and larger interior volume as compared to Room 71. This situation might be explained by the fact that Room 85 had more wall surfaces having heat storage capacity and a thermal insulation panel on inside the wall exposed to North direction. On the other hand, floor-to-ceiling windows in Room 71 allow more sun light to enter the interior, but in the evening, indoor heat is lost through these windows easily as compared to the smaller windows in Room 85.

H_{02}: There is no difference between the humidity in rooms 85 and 71.

Table 4.17. ANOVA for humidity data of rooms 85 and 71.



Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Mean*	*Variance*		
room 85:dc2	448	20004,5	44,6529	5,442497		
room 71:dc4	448	17485,4	39,02991	4,315077		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	7082,438	1	7082,438	1451,68	1,9E-189	3,851881
Within Groups	4361,635	894	4,878787			
Total	11444,07	895				

According to Table 4.17, the $F_{calc}>F_{crit}$, there is a significant difference between the humidity in Room 85 and Room 71. from Table 4.17 and Figure 4.17b it could be seen that humidity values in Room 85 were higher than those in Room 71. This was again an unexpected result because we know the temperature values in Room 85 were higher than those in Room 71, from previous discussion section. This could be explained as a result of microclimatic influences on the surfaces of the exterior walls of Room 85 which are covered with vines. In this situation, vines might have increased the humidity level in Room 85 though temperature values were higher than those in Room 71.

CHAPTER 5

CONCLUSION

This study focused on assessing thermal comfort conditions in the METU faculty of architecture building, which is situated in Ankara. The aim of the study was to understand and evaluate the effects of design dependent elements such as thermal mass, size and orientation of windows, shading, and surrounding vegetation on thermal comfort conditions in the case study building. To perform this study, data loggers were used to record temperature and humidity data in predetermined rooms of the case study building. Data were collected during certain periods in July, August, and September 2006. It was not possible to record the temperature and humidity data in all the predetermined rooms concurrently due to shortage of data loggers. Meanwhile, measurements of windows and exterior photos of rooms were obtained. Moreover, data related to exterior weather conditions were recorded during the study.

At the end of the study, raw data collected by data loggers were converted to graphs and statistical test (ANOVA) was applied to raw data. Analysis and discussions were done by using temperature and humidity graphs, and ANOVA test. Following design parameters helped the author to evaluate the results of the ANOVA test and temperature and humidity graphs; these influences are explained in more detail in the following paragraphs:

- Orientation and size of windows.
- Orientation and size of room, including height of ceilings.
- Thermal mass effect
- Vegetation next to windows of the room investigated.

- Sun control device or shading from any obstacle.
- Blinds/curtains being closed or open during data logging.

This study showed that temperature and humidity data graphs, and ANOVA test results were compatible with each other. Findings about the effects of design dependent parameters on thermal conditions in the rooms were summarized as below:

Thermal mass:

- High thermal mass in the thick concrete walls and slabs caused stable temperature in the rooms facing East and West directions (*e.g.* in rooms 85, 79, 61 and Room 70).
- Rooms with more thermal mass had higher temperature values. Room 79, for instance, had more interior wall surfaces than those in Room 70.
- Thermal mass effect is more obvious in rooms with smaller windows (*e.g.* in Room 23 and Room 85).

Orientation and size of windows:

- Rooms with windows facing East , West or South were warmer than those with windows on the North (*e.g.* Room 54 and Room 85 have higher temperature than that in Room 57).
- Floor-to-ceiling windows caused heat loss at night and also strong temperature fluctuations (*e.g.* in rooms 54, 31 and Room 57).
- Rooms with smaller windows lost less heat at night, therefore they were hotter (*e.g.* Room 85 and Room 23).
- Size of the south and west facing windows should be smaller to control the amount of sunlight coming in, provided no sun shading or vegetation is to be used (*e.g.* Room 54 and Room 61).

Shading effects:

- Horizontal shading devices in rooms facing West and East orientation were not very effective (*e.g.* Room 79, Room 46 and Room 22)

- Neighbouring construction and trees next to windows provided shading and increased humidity values as in Room 61 or Room 22 which was cooler than Room 46 because it had an exterior wall, which was always shaded.
- Egg-crate concrete grills on the west of the balcony had no desirable effect on the thermal conditions in Room 46, and Room 22 because the lower sunlight from the west was not prevented from entering the rooms. This was because the concrete grills did not have a sufficient depth and were far from the windows. Moreover, the balconies in front of these rooms were not protected by grills on their southern façade, which allowed exposure to direct sunlight.

Orientation and size of room

- Depending on the orientation of the rooms, average temperatures in rooms changed ; those facing North orientation were cooler (*e.g*. Room 54 and Room 57).
- Rooms facing East and West directions had almost the same temperature when the size of the one facing west had a larger volume (*e.g*. Room 23, Room 31).
- Rooms with more exterior walls had higher humidity values especially when one was facing North or was shaded. For example Room 22 was cooler than Room 46 since it had an exterior wall facing north, and a larger volume.

Effects of vegetation

- There was a cooling effect of surrounding vegetation in the rooms (*e.g*. Room 22 and Room 31).
- Greenery in the atrium and vines on the walls caused higher humidity values; *e.g*. Room 85 and Room 54, even though they were hotter as compared to Room 57.
- Room 61 had a tree next to its window this tree prevented direct sunlight and kept the temperatures at lower level.

Blinds/curtains

- Closed Venetian blinds prevented overheating in Room 54.
- Closed Venetian blinds in Room 54 increased the humidity level.

- Closed blinds and curtains kept the temperatures stable in all the rooms with the help of night time insulation.

This study revealed that effect of thermal mass was almost the same for all the rooms investigated because whole building had been constructed with concrete curtain walls. It was also seen that building materials with high thermal storage capacity could improve thermal performance of buildings in Ankara climatic conditions if thermal insulation and necessary glazing was provided. Furthermore, other design parameters had an influence on thermal performance of the case study building when the location of rooms and size and orientation of the windows are considered.

There are many design approaches to improve building thermal performance, such as, environmental design, climate responsive design, energy efficient design, passive solar design, passive and low energy architecture *etc*. All these design approaches aim to improve the occupant's thermal comfort and thermal performance of the buildings without using excessive energy. The results of this research helped to highlight the energy efficient features of the case study building.

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APPENDIX A

MONTHLY TEMPERATURE DATA FOR ANKARA

Table A.1. Monthly Temperature Data for Ankara, July 2006
(Turkish State Meteorological Service)

hours	01.07. 2006	02.07. 2006	03.07. 2006	04.07. 2006	05.07. 2006	06.07. 2006	07.07. 2006	08.07. 2006	09.07. 2006	10.07. 2006
1	17,2	19,9	20,3	14,3	15,8	15,7	15,2	14,1	15,2	17,4
2	16,3	19,1	19,7	13	14,3	15,2	14,9	13,8	14,6	16,8
3	15,5	18	19,1	12	13,4	14,3	14,2	12,5	13,7	16,2
4	15,1	17,3	19,1	11,2	13	14	14	11,6	12,8	15,3
5	14,9	17,1	18,9	10,3	12,5	13,5	13,3	11	12,2	14,5
6	16,6	18,1	18,8	12,1	13,9	15,2	14,2	13	13,4	15,2
7	18,4	20	19,8	14	15,2	16,3	15,8	15	16,4	17,7
8	21,4	22,1	19,7	16	16,9	18,4	18,2	16,3	17,1	18,5
9	22,7	24,2	20,8	17,9	18,1	20,3	20,1	19	19,6	20,6
10	24,5	24,9	24,1	19,2	19,4	21,5	21,8	20,2	20,3	23,8
11	25	26	25	21,3	20,3	22,1	22	22	22,1	24,3
12	26,3	27,3	26,2	22,7	20,6	22,8	22,7	22,6	23	25,4
13	27,6	28,4	24,8	24,3	21,5	23	23,3	23,2	24,4	27,8
14	28,1	28,2	19	24,2	22,4	23,8	24	22,6	25,8	28
15	28,4	28,3	19,9	24,8	23,3	24	24,5	24,3	26,5	28,6
16	28,1	28,8	20,2	24,4	24,1	24,3	23,8	23,6	26	28,9
17	28,5	28,1	20,3	24,1	23,1	24,5	23,3	24	26,9	28,4
18	28,2	27,7	21,4	23,6	23,1	23,9	22,9	22,9	26,1	28,1
19	27,5	27,1	20,6	23,1	22,5	22,8	22	21,5	24,7	26,8
20	26,3	26	20,3	21,9	21,3	20,9	20,2	20,3	23,7	24,3
21	24,2	24,6	19,3	20,6	20,1	19,4	19,1	18,8	22,3	23
22	21,8	23,9	18,5	18,7	18,4	18	17,7	18,2	21,3	21,2
23	20,3	23	17,3	17,8	17,2	17,2	16,9	17,3	20,3	20,7
24	20,3	20,3	15,6	16,7	16,3	15,9	15,6	16,7	18,5	19,8

Table A.1. (Continued)

hours	11.07. 2006	12.07. 2006	13.07. 2006	14.07. 2006	15.07. 2006	16.07. 2006	17.07. 2006	18.07. 2006	19.07. 2006	20.07. 2006
1	19	20,4	20,9	23,8	19,3	19,9	21,3	19,3	18	18,3
2	18,2	19,4	20,3	23,1	19,9	19,4	20,7	18,4	17,4	17,5
3	18	19	20	22,3	19,8	18,1	20,1	17,6	16,8	16,7
4	17	18,4	19,1	21,3	19,3	17,4	19,4	17,1	16,3	16
5	16,5	18	18,4	21	18,5	17,2	19	16,4	16	15
6	17,5	18,4	19,2	21	18,2	17,4	19,1	16,8	16,2	15,8
7	19,3	20,2	21,9	21,4	19,6	20,4	21,4	19	18,1	18,4
8	20,9	22,4	22,8	23,2	20,9	21,7	21,2	20,3	20,2	19,3
9	23	25,3	24,7	23,8	23,1	23,4	22,2	21,8	21,9	21,2
10	24,3	26,1	26,3	25,7	24,2	24,8	25,8	23,3	23,3	22,3
11	25,4	27,3	27,9	27	25,7	26,3	27,4	25,1	24,5	23,4
12	26,8	29	29,3	28,8	27,3	26,9	28,8	25,4	25,6	23,8
13	28,2	29,7	30,2	29,8	28,2	28	29,3	26,5	27,2	26,2
14	29,3	31	30,8	30,3	28,8	29,4	29,8	27,9	27,2	26,7
15	30,5	31,1	31,4	31	28,6	29,1	26,9	28,4	28	27,8
16	30,6	31,2	32	30,9	29,1	29,6	28,1	28,6	28,6	28,1
17	30,5	31,3	31,8	29,8	29,1	28,7	29,3	28,1	28,2	28
18	28,9	30,9	31,1	28,8	28,3	28,3	27,2	27,4	27,5	27,3
19	26,8	28,8	29	26,8	27,2	28,7	25	25,9	26,7	26,3
20	25,7	27,8	25,3	24,8	24,9	27,2	23,8	24,1	25,2	24,9
21	24,6	26,5	25,8	23,3	23	25,4	22,7	22,2	23,4	23
22	23,2	24,7	25	22,1	22	24,3	21,7	20,9	22,2	21,6
23	22,3	23,1	24,8	21,4	21,5	22,9	20,8	20,2	21,2	20,2
24	21,4	22,2	24,2	20,4	20,6	22,3	20,1	19,1	19,6	19

hours	21.07. 2006	22.07. 2006	23.07. 2006	24.07. 2006	25.07. 2006	26.07. 2006	27.07. 2006	28.07. 2006	29.07. 2006	30.07. 2006	31.07. 2006
1	18,2	18,2	19,9	18,2	19,9	20,1	21,3	21	19,5	19,3	20,7
2	17,3	17,4	19,1	17,3	19,2	19,1	20,4	20,1	19	18,9	19,9
3	16,7	16,8	18,7	17	18,2	18,2	20	19,8	17,9	18	19,3
4	16,1	16,2	18,2	16,4	17,5	17,3	19,3	18,8	17,2	16,7	18,4
5	15	15,8	17,6	15,7	17	16,7	19	17,8	16,4	16,2	18,1
6	15,9	16,2	18	15,5	18,2	18	19,9	18,7	17,8	17,4	18,2
7	18	17,8	20	19,2	19,4	19,8	21,1	20,1	20,4	19	20,7
8	19,2	18,2	21,8	20,4	20,9	22,4	23	22	21,3	20,9	22,2
9	21,1	19,6	23,5	22,6	23,4	24,2	25	23,6	22,9	22,4	24,3
10	21,6	21	25,1	25,8	25,4	25	26,7	25,5	23,5	24	27,2
11	21,9	22,5	25,9	26,7	25,8	26,5	28,3	26,7	25,3	25	28,2
12	23,9	22,8	26,5	28,1	26,8	27,6	29,5	27,8	26,2	26,1	29,3
13	24,5	23,7	28,3	28,9	27,8	28,4	29,3	28,1	26,7	27,5	30,5
14	26	24,8	29,6	29,4	28	29,4	29,6	29,2	27,4	28,4	31,2
15	26,6	25,8	29,8	29,5	28,8	29,9	30,3	29,3	28,8	28,8	31,3
16	27	26,4	27,8	29,9	28,9	29,9	30,9	29,2	27,6	29,3	31,2
17	26,5	26,8	28,4	29	29	29,6	30	28,8	27,3	29,3	30,5
18	26	26,2	26,4	28	28,5	29	29,3	27,9	27,4	29,1	29,6
19	25,2	25,7	25,5	26,8	27,7	28,2	28,8	26,8	26,9	28	28,6
20	23,6	24,9	23,4	25,1	26,3	26,9	27,7	24,9	24,9	26,8	26,7
21	22	24	22	24,2	25,1	26,4	26,2	23,6	23,2	25,4	25,7
22	20,7	22,8	21,2	22,6	23,7	24,4	24,3	21,9	22	24	24,2
23	19,7	22	19,8	21,7	22,4	23	23,3	20,9	20,6	22,3	22,9
24	18,9	20,7	19	20,8	21,4	22	21,9	20,5	20	22	21,7

Table A.2. Monthly Temperature Data for Ankara, August 2006
(Turkish State Meteorological Service)

hours	01.08. 2006	02.08. 2006	03.08. 2006	04.08. 2006	05.08. 2006	06.08. 2006	07.08. 2006	08.08. 2006	09.08. 2006	10.08. 2006
1	21,2	20,1	20,4	22,4	22,7	26,2	26,3	24,8	19,9	20,8
2	20,1	18,6	19,9	21,4	21,6	25,2	25,7	23,2	19	20,2
3	19,2	17,7	18,9	20,2	21,2	24,6	25,2	22,2	18	19,4
4	17,9	17,2	18,2	19,5	19,9	23,9	24,5	21,6	17	18,5
5	17,1	16,7	17,5	18,6	19,8	24,1	24,1	21,2	16,3	18,4
6	18,5	18,2	18,3	19,5	20,2	23,4	23,4	21	17,2	19,2
7	20,3	20,5	20,4	22,3	22,4	26,5	25,6	22,3	19	20,6
8	23,2	22,9	23,2	24,7	24,1	28,3	26,1	24,3	22	23,2
9	25,2	24,7	25,7	27,4	27,4	30,8	29,8	25,5	25,5	25,5
10	27,1	26,2	27,7	29,5	30,3	32,9	32,8	27,4	26,4	27,7
11	28,9	27,4	29,5	32,1	32,6	34,9	35,2	29,2	27,5	29,4
12	29,3	28,3	30,7	33,3	34,7	35,6	37,1	30,3	28,7	30,3
13	30,1	30	32,3	34,3	36,2	37,2	37,5	31,1	29,4	32
14	31	30,3	32,8	34,6	36,3	37,2	37,3	31,6	30,4	32,9
15	31	31,3	33,4	35,3	36,6	37,5	37,3	31,7	31,1	33
16	30,8	31,3	33,4	35,1	36,4	37,3	37,3	30,7	30,9	32,9
17	30,7	30,3	32,9	34,9	36,3	37,4	37,1	30,1	30,3	32,7
18	29,5	29,4	32,2	33,7	35,5	36,6	35,7	29,1	30,1	32,2
19	27,6	28,3	30,3	32	33,4	34,8	33,2	26,2	28,3	30,4
20	25,7	26,5	28,7	30,2	32,1	33,2	30,6	24,5	26,4	29,3
21	24,4	25,3	26,8	30	29,4	29,9	30,3	23,3	25,1	26,8
22	22,9	24,4	25,5	27,6	28	28,5	28,4	22,7	24,3	25,7
23	21,8	22,6	24,4	26,2	27,6	29	28,2	22,1	23,4	24,2
24	20,9	21,4	23,3	24,2	27,2	27,6	26,2	20,9	22,2	23,2

hours	11.08. 2006	12.08. 2006	13.08. 2006	14.08. 2006	15.08. 2006	16.08. 2006	17.08. 2006	18.08. 2006	19.08. 2006	20.08. 2006
1	22,3	23,8	24,2	25,9	25,4	25,4	24,6	26	24	22,7
2	22,3	23,1	23,3	24,8	24,5	25	23,4	25,5	22,8	21,6
3	21,3	22,1	22,9	23,5	24	24	22,8	25,1	22	20,4
4	21,2	21,4	22,3	22,3	23,3	22,3	22,4	24,4	21	19,4
5	20,7	20,2	20,8	21,4	22	22	22,1	23,6	20,1	19
6	20,5	19,9	20,8	20,8	22,2	21,8	21,2	23,2	19,4	19
7	23,6	22,2	23,4	23,2	23,4	23,4	23,4	24,1	22	20,5
8	25,3	23,7	24,3	24,7	24,5	25,4	24,4	24,4	23,1	21,4
9	28,3	25,6	26,4	26,8	27,3	27,7	25,3	26,2	25	23,2
10	30,3	29,4	28,2	30	29,1	29	28,3	28,1	27,2	25,4
11	32,1	30,7	30,3	32	30,6	29,7	30,6	28,5	28,3	27
12	32,4	32,1	31,3	29,6	32,3	30,6	31,5	30,9	29,4	28,1
13	33,9	33,3	33,2	30,7	33,8	31,4	32,5	31,6	30,5	29
14	35,1	34,4	35	37,2	34	32,4	34,6	32	31,8	30
15	35	35,3	35,2	36,8	34,4	33,3	35,2	32,8	32,2	30,3
16	35,1	35,2	35,2	36,7	34,5	33,4	35,6	32,4	32,2	30,7
17	34,5	34,3	34,6	35,2	34,5	33,3	35,5	32,8	32	30,6
18	33,5	33,3	34	33,3	33,9	32,3	34,2	32,1	32	30,5
19	32,3	32,2	33,2	32,1	32,3	30,8	33,3	31,5	31,1	30
20	31,2	29,3	30,3	31	31	29,5	32	30,3	29,4	28,5
21	29,3	27,8	30,2	29,8	29,8	28,4	30,4	28	27,2	26,6
22	28	27,1	28,7	28,6	28,8	27,2	29,4	27	25,8	25,4
23	27	25,7	28	27,4	27,7	26,4	27,5	25,9	25,5	24,5
24	25,4	25,1	26,8	26,5	26,5	25,3	26,8	24,6	23,6	23,6

Table A.2. (Continued)

hours	21.08. 2006	22.08. 2006	23.08. 2006	24.08. 2006	25.08. 2006	26.08. 2006	27.08. 2006	28.08. 2006	29.08. 2006	30.08. 2006	31.08. 2006
1	22,5	21,8	22,3	21,4	20,6	24,5	24,1	22,1	24,1	18,2	20,4
2	21	21,5	21,4	20,9	20,1	24	23	21,3	22,4	17,6	20,1
3	19,6	20,1	20,5	20,3	19,4	23,7	22,9	20,3	21,2	17,1	19,2
4	19,1	19,8	19,7	19,7	19	22,8	22,1	19,1	20,3	16	18,2
5	18,1	19	19,4	19,1	18,6	22,8	21,3	18,4	19,1	15,1	17,3
6	18,4	18,9	19,2	18,9	18,8	22,3	20,8	17,5	18,7	15,2	17
7	20,6	21,1	21,4	20,3	20,2	24,5	22,4	19,5	19,4	18	20
8	23,2	23,7	24,4	22,5	21,9	26,7	24,2	21,7	20,2	21,3	22,9
9	25,5	25,6	26,2	24,1	24	29,2	25,1	25,3	21,2	23,8	25,1
10	27,3	27,2	28,5	25,6	25,7	30,4	27,8	28,9	22,6	26,2	26,4
11	28,2	28,4	29,3	26,8	27,6	32,4	29,4	31	24	27,5	28,2
12	29,3	30,8	31,4	28,7	29,3	34,3	31,2	31,4	24,4	29,2	29,3
13	29,9	32	32,2	29	30,5	35,3	33,1	32,9	26,1	31	30,4
14	30,2	33	32,1	30,3	32	35,7	33,2	33,4	26,8	32,5	30,8
15	30,8	33,1	32,7	30,4	31,8	35,7	34	33,8	27	33,4	31,8
16	30,7	33,2	33	30,3	32,7	34,6	33,3	33,1	27,3	33	31,5
17	30,5	32,5	32,2	30	32,4	34,2	32,9	33,2	27,1	32,6	30,9
18	29,9	31,2	30,5	28,5	31,8	33,7	32	32,1	26,3	31,1	29,2
19	28,4	30,1	29,4	26,9	29,3	32,2	30,3	29,2	25,2	29,2	28,1
20	26,8	28,6	26,2	26,1	27,9	30,2	28,1	28,1	23,9	26,5	25,2
21	25,8	27	25	24,3	27,1	29	25,7	26,8	22,2	25	24
22	24	25,3	23,9	23,5	27,3	27,5	24,4	27,5	21,2	24	22,5
23	23,3	24,4	22,9	22,4	25,6	26,3	23,4	26,3	20,3	22,4	20,2
24	22,3	23,5	22,4	21,5	24,9	24,9	22,8	25,3	19,2	21,4	19,6

Table A.3. Monthly Temperature Data for Ankara, September 2006
(Turkish State Meteorological Service)

hours	01.09. 2006	02.09. 2006	03.09. 2006	04.09. 2006	05.09. 2006	06.09. 2006	07.09. 2006	08.09. 2006	09.09. 2006	10.09. 2006
1	19,2	11,1	12,5	14,5	17	19,3	12,5	14,3	16,3	18,1
2	19	10,6	11,7	14,2	15,7	18,5	12,1	14,1	15,3	17,4
3	18,9	10,5	11,2	13,1	15	17,3	11,4	13,4	14,9	17,5
4	18,8	10,4	10,7	13,1	13,2	16,1	10,4	13,2	14	17,2
5	19,1	10,3	10,7	12,6	13,2	15,4	10,1	13,1	13,2	16,6
6	18,8	10,4	10,3	12,5	12,6	15,2	9,6	12,5	12,4	16,4
7	19,2	11,5	11,2	15	15,3	16,8	11,5	14,9	14,2	17,6
8	19,2	11,5	12,5	17	18,6	18,5	13,5	16,6	17,4	18,9
9	19,6	12,4	15,1	18,9	20,3	20,5	16,5	19	20,3	20,3
10	20,4	14	16,9	20,9	22,5	22,1	18,7	21,1	24	21,9
11	21,2	15,3	18,2	22,3	24,4	23,4	19,6	22,2	26	23,5
12	20,5	16,8	20,4	23,5	24,9	24,8	21,1	23,9	27,2	24,9
13	19,7	17,2	21,9	24,5	26,2	24,6	21,8	24,9	27,8	25,6
14	19,1	18,8	22,8	24,8	26,8	24,6	23,2	26,2	28,8	25,9
15	17,6	19	22,4	25,5	27,3	24,8	23,2	26,1	29	25,4
16	16,2	18,9	22,3	25,7	26,9	24,3	23,5	26,4	29	25
17	14,7	19,1	22,5	25,4	26,7	23,2	23,2	26,3	29,1	24,6
18	12,3	18,8	22	23,9	25,9	21,4	22,4	24,8	27,1	24,2
19	10,2	17,8	20,1	23,1	25	19,8	21	23	25,8	23,6
20	10,3	16,5	19,1	22,2	23,5	17,7	19,9	20,9	24,1	23,2
21	10,5	15,4	18	20,4	22,8	16,8	18,2	19,6	22,5	22,3
22	10,6	14,6	17	19,7	22,4	15,5	16,9	18,5	21,5	21,7
23	11,1	14,1	16,1	18,5	21,4	14,3	16,2	17,5	20	21,4
24	11	13,5	15,4	17,8	20,6	13,5	15,2	17	19	20,5

hours	11.09. 2006	12.09. 2006	13.09. 2006	14.09. 2006	15.09. 2006	16.09. 2006	17.09. 2006	18.09. 2006	19.09. 2006	20.09. 2006
1	19,5	15,5	14,6	14,6	14,9	15,7	16,3	13,9	16,9	16
2	19,1	15,2	14,1	14	13,9	14,5	15,2	13,2	17,1	15,3
3	18,4	15,2	13,2	13,4	13,1	13,4	14,7	12,7	17	14,9
4	17,5	15,1	12,7	12,9	13	13	13,9	11,8	16,4	14,3
5	17,3	15,1	12,3	12,6	12,1	12,8	13,2	11,7	16,2	14,1
6	16,5	15	11,7	13,1	12	12,4	13,1	11,1	17,3	14
7	16,4	15	13,2	14,8	13,2	13,4	13,6	14	17,4	15,1
8	16,5	15,4	15,2	15,8	15,1	15	15,5	16,5	20,9	16,8
9	17,7	16,3	17,3	18,6	17,5	19,1	18,1	19	23	18,3
10	20,3	17,3	18,7	20,1	20	21,3	19,4	22,6	25,4	20,5
11	22,2	19,1	20,5	21,2	21,7	23,3	20,8	24,9	27	22,2
12	23,3	19,4	21,6	22,3	22,9	25,4	22,2	26,8	27,3	24,6
13	24,3	20,2	23,1	23	23,4	26,4	23,6	27,5	28	25
14	25	21,2	22,8	23,2	24,6	27	24,2	28	28,4	25,8
15	24,3	21,1	22,5	24,4	24,8	26,9	25,2	28,3	26,9	26,1
16	24,2	21,4	22,9	23,9	25	26,1	25	28,5	26,2	25,3
17	21,3	21,3	23,3	23,2	24,3	25,8	24,5	27,5	25	24,4
18	18,1	21	21,9	22,5	23,1	24,3	23,3	24,8	23,2	23,5
19	17,2	20,2	20,7	21,1	21,1	22,7	21,7	22,5	22,3	22,8
20	17,2	19,5	19,4	20,1	19,5	21,4	19,2	20,7	21	21,9
21	17	18,6	18,6	18,8	18,5	20,4	18	19,6	20,2	21,3
22	16,6	17,1	17,8	17,4	17,4	19,4	16,1	18,8	18,4	16,9
23	16,1	16,1	16,8	16,3	17,1	18,1	15,4	17,8	17,5	16
24	16	15,1	15,4	15,9	16,9	17,1	15,2	17,9	17	14

Table A.3. (Continued)

hours	21.09. 2006	22.09. 2006	23.09. 2006	24.09. 2006	25.09. 2006	26.09. 2006	27.09. 2006	28.09. 2006	29.09. 2006	30.09. 2006
1	14,2	15,2	14,2	13,2	13	13,2	11,9	15,4	15,2	13,6
2	14,3	15	14,2	12,9	12,9	12,4	11,5	15	14,9	13,6
3	14,3	14,5	14,2	12,4	12,9	12,1	11,4	14,4	14,9	13,6
4	14,3	14,4	14,4	12,4	12,9	11,4	11,2	14,1	15,1	13,4
5	14,3	14,3	14,4	12,6	12,6	11,2	10,6	13,5	15,2	13,2
6	14,3	14,2	14,3	12,8	12,6	11	10,3	13	15,3	13,2
7	14,5	14,6	14,4	13	12,8	11,4	11,8	14,4	15,5	13,4
8	15,2	15,4	14,7	13,5	13	12,1	13,3	16	16,3	14,3
9	15,9	16,3	15,6	15,8	14,3	13,1	16,1	19,3	17,3	15,2
10	16	18,3	16,6	18,2	15,3	14	18,5	22,3	18,4	16,3
11	16,2	18,2	17,1	19,7	16,2	16,1	20,2	23,3	19	17,4
12	16,4	18,8	17,9	21,3	16,2	17,3	22,5	25	19,2	18,1
13	14,5	18	18,9	21,5	16,9	19,1	23,4	25,4	19,6	18,7
14	15,4	15,9	18,7	21,8	17,8	20,1	23,6	26	20,2	19,6
15	16,9	14,7	19,4	21,2	17,9	20	23,5	25,1	20	19,2
16	17	15,4	19,3	19,2	16	20,1	23,2	24,2	19,2	18,4
17	17	16,3	19	18	16,2	19,5	22,5	23,2	18,9	17,9
18	16,9	16	17,3	14,6	15,3	18,1	21,8	17,3	15,4	16,8
19	16,3	15,2	16	14,7	15,1	16,3	20,2	17,2	14,9	16
20	16,2	15,1	15,9	13,8	14,8	15,6	18,4	16,9	14,6	15,3
21	16,2	15	16	13,5	14,5	14,5	18	16,2	14,5	15,4
22	16,1	14,3	14,8	13,4	14,2	13,6	17	15,4	14	14,9
23	15,9	14,2	14,2	13	13,9	13,1	16,5	15,6	14	14,8
24	15,5	14,2	13,8	12,8	13,5	12,3	15,6	15,6	13,7	14,2

APPENDIX B

TEMPERATURE DATA GROUPED FOR ANOVA

Table. B.1. Temperatures measurements for Room 54, Room 57 (10 – 14 July) and Room 85 (14 – 18 July) recorded at 15 minutes intervals.

Sr.No.	Rm 54:dc4	Rm 57:dc1	Rm 85:dc4		Sr.No.	Rm 54:dc4	Rm 57:dc1	Rm 85:dc4		Sr.No.	Rm 54:dc4	Rm 57:dc1	Rm 85:dc4
1	27.6	25.4	28.7		26	26.1	24.4	26.9		51	25.4	24.1	26.9
2	27.6	25.4	27.2		27	26.5	24.4	26.5		52	25.4	24.1	26.9
3	28.3	25.4	27.2		28	26.5	24.7	26.9		53	25.4	23.7	26.5
4	27.2	25.4	26.9		29	25.8	24.7	26.9		54	25.4	23.7	26.5
5	27.6	25.4	26.5		30	25.8	24.7	26.5		55	25.1	23.4	26.5
6	27.6	25.4	26.9		31	26.1	24.4	26.9		56	25.1	23.7	26.5
7	27.9	25.4	26.5		32	26.1	24.4	26.9		57	25.1	24.1	26.9
8	27.9	25.4	26.5		33	26.5	24.4	26.9		58	25.1	24.1	26.9
9	27.6	25.4	26.5		34	26.1	24.4	26.5		59	25.1	24.1	26.5
10	27.2	25.4	26.9		35	26.1	24.1	26.9		60	24.7	24.1	26.1
11	27.2	25.4	26.1		36	25.8	24.4	26.9		61	24.7	23.7	26.5
12	27.6	25.4	26.9		37	25.4	24.4	26.9		62	24.7	23.7	26.1
13	27.2	25.4	26.5		38	25.8	24.4	26.5		63	24.7	23.7	26.9
14	27.2	25.1	26.5		39	25.8	24.4	26.9		64	25.1	23.7	26.9
15	27.2	25.1	26.5		40	25.8	23.7	26.5		65	25.1	24.1	26.9
16	27.2	25.1	26.9		41	26.1	23.7	26.9		66	25.1	24.4	26.9
17	27.2	24.7	26.9		42	26.1	23.7	26.5		67	25.1	24.4	26.9
18	27.2	25.4	26.9		43	25.8	23.7	26.9		68	25.1	24.4	26.9
19	27.2	25.4	26.9		44	25.8	23.7	26.1		69	25.4	24.4	26.9
20	26.9	24.7	26.9		45	25.8	23.7	26.5		70	25.1	24.7	27.2
21	26.9	25.4	26.9		46	25.1	23.7	26.5		71	25.1	24.7	26.5
22	26.5	24.7	26.5		47	25.1	24.1	26.5		72	25.8	24.4	26.9
23	26.5	24.7	26.5		48	25.1	24.1	26.5		73	25.8	25.1	26.5
24	26.5	24.7	26.5		49	25.4	24.1	26.5		74	25.4	25.1	26.5
25	26.1	24.7	26.5		50	25.4	23.7	26.5		75	26.1	25.1	26.9

Table B.1. (Continued)

Sr. No.	Rm 54: dc 4	Rm 57: dc 1	Rm 85: dc 4		Sr. No.	Rm 54: dc 4	Rm 57: dc 1	Rm 85: dc 4		Sr. No.	Rm 54: dc 4	Rm 57: dc 1	Rm 85: dc 4
76	26.5	25.1	26.5		126	26.9	24.7	26.9		176	27.2	26.1	26.9
77	26.9	25.1	26.9		127	26.5	24.7	26.9		177	27.2	26.1	26.5
78	26.5	25.4	26.9		128	26.1	25.4	26.5		178	27.9	26.1	26.5
79	26.5	25.4	26.9		129	26.5	25.4	26.9		179	28.3	26.1	26.5
80	27.2	25.4	26.5		130	26.5	24.7	26.5		180	28.3	26.1	26.5
81	27.6	25.8	26.5		131	26.9	25.1	26.5		181	28.3	26.1	26.9
82	27.2	25.4	26.5		132	26.9	24.7	26.5		182	28.3	26.1	26.9
83	27.2	25.4	26.9		133	26.5	24.7	26.5		183	29.1	26.1	26.9
84	27.9	25.4	26.9		134	26.9	24.7	26.5		184	29.1	26.1	26.5
85	27.9	25.4	26.9		135	26.9	24.7	26.1		185	29.1	26.1	26.9
86	28.3	25.8	26.5		136	26.5	24.7	26.1		186	29.1	26.1	26.9
87	28.3	25.4	26.9		137	26.5	24.4	26.1		187	29.1	26.1	26.5
88	28.3	25.8	26.9		138	26.5	24.4	26.1		188	29.1	26.1	26.9
89	27.9	26.1	26.9		139	26.5	24.4	26.1		189	29.1	26.1	26.9
90	27.9	26.1	26.9		140	25.8	24.4	26.5		190	29.1	25.8	26.5
91	28.7	26.1	26.5		141	26.1	24.4	26.1		191	29.1	26.1	26.5
92	28.7	26.1	26.9		142	26.1	24.4	26.1		192	29.1	26.1	26.5
93	28.7	26.1	26.9		143	26.1	24.4	26.1		193	29.4	26.1	26.1
94	27.9	26.1	26.9		144	26.1	24.4	26.1		194	29.1	26.1	26.1
95	28.7	26.1	26.9		145	26.1	24.4	26.5		195	29.1	26.5	26.1
96	28.7	25.8	26.9		146	26.1	24.1	26.1		196	29.1	26.5	26.1
97	28.7	25.8	26.9		147	26.1	24.4	26.1		197	28.7	26.9	26.5
98	28.7	25.8	26.1		148	26.1	24.1	26.5		198	28.7	26.9	26.9
99	28.3	26.1	26.1		149	26.1	24.1	26.5		199	29.1	26.9	26.1
100	28.3	26.1	26.5		150	25.8	24.1	26.5		200	28.7	26.9	26.9
101	28.3	25.8	26.5		151	25.8	24.1	26.1		201	29.1	26.9	26.9
102	28.3	25.8	26.5		152	25.4	24.1	26.5		202	29.1	26.9	26.1
103	28.7	25.8	26.5		153	25.4	24.1	26.1		203	29.1	26.9	26.5
104	27.9	25.8	26.5		154	25.4	24.1	26.5		204	29.1	26.9	26.9
105	28.3	25.8	26.5		155	25.4	24.1	26.9		205	28.7	26.9	26.9
106	28.3	25.8	26.9		156	25.4	24.1	26.9		206	28.7	26.5	27.2
107	27.6	25.8	26.5		157	25.4	24.4	26.1		207	28.3	26.5	26.9
108	28.3	25.8	26.5		158	25.4	24.4	26.9		208	28.3	26.5	26.5
109	28.3	25.4	27.2		159	25.4	24.4	26.9		209	28.3	26.5	26.5
110	27.9	25.8	27.2		160	25.8	24.4	26.9		210	28.3	25.8	26.5
111	27.9	25.8	26.9		161	25.8	24.7	26.5		211	28.3	25.8	26.9
112	27.2	25.8	26.9		162	25.8	24.7	26.9		212	27.9	25.8	26.9
113	27.6	25.8	26.5		163	26.1	24.7	26.5		213	28.3	25.8	26.9
114	27.6	25.8	26.5		164	26.1	24.7	26.9		214	28.3	25.8	26.9
115	27.9	25.4	26.9		165	25.8	25.1	26.9		215	28.3	25.8	26.5
116	27.6	25.4	26.5		166	26.5	25.1	26.5		216	27.9	25.8	26.9
117	27.9	25.4	26.5		167	26.1	25.4	26.9		217	27.9	26.1	26.9
118	27.6	25.1	26.5		168	26.1	25.1	26.9		218	27.2	25.8	26.9
119	27.6	25.1	26.5		169	25.8	25.4	26.9		219	27.2	25.8	26.9
120	27.2	25.1	26.1		170	26.5	25.1	26.5		220	27.6	25.4	26.9
121	26.9	25.1	26.5		171	26.9	25.8	26.5		221	27.9	25.4	26.9
122	27.2	25.4	26.9		172	26.9	25.4	26.5		222	27.6	25.4	26.9
123	26.5	25.1	26.1		173	26.5	25.8	26.9		223	27.9	25.8	26.5
124	26.9	25.1	26.1		174	27.2	26.1	27.2		224	27.6	25.1	26.5
125	27.2	25.1	26.9		175	27.6	25.8	26.9		225	27.2	25.8	26.1

Table B.1 (Continued)

Sr.No.	Rm 54:dc4	Rm 57:dc1	Rm 85:dc4		Sr.No.	Rm 54:dc4	Rm 57:dc1	Rm 85:dc4		Sr.No.	Rm 54:dc4	Rm 57:dc1	Rm 85:dc4
226	27.2	25.4	26.5		272	28.7	26.5	26.9		318	27.9	25.8	26.9
227	27.2	25.4	26.5		273	28.7	26.5	26.9		319	27.9	25.8	26.5
228	27.6	25.4	26.1		274	28.7	26.5	27.2		320	27.6	25.8	26.1
229	27.2	25.1	26.5		275	28.7	26.5	27.2		321	28.3	26.1	26.5
230	27.2	25.1	26.5		276	28.3	26.9	26.9		322	28.3	25.8	26.9
231	26.5	25.4	26.1		277	29.1	26.9	26.9		323	28.3	26.1	26.9
232	26.5	25.4	26.5		278	29.1	26.5	26.9		324	27.9	26.1	26.9
233	26.9	25.4	26.5		279	28.7	26.9	26.9		325	27.9	26.1	26.5
234	26.9	25.1	26.9		280	29.1	26.9	26.9		326	27.9	25.8	26.1
235	26.9	25.1	26.1		281	29.1	26.9	26.9		327	27.2	25.8	26.5
236	26.9	25.1	26.9		282	29.8	26.9	26.9		328	27.2	25.8	26.5
237	26.9	25.1	26.1		283	29.8	26.9	26.5		329	27.6	25.8	26.9
238	26.5	25.1	26.9		284	29.8	26.5	26.9		330	27.6	25.8	26.9
239	26.1	24.7	26.9		285	29.4	26.9	26.9		331	27.6	25.8	27.2
240	26.5	24.7	26.9		286	29.8	26.5	26.5		332	27.6	26.1	26.9
241	26.9	24.7	26.9		287	29.4	26.5	26.5		333	27.6	25.8	26.9
242	26.9	24.7	26.5		288	29.1	26.9	26.5		334	27.6	25.8	26.9
243	26.5	24.7	26.5		289	29.4	26.9	26.5		335	27.2	25.8	26.9
244	26.5	24.7	26.1		290	29.8	26.9	26.5		336	27.2	25.4	26.9
245	26.5	25.1	26.5		291	29.8	26.9	26.5		337	26.9	25.4	26.9
246	25.8	25.1	26.9		292	29.8	26.9	26.5		338	27.2	25.8	26.5
247	25.8	25.1	26.9		293	29.4	26.9	26.5		339	27.2	25.8	26.5
248	25.8	24.7	26.5		294	29.4	27.2	26.5		340	27.2	25.8	26.5
249	26.1	24.7	26.5		295	29.4	26.5	26.5		341	27.2	25.1	26.5
250	25.8	24.4	26.1		296	28.7	26.5	26.9		342	27.6	25.4	26.5
251	25.8	24.7	26.5		297	28.7	26.5	26.9		343	27.2	25.4	26.9
252	25.8	24.4	26.9		298	28.7	26.5	26.9		344	27.6	25.4	26.9
253	26.1	24.4	26.9		299	28.7	26.5	26.9		345	27.6	25.4	26.9
254	26.1	24.7	26.1		300	28.7	26.5	27.2		346	27.2	25.4	26.1
255	26.1	25.1	26.5		301	28.7	26.5	26.9		347	27.2	25.4	26.5
256	25.8	25.1	26.9		302	28.7	26.5	26.9		348	27.2	25.4	26.5
257	26.5	25.1	26.1		303	28.3	26.5	26.9		349	27.2	25.4	26.5
258	26.9	25.4	26.5		304	28.7	26.5	26.5		350	27.2	25.4	26.5
259	26.1	25.1	26.9		305	29.1	26.5	26.5		351	27.2	25.1	26.5
260	26.5	25.1	26.5		306	28.7	26.9	26.9		352	27.2	25.8	26.5
261	26.9	25.8	26.9		307	29.1	26.9	26.9		353	27.2	25.8	26.9
262	26.5	25.8	26.5		308	28.3	26.5	26.9		354	26.9	26.1	27.2
263	27.2	25.8	26.9		309	28.7	26.5	26.9		355	26.9	26.1	26.5
264	27.2	25.8	26.5		310	28.3	26.5	26.9		356	27.2	26.1	27.2
265	27.6	26.1	26.9		311	28.7	26.5	26.9		357	27.2	26.9	26.9
266	27.2	26.1	26.9		312	28.3	25.8	26.5		358	27.6	26.1	27.2
267	27.6	26.1	26.9		313	27.9	25.8	26.9		359	27.6	26.5	27.2
268	27.6	26.1	26.9		314	27.9	26.1	26.9		360	27.2	26.5	26.5
269	28.3	26.1	26.9		315	27.9	26.1	26.9		361	27.2	26.5	26.9
270	28.3	26.5	26.5		316	28.3	26.1	26.9		362	27.2	26.9	26.9
271	28.7	26.5	26.5		317	28.3	26.1	26.9					

Table. B.2. Temperatures Measurements for Room 61, Room 70 (22 – 25 August) and Room 79 (18 - 21 August) recorded at 15 minutes intervals.

Sr. No.	Rm 61:dc4	Rm 70:dc1	Rm 79:dc1		Sr. No.	Rm 61:dc4	Rm 70:dc1	Rm 79:dc1		Sr. No.	Rm 61:dc4	Rm 70:dc1	Rm 79:dc1
1	27.8	27.7	31.1		41	29.9	32	32.4		81	30.4	32.9	31.1
2	26.9	27.2	32		42	29.9	32	32.4		82	30.4	32	31.1
3	26.9	27.2	32		43	30.4	32	32.4		83	30.8	32.4	31.1
4	26.9	27.2	32		44	30.4	32	32.9		84	30.4	32.4	29.4
5	26.9	27.7	32		45	30.4	32.4	32.9		85	30.4	32	30.7
6	27.3	27.7	32		46	30.4	32.4	32.4		86	30.4	32	29
7	27.3	27.7	32		47	30.4	32.9	32.4		87	30.4	32	29.8
8	27.3	28.1	32.4		48	30.8	32.9	32		88	30.4	32	28.5
9	27.3	28.5	32.4		49	30.4	32.9	32.4		89	30.4	31.6	29
10	27.8	28.5	32.4		50	30.4	33.3	32.4		90	30.4	31.6	29.4
11	27.8	29	32.4		51	30.4	33.3	32.4		91	30.4	31.1	29
12	27.8	29.4	31.6		52	30.4	33.3	32.4		92	29.9	31.6	27.7
13	27.8	29.4	31.6		53	30.4	33.3	32.4		93	29.9	31.1	26.8
14	27.8	29.4	31.6		54	30.8	33.3	32.4		94	29.5	30.3	27.2
15	27.8	29.4	32		55	30.8	33.8	32.9		95	29.5	29.8	28.5
16	28.2	29.8	32		56	30.8	33.8	32.9		96	29.5	30.3	27.2
17	28.2	29.4	32		57	30.8	33.3	32.9		97	29.1	30.3	29
18	28.2	29.4	32		58	31.3	33.8	32.9		98	29.1	30.3	27.7
19	27.8	29.4	32		59	31.3	33.8	32.9		99	29.1	30.7	29
20	27.8	29.8	32.4		60	31.7	33.8	32.9		100	29.1	30.7	29
21	28.2	29.8	32.9		61	31.3	33.8	32.9		101	29.1	30.3	28.5
22	28.2	30.3	32.4		62	31.3	33.8	32.9		102	29.1	30.3	29
23	28.6	30.7	32.9		63	31.7	33.8	32.9		103	29.1	30.3	27.2
24	28.2	30.7	32.9		64	31.3	33.8	32.9		104	29.1	30.3	28.5
25	28.2	31.1	32.9		65	32.1	33.8	32.9		105	29.1	30.3	29
26	28.2	31.1	32.9		66	32.1	33.8	32.9		106	29.5	30.7	28.5
27	28.6	31.6	32.9		67	32.6	33.8	32.9		107	29.5	31.1	28.5
28	28.6	31.6	32.9		68	32.1	33.8	32.9		108	29.5	31.1	28.5
29	29.1	31.6	32.9		69	32.1	33.8	32.9		109	29.9	31.6	28.5
30	28.6	31.1	32.9		70	32.6	33.3	32.4		110	30.4	31.1	28.5
31	29.1	31.1	32.9		71	32.1	33.3	32		111	30.4	31.1	29
32	29.1	31.1	32.9		72	32.6	33.8	31.6		112	30.4	31.6	29
33	29.1	31.1	32.9		73	32.1	33.3	32		113	30.4	31.6	29
34	29.1	31.1	32.9		74	30.8	33.8	31.6		114	30.4	32	29.4
35	29.1	31.6	32.9		75	30.4	33.3	31.1		115	30.8	32.4	29
36	29.1	31.6	32.9		76	30.4	33.8	31.6		116	31.3	32.4	29
37	29.5	31.6	32.9		77	30.4	33.8	31.1		117	31.3	32.9	29.4
38	29.5	31.6	32.9		78	30.4	33.3	31.6		118	31.3	32.9	29.4
39	29.9	32	32.9		79	30.4	33.3	31.6		119	31.3	33.3	29.4
40	29.9	32	32.9		80	30.8	32.9	31.1		120	31.3	33.3	28.5

Table B.2 (Continued)

Sr. No.	Rm 61:dc4	Rm 70:dc1	Rm 79:dc1		Sr. No.	Rm 61:dc4	Rm 70:dc1	Rm 79:dc1		Sr. No.	Rm 61:dc4	Rm 70:dc1	Rm 79:dc1
121	31.3	32.9	28.5		166	34.4	36	31.1		211	29.9	31.1	30.3
122	31.3	33.3	28.5		167	34.4	35.5	31.6		212	29.9	31.6	29.8
123	31.3	33.3	29		168	34.8	35.5	31.6		213	30.4	32	30.3
124	31.3	33.3	29		169	34.4	35.5	31.6		214	30.4	32	29.8
125	31.3	33.3	29		170	34.8	35.5	31.6		215	30.8	32	29.8
126	31.3	33.3	29.4		171	34.8	35.5	31.6		216	30.4	32.4	29.8
127	31.3	33.8	29		172	34.4	35.5	31.1		217	30.4	32.4	29.4
128	31.3	33.8	29.4		173	33.9	35.5	31.6		218	30.8	32.9	29.4
129	31.3	33.8	29.4		174	33.5	35.5	31.1		219	31.3	32.9	29.4
130	31.7	33.8	29.4		175	33.9	36	31.6		220	32.1	33.3	29.8
131	31.7	33.8	29.8		176	33.9	36	31.6		221	32.6	33.8	29.8
132	31.3	33.3	29.8		177	33.5	35.5	31.6		222	32.6	33.8	29.8
133	31.3	33.8	29.8		178	33	35.1	31.6		223	32.6	33.3	29.8
134	31.3	33.3	29.8		179	32.6	35.1	31.1		224	32.6	33.3	29.8
135	31.7	33.3	29.8		180	32.6	34.6	31.6		225	33	33.8	29.8
136	31.7	33.8	30.3		181	32.6	34.2	31.6		226	33.5	33.8	29.8
137	32.1	33.8	30.3		182	32.6	33.8	31.6		227	33.5	34.2	29.8
138	32.1	33.8	30.3		183	32.6	33.3	31.6		228	33	34.2	29.8
139	32.1	34.2	30.7		184	32.6	33.3	31.6		229	33.5	34.2	29.8
140	32.1	34.2	30.7		185	32.1	33.3	31.6		230	33.9	34.6	30.3
141	32.6	34.6	30.7		186	32.1	33.3	31.1		231	34.4	34.6	30.3
142	32.6	34.6	30.7		187	32.1	32.4	31.6		232	33.9	35.1	30.3
143	32.6	35.1	30.7		188	31.7	32.4	31.1		233	33.9	35.1	30.3
144	32.6	35.1	30.7		189	31.3	31.6	30.7		234	34.8	35.5	30.3
145	32.6	35.5	31.1		190	30.8	31.6	31.1		235	34.8	35.5	30.3
146	32.6	35.5	31.1		191	30.8	31.6	30.7		236	34.4	35.5	30.3
147	32.6	35.5	31.1		192	30.4	31.1	30.7		237	34.8	35.5	30.3
148	33	35.5	31.1		193	30.4	31.1	30.3		238	34.8	36	30.3
149	33	35.5	31.1		194	30.8	31.6	30.3		239	34.4	36	30.3
150	33	35.5	31.1		195	30.8	31.1	30.3		240	34.8	35.5	30.3
151	33	35.5	31.1		196	30.8	30.7	29.8		241	34.8	35.5	30.3
152	33.5	36	31.1		197	30.4	30.7	29.8		242	34.4	35.5	30.3
153	33.5	35.5	31.1		198	30.4	30.7	29.8		243	34.4	35.5	30.3
154	33.5	35.5	31.1		199	30.4	31.1	29.8		244	34.4	36	30.3
155	33.5	36	31.1		200	30.8	31.6	29.8		245	34.4	36	30.3
156	33.5	35.5	31.1		201	30.4	31.1	29.8		246	34.8	36	30.7
157	33	36	31.1		202	29.9	31.6	30.3		247	34.8	36	30.7
158	33.5	35.5	31.1		203	30.4	31.1	30.7		248	34.8	36.4	30.7
159	33.5	36	31.1		204	29.9	31.1	30.7		249	35.7	36.4	30.7
160	34.4	36	31.1		205	29.9	31.1	30.7		250	36.7	36.4	30.7
161	33.9	35.5	31.6		206	29.5	31.1	30.7		251	36.7	36.4	30.7
162	34.4	36	31.6		207	29.5	30.7	30.7		252	36.7	36.4	30.7
163	34.8	36	31.6		208	29.5	31.1	31.1		253	37.1	36.4	30.7
164	34.4	36	31.6		209	29.1	31.1	31.1		254	37.1	36.9	29.4
165	34.4	36	31.6		210	29.1	31.1	30.7					

Table. B.3. Temperatures measurements for Room 23, Room 31 (28 – 31 August) recorded at 15 minutes intervals.

Sr. No.	Rm 23:dc4	Rm 31:dc1		Sr. No.	Rm 23:dc4	Rm 31:dc1		Sr. No.	Rm 23:dc4	Rm 31:dc1		Sr. No.	Rm 23:dc4	Rm 31:dc1
1	28.7	28.3		50	26.9	27.2		99	26.1	26.9		148	25.8	26.9
2	27.2	27.6		51	26.5	27.2		100	26.1	26.5		149	25.8	26.9
3	26.9	27.2		52	26.5	27.6		101	26.1	26.5		150	25.8	26.9
4	26.9	27.2		53	26.9	27.2		102	25.8	26.5		151	26.1	26.9
5	26.1	26.9		54	26.5	27.2		103	26.5	26.5		152	26.1	26.5
6	26.9	27.2		55	26.9	27.2		104	26.5	26.5		153	26.1	26.5
7	26.1	26.9		56	26.9	27.2		105	26.5	26.5		154	26.1	26.9
8	26.1	26.9		57	26.1	27.2		106	26.1	26.5		155	26.1	26.5
9	26.5	26.9		58	26.5	27.6		107	26.1	26.5		156	26.1	26.5
10	26.5	26.9		59	26.5	27.2		108	25.8	26.9		157	25.8	26.5
11	26.9	27.2		60	26.5	27.2		109	25.8	26.5		158	26.5	26.5
12	26.1	27.2		61	26.9	27.2		110	25.8	26.5		159	26.1	26.5
13	26.1	27.2		62	26.5	27.2		111	25.8	26.5		160	25.8	26.5
14	26.5	27.2		63	26.5	27.2		112	25.8	27.2		161	26.1	26.1
15	26.9	27.6		64	26.5	27.2		113	26.5	27.2		162	26.1	26.5
16	26.5	27.2		65	26.5	27.2		114	26.1	26.9		163	25.8	26.5
17	26.9	27.6		66	26.9	27.2		115	26.5	26.9		164	26.1	26.5
18	26.1	27.2		67	26.1	27.6		116	26.1	26.5		165	26.1	26.5
19	25.8	27.2		68	26.1	27.2		117	26.1	27.2		166	25.8	26.1
20	26.1	27.2		69	26.9	27.2		118	26.1	27.2		167	25.8	26.9
21	26.5	27.6		70	26.9	27.2		119	26.5	27.2		168	25.8	26.1
22	26.1	27.6		71	26.9	27.2		120	26.5	27.2		169	26.1	26.1
23	26.9	27.6		72	26.9	27.2		121	26.1	27.2		170	25.8	26.1
24	26.1	27.6		73	26.5	26.9		122	26.1	27.2		171	26.1	26.1
25	26.9	27.6		74	26.9	26.9		123	26.5	27.6		172	26.1	26.1
26	26.5	27.6		75	26.5	26.9		124	26.5	27.2		173	26.1	26.1
27	26.1	27.9		76	26.5	26.9		125	26.5	27.2		174	25.8	26.1
28	26.1	27.6		77	26.9	26.9		126	26.1	26.9		175	26.1	26.1
29	26.1	27.6		78	26.1	27.2		127	26.1	27.2		176	25.8	26.1
30	26.1	27.2		79	26.9	27.2		128	25.8	27.6		177	25.4	26.1
31	26.9	27.6		80	26.9	27.2		129	25.8	27.6		178	25.8	26.1
32	26.1	27.6		81	26.5	26.9		130	26.1	27.2		179	25.8	26.1
33	26.5	27.2		82	26.9	27.2		131	26.5	27.6		180	25.8	26.1
34	26.9	27.6		83	26.9	26.5		132	26.5	27.6		181	25.8	26.1
35	26.9	27.6		84	26.5	26.5		133	26.1	27.6		182	25.8	26.1
36	26.5	27.6		85	26.5	26.5		134	25.8	27.2		183	25.8	26.1
37	26.9	27.2		86	26.5	26.5		135	26.1	27.2		184	25.4	26.1
38	26.5	27.6		87	26.5	26.9		136	26.1	27.2		185	25.4	26.1
39	26.9	27.6		88	26.1	26.9		137	25.8	27.2		186	26.1	26.1
40	26.9	27.6		89	26.1	26.9		138	26.5	26.9		187	26.1	26.1
41	26.5	27.2		90	26.5	26.5		139	25.8	26.9		188	25.8	25.8
42	26.1	27.2		91	26.5	26.9		140	26.1	26.9		189	25.8	26.1
43	26.5	27.2		92	26.1	26.9		141	26.5	26.9		190	25.4	26.1
44	26.1	27.2		93	26.1	26.9		142	26.1	26.9		191	25.8	26.1
45	26.5	27.2		94	26.5	26.5		143	25.8	26.9		192	25.4	26.1
46	26.9	27.2		95	26.5	26.9		144	26.1	26.9		193	25.4	26.1
47	26.9	27.2		96	26.1	26.9		145	26.1	26.9		194	25.8	26.1
48	26.5	27.6		97	26.1	26.9		146	25.8	26.9		195	25.4	26.1
49	26.9	27.6		98	26.9	26.9		147	26.5	26.9		196	25.8	26.1

Table B.3 (Continued)

Sr. No.	Rm 23:dc4	Rm 31:dc1		Sr. No.	Rm 23:dc4	Rm 31:dc1		Sr. No.	Rm 23:dc4	Rm 31:dc1		Sr. No.	Rm 23:dc4	Rm 31:dc1
197	26.1	26.1		224	25.4	27.2		251	26.1	26.9		278	25.8	25.8
198	25.4	26.1		225	25.8	27.2		252	25.8	26.9		279	26.1	26.1
199	25.8	25.8		226	25.8	27.2		253	26.1	26.9		280	25.4	26.1
200	25.8	26.5		227	25.8	27.2		254	25.8	26.9		281	25.8	26.1
201	25.4	26.5		228	25.4	27.2		255	25.4	26.9		282	25.4	26.1
202	25.4	26.5		229	25.8	27.2		256	25.8	26.9		283	25.8	26.1
203	25.8	26.5		230	25.8	27.2		257	25.8	26.9		284	25.8	26.1
204	25.8	26.5		231	25.8	27.2		258	26.1	26.9		285	26.1	26.1
205	25.4	26.5		232	25.4	26.5		259	25.4	26.9		286	25.8	26.1
206	25.8	26.5		233	25.4	26.9		260	25.8	26.5		287	25.4	26.1
207	25.8	26.5		234	25.8	26.9		261	25.8	26.5		288	25.4	26.1
208	25.8	26.9		235	25.4	26.9		262	25.8	26.5		289	25.4	26.1
209	25.8	26.9		236	25.8	26.9		263	25.8	26.5		290	25.4	26.1
210	25.4	26.5		237	25.8	27.2		264	25.4	26.5		291	25.8	26.1
211	25.4	26.9		238	26.1	27.2		265	25.8	26.9		292	25.4	26.1
212	25.8	26.9		239	25.4	26.9		266	25.8	26.9		293	25.4	26.1
213	25.8	26.5		240	25.8	26.9		267	25.8	26.9		294	25.8	26.5
214	25.4	26.9		241	25.8	26.5		268	25.4	26.5		295	25.8	26.5
215	25.4	26.9		242	25.8	26.5		269	25.4	26.5		296	26.1	26.5
216	25.8	27.2		243	25.8	26.5		270	25.8	26.5		297	25.4	26.5
217	25.8	26.9		244	25.8	26.5		271	25.4	26.1		298	25.4	26.5
218	25.4	26.9		245	26.1	26.9		272	25.8	26.5		299	25.4	26.5
219	25.4	27.2		246	26.1	26.9		273	25.4	26.5		300	25.4	26.5
220	25.8	27.2		247	25.8	26.9		274	26.1	26.5		301	25.8	26.5
221	25.8	27.2		248	25.8	26.9		275	26.1	26.5		302	25.8	26.5
222	26.1	27.6		249	25.8	26.9		276	26.1	26.5		303	25.8	26.5
223	25.8	27.2		250	25.4	26.9		277	25.4	26.5				

Table. B.4. Temperatures measurements for Room 46, Room 22
(1 – 5 September) recorded at 15 minutes intervals.

Sr. No	Rm 46:dc2	Rm 22:dc4		Sr. No	Rm 46:dc2	Rm 22:dc4		Sr. No	Rm 46:dc2	Rm 22:dc4		Sr. No	Rm 46:dc2	Rm 22:dc4
1	27,9	27,6		50	27,6	25,1		99	25,8	24,1		148	26,9	24,1
2	28,7	26,9		51	27,6	25,1		100	25,8	24,1		149	26,9	24,4
3	29,1	27,2		52	27,2	25,1		101	25,4	23,7		150	26,9	24,4
4	28,7	26,9		53	26,9	25,1		102	25,8	24,4		151	26,5	23,7
5	29,1	26,5		54	26,9	25,1		103	26,1	24,1		152	26,5	23,7
6	29,1	26,5		55	26,9	24,7		104	26,1	23,7		153	26,5	23,7
7	28,7	27,2		56	26,9	25,4		105	25,8	23,7		154	26,5	23,7
8	29,4	26,9		57	26,9	25,4		106	25,8	23,7		155	26,5	23,7
9	29,1	26,9		58	26,9	25,4		107	26,1	24,1		156	26,5	23,7
10	28,7	26,9		59	26,9	25,1		108	26,1	24,4		157	25,8	24,1
11	28,7	27,2		60	26,5	25,1		109	26,1	24,4		158	25,8	24,1
12	28,7	26,5		61	26,9	24,4		110	26,1	24,4		159	26,1	23,7
13	28,7	26,9		62	26,5	24,4		111	26,1	24,4		160	26,1	24,1
14	28,7	26,5		63	26,9	24,7		112	26,1	24,1		161	26,1	23,7
15	28,7	26,5		64	26,9	24,4		113	26,1	24,7		162	26,1	23,4
16	28,7	26,5		65	26,5	24,7		114	26,1	24,4		163	26,1	23,7
17	28,7	26,9		66	26,5	24,1		115	26,1	24,7		164	26,1	23,4
18	27,9	26,1		67	26,9	24,4		116	26,1	24,7		165	26,1	23,4
19	28,3	26,5		68	26,9	24,7		117	26,1	24,7		166	26,1	23,7
20	28,3	26,5		69	26,5	24,7		118	26,1	24,7		167	26,1	23,7
21	28,3	26,1		70	26,5	24,4		119	26,1	24,7		168	26,1	24,1
22	28,3	26,5		71	26,1	24,4		120	26,1	24,4		169	25,8	24,1
23	27,9	26,5		72	26,1	24,1		121	26,5	24,4		170	25,8	23,7
24	27,9	26,1		73	26,1	24,4		122	26,5	24,4		171	25,8	23,7
25	28,3	26,1		74	26,1	24,4		123	26,5	24,1		172	25,8	23,7
26	28,3	25,8		75	26,1	24,4		124	26,9	24,4		173	25,4	23,4
27	28,3	26,1		76	26,1	24,4		125	26,5	24,4		174	25,8	23,7
28	27,9	25,8		77	26,1	24,4		126	26,5	24,1		175	25,8	23,7
29	28,3	25,8		78	26,1	24,4		127	26,5	24,7		176	25,8	23,7
30	27,2	26,1		79	26,1	24,4		128	26,9	24,7		177	25,8	23,4
31	27,6	25,8		80	25,8	24,4		129	26,5	24,7		178	26,1	23,7
32	27,9	25,8		81	25,8	24,7		130	26,5	24,4		179	25,8	23,4
33	27,9	26,1		82	26,1	24,1		131	26,5	24,7		180	25,8	23,4
34	27,6	26,1		83	26,1	23,7		132	26,1	24,4		181	25,8	23,4
35	27,9	26,1		84	26,1	24,4		133	26,5	24,4		182	25,4	23,4
36	27,6	25,4		85	26,1	24,4		134	26,1	24,7		183	25,8	23,4
37	27,2	25,4		86	26,1	24,4		135	26,1	24,4		184	25,8	23,1
38	27,6	25,8		87	26,1	24,1		136	26,5	24,7		185	25,1	23,1
39	27,6	25,8		88	26,1	23,7		137	26,5	24,4		186	25,8	23,4
40	27,6	26,1		89	26,1	24,4		138	26,5	24,7		187	25,1	23,4
41	27,6	25,8		90	25,8	24,4		139	26,5	24,4		188	25,1	23,4
42	27,6	25,8		91	25,8	24,1		140	26,5	24,1		189	25,1	23,1
43	27,6	25,4		92	25,8	23,7		141	26,9	24,7		190	25,1	23,1
44	27,6	25,4		93	25,8	24,1		142	26,9	24,4		191	25,1	23,1
45	27,6	25,8		94	25,8	24,1		143	26,9	24,4		192	25,1	23,4
46	27,6	25,1		95	25,8	24,1		144	26,9	24,4		193	25,1	23,4
47	27,2	25,4		96	25,8	23,7		145	26,9	24,1		194	25,1	23,1
48	27,2	25,8		97	26,1	24,1		146	26,9	24,1		195	25,8	23,4
49	27,6	25,1		98	25,8	23,7		147	26,9	24,1		196	25,8	23,7

Table B.4 (Continued)

Sr. No	Rm 46:dc2	Rm 22:dc4		Sr. No	Rm 46:dc2	Rm 22:dc4		Sr. No	Rm 46:dc2	Rm 22:dc4		Sr. No	Rm 46:dc2	Rm 22:dc4
197	25,4	23,4		246	27,2	24,1		295	25,8	23,4		344	26,9	24,4
198	25,4	23,1		247	27,2	24,7		296	26,1	23,7		345	26,9	24,7
199	25,4	23,4		248	26,5	24,4		297	26,1	24,1		346	26,9	24,1
200	25,4	23,4		249	26,5	24,4		298	26,1	24,1		347	26,9	24,4
201	25,1	23,1		250	26,5	24,4		299	26,1	24,1		348	26,9	24,4
202	25,8	23,4		251	26,9	24,4		300	26,1	23,4		349	26,5	24,1
203	25,8	24,1		252	26,5	24,4		301	25,8	23,7		350	26,5	24,1
204	26,1	24,1		253	26,9	23,7		302	26,5	24,1		351	26,5	24,1
205	25,8	23,4		254	26,9	24,4		303	26,1	23,7		352	26,5	24,1
206	25,8	24,1		255	26,9	24,1		304	26,5	23,7		353	26,9	24,1
207	25,8	24,1		256	26,9	23,7		305	26,5	24,4		354	26,5	24,1
208	25,8	24,1		257	26,9	23,7		306	26,5	24,4		355	26,5	24,1
209	25,8	24,1		258	26,9	24,1		307	26,9	24,1		356	26,5	24,1
210	25,8	23,7		259	26,9	24,1		308	26,9	24,4		357	26,5	24,1
211	26,1	23,7		260	26,9	24,1		309	26,9	24,4		358	26,5	24,4
212	26,5	24,4		261	26,9	24,4		310	26,9	24,4		359	26,5	24,4
213	26,1	24,1		262	26,9	24,1		311	26,9	24,4		360	26,5	24,1
214	26,9	23,7		263	26,9	24,1		312	26,9	24,7		361	26,5	24,4
215	26,1	24,1		264	26,9	24,4		313	27,2	24,4		362	26,5	24,4
216	26,1	24,1		265	26,9	24,1		314	27,2	24,4		363	26,5	23,7
217	26,1	24,4		266	26,9	24,1		315	27,2	24,7		364	26,5	24,1
218	26,5	24,1		267	26,9	24,1		316	27,2	24,7		365	26,5	24,1
219	26,5	24,4		268	26,5	24,1		317	27,2	24,4		366	26,5	24,1
220	26,5	24,1		269	26,5	24,1		318	27,2	24,7		367	26,1	23,7
221	26,9	24,1		270	26,5	24,1		319	27,2	24,1		368	26,5	23,7
222	26,9	24,1		271	25,8	23,7		320	26,9	24,4		369	26,5	23,7
223	26,9	24,4		272	26,1	23,4		321	26,9	24,7		370	26,1	23,7
224	26,5	24,4		273	26,1	23,4		322	26,9	25,1		371	26,1	23,7
225	26,5	24,4		274	26,1	23,4		323	27,2	24,7		372	26,1	24,1
226	26,5	24,1		275	26,1	23,4		324	27,6	24,7		373	26,1	23,7
227	26,5	24,4		276	26,1	23,7		325	27,6	24,4		374	26,1	23,4
228	26,5	24,7		277	26,1	23,7		326	27,2	24,7		375	26,1	23,7
229	26,5	24,7		278	26,5	23,7		327	27,2	24,7		376	26,1	24,1
230	26,5	24,4		279	26,5	23,1		328	27,6	24,7		377	26,1	23,7
231	26,5	24,4		280	26,1	23,7		329	27,2	24,4				
232	26,5	24,1		281	26,5	23,4		330	27,2	24,7				
233	26,5	24,7		282	26,1	23,1		331	27,6	24,4				
234	26,5	24,4		283	26,1	23,1		332	27,6	24,7				
235	26,5	24,4		284	25,8	23,7		333	27,6	24,4				
236	26,5	24,4		285	25,8	23,4		334	27,2	24,7				
237	26,9	24,4		286	25,8	23,1		335	27,2	24,7				
238	26,9	24,7		287	26,1	23,7		336	27,2	24,4				
239	26,9	24,1		288	26,1	23,1		337	27,2	24,7				
240	26,9	24,7		289	25,8	23,7		338	27,2	24,7				
241	26,9	24,4		290	26,1	23,7		339	26,9	24,7				
242	26,9	24,1		291	26,1	23,4		340	26,9	24,7				
243	26,9	24,4		292	26,1	23,7		341	27,2	24,1				
244	26,9	24,4		293	26,1	23,7		342	26,9	24,4				
245	26,9	24,1		294	25,8	23,4		343	26,9	24,4				

Table. B.5. Temperatures measurements for Room 85, Room 71 (1 – 5 September) recorded at 15 minutes intervals.

Sr. No	Rm 85:dc2	Rm 71:dc4		Sr. No	Rm 85:dc2	Rm 71:dc4		Sr. No	Rm 85:dc2	Rm 71:dc4		Sr. No	Rm 85:dc2	Rm 71:dc4
1	26,5	24,7		50	23,4	23,1		99	25,1	23,4		148	23,1	22,4
2	26,5	24,7		51	23,4	23,1		100	24,7	23,4		149	23,1	22,4
3	26,9	24,1		52	23,4	23,1		101	24,4	23,4		150	23,1	22,4
4	26,9	24,4		53	23,1	23,4		102	24,4	23,4		151	23,1	22,4
5	26,9	24,4		54	23,4	23,4		103	24,4	23,1		152	22,7	22,4
6	26,5	24,1		55	23,1	23,4		104	23,7	23,1		153	22,7	22,4
7	26,5	23,7		56	23,4	23,4		105	24,1	23,1		154	22,7	22,4
8	26,9	24,1		57	23,4	23,4		106	24,1	23,1		155	22,7	22,4
9	27,6	23,7		58	23,4	23,4		107	24,1	23,1		156	22,7	22,4
10	26,9	24,1		59	23,4	23,4		108	24,1	23,1		157	22,7	22,7
11	25,1	24,1		60	23,1	23,1		109	23,7	23,4		158	22,7	22,7
12	24,7	24,1		61	23,1	23,4		110	24,1	23,4		159	23,1	22,7
13	24,7	24,1		62	23,4	23,4		111	23,7	23,4		160	23,1	22,7
14	24,7	23,7		63	23,4	23,4		112	23,7	23,4		161	23,1	22,7
15	24,4	24,1		64	23,1	23,1		113	23,7	23,1		162	23,4	22,7
16	24,1	24,1		65	23,1	23,1		114	23,4	23,1		163	23,1	22,7
17	24,4	24,1		66	23,4	23,1		115	23,4	23,1		164	23,4	22,7
18	24,1	23,7		67	23,4	23,1		116	23,4	23,1		165	23,4	22,4
19	24,1	24,1		68	23,4	23,1		117	23,4	22,4		166	23,1	22,7
20	24,1	23,7		69	23,4	23,1		118	23,4	22,7		167	23,1	22,7
21	23,7	23,7		70	23,4	23,1		119	23,4	23,1		168	23,1	22,7
22	23,7	23,7		71	24,4	23,1		120	23,4	22,7		169	23,1	22,7
23	23,7	23,4		72	25,1	23,4		121	23,7	22,7		170	23,1	22,7
24	24,1	24,1		73	25,8	23,1		122	23,4	22,7		171	23,4	22,4
25	23,7	23,7		74	25,8	23,1		123	23,4	23,1		172	23,4	22,4
26	23,7	24,1		75	26,1	23,4		124	23,4	23,1		173	22,4	22,4
27	24,1	23,7		76	26,5	23,4		125	23,4	22,7		174	23,1	22,4
28	23,4	24,1		77	26,5	23,4		126	23,4	23,1		175	23,1	22,4
29	23,4	24,1		78	26,5	23,1		127	23,1	22,7		176	22,7	22,4
30	24,1	24,1		79	26,9	23,4		128	23,1	23,1		177	23,1	22,4
31	23,7	24,1		80	26,5	23,4		129	23,1	23,1		178	23,4	22,7
32	23,7	24,1		81	26,9	23,4		130	23,1	23,1		179	23,1	22,7
33	23,7	23,7		82	26,5	23,1		131	23,4	22,7		180	23,4	22,7
34	23,1	23,7		83	26,5	23,4		132	23,1	23,1		181	23,1	22,7
35	23,7	23,7		84	26,5	23,1		133	23,1	23,1		182	23,4	22,4
36	23,4	23,4		85	26,1	23,4		134	23,1	23,1		183	23,1	22,7
37	23,4	23,4		86	26,5	23,1		135	23,1	23,1		184	23,1	22,4
38	23,7	23,4		87	26,1	23,7		136	23,4	22,4		185	23,4	22,4
39	23,4	23,4		88	25,4	23,4		137	23,4	23,1		186	23,1	22,4
40	23,4	23,4		89	25,8	23,1		138	23,4	22,4		187	23,4	22,4
41	23,7	23,4		90	25,4	23,4		139	23,4	22,4		188	23,4	22,7
42	23,7	23,4		91	25,8	23,1		140	23,4	22,4		189	23,1	22,7
43	23,4	23,4		92	26,1	23,1		141	23,4	22,4		190	23,4	22,7
44	23,7	23,1		93	25,4	23,1		142	23,1	22,4		191	23,4	22,4
45	24,1	23,1		94	25,4	22,7		143	23,4	22,4		192	23,4	22,4
46	23,1	23,1		95	25,1	23,1		144	23,4	22,4		193	23,4	22,4
47	23,7	23,1		96	25,1	23,4		145	23,1	22,7		194	23,1	22,4
48	23,1	23,1		97	25,1	23,4		146	23,1	22,4		195	23,1	22,7
49	23,4	23,1		98	25,4	23,4		147	23,1	22,4		196	23,1	22,7

Table B.5 (Continued)

Sr. No	Rm 85:dc2	Rm 71:dc4		Sr. No	Rm 85:dc2	Rm 71:dc4		Sr. No	Rm 85:dc2	Rm 71:dc4		Sr. No	Rm 85:dc2	Rm 71:dc4
197	23,1	22,4		246	22,7	22,1		295	22,7	21,8		344	22,7	21,1
198	23,1	22,4		247	22,4	22,1		296	22,4	22,1		345	22,7	21,1
199	23,1	22,4		248	23,1	22,1		297	22,7	22,1		346	22,7	21,4
200	23,1	22,4		249	22,7	22,1		298	22,7	21,8		347	22,7	21,1
201	23,1	22,4		250	22,4	22,1		299	22,7	21,8		348	22,1	21,1
202	23,4	22,4		251	22,7	22,1		300	22,7	21,8		349	22,1	21,4
203	23,1	22,4		252	22,7	21,8		301	22,7	21,4		350	22,4	21,1
204	23,1	22,4		253	22,7	21,8		302	22,7	21,8		351	22,4	21,1
205	23,1	22,4		254	22,7	21,8		303	22,7	21,4		352	22,4	20,8
206	22,7	22,4		255	22,7	21,8		304	22,7	21,4		353	22,1	21,1
207	23,1	22,4		256	22,4	21,8		305	22,4	21,4		354	22,1	21,1
208	23,1	22,4		257	22,7	21,8		306	22,4	21,4		355	22,4	20,8
209	23,1	22,4		258	22,4	21,8		307	22,7	21,4		356	22,7	21,1
210	23,4	22,4		259	22,4	21,8		308	22,4	21,4		357	22,7	20,8
211	23,4	22,4		260	22,7	21,4		309	22,7	21,4		358	22,7	20,8
212	23,1	22,1		261	22,7	21,4		310	22,7	21,4		359	22,4	21,1
213	23,1	22,4		262	22,7	21,8		311	22,4	21,4		360	22,4	21,1
214	23,1	22,4		263	22,4	21,8		312	22,4	21,4		361	22,1	21,4
215	23,1	22,1		264	22,7	22,1		313	22,7	21,4		362	22,4	21,4
216	23,1	22,4		265	22,7	21,8		314	22,4	21,4		363	22,4	21,8
217	22,7	22,4		266	22,7	21,4		315	22,4	21,4		364	22,4	21,4
218	23,1	22,4		267	22,7	21,8		316	22,4	21,4		365	22,4	21,8
219	23,1	22,4		268	23,1	21,8		317	22,7	21,4		366	22,7	21,4
220	23,4	21,8		269	22,4	21,8		318	22,4	21,4		367	22,4	21,8
221	23,1	21,8		270	22,4	21,8		319	22,4	21,8		368	22,1	21,1
222	23,1	21,8		271	22,7	21,8		320	22,4	21,4		369	22,4	21,4
223	23,4	22,4		272	22,4	21,8		321	22,4	21,8		370	22,7	21,4
224	23,4	22,4		273	22,4	21,4		322	22,7	21,4		371	22,4	21,8
225	23,1	22,1		274	22,7	21,8		323	22,7	21,4		372	22,7	21,8
226	23,1	22,1		275	22,7	22,1		324	22,4	21,4		373	22,4	21,1
227	22,4	22,1		276	22,7	21,8		325	22,4	21,4		374	22,1	21,8
228	23,1	21,8		277	22,7	21,8		326	22,4	21,4		375	22,4	21,1
229	23,4	22,1		278	22,4	21,8		327	22,4	21,8		376	22,4	21,1
230	23,1	21,8		279	22,7	21,8		328	22,4	21,4		377	22,1	21,1
231	23,1	21,8		280	22,7	21,4		329	22,4	21,8		378	22,4	21,4
232	23,1	21,8		281	22,7	21,4		330	22,1	21,4		379	22,4	21,4
233	23,1	22,1		282	22,7	21,4		331	22,4	21,8		380	22,4	21,4
234	22,7	22,1		283	22,7	21,8		332	22,4	21,4		381	22,1	21,4
235	23,1	22,1		284	22,4	21,4		333	22,4	21,4		382	22,4	21,4
236	23,1	22,1		285	22,4	21,8		334	22,1	21,4		383	22,4	21,1
237	23,1	21,8		286	22,4	21,8		335	22,4	21,4		384	22,1	21,1
238	23,1	21,8		287	22,4	21,8		336	22,4	21,1		385	22,4	21,1
239	23,1	22,1		288	22,7	21,8		337	22,1	21,4		386	22,4	21,8
240	23,1	21,8		289	22,4	21,8		338	22,7	21,1		387	22,7	21,1
241	23,1	21,8		290	22,4	21,8		339	22,1	21,1		388	22,4	21,4
242	22,7	21,8		291	22,4	22,1		340	22,4	21,1		389	22,4	21,4
243	22,7	22,1		292	22,7	22,1		341	22,7	21,1		390	22,1	21,4
244	22,7	22,1		293	22,7	22,1		342	22,1	21,1		391	22,4	21,4
245	22,7	22,1		294	22,4	21,8		343	22,7	21,1		392	21,8	21,4

Table B.5 (Continued)

Sr. No	Rm 85:dc2	Rm 71:dc4		Sr. No	Rm 85:dc2	Rm 71:dc4		Sr. No	Rm 85:dc2	Rm 71:dc4		Sr. No	Rm 85:dc2	Rm 71:dc4
393	22,4	21,1		408	22,1	21,1		423	22,1	21,1		438	22,1	20,8
394	22,4	21,4		409	22,1	21,4		424	22,1	21,1		439	22,1	21,1
395	22,1	21,4		410	22,1	21,1		425	22,1	20,8		440	21,8	20,5
396	22,1	21,4		411	22,1	21,4		426	21,8	21,4		441	22,1	20,5
397	21,8	21,1		412	22,1	21,4		427	22,1	21,1		442	22,1	20,8
398	22,4	21,1		413	22,4	21,4		428	22,1	21,1		443	22,1	20,8
399	22,1	21,1		414	22,4	21,4		429	22,1	20,8		444	21,8	20,8
400	22,1	21,1		415	22,1	21,1		430	22,1	20,8		445	21,8	20,8
401	22,4	21,4		416	22,1	21,1		431	22,1	20,8		446	22,1	20,8
402	22,1	21,4		417	22,1	21,4		432	22,1	21,4		447	22,1	20,5
403	21,8	21,4		418	21,8	21,4		433	21,8	20,8		448	22,1	23,1
404	21,8	21,1		419	21,8	21,4		434	21,8	20,8				
405	22,4	20,8		420	21,8	21,4		435	22,1	20,8				
406	22,1	21,1		421	22,1	21,4		436	21,8	21,1				
407	22,4	21,4		422	22,1	21,1		437	22,1	21,1				

APPENDIX C

HUMIDITY DATA GROUPED FOR ANOVA

Table. C.1. Humidity measurements for Room 54, Room 57 (10 – 14 July) and Room 85 (14 – 18 July) recorded at 15 minutes intervals.

Sr. No.	Rm 54:dc4	Rm 57:dc1	Rm 85:dc4		Sr. No.	Rm 54:dc4	Rm 57:dc1	Rm 85:dc4		Sr. No.	Rm 54:dc4	Rm 57:dc1	Rm 85:dc4
1	37.1	36	37.6		26	38	37.8	39.4		51	39.4	38.2	39
2	37.1	36	38.5		27	38	37.8	39.4		52	39.4	38.2	39
3	37.1	36	39.4		28	38	37.8	39.4		53	39.4	38.2	38.5
4	37.1	36	39		29	38.5	37.8	39.4		54	39.4	38.2	39
5	37.1	36	39		30	38.5	37.8	39.4		55	39.4	38.2	39
6	37.1	36	39		31	39	37.8	39.4		56	39.4	38.2	39
7	37.1	36	39.4		32	39	37.8	39.4		57	39.4	38.7	39
8	37.1	36	39		33	39	37.8	39.4		58	39.9	38.7	39
9	37.1	36	39.4		34	39	37.8	39.4		59	39.9	38.7	38.5
10	37.1	36	39		35	39	37.8	39.4		60	39.9	38.7	38.5
11	37.1	36	39.4		36	39	38.2	39.4		61	39.9	38.2	38.5
12	37.1	36	39		37	39	38.2	39.4		62	39.9	38.2	38.5
13	37.1	36	39		38	39	38.2	39.4		63	39.9	38.2	39
14	37.1	36	39.4		39	39	37.8	39.4		64	39.9	38.2	39
15	37.6	36	39.4		40	39	37.8	39.4		65	39.9	38.2	38
16	37.6	36	39.4		41	39	37.8	39.4		66	39.9	38.7	37.1
17	37.6	36	39.4		42	39	37.8	39.4		67	39.9	38.7	36.7
18	37.6	36	39.4		43	39	37.8	39.4		68	39.4	39.1	37.1
19	37.6	36	39.4		44	39	37.8	39		69	39.4	38.7	37.6
20	37.6	36.4	39.4		45	39.4	37.8	39		70	39.4	39.1	37.6
21	37.6	36.4	39.4		46	39.4	37.8	39.4		71	39.4	39.1	38
22	38	37.3	39.4		47	39.4	37.8	39.4		72	39	38.7	38
23	38	37.3	39.4		48	39	37.8	39.4		73	39	39.6	38.5
24	38	37.3	39.4		49	39.4	37.8	39		74	39	38.2	38.5
25	38	37.8	39.4		50	39.4	38.2	39		75	39	37.8	39

Table C.1 (Continued)

Sr. No	Rm 54: dc4	Rm 57: dc1	Rm 85: dc4		Sr. No.	Rm 54: dc4	Rm 57: dc1	Rm 85: dc4		Sr. No.	Rm 54: dc4	Rm 57: dc1	Rm 85: dc4
76	39	37.8	38.5		126	39	37.8	39		176	38	37.3	39.4
77	39	38.2	39		127	38.5	37.8	39		177	38	37.3	39.4
78	39	38.2	39		128	39	37.8	39		178	37.6	37.3	39.4
79	38.5	37.8	39		129	39	37.8	39		179	37.6	37.3	39.4
80	38.5	38.2	39		130	39	38.2	39.4		180	37.6	37.3	39
81	38	37.8	39		131	39	38.2	39.4		181	37.1	37.3	39
82	38	37.8	39		132	39	38.2	39.4		182	37.1	37.3	39
83	38	37.8	39		133	39	38.7	39.4		183	37.1	37.3	39
84	37.6	37.8	39		134	39	38.7	39.4		184	37.1	37.3	39
85	37.6	37.8	39		135	39	38.7	39.4		185	37.1	37.3	39
86	37.6	37.8	39		136	39	38.7	39		186	36.7	37.3	39
87	37.6	37.8	39		137	39	39.1	39		187	37.1	37.3	38.5
88	37.1	37.8	39		138	39.4	39.1	39		188	37.1	37.3	38
89	37.1	37.8	39		139	39.4	39.1	39.4		189	37.1	37.3	37.6
90	37.1	37.3	39		140	39	39.1	39.4		190	37.1	37.3	37.6
91	37.1	37.8	39.4		141	39.4	39.1	39		191	37.1	37.3	37.1
92	37.1	37.3	39		142	39.4	39.1	39		192	36.7	37.3	37.1
93	37.1	37.3	39		143	39.4	39.1	39		193	37.1	37.3	37.1
94	37.1	37.3	39		144	39.4	39.1	39		194	37.1	37.3	37.1
95	37.1	37.3	39		145	39.4	39.1	39.4		195	37.1	36.9	37.1
96	37.1	37.3	39		146	39.4	39.1	39.4		196	36.7	36.9	37.1
97	37.1	37.3	39		147	39.4	38.7	39		197	37.1	36.4	37.1
98	37.1	37.3	39		148	39.4	39.1	39.4		198	36.7	36.4	37.6
99	37.1	37.3	39		149	39.4	38.7	39.4		199	36.7	36.4	37.1
100	37.1	37.3	39		150	39.4	38.7	39.4		200	36.7	36.4	37.1
101	37.6	37.3	38.5		151	39.9	39.1	39		201	37.1	36.4	37.1
102	37.6	37.3	39		152	39.9	39.1	39.4		202	37.1	36.4	37.1
103	37.6	37.3	38.5		153	39.9	39.1	39		203	37.1	36.4	37.6
104	37.6	37.3	39		154	39.9	39.1	39.4		204	37.1	36.4	37.6
105	37.6	37.3	39		155	39.9	39.1	39		205	37.1	36.4	37.6
106	37.1	37.3	39		156	39.9	39.1	39		206	37.1	36.9	37.6
107	37.1	37.3	39		157	39.9	38.7	39		207	37.1	36.9	37.6
108	37.1	37.3	39		158	39.9	39.1	39		208	37.6	36.9	37.6
109	37.6	37.3	39		159	39.9	38.7	39		209	37.6	37.3	37.6
110	37.6	37.3	39		160	39.4	39.1	39		210	37.1	37.3	38
111	37.6	37.3	39		161	39.4	38.7	38.5		211	37.6	37.3	38
112	38	37.3	39		162	39.4	38.7	38.5		212	37.6	37.3	38
113	38	37.3	38.5		163	39.4	38.7	36.2		213	38	37.3	38
114	38	37.8	39		164	39.4	38.2	37.6		214	38	37.3	38
115	38	37.8	39		165	39.4	38.2	38		215	38	37.3	38
116	38	37.8	39		166	39	38.2	38.5		216	38	37.3	38
117	38	38.2	38.5		167	39	37.8	38.5		217	38	37.3	38
118	38	37.8	39		168	39	37.8	39		218	38.5	37.3	38
119	38	37.8	39		169	38.5	37.8	39		219	38.5	37.3	38
120	38.5	37.8	39		170	39	37.8	39		220	39	37.3	38
121	38.5	37.8	39		171	39	37.8	39		221	39	37.3	38
122	38.5	38.2	39		172	39	37.8	39		222	39	37.3	38
123	38.5	37.8	39		173	38.5	37.8	39		223	39	37.8	38
124	39	37.8	39		174	38.5	37.8	39		224	39	37.8	38.5
125	39	37.8	39		175	38	37.8	39		225	39	37.8	38.5

Table C.1 (Continued)

Sr. No	Rm 54: dc4	Rm 57: dc1	Rm 85: dc4		Sr. No.	Rm 54: dc4	Rm 57: dc1	Rm 85: dc4		Sr. No.	Rm 54: dc4	Rm 57: dc1	Rm 85: dc4
226	39	37.3	38.5		272	36.7	37.3	39.4		318	38	37.8	39.9
227	39	37.3	38.5		273	36.2	37.3	39.4		319	38.5	37.8	40.3
228	39	37.8	38.5		274	36.7	37.3	39.4		320	38.5	37.8	40.3
229	39	37.8	38.5		275	35.7	37.3	39.4		321	39	37.8	40.3
230	39	37.8	38.5		276	36.2	37.3	39.4		322	39	38.2	40.3
231	39	37.8	38.5		277	36.7	37.3	39.4		323	39	38.2	40.8
232	39	38.2	38.5		278	36.7	37.3	39.4		324	39	38.2	40.8
233	39	38.2	39		279	36.7	37.3	39.4		325	39	38.2	40.8
234	39	38.2	39		280	36.7	37.3	39.4		326	39	38.2	41.3
235	39	37.8	38.5		281	37.1	37.3	39.4		327	38.5	38.2	41.3
236	39	37.8	39		282	37.1	37.3	39.4		328	39	38.2	41.3
237	39.4	37.8	38.5		283	37.1	37.3	39.4		329	39	38.2	40.8
238	39.4	37.8	39		284	36.7	37.3	39.4		330	39	38.7	41.3
239	39	37.8	39		285	36.7	37.3	39.4		331	39	38.7	40.8
240	39.4	37.8	39		286	36.7	37.3	39.9		332	39	38.7	40.8
241	39.4	37.8	39		287	36.7	37.3	39.9		333	39	38.7	41.3
242	39.4	37.8	39		288	36.7	37.3	39.4		334	39	38.7	40.8
243	39.4	37.8	39		289	37.1	37.3	39.9		335	39	38.7	41.3
244	39.4	37.8	39		290	37.1	37.3	39.9		336	39.4	39.1	40.8
245	39.4	38.2	39		291	37.1	37.3	39.9		337	39	39.1	41.3
246	39.9	38.2	39		292	37.1	37.3	39.4		338	39.4	39.6	41.3
247	39.9	38.2	39		293	37.1	37.3	39.9		339	39.4	39.6	41.3
248	39.9	38.2	39		294	37.1	36.9	39.4		340	39.4	39.6	41.3
249	39.9	38.2	39.4		295	37.1	36.9	39.4		341	39.4	39.6	40.8
250	39.9	38.2	39.4		296	37.1	37.3	39.4		342	39.4	39.6	40.8
251	39.9	38.2	39.4		297	37.1	36.9	39.4		343	39.4	39.6	40.8
252	39.4	38.2	39		298	37.1	36.9	39.4		344	39.4	39.6	40.3
253	39.4	38.2	39		299	37.1	36.9	39.4		345	39.4	40	40.3
254	39.4	38.2	39		300	37.1	36.9	39.4		346	39.4	40	40.3
255	39.4	38.2	39		301	37.6	36.9	39.4		347	39.4	40	40.3
256	39.4	38.2	39		302	37.1	36.9	39.4		348	39.4	40	39.9
257	39.4	38.2	39		303	37.1	37.3	39.4		349	39.4	39.6	39.9
258	39	38.2	39.4		304	37.1	37.3	39.9		350	39.4	39.6	39.9
259	39	38.2	39.4		305	37.6	37.3	39.9		351	39.4	39.6	39.4
260	39	38.2	39.4		306	37.1	37.3	39.9		352	39.4	39.6	39.4
261	39	38.2	39.4		307	37.1	37.3	39.9		353	39.4	39.6	39
262	38.5	38.2	39.4		308	37.1	37.3	39.9		354	39.4	39.6	39
263	38	37.8	39		309	37.6	37.3	40.3		355	39.4	39.1	36.7
264	37.6	37.8	39		310	37.6	37.3	39.9		356	39.4	39.1	37.6
265	37.6	37.8	39		311	37.6	37.8	39.9		357	39	39.1	38.5
266	37.1	37.8	39		312	37.6	37.8	39.9		358	39	39.1	39
267	37.1	37.3	39		313	37.6	37.8	39.9		359	39	38.7	39
268	36.7	37.3	39		314	38	37.8	39.9		360	39	38.7	39
269	36.7	37.3	39		315	38	38.2	39.9		361	39	38.2	39
270	36.7	37.3	39		316	38	37.8	39.9		362	38.5	38.2	39
271	36.7	37.3	39		317	38	37.8	39.9					

Table. C.2. Humidity measurements for Room 61, Room 70 (22 – 25 August) and Room 79 (18 - 21 August) recorded at 15 minutes intervals.

Sr. No	Rm 61:dc4	Rm 70:dc1	Rm 79:dc1		Sr. No	Rm 61:dc4	Rm 70:dc1	Rm 79:dc1		Sr. No	Rm 61:dc4	Rm 70:dc1	Rm 79:dc1
1	27,8	27,7	31,1		51	30,4	33,3	32,4		101	29,1	30,3	28,5
2	26,9	27,2	32		52	30,4	33,3	32,4		102	29,1	30,3	29
3	26,9	27,2	32		53	30,4	33,3	32,4		103	29,1	30,3	27,2
4	26,9	27,2	32		54	30,8	33,3	32,4		104	29,1	30,3	28,5
5	26,9	27,7	32		55	30,8	33,8	32,9		105	29,1	30,3	29
6	27,3	27,7	32		56	30,8	33,8	32,9		106	29,5	30,7	28,5
7	27,3	27,7	32		57	30,8	33,3	32,9		107	29,5	31,1	28,5
8	27,3	28,1	32,4		58	31,3	33,8	32,9		108	29,5	31,1	28,5
9	27,3	28,5	32,4		59	31,3	33,8	32,9		109	29,9	31,6	28,5
10	27,8	28,5	32,4		60	31,7	33,8	32,9		110	30,4	31,1	28,5
11	27,8	29	32,4		61	31,3	33,8	32,9		111	30,4	31,1	29
12	27,8	29,4	31,6		62	31,3	33,8	32,9		112	30,4	31,6	29
13	27,8	29,4	31,6		63	31,7	33,8	32,9		113	30,4	31,6	29
14	27,8	29,4	31,6		64	31,3	33,8	32,9		114	30,4	32	29,4
15	27,8	29,4	32		65	32,1	33,8	32,9		115	30,8	32,4	29
16	28,2	29,8	32		66	32,1	33,8	32,9		116	31,3	32,4	29
17	28,2	29,4	32		67	32,6	33,8	32,9		117	31,3	32,9	29,4
18	28,2	29,4	32		68	32,1	33,8	32,9		118	31,3	32,9	29,4
19	27,8	29,4	32		69	32,1	33,8	32,9		119	31,3	33,3	29,4
20	27,8	29,8	32,4		70	32,6	33,3	32,4		120	31,3	33,3	28,5
21	28,2	29,8	32,9		71	32,1	33,3	32		121	31,3	32,9	28,5
22	28,2	30,3	32,4		72	32,6	33,8	31,6		122	31,3	33,3	28,5
23	28,6	30,7	32,9		73	32,1	33,3	32		123	31,3	33,3	29
24	28,2	30,7	32,9		74	30,8	33,8	31,6		124	31,3	33,3	29
25	28,2	31,1	32,9		75	30,4	33,3	31,1		125	31,3	33,3	29
26	28,2	31,1	32,9		76	30,4	33,8	31,6		126	31,3	33,3	29,4
27	28,6	31,6	32,9		77	30,4	33,8	31,1		127	31,3	33,8	29
28	28,6	31,6	32,9		78	30,4	33,3	31,6		128	31,3	33,8	29,4
29	29,1	31,6	32,9		79	30,4	33,3	31,6		129	31,3	33,8	29,4
30	28,6	31,1	32,9		80	30,8	32,9	31,1		130	31,7	33,8	29,4
31	29,1	31,1	32,9		81	30,4	32,9	31,1		131	31,7	33,8	29,8
32	29,1	31,1	32,9		82	30,4	32	31,1		132	31,3	33,3	29,8
33	29,1	31,1	32,9		83	30,8	32,4	31,1		133	31,3	33,8	29,8
34	29,1	31,1	32,9		84	30,4	32,4	29,4		134	31,3	33,3	29,8
35	29,1	31,6	32,9		85	30,4	32	30,7		135	31,7	33,3	29,8
36	29,1	31,6	32,9		86	30,4	32	29		136	31,7	33,8	30,3
37	29,5	31,6	32,9		87	30,4	32	29,8		137	32,1	33,8	30,3
38	29,5	31,6	32,9		88	30,4	32	28,5		138	32,1	33,8	30,3
39	29,9	32	32,9		89	30,4	31,6	29		139	32,1	34,2	30,7
40	29,9	32	32,9		90	30,4	31,6	29,4		140	32,1	34,2	30,7
41	29,9	32	32,4		91	30,4	31,1	29		141	32,6	34,6	30,7
42	29,9	32	32,4		92	29,9	31,6	27,7		142	32,6	34,6	30,7
43	30,4	32	32,4		93	29,9	31,1	26,8		143	32,6	35,1	30,7
44	30,4	32	32,9		94	29,5	30,3	27,2		144	32,6	35,1	30,7
45	30,4	32,4	32,9		95	29,5	29,8	28,5		145	32,6	35,5	31,1
46	30,4	32,4	32,4		96	29,5	30,3	27,2		146	32,6	35,5	31,1
47	30,4	32,9	32,4		97	29,1	30,3	29		147	32,6	35,5	31,1
48	30,8	32,9	32		98	29,1	30,3	27,7		148	33	35,5	31,1
49	30,4	32,9	32,4		99	29,1	30,7	29		149	33	35,5	31,1
50	30,4	33,3	32,4		100	29,1	30,7	29		150	33	35,5	31,1

Table C.2 (Continued)

Sr. No	Rm 61:dc4	Rm 70:dc1	Rm 79:dc1		Sr. No	Rm 61:dc4	Rm 70:dc1	Rm 79:dc1		Sr. No	Rm 61:dc4	Rm 70:dc1	Rm 79:dc1
151	33	35,5	31,1		201	30,4	31,1	29,8		251	36,7	36,4	30,7
152	33,5	36	31,1		202	29,9	31,6	30,3		252	36,7	36,4	30,7
153	33,5	35,5	31,1		203	30,4	31,1	30,7		253	37,1	36,4	30,7
154	33,5	35,5	31,1		204	29,9	31,1	30,7		254	37,1	36,9	29,4
155	33,5	36	31,1		205	29,9	31,1	30,7					
156	33,5	35,5	31,1		206	29,5	31,1	30,7					
157	33	36	31,1		207	29,5	30,7	30,7					
158	33,5	35,5	31,1		208	29,5	31,1	31,1					
159	33,5	36	31,1		209	29,1	31,1	31,1					
160	34,4	36	31,1		210	29,1	31,1	30,7					
161	33,9	35,5	31,6		211	29,9	31,1	30,3					
162	34,4	36	31,6		212	29,9	31,6	29,8					
163	34,8	36	31,6		213	30,4	32	30,3					
164	34,4	36	31,6		214	30,4	32	29,8					
165	34,4	36	31,6		215	30,8	32	29,8					
166	34,4	36	31,1		216	30,4	32,4	29,8					
167	34,4	35,5	31,6		217	30,4	32,4	29,4					
168	34,8	35,5	31,6		218	30,8	32,9	29,4					
169	34,4	35,5	31,6		219	31,3	32,9	29,4					
170	34,8	35,5	31,6		220	32,1	33,3	29,8					
171	34,8	35,5	31,6		221	32,6	33,8	29,8					
172	34,4	35,5	31,1		222	32,6	33,8	29,8					
173	33,9	35,5	31,6		223	32,6	33,3	29,8					
174	33,5	35,5	31,1		224	32,6	33,3	29,8					
175	33,9	36	31,6		225	33	33,8	29,8					
176	33,9	36	31,6		226	33,5	33,8	29,8					
177	33,5	35,5	31,6		227	33,5	34,2	29,8					
178	33	35,1	31,6		228	33	34,2	29,8					
179	32,6	35,1	31,1		229	33,5	34,2	29,8					
180	32,6	34,6	31,6		230	33,9	34,6	30,3					
181	32,6	34,2	31,6		231	34,4	34,6	30,3					
182	32,6	33,8	31,6		232	33,9	35,1	30,3					
183	32,6	33,3	31,6		233	33,9	35,1	30,3					
184	32,6	33,3	31,6		234	34,8	35,5	30,3					
185	32,1	33,3	31,6		235	34,8	35,5	30,3					
186	32,1	33,3	31,1		236	34,4	35,5	30,3					
187	32,1	32,4	31,6		237	34,8	35,5	30,3					
188	31,7	32,4	31,1		238	34,8	36	30,3					
189	31,3	31,6	30,7		239	34,4	36	30,3					
190	30,8	31,6	31,1		240	34,8	35,5	30,3					
191	30,8	31,6	30,7		241	34,8	35,5	30,3					
192	30,4	31,1	30,7		242	34,4	35,5	30,3					
193	30,4	31,1	30,3		243	34,4	35,5	30,3					
194	30,8	31,6	30,3		244	34,4	36	30,3					
195	30,8	31,1	30,3		245	34,4	36	30,3					
196	30,8	30,7	29,8		246	34,8	36	30,7					
197	30,4	30,7	29,8		247	34,8	36	30,7					
198	30,4	30,7	29,8		248	34,8	36,4	30,7					
199	30,4	31,1	29,8		249	35,7	36,4	30,7					
200	30,8	31,6	29,8		250	36,7	36,4	30,7					

Table. C.3. Humidity measurements for Room 23, Room 31 (28 – 31 August) recorded at 15 minutes intervals.

Sr. No.	Rm 23:dc4	Rm 31:dc1		Sr. No.	Rm 23:dc4	Rm 31:dc1		Sr. No.	Rm 23:dc4	Rm 31:dc1		Sr. No.	Rm 23:dc4	Rm 31:dc1
1	42.6	33.3		50	46.9	35.5		99	45.4	38.7		148	47.8	37.8
2	44	35.1		51	46.4	35.5		100	45.4	38.7		149	47.3	37.8
3	45.4	35.5		52	45.9	36		101	45.4	38.7		150	47.3	37.8
4	45.4	35.5		53	45.9	36		102	45.4	38.7		151	47.8	37.8
5	45.4	35.5		54	45.9	35.5		103	45.4	38.7		152	47.8	37.8
6	45.9	36		55	45.9	35.5		104	45.4	38.7		153	47.8	37.8
7	45.4	36		56	45.9	36		105	45.4	38.7		154	47.8	37.8
8	45.4	36		57	45.4	36		106	45.4	38.7		155	47.8	37.8
9	45.4	36		58	45.4	35.5		107	45.4	38.7		156	47.8	37.8
10	45.4	36		59	45.4	35.5		108	45.4	38.2		157	47.3	37.8
11	45.4	36		60	45.4	35.5		109	44.9	37.8		158	47.8	38.2
12	45.4	36		61	45.9	36		110	44.9	37.8		159	47.8	38.2
13	44.9	36		62	45.4	36		111	45.4	37.8		160	48.3	38.2
14	44.9	36		63	45.4	36.4		112	44.9	37.8		161	48.3	37.8
15	44.9	36		64	45.4	36.4		113	44.9	37.8		162	48.3	37.8
16	44.9	36		65	45.4	36.4		114	44.9	37.8		163	48.3	37.8
17	44.9	36		66	45.4	37.3		115	44.9	37.8		164	48.8	37.8
18	44.9	35.5		67	45.4	37.3		116	44.9	38.2		165	48.8	37.8
19	44.5	35.5		68	45.4	37.3		117	44.9	38.2		166	49.3	37.8
20	44.5	35.5		69	45.4	37.3		118	44.5	37.8		167	49.3	37.8
21	44.5	35.5		70	45.4	37.3		119	44.5	37.8		168	49.3	37.8
22	44.5	35.5		71	45.4	37.8		120	44.5	37.3		169	49.8	37.8
23	44.9	35.5		72	45.4	38.2		121	44	37.3		170	49.8	37.8
24	44.9	35.5		73	45.4	37.8		122	44	37.3		171	49.3	37.8
25	44.9	35.5		74	45.9	37.8		123	44	37.3		172	49.8	37.8
26	44.5	35.5		75	45.9	37.8		124	44	36.9		173	50.2	37.8
27	44.5	36		76	45.9	37.8		125	44	36.9		174	50.7	37.8
28	44.5	36		77	45.9	37.8		126	43.6	36.9		175	50.2	37.8
29	44.9	36		78	45.9	38.2		127	43.6	36.9		176	50.7	37.8
30	44.5	35.5		79	45.9	38.7		128	43.6	36.4		177	50.7	37.8
31	44.9	35.1		80	45.9	38.2		129	43.6	36.4		178	50.7	37.8
32	44.9	35.1		81	45.9	38.2		130	44	36.9		179	50.7	37.8
33	44.5	35.1		82	45.9	38.2		131	44	36.4		180	50.7	37.8
34	44.5	35.1		83	45.9	38.7		132	44	36.4		181	50.7	37.8
35	44.5	35.5		84	45.9	38.7		133	44	36.4		182	50.2	37.8
36	44	35.5		85	45.9	39.1		134	44.5	36.4		183	50.2	37.8
37	44	35.1		86	45.9	39.1		135	44.9	36.9		184	50.2	37.8
38	44	35.1		87	45.9	39.6		136	44.9	36.9		185	50.2	37.8
39	44.5	35.5		88	45.9	39.6		137	45.4	37.3		186	49.8	37.8
40	45.4	35.5		89	46.4	40		138	45.4	37.3		187	49.3	37.8
41	45.4	35.5		90	46.4	40		139	45.4	37.8		188	48.8	37.8
42	45.4	35.5		91	46.4	39.6		140	45.9	37.8		189	48.8	37.8
43	45.9	36		92	46.4	39.6		141	45.9	37.8		190	48.8	37.8
44	45.4	36		93	46.4	39.6		142	46.4	37.8		191	48.3	37.8
45	45.9	36		94	45.9	39.1		143	46.4	37.8		192	48.3	37.8
46	46.4	36		95	45.9	39.1		144	46.9	37.8		193	48.3	37.8
47	46.4	36		96	45.4	38.7		145	46.9	37.8		194	47.8	37.8
48	46.9	36		97	45.4	38.7		146	46.9	37.8		195	47.3	37.8
49	47.3	36		98	45.9	38.7		147	47.3	37.8		196	47.3	37.8

Table. C.3 (Continued)

Sr. No.	Rm 23:dc4	Rm 31:dc1		Sr. No.	Rm 23:dc4	Rm 31:dc1		Sr. No.	Rm 23:dc4	Rm 31:dc1		Sr. No.	Rm 23:dc4	Rm 31:dc1
197	47.3	37.8		225	44	36		253	47.3	36.4		281	48.8	37.3
198	47.3	37.8		226	43.6	36		254	47.3	36.4		282	48.3	37.3
199	46.9	37.8		227	44	35.5		255	47.3	36.4		283	47.8	37.3
200	46.9	38.2		228	44	36		256	47.8	36.4		284	47.8	37.3
201	46.9	38.2		229	44	35.5		257	47.8	36.4		285	47.3	37.3
202	46.4	38.2		230	44	35.5		258	47.8	36.4		286	46.9	37.3
203	46.4	38.2		231	44.5	35.5		259	48.3	36.4		287	46.9	37.3
204	45.9	38.2		232	44.5	35.5		260	48.3	36.4		288	46.9	37.3
205	46.4	37.8		233	45.4	35.5		261	48.3	36.4		289	46.4	37.3
206	45.9	37.8		234	45.4	35.5		262	48.3	36.9		290	46.4	37.3
207	45.9	37.8		235	45.4	36		263	48.8	36.9		291	46.4	36.9
208	45.9	37.8		236	45.9	36		264	48.3	36.9		292	45.9	36.9
209	45.9	37.8		237	46.4	36		265	48.8	37.3		293	46.4	36.9
210	45.9	37.3		238	46.4	36		266	48.8	37.3		294	45.9	36.9
211	45.4	37.3		239	46.4	36		267	48.8	37.3		295	45.9	36.9
212	45.4	36.9		240	46.9	36		268	49.3	37.3		296	45.9	36.4
213	45.4	36.9		241	46.9	36		269	49.3	37.3		297	45.4	36.4
214	45.4	36.4		242	46.9	36		270	49.8	37.3		298	45.9	36.4
215	45.4	36.4		243	46.9	36		271	49.8	37.3		299	45.4	36.4
216	44.9	36		244	46.9	36		272	49.8	37.3		300	45.4	36.9
217	44.9	36		245	46.9	36.4		273	49.8	37.3		301	45.4	36.4
218	44.9	35.5		246	46.9	36.4		274	49.8	37.3		302	45.4	33.8
219	44.5	35.5		247	46.9	36.4		275	49.3	37.3				
220	44.5	35.5		248	47.3	36.4		276	49.8	37.3				
221	44.5	35.5		249	46.9	36.4		277	50.2	37.3				
222	44.5	36		250	47.3	36.4		278	50.2	37.3				
223	44	36		251	47.3	36.4		279	50.7	37.3				
224	44	35.5		252	47.3	36.4		280	50.2	37.3				

Table. C.4. Humidity measurements for Room 46, Room 22
(1 – 5 September) recorded at 15 minutes intervals.

Sr. No	Rm 46:dc2	Rm 22:dc4		Sr. No	Rm 46:dc2	Rm 22:dc4		Sr. No	Rm 46:dc2	Rm 22:dc4		Sr. No	Rm 46:dc2	Rm 22:dc4
1	33,7	46,4		50	33,3	53,1		99	33,3	52,2		148	32,5	53,6
2	32,5	46,4		51	33,3	53,1		100	32,9	51,7		149	32,5	54,1
3	32,5	46,4		52	32,9	53,1		101	32,9	51,7		150	32,5	54,1
4	32,1	46,4		53	32,9	53,1		102	32,9	51,2		151	32,5	54,1
5	31,6	46,4		54	32,9	53,1		103	32,5	50,7		152	32,5	54,1
6	31,6	45,9		55	32,9	53,1		104	32,5	50,7		153	32,5	54,1
7	31,2	45,9		56	32,9	53,1		105	32,5	50,2		154	32,5	54,1
8	31,2	45,9		57	32,9	53,1		106	32,5	50,2		155	32,5	54,1
9	30,8	45,9		58	33,3	53,1		107	32,5	49,8		156	32,5	54,1
10	30,8	45,4		59	33,3	53,1		108	32,5	49,8		157	32,5	54,1
11	30,8	45,9		60	33,7	53,6		109	32,5	49,8		158	32,5	54,6
12	30,8	45,4		61	33,7	53,6		110	32,5	49,8		159	32,5	54,1
13	30,8	45,4		62	33,7	53,6		111	32,5	49,8		160	32,5	54,1
14	30,8	45,4		63	33,7	53,6		112	32,5	49,3		161	32,5	54,6
15	30,8	45,4		64	33,7	53,6		113	32,5	49,8		162	32,5	54,6
16	30,4	45,4		65	33,7	54,1		114	32,5	49,8		163	32,5	54,6
17	30,4	45,4		66	33,7	54,1		115	32,5	49,3		164	32,5	54,6
18	30,4	45,4		67	33,7	54,6		116	32,5	49,3		165	32,5	54,6
19	30,4	45,4		68	33,7	54,1		117	32,5	49,3		166	32,5	54,6
20	30,4	45,4		69	34,2	54,1		118	32,5	49,3		167	32,5	54,6
21	30,4	45,4		70	34,2	54,6		119	32,5	49,3		168	32,5	55,1
22	30,4	45,4		71	34,2	54,6		120	32,5	49,3		169	32,9	54,6
23	30,4	45,9		72	34,2	54,6		121	32,1	48,8		170	32,5	55,1
24	30,4	45,9		73	34,2	54,6		122	32,1	48,8		171	32,9	55,1
25	30,4	45,9		74	34,2	54,1		123	32,1	48,3		172	32,9	55,1
26	30,8	46,4		75	34,2	54,1		124	32,1	48,8		173	32,9	55,1
27	30,8	47,3		76	34,2	54,1		125	32,1	48,8		174	32,9	55,1
28	30,8	47,8		77	34,2	54,1		126	32,1	49,3		175	32,9	55,1
29	30,8	48,8		78	34,2	54,1		127	32,1	49,3		176	32,9	55,1
30	31,2	49,3		79	34,2	54,1		128	32,1	49,8		177	32,9	55,1
31	31,6	49,8		80	34,2	54,1		129	32,1	50,2		178	32,9	55,1
32	31,6	50,2		81	34,2	54,1		130	32,1	50,7		179	32,9	55,1
33	31,6	50,2		82	33,7	54,1		131	32,1	50,7		180	33,3	54,6
34	32,1	50,7		83	34,2	54,1		132	32,5	51,2		181	33,3	54,6
35	32,1	50,7		84	33,7	54,1		133	32,5	51,7		182	32,9	54,6
36	32,5	51,2		85	34,2	54,1		134	32,5	52,2		183	32,9	54,6
37	32,5	51,2		86	33,7	54,1		135	32,5	51,7		184	33,3	54,6
38	32,5	51,2		87	33,7	53,6		136	32,5	52,2		185	33,3	54,6
39	32,5	51,2		88	34,2	53,6		137	32,1	52,6		186	33,3	54,1
40	32,5	51,2		89	33,7	53,6		138	32,5	53,1		187	33,3	54,1
41	32,9	51,7		90	33,7	53,1		139	32,5	53,1		188	33,3	54,6
42	32,5	51,7		91	33,7	53,1		140	32,5	53,1		189	33,3	54,1
43	32,5	52,2		92	33,7	53,1		141	32,5	53,1		190	33,3	54,1
44	32,5	52,2		93	33,7	52,6		142	32,5	53,6		191	33,3	54,1
45	32,5	52,2		94	33,7	52,6		143	32,5	53,6		192	33,3	54,1
46	32,9	52,6		95	33,7	52,6		144	32,5	53,6		193	33,3	53,6
47	32,9	52,6		96	33,7	52,6		145	32,5	53,6		194	33,3	53,6
48	32,9	52,6		97	33,3	52,2		146	32,5	53,6		195	33,3	53,1
49	33,3	53,1		98	33,3	51,7		147	32,5	53,6		196	33,3	53,1

Table C.4 (Continued)

Sr. No	Rm 46:dc2	Rm 22:dc4		Sr. No	Rm 46:dc2	Rm 22:dc4		Sr. No	Rm 46:dc2	Rm 22:dc4		Sr. No	Rm 46:dc2	Rm 22:dc4
197	32,9	52,6		246	32,5	55,5		295	32,9	52,2		344	32,1	54,6
198	32,9	52,2		247	32,5	56		296	32,5	52,2		345	32,1	55,1
199	32,9	51,2		248	32,5	56		297	32,5	51,7		346	32,1	54,6
200	32,9	52,2		249	32,5	56		298	32,5	52,2		347	32,1	54,6
201	32,9	51,7		250	32,5	56		299	32,9	51,7		348	32,1	54,1
202	32,5	51,7		251	32,5	56		300	32,5	51,7		349	32,1	54,6
203	32,5	52,2		252	32,5	56		301	32,5	51,7		350	32,1	54,6
204	32,5	51,7		253	32,5	56		302	32,5	51,2		351	32,1	54,6
205	32,5	51,7		254	32,5	56,5		303	32,5	50,7		352	32,1	54,6
206	32,5	51,7		255	32,5	56,5		304	32,1	50,7		353	32,1	54,6
207	32,9	51,2		256	32,5	56		305	32,1	50,7		354	32,1	54,6
208	32,5	51,2		257	32,5	56,5		306	32,1	50,2		355	32,1	54,6
209	32,5	50,7		258	32,5	56,5		307	32,1	50,2		356	32,1	54,6
210	32,5	51,2		259	32,5	56,5		308	32,1	50,2		357	32,1	54,6
211	32,5	50,7		260	32,5	56,5		309	32,1	50,2		358	32,1	54,6
212	32,5	50,7		261	32,5	57		310	32,1	50,2		359	32,1	55,1
213	32,5	50,7		262	32,5	56,5		311	32,1	50,2		360	32,1	55,1
214	32,5	50,7		263	32,5	56,5		312	32,1	50,2		361	32,1	55,1
215	32,5	50,7		264	32,5	57		313	32,1	50,2		362	32,1	55,1
216	32,5	50,7		265	32,5	57		314	32,1	51,2		363	32,1	55,1
217	32,1	51,2		266	32,5	57		315	32,1	51,2		364	32,1	55,1
218	32,1	50,7		267	32,5	57		316	32,1	51,2		365	32,1	55,5
219	32,1	50,7		268	32,5	56,5		317	32,1	50,7		366	32,1	55,5
220	32,1	50,7		269	32,5	56,5		318	32,1	50,2		367	32,5	55,5
221	32,1	50,7		270	32,5	56,5		319	32,1	50,2		368	32,5	55,5
222	32,1	50,7		271	32,9	56,5		320	32,1	50,2		369	32,5	55,5
223	32,1	50,7		272	32,9	56,5		321	31,6	50,2		370	32,1	55,5
224	32,1	50,2		273	32,9	56,5		322	32,1	50,7		371	32,5	55,5
225	32,1	50,7		274	32,9	56		323	32,1	51,2		372	32,5	55,5
226	32,1	50,7		275	32,9	56		324	32,1	51,2		373	32,5	55,1
227	32,1	51,2		276	32,9	56		325	32,1	51,7		374	32,5	55,1
228	32,1	51,2		277	32,9	56,5		326	32,1	52,2		375	32,5	55,1
229	32,1	52,2		278	33,3	56,5		327	32,1	52,2		376	32,5	55,1
230	32,1	52,2		279	33,3	56		328	32,1	52,6		377	32,5	55,1
231	32,1	52,6		280	33,3	56		329	32,1	52,6				
232	32,1	53,1		281	33,3	55,5		330	32,1	53,1				
233	32,1	53,1		282	33,3	55,5		331	32,1	53,1				
234	32,1	53,6		283	33,3	55,5		332	32,1	53,1				
235	32,1	54,1		284	33,3	55,5		333	32,1	53,6				
236	32,1	54,1		285	33,3	55,5		334	32,1	53,6				
237	32,1	54,1		286	33,7	55,1		335	32,1	53,6				
238	32,1	54,1		287	33,7	55,1		336	32,1	54,1				
239	32,5	54,6		288	33,7	54,6		337	32,1	54,1				
240	32,5	54,6		289	33,7	54,1		338	32,1	54,1				
241	32,5	55,1		290	33,3	54,1		339	32,1	54,1				
242	32,5	55,1		291	32,9	53,1		340	32,1	54,1				
243	32,5	55,1		292	32,9	53,1		341	32,1	54,6				
244	32,5	55,5		293	32,9	52,6		342	32,1	54,6				
245	32,5	55,5		294	32,9	52,6		343	32,1	54,6				

Table. C.5. Humidity measurements for Room 85, Room 71
(20 – 25 September) recorded at 15 minutes intervals.

Sr. No	Rm 85:dc2	Rm 71:dc4		Sr. No	Rm 85:dc2	Rm 71:dc4		Sr. No	Rm 85:dc2	Rm 71:dc4		Sr. No	Rm 85:dc2	Rm 71:dc4
1	36,3	33,5		50	42,8	36,2		99	43,7	37,6		148	45	37,6
2	35	34,4		51	43,2	36,2		100	43,7	37,6		149	45	37,6
3	34,6	34,4		52	43,2	36,2		101	44,1	37,6		150	45	37,6
4	34,6	34,8		53	43,2	36,2		102	44,1	37,6		151	45	37,6
5	34,6	34,8		54	43,7	36,2		103	44,6	37,6		152	45	37,6
6	34,6	34,8		55	43,2	36,2		104	44,6	37,6		153	44,6	37,6
7	35,9	34,4		56	43,2	36,7		105	45	37,6		154	44,6	37,6
8	35,4	34,8		57	43,7	36,7		106	45	37,6		155	45	38
9	34,6	34,8		58	43,7	36,7		107	45	37,6		156	44,6	37,6
10	37,1	34,8		59	43,7	36,7		108	45	37,6		157	44,6	38
11	38,4	34,8		60	43,7	36,7		109	45	37,6		158	44,6	38
12	38,9	34,8		61	44,1	37,1		110	45	37,6		159	44,6	38
13	39,3	34,8		62	44,1	36,7		111	45,5	37,6		160	44,6	38
14	39,7	34,4		63	44,1	36,7		112	45,5	37,6		161	44,6	38
15	39,7	34,8		64	44,1	36,7		113	45,5	37,6		162	44,6	38
16	40,2	34,8		65	44,1	36,7		114	45,5	37,6		163	44,1	38
17	40,2	34,8		66	44,1	37,1		115	45,5	37,6		164	44,1	38
18	40,2	34,4		67	44,1	36,7		116	45,5	37,6		165	44,1	38
19	40,2	34,8		68	44,6	36,7		117	45,5	37,6		166	44,1	38
20	40,2	35,7		69	44,1	37,1		118	45,5	38		167	44,1	38
21	40,6	36,2		70	44,6	37,1		119	45,5	38		168	44,1	38
22	40,6	36,2		71	41,5	37,1		120	45	38		169	44,1	38
23	40,6	36,2		72	39,7	37,1		121	45	38		170	44,1	38
24	40,6	36,7		73	39,3	37,1		122	45	38		171	44,1	38
25	41	36,7		74	39,3	37,1		123	45,5	38		172	44,1	38,5
26	41	36,2		75	38,4	37,1		124	45,5	38		173	44,1	38
27	41	35,7		76	38,4	37,1		125	45,5	38		174	44,6	38
28	41	35,7		77	38,4	37,1		126	45,5	38		175	44,6	38,5
29	41	35,7		78	38,9	37,1		127	45,5	38		176	45	38,5
30	41	35,7		79	38,4	37,1		128	45,5	38		177	44,6	38,5
31	41,5	35,7		80	38,4	37,1		129	45,5	38		178	45	38,5
32	41,5	35,7		81	38,9	37,1		130	45,5	37,6		179	45,5	38,5
33	41,5	35,7		82	38,9	37,1		131	45	38		180	45	39
34	41,5	35,7		83	39,3	37,1		132	45,5	37,6		181	45	39
35	41,9	36,2		84	41,9	37,1		133	45,5	37,6		182	45	39
36	42,3	36,2		85	41	37,1		134	45,5	37,6		183	45	39
37	42,3	36,2		86	41,5	37,1		135	45	37,6		184	44,6	39
38	42,8	36,2		87	41,9	37,1		136	45	37,6		185	44,6	39
39	42,3	36,2		88	43,2	37,1		137	45	37,6		186	45,5	39
40	42,8	36,2		89	43,2	37,1		138	45	37,6		187	45	38,5
41	42,8	36,2		90	43,2	37,1		139	45	37,6		188	45,5	39
42	42,8	36,2		91	43,2	37,6		140	45	37,6		189	46,3	39
43	42,8	36,2		92	44,1	37,6		141	45	37,6		190	47,7	39
44	42,8	36,2		93	44,1	37,1		142	45	37,6		191	47,7	39
45	43,2	36,2		94	43,7	37,6		143	45	37,6		192	47,2	39
46	42,8	36,2		95	43,2	37,6		144	45	37,6		193	47,2	39,4
47	43,2	36,2		96	43,2	37,6		145	45	37,6		194	46,3	39,4
48	42,8	36,2		97	43,2	37,6		146	45	37,6		195	46,3	39,4
49	43,2	36,2		98	43,7	37,6		147	45	37,6		196	46,3	39

Table C.5 (Continued)

Sr. No	Rm 85:dc2	Rm 71:dc4		Sr. No	Rm 85:dc2	Rm 71:dc4		Sr. No	Rm 85:dc2	Rm 71:dc4		Sr. No	Rm 85:dc2	Rm 71:dc4
197	46,3	39,4		246	46,3	39,4		295	45	39,9		344	45,5	40,3
198	47,2	39,4		247	46,3	39,4		296	45	39,9		345	45,5	40,3
199	47,2	39,4		248	46,3	39,4		297	45	39,9		346	45,5	40,3
200	47,2	39,4		249	46,3	39,4		298	45	39,9		347	45,5	40,3
201	47,2	39		250	46,3	39,4		299	45	39,9		348	45,5	40,3
202	46,8	39		251	46,3	39,4		300	45	39,9		349	45,5	40,3
203	47,2	39,4		252	46,8	39,4		301	44,6	39,9		350	45,5	40,3
204	47,2	39,4		253	46,3	39,4		302	45	39,9		351	45,5	40,3
205	47,2	39,4		254	46,3	39,4		303	45	39,9		352	45,5	40,3
206	47,2	39,4		255	46,3	39,4		304	45	39,9		353	45,5	40,3
207	47,2	39,4		256	46,3	39,4		305	45	39,9		354	45,5	40,3
208	47,2	39,4		257	46,3	39,4		306	45	39,9		355	45,5	40,3
209	47,2	39,4		258	46,3	39,4		307	45,5	39,9		356	45,5	40,3
210	47,2	39,4		259	46,3	39,9		308	45	39,9		357	45,5	40,3
211	46,8	39,4		260	45,9	39,9		309	45,5	39,9		358	45,5	40,3
212	46,8	39,4		261	45,5	39,9		310	45	39,9		359	45,5	40,3
213	46,8	39,4		262	45,9	39,9		311	45	39,9		360	45,5	40,3
214	46,3	39,4		263	46,3	39,4		312	45	39,9		361	45,5	40,3
215	46,8	39,4		264	45,9	39,4		313	45	39,9		362	45,5	40,3
216	46,3	39,4		265	45,9	39,4		314	45,5	39,9		363	45	40,8
217	46,3	39,4		266	45,5	39,9		315	45	39,9		364	45	40,8
218	46,3	39,4		267	45,5	39,9		316	45,5	39,9		365	45	40,8
219	46,3	39,4		268	45,5	40,3		317	45,5	39,9		366	45,5	40,8
220	46,3	39,4		269	45,5	39,9		318	45	39,9		367	45,5	40,8
221	46,3	39		270	45,5	39,9		319	45,5	39,9		368	45,5	40,8
222	46,3	39,4		271	45,5	39,9		320	45,5	39,9		369	45	40,8
223	45,9	39,4		272	45,5	39,9		321	45	40,3		370	45,5	40,8
224	46,3	39,4		273	45,5	40,3		322	45,5	39,9		371	45,5	40,8
225	45,9	39,4		274	45,5	40,3		323	45	40,3		372	45,5	40,8
226	46,3	39,4		275	45	40,8		324	45,5	40,3		373	45	41,3
227	46,3	39,4		276	45	40,3		325	45,5	40,3		374	45,5	40,8
228	46,3	39		277	45,5	40,3		326	45,5	39,9		375	45,5	41,3
229	45,9	39,4		278	45,5	40,3		327	45	39,9		376	45,5	41,3
230	45,9	39,4		279	45,5	40,3		328	45	40,3		377	45	41,3
231	45,9	39,4		280	45,5	40,3		329	45,5	39,9		378	45	41,3
232	45,9	39,4		281	45,5	40,3		330	45,5	39,9		379	45	41,3
233	45,9	39,4		282	45,5	40,3		331	45,5	39,9		380	45	41,3
234	45,9	39,4		283	45	40,3		332	45,5	40,3		381	45	41,3
235	46,3	39,4		284	45	40,3		333	45,5	40,3		382	45	40,8
236	46,3	39,4		285	45,5	40,3		334	45,5	40,3		383	45	41,3
237	46,3	39,4		286	45	40,3		335	45,5	39,9		384	45	41,3
238	46,3	39,4		287	45	40,3		336	45	40,3		385	45	41,3
239	46,3	39,4		288	45,5	40,3		337	45,5	40,3		386	45	41,3
240	46,3	39,4		289	45	40,3		338	45,5	39,9		387	45,5	41,3
241	46,3	39,4		290	45	40,3		339	45	40,3		388	45,5	41,7
242	46,3	39,4		291	45	39,9		340	45,5	40,3		389	45,5	41,3
243	46,3	39,4		292	45	39,9		341	45,5	40,3		390	45,5	41,7
244	46,3	39,4		293	45	39,9		342	45,5	40,3		391	45,9	41,7
245	46,3	39,4		294	45	39,9		343	45,5	40,3		392	45,5	41,7

Table C.5 (Continued)

Sr. No	Rm 85:dc2	Rm 71:dc4		Sr. No	Rm 85:dc2	Rm 71:dc4		Sr. No	Rm 85:dc2	Rm 71:dc4		Sr. No	Rm 85:dc2	Rm 71:dc4
393	45,5	41,7		408	45,5	42,2		423	46,8	41,7		438	46,8	42,2
394	45,5	41,7		409	45,5	42,2		424	46,3	41,7		439	46,8	42,2
395	45,5	41,7		410	45,5	42,2		425	47,2	41,7		440	47,2	42,2
396	45,5	41,7		411	45,5	41,7		426	46,3	41,7		441	47,7	42,2
397	45,5	41,7		412	45,5	42,2		427	46,3	41,7		442	47,7	42,2
398	45,9	41,7		413	45,9	42,2		428	46,3	42,2		443	47,7	42,6
399	45,5	41,7		414	45,9	41,7		429	47,2	41,7		444	47,2	42,6
400	45,5	41,7		415	45,9	42,2		430	47,2	41,7		445	47,2	42,2
401	45,5	41,7		416	45,9	41,7		431	47,7	41,7		446	47,2	42,6
402	45,5	42,2		417	45,9	41,7		432	47,2	41,7		447	47,7	42,6
403	45,5	41,7		418	45,9	41,7		433	47,7	41,7		448	47,7	53,6
404	45,5	42,2		419	45,9	41,7		434	47,2	41,7				
405	45,9	42,2		420	45,9	41,7		435	47,2	41,7				
406	45,5	42,2		421	45,9	41,7		436	47,2	42,2				
407	45,9	42,2		422	47,2	41,7		437	46,8	42,2				