Thermal Comfort and Energy Efficiency in Yemeni Houses

Fuad Hamoud Al-Shibami

School of Architecture
The University of Sheffield

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SUMMARY

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(Fuad H. Al-Shibami)

School of Architecture Studies, University of Sheffield

The question posed in this thesis is: by incorporate traditional architecture forms and design features, can new housing provide thermal comfort without the need for excessive use of air- conditioning as is the case in current new building methods and designs. There has been some evidence that the new type of housing being built in the hot areas in Yemen has inherently produced unacceptable comfort conditions resulting in a greater use of air conditioning while the traditional housing naturally provided more comfortable conditions and did not need to use air conditioning.

This thesis investigated the effect of different building materials on both human comfort and energy consumption in domestic buildings in the Yemen with special reference to the City of Seiyun.

The methodology used in this thesis was divided into two parts. The first part dealt with a questionnaire and building monitoring relating to the perceived thermal comfort inside three types of houses and the use of fans and/or air conditioning to maintain thermal comfort.

Based on the results of this survey a computer model was calibrated and used to carry out a parametric study into the choice of building materials and architectural design to optimise the design of housing to minimise the use of air conditioning.

The results of the survey indicated that occupants were more dissatisfied with their internal environment in housing constructed of concrete than in traditional housing and also they used a significant amount of air conditioning to maintain thermal comfort.

The main conclusion to be drawn from this work was that it was possible to design new housing in such a way so as to reduce the demand for air conditioning and at the same time provide thermal comfort and inhabitant satisfaction with building appearance. Also one of the most effective design features was the use of a courtyard with a high thermal mass.

This thesis is dedicated to

The Soul of my Mother

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1.1 Research background

A review conducted as part of this PhD project suggests that Yemeni construction industry is not committed to a sustainable environmental development [International Energy Agency]. Architects in Yemen seem to pay little attention to utilising passive means of thermal control due to the absence of building regulations and standards [Ayssa, 1995]. There are no building regulations, standards or codes in Yemen that govern the thermal behaviour of buildings. The only building regulation in use is concerned with building construction planning and town planning. This affects the Yemeni economy by increasing the energy demand in the domestic sector needed for cooling due to poor building design. Growing evidence suggests that the major economic sectors in the Yemeni economy, which include the industrial; transport and domestic sector, to this day have not been sensitive to environmental issues especially in terms of energy efficiency.

Most contemporary buildings in Yemen are inadequately designed, and thus occupants experience long periods of overheating [alshibami, 2002]. These solar ovens are soon converted to walk-in refrigerators by using air conditioners powered by non-renewable energy sources.

Notably there is distinctive lack of a clear strategy for energy efficiency in housing design in Yemen [Ayssa, 1995]. This again is due to the absence of a clear policy on building regulations with reference to an eco-sensitive and environmental friendly approach to the design and construction of domestic buildings.

The growing demand for energy within the Yemeni domestic sector could be met through the development of a more responsive architecture to avoid the adverse effect of increasing the CO_2

emissions due to the increased levels of burning fossil fuel. Evidence suggests that passive techniques and other related design strategies would go a long way in reducing the cooling loads as well as other energy requirements of domestic buildings [al-shibami, 2001].

1.2 Research Problem

The current architectural practices used in Yemen today are not in harmony with natural environment. The attempts at originality can be seen in some building design, yet the lack of response to the local climate is obvious especially in regions with extreme climatic conditions [Ayssa, 1995]. This lack of response to changes in climate leads to an uncomfortable indoor thermal environment and consequently requires artificial conditioning equipment to solve the problem. The following sections will demonstrate the urgency of the energy problem in Yemen and the need for viable solutions which will help maintain comfortable environments for building occupants.

1.2.1 Energy consumption and demand in Yemen

The energy crisis in Yemen calls for the urgent development of a new strategy or a complete re-engineering of the existing energy policies in Yemen as a whole [Ministry of Electricity]. A building design strategy, with regards to energy load reduction, needs to be urgently reviewed. This is echoed by the fact that recent studies indicated that the Yemeni domestic sector is the largest consumer of electricity [alshibami, 2002] as shown in Figure (1-1).

One of the main provisions in the international Monterey Fund (IMF) reform package calls for the Yemeni government to reduce subsidies [International Energy Agency]. The first two phases of reforms is aimed at reducing subsidies on oil and electricity. Transportation fuel prices were doubled in March 1995 and subsequently prices for domestic fuel and electricity were increased in January 1996 approximately 75%. The third phase of the reform program began in July 1997, with additional increases to electricity rates, water rates and fuel prices. Transportation fuel prices rose again by more than 30% and kerosene prices by more than 85%. In June 1998, the Yemeni government once again raised prices on gasoline, kerosene, and cooking gas by around 40%.

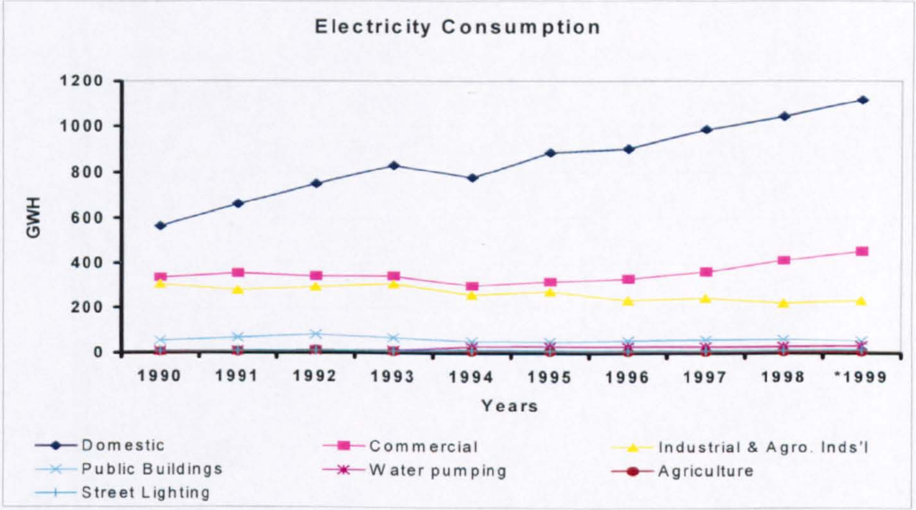

Figure 1-1: Electricity consumption in Yemen.

Yemen generated 2.2 billion kilowatt-hours of electricity in 1998 with an installed generating capacity of 810 megawatts (MW). Most of this capacity is oil-fired contributing to the CO_2 emissions.

The main problem is that Yemen's energy generating capacity is inadequate for the country's needs, and a rolling blackout schedule is maintained in many cities. Yemen continues to face serious power shortages, and has announced plans to reform the country's power sector, and to double power generating capacity within the coming few years.

Figure (1-2) shows quite clearly that the electricity generated in Yemen exceeds the electricity sold. Moreover Figure (1-3) shows that the electricity demand is escalating. This suggests an enormous energy loss in the government's current power strategy. Therefore, the government proposal to double the electricity supply is not likely to be a total solution to the energy crisis in Yemen. This proposal is bound to prove to be an expensive and fruitless exercise, if not coupled with more research channelled towards design optimisation.

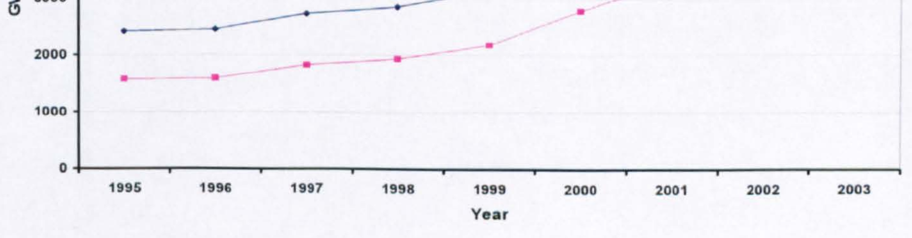

Figure 1-2: Electricity Supply in Yemen

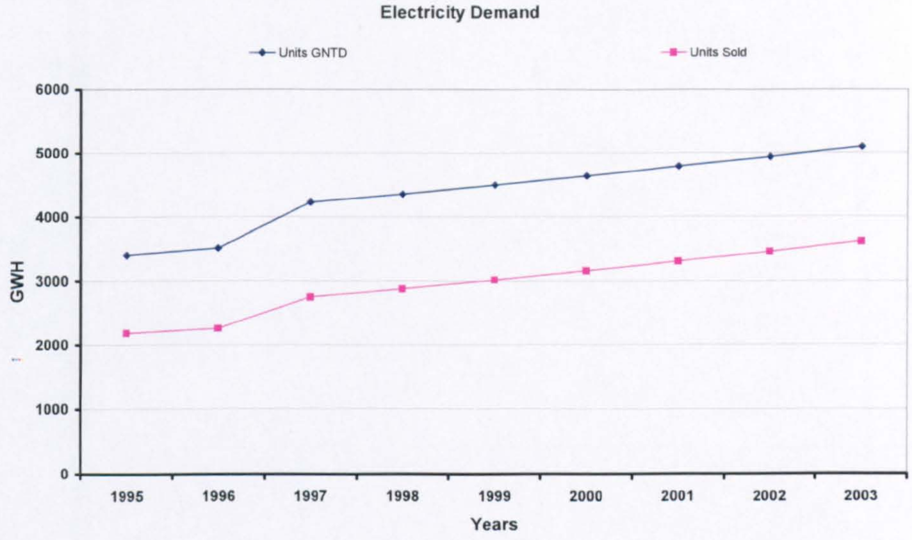

Figure 1-3: Electricity Demand in Yemen.

1.2.2 Fuel consumption in generating electricity

Figure (1-4), illustrates a comparative analysis based on data obtained from the Yemeni authorities. It clearly shows that a vast amount of fossil fuels is used in generating a comparatively small amount of electrical energy. The graph highlights the disproportional relationship between the two variables.

This policy would indicate that an unacceptable amount of CO_2 is currently released into the atmosphere and that if the current policies continue these emissions will escalate astronomically. The current energy policy of doubling energy production by of the utilisation of fossil fuel is in the view of the author a price not worth paying given the adverse environmental ramifications.

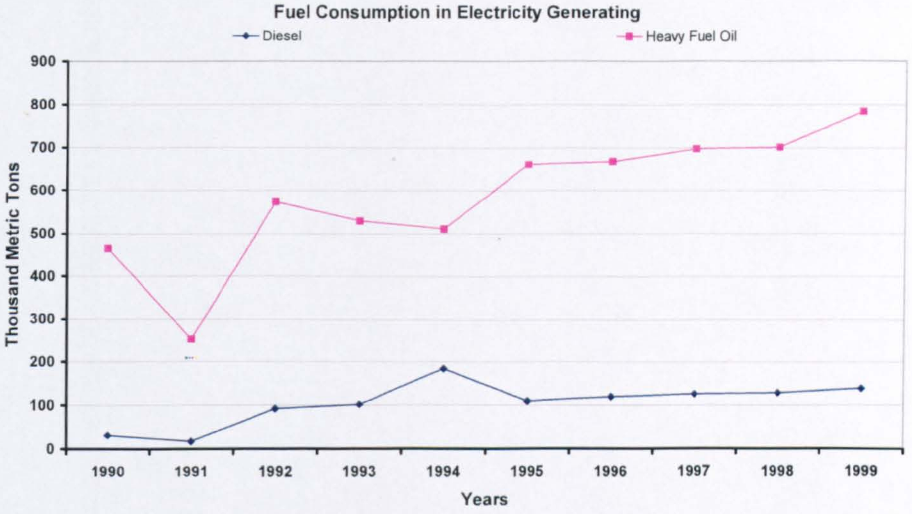

Figure 1-4: Fuel consumption to generate electricity.

The proportional use of energy in the domestic sector has been significantly increasing within the recent years, whereas many of the developed or developing countries have been trying to formulate strategies of minimising their energy expenditure while optimising energy use with improved building design, Yemen is still some steps behind. There is a noticeable lack of research in the field of building energy consumption and there is a lack of general understanding that minimising building energy consumption while at the same time providing comfortable thermal conditions are indicative of preferable building design.

As such it is critical that Yemen adopts a policy which, while on one hand, aims to provide desirable comfortable indoor thermal conditions for people in Yemen and on the other hand optimises the use of energy in buildings particularly in hot regions where air conditioning in buildings is a prime source of unnecessary energy loss .

Preliminary results of this study indicate that the proposal to reform the country's power sector will merely scratch the surface of the potential growing difficulties. The proposed solution to the energy difficulties highlighted in this study lies in the optimisation of energy distribution through effective building design. The proposed design strategies and techniques put forward by this study are intended to minimise energy losses by reducing the cooling loads of domestic dwellings.

1.3 Aim of research

As stated previously this study indicates that a more appropriate strategy will be to strike a balance between energy demand and energy supply. Efforts would be more focused and useful if they were directed towards tackling the growing energy demand of the Yemeni domestic sector; the largest users of electrical energy. One method of achieving this is through optimum energy efficient architectural design. The survey revealed that there is enormous scope for improvement in the energy efficiency of Yemeni domestic buildings.

The main aim of this work is to quantify the effectiveness of some suggested passive measures aimed at improving the environmental performance of Yemeni contemporary houses in the city of Seiyun with the goal of achieving energy efficiency and thermal comfort. This study encourages more research in environmentally responsive methodologies to meet the growing energy demand in the Yemeni domestic sector. The use of passive means and other renewable energy efficient technology should be encouraged.

Main aims, objectives and sub aims of this research and the means of fulfilling it are illustrated in the Figure (1-5).

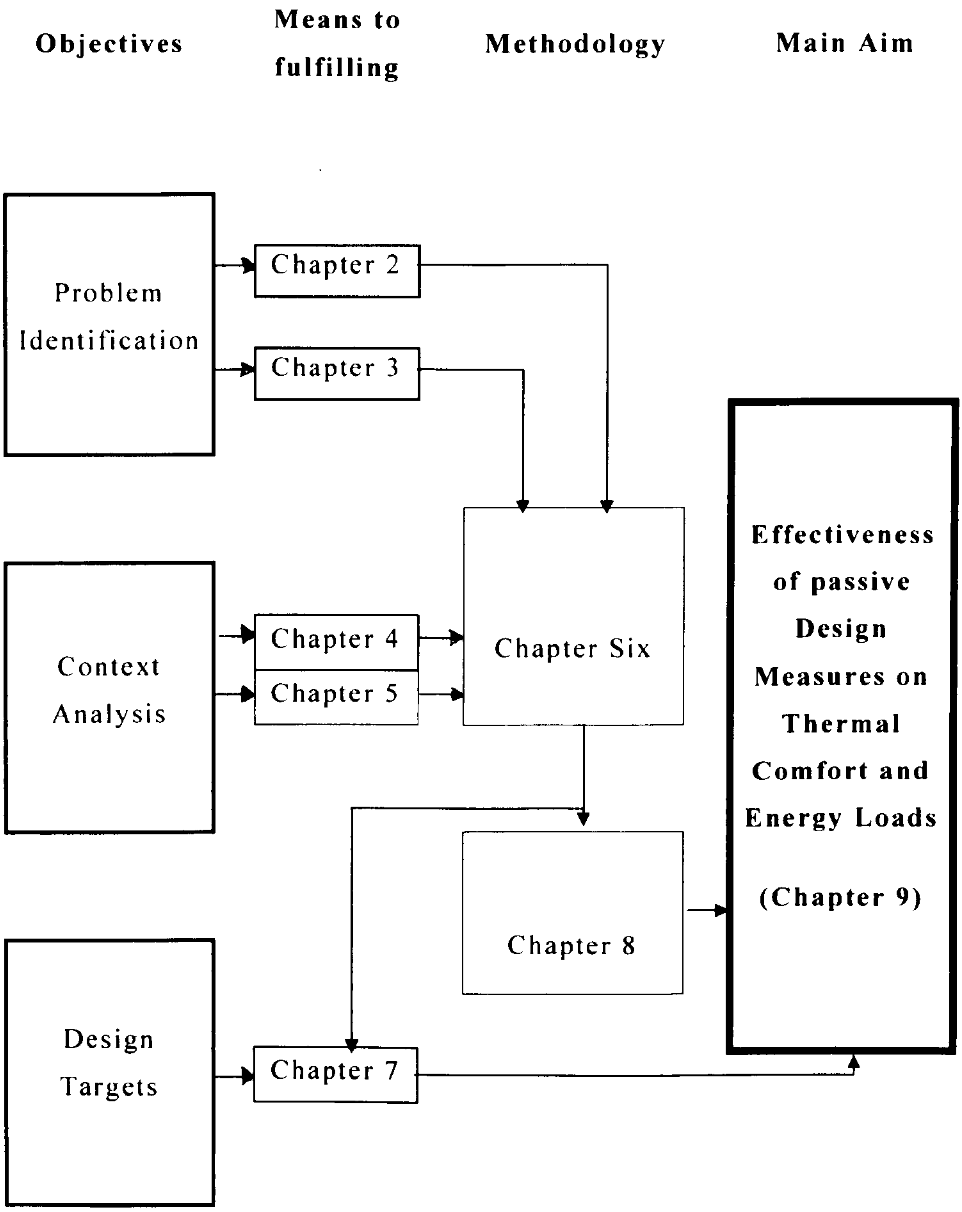

Figure 1-5: Research Plan.

1.4 Methodology

The Yemeni domestic building typologies in Seiyun (the area under study) were categorised into 3 major strata's. Site measurements as well as questionnaires that incorporated 342 occupants were carried out during summer and winter seasons. During the same period three types of building structures were chosen as case studies to be monitored and the internal temperatures were recorded. The survey suggested that thermal comfort can be achieved for the majority of the summer time by using active means such as air conditioning which is a highly inefficient use of energy.

The regional climate of Yemen in general and especially the climate of Seiyun (the area under study) was analysed and passive design strategies and measures were formulated.

A thermal simulation based on local building materials, thermal comfort, and field study results was carried out to optimise the chosen case study.

1.5 Thesis structure

This thesis is divided into three main parts. The first part is the research background which includes two chapters. Chapter two discusses the relationship between building, climate and energy. Chapter three looks at thermal comfort research and theories. A brief outline of the history and current approaches to thermal comfort theory were also reviewed in this chapter.

The second part includes the reviews of literature and consists of two chapters. The first of which is chapter four which reviews the

Yemeni Climatic context and the second is chapter five which carries out a review of the climatic response of housing in Yemen.

The last part of this study includes the field study and thermal modelling of this thesis and encompasses four chapters. Chapter six illustrates the methodology used to fulfil the purpose of this study. Chapter seven analyses the climate of Seiyun using the weather tool and Mahoney tables. Chapter eight discusses the results of the field study conducted during two seasons in Seiyun and Chapter nine includes the thermal modelling which is based on the results of chapters seven and eight. Chapter ten concludes the research and summarises this study. It also gives some suggestions for future research.

Part One

Research Background.

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2.1 Introduction

This chapter is divided into three sections. The first section illustrates in detail the relationship between building and climate showing the effect of orientation and building materials on indoor climate. The second section describes the role of energy in naturally ventilated and air conditioned buildings ending with the role of buildings in minimising energy consumption. The last section will provide the building design principles for hot and dry climate.

2.2 Building and climate

Climate has a major effect on building performance and energy consumption [Karyono, 1996]. The process of identifying, understanding and controlling climatic influences at the building site is perhaps the most critical part of the building design process [alshibami, 2002].

Climate has a major effect on building performance and energy consumption. The process of identifying, understanding and controlling climatic influences at the building site is perhaps the most critical part of building design. The key objectives of climatic design include:

- reducing running cost of buildings
- the use of "natural energy" instead of mechanical system and power
- providing a comfortable and healthy environment for people

The relationship between building design and materials on one hand, and the surrounding climate condition on the other determine the amount of energy consumed. This is evidence when designers take climate conditions into account, buildings would provide a better comfort situation for the occupants. Therefore, less energy would be consumed to provide thermal comfort. It can therefore be said that when the relationship between buildings and climate plays an important role in reducing energy consumption.

2.2.1 Solar radiation and shading devices

The indoor climate of a building is affected by the direct and indirect solar radiation. Direct solar radiation affects the indoor climate when the radiation impinges on the external surfaces of the building or penetrates the internal surfaces of the rooms. Indirect radiation occurs when the surrounding environment of a building receives direct or indirect radiation from the sun, and subsequently re-radiates its heat into the building (Figure 2-1).

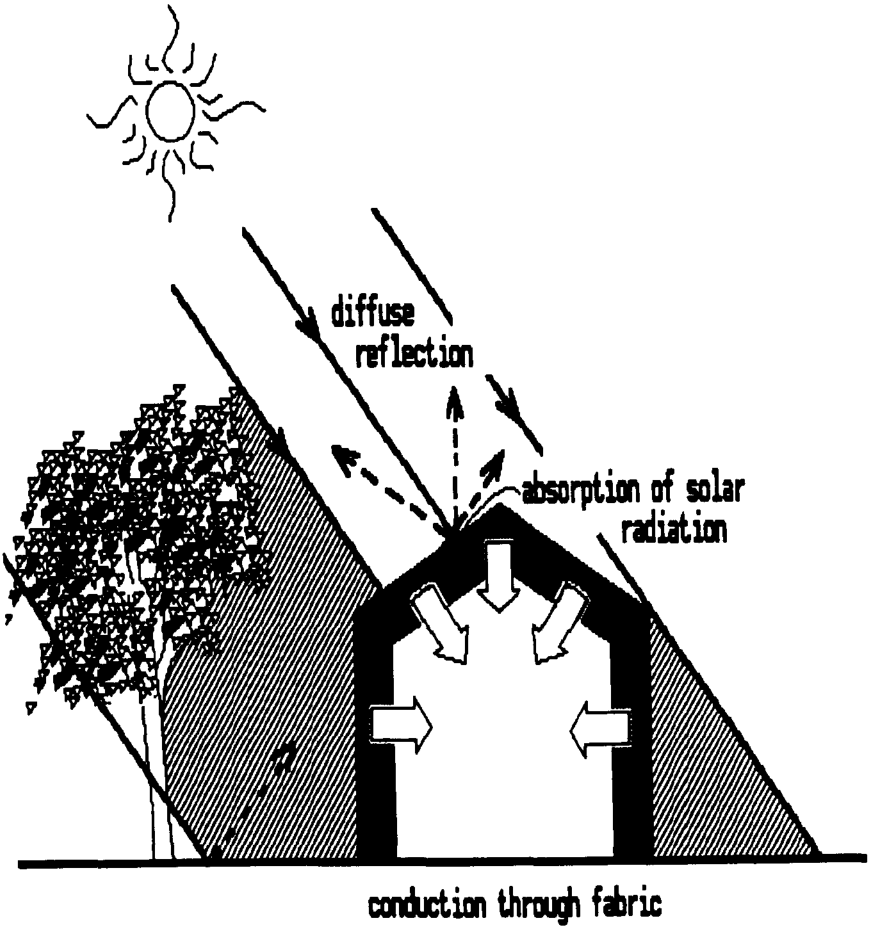

Figure 2-1: Solar heat gain through fabric (after Baker 1987).

Both theoretically and practically, the orientation of a building affects the rooms' temperatures. It stands to reason that rooms facing the direct sun's radiation will have higher temperatures than those that are not. However, there are additional factors that determine the level of significance that building orientation has on the indoor climate such as: exterior surface colour, resistance and heat capacity of the envelope materials. Givoni [1976] shows that a whitewashed external surface can reduce the levels of solar radiation absorption of the walls, subsequently minimising the heating the buildings external envelope and thus reduce the overall indoor temperatures. While the increase of thermal resistance and heat capacity of the structure will moderate the internal heating effect of the elevated external surface temperature, the internal maxima will be lowered and the minima will be raised. In his experiment in temperate climate in the northern hemisphere, Givoni [1998] showed that the internal surface temperatures of walls at a different orientation showed the following conditions:

1. Rooms with whitewashed painted external walls have a slight difference in internal surface temperatures between the orientations; walls with 10 cm thickness have maximum differences between the warmest (east and west) and the coolest (north) of 1.5°C, while 20 cm thick walls have a maximum difference of 1°C between the warmest (east and west) and the coolest (north). Internal surface temperatures fluctuated above the average outdoor level, but the fluctuation was greater for the thinner walls.

2. Rooms with grey external colour showed a more significant difference in internal surface temperatures due to orientations. And again, the thickness of the walls affected the fluctuation of internal surface temperatures more greatly. The 10 cm walls had maximum differences between the warmest (east and west) and the coolest (north) of about 4.5°C and a difference between the highest (west at 18.00 hours) and the lowest (north, at 6.00 hours) is 14.5°C. While the 20 cm walls had less maximum difference between the warmest (east) and coolest (north) of about 1.5°C, a difference between the highest (east, at 19.00

hours) and the lowest (north, 10.00 hours) is 5.5°C. Internal surface temperatures fluctuated more in grey painted external walls than the white colour.

The above findings show that the effect of orientation on internal surface temperature is determined by the external surface colour and the walls' thickness; the lighter the colour of the external surface and the thicker the walls, the less significant is the effect of orientation on the internal surface temperature, while the darker the external surface colour and the thinner the walls, the more significant is the effect of orientation on the internal surface temperature.

It was also shown by the experiment carried out by BRS in Haifa [Givoni 1976] that the effect of orientation on glass walls and windows on indoor temperature were determined by the following factors:

I. **External and internal shadings with their colours**:

External shading gives more protection against the penetration of radiant heat through the glass walls than the internal ones. Results from the above study showed that, compared with temperatures of the same sides of a room with internal shading, for a dark coloured external shading with the window closed, the average maximum indoor temperature of east-west sides was 5.3°C lower and the temperature for north-south sides was 2.45°C lower.

II. Colour of shadings

The lighter the shading colour, the lesser the radiant heat is penetrated to the building, thus creating a lower indoor temperature. From this study, it was found that with a light colour, the indoor temperature can be up to 2.5°C lower than the dark shadings.

III. Openings

The opening helps to enhance ventilation within the building, therefore, reduces indoor temperatures. This may not be appropriate in a condition where the outdoor temperature is warmer than indoor. When the window and opening were opened, the indoor temperature could be up to 5.9°C lower at the east side than when it was closed. This occurred in an experiment when there was no shading provided.

2.2.2 Heat transfer through building elements

The heat transfer between the building and its surrounding environment may occur in four different ways: by radiation, conduction, convection and evaporation (or condensation) [Karyono, 1996]. Heat transferral by radiation is through space by way of electromagnetic waves. Conduction is the transfer of heat through material by the flow of energy from warmer to colder molecules. Convection is the transferral of heat by movement of molecules already containing energy from one place to another and then a dissipation of that energy into the environment. By evaporation and condensation, heat is transferred by the natural energy loss of matter through the changes of state, such as from liquid to gas and vice versa, in which the process involves the absorption or dissipation of heat. Therefore we can say that, while the transfer of the sun's heat directly into a building is done by way of radiation, the transfer of heat to/ from the building to both its surrounding and internal environment is carried out by either conduction, convection or evaporation (or condensation) or a combination of all.

Ideally the outer layer of the building should act as insulation from the outdoor environment. It attenuates or prevents the direct effect of climatic variables such as outdoor air temperature, solar radiation, humidity, wind, rain, etc. and accentuates the benefits of any internal climatic modifiers such as air conditioning. Factors, which affect the encroachment of outdoor climatic conditions into the indoor climate: orientation, glass walls, windows, openings, shading devices, colour and building materials.

The property of the building's envelope material has a direct effect on the indoor temperature. The amplitudes and phase of the heat waves bombarding the external surface will be changed when they pass through the material. The degree of change is dependent on the properties and dimension of the material, such as conductivity, transmittance, heat capacity, absorbtivity, emissitivity and thickness. The ratio between the external and internal amplitudes waves is called the decrement factor, and the difference between the external and the internal phase of the waves is called the time lag.

The time lag is useful in a building where it is not occupied for the whole 24 hours. Choosing materials for the envelope which can absorb the radiant heat during the day and release it during the night, when the building is unoccupied, would be very useful in providing a comfortable indoor temperature during the day.

2.2.2.1 The effect of thermal mass

High thermal mass can be described as a material which has the ability to store thermal energy (heat or cooling). Materials of thermal mass are considered as dense and heavy materials.

As a result of the very high intensity of solar radiation and the great heat build up during the day, followed by cold at night, massive walls have a high heat absorption/ retention capacity. The importance of thermal mass construction that it works by storing the heat and releasing it several hours later (time lag factor). Releasing heat time is different from building to another depends on the material specifications.

The advantages of using high thermal mass construction distributes for both summer and winter seasons and provide occupants with a better internal comfort than light construction.

In summer, first during the warm periods massive walls absorb heat without immediately transmitting it to the interior spaces which therefore remain relatively cool. At night when the external air temperature drops down the absorbed heat will be re-radiated gradually to warm the interior space [Karaman and Egli, 1981] making walls ready to absorb heat in the following day. This can help to maintain thermal comfort for the occupants for longer periods of time (depends on time load factor). Secondly, according to storing heat in the walls the demand for cooling can either be cut or reduced.

In winter, heat (can be solar energy, occupants or any equipment gains) is stored during the day and when released it helps to keep the building warm. Also the inside temperature will not raise or decrease immediately due to the time lag factor so the cooling of the space will be slower.

2.2.2.2 The effect of roof construction

It is well documented that the major source of solar heat gain in the tropics, apart from the glazing is the roof According to that a flat and thick is required to reduce heat gain [Yakubu, 1990]. It is the building component most exposed to the climatic elements. Heat gain through the roof makes up a major share of the building's cooling load [Parker, 2003].

In hot regions it is popularly believed that the roof is the main heating element of a house [Givoni, 1976]. Its external surface is often subject to the largest temperature fluctuation, depending on its type and external colour.

Solar gain through the roof can be minimised by the means of using the following steps:-

1. Reflection of solar radiation by whitewashing
2. Increase in thermal resistance by layers of insulating materials such as sea shells, burnt clay bricks, coating etc.
3. Shading provided by wooden boards.
4. Combination of the above.

2.2.2.3 The effect of courtyard

Family members use the courtyards for day and night activities such as: working, praying, washing and hanging clothes, entertaining guests family gathering place and a children play area. So a courtyard is considered to be an important design element in vernacular houses. It is also seen as a micro climatic initiator. It enhances ventilation, natural cooling and day lighting.

Due to the lack of artificial light from thick walls facing the heat since it has to be with little or no fenestration, courtyards are considered to be a main source of day light and openings are recommended to be opened to the courtyards.

The courtyard therefore not only initiates passive cooling but also carries out diverse functions that increase the sense of comfort to the occupants in hot arid climates. It also stimulates the cultural trait of community living and enhances the sense of belonging to the family unit [Yakubu, 1990].

2.3 Role of energy in air conditioned buildings

The essential function of a building is to modify extremes of the outdoor climate, without any mechanical means into desirable indoor conditions to offer protection and comfort to the inhabitants.

However, in many cases new buildings have failed to do so. This is firstly due to, an inappropriate design, which neglects climate consideration in the design, and secondly, due to the extreme outdoor conditions which probably make impossible for any building to fully nullify the affects and result in a failure to reach a certain level of desired indoor conditions.

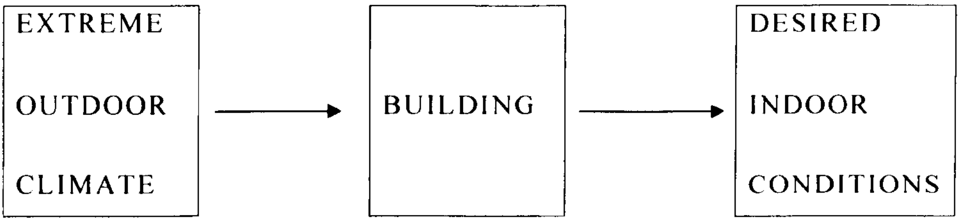

Figure 2-2: The role of building is to modify unwanted outdoor climate into desired indoor conditions

Quite a few buildings are not designed according to the need to modify unwanted outdoor climate into desirable indoor conditions. Buildings were just thought of as basic shelters to protect human indoor activities from rain, wind and the direct solar radiation.

Desirable indoor air temperature has never been considered to be one of the main objectives of designing a building. The result is that it is quite common that naturally ventilated buildings have failed to provide indoor air temperatures that are comfortable for the occupants.

Quite a few architects assume that it is difficult to provide desirable indoor conditions within buildings without employing any artificial means. Since there were no studies into how the design and materials of a building can be utilised to adapt to the local climate, those naturally ventilated buildings have failed to achieve comfortable conditions. This fact gives the impression to both architects and building industry contractors, and even the end users of the buildings convinced that it is impossible for naturally ventilated buildings to provide indoor thermal comfort for the building's occupants.

Consequently, new buildings are normally designed with air conditioning in mind in the belief that this can guarantee that the buildings will provide desirable indoor thermal conditions.

Therefore, energy in the form of electricity is expended for air conditioning systems as well as for artificial lighting. This is an uneconomical method to achieve the indoor climatic conditions, which are required by the buildings' users. Figure (2-3) shows that energy is eventually necessary to help the building provide desired indoor climatic conditions.

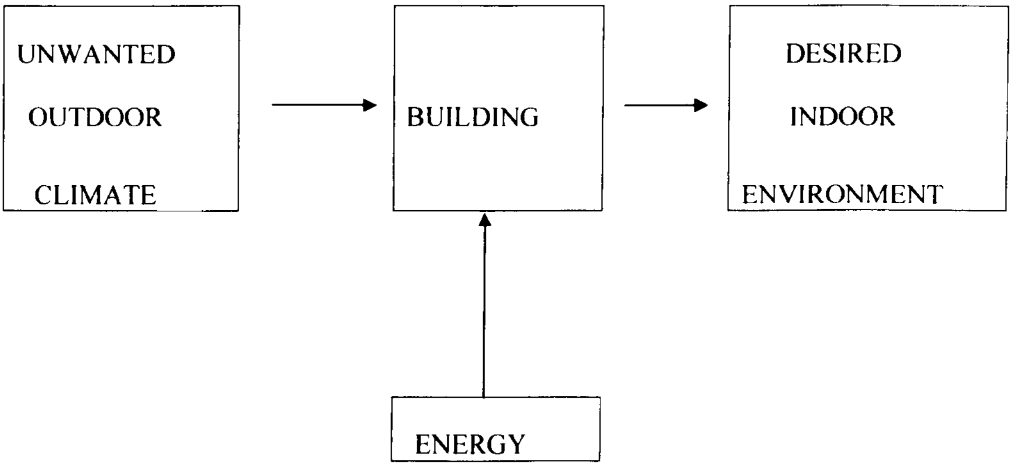

Figure 2-3: Energy is required to help the building to provide desired indoor climate conditions.

But, again, in some cases the buildings have failed to provide desirable indoor thermal conditions even when air conditioning has been utilised in the buildings. The building's indoor temperatures can be either too warm or even too cool for the buildings' occupants. However, with regard to indoor lighting, it is rare that occupants have made any complaints about it. This can be an indication that people can adjust more easily to the changing of the visual environment rather than to that of the thermal

'Too warm' an indoor temperature can occur even when a large amount of energy is used for air-cooling. This probably occurs due to the inappropriate design of the building whereby excessive direct sun's radiation penetrates the building through a large area of un-shaded glazed wall. While on the other hand, the 'too cool' indoor thermal environment can occur due to the lower setting standard of the rooms' temperatures. The design of the buildings can be categorised as good or poor depending on how much energy is being used for cooling/heating. Good buildings must consume low energy and provide a comfortable indoor environment, while the poor ones may consume uneconomical amounts to provide a comfortable indoor environment and some bad designs may even utilise excessive energy and still not provide a suitable living/working environment. Figure (2-4) shows that even with an adequate supply of energy, a building which is inadequately designed could fail to provide a desired indoor climatic environment.

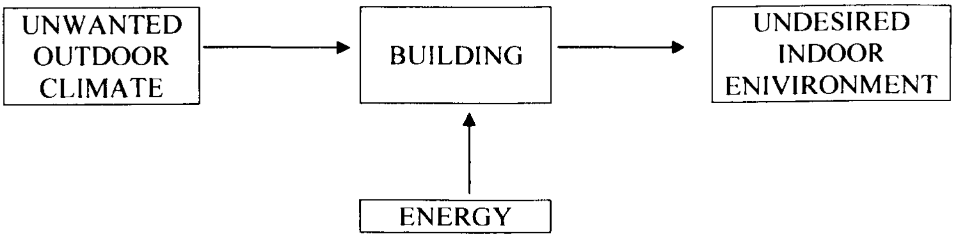

Figure 2-4: Even with the supply of energy, a building quite often fails to provide desired indoor conditions

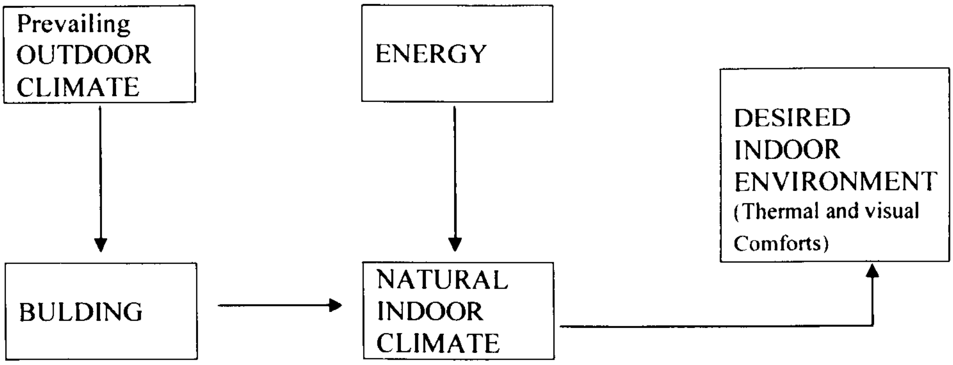

Figure 2-5: 6Relationship between: prevailing outdoor climate, building natural indoor climate, desired indoor environment (comfort) and energy.

Figure (2-5) summarises the relationship between the prevailing outdoor climate, the building, the natural indoor climate, the desired indoor environment and the role of energy in the building. It can be seen that the role of the building is to modify the prevailing outdoor climate to a suitable condition of indoor climate, in which the desired comfortable indoor environment is to be achieved. When the natural indoor climate matches the range of the desired indoor environment, no energy is required in building. However, this situation is usually rare and may not be completely achieved without some use of an external energy source.

In air--conditioned buildings, the role of energy is more crucial. Buildings are heavily dependent on the use of external energy sources. In relation to the desired indoor environment, energy is used both for artificial light and for air-conditioning. An excessive, uneconomical use of energy would inevitably occur if the building was not correctly designed to minimise solar heat gain.

2.4 Role of energy in natural ventilated buildings

The role of energy in naturally ventilated buildings is less crucial than that in air conditioned buildings since a correctly designed naturally ventilated building is less dependent on energy than that of air conditioned ones. The role of energy in naturally ventilated buildings in relation to the desired indoor environment is to help the building provide adequate illumination for the users. Therefore, the main concern arises for the need of naturally ventilated buildings to deal with the illumination problem with the minimum use of artificial lighting, or in other words, is to maximise the use of daylight during the day hours. The use of energy for artificial lighting per square meter should be relatively low compared to the energy use for the cooling required by an air-conditioned building.

2.5 Minimising energy consumption in buildings

In minimising energy consumption there should be some criteria to be fulfilled by the building such as, low air temperature, low radiant temperature and optimum air movement. In this type of buildings, there should be no energy requirement to regulate any level of indoor climatic parameters, such as air and mean radiant temperatures and air movement since all of these would be entirely dependent on the nature of the building design itself.

In the absence of a heated body or material such as a person, electrical equipment, etc., temperatures within naturally ventilated building are determined by the combination of the effect of the heat flow across the walls and the airflow from outdoors into the building. As shown earlier when the external colour of the envelope fabric is dark, the possible heat flow across the walls is increased, the effect of the sun's radiation on un-shaded walls on indoor temperature would be greater, and the thickness of the walls would noticeably affect the indoor temperature.

Air movement is a crucial factor to be provided for in naturally ventilated buildings.

In the case of air-conditioned buildings, apart from the role of the building envelope, energy use for cooling/ heating is largely dependent on the outdoor-indoor temperature differences. The smaller the differences, the lower the cooling load required. Energy used in an air-conditioned building is also determined by the setting of indoor temperatures.

In air conditioned building, however, there is no need for direct ventilation from windows. Ventilation will elevate the indoor temperature due to the heat exchange with the outdoor air, which is cooler than the indoor air in the night time. The air conditioning systems will take adequate fresh air from outside to be cooled before being distributed to the rooms. The energy for cooling could be minimised when temperatures within the building can be kept low by using high thermal mass to avoid solar gain.

Solar radiation impinging on building walls, which is eventually absorbed by the building's fabric, should be kept at a minimum to reduce the heat's penetration into the internal walls.

2.6 Design principles in hot dry climates

2.6.1 Site layout

- Compact building layout with minimal surface exposure [Baroum, 1983],
- Patios and shaded internal courtyards provide social and sleeping areas [Imamoglu,1980],
- Use of internal ponds and fountains for evaporative cooling [Al-Mutawa,1981],
- Possibly increased cross-ventilation at night to cool internal mass,
- Inclusion of underground spaces,
- Protection from hostile outdoors: heat, wind, dust, glare. Often design for such protection results in inward looking buildings, sometimes with courtyards [[Yakubu, 1990],

- Evaporative cooling is effective [Al-Mutawa, 1981]. In such climates water is often in short supply, so it needs to be conserved. Ponds and vegetation may be contained in courtyards, 'ponding' the cooled air,
- Vegetation can be used to shade building elements, for cooling by transpiration, for trapping cooled air, and for filtering dust [Mofidi 1998].

2.6.2 Choice of materials

- Use of light colours to reflect incident solar radiation [Givoni,1981],
- Flat roofs preferable made of adobe to be used as sleeping areas in summer [faris,1981],
- Large thermal mass [Mofidi, 1998]. Thermally massive external walls delay the passage of heat from the peak hot period outside, so that it arrives at the internal surfaces later in the day. Large thermal mass inside absorbs excess heat and helps the interior to stay cool for longer.

2.6.3 Façade design

- Reduce ventilation during the day to exclude hot, dusty outdoor air,
- Use of small windows and openings to minimise direct solar gains [Yakubu, 1990],

- If possible, use of insulation on external surface of mass,

2.6 Conclusion

A building may be considered as a 'climate modifier' which shields the indoor environment from the external climate. Before designing a building at a given place, the changes of weather from season to season (i.e. the climate) must be well understood so that the building can be built to shelter people all year round. Traditionally, people stay indoors during the day, in a thermally massive building with limited ventilation. In the evening, the living quarters are opened to night-time ventilation, to cool down by next morning. The inhabitants move to lighter construction sleeping quarters (in some cultures, on the roof), which cool down rapidly once the sun sets, partly by ventilation, but also by radiation to the night sky.

It can be concluded that all discussed passive design techniques have a major impact on indoor thermal conditions, especially in hot and dry climates where the temperature is high during summer.

3. Thermal comfort inside buildings

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3.1 Introduction

This chapter describes the need and importance of thermal comfort . It looks at the theories of thermal comfort, which begins to illustrate the thermo-regular system of human comfort. This is followed by a description of the main factors affecting thermal comfort and the models and research methods used to determine thermal comfort are discussed and compared. The last section of this chapter explains the energy usage required to obtain thermal comfort.

3.2 What is thermal comfort?

Thermal comfort is generally defined as that state of mind which expresses satisfaction with the thermal environment [ASHRAE; 1992]. Dissatisfaction may be caused by the body being too warm or cold as a whole, or by unwanted heating or cooling of a particular part of the body (local discomfort). It could be said that thermal comfort is strongly related to the thermal balance of the body [Fanger 1972, McIntyre 1980, and Gagge 1986].

3.3 Importance of Thermal Comfort

All building elements should be designed to respond to the climate and to provide comfortable conditions for occupants because all human physical conditions will be generally be at their peak when they are in their most comfortable state and they will decrease in the unfavourable seasons [Hunting, 1951].

Nicol [1993] has indicated three reasons for the importance of thermal comfort:

1) To control energy consumption
2) To provide a satisfactory living conditions for people
3) To suggest and set standards

The advantages of doing research in thermal comfort have been identified by Raw and Oseland [1994] and these are:

1) Achieving energy saving
2) Control over environment by people
3) Reduce the harm on the environment by reduced CO_2 production
4) Improving internal air quality
5) Affecting the work efficiency of the building occupants
6) Reasonable recommendation for improving or changing standards

3.4 Thermal Comfort and Energy Consumption

The consumption of primary energy in residential and commercial buildings counts for about one third of the total world energy demand and thus buildings represent consequently a major primary contributor to global pollution [ECBCS 1999]. Even if big efforts have been made to reduce the energy consumption in buildings for example by constructing super thermally insulated envelopes, by improving the quality of window glazing and by using the thermal storage of the construction itself there is still a broad saving potential left.

Heating and cooling of buildings account today for high energy consumption. Higher living standards lead to active Climatization of buildings. Air-conditioning plants are installed without any adaptation of the buildings to these new appliances, which leads to excessive energy consumption and high cost, and may also damage the building [Adamson and Åberg 1993]. Alternatively, recent buildings without active Climatization, both low-cost and luxury, give a poor indoor climate, leading to fatigue and health risks.

For the building to be energy efficient it is necessary to control the input of energy through regulatory systems and/ or through 'passive' techniques. The former requires sophisticated equipment and depends on their smooth functioning and energy supply. The latter, 'passive' techniques, normally requires more interaction, monitoring and knowledge by the user, and is therefore more sensitive to human factors, though technically simpler and more reliable.

The way of building design, construct, and operate buildings has profound implications for the quality of both the natural and built environments. All too often today's buildings require massive resource inputs, create bleak or potentially unhealthy indoor environments, pollute both their local and global environments through increased greenhouse emissions, as well as contributing to the destruction of natural habitats [Barnett and Browning 1995]. The energy required to heat and cool buildings, and the very way that define the "comfortable" thermal conditions are trying to maintain, play significant roles in this environmental impact. The use of energy for heating, ventilating and air-conditioning (HVAC) of the indoor environment is already the largest sector in energy consumption in most of the developed world [Griffiths et al 1988]. As well we are now seeing a significant increase in HVAC energy uses in developing and newly industrialized countries as well [Ang 1986, Abro 1994].

3.5 Human Thermo-regulatory System

The human temperature regulation determines the physiological thermal comfort of the occupant of a room, as the human body exchanges heat with the environment. Heat is exchanged by radiation, convection and evaporation. The heat is primarily produced by metabolism, which results from digestion. During normal rest and exercise this results in an average temperature of the vital organs near 37°C. The body's temperature control system tries to maintain this temperature when internal or environmental thermal disturbances occur. Figure (3-1) shows the human thermoregulatory system as presented by Hensel [1981]. The controlled variable in the system is a weighted mean body temperature. It represents a combined value of the internal body temperature and the average skin temperature, in which the internal body temperature has an approximately ten times higher weight. Thermal disturbances are either internal, e.g. heat generation due to exercise, or external, e.g. hot or cold environments. Thermoreceptors in the skin register external thermal disturbances so that the thermoregulatory system can react before the disturbance has reached the body core. This thermoreceptive system also responds to the rate of change of temperature.

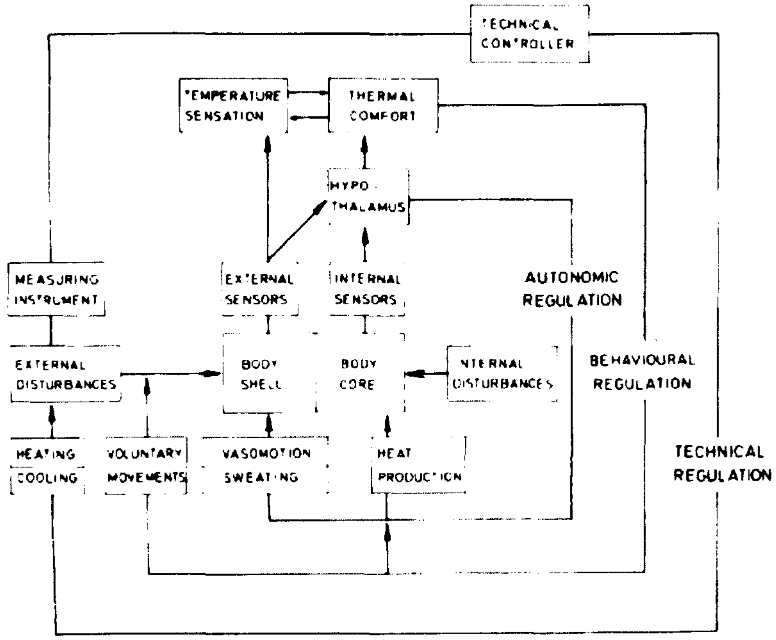

Figure 3-1: Schematic diagram of the human thermoregulatory system (from Hensel (1981)).

The human thermoregulation system can be subdivided in an autonomic and a behavioural regulation (Hensel 1981]. The autonomic regulation is controlled by the hypothalamus, governing the heat production (e.g. by shivering); the internal thermal resistance (e.g. by control of the skin blood flow); the external thermal resistance (e.g. by respiratory dry heat loss) and water secretion and evaporation (e.g. by sweating and respiratory evaporative heat loss). The set-temperatures for these various autonomic control actions can be different for each person and they may vary separately and independently. The behavioural thermoregulation is associated with conscious temperature sensation and feelings of thermal comfort/discomfort [Hensel 1981]. The temperature sensation results from the thermo receptor activity. Thermal comfort/discomfort conveys the general state of the thermoregulatory system, i.e. the resultant of the thermo receptor signals, internally and at the skin. Examples of the behavioural regulation are active movement and adjustment of clothing. The technical regulation, indicated in Figure (3-1), relates to artificial control systems, e.g. an air conditioning system.

In Hensel [1981] a summary is given of the physiological conditions for steady state general thermal comfort. General thermal comfort results from the integrated signals from various internal and external thermo-receptors. Warm discomfort is closely related to the rate of sweating, which in itself is initiated by a warmth-sensation receptor in the hypothalamus [Benzinger 1979]. Cold discomfort is a response to the temperature of the skin, as monitored by cold-receptors in the skin. Ideal thermal comfort, according to Benzinger, can be therefore defined objectively as "the absence of punitive impulses from both receptor fields" or "a state in which there are no driving impulses to correct the environment by behaviour". Ideal thermal comfort is defined by the absence of cold-reception at the skin and central warmth-reception, without overlapping. In most cases however, e.g. when performing exercises, a mixed comfort situation is obtained with cold discomfort at the skin and warm discomfort due to a too high central temperature.

When designing the indoor climate, thermal comfort should be attainable for the occupants. Two types of approaches are found to predict steady state thermal comfort. One approach is based on the heat balance of the human body. The second approach assumes an adaptation to the thermal environment to a certain degree.

3.6 Factors Influences Thermal Comfort

Six major factors affect thermal comfort. These factors are divided into three main categories. The first category consists of environmental factors such as, air temperature, mean radiant temperature, relative humidity and air movement.

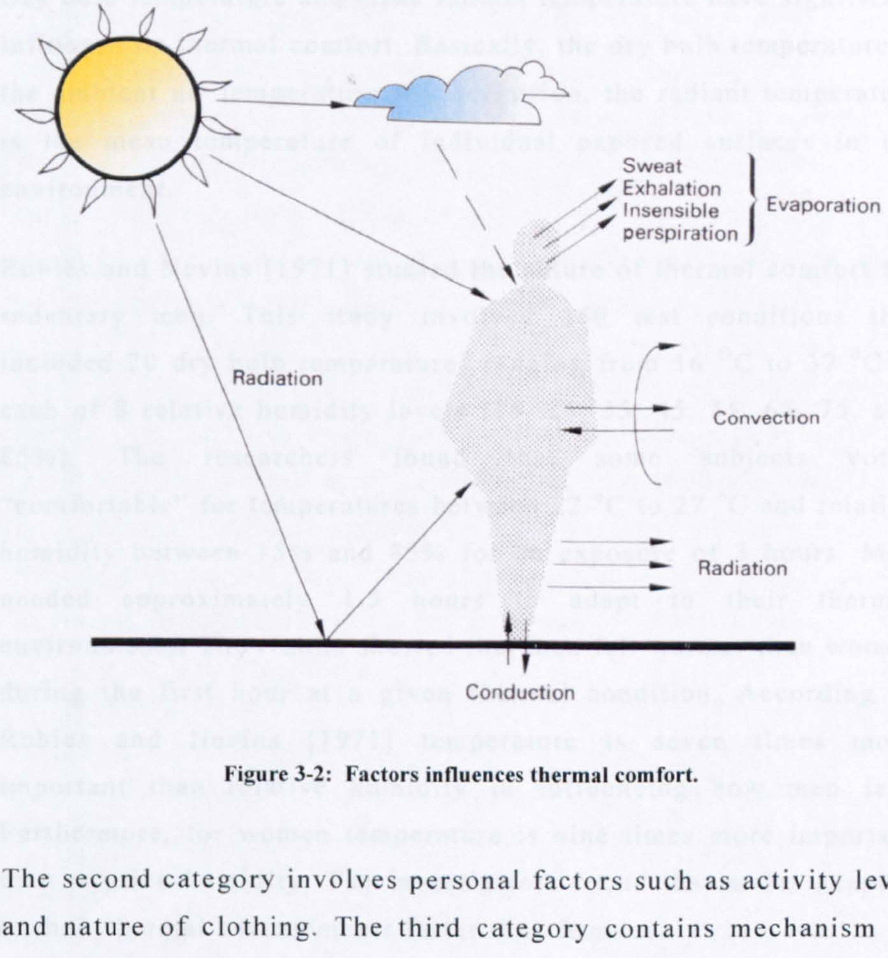

Figure 3-2: Factors influences thermal comfort.

The second category involves personal factors such as activity level and nature of clothing. The third category contains mechanism of heat transfer Figure (3-2). In addition to these factors, secondary factors such as the rate of change of any of the above mentioned factors could result in the change of the thermal comfort. If any one of the above-mentioned determinants changed, the others must be adjusted to maintain the thermal equilibrium between heat gain and heat loss in the body [Broadshaw 1985].

3.6.1 Environmental Factors

3.6.1.1 The Effect of Dry Bulb Temperature/Mean Radiant Temperature.

Dry bulb temperature and mean radiant temperature have significant influence on thermal comfort. Basically, the dry bulb temperature is the ambient air temperature. By definition, the radiant temperature is the mean temperature of individual exposed surfaces in the environment.

Rohles and Nevins [1971] studied the nature of thermal comfort for sedentary men. This study involved 160 test conditions that included 20 dry bulb temperatures ranging from 16 ^{0}C to 37 ^{0}C at each of 8 relative humidity levels (15, 25, 35, 45, 55, 65, 75, and 85%). The researchers found that some subjects voted "comfortable" for temperatures between 22 ^{0}C to 27 ^{0}C and relative humidity between 15% and 85% for an exposure of 3 hours. Men needed approximately 1.5 hours to adapt to their thermal environments. The results showed that men felt warmer than women during the first hour at a given thermal condition. According to Rohles and Nevins [1971] temperature is seven times more important than relative humidity in influencing how men felt. Furthermore, for women temperature is nine times more important than relative humidity. The investigators found that males adapted to their thermal environments faster than females.

The study carried out by Sprague and McNall [1970] examined the effects of fluctuations in temperature on thermal comfort. The test conditions for the temperature fluctuations ranged from a peak-to-peak amplitude of 5 -15 °C with a period of a half-hour to a peak-to-peak amplitude of 6 -14.4 °C with a period of one hour. They concluded that no serious occupant complaints would occur due to temperature fluctuations.

3.6.1.2 The Effect of Relative Humidity

The relative humidity range is important not only for comfort, but also for health issues. According to Sterling [1985], an increase in relative humidity encourages mildew growth, but low relative humidity can result in respiratory problems due to dryness. The bacterial populations typically increase below 30% and above 60% relative humidity. Relative humidity below 40% may cause respiratory infections. High relative humidity causes chemical reactions to occur. Conversely, low relative humidity produces ozone that irritates the mucous membranes and eyes.

From the health literature of relevant biological and chemical interactions, Sterling et al. [1985] identified an optimal range of humidity where overall health risks would be minimized. Sterling et al. concluded that the optimal relative humidity range should be from 40% to 60%. This range of relative humidity is included in the recommendation for ASHRAE Standard 55-1994.

Sprague and McNall [1970] studied the effects of fluctuating temperature and relative humidity on the thermal sensation (thermal comfort) of sedentary subjects. During the test, all other variables except relative humidity were held constant. The exposure time was 3 hours for all tests. The ranges for the relative humidity fluctuation were 3% peak-to-peak fluctuation amplitude with a half-hour fluctuation period and 14% peak-to-peak fluctuation amplitude with a fluctuation period of one hour. From the study, the investigators found that there were no serious occupant complaints from fluctuations of relative humidity. Also, Nevins et al. [1974]

found that males sensed a greater discomfort when the humidity was increased from 60% to 80% at an activity level of 1.2 met. In addition, the discomfort at 80% relative humidity was significantly higher in males than in females.

3.6.1.3 The Effect of Air Velocity

Air velocity has profound effects on thermal comfort. In order to keep the same thermal sensation if the temperature increased, then the air velocity also has to be increased. The study conducted by McIntyre [1978] showed that the subjects chose air velocities that increased with air temperature to maximum of about 2 m/s at 30 °C. According to McIntyre, the perception of the strength of an airflow increases as the square of the air velocity while the cooling effect increases as the square root of the velocity. For warmer ambient temperature, regulating the fan speed (increasing air velocity) can reduce discomfort. However, the upper limit for comfort was 28 °C. For a temperature above 28 °C, increased air movement will cause too many disturbances (i.e., noise and papers will be blown off).

ASHRAE Standard 55-1994 recommends that a maximum mean velocity for winter of 30 ft/min (0.152 m/s) and for summer of 50 ft/min (0.254 m/s). In addition ASHRAE Standard 55-1994 specifies that acceptance of the increased air speed depends on the occupants' abilities to control local air speed.

Rohles et al. [1974] investigated the effects of air movement and temperature on the thermal sensations of sedentary subjects. Ninety subjects (45 male and 45 female) participated in the 3-hour experiment. The air velocities selected for the study were 40, 80, and 160 ft/min, and the temperatures were 22 °C, 26 °C, and 29 °C. The clothing insulation was 0.6 clo. The relative humidity was 50% throughout the study. The investigators found that air temperature and velocity significantly influenced mean skin temperature. The skin temperature exhibited significant interactions with exposure period. No important gender differences existed in the thermal sensations at the higher velocities in the 3-hour test.

3.6.2 Individual Factors

3.6.2.1 The Effects of Activity Level

Activity level has the largest effect on thermal comfort. To measure how much heat is generated by a body for different activity levels, metabolic rate measurements can be performed. Metabolic rate increases in proportion to exercise intensity. By ASHRAE definition, the metabolic rate is the rate of energy production of the body and is expressed in met units. One met is defined as 58.2 W/m_2 (the energy produced per unit surface area of a seated person).

McNall et al. [1967] tested several metabolic rates and found little humidity effects at low metabolic rates and increased humidity effects at higher metabolic rates. Also, sweating and an increase in skin temperature occur when metabolism is increased. Another hypothesis for discomfort is related to periodic variation in metabolic levels. People at light metabolic level (< 1.2 met) may temporarily elevate their met levels by climbing stairs or carrying things. During the elevated activity, a higher heat loss is required for thermal balance. If humidity is high, the heat dissipation ability of the body is reduced and the sweat rate will increase over that of a body in a dry environment. The resulting skin wittedness may persist after the activity rate has subsided and the skin cooled off. Discomfort can result from increased skin temperature during the intermittent exercise or residual skin wittedness left over after the exercise.

3.6.2.2 The Effects of Clothing

Clothes worn will affect the heat exchange between the body and the surrounding environment, thus will affect the state of comfort. As the heat produced by the human body must be dissipated into its surrounding environment in order to maintain a constant body temperature, clothes will retard the heat loss from the body to the environment.

In low ambient temperature, thick clothes are required to keep the dissipated heat by the body, on the other hand, in high ambient temperature close to skin temperature, thin and loose clothes are needed to allow the dissipation of heat from the body to the surrounding environment. Clothing, however, can be a means of indicating the prevailing climate. In warm weather, people tend to wear thinner and looser clothes than in cold or temperate climates.

The insulation of the clothing is expressed in "clo units". The clo unit was introduced to facilitate the visualization of clothing level. 1 clo or about that of an office suite is the insulation necessary to keep a person comfortable at 21 °C. 1 clo of thermal insulation is equivalent to 0.155 m^2K/W.

3.6.3 Other Factors

There are other phenomena related to the climate, such as hail, frost, thunder, fog, smog, rain, dust and sandstorms, hurricanes and earthquakes. These are more occasional, extreme conditions and are not addressed here, but where they might occur, they must be considered, since they may strongly affect the design of buildings.

3.7 Models for thermal comfort

Different concepts have been applied to derive a practical relation between the thermal environment and the physiological and psychological well-being of the person that is or will be exposed to this environment. These concepts can be categorised into two clearly distinguishable approaches:

- **The heat balance approach**
- **The adaptive approach**

In the following two sections the two approaches will be discussed with respect to the practical application.

3.7.1 The heat balance approach

This method of calculating the steady state thermal comfort obtained from climate chamber research. Fanger [1970] is a well-known representative of the heat balance approach. Fanger assumed homogeneous climatological conditions around the human body and formulated a steady state heat balance equation for the human body to arrive at a thermal comfort relation. This heat balance equation is given by:

$$H - E_d - E_{sw} - E_{re} - L = K$$

$$K = R + C \qquad \text{(Equation 3-1)}$$

where, H is the internal heat production in the human body, E_d the heat loss by water vapour diffusion through the skin, E_{sw} the heat loss by evaporation of sweat from the surface of the skin, E_{re} the latent respiration heat loss, L the dry respiration heat loss, K the heat transfer from the skin to the outer surface of the clothed body (conduction through the clothing), R the heat loss by radiation from the outer surface of the clothed body and C the heat loss by convection from the outer surface of the clothed body.

Fanger defined satisfaction of Equation (3-1) to be a necessary but certainly not sufficient condition for steady state thermal comfort. The human thermoregulatory system is very effective and therefore will be able to create heat balance within wide limits of the environmental variables, even if thermal comfort does not exist. In Equation (3-1), the skin temperature (T_{sk}), as appears in Ed and K, and the sweat secretion (E_{sw}) are the only physiological variables that can influence the heat balance at a certain activity level. However, the range over which T_{sk} and E_{sw} may vary is limited for thermal comfort conditions and only applicable to an individual person at a specific activity level [Hensel 1979, Benzinger 1979]. Climate chamber results were applied to develop empirical relations for the mean skin temperature and sweat secretion as a function of activity level, clothing insulation and environmental conditions [Fanger 1970].

3.7.1.1 Predicted Mean Vote

Practical application of the heat balance equation was proposed by Fanger, by formulating a thermal comfort equation which allows the prediction of the thermal sensation of a group of persons in an arbitrary, but stationary, climate, the Predicted Mean Vote (PMV). The basis of this equation was obtained from the above mentioned experiments, in which the thermal sensation vote indicated the personally experienced deviation to the heat balance (-3 [cold] to +3 [hot]; seven point scale, 0 = neutral (optimum)). Applying this

PMV-equation, the thermal sensation for a large group of persons can be determined as a function of the activity, clothing, air temperature, mean radiant temperature, relative air velocity and air humidity.

In Figure (3-3) the sensitivity of PMV to velocity, humidity, clothing insulation and metabolism is presented as a function of the temperature. For each variable the range that can be found in a normal office environment is indicated [ASHRAE 1992, Loomans and van Mook 1995]. Given the boundary conditions and the applied ranges, in Figure (3-3) PMV generally varies between cool (-2) and warm (+2). The sensitivity of PMV to the temperature is largest. Of the other variables, the sensitivity to the metabolism is most pronounced.

Fanger assumed that the vapour permeability of the clothing was not important in the prediction of PMV. The heat loss from sweat secretion is defined at the surface of the skin and assumed to evaporate completely at the skin at moderate sweat secretion and air temperatures. An improvement of the PMV-model was proposed by Gagge et al. [1986] by including the physiological heat strain caused by the relative humidity and vapour permeability properties of clothing.

3.7.1.2 Predicted Percentage of Dissatisfied

Fanger derived a second equation, the Predicted Percentage of Dissatisfied (PPD), which indicated the variance in the thermal sensation of the group of persons exposed to the same conditions. This equation was derived from the earlier described experiments. Dissatisfaction with the thermal environment, discomfort, was defined for those who voted cool (-2), cold (-3), warm (+2) or hot

(+3). Under optimal thermal conditions (PMV = 0) a minimum of 5% dissatisfied is found, assuming identical activity levels, clothing and environmental conditions. In Figure (3-3) the PPD-value is given at the outermost right axis (non-linear scale).

Fanger [1970] furthermore assumed that a room-averaged PPD-value can be derived for thermally non-uniform rooms. From the measured thermal variables at equally distributed positions in the occupied zone of a room the PMV and the corresponding PPD-value can be calculated. The room-PPD-value can be then determined as the average from the PMV value at the points.

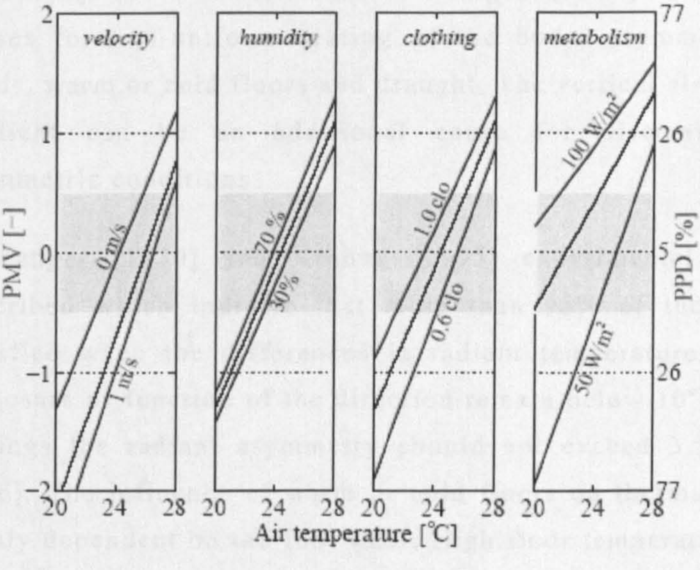

Figure 3-3: ***Sensitivity of PMV to variation in velocity, humidity, clothing insulation and metabolism as function of the homogeneous air temperature (T_{mrt} = T_{air}). For each variable three lines are given. The thick lines present the result for the indicated range of the investigated variable and the thin line the result for the median value. When the variable is not changed constant values are used: $u = 0.1$ m/s, $\varphi = 50\%$, $I_{clo} = 0.8$ clo, $M = 58.2$ W/m2. The corresponding PPD-value is indicated at the outermost right axis (non-linear scale).***

As Fanger derived the thermal comfort equation from experiments in a thermally uniform environment, the validity of a PPD-value in a point in a non-uniform environment however is questionable. It supposes thermal comfort in a point, whereas the mathematical model has been based on the judgement by people (at a larger scale).

3.7.1.3 Asymmetric Thermal Conditions

It is possible to balance Equation (3-1) under asymmetrical thermal conditions, but there are restrictions with respect to the degree of asymmetry for thermal comfort. Fanger [1970] indicated three causes for non-uniform heating of the body: asymmetric radiant fields, warm or cold floors and draught. The vertical air temperature gradient can be an additional cause for discomfort due to asymmetric conditions.

In Fanger [1970] and Krühne [1995] experimental results are described which indicate that more than 95% of the people are satisfied when the differences in radiant temperatures within the enclosure as function of the direction remain below 10°C. For warm ceilings the radiant asymmetry should not exceed 3.5°C [Krühne 1995]. The influence of warm or cold floors on thermal comfort is highly dependent on the foot wear. High floor temperatures of 29°C did not show discomfort for persons wearing light shoes. The lower temperatures at which comfort can be attained is 17-18°C [Nevins and Feyerherm 1967].

The sensation of draught, defined as an unwanted local convective cooling of a person, is dependent of the thermal comfort state of the person. Persons already feeling cool will complain of the sensation of draught, whereas the same condition may have a positive effect on a person feeling warm. Fanger et al. [1988] derived a relation for the risk of draught, the predicted percentage of dissatisfied due to draught (PD), as a function of the temperature, the mean air velocity and the turbulence intensity. This relation was obtained from similar climate chamber research as for the PMV-model. The velocity and turbulence intensity were registered at three points in a vertical line at 0.15 m behind the neck of a seated person. The registered values at head level (1.1 m) were used for the PD-model.

The draught risk model has been introduced to compensate for the heat transfer effect of turbulence which is not accounted for in the PMV-model. Under normal office indoor air conditions, the draught risk model typically lead to the requirement to keep the velocities very low ($u < 15$ m/s). In Figure (3-4) the sensitivity of PD to the turbulence intensity and the temperature as a function of the velocity is shown. The standards [ASHRAE 1992] require that PD < 15% (Figure 3-4).

Warm discomfort at the head and/or cold discomfort at the feet can be expected in thermally stratified flow patterns as for example present in a displacement ventilated room. Olesen et al. [1979] reported that more than 5% of the people feel locally uncomfortable when the air temperature difference between head (1.1 m) and ankle (0.1 m) is larger than 2.8^{o}C. The test was made for 3 hours occupancy.

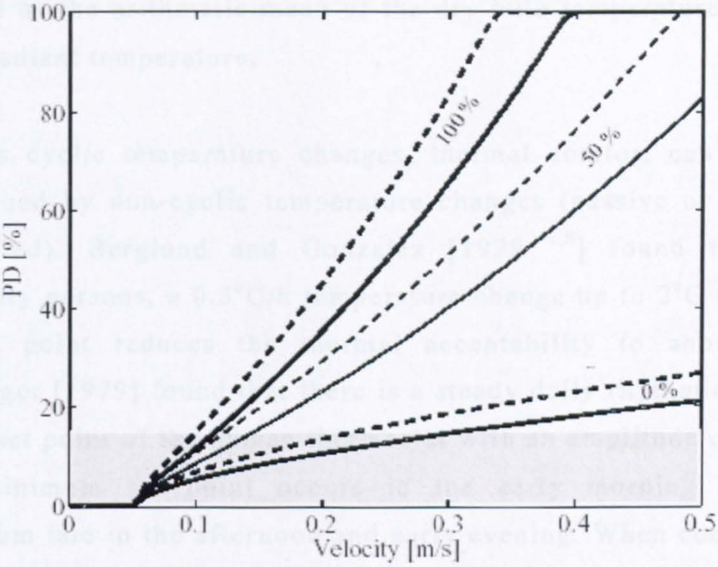

Figure 3-4: Sensitivity of PD to turbulence intensity (TI = 0.100 %) and temperature.

3.7.1.4 *Non-Steady Thermal Conditions*

According to Fanger [1970] the PMV-equation can also be applied under quasi-steady-state conditions. Fanger concludes that sudden changes in the temperature are anticipated promptly by the regulatory mechanism. From a comfort point of view, harmonic temperature fluctuations were found to be acceptable if T2 cph < 4.6°C2/h, where T is the peak-to-peak amplitude of the air temperature and cph the cycling frequency per hour [Sprague and McNall 1970]. The peak-to-peak temperature amplitude decreases with increasing fluctuation frequency as the cold-receptors at the skin also sense the rate of change of the temperature. Therefore it is an additional critical parameter for thermal comfort. Radiant temperature fluctuations were not included in the temperature fluctuation experiments of Sprague and McNall. Hensen [1991] derived a peak-to-peak amplitude and cycle rate of the operative temperature at T2 cph < 1.2°C2/h, if the operative temperature is defined as the arithmetic mean of the dry bulb temperature and the mean radiant temperature.

Besides cyclic temperature changes, thermal comfort can also be influenced by non-cyclic temperature changes (passive or actively controlled). Berglund and Gonzalez [1978 [a,b]] found that, for sedentary persons, a 0.5°C/h temperature change up to 2°C from the neutral point reduces the thermal acceptability to about 80%. Benzinger [1979] found that there is a steady daily rhythmic change of the set point of the human thermostat with an amplitude of 0.5°C. The minimum set point occurs in the early morning and the maximum late in the afternoon and early evening. When cooling, an energy conserving slow rise during day-time therefore may be preferable, as the tolerance for heat increases during the day [Benzinger 1979].

3.7.2 The adaptive approach

A relation for steady state thermal comfort derived from studies in the field. Assuming people will have adapted to the indoor thermal conditions, incorporating known and unknown psychological influences, the indoor and outdoor temperatures are the dependent variables.

Instead of the use of climate chamber experiments to determine the heat balance as found in the work of Fanger, Humphreys [1976, 1994] supports the so called adaptive approach. From a global field-study on the relation between thermal comfort and temperatures, Humphreys found the existence of large temperature differences between different groups of people feeling thermally comfortable. These differences could not be explained solely from differences in clothing, the range was about twice that large. As a result comfortable temperatures as derived from the heat balance approach could not be brought into agreement with the comfort conditions found in daily life [Humphreys 1976].

Humphreys, unlike Fanger [1970], found a relation between the mean temperature (T_m), defined as the mean air temperature experienced by the population under investigation during their waking hours over a period of a month, and the neutral room temperature (T_n), defined as the air temperature found to be "neither warm nor cool" (or "comfortable"). So people will adapt to certain outdoor climatic conditions. E.g., in a hot climate people will acclimatise to higher temperatures indoors than in temperate climates, even though other environmental thermal comfort parameters suggest a too high PMV. Given this fact Humphreys [1976] derived a relation for the prediction of thermal comfort as a function of the prevailing room temperature and the above defined Tm.

Three equations relating the indoor comfort temperature to the outdoor monthly mean temperature was proposed by Humphreys & Nicol [1994] as follows:

1. Free running buildings

$$T_c = 11.9+0.534T_o\ (^\circ C) \qquad \text{Equation 3-2}$$

2. Heated or cooled buildings

$$T_c = 23.9+0.295(T_o-22)\exp(-[(T_o-22)/(24\sqrt{2})]^2)\ (^\circ C) \qquad \text{Equation 3-3}$$

3. All building pooled

$$Tc = 24.2+0.430(To-22)\exp(-[(To-22)/(20\sqrt{2})]^2)\ (oC) \qquad \text{Equation 3-4}$$

The equations above were obtained from a global field study. Humphreys and Nicol [1994] show the power of the adaptive principle in their paper as illustrated in Figure (3-5).

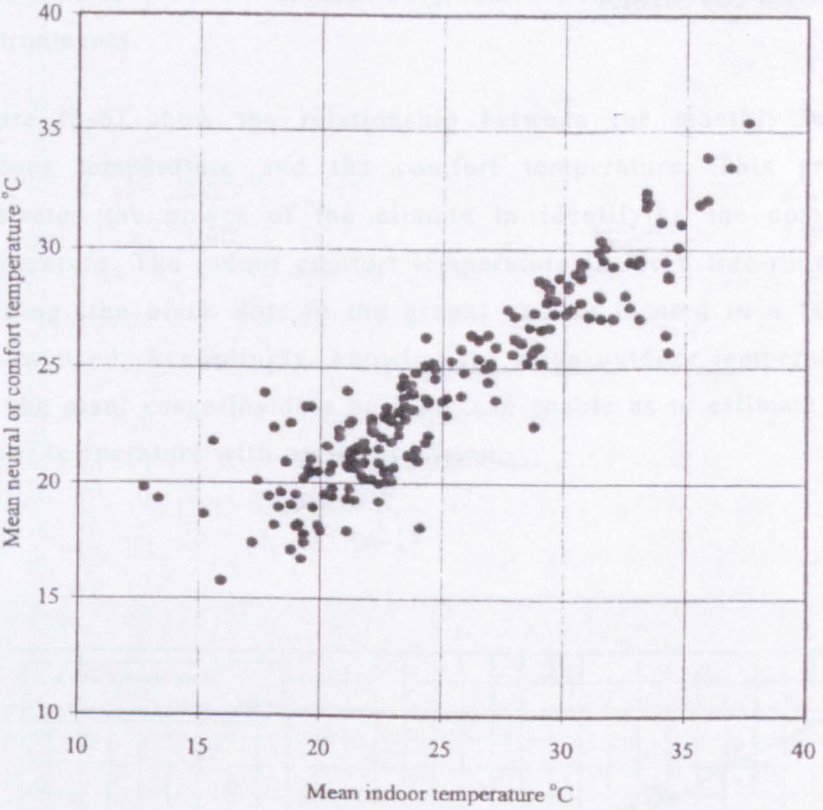

Figure 3-5: The correlation between the mean indoor temperature and the mean comfort temperature.

It can be seen that there is a high correlation (r=0.94) between the mean indoor temperature of the accommodation and the mean comfort temperature of the occupants. This high correlation suggests the power of the adaptive principle. However, it can be noted that there are several outlier points in this graph. This suggests that there are "circumstances were adaptation has not been completed" Humphreys and Nicol [1994]. Those outlier values are limited only to the very hot or the very cold environments. This suggests that the adaptive principle might not be applicable for hot environments found in Yemen. However, the data outliers in Figure (3-5) tend to occur in the cold environments rather than in the hot environments.

Figure (3-6) show the relationship between the monthly mean outdoor temperature and the comfort temperature. This graph illustrates the power of the climate in identifying the comfort temperature. The indoor comfort temperature inside a free-running building (the black dots in the graph) can be located in a fairly narrow band. Accordingly, knowing the mean outdoor temperature and the plant usage inside a building can enable us to estimate the indoor temperature with useful precision.

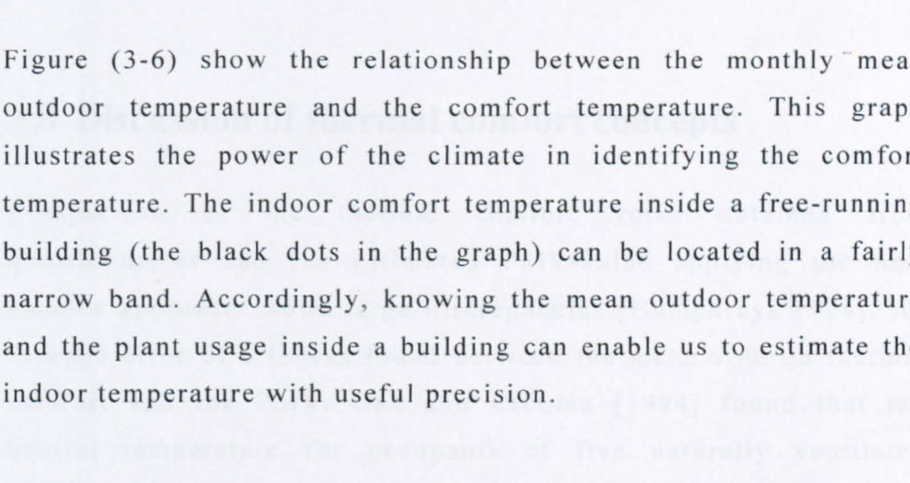

Figure 3-6: The relationship between the monthly mean outdoor temperature and the comfort temperature, after Humphreys and Nicol [1994]

In this work the adaptive model is used to identify the expected comfort bands inside the case study buildings. Equation 3-2 and equation 3-3 were used depending on the plant usage inside the case studies. Further discussion about the applicability of the adaptive model in the case study investigated in this work can be found in section 9.2.1.

3.8 Discussion of thermal comfort concepts

Comparison of the thermal comfort votes obtained from questionnaires and the estimated PMV-value applying the heat balance approach shows large discrepancies [Humphreys 1994]. An average error of $3^{\circ}C$ was found between the mean vote on thermal comfort and the PMV. Gan and Croome [1994] found that the neutral temperature for occupants of five naturally ventilated offices, situated in the United Kingdom, was 1 to $2^{\circ}C$ lower than the temperature that would be determined from Fanger [1970]. Increasing deviations in the estimated comfort value are found when clothing and activity level differ from the sedentary subject in light clothing. As activity levels frequently vary and often differ from the sedentary activity, the thermal comfort prediction as found via PMV is therefore questionable.

An invariable neutral temperature for thermal comfort at standard metabolic rate and standard clothing, though expected to exist, seems to vary more profoundly than presumed. Humphreys [1978] indicates that (personal) comfort temperatures seem to be correlated with climatological conditions. Despite the lighter clothing and higher velocities, evidence of acclimatisation was also proposed by Busch [1992] to describe the contrasts in thermal neutrality between Thai office workers in naturally ventilated and air conditioned offices. Hensel [1981] summarises some results which discuss the accommodation to extreme thermal conditions. However, in Brager and de Dear [1998] results are summarised which do not subscribe to the effect of accommodation of building occupants to the outdoor conditions. The work of Humphreys in this respect can be criticised, as non-temperature related changes in the thermal comfort parameters have not been addressed in the field studies. Therefore, the influence of these other parameters on the thermal comfort cannot be judged.

The sensitivity of the thermal comfort equations to the different variables is shown in Figures (3-3) and (3-4). The grey areas in both Figures indicate the combined value for the different variables which satisfy the standards criteria [ASHRAE 1992, ISO 1984]. Besides the requirement of uniform thermal conditions, the accurate prediction of thermal comfort by the PMV- and PD-equation is hampered by,

- uncertainties in the estimated clothing insulation,
- uncertainties in the estimated metabolic rate,
- Uncertainties in the posture in relation to the effective surface area,
- Uncertainties regarding the generalization of the results obtained for a particular group under particular conditions.

Several authors discuss results which indicate the above mentioned restrictions of the use of PMV and other comfort equations for the determination of thermal comfort [Wyon 1994, Ong 1995, Parsons 1994, Brager and de Dear 1998]. E.g. the metabolism is sensitive to the weight, the health and the gender of a person. Even for sitting quietly, the difference can mount up to 40% [Ong 1995]. A broad consensus can be found on the fact that thermal comfort or neutral thermal sensation is not necessarily equal for a significant number of people. Brager et al. [1995] concludes that "people's preferences for non-neutral (warm or cool) thermal sensations are common, vary asymmetrically around neutrality, and in several cases are influenced by season". Wyon [1994] shows that the average neutral temperature is of little interest because the 95% range of the individual neutral temperature falls within a wide range of 10°C.

Further remarks can be made on the steady state of thermal comfort. Though most comfort indices, such as PMV, were determined for steady state conditions, everyday live is far from being steady state. For example, time lags appear between the start of an activity and the thermal equilibrium of the body. Typically, this time lag is small, in the order of several minutes. However, the recovery of thermal comfort after ending the activity normally takes longer.

Finally, a psychological point of departure for the concept of thermal comfort is given by Cabanac [1996]. When comfort is defined as the "subjective indifference to the thermal environment", indicating a stable situation, sensory pleasure is aroused if a troubled situation is corrected. Sensory pleasure, which is more pleasant than the indifferent comfort, is temporary, as from the troubled situation a comfortable situation is wanted. Therefore, if the human being is given the freedom to change a situation, it will strive for maximising the pleasure. From this concept one may conclude that variations in the thermal comfort conditions (in time and place) shouldn't be avoided at all costs, as long as one is able to correct the situation to a comfortable one. In this context McIntyre [1981] stated that a "person's reaction to a temperature which is less than perfect will depend very much on his expectations, personality and what else he is doing at the time".

Brager and de Dear [1998] describe that people's expectations in naturally ventilated offices were much more relaxed than those for closely controlled air conditioned buildings. They conclude that not only behavioural adjustment but also expectation has a great influence on thermal comfort.

3.9 Review of thermal comfort field studies

3.9.1 Thermal Comfort Study in Iraq

Baghdad is the capital city of Iraq and has a hot dry climate. Between June and July of 1962 Webb made a study in Baghdad using modern designed houses with walls of concrete block as his data source. Based on Webb's observation data, Nicole [1972] reported results of his analysis.

Thermal comfort factors (Air temperature, Relative Humidity and Air Velocity) were measured and the seven point Bedford scale was used for sensation analysis. The Nicole study concluded that:-

1. People in Baghdad were more comfortable at an ambient temperature of 32 °C.
2. The air velocity was greater than 0.25 m/s.
3. A statistically significant response was presented but the humidity was not significant in the multiple regression equation computed for the responses.
4. The sedentary acclimatised subjects had little discomfort
5. When temperature rose above 36 °C thermal discomfort exceeded 20 %.

3.9.2 Thermal Comfort Study in Pakistan

In late 1993 and early 1994 Nicole [1994] and his team carried out a longitudinal field survey in Pakistan. This study was carried out during both summer (July 1993) and winter (December/ January 1994). In order to meet the climatic variation, Pakistan was divided in to five climatic zones. The aims of the project were:-

- To compare the actual indoor temperature of the existing building designs with the standards derived from laboratory studies.
- To suggest new standards which related indoor temperatures to local climate and seasons.
- To reduce energy consumption in buildings.

The main results of this project were:

1. Comfort temperatures in summer were found between 26.7 °C and 29.9 °C while in winter it was found between 19.8 °C and 25.2 °C.

2. The differences of comfort temperatures between climatic zones and seasons averaged about 7 K throughout the country.

3. In summer, normal air velocity gave cooling equivalent of a shift of up to 4 K, but high humidity was perceived as increasing hotness by the equivalent of 2 K.

4. In winter, air velocity and humidity showed no significant effect on comfort temperature.

5. In summer, the comfortable temperature can be calculated by the following equation:

$$T_n = 17.0 + 0.38\,T_m \qquad \textbf{(Equation 3-5)}$$

T_n Comfort Temperature

T_m Monthly Mean Outdoor Temperature

6. The mean comfort vote and mean preference vote were more consistent in summertime while more variable in winter time.
7. Mean activity showed very little seasonal variation.
8. Half to two–thirds of the differences between the comfort temperatures in summer and winter are justified by changes in the clothing worn.
9. Using the equation (3-4) above for designing indoor air temperatures, the energy consumption was expected to reach savings of approximately 20 – 25%.

3.9.3 Thermal Comfort Study in Thailand

In Bangkok, the capital of Thailand, Busch [1990a; 1992; 1995] conducted a field study in thermal comfort in naturally ventilated (N/V) and air–conditioned (A/C) offices. This study was carried out in hot and wet seasons. Both the McIntyre scale and the ASHRAE scale were used for the analysis. The main results of this study showed:

1. The effect of the neutral temperature was found between subjects of A/C and N/V groups and there was no significant effect between seasons.

2. By using linear regression it was found that the neutral temperature of the N/V group was 27.4 °C ET while it was 24.7 °C ET in A/C group.

3. The natural temperature for the combined date was estimated at 25 °C ET.

4. For both buildings, the subjects' response to preferred conditions was closer to "slightly cooler" than "natural".

3.9.4 Thermal Comfort Study in Indonesia

In Jakarta, the capital of Indonesia, Karyono [1995a; 1995b; 1996a; 1996b] conducted a field study of seven multi storey office buildings. Five of them were air–conditioned, one was naturally ventilated, while the last was a hybrid building. Seven points scale was used to analyse the thermal sensation. Results of the study showed:

1. The neutral temperature from the actual votes was about 1 K lower than that calculated from the PMV model.

2. The range of the comfort zone was found between 23.8 °C and 29.3 °C (T_a) and was defined as temperatures within the votes between -1 and +1 of the ASHRAE scale.

3. By using linear regression analysis it was found that the neutral temperature for the combined data was 26.5 °C (T_a) or 26 .8 °C (T_o) or 25.6 °C (T_{eq}).

This study concluded that properly designed buildings were able to provide indoor thermal comfort without using air–conditioning, because the comfort range of workers lies closely to the general outdoor temperature.

3.9.5 Thermal Comfort Study in Singapore

De Dear el al [1991c] conducted a field study of different types of buildings. Naturally ventilated dwellings and air–conditioned office buildings were examined in Singapore. The main data used in this study for both buildings are shown in the table (3-1).

Building Type	Clothing Insulation (clo)	Mean metabolic rate (w/m^2)	Air Temperature (^oC)	Relative Humidity (%)	Air Velocity (m/s)
N/V	0.26	70	29.6	74	0.22
A/C	0.44	57	23.5	56	0.11

Table 3-1: The main date examined in Singapore for thermal comfort.

The seven points sensation scale was used to assess thermal sensation. The out come of this study showed:

1. Naturally Ventilated Buildings
   - Mean vote was + 0.66 which was between "just right" and "slightly warm".
   - Neutral temperature (T_o) was found at 28.5 ^oC
2. Air–conditioned Buildings

- Mean vote was -0.34, which was on the cooler boundary of "just right".
- Neutral temperature (T_o) was found at 24.2 °C.

It is notable that the psychological perception of thermal comfort and the affects of different physiological samples on the thermal comforts seem to account for the differences in actual thermal comfort within the test group. This seemed to contradict the expected affect of the basic heat balance variables on the thermal comfort values between naturally ventilated and air-conditioned buildings. In simple terms this would indicate that people expect to be comfortable in certain environments and also expect a certain level of discomfort in others. This shows that the physical appearance of one environment and, to some extent, the cultural origins of the intended occupants, have also to be considered when designing buildings for a certain thermal comfort target.

3.9.6 Thermal Comfort Study in Iran

In Ilam, Heidari [2000] conducted a field study of naturally ventilated courtyard housing. This study was carried out in two different seasons and based on observations in the actual environment. The first was in July and August 1998 during the hot season and the second in December 1998 during the cool season. The main important criteria of the examined housing in Ilam are:

1. All houses must be courtyard housing.
2. Courtyard traditional housing should be small in size and as much as possible central courtyard.
3. Recently built houses (no more than 20 years old).

4. Naturally ventilated.
5. Typical in terms of design and materials as close as possible.

The aim of the study was to establish the neutral temperature and the acceptable range of environmental conditions for Ilam people in their houses. Climatic elements were measured during the survey and the ASHRAE and three point scales were used for the analysis. The main results of this study were:

1. In summer season
    - The mean sensation votes were 0.59.
    - Mean clothing value was 0.60.
    - The neutral temperature was 28.1 °C with acceptability limits of 24.0°C to 31.8 °C and a regression slope of 0.24.
    - The neutral temperature was higher in the traditional housing as compared to the contemporary housing.
2. In winter season
    - The mean sensation votes were – 0.20.
    - Mean clothing value was 1.49
    - The neutral temperature was 20.8 °C with acceptability limits of 17.2°C to 24.2 °C and a regression slope of 0.25.
3. The environmental conditions did not have an influence on the activities.
4. In both seasons it was found that there was a little difference in neutral temperature between males and females (around 0.5 °C).

5. The comfort Temperature (T_n) which depends on outdoor temperature (T_{om}) could be obtained from the equation:

$$T_n = 17.3 + 0.36\ T_{om} \qquad \text{(Equation 3-6)}$$

Figure (3-7) concluded the results of thermal comfort temperatures in six reviewed countries. It is clear that three reviewed studies were found within the hot dry climate while the other three studies were found in the tropical climate.

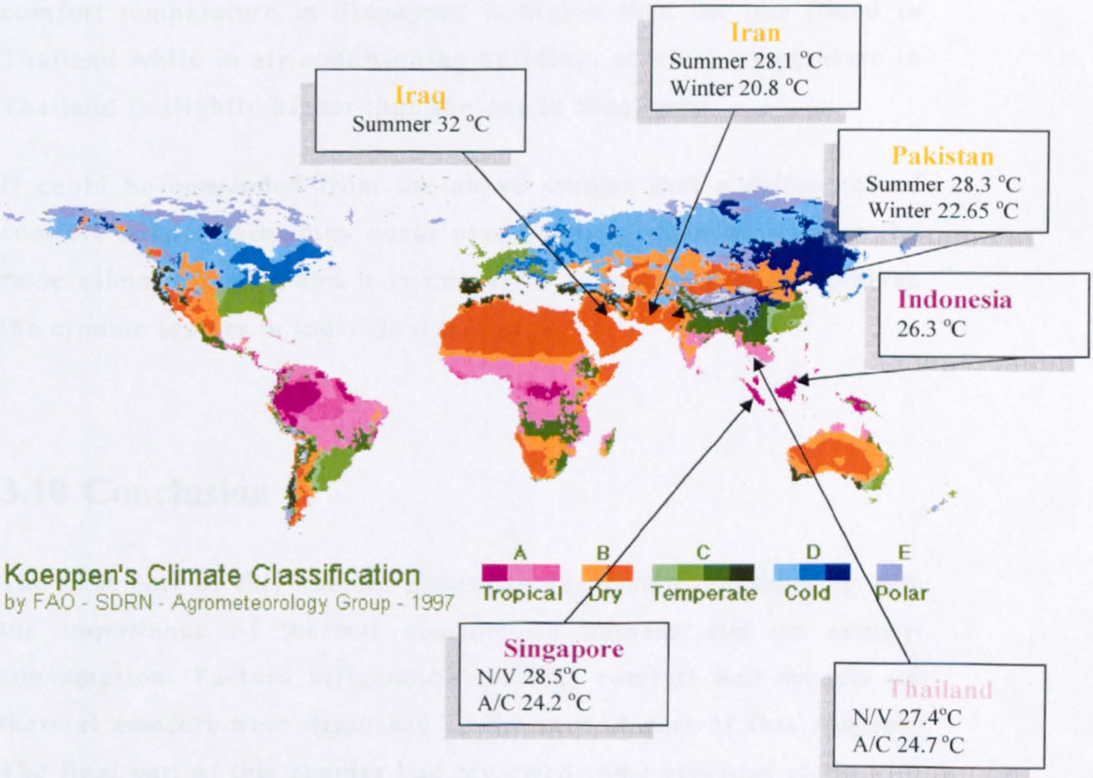

Figure 3-7: Thermal comfort temperatures in six reviewed countries.

Iraq, Iran and Pakistan were found in hot dry climate. In summer, thermal comfort temperatures in Iran and Pakistan were found close to each other (28.1 °C and 28.3 °C) while it was higher in Iraq (32 °C). In winter it was found that thermal comfort temperature in Pakistan is higher than in Iran, 1.85 °C differences. The variation in comfort temperatures may occur due to the difference in temperature frequency between the three countries.

Indonesia, Thailand and Singapore were found in the tropical climate. Conducted studies in Singapore and Thailand intended to obtain thermal comfort temperatures in natural ventilated and air conditioning buildings. In natural ventilated building, thermal comfort temperature in Singapore is higher than the one found in Thailand while in air conditioning building, comfort temperature in Thailand is slightly higher than the one in Singapore.

It could be concluded from the above studies that a difference of comfort temperatures may occur even between countries within the same climatic region and it is important to understand and analyse the climate factors in individual bases.

3.10 Conclusion

The first part of this chapter generally illustrated the meaning and the importance of thermal comfort on humans and on energy consumption. Factors influencing thermal comfort and models of thermal comfort were discussed in the second part of this chapter. The final part of this chapter had reviewed some previous studies of thermal comfort. Humphreys Equations 3-2 and 3-3 from this chapter will be used in this study to determine the comfort bands for the area under study.

Part Two

Literature Reviews.

4. Yemeni Climatic context and thermal comfort

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4.1 Introduction

Correctly defining the geography and climate of the target environment is one of the most critical steps in formulating a useful study of its influence on thermal comfort [Gado, 2001]. By correctly describing the climate and climatic elements one can illustrate the affects of the surrounding environment on people and buildings. With this in mind, it is the aim of this chapter to provide a general understanding of the climate and geography of Yemen, with a more precise focus on the exact locality, geographical area and climate of the area under study.

This chapter is divided into three sections. The first section generally describes the climate classification and elements. The second section generally describes the climatic classification and elements of Yemen. Finally the last section will review previous work in thermal comfort in Yemen.

4.2 Climate Classification

4.2.1 Definition

Academic literature provides several definitions for the concept of climate. For instance, the Oxford English Dictionary defines climate as " a region with certain conditions of temperature, dryness, wind, light, etc".

Koenigberger et al [1973] provides a scientific and semantic definition for climate as "an integration in time of the physical states of the atmospheric environment, characteristic of a certain geographical location". Two significant aspects are highlighted in this definition – time and location – which reflect an infinite variety of climates. This variety is subject to continuous change caused by both natural factors and acts of human interference, either intentional or un-intentional.

4.2.2 Classification of Climate

Climatic studies for a given region may adopt various classification criteria. These could be based on analysing the affect of a single element or a combination of elements with an emphasis on the relationship between them. Identifying this relationship is important in this context because the combined affect of numerous elements is usually different from the affect of one element [Gotz; 1986]. In addition, the altitude, past experience, physiological metabolism of individuals and the subsequent desirable conditions could result in a variation in the analysis of the climate.

Among many climatic classification systems, W. Koppen's [1936] system is generally the most accepted. Koppen established his method on the basis of organising the various types of climate into several classes. As such, this method exhibits the attractive characteristic of simplicity. The appeal of this scheme can be demonstrated in its use of numerical values to define the boundaries and symbols for major climatic types as well as lesser subdivisions.

By using the relationship of climate to vegetation, Koppen determined that the five basic climatic zones are:

1. Hot – humid (tropical rainy climates with no cool season)
2. Hot – arid and semiarid (dry climates)
3. Temperate (middle – latitude rainy climates with mild season)
4. Cold (middle – latitude snow climates with severe winter)
5. Arctic or polar climates with no warm season

For the purpose of this study the second category, which is the most relevant to our topic, will be further illustrated.

4.2.3 Hot dry region

This is the region under focus in this study of Yemen. Hot dry regions are located in the Middle East, central and western Asia, central and northwest Australia, Africa and North and South America. According to Givoni [1998] the main characteristics of the hot dry regions are aridity, high summer daytime temperature, large diurnal temperature ranges and high solar radiation accompanied by low humidity. These characteristics are influential in the determination of human comfort and building design. Summer is a stressful season while winter in some dry regions is the most comfortable season of the year.

The boundary between this category (semiarid and desert is determined by the rainfall value and can be established by the following formulae:

For semiarid regions:

- If rainfall is evenly distributed: $R>T+7$
- If rainfall is concentrated in winter: $R>T$
- If rainfall concentrated in summer: $R>T+14$

For desert regions:

- If rainfall is evenly distributed: R<T+7
- If rainfall is concentrated in winter: R<T
- If rainfall is concentrated in summer: R<T+14

Where: R is the average annual rainfall in (cm)

T is the average annual temperature in (°C)

4.3 Climatic elements

The principle climatic elements for a building design in hot regions are solar radiation, air temperature, humidity and wind. These elements will be illustrated in this section.

4.3.1 Solar Radiation

The most single important element that controls the climate is solar radiation because it is the ultimate cause of all changes and motions in the atmosphere. The radiant energy from the sun provides 99.97 percent of the total energy of the atmosphere [Trewantha; 1968].

The climatic definition of any location can be determined by the net gain and loss of heat in form of radiation [Lamb; 1972]. The latitude of the location and solar activity at a certain time determine the intensity of solar radiation that reaches the relevant local. The amount of incoming solar radiation from the sun which reaches the earth's terra is affected by certain natural characteristics which are:

- The partial reflection of the incoming solar radiation by the surface of the clouds.
- The partial absorption by the atmosphere in layers.
- The partial scattering in all directions by the air molecules themselves.

The geographic location, weather and the altitude play an important role in controlling the percentage of incoming solar radiation to the land masse. In the case of hot arid regions a large percentage of incoming solar radiation reaches the ground than in other climatic regions, due to a lack of the previously mentioned factors which cause loss of solar energy.

This energy is in turn transferred into the surrounding areas of the location under investigation and, by way of heat radiation, affects the temperatures and levels of comfort of the structures in that area.

There are four main channels of radiation heat transfer affecting buildings:

- Direct short – wave radiation from the sun
- Short – wave radiation reflected from the surrounding terrain
- Diffused (part of the scattered radiation) short – wave radiation from the sky – vault
- Long – wave radiation from the heated ground and nearby objects.

It is also important to mention the ways that the above channels of heat transfer affect buildings in different ways:

- Through being absorbed by the external surface of the building
- By entering through windows and being absorbed by the internal surface.
- Long – wave radiation exchange with the sky. This affect is reduced when the sky is clouded and increases when the sky is clear and dry as in hot arid regions. This factor can be utilised as a source of energy for cooling buildings [Konya; 1980].

Architects designing buildings in hot climates need to have a working understanding of the above effects. This knowledge can then be utilised to influence building design in order to respond to different modes of heat transfer and other factors that may affect the thermal comfort provided by buildings.

4.3.2 Air Temperature

Air temperature is the most important element of the four variables which determine thermal comfort [Markus and Morris; 1980]. The variances in the local air temperature must be studied and the affects of such variances used for architectural design purposes. As such, a complete knowledge of the air temperature and its influencing factors is necessary for designers.

The rate of heating and cooling of the surface of the earth is the main factor determining the temperature of the air above it [Givoni; 1976]. The surface of the earth is usually colder than the air at night as a result of long – wave radiation to the sky and so the air in contact with the ground is cold and the net heat exchange is reversed. The air temperature reaches the lowest just before the sunrise, as diffused radiation from the sky causes the temperatures to rise even before dawn, while temperatures reach the highest at early after noon when the effects of the direct solar radiation and the high temperatures already prevailing are combined.

4.3.3 Wind

Wind is a very unstable element and its speed and direction affect the thermal regime of a building in two ways. Primarily wind transports the heat that causes variation in heating and cooling of the land and secondly it is affected by the topography and the seasonal global distribution of air pressure.

Wind is characterised by three variables, which are:

- Direction (winds are always named by the direction they come from)
- Speed (wind speed increases rapidly the heigher above the ground level).
- Degree of uniformity (wind is not a steady current but is made up of a succession of gusts, slightly variable in direction, and separated by lulls).

Wind in a hot climate is important because of the high requirement of ventilation for cooling to provide appropriate ventilation. Wind can also determine the size and level of any openings needed for any utilised ventilation system.

4.3.4 Relative Humidity

Relative humidity is the last parameter and it is referred to as the water in gas form, or water vapour, in the atmosphere [Gates; 1972]. The relative humidity of the air will vary with any change in air temperature. In hot dry regions relative humidity is usually low but it is an important consideration which must be quantified.

4.4 General description of Yemen

4.4.1 Yemen historical background

Yemen has a very rich and varied history. It was mentioned by Greek historians and given the name of the Arabian Felix since it was thought to be the source of enormous riches. This was due to the fact that Yemeni Traders brought the spices, incense and other valuable commodities from the east and transported them to various crossroads with the west. This led to historians mistakenly assuming that Yemen was the source of many of these valuable goods. Yemen has also been mentioned in all of the three main religious books and is thought to be the land of the Kingdom of the Queen of Sheba and the Prophet Shuaib to mention a few. The main Himyarite Kingdoms of Yemen go back more than a thousand years before Christ and lasted until about six hundred years into the first millennia AD, when it was thought that a catastrophic collapse of the Mareb dam caused a major exodus of the Yemeni Tribes into the Arabian Peninsula. The little knowledge that is available of the early Yemeni History indicates that Yemen was first inhabited around 3750 B.C. and evolved into a major civilisation which used advanced methods of architecture to build temples, dams and fortresses and utilised then highly developed methods of agriculture and irrigation. In recent history, after World War I and upon gaining independence from the Ottoman Empire, the northern part of Yemen was ruled by the Immamate family of Hamid Al-Din whose policy was one of isolation. This lasted until World War II.

The British, who had set up a protectorate area around the southern port of Aden in the 19th century, withdrew in 1967 from what became South Yemen. Three years later, the southern government adopted a Marxist orientation resulting in the massive exodus of hundreds of thousands of Yemenis from the south to the north and helped contribute to two decades of hostility between the states. The two countries were formally unified as the Republic of Yemen in 1990.

There is still a lot of work to be carried out to fully study and catalogue the antiquity of Yemen and this is a source of interest to many national and foreign researchers, scientist and archaeologists.

According to the last projection in 1991 that is based on the 1986 census for the Northern provinces, the total population was 10,727, 258; while the latest projection of the total population in 1991 based on the 1988 census in the Southern Governorates' was 2,704,900. Therefore, the total population of the Republic of Yemen in 1991 was an estimated 13,432,150 inhabitants with an average population density of about 24.2 persons per sq. km. The density of the population varies sharply from one part of the country to another due to geographical locations and climatic conditions. Most of the urban population is concentrated in Sana'a, Aden, Al-Houdaydah, Taiz, Hadramout and Ibb. The pattern and hierarchy of the Republic of Yemen settlements, especially in the rural areas, are very much affected by the variation in the population density of the area, distances between settlements, and the prevailing environmental conditions of each area and the available water resources.

One of the main features of the Yemeni society is its high rate of both internal and external migration [MHUP, 1993]. By far the largest numbers of migrants are unskilled workers [World Bank, 1979]. The sources of these migrants are rural areas and as such they have two major effects on the demography of their relevant areas:

1. The abandonment of their villages.
2. A reduction in the available labour, especially for traditional agriculture, which consequently influences the productivity of the rural population.

While external migration is the dominant feature of Yemen's population movements, there is also a sizeable domestic migration. Nevertheless, *85%* of the population still live in rural areas and small towns [MPD, 199 1:27].

After the 1962 Revolution, the government started to utilise modern techniques of urban planning in order to improve the living standards of the local population and to allow Yemen to take its place among the modern nations. However, urban planning in Yemen is still at an early stage and requires a lot of development.

4.4.2 Yemen location

Yemen is situated within the continent of Asia. It located in the south west of the Arabian Peninsula. It is situated between Latitude 12° 40` and 17° 26` and Longitude 42° 30` and 46° 31` [Alshibami, 1999]. On the 22 May 1990, North Yemen (with an area of 195,000 sq km) and South Yemen(with an area of 360,000 sq km) reunited and became one state known as "the Republic of Yemen" which now covers a total area of some 555,000 sq .km with an estimated coastline of approximately 2400km. It shares borders with Saudi Arabia (1,458 Km) and Oman (288 Km).

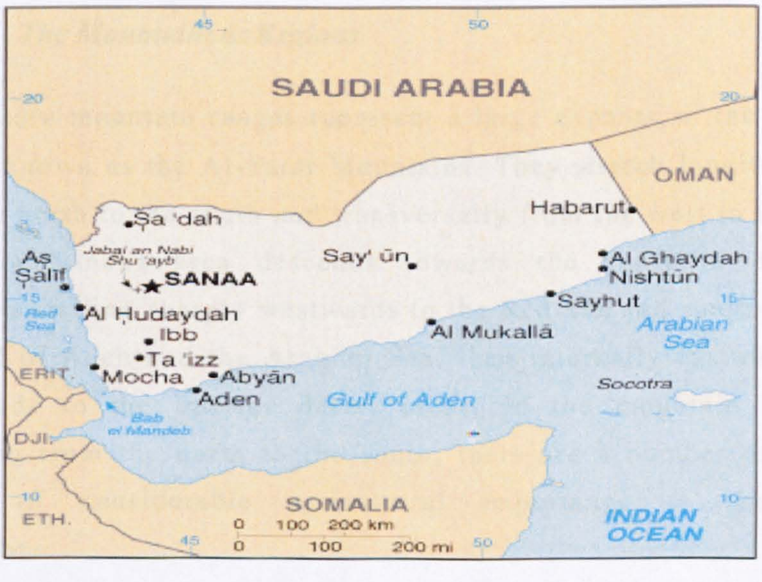

Figure 4-1: Geographical map of Yemen showing the location of Seiyun (area under study).

Yemen's geographical location is characterised by rich physical geographic features which are:

4.4.2.1 The Coastal Area

This area includes the coastal plains overlooking the Red Sea, Gulf of Aden and the Arabian Sea. They are connected to each other forming a coastal strip that extends from the Oman border south-westward to Bab Al-Mandab. This coastal strip then changes its direction northward to the borders of Saudi Arabia, thus making it more than 2400km. long. The width of the plains ranges from 30 to 60 km.

4.4.2.2 The Mountainous Regions

The western mountain ranges represent a large expanse of the country and are known as the Al-Sarat Mountains. They stretch longitudinally from the north to the south and transversally from the west to the east. This mountainous area descends towards the coast in different directions, falling sharply westwards to the Red Sea and southwards to the Gulf of Aden and the Arabian Sea, then internally eastwards and northwards to the interior desert areas. In the mountain heights, stretching from the north to the south, there are a number of basins (beds), of considerable agricultural importance to the large populations.

4.4.2.3 The Eastern region

This area lies to the east and north of the mountainous heights going in parallel to the heights towards the desert Quarter. The maximum height of this area is 1000m gradually descending. This region will be analysed in detail in chapter seven

4.4.2.4 Desert region

This area consists of desert plains covered with gravel, sand and sandy dunes. Evolving in some parts are desert plants and vast oases that were formed by the collection of the seasonal water. The wandering nomads inhabited these areas because of its pastoral land.

4.4.2.5 The Yemeni Islands

This part of the country consists of islands scattered along the coast of Yemen. There are 120 islands, most of which are located in the Red Sea. In addition to these there are islands located in the Gulf of Aden and the Arabian Sea.

4.5 Climate of Yemen

4.5.1 Air Temperature and Humidity

At first glance Yemen seems to be the continuation of the desert that exists in most of the Arabian Peninsula. However, Yemen has a very different climate, mainly because of its altitude. The climate differs from one region to another according to the relief and the nearness to the equator. The climate degrades from the hot-wet equatorial climate to a cold climate, although there are no major seasonal differences.

Temperature varies greatly due to the extreme differences in elevation. Mean annual temperatures range from less than 15 ^{o}C in the highland region to 30 ^{o}C in the coastal plains region. Recorded temperatures may rise to 40 ^{o}C during the summer in the coastal plains region, and to over 40 ^{o}C in the desert plateau region. However, the winter temperatures may decrease to freezing in the highland region.

Rainfall is highly erratic in time, quantity and location. It occurs in two periods, the first from March through May, and the second from July until September, which is the heaviest rainy season. Normally, there is little or no rain from November to February but there are exceptions in certain regions and during certain years. Rainfall varies from less than 50 mm in the coastal plains region and desert plateau region, to more than 1200 mm in the western mountainous highland region. In general, annual rainfall increases with distance from the Red Sea, reaching 15mm in the Coastal Tihama Plain (Western coastal plain of the coastal plains region), and up to 300-400 mm on the foothills of the mountains. Again, the rainfall increases from south to north and in the western mountainous highlands. Then it decreases in the central highlands towards the capital, Sana'a towards the north in Sa'ada. The country can be divided into three climates:

1) Hot humid climate: this climate covers the coastal plains and Lower Mountain slopes in the west and south, and is characterized by high temperatures and low precipitation ranging from 0 to 400 mm.

2) Temperate climate: this covers the mountains ranging in altitude from 1800 to 3700m above sea level. Precipitation varies from 200 mm to more than 1500 mm.

3) Hot dry climate: this covers the desert and semi desert region which lies in the east and north east of the country. The weather in this area is accentuated by a hot dry summer and cold winter.

Figure (4-2) shows the mean monthly air temperature in each group. While Figure (4-3) shows the monthly relative humidity.

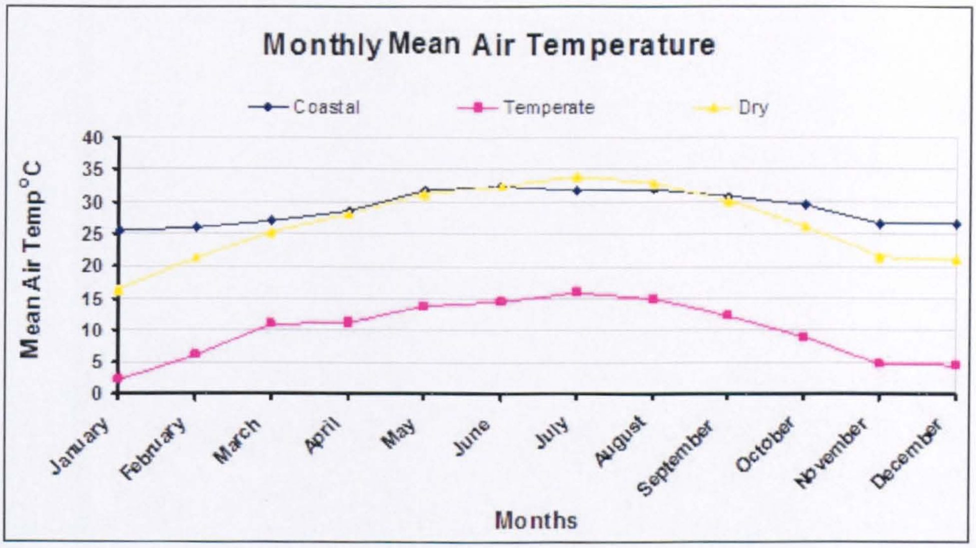

Figure 4-2: The monthly mean air temperature in the main climatic regions of Yemen.

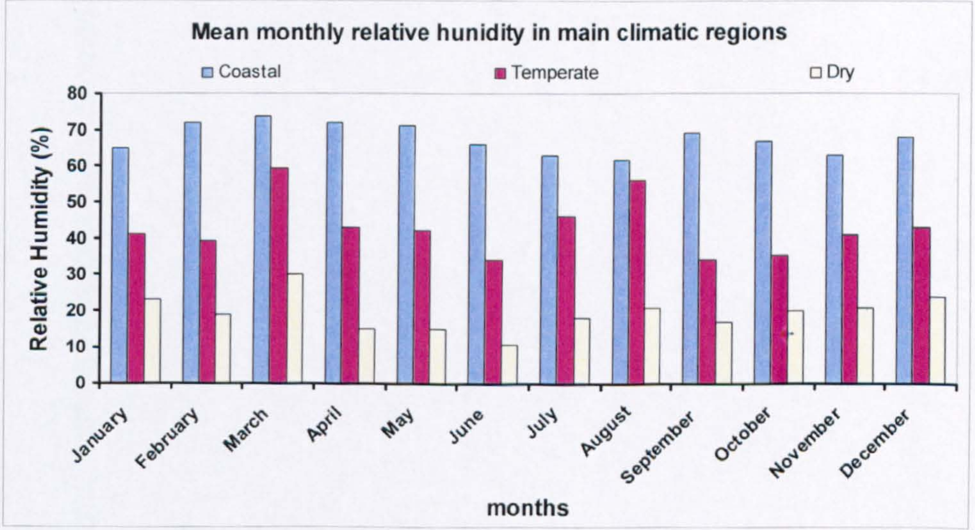

Figure 4-3: The monthly mean relative humidity in the main climatic regions of Yemen.

4.5.2 Prevailing wind

Shaban [2000] conducted a climatic study in the region of Hadramout in order to provide a climatic basis for future researchers. He studied two different climates, the hot humid and the dry climate within a close local region.

Figure (4-4) shows the monthly percentage of wind speed and prevailing wind for the hot dry climate while Figure (4-5) shows the wind monthly percentage speed and prevailing for the hot and humid climate in the region of Hadramout. It is noticed that prevailing wind always comes from the east for most of the year, while it comes from the south east in January, from the south in April and from the west in May.

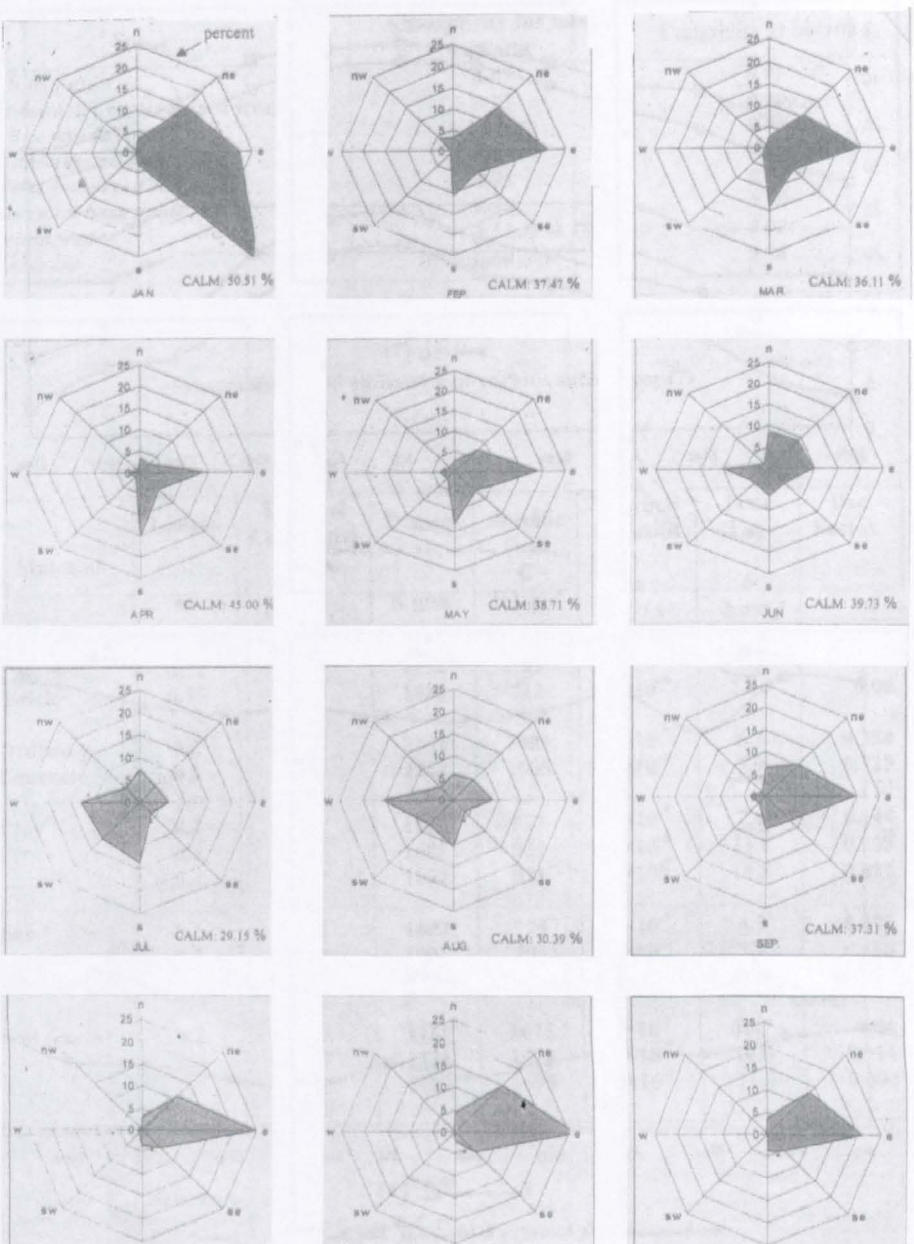

Figure 4-4: Prevailing wind in hot dry climate (Seiyun).

(Source Shaban 2000)

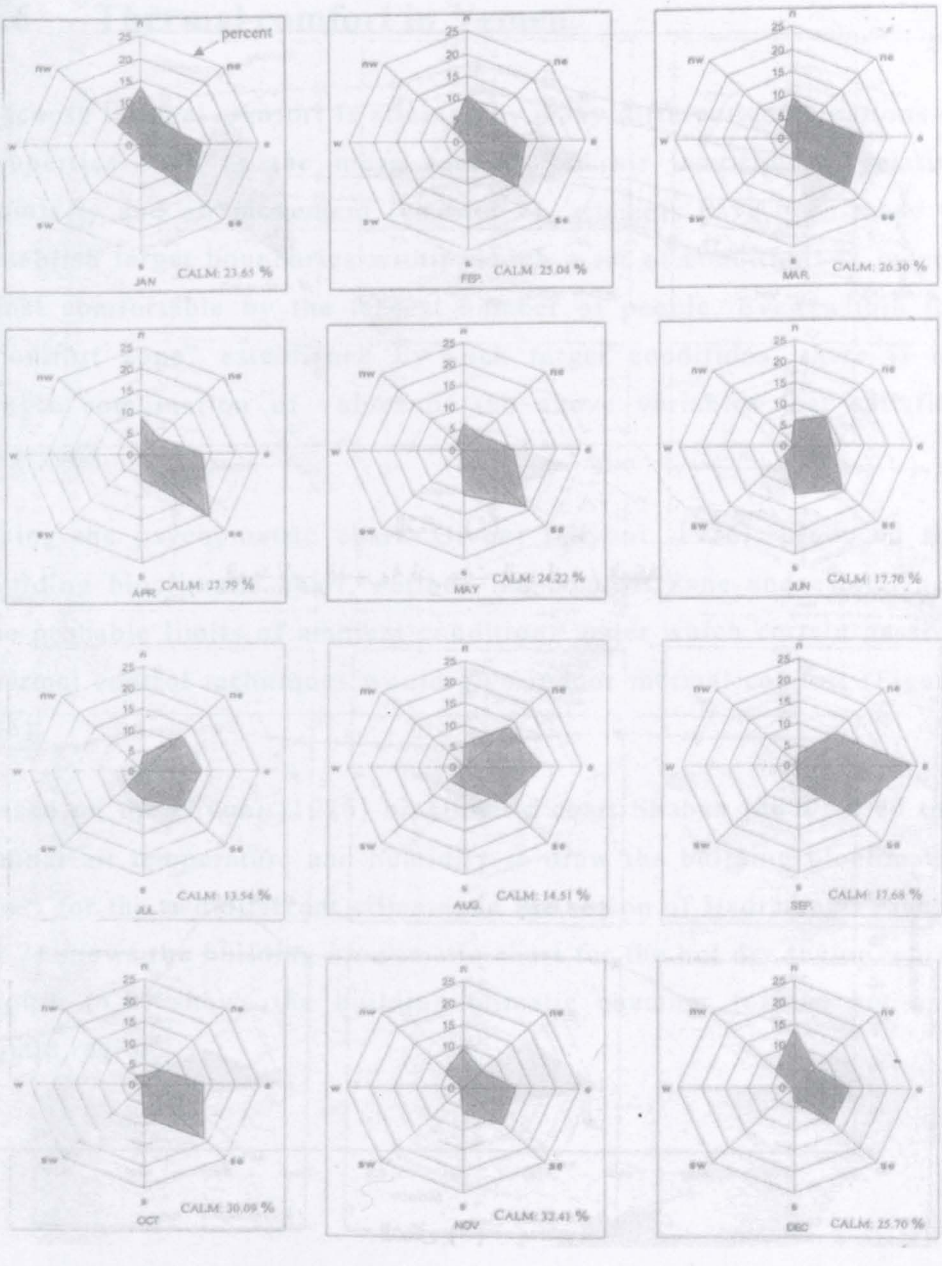

Figure 4-5: Prevailing wind in hot humid climate (Mokalla).

(Source Shaban 2000)

4.6 Thermal comfort in Yemen

Because thermal comfort is attained by many different combinations of properties such as the mean radiant and air temperature, relative humidity and air movement (chapter 2), attempts have been made to establish target boundaries within which a set of conditions is judged most comfortable by the largest number of people. Even within the "comfort zone" established by such target conditions, there is no single combination of values of the above variables that satisfies everyone.

Using the psychometric chart, Givoni [Givoni, 1976], produced the building bioclimatic chart, defined the comfort zone and established the probable limits of ambient conditions under which certain passive thermal control techniques would give indoor thermal comfort (Figure 4-6).

Based on the Givoni [1976] bioclimatic chart Shaban [2000] used the annual air temperature and humidity to draw the building bioclimatic chart for the two different climates in the region of Hadramout. Figure (4-7) shows the building bioclimatic chart for the hot dry region while Figure (4-8) shows the building climatic chamber for the hot and humid region.

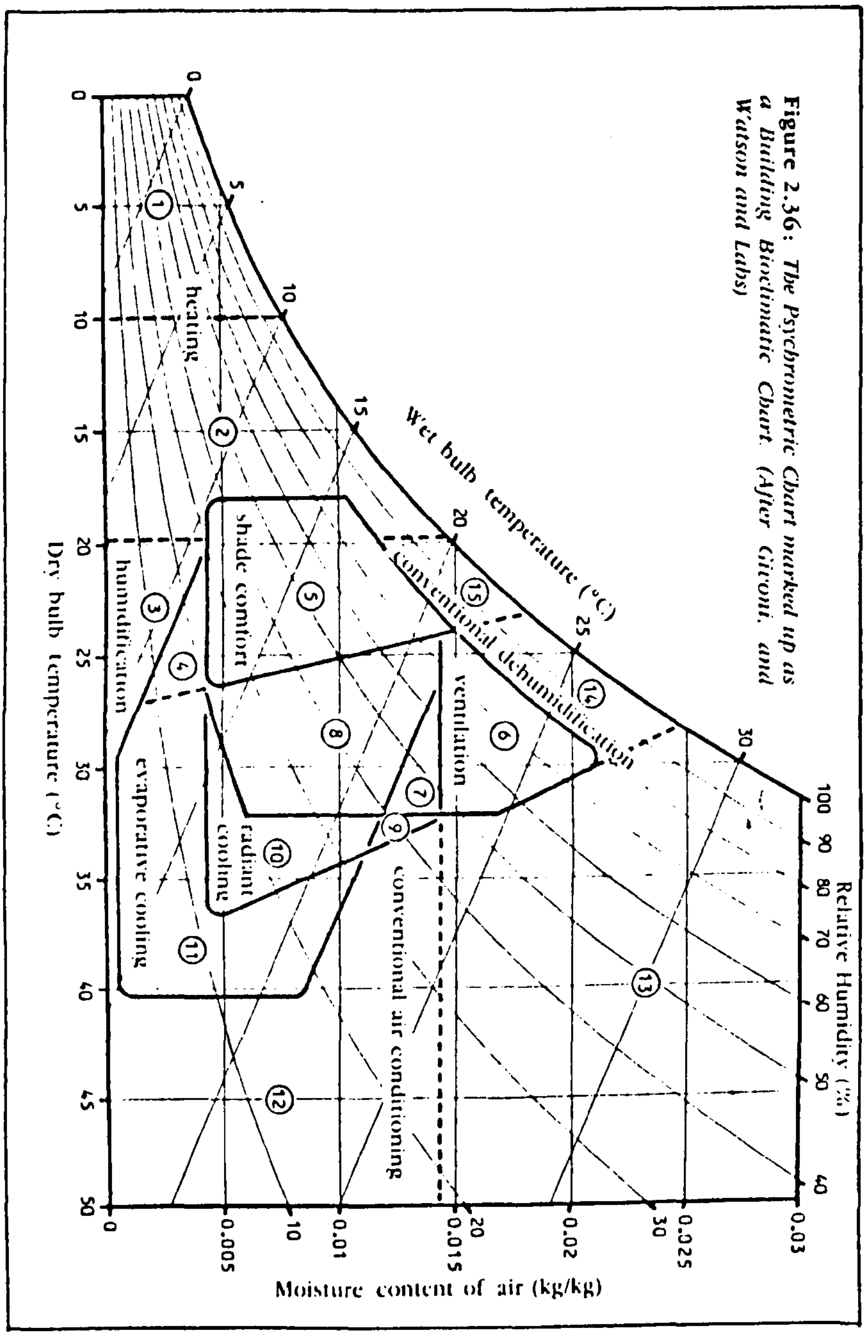

Figure 4-6: The bioclimatic chart (after Givoni, (1969, 1976)

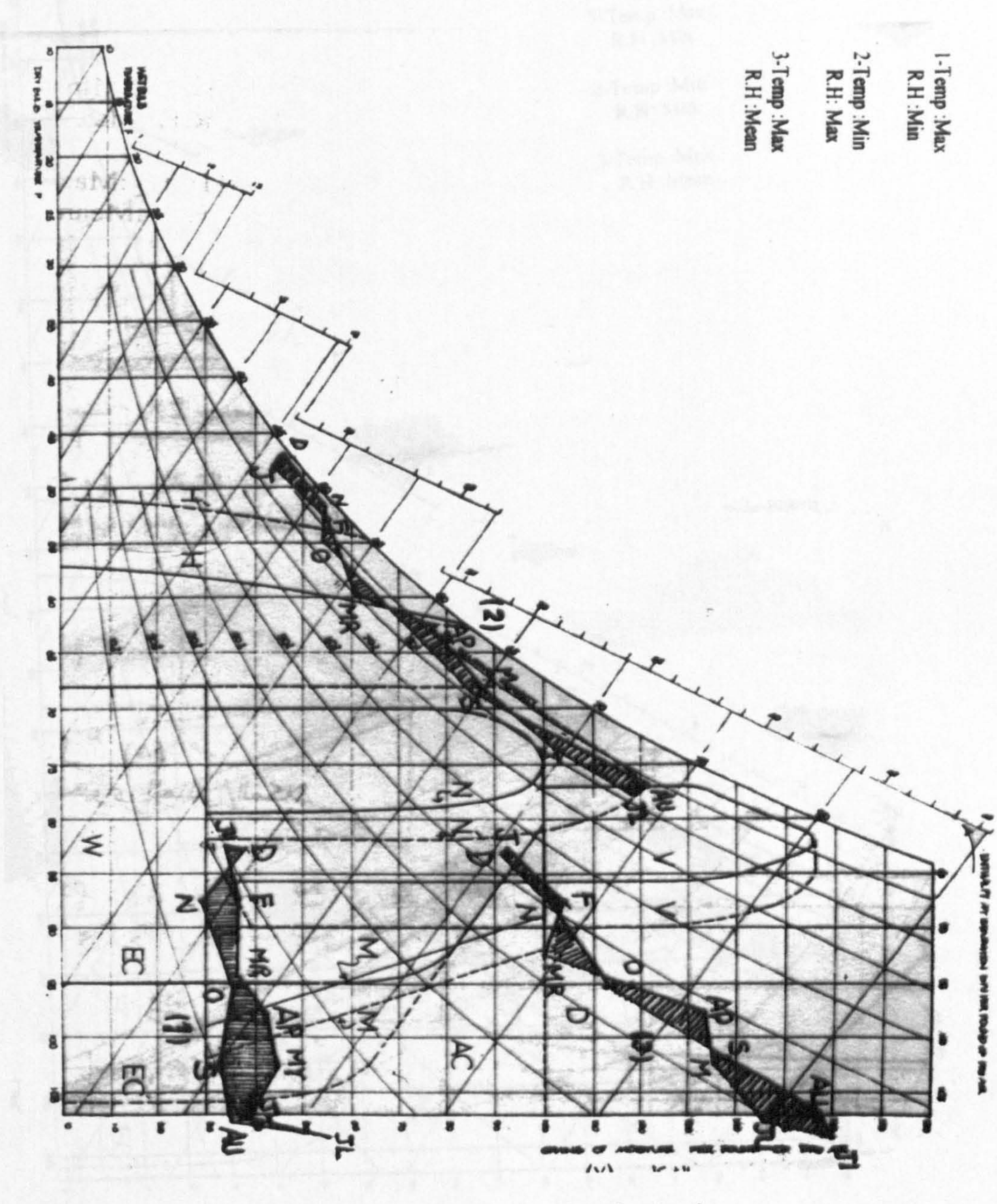

Figure 4-7: The building bioclimatic chart for the hot dry region
(Source Shaban 2000)

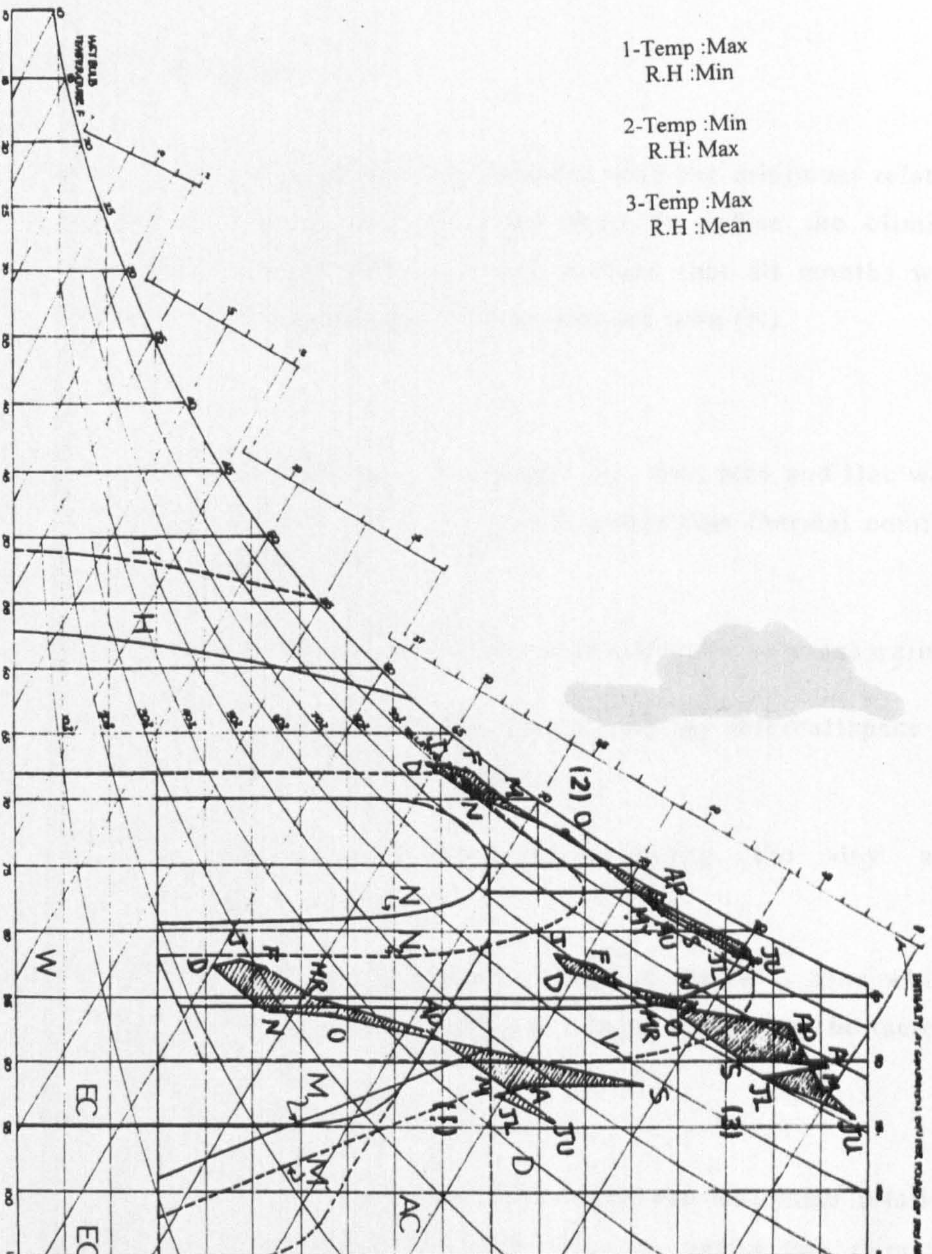

Figure 4-8: The building bioclimatic chart for the hot and humid region.
(Source Shaban 2000)

From Figures (4-7 and 4-8) he concluded from his study the following:

- Hot Dry Region

1. When the maximum air temperatures with the minimum relative humidity were plotted onto the chart to define the climatic situation in the afternoon it was noticed that all months were found outside the natural thermal comfort zone (N).

   I. Months Jan, Feb, Mar, Apr, May, Sep. Oct, Nov and Dec were found within the (M) zone which means that thermal comfort can be achieved by :

   - The use of heavy construction with reflective external walls.
   - Preventing sunshine from approaching the internal space by using small openings in façade.
   - Preventing natural ventilation during the day and encouraging it at night.

   II. Months Jun, Jul and Aug were found in the (EC) zone which means that evaporation cooling is needed as well as the factors mentioned above.

2. When the minimum air temperature with the maximum relative humidity were plotted onto the chart to define the climatic situation in winter before the sun rise, it was found that months Jan, Feb, Mar, Nov and Dec were found on the edge of the cold zone (H). Thermal comfort can therefore be easily achieved by

utilising insulating construction materials and directing the sun shine into the building.

3. When the maximum air temperature with the mean relative humidity were plotted onto the chamber it was noticed that most of the months was found between the zones (V) and (D) which is expected.

- Hot Humid Region

1. When the maximum air temperatures with the minimum relative humidity were plotted onto the chart to define the climatic situation in the afternoon, it was noticed that all months were found outside the natural thermal comfort zone (N).

   I. Months Jan, Feb, Mar, Apr, Oct, Nov and Dec were found within the (M) zone which means that thermal comfort can be achieved by utilising insulating construction materials with external reflective walls and increasing the natural ventilation.

   II. Months Mar, Jun, Jul, Aug and Sep were found within the zones (D) and (V) which means that thermal comfort could be attained by:

      - The use of light structure with external reflection walls.
      - The use of insulation.
      - The use of openings in façade to encourage natural ventilation.

- In the some months air conditioning could be used for Dehumidification.

2. When the minimum air temperature with the maximum relative humidity were dropped into the chamber to define the climatic situation in winter before the sun rise, it was noticed that all months were found outside the comfort zone which means it is important to enhance the natural ventilation.

4.7 Conclusion

This chapter explored the topic of climate and also touched upon the characteristics of climate in general and the hot dry climate in particular. The topography and climate variation of Yemen were also illustrated. Although the information given in this chapter is general in nature, it provides the basis and direction of achieving an environmentally friendly, economic solution to the problem of human comfort in such a harsh climate.

5. Climatic responsive housing in Yemen

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5.1 Introduction

Contemporary buildings in developing countries are often designed without taking sufficient account of the climate. Factors such as the urban surroundings or site characteristics, orientation and architectural design of the building, choice of building materials, etc. are not given enough importance. Consequently buildings often have a poor indoor climate, which affects comfort, health and energy efficiency in cases of air conditioned buildings.

As living standards rise people want to install cooling and heating equipment to improve thermal comfort. For buildings not adapted to the climate, the amount of energy to run the equipment, and its cost, will be excessively high, and it will have a negative impact on both the environment and the economy. A good or at least acceptable, indoor climate can often be achieved with little or no extra input of energy.

Apart from a general lack of norms and regulations in Yemen one reason why buildings are poorly adapted to the climate in Yemen is lack of knowledge about among architects, planners and engineers. Central concepts such as thermal capacity and thermal insulation are often misunderstood. The knowledge from traditional construction, which was fairly well adapted to the climate, is often lost or difficult to translate to modern techniques and society.

This chapter aims to illustrate the differences between the passive design in traditional and contemporary. It shows how traditional building responds to climate with passive means and on the other hand it shows the lack of passive design in contemporary houses.

5.2 Traditional housing design in Yemen

The Yemeni traditional building materials and techniques were related and categorised to the natural climatic and geographical regions described earlier in chapter two. Building materials and techniques change from region to other according to geography, climate, culture and natural land materials. This variety in building design and materials create the independent characteristics for each region.

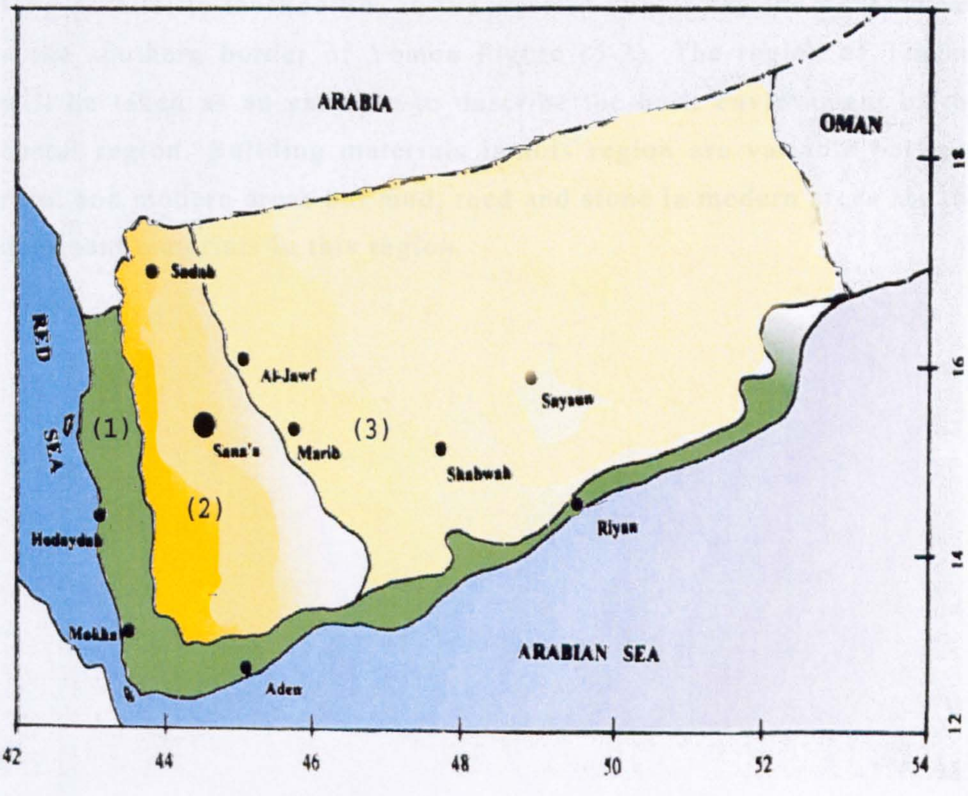


Figure 5-1: Climatic housing map.

According to [Ayssa, 1995] the main environmental building design can be divided into three categories:

1. The coastal region,
2. The mountainous region,
3. The eastern region.

5.2.1 Coastal Region

Height of this area is 1-500 m above sea level and is around 1200 km long parallel to the Red Sea in the western border and the Arabian Sea – the southern border of Yemen Figure (5-2). The region of Tihama will be taken as an example to describe the built environment of the costal region. Building materials in this region are variable between rural and modern areas but mud, reed and stone in modern areas are the dominant materials in this region.

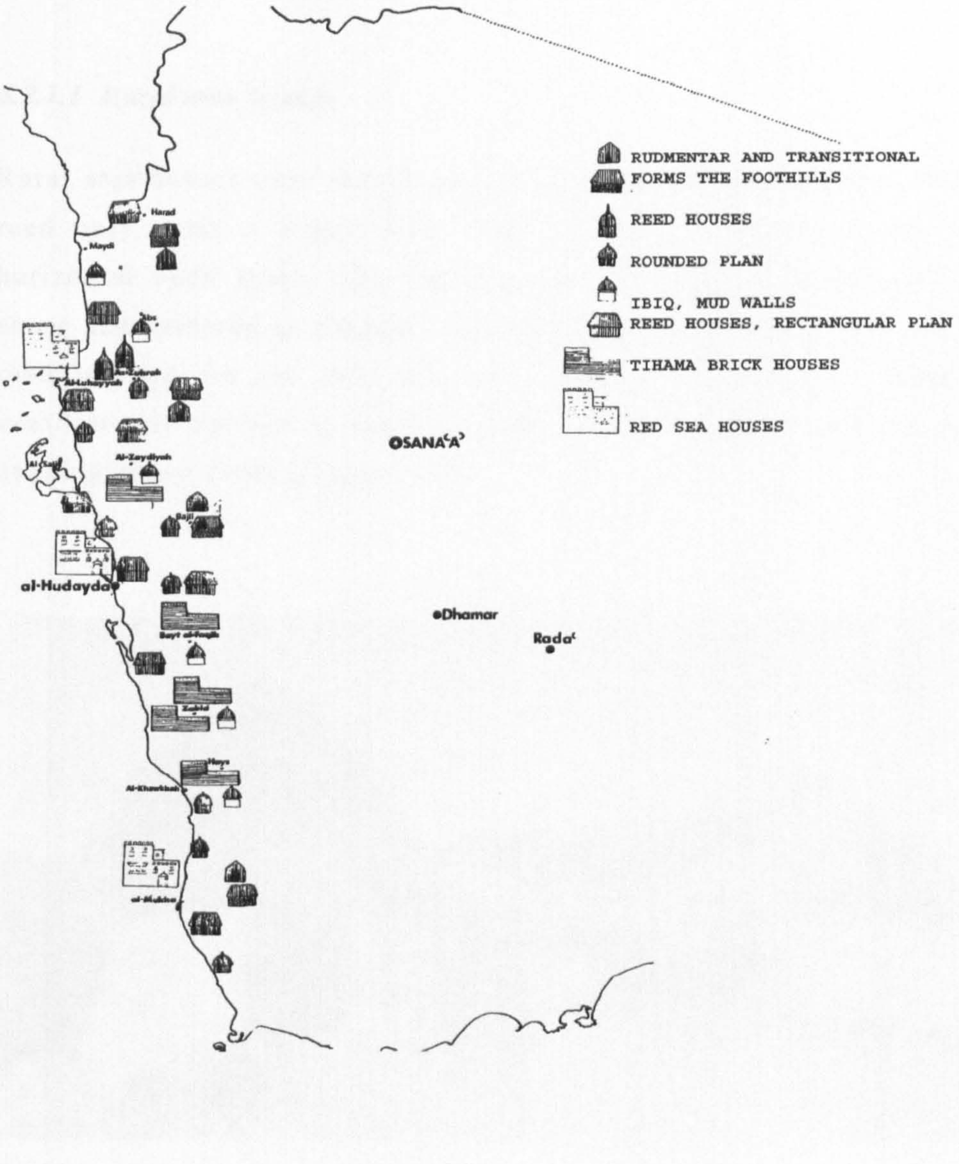


Figure 5-2: Climatic housing map for the costal region.

The primary concern in buildings of this region is fresh air for cooling and ventilating the internal space. Figure (5-2) illustrates the map of building design and materials for Tihama district.

5.2.1.1 Rural area houses

Rural area houses were constructed using a mixture of mud and reed or reed only, with a single floor. The interior design was based on horizontal open space. The buildings are circular or rectangular in shape and gathered as cottages. Building walls are made of mud while reed is used for the roof structure Figure (5-3 and 5-4). Natural ventilation is attained by creating either small openings in mud wall or opening above doors (Figure 5-5).

Figure 5-3: Traditional rural mud house in coastal region

The second type of building in this area is built by using reed for walls and roof Figure (5-6).

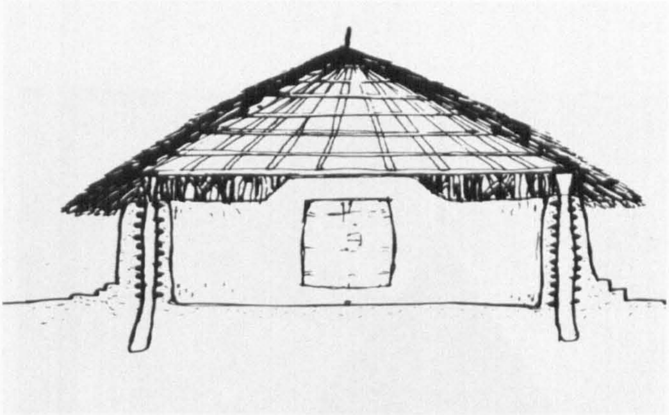


Figure 5-4: Section plan of rural mud house in coastal region

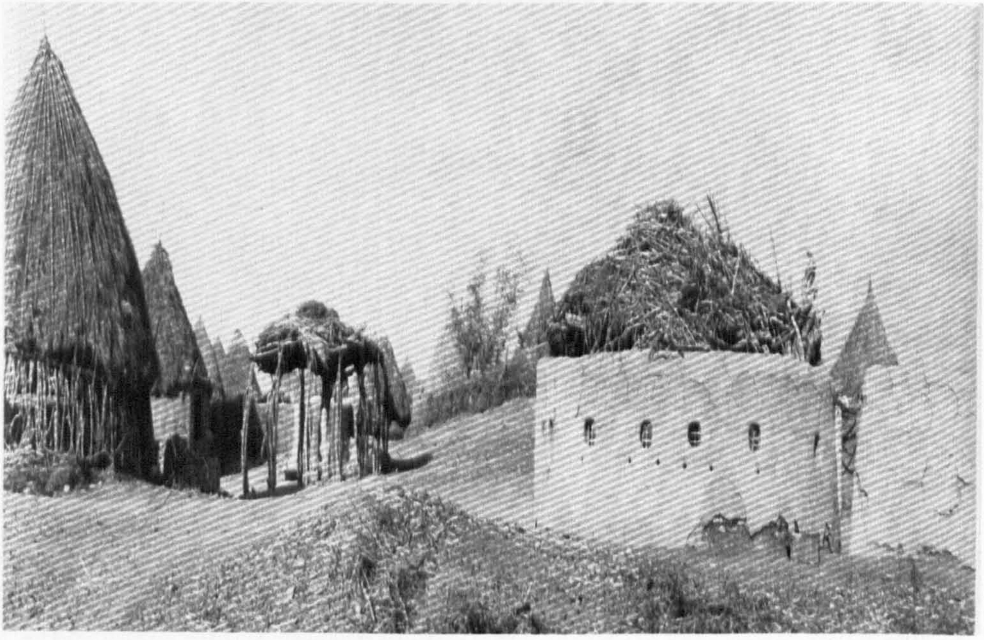


Figure 5-5: small openings in rural mud walls in coastal region

The second type of building in this area is built by using reed for walls and roof Figure (5-6).

Figure 5-6: Traditional reed rural house in coastal region

5.2.1.2 City Houses

Modern area houses were built by using brick. Using brick techniques made it easier to build up to two floors. The interior design was also based on horizontal open space. All spaces were gathered around an interior open space. Openings in the facades were small to minimise heat gain and at high level. Shading devices were also used to reduce heat gain and sun penetration (5-7).

Figure 5-7: Traditional brick city house in coastal region

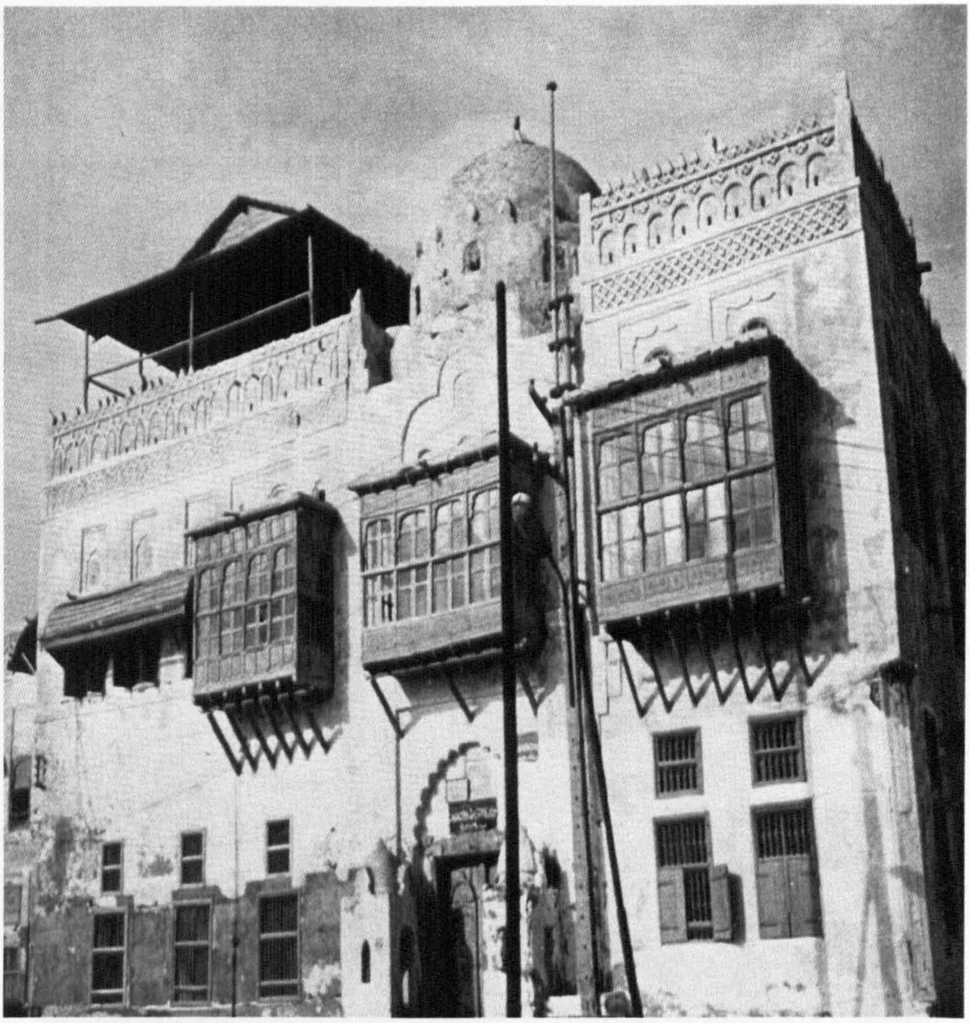


Figure 5-8: Shaded windows and roof in city house in coastal region

The brick houses are usually one storey high; however, houses with two stories may be found in large cities. Roofs in these houses are often used as a sleeping area at night [Ayssa, 1995], and as sitting area during the day time if shaded (Figure 5-8).

5.2.1.3 Modern Houses

High areas were built by using stone and concrete as the available materials. This building material gave the building more strength which enabled them to build up to four floors Figure (5-9).

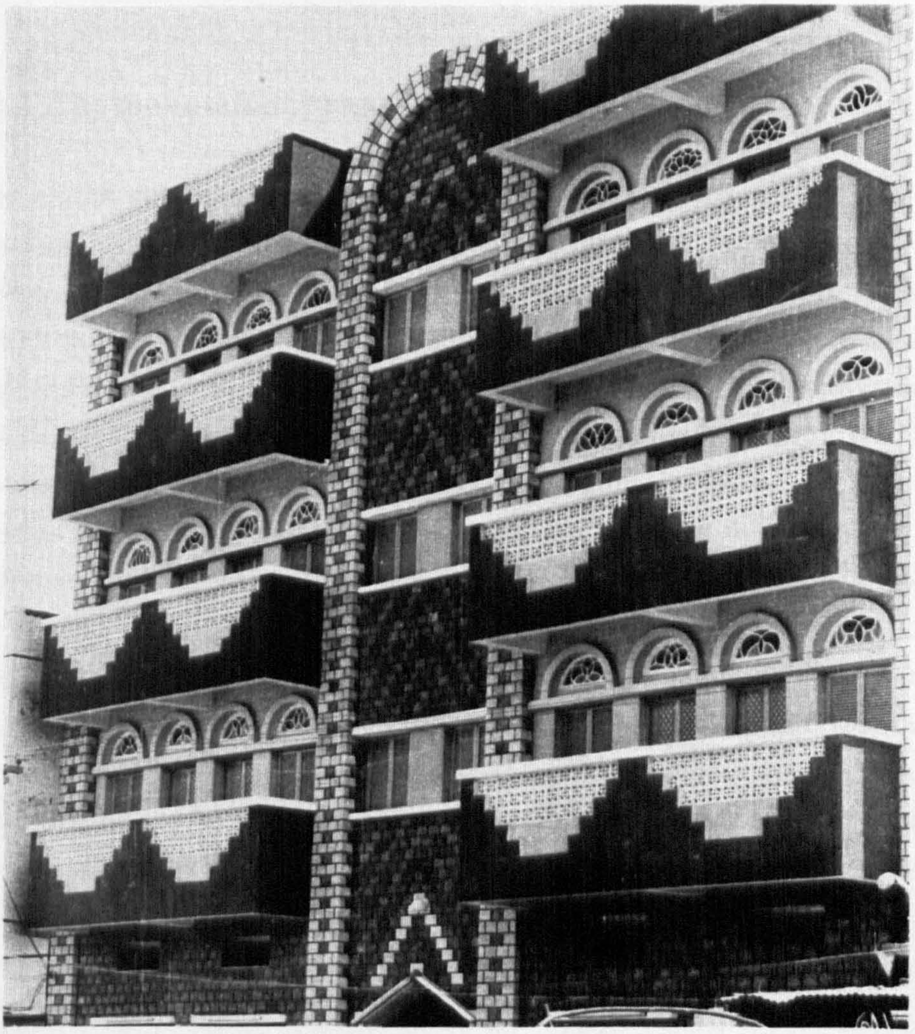


Figure 5-9: Contemporary house in coastal region

The interior design was switched from horizontal to vertical use and from open to closed space. Spaces start to have the own uses, ground floor used for economic storage while living spaces were located on the upper floors. Openings were small to prevent sun penetration and covered by wood to enhance natural ventilation and reduce heat gain through the windows.

5.2.2 The mountainous region

This region consists of the midland and high mountains. The height of this region starts from 1800m above sea level in midland areas to 3660m above sea level in high mountains. Stone and burnt brick architecture is predominant in the midlands and the central spine of the highlands, while pockets of mud or combination of mud and stone architecture occur in the valleys [Varanda, 1981]. Illustration of building material map of the mountain region is shown in Figure (5-10). The building design and function are common in all houses in different districts within this region. The interior function starts from the ground floor and is used for the economical use as the occupant's food stores. Living areas come in the next floors, then sleeping, and quiet areas were allocated on the top floors. Fenestration for this regions building are small in ground floor and become larger in upper floors till be the largest in the top floor (Figure 5-11). Wooden shading devices are used above windows to reduce the both heat gain and luminance through windows. The city of Sana'a (the capital of Yemen) will be taken as an example to illustrate the design elements and building materials.

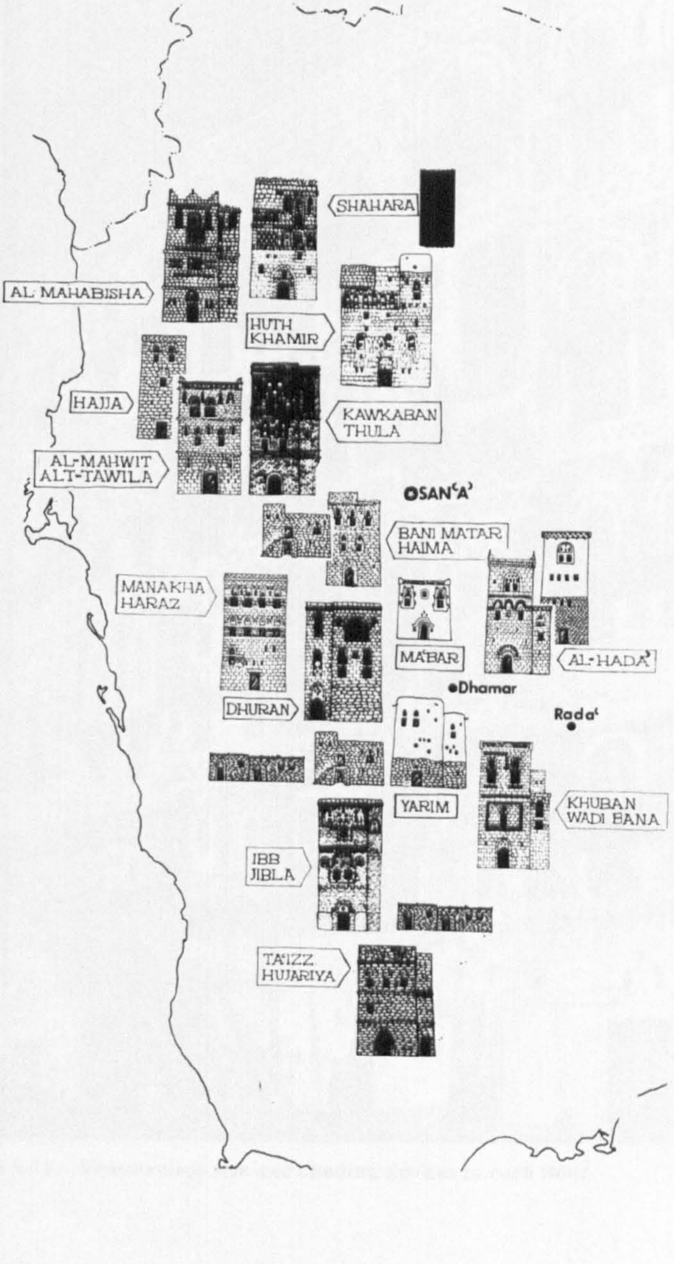


Figure 5-10: Climatic map for the mountainous region.

Figure 5-11: Fenestration size and shading devices in each floor.

The main building type in Sana'a is the tower house. This type of house is up to seven storeys and each storey is identified for specific use. The function of the interior space is divided into three main parts.

First is the storage space which is located on the ground and first floor. Secondly the reception and guests rooms are located on second and third floors, and finally the occupants sleeping rooms are located on the upper floors of the building (Figure 5-12). As shown in Figure (5-11) fenestrations are varied in size depending on floor use and become larger on upper floors. It is also shown from Figure (5-11) that two passive elements are used to reduce heat gain through the windows which are wooden shading devices above windows and wooden external covers.

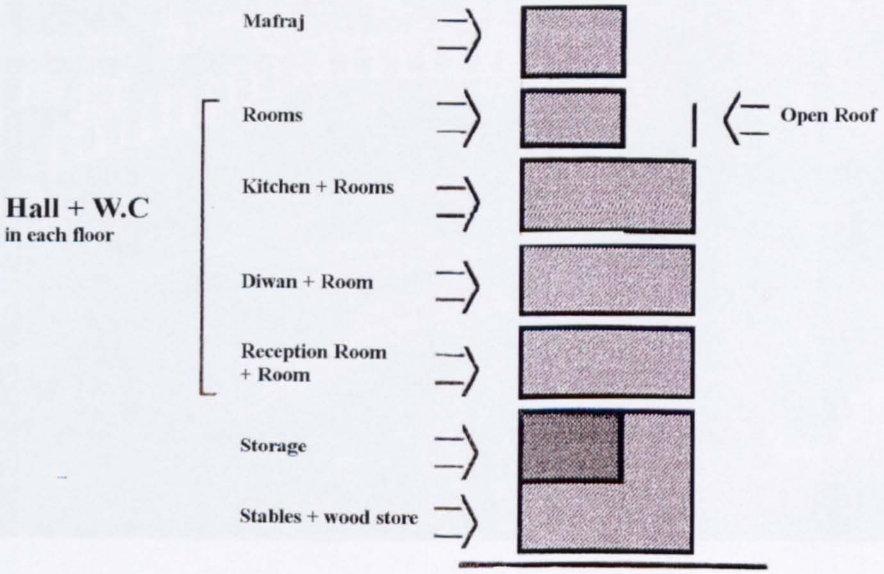


Figure 5-12: A diagram shows the function of the vernacular tower house in Sana'a

The main building materials for the tower houses are stone on the ground and first floors while burnt brick is used to build the upper floors (Figure 5-13). The burnt brick is made from local materials and fired locally. Variation in building construction materials between districts in this region is related to the variation in the local materials for each independent district.

Figure 5-13 Stone used for the ground and first floors while brick for the upper floors.

5.2.3 The eastern region

This region is 1200m above the sea level. In terms of building material, this region is extended from north Yemen Sada'a to the east part of the country Hadramout (area under study). The building map of this region is shown in Figure (5-14) below.

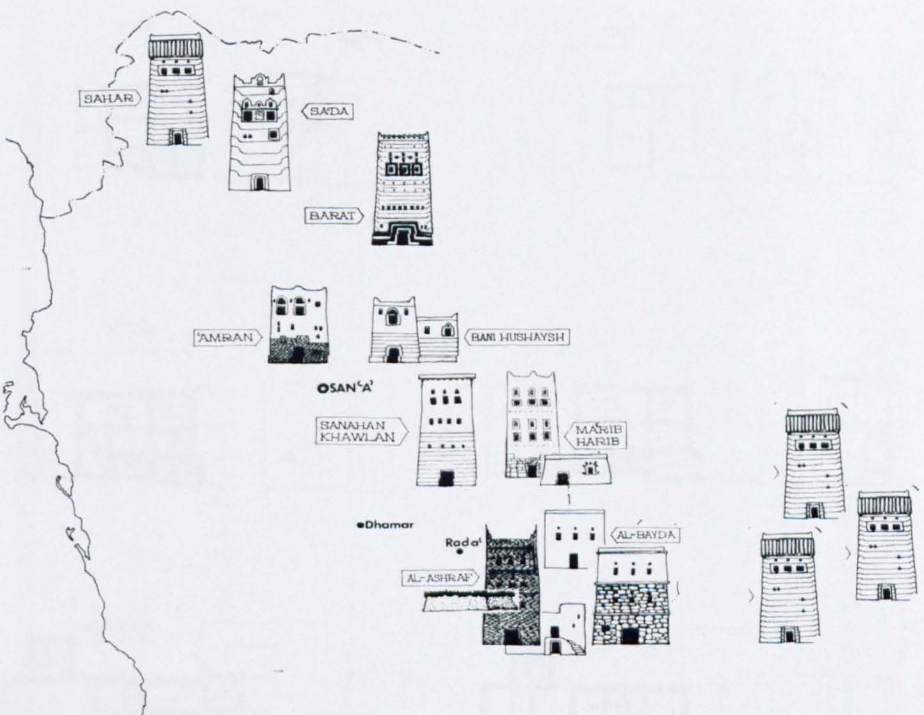


Figure 5-14: Climatic map for the Eastern region.

Building constructed of mud and multi storey houses are common in this region. Two main examples will be presented for this region one from the north part and the other from the south east part of Yemen: houses of Sa'da city and other houses from Hadramout.

Sa'da district lies in the northern part of Yemen. It is considered to be the most important city in the north [Varanda, 1981]. Beside its unique architecture it is situated on the main road to Saudi Arabia. The average number of floors in this type of houses is up to five floors.

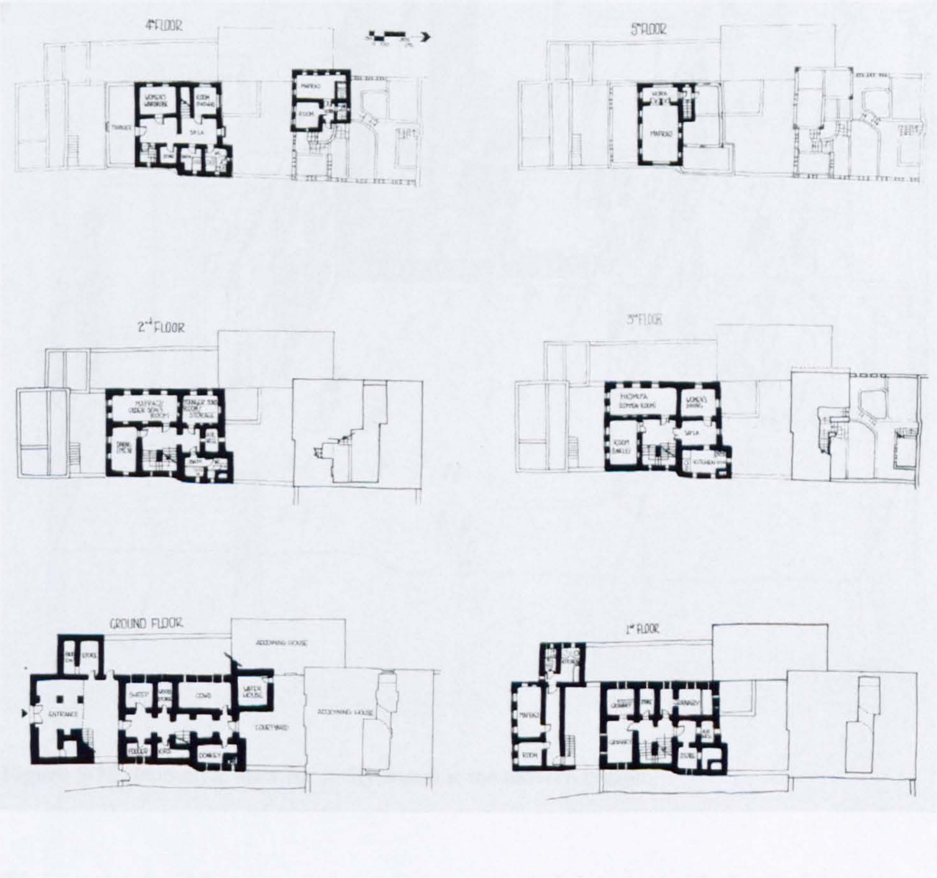


Figure 5-15: plans of a common housing design in eastern region.

The function of the interior spaces of houses in this city is not different from the midland and highland houses. Ground floor is used for storage purposes while the upper floors are used for living and sleeping rooms. Figure (5-15) illustrates plans of a common housing design and Figure (5-16) is an axonometric diagram for the city houses.

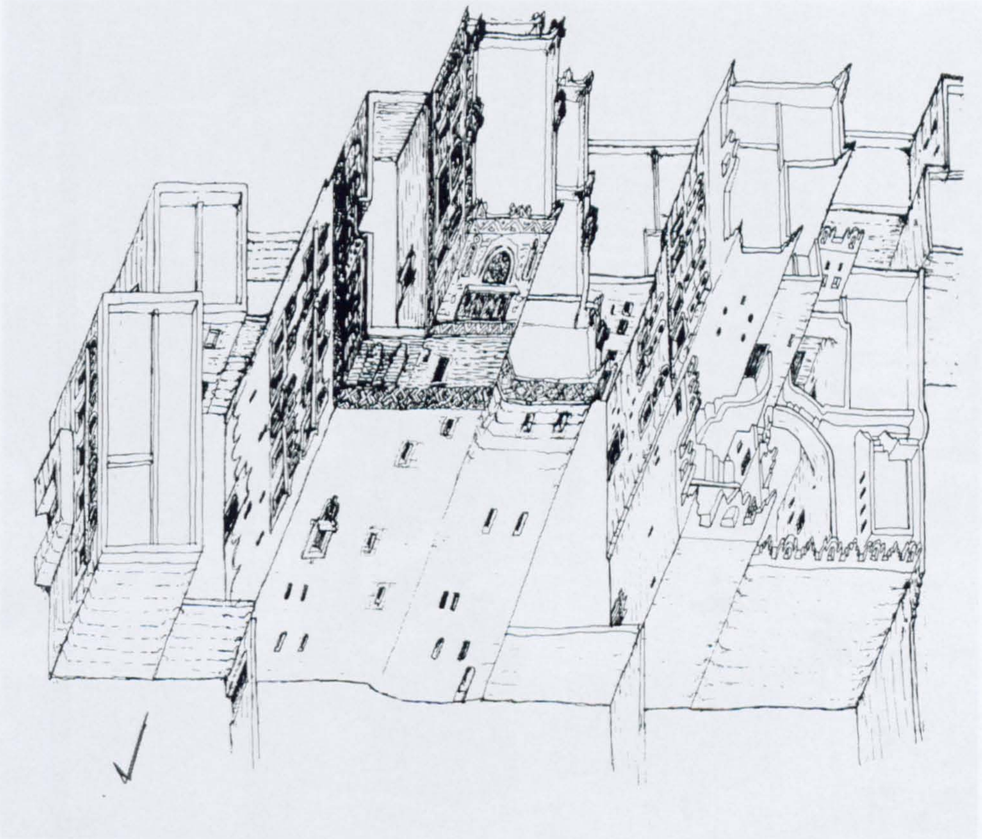


Figure 5-16: Isometric view for a city house n the eastern region.

The main building construction material is mud (Zabur) for all walls. Built of earth, multi storey houses with small openings in lower floors and middle size in upper floors. The external climate affects were taken into account in terms of construction materials, fenestrations and roof. Heavy mass walls, small openings and isolated roof were used to build the houses in this tropical region (Figure 5-17).

Figure 5-17: Traditional Mud houses in Barat

The roof is the main source of heat gain (chapter 2), it is well insulated in the vernacular architecture of this city. The use of a local material called *Nawra* is used to protect the roof from heat gain. Its white colour reduces the absorption of solar radiation (Figure 5-18).

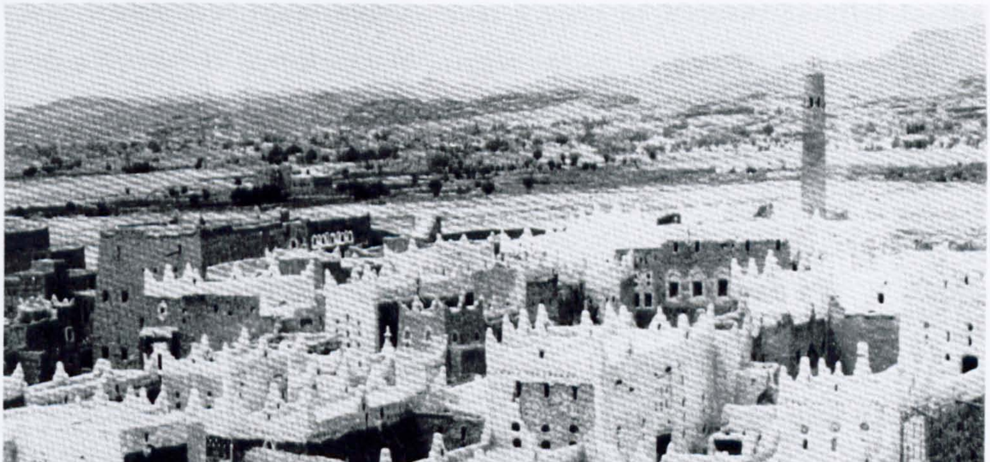


Figure 5-18: white washed roof in traditional houses

5.3 Vernacular and Contemporary Buildings in Wadi Hadramout

This is the region under study and is located within the eastern region as mentioned in section (5.2.3)

Wadi Hadramout runs roughly east – west of Yemen, parallel to the Indian Ocean. It is the second largest valley on the Arabian Peninsula. This region is classified amongst the most important and tangible examples of urban and rural architecture in the Arab world [Alshibami, 1999].

According to Damluji [1992], Wadi Hadramout is unique in three major ways:-

1. Complete towns and quarters, planned and built over a period of 300 years which still exist and are still inhabited.
2. Continuation the use of traditional materials which means that the local building sector still rely on available natural resources.
3. Wadi Hadramout architecture is unique in the manners and degree in which the use of mud brick has been developed as one of the main current material sources.

The building in this region may reach 30m height and rise up to ten storeys. They can also incorporate complex features including vaults, domes and many others reflecting western colonial and neoclassical styles, all built in mud brick [Damluji, 1992].

Currently there are three main entrances along the paved road of Wadi Hadramout which are:

1. Shibam, a walled city entered through a monumental gate (Figure 5-19).

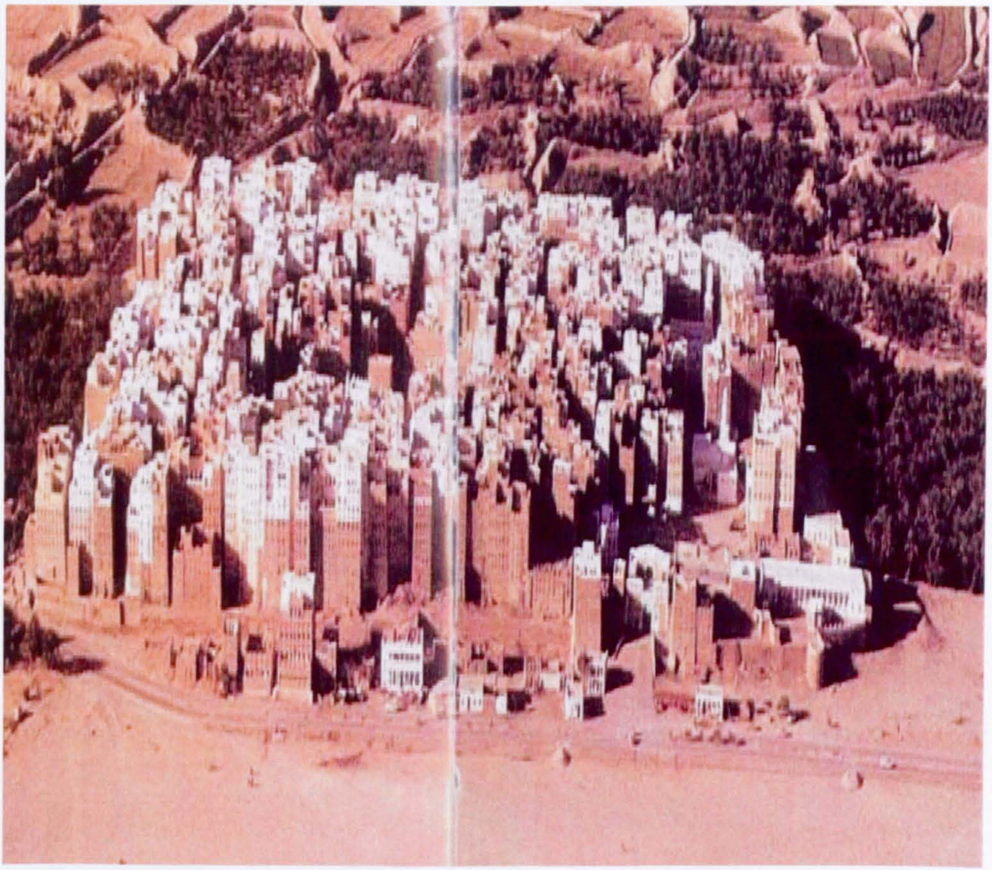


Figure 5-19: View of Shibam Hadramout

2. Seiyun, the provincial capital. This city is the area under study and was chosen due to the variation in building materials from traditional to concrete (Figure 5-20).

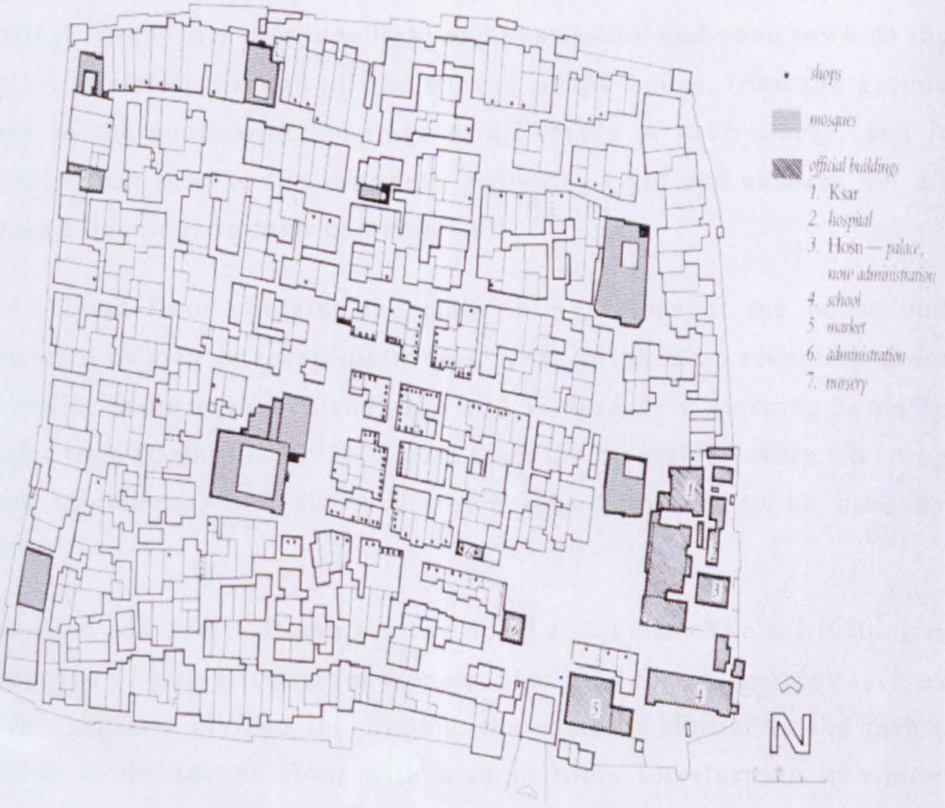
Figure 5-20: Centre of Seiyun

3. Tarim, which is characterized by its eclectic mud palaces (Figure 5-21).

Figure 5-21: Palace in Tarim

5.3.1 Vernacular Houses of Wadi Hadramout

The city of Shibam exhibits the best live expression of traditional houses and building methods in this region [Leslie, 1991]. This city is surrounded with a massive earth wall for security purposes. The multi –storey houses are the dominant building types in Shibam. With their nine or ten stories built of earth they tower over a network of narrow streets (Figure 5-22)



Site plan of the city of Shibam, South Yemen. Indicated on the plan are institutional buildings, commerce, mosques and residences.

Figure 5-22: City plan of Shibam

5.3.1.1 Design concepts of Hadramout houses

The design concept of vernacular houses is varied in each floor (Figure 5-23). The ground floor is composed of the main entrance to the house leading to a long, narrow corridor. Most of the ground and first floors are divided into rooms set aside for storing grains and stalk. In all cases the ground floor contains the main storehouse or used as a shop but never designed for living in. the first floor contains the rest of the store rooms. The ground floor contains one of the most important design elements called (manwar or shamasah) which is a vertical tunnel that provides light and ventilation and open towards the sky. It stretches through all the storeys of the house, from the ground floor to the roof, with openings at all levels of each storey, and is usually built next to the stairwell, providing light and absorbs hot air through openings in their common wall.

The second floor contains the main living rooms of the house and restricted to men as reception rooms. Next to the main reception room a smaller room called (mahdarah) and is used as a sleeping room in winter time [Damluji, 1992]. A part from the reception rooms, sleeping room (mahdarah) and stairway, there is a bathroom to be used by guests.

The third and fourth floors are restricted to women. The third floor is composed of living rooms for women, also used for ceremonies such as weddings. It is divided into rooms, the same or similar to the men's section in the second floor with a small room for sleeping in winter time. This floor also contains the kitchen and toilets. The fourth floor contains sleeping rooms used during summer time.

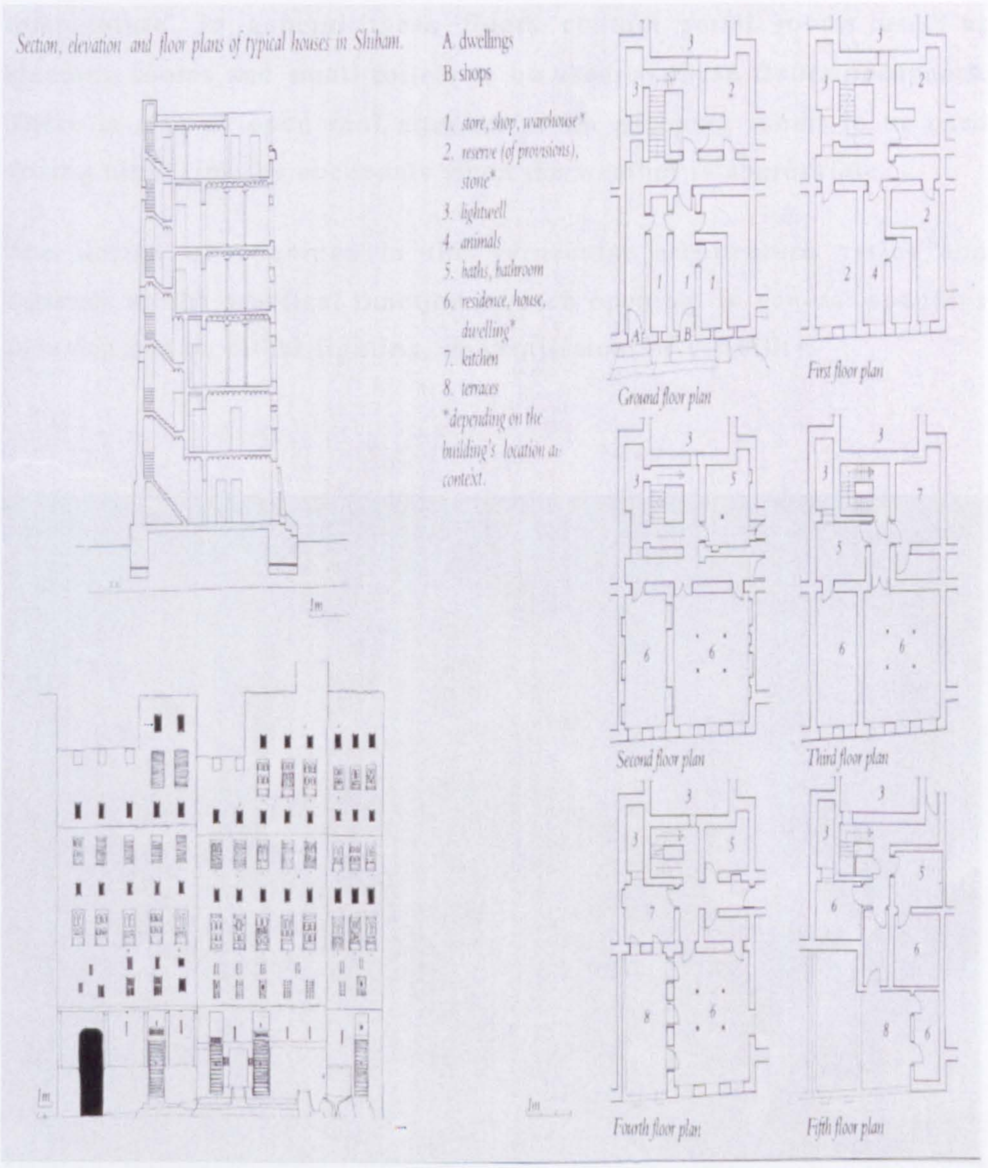


Figure 5-23: Design concepts of a traditional house in Shibam

The fifth floor and above which are upper floors are either allocated to the married children in the house or for the joint use by the whole family during certain seasons, depending on changes in weather and temperature. In general these floors contain small rooms used as sleeping rooms and small toilets to be used by these floors occupants. There is also an open roof attached to the sleeping rooms to be used during night time by occupants when the weather is appropriate.

The design of openings in the vernacular architecture varies and depends on the practical function of each opening. In general openings function can be either lighting, or ventilation, or visibility.

Figure 5-24: Variation opening sizes in traditional house in Seiyun

Also sometimes a combination of the above functions or two of them are required. This in turn means a variety of interior and exterior openings will occur within the same building and the function will determine the form, allocation and dimensions of each window. Figure (5-24) and section plan in Figure (5-23) illustrates the opening design in each floor with in the vernacular houses.

5.3.1.2 Vernacular construction materials

In Wadi Hadramout all vernacular houses are constructed of mud brick. The mud brick in Hadramout is known by local people as (madar) and it is the main material used in construction. It is made of mud extracted from agricultural fields and mixed with local chopped straw to act as a shrinkage compensator and for reinforcement [Hughes, 1983].

Mud brick are made in a wooden frame that varies in size according to the use and location in the building. Initially the wooden frames are wetted, and mud –and- straw mixture is dumped from a wheelbarrow into them. Often, sand or loose soil is sprinkled on the ground first to prevent the raw mud brick from sticking. The mud mixture is normally smoothed in by hand, and the edges are defined with the index finger. The thickness of walls in the ground floor is up to a meter. The thickness of the walls gradually decreases as they rise up the floors of the building, tapering inwards until they reach the roof, where the width of the wall is about 20–30 centimetres.

Figure 5-25: Alkatheri palace in Seiyun

Figure 5-26: Hand mixture of mud

Roofs are flat and vary in thickness depending on location. Intermediate floors are thinner than the top roof. The top roof is constructed in such a way as to minimise hear gain and is perhaps the most important element in the building.

Figure 5-27: Internal view of a traditional roof

The top roof construction is:

- Timber joists made from date palm trees.
- Mud bricks are broken and placed over the joists.
- Soil is faced over the bricks.
- 2 coats of mud plasters.
- 2 coats of lime (Nawra) plasters.

The roof takes three months to dry and after the last coat of lime is applied it is polished and white washed. An internal isometric view of a typical roof in vernacular of Wadi Hadramout houses is shown in Figure (5-27) and a roof section of vernacular hoses in Sana'a is shown in Figure (5-28).

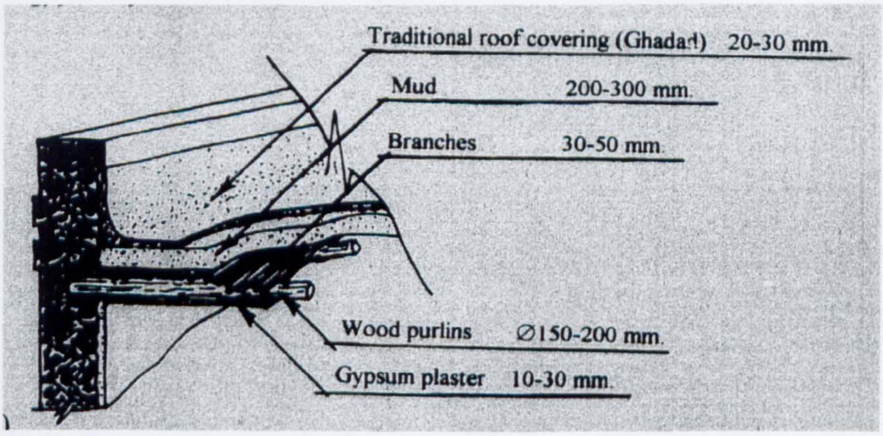


Figure 5-28: Section plan of a traditional roof

5.3.2 Contemporary Buildings in Wadi Hadramout

5.3.2.1 Background and Design Concept

The 1990 reunification of Yemen has resulted in a building boom. Immigrants returning from Gulf States have brought with them different aesthetic concepts, along with concrete construction [Jermoe, Chiari and Borelli, 1999]. Concrete has been used mainly along the paved road. This brought an idea that a change in attitude has meant a change in building typology.

For example, in the city of Seiyun, the monumental palace is gradually being surrounded by concrete buildings (Figure 5-29).

Figure 5-29: Contemporary houses in Seiyun

In the new modern part of the city of Seiyun, as it is found in all cities in Yemen, there are two types of contemporary buildings. First is a residential building which can be divided into two types, multi storey contain flats and detached house which is the most preferable due to its privacy. The detached house is more likely to be built as one or two floors. The second type of contemporary buildings are commercial buildings such as shops, motels.

In single floor houses all occupancy zones are on the ground floor. In two floor houses the most private rooms are usually on the second floor while the ground floor is used for services, day activities and family gatherings. In most contemporary houses (single and two floors) a private garden surrounded by wall is mostly important to provide privacy and as a children playground.

5.3.2.2 Contemporary Construction Materials

As a result of the new building typology, the use of reinforced concrete frames and cement blocks for housing in this region and other cities on coastal ,high land and lowland regions [Bonnenfant 1981]. All concrete techniques are the same in all regions without any concerns to the climatic characteristics of individual regions. The negligence of passive design to reduce the sun penetration such as the ignorance of orientation and wider openings without shading make the situation even worse.

Contemporary houses are commonly built by the mean of using reinforced concrete frame constructions with concrete block walls. These materials are mostly imported and less reliable quality than traditional materials [Miles, 1984] [Al-ttar, 1983]. In addition, traditional builders generally admit the poor performance of houses that were built by reinforced concrete frame and concrete blocks walls compared with houses built by traditional materials [Leslie, 1991] [Matthews, 1980].

Walls are built either by using concrete block or stone in most of new houses. They are generally plastered and painted from both external and internal faces. People began to compare both traditional and concrete houses and realised the advantage of traditional materials. Massive mud walls have the advantage of more insulation and heat storage.

Roofs are still the same as being flat roofs. The roof materials have changed as the wall materials changed. In modern houses, roof mainly consists of:

1. Reinforced concrete
2. Water proofing
3. Mortar
4. Cement tiles

Layers in order of a recommended concrete roof are shown in Figure (5-30) below. In some cases the last three layers shown in the Figure (5-30) are often ignored which cause an extra leakage in thermal performance [Ayssa, 1995].

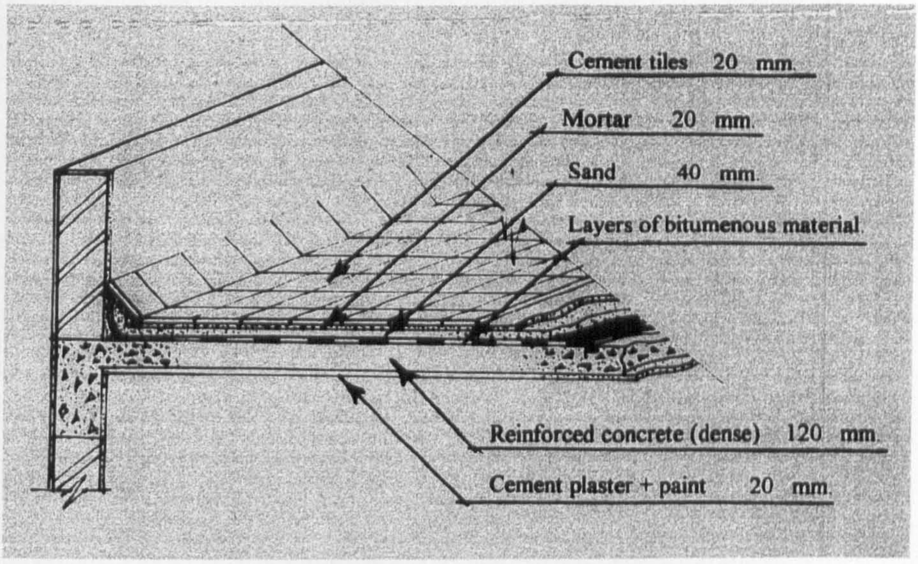


Figure 5-30: Section plan of contemporary roof

5.4 Conclusion

This chapter in general reviewed the climatic responsive housing in different climatic regions of Yemen, particularly in the region of Wadi Hadramout (area under study). Passive design techniques used in traditional houses in different climatic regions were discussed while the lacks of using passive design techniques in contemporary houses were also illustrated.

Part Three

Field Study, Climatic analysis and Thermal Modelling.

6. Research Methodology

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6.1 Introduction

This chapter illustrates the methodology and implementation plan utilised in carrying out this research. The first part describes the research case studies in terms of location, difficulties and solutions. The second part describes the field study process and the outcome expected from the field study. The last part of this chapter will describe the thermal modelling tool, expected outcome, limitation and solutions of the modelling tool limitations.

6.2 Case Studies location

One of the most paramount and critical criteria in carrying out a successful environmentally based research program is the correct selection of the location of any required field studies. According to Cena [1994] it was more difficult to organise an extensive study in private homes than in work places. This was due to the natural reservation of the occupants to have any intrusion into their private lives especially in countries with a religiously influenced culture such as that in Yemen. However, information about comfort conditions in houses is very important, not only in terms of energy conservation but also in terms of occupant satisfaction [Heidari, 2000].

The chosen city for this study is Seiyun. It is located in the east part of Yemen on latitude 15^0 56` N and 48$^0$ 47` E. It lies at 941 meters above sea level and is the capital of one of the most historical valleys in the country, the valley of Wadi Hadramout. It is also located between the two historical cities of Shibam and Tarim, giving it an important standing in the Hadramout valley. Seiyun is found in the hot semi arid region of Yemen therefore its climatic classification is a hot and dry climate.

As stated it is situated in the hot dry region where the air temperature is extremely hot in summer. This city was chosen due to its historical and social importance in the development of the area. Many Yemeni immigrants in the surrounding countries, especially in Saudi Arabia, are from this region. As such, there is a significant number of both residential and commercial construction projects which would benefit from advanced techniques and construction materials (both local and imported) aimed at optimising the thermal comfort of occupants in an efficient and economical manner. Utilising building construction systems based on a hybrid mixture of both traditional and modern material resources such as mud, stone or cement will provide suitable options which will allow this goal to be achieved.

With this in mind a major objective of this study is to compare the internal air temperature in different domestic buildings having different construction systems. There were difficulties in sourcing buildings of similar internal design and size which used either traditional mud or modern concrete building materials for comparison. It was finally decided to choose a 2 storey old style traditionally ventilated mud, a newly built mud single story building using both traditional and modern ventilation techniques and a single story concrete building using both traditional and modern ventilation techniques, all in relatively close local of each other within the city of Seiyun and of similar floor plan size.

All houses used in this case study were occupied family residential houses.

6.3 Methodology

The methodology of this work is divided into three main parts:

1. A Metrological Analysis of the Seiyun Area
2. The Field study
3. Detailed Thermal Modelling

The Flowchart shown in Figure (6-1) below illustrates the plan of the methodology.

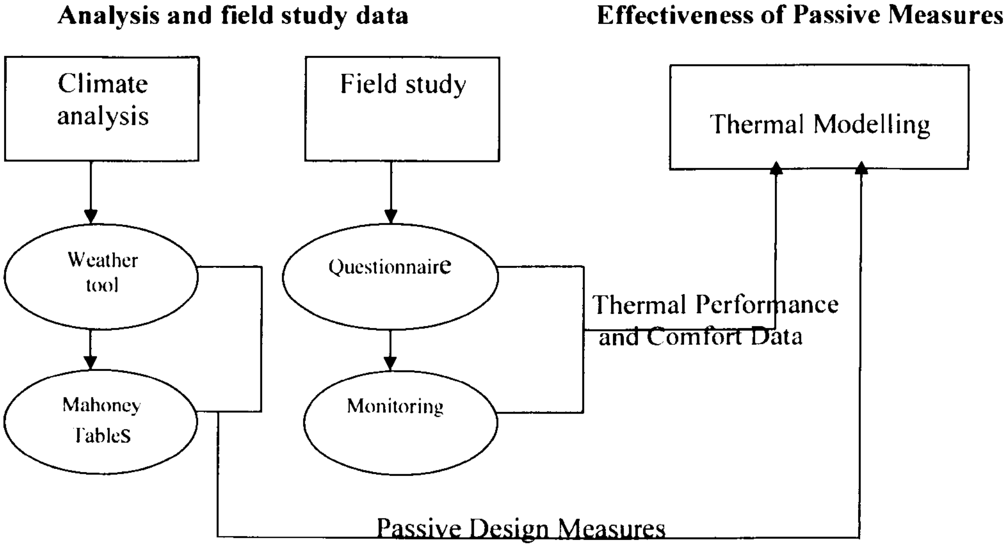

Figure 6-1: Methodology plan.

An examination of Figure (6-1) indicates that results obtained from the climate analysis will help ascertain possible passive design techniques which will be relevant to the climatic region under study. Also the results obtained from the field study will indicate the target buildings thermal performance and the ensuing human comfort in buildings of different construction materials and techniques. Both results will then accumulate as the raw data to be used in the thermal modelling.

6.3.1 Field Study Methodology

According to Nicole [1993], a key component of a field study is the methodology used for the survey. He adds that the first thing for anyone contemplating conducting a field study is to have a clear idea of what it is he/she wants to measure and how he/she intends to measure it. A major objective of this field survey is to establish a basis for determining what thermally comfortable conditions are in relation to the daily lives of the people of Seiyun.

This study was divided into two parts. The first used a questionnaire distributed at a random basis and another questionnaire targeted at the occupants of the measured case studies. The second was the monitoring of the target case studies. This method is based on the observations in the actual environments and simultaneously collects the subjective comfort responses of the respondents from the surveyed questionnaires.

6.3.1.1 Questionnaire

The questionnaire was conducted during two summer days, the first at the peak of summer of the year 2000 (20th of August) and the second at the end of the summer of the same year (11th of September). Also it took place on two days during the winter of the year 2001, the first was at the beginning of the winter (14th of January) while the second was at the end of winter (14th of February). A questionnaire was distributed at random to more than 300 houses in different categories of the society. In addition to the personal information and building specifications, the questionnaire included questions relating to thermal comfort. They were in order of thermal sensation and preferences (copy of the survey form in English and Arabic is given in Appendix A).

6.3.1.1.1 Aim of the Questionnaire

The main aim of the questionnaire is to obtain a basis regarding an occupant's satisfaction or dissatisfaction about their internal environment in different types of building constructions. Also it will document the occupant's internal environmental preferences. It is hoped that results of the questionnaire will define a typical inhabitants comfort and preferences which will then be utilised to formulate the target thermal comfort level.

6.3.1.1.2 Questionnaire Respondents

The total number of respondents who took part in this survey were 342 subjects all of whom were male as shown in table (6-1).

From table (6-1) it is clear that there were 190 participants in the winter season and 152 participants in the summer season. These participants are categorised into three groups: the first group are people who live in traditional houses; the second group are people who live in new mud houses while the third group are people who live in concrete houses.

	Winter	Summer
Traditional	75	52
New Mud	92	76
New Concrete	23	24
Total	**190**	**152**

Table 6-1: Amount respondents in each building structure

Residents of traditional houses: 127 subjects (75 in winter season and 52 in summer season).

Residents of new mud houses: 168 subjects (92 in winter season and 76 in summer season).

Residents of concrete houses: 47 subjects (23 in winter season and 24 in summer season).

6.3.1.1.3 Use of Building Services

As with the thermal survey questionnaire, another questionnaire was conducted for case studies occupants. All questions were translated and distributed in Arabic and it was explained to the respondents not to forget to mention the building type in terms of construction. All questions required the respondents to tick the appropriate choice (copy of the survey form in English and Arabic is given in Appendix A).

This questionnaire included questions about whether any electrical air conditioning equipment was installed in the building (Fans, heaters and Air conditioners) and how many hours they were used to cool/heat the building. Each sheet was used for a whole week and participants were instructed to fill out the form during the measurements period

6.3.1.1.4 Output scale

For the determination of the perceived thermal sensation the Seven point ASHRAE scale was used as this is generally regarded as being the most appropriate.

-3	-2	-1	0	1	2	3
cold	cool	Slightly cool	Normal	Slightly worm	Worm	hot

Table 6-2: Seven point ASHRAE scale

For the thermal preferences vote the three point McIntyre scale was used. This gave an indication as to whether the occupants prefer the room to be warmer or cooler.

-1	0	1
Cooler	No change	Warmer

Table 6-3: three point McIntyre scale

6.3.1.2 Onsite Monitoring

The method used to gather the relevant information required for the monitoring section of this study was to use measurement equipment to record the internal temperature within the three case studies at the same time for a fixed length of time during the period under investigation. Then the recorded data was compared and discussed. Measurements were conducted during the winter and summer seasons. The first period being the 13th of January to 16th of February 2001 and the second being the 20th of June to the 20th of August 2001 respectively. The measurements were taken in the reception room for all case studies (used as a sitting room when there are no guests)

6.3.1.2.1 Aim of the Monitoring

As stated the main objective of this form of monitoring was to establish a database of readings about the internal temperature in all case studies which could be used as the source data for the thermal modelling. Theses readings hopefully provide this study with information of how buildings constructed of different materials respond differently to changes in the climate and to examine the effect of building materials on human comfort.

6.3.1.2.2 Equipment

The main piece of equipment used in this survey was a data logger that recorded the internal air temperature in the relevant case studies areas. Due to cultural restrictions of the occupants it was important to choose a data logger that could be easily and quickly set up for a period of time, be as non-intrusive as possible and accurately and reliably store the data for the duration of the study Figure (6-2).

Figure 6-2: Data logger (HOBO)

This equipment was set up to record the internal air temperature every one hour for 30 days and download the stored material to a laptop computer for analysis. One data logger was set-up in each of the case study building and left for the required duration.

6.3.1.2.3 Output of the monitoring

The outcome of monitoring the temperature in each case study building resulted in a database of temperature readings recorded by the data logger (HOBO) which was, at the end of the monitoring period, downloaded to computer and analysed. The data and the comparison between the three target case studies will be discussed in chapter eight.

6.3.2 Thermal modelling methodology

It was not feasible to monitor the case studies for the whole year, thus monitoring was carried out during four months only. Accordingly computer thermal modelling was used to simulate the internal temperatures inside the case studies for the whole year. More importantly, this allowed investigating the effectiveness of the proposed passive measures.

Initially, twenty three proposed environmental modifying measures described in chapter nine and base data were introduced into the Ecotect one at a time The impact of each measure on the internal environment was modelled. Ecotect produces the results by first determining the hourly internal dry resultant temperature (IDRT) in each individual zone using the admittance method Analysing the climatic data for each month and applying the adaptive algorithms of

Humphreys (chapter 3) to determine the upper and lower comfort temperatures. Both the free running and the air conditioned cases can be modelled.

Secondly, five of the most carefully chosen successful recommended combinations were earmarked from among all the suggested measures (more details in part 9.2.2)and each recommended combination was also modelled and tested and compared with the baseline case building.

The final stage was to obtain heating, cooling and total spaces loads on the occupied zones of the building (kWh). The admittance method is also used to calculate the cooling and heating loads in each zone. These calculations depend on whether the building is air conditioned or free running and by integrating the hours spent under the lower comfort limit the coldest degree hours and/or the heating loads can then be determined. It also integrates the hours spent over the upper limit to calculate the hottest degree and/or the cooling loads.

Results will be shown in the six zones (more details in part 9.2.1). Equinox dates were chosen to display the results. Table (6-4) illustrates the dates chosen to represent the modelling results.

Vernal Equinox	19th of March
Summer Solstice	21st of June
Autumnal Solstice	23rd of September
Winter Solstice	22nd of December

Table 6-4: chosen dates to present the results.

Results obtained from thermal simulation will be analysed using both methods, graphically and statistically. The graphical analysis will illustrate the distance between the internal dry resultant temperature (IDRT) in each case and the comfort band. The statistical analysis will suggest the significance of the spotted differences.

6.3.2.1 Thermal modelling tools

Reviewing energy simulation tools available in the market revealed 89 tools including; Building Energy Analyzer, BV2, COMFIE, DEROB-LTH, HOT 2 XP and SolArch. From this vast number of tools several key tools were identified:

1. ESP-r[1]

ESP-r is a general purpose simulation environment which supports an in-depth appraisal of the factors which influence the energy and environmental performance of buildings. It has the objective of simulating building performance in a manner that:

a) is realistic and adheres closely to actual physical systems,

b) Supports early-through-detailed design stage appraisals, and

c) Enables integrated performance assessments in which no single issue is unduly prominent.

Using the ESP-r the building geometry can be defined either using CAD tools or in-built facilities. This simulation tool is compatible

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[1] www.esru.strath.ac.uk/Programs/ESP-r.htm

with the AutoCAD and ECOTECT which can be used to create a building representation of arbitrary complexity. Models can be exported to other assessments tools such as TSB13 and Radiance. Constructional and operational attribution is achieved by selecting products and entities from the support databases and associating these with the surfaces and spaces comprising the problem. Models can be further attributed to account for temporal shading and insulation patterns, explicit radiation view factors, facade-integrated photovoltaic modules, temperature dependent thermo physical properties and CFD domains. As required, component networks can be defined to represent, for example, HVAC systems, distributed fluid flow (for the building-side air or plant-side working fluids) and electrical distribution systems.

ESP-r is a simple models and operating regimes composed in a few minutes can be extended, in steps, to encompass the simultaneous solution of fabric (1/2/3D), air flow (network and/or coupled, transient CFD), electrical power, embedded renewable, plant system components, indoor air quality and lighting assessments via Radiance. Building and flow simulations can be undertaken at frequencies of one minute to one hour and system simulations can be from fractions of a second to an hour.

ESP-r is flexible and powerful enough to simulate many innovative or leading edge technologies including daylight utilisation, natural ventilation, combined heat and electrical power generation and photovoltaic facades, CFD, multi-griddling, and control systems. An active user community and mailing list ensures a quick response to technical issues.

As ESP-r is a general purpose tool and the extent of the options and level of detail slows the learning process. Specialist features require knowledge of the particular subject. Although robust and used for consulting by some groups, ESP-r still shows its research roots.

2. HTB2[2]

HTB2 is a software suite intended for the general purpose simulation of the energy and environmental performance of buildings. It is suitable for use within research, teaching and design environments. Based on a simple Finite Difference Heat transport model, it incorporates sub-models for;

- Fabric heat transport and thermal storage
- Internal and external thermal radiation exchange
- Glazing heat transport, solar energy gains, and shading devices
- The transfer of heat and moisture by ventilation and infiltration
- Heating and cooling plant and controls characteristics
- Incidental internal heat sources
- Occupant control and intervention.

HTB2 is user unfriendly and the input is not 3D which make it more difficult to use than the graphical interface.

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[2] www.cf.ac.uk/archi/research/envlab/htb2_1.html

3. Energy Plus[3]

Energy Plus is a new generation building energy simulation program that builds on the most popular features and capabilities of BLAST and DOE-2. EnergyPlus includes innovative simulation capabilities including time steps of less than an hour, modular systems simulation modules that are integrated with a heat balance-based zone simulation and input and output data structures tailored to facilitate third party interface development. Other planned simulation capabilities include multi zone airflow, and electric power simulation including fuel cells and other distributed energy systems.

EnergyPlus uses a simple ASCII input file. Private interface developers are already developing more targeted / domain specific user-friendly interfaces.

Energy Plus is Accurate and detailed simulation capabilities through complex modelling capabilities. Input is geared to the 'object' model way of thinking. It is a successful interfacing using IFC standard architectural model available for obtaining geometry from CAD programs. Extensive testing (comparing to available test suites) is completed for each version and results are available on the web site.

It is user unfriendly as the input is not 3D which may make it more difficult to use than the graphical interface.

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[3] www.eere.energy.gov/buildings/energyplus

4. Ecotect[4]

Complete environmental design tool which couples an intuitive 3D modelling interface with extensive solar, thermal, lighting, acoustic and cost analysis functions. ECOTECT is one of the few tools in which performance analysis is simple, accurate and most importantly, visually responsive.

ECOTECT is driven by the concept that environmental design principles are most effectively addressed during the conceptual stages of design. The software responds to this by providing essential visual and analytical feedback from even the simplest sketch model, progressively guiding the design process as more detailed information becomes available. The model is completely scalable, handling simple shading models to full-scale cityscapes. Its extensive export facilities also make final design validation much simpler by interfacing with Radiance, EnergyPlus and many other focused analysis tools.

This work utilized ECOECT[5] as the main tool for modelling and thermal simulation. ECOTECT was written by Dr. Andrew March of Square One Research LTD[6]. There are two methods that can be used to calculate internal temperatures inside any space; steady state or dynamic state method. The second gives the swing in temperature through the examined period rather than a single time only, thus taking into consideration the effect of thermal mass [Gado, 2001]. The admittance method (more details in part 6.3.2.4.1) is one of the methods that utilise this concept. ECOTECT has a wide range of features. It includes thermal modelling, which is based on the admittance method. It is different from other thermal modelling

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[4] www.ecotect.com

[5] www.ecotect.com

[6] www.squ1.com

software as it deals with a 3-D model rather than a tabulated or un-friendly user interface. It includes many features that contribute to the accuracy of the modelling such as, for example, the intern-zone adjacency test which highlights any mistakes made through the drawing of the model. It also "allows the definition of all types of elements as on or off, open or closed etc. The resulting thermal analysis using appropriate scheduling takes into account how spaces are used, as well as the use of appliances and equipment within the space" and whether it is naturally or mechanically ventilated.

6.3.2.2 Limitations

The limitations of Ecotect lie in the inherited limitations of the admittance method [Ecotect help file]. It is known that this method is a pseudo-dynamic method only since it is based on a variation about a mean value. The second limitation is that the method does not trace solar radiation once it enters the building space [Gado, 2001].

6.3.2.3 Checking the thermal modelling tool

It was important at this stage to examine the accuracy of Ecotect results. There is no literature that investigated the accuracy of using ECOTECT as a thermal modelling tool. In this work two methods were used to validate Ecotect.

1. Validate the results of the thermal modelling with validated software.

2. Second, make a comparison of the calculated energy load of the concrete case study in field study chapter with the energy load calculated by the thermal modelling tool for the same period of time.

6.3.2.4 Outcome of thermal modelling

6.3.2.4.1 Internal temperature calculation

The air temperature is the most important affecting factor that influences human thermal comfort. Thus, it is used as the testing parameter. Two methods (steady state and dynamic state) were used to calculate internal temperature inside any built space. The more appropriate method to use is the dynamic state since it gives the swing in temperature through the examined period rather than a single time only, thus taking into consideration the effect of thermal mass [Gado, 2001]. The admittance method is one of the methods that utilise this concept, which in turn is the method implemented in ECOTECT.

It is important to note that internal zone temperatures displayed in ECOTECT are not straight air temperatures. They are known as the 'dry resultant temperature' which, "*is the temperature registered by a thermometer at the centre of an externally blackened sphere 150 mm diameter, being a function of air temperature, mean radiant temperatures and wind velocity. It is used as an index temperature for comfort where the air velocities are low*" CIBSE Guide A

Even though the air temperatures may be low, the wall surface temperatures may be high, so the resultant value will be somewhere in between. Whilst it is possible to derive straight air temperatures, the dry resultant is a much more relevant indicator of thermal sensation within a space so it is definitely the most significant value to display.

6.3.2.4.2 Cooling and Heating Loads calculation

ECOTECT takes a proactive approach to heating and cooling loads, calculating that a small amount of heating injected into the environment as soon as temperatures begin to fall may save a large amount of heating later when the fall is large enough to trigger the thermostat. However this has lead to a fair amount of confusion amongst some users when they could see small HVAC loads at times when the internal zone temperature appeared to be within the comfort band.

6.4 Conclusion

This chapter illustrates the methodology utilised for this study. It describes the field study process stage by stage, the aim of each step within the field study process and the expected outcome of each stage. The thermal modelling was determined and the limitation of the chosen thermal modelling tool was illustrated. The solutions of the thermal modelling limitations were suggested by two ways of validations and the expected outcomes of the thermal modelling were listed.

7. Climatic Analysis of Seiyun

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7.1 Introduction

This chapter will focus on the climate of Seiyun (area under study). It will start with a review of the climatic data obtained from the Yemeni authorities. The second section on this chapter will analyze the climate of Seiyun and discusses the most appropriate passive design measures using the weather tool and Mahoney tables.

7.2 Climate of Seiyun

The climate of the city of Seiyun is hot for most of the year and means outdoor temperatures range between 17.1 ^{0}C in winter to 33.9 ^{0}C in summer. On the other hand it has been found that the difference between day and night outdoor air temperatures is high and can reach 20 ^{0}C. The temperature difference between summer and winter and also between day and night creates an environmental dilemma when attempting to determine the appropriate profile for the building in terms of the design elements and the construction as a whole.

From the point of view of temperature studies, it has been found that the most critical months of the year are during the midsummer when temperature extremes usually occur. Figure (7-1) shows the historical outdoor air temperature of the city and Figure (7-2) shows the recorded relative humidity.

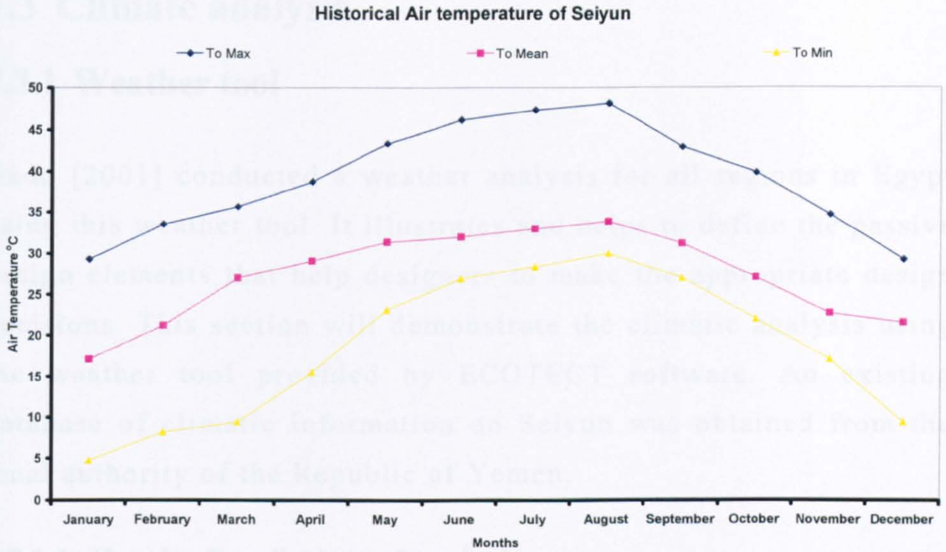

Figure 7-1: Historical air temperature of Seiyun.

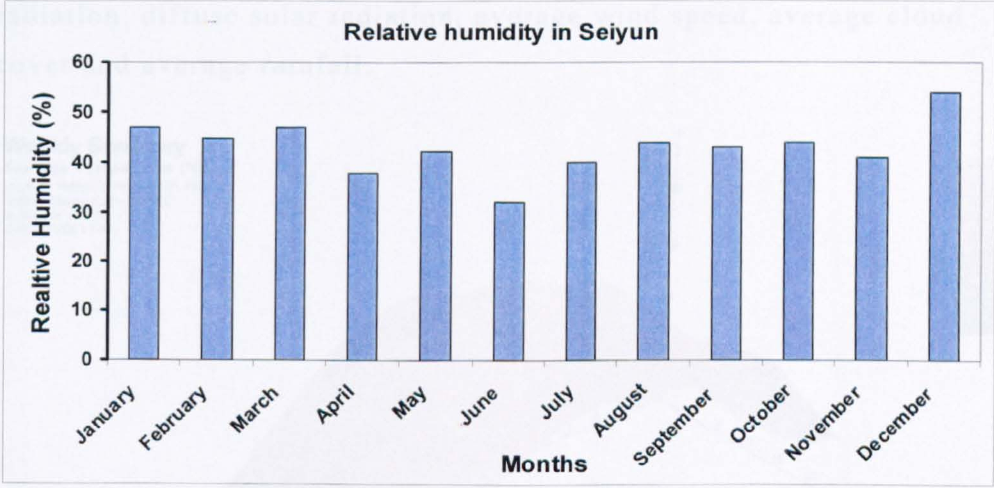

Figure 7-2: Monthly relative humidity in Seiyun

7.3 Climate analysis

7.3.1 Weather tool

Gado [2001] conducted a weather analysis for all regions in Egypt using this weather tool. It illustrates and helps to define the passive design elements that help designers to make the appropriate design decisions. This section will demonstrate the climatic analysis using the weather tool provided by ECOTECT software. An existing database of climatic information on Seiyun was obtained from the local authority of the Republic of Yemen.

7.3.1.1 Hourly climatic data of analysis

Figures (7-3a to 7-3h) illustrates the hourly climatic data during the year. The Figures show the average, maximum and the minimum air temperature. It also illustrates relative humidity, direct solar radiation, diffuse solar radiation, average wind speed, average cloud cover and average rainfall.

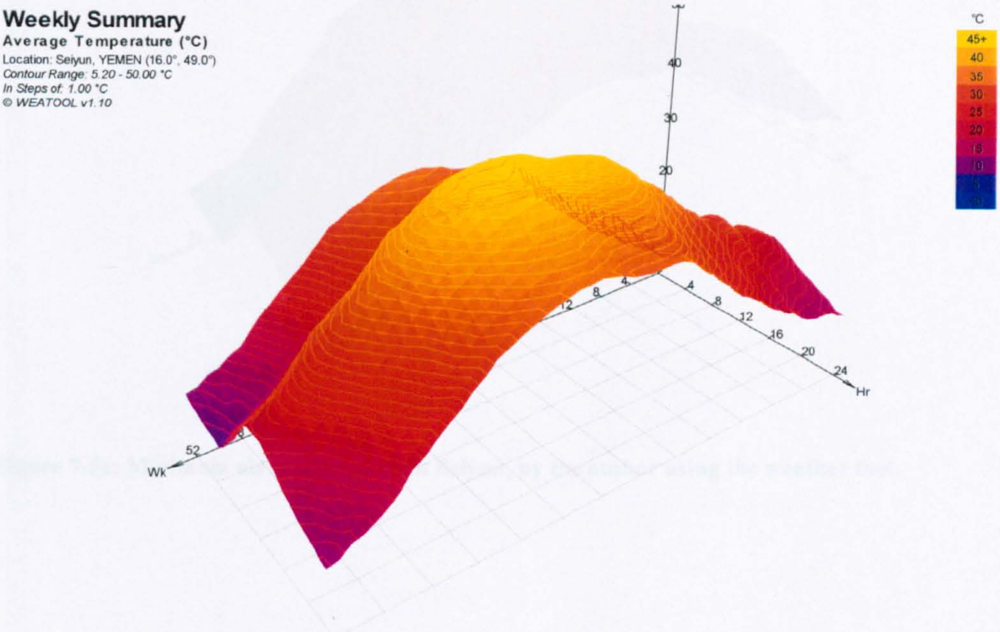

Figure 7-3a: Average air temperature in Seiyun, by the author using the weather tool.

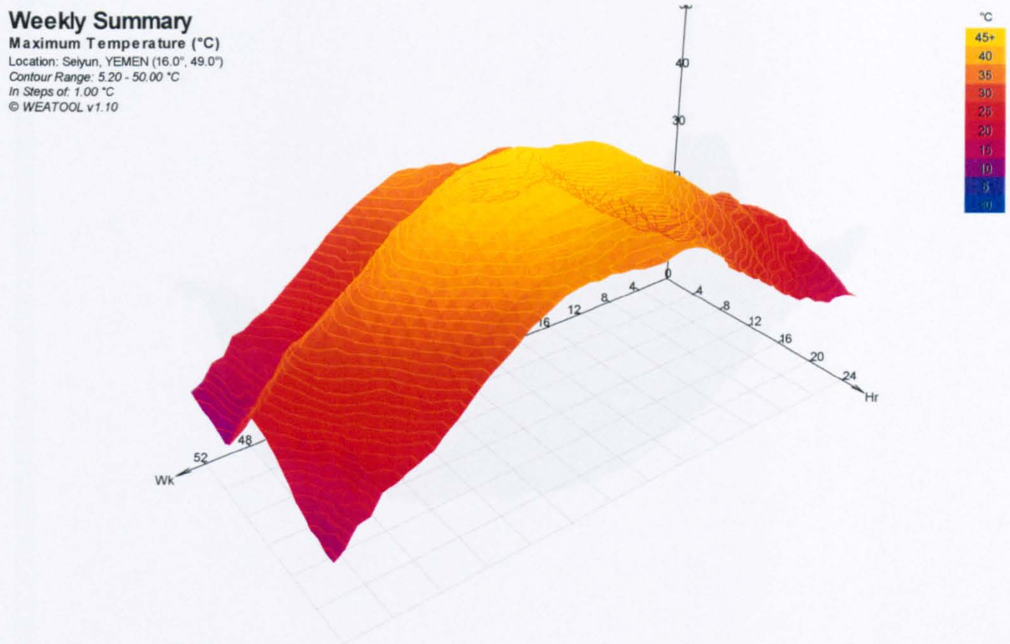

Figure 7-4b: Maximum air temperature in Seiyun, by the author using the weather tool.

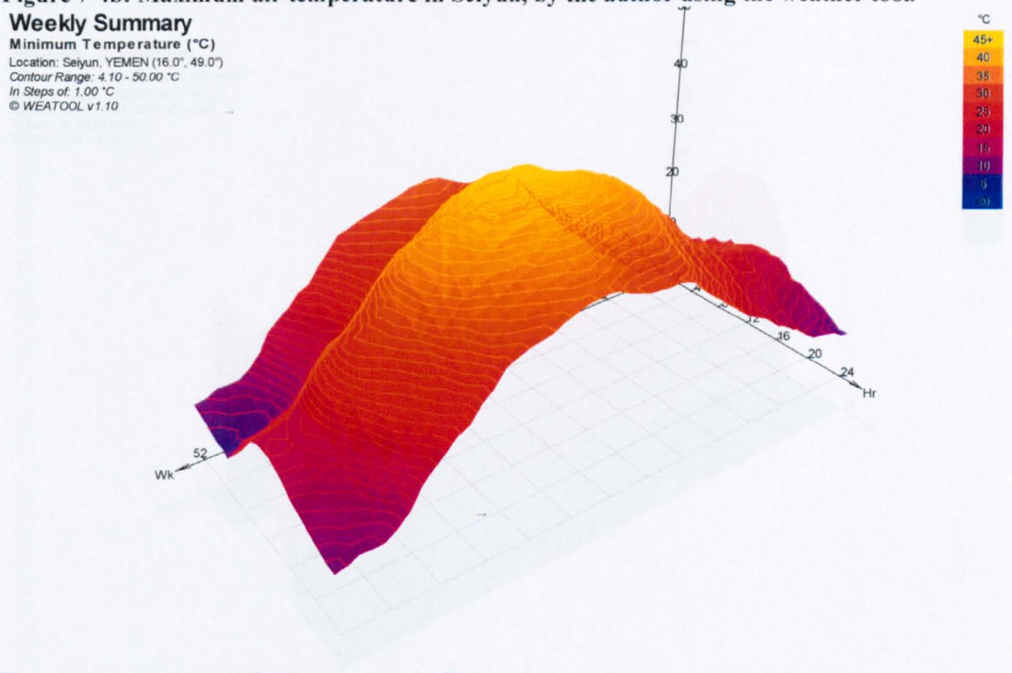

Figure 7-5c: Minimum air temperature in Seiyun, by the author using the weather tool.

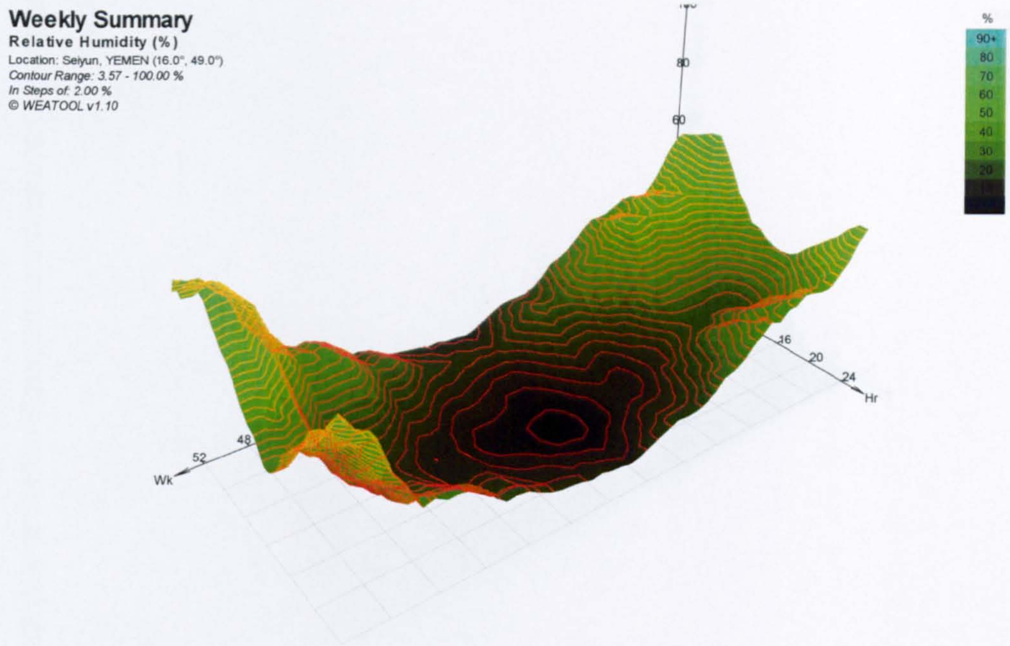

Figure 7-6d: Relative humidity in Seiyun, by the author using the weather tool.

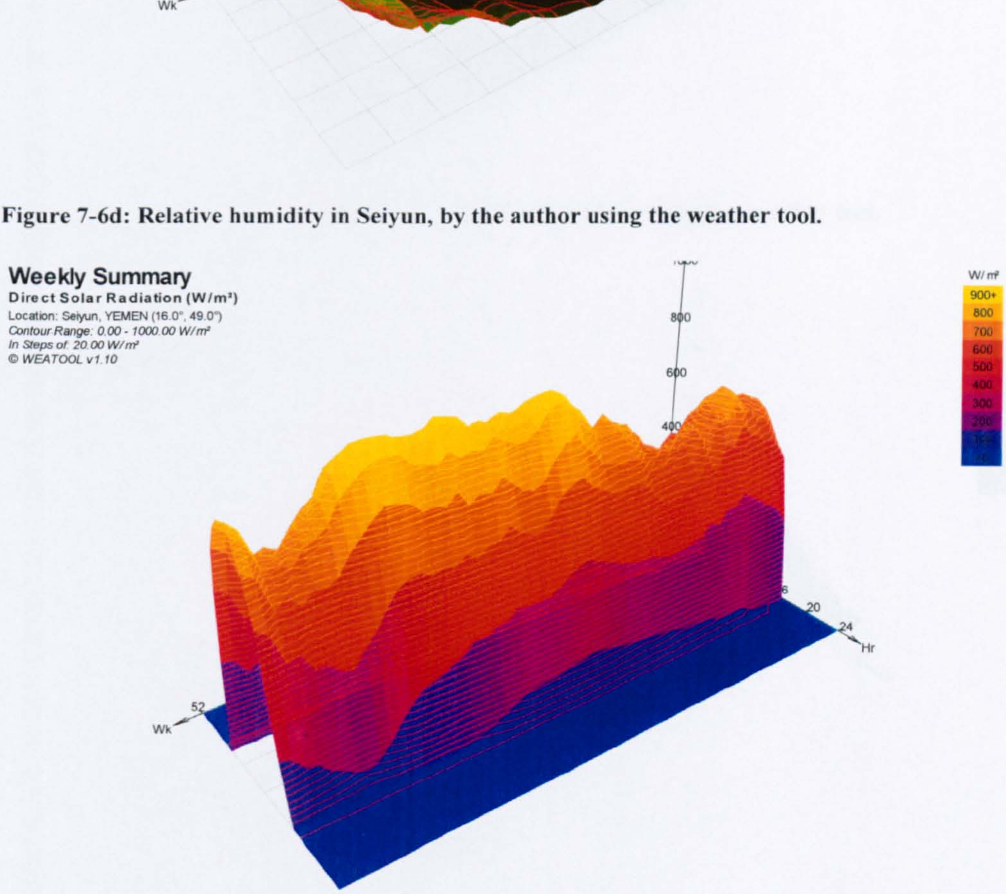

Figure 7-7e: Direct solar radiation in Seiyun, by the author using the weather tool.

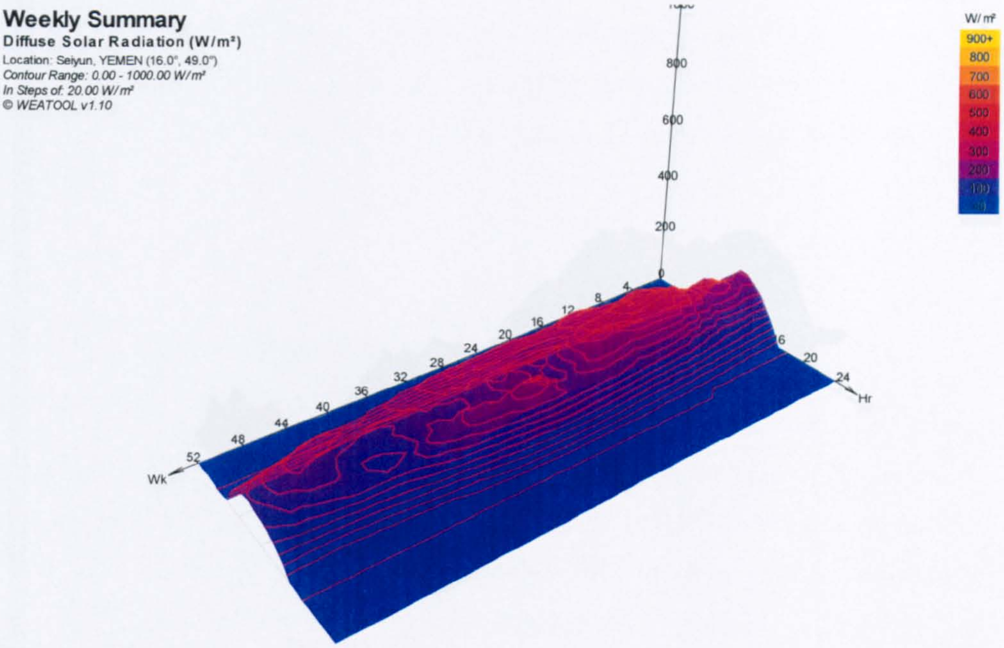

Figure 7-8f: Diffuse solar radiation in Seiyun, by the author using the weather tool.

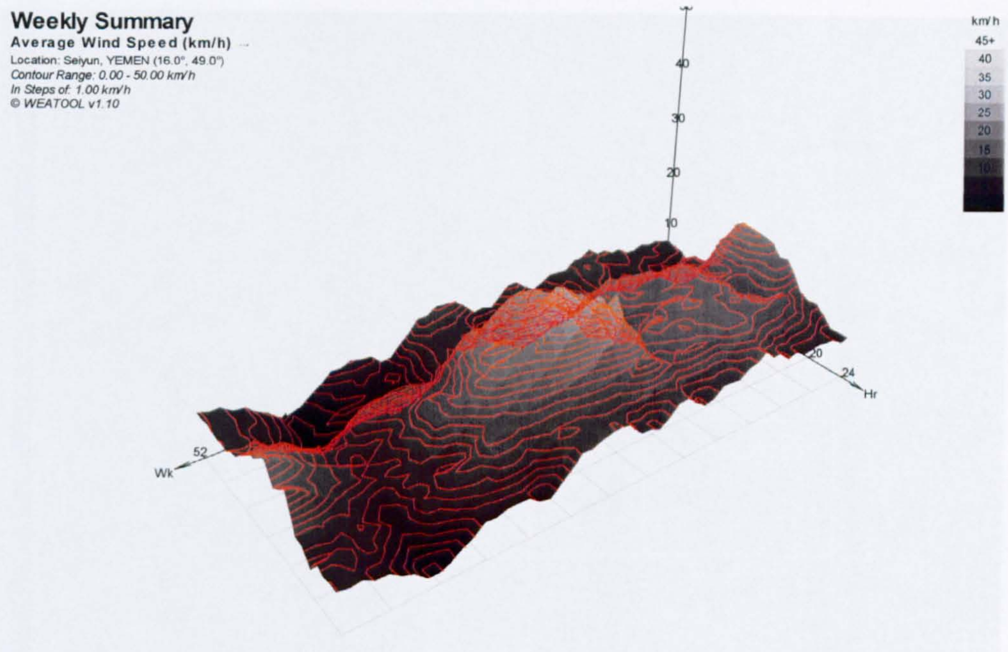

Figure 7-9g: Average wind speed in Seiyun, by the author using the weather tool.

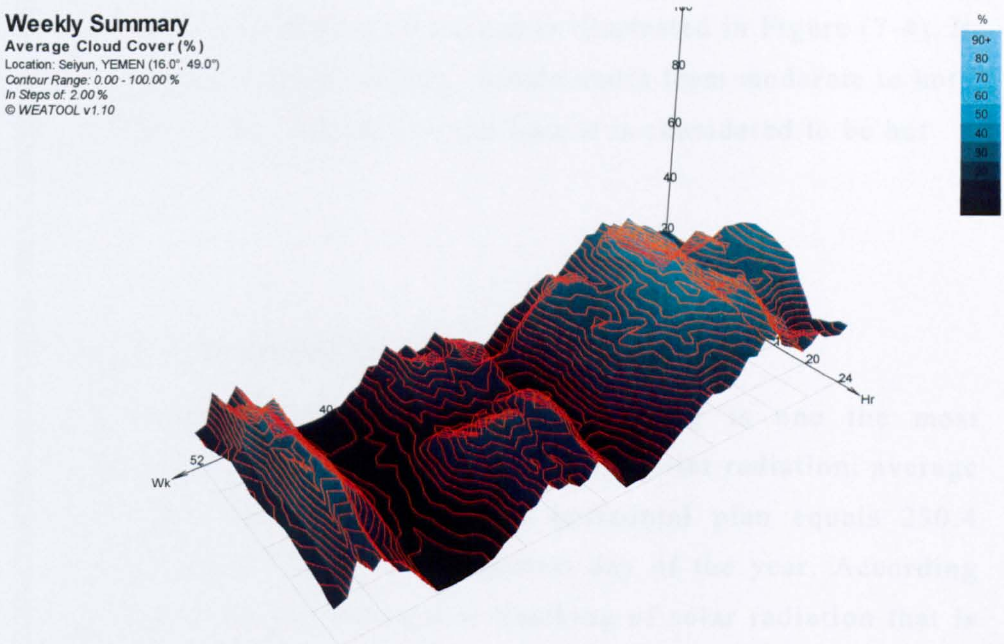

Figure 7-10h: Average cloud cover of Seiyun, by the author using the weather tool.

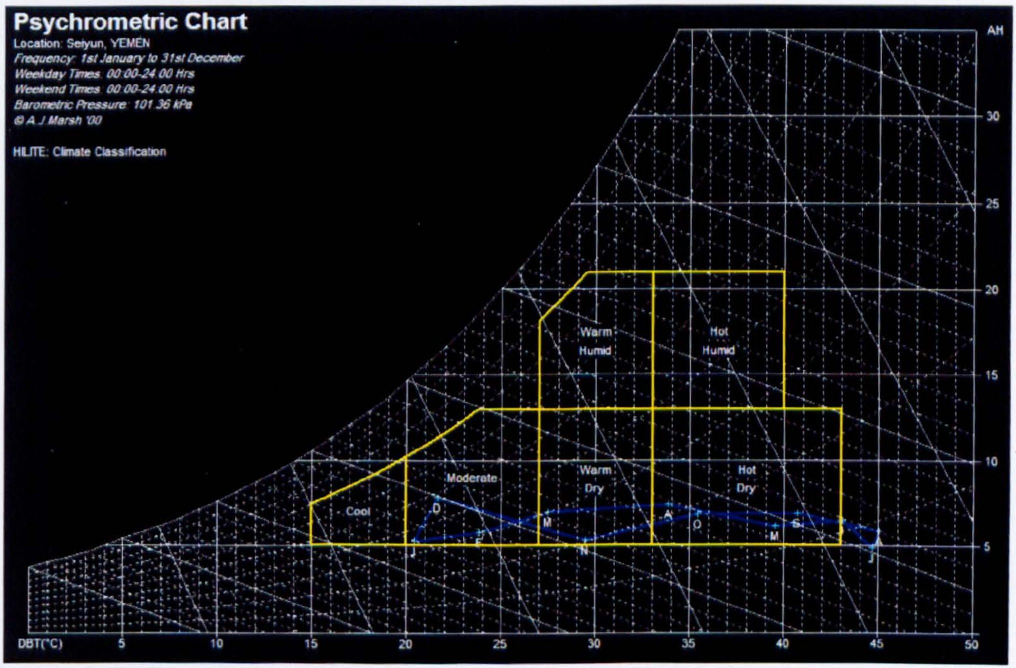

Figure 7-11 : Climatic classification of Seiyun, by the author using the weather tool.

The climate classification of Seiyun is illustrated in Figure (7-4). It is clear from the graph that the climate starts from moderate to hot dry. In fact for the majority of the time it is considered to be hot dry.

7.3.1.2 Best Orientation for Buildings

In this climatic region, avoiding overheating is one the most important factors in comfort due to the high solar radiation; average annual global solar radiation on a horizontal plan equals 230.4 W/m^2 reaching 930W/m^2 on the hottest day of the year. According to that the maximum rejection or blocking of solar radiation that is possible is required.

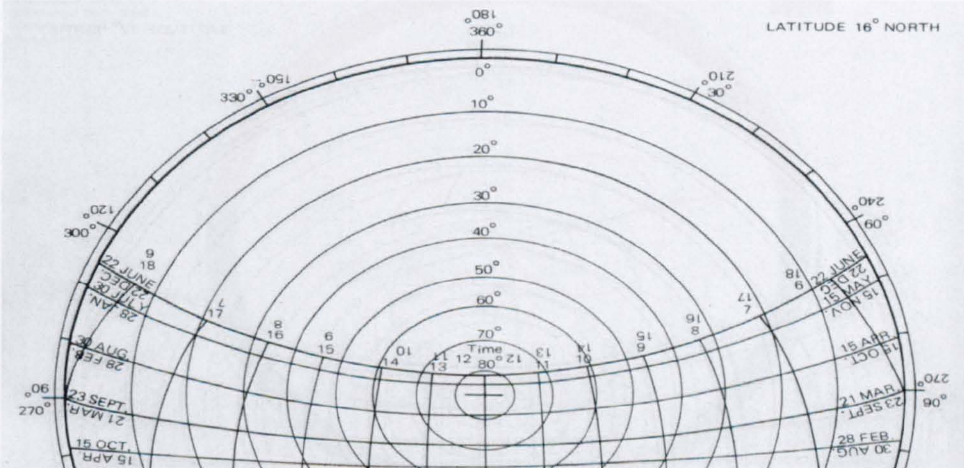

Figure 7-12: Solar chart of Seiyun.

Figure (7-5) shows the sun angel during the whole year. it is obvious that during the months April, May, June and July the sun is heating the north façade while it is heating the south façade during the rest of the year. Figure (7-6) shows the optimum orientation for buildings for solar collection, which is 165°. This method takes into account the total protection of the western and eastern elevations as well as the protection of the opening of the north façade for the protection from early morning and the late afternoon summer radiation.

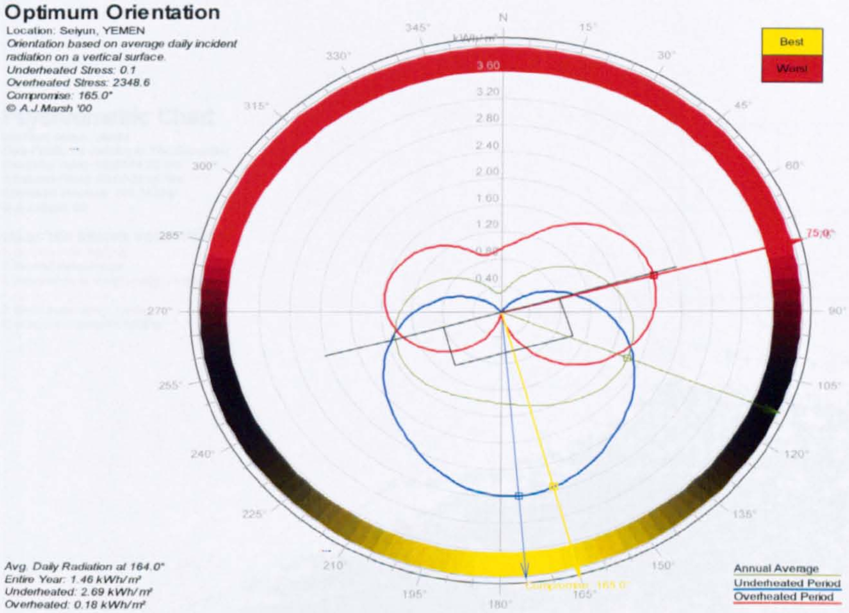

Figure 7-13: The optimum solar orientation, by the author using the weather tool, by the author using the weather tool.

7.3.1.3 Passive Design Strategies

This part of the chapter investigates the effect of using six passive measures on the thermal comfort in Seiyun Figure (7-7). These passive measures are:

1. Thermal Mass
2. Night Purge Ventilation
3. Passive Solar Heating
4. Natural Ventilation
5. Direct Evaporative Cooling
6. Indirect Evaporative Cooling

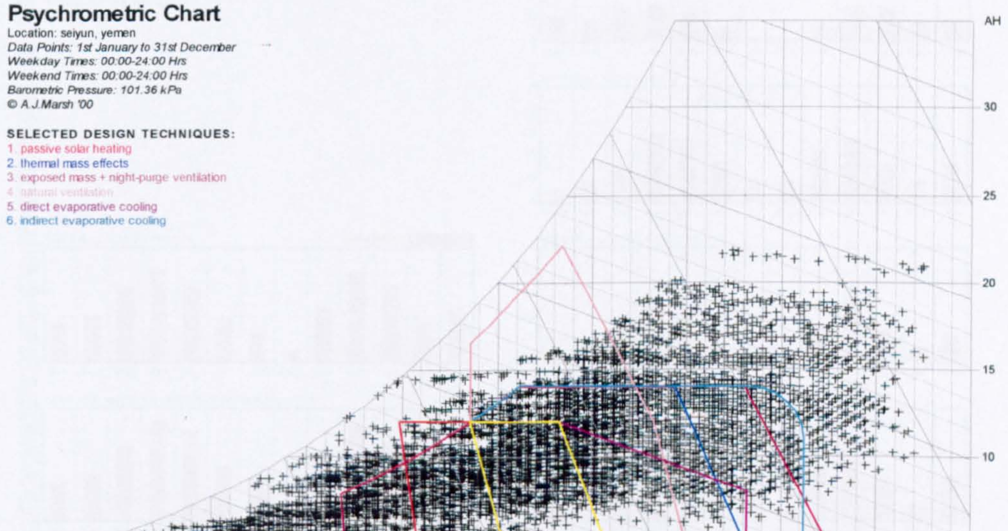

Figure 7-14: The effect of using passive design measure on the human comfort, by the author using the weather tool.

In Figure (7-7) the hourly climatic data points are plotted on the psychometric chart. The comfort zone is presented by the yellow line. Each measure is then represented on the graph by a different coloured line as illustrated in the legend. From this graph, it is clear that different measures have different effects on the comfort zone. Exposed mass and night purge ventilation, thermal mass, indirect evaporative cooling and natural ventilation, have the most effect on the comfort zone area.

Figure (7-8) illustrates the effect of six different passive measures on the percentage time the climate is in the human comfort zone inside the space before and after using the factor.

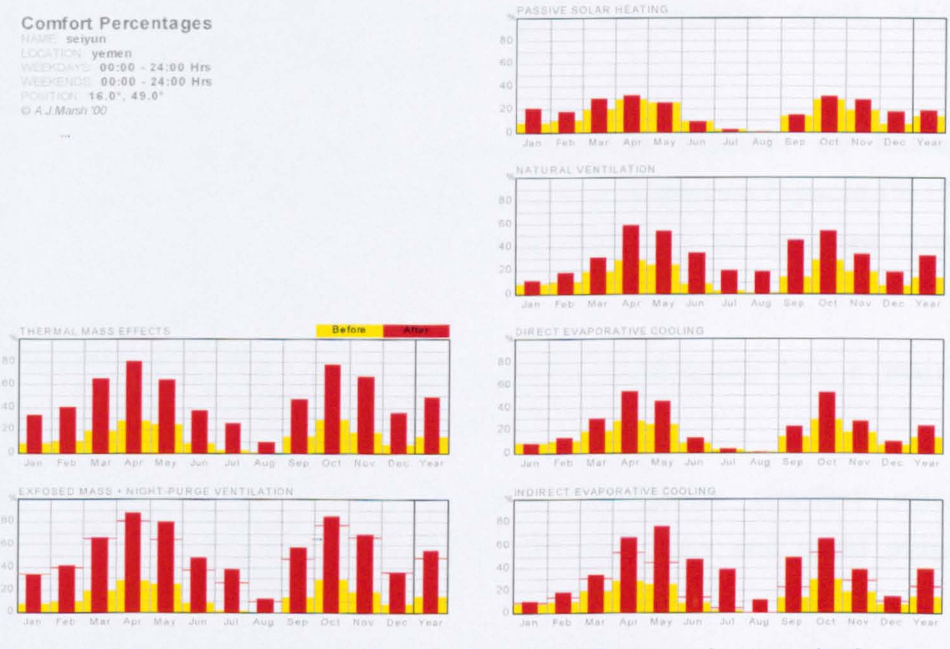

Figure 7-15: Comfort percentages before and after using different passive strategies, by the author using the weather tool.

1. Using lots of thermal mass is most effective in terms of thermal comfort during the months March, April, May, September October and November boosting the

percentage of comfort inside buildings in these months by 80%. It is also effective during the rest of the year.

2. Exposed mass + night purge ventilation have much more effect than thermal mass throughout the year and reaches its maximum comfort percentage in April with 88%.
3. Natural ventilation has a major effect on comfort percentage during the period April, May, September and October.
4. The effect of solar gains in comfort percentage occurred but with low effect throughout the year.
5. Direct and indirect evaporative cooling is considered as an effective strategy during the months April, May, September and October.

The effect of multiple measures work together on human comfort percentages for each month is shown in Figures (9-10, 11, 12, and 13). The main points that can be obtained from theses Figures are:-

1. Exposed mass + night purge ventilation has a major effect with any combination.
2. An achievement of 55% on human comfort when combining solar heating, thermal mass and night purge ventilation.
3. The above percentage has decreased to 53% when natural ventilation is used instead of night purge ventilation.

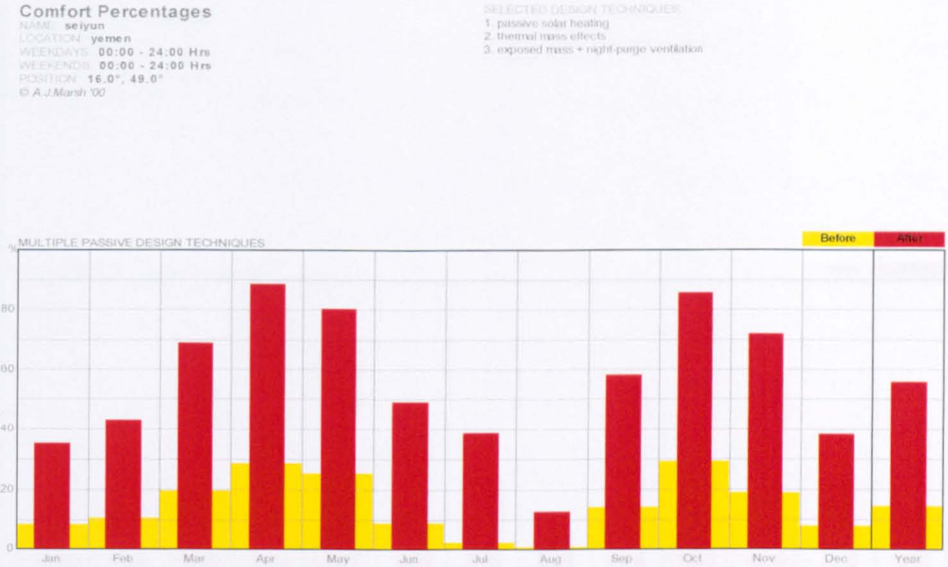

Figure 7-16: Comfort percentages before and after using the combinations of thermal mass, exposed mass + night purge ventilation and passive solar heating, by the author using the weather tool.

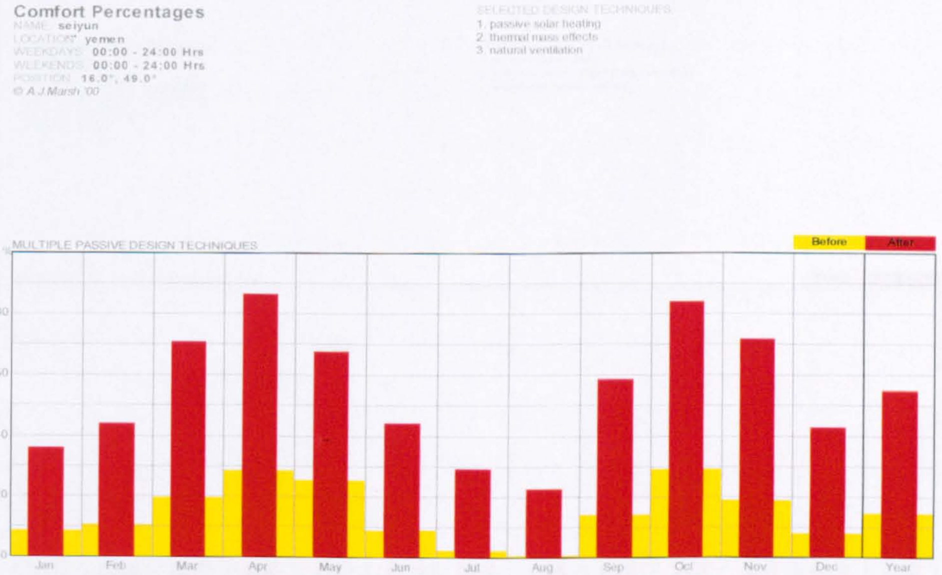

Figure 7-17: Comfort percentages before and after using the combinations of thermal mass, natural ventilation and passive solar heating, by the author using the weather tool.

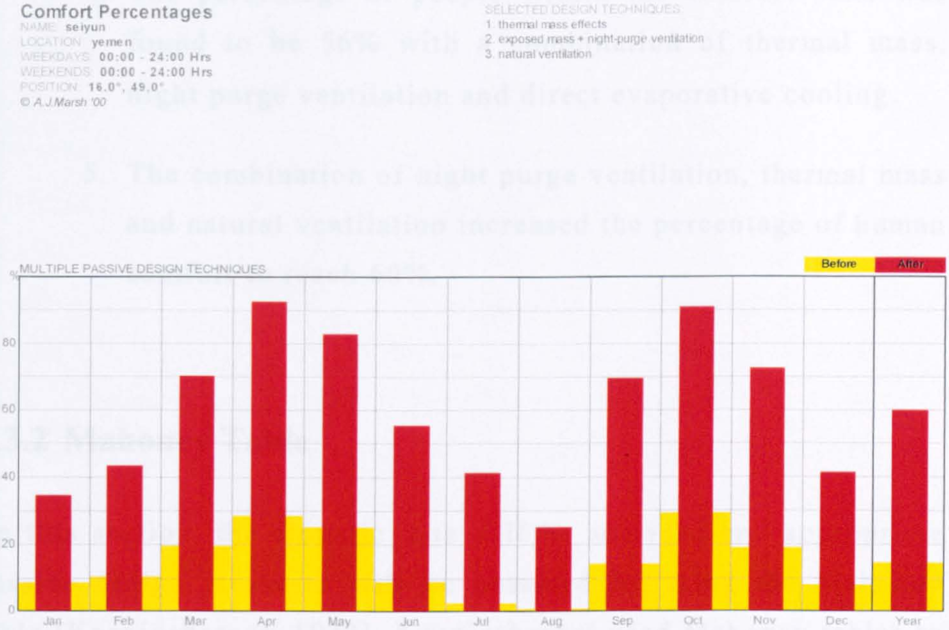

Figure 7-18: Comfort percentages before and after using the combinations of thermal mass, night purge ventilation and natural ventilation, by the author using the weather tool.

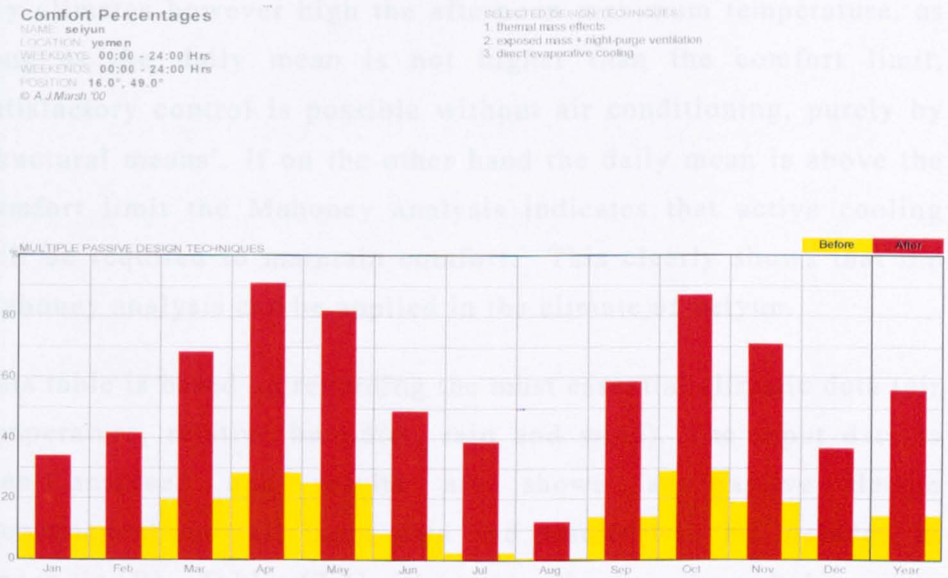

Figure 7-19:Comfort percentages before and after using the combinations of thermal mass, exposed mass + night purge ventilation and direct evaporative cooling, by the author using the weather tool.

4. The percentage of people within the comfort band was found to be 56% with a combination of thermal mass, night purge ventilation and direct evaporative cooling.

5. The combination of night purge ventilation, thermal mass and natural ventilation increased the percentage of human comfort to reach 60%.

7.3.2 Mahoney Table

In this section, the climatic data will be analysed and appropriate passive design measures will be obtained by using the Mahoney table [Koenigsberger, 1973]. Koenigsberger used Mahoney tables to analyse the climatic data of the city of Baghdad which has a climate classification as hot and dry climate and he concluded that 'In hot-dry climates however high the afternoon maximum temperature, as long as the daily mean is not higher than the comfort limit, satisfactory control is possible without air conditioning, purely by structural means'. If on the other hand the daily mean is above the comfort limit the Mahoney analysis indicates that active cooling will be required to maintain comfort. This clearly shows that the Mahoney analysis can be applied in the climate of Seiyun.

This table is based on recording the most essential climatic data (air temperature, relative humidity, rain and wind). The input data is then analysed and results are shown as passive design recommendations (all input data and results will be included in Appendix B). Table (7-1) illustrates the recommended passive design for the city of Seiyun.

Passive measure	Recommended passive techniques
Layout	Compact courtyard planning.
Spacing	Compact layout of estates.
Air movement	No air movement requirement.
Openings	Very small openings, 10–20%.
Walls	Heavy external and internal walls.
Roofs	Heavy roofs, over 8h time-lag.
Outdoor sleeping	Space for outdoor sleeping required.
Size of opening	Very small openings, 10–20%.
Position of openings	In north and south walls at body height on windward side, openings also in internal walls.
Production of openings	Exclude direct sun light.

Table 7-1: The recommended passive techniques for Seiyun obtained from Mahoney tables

7.4 Climatic influence on human Thermal comfort

Using the adaptive equation of Humphreys and Nicole equation (chapter 3), the T_c was calculated for each month using the monthly maximum and minimum temperatures. Calculated comfort temperatures are shown in table (7-2) and Figure (7-13).

	To $_{Max}$	To $_{Min}$	Tc $_{Max}$	Tc $_{Min}$
January	29.3	4.7	27.429	14.391
February	33.5	8.1	29.655	16.193
March	35.7	9.4	30.821	16.882
April	38.8	15.5	32.464	20.115
May	43.4	23.1	34.902	24.143
June	46.2	26.9	36.386	26.157
July	47.4	28.4	37.022	29.072
August	48.2	30	37.446	30.768
September	43	27	34.69	27.376
October	39.9	22	33.047	23.56
November	34.8	17.1	30.344	20.963
December	29.3	9.4	27.429	16.882

Table 7-2: The annual comfort temperatures for Seiyun.

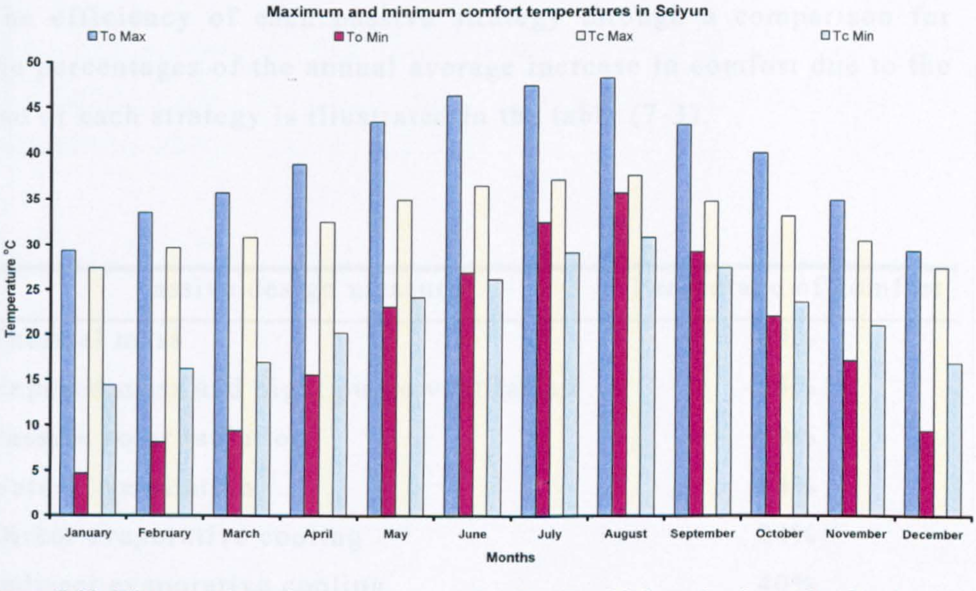

Figure 7-20: The annual comfort temperatures for the city of Seiyun, by the author leaning on the findings of this chapter.

7.5 Conclusion

In the present chapter the topic of climate was explored and the characteristics of the climate in general and the hot dry climate in particular were discussed. Topography and climate variation of Yemen and in particular of the area under study were also illustrated. Although the information given in this chapter is general in nature, it provides the basis and direction of finding an environmentally friendly economic solution to the problem of human comfort in such a harsh climate.

It can be concluded from this chapter that the climatic classification of the city of Seiyun is moderate, warm dry and dry climate. The optimum orientation for solar collection is 165°.

The efficiency of each passive strategy through a comparison for the percentages of the annual average increase in comfort due to the use of each strategy is illustrated in the table (7-3).

Passive design measure	Percentage of comfort
Thermal mass	49%
Exposed mass and night purge ventilation	55%
Passive solar radiation	19%
Natural ventilation	34%
Direct evaporative cooling	24%
Indirect evaporative cooling	40%

Table 7-3: Summery for the efficiency of using different passive strategies in the city of Seiyun, by the author leaning on the findings of this chapter.

From this table it is very clear that the most efficient strategy in all the regions is the use of thermal mass. Thus the passive strategies could be arranged in descending order as follows:

1. Exposed mass and night purge ventilation.
2. Thermal mass.
3. Indirect evaporative cooling.
4. Natural ventilation.
5. Direct evaporative cooling.
6. Passive solar radiation.

The combination of thermal mass, night purge ventilation and natural ventilation increases the percentage of human comfort to 60%.

Finally it is worth mentioning that the passive design recommendations obtained from Mahoney tables and weather tool corroborate each other with some extra passive recommendations obtained by using Mahoney tables.

8. Field Study Results

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8.1 Introduction

It is well known among local inhabitants of Seiyun that traditionally designed and built buildings provide a better internal environment than the new concrete buildings. This thermal field survey has been conducted to investigate and prove this premise.

This chapter will address the findings and results of the field study. Questionnaire, monitoring measurements, preferences votes and the calculated cooling loads for all buildings will be illustrated and discussed in this chapter.

8.2 Results and Discussion

8.2.1 Analysing of Thermal Comfort

The results below show the participant thermal sensation responses gathered during the day (morning, early after early after noon and evening) on the day of the survey. The results of the questionnaire were analysed using normal statistical techniques to establish the mean and standard deviation.

8.2.1.1 Summer season

The graphs below show the thermal sensation responses for the summer time. Figure (8-1) illustrates that the hottest perceived time in all buildings is around early after early after noon (between 12:00 and 3:00 pm) when the external air temperature is at its peak and buildings absorb most of the solar radiation. It is clear that there is different perceived sensation between the three types of buildings.

In traditional building, occupants feel between normal and slightly cool (-0.62) while there perceived sensation response goes up closer to warm (+1.55) at early after early after noon time. People under this survey express that they feel just slightly cooler at night time (-0.25).

From the Figure (8-1) new mud building occupants say that this type of building is better than the traditional. People state that they feel slightly warmer than in traditional buildings in the morning (-0.51). They also indicated that they feel above slightly warm but again cooler than the temperature perceived by occupants of traditional buildings (+1.24). The responses fell just above normal during night time (+0.12) which, again, is also warmer than the traditional building.

Concrete constructed buildings are the hottest buildings among the three types of buildings. Occupants responded that they perceive that the building is above slightly warm (+1.40) in the morning until it is almost reaching hot by early after early after noon (+2.70). It is also above slightly warm and close to warm during the night (+1.90) which means that people in this type of building feel that they are hot and discomforted.

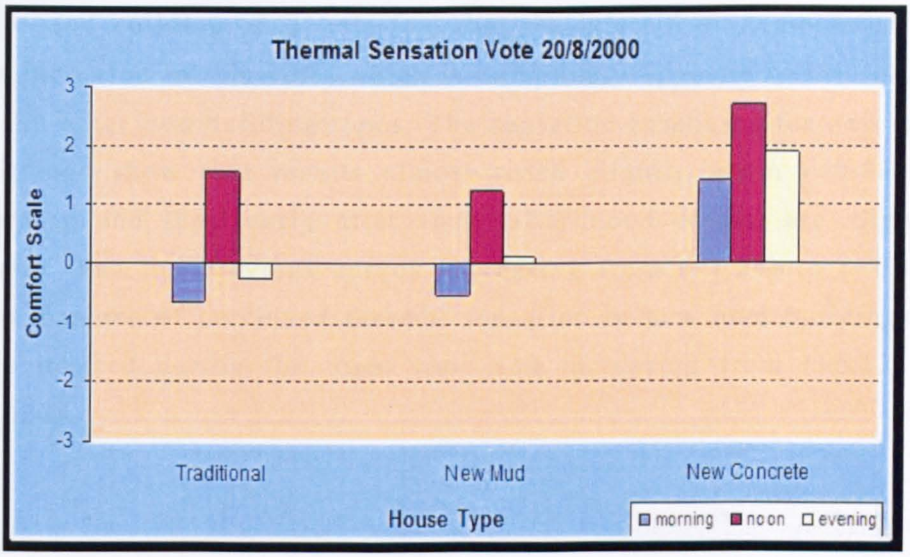

Figure 8-1: The first sensation vote in summer

The second perceived sensation census was conducted in September 2000. Results of this survey are illustrated in Figure (8-2). It is clear from the Figure below that early after early after noon is still the hottest time for occupants of all buildings but indicate that they felt less hot in traditional and concrete building than indicated in the previous poll. This could be expected as it was no longer peak summer.

From Figure (8-2) below it is clear that the traditional building is cooler than the previous vote (-0.96) and almost reaching slightly cool in morning time. It is less hot than the previous vote (+1.40) in the middle of the day but a little cooler than the previous vote (-0.28) during the night. It is clear from the Figure below that people feel that the internal air temperature had reduced for the whole day at this time of the year

New mud building occupants feel that the internal air temperature of has increased in this vote, which is completely opposite to the results of the other two building types. The sensation responses for new mud buildings show that results almost reach slightly warm (+0.88) in morning and their early after early after noon results are slightly higher than the previous survey increasing from (+1.24) to (+1.34). The increase of perceived thermal sensation in new mud buildings is also noticed during the night time and increasing from (+0.12) to (+0.20).

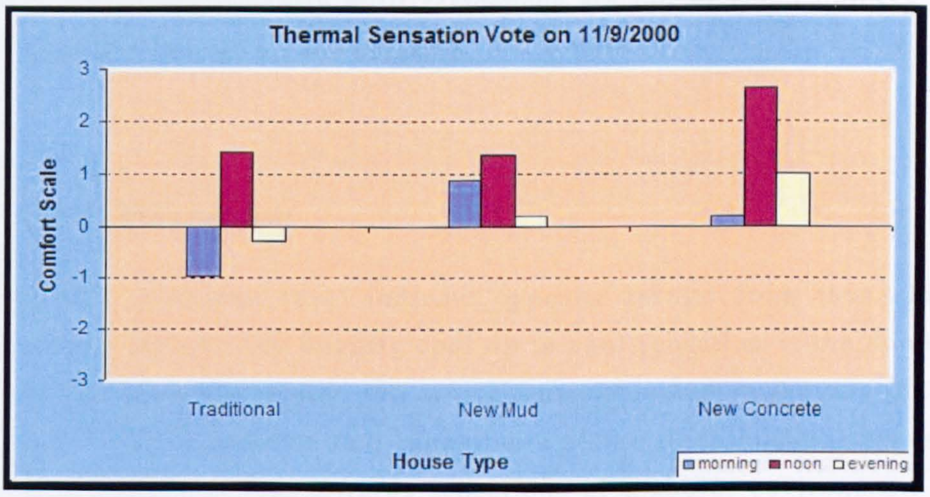

Figure 8-2: The second sensation vote in summer

Concrete building occupants express a large drop in their perception of heat at both morning and night. From Figure (8-2) it is clear that in the morning time, the sensation result drops from (+1.40) in previous vote to (+0.21). At early after early after noon only a very slight change is found in the perceived sensation results, as they drop down from (+2.70) to (+2.64) which is still close to a hot vote and can be considered as consistent. Again occupants indicate that they are still feeling warm but their sensation results drop almost half from the previous vote. It was (+1.90) in August while it drops to (+1.00) in September.

The external air temperature slightly decreases from August to September but survey results occupants in new mud and concrete buildings are significantly changed, which indicates that a small decrease in the external air temperature results in a reduction in the perception of heat by occupants. The results can also be interpreted to mean that traditionally built residences are not effected quickly by a small decrease in air temperature.

8.2.1.2 Winter season

Figures (8-3) and (8-4) indicate opposite results from those in the summer survey. The slightly cool up to cool sensation is the dominant perception in the winter poll which was conducted in January the 14th 2001. Results indicate that inhabitants of the three building types are leaning more or less towards sensations of a cooler environment with morning being cooler than evening. This is indicated in Figure (8-3) where occupants point towards feeling slightly cool (-0.70) while results are just above normal in early after early after noon time (+0.19).

Figure (8-3) shows that perceived sensation results in new mud buildings during the morning is (-1.10) and increases to be just below normal (-0.13) at early after early after noon, while decreasing again to reach close to slightly cool (-0.90) in evening.

Again, concrete buildings receive the worst results with the greatest deviation from optimum comfort in both winter and summer and at the three main periods examined throughout the day. Occupants indicate that the coldest time is in morning where the results are-1.83. Internal sensation perception increases at the middle of the day to reach above normal (+0.35) and drops again at night time to pass the line of slightly cool (-1.16).

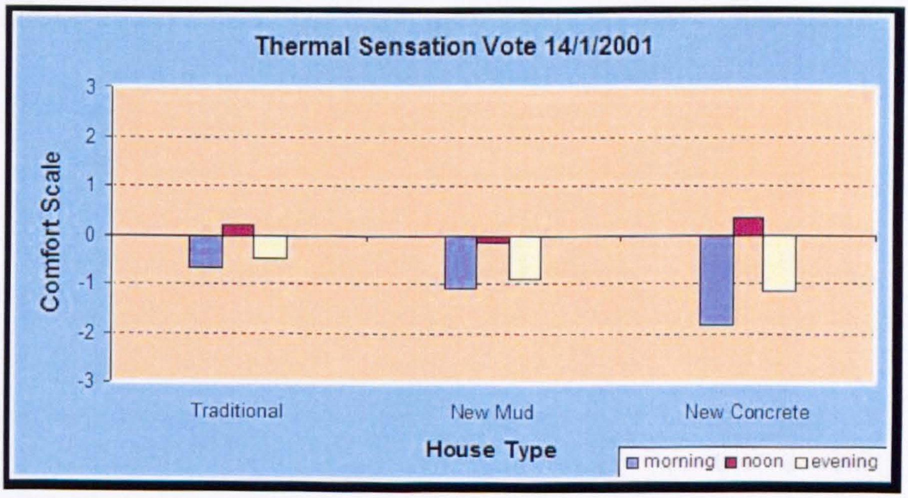

Figure 8-3: The first sensation vote in winter

The second survey for winter was conducted on February the 14th 2001. The results of the perceived sensation poll are shown in Figure (8-4) below. From Figure (8-4) it is apparent that people felt that all buildings were cooler than the previous vote which is expected because it was winter. In fact the participants tended towards feeling discomfort due to the cold. The survey indicates that in general the response was similar to the previous winter poll except for the concrete buildings which were perceived to be colder at early after early after noon.

Occupants of traditional buildings indicated that this type of building was almost slightly cool in the morning (-0.93) while it was (-0.70) in the previous vote. It was a bit warmer around the early after noon period than in the morning and it was showing an above normal result (+0.21). It was also warmer than the previous vote during the same times of the day. Occupants feel that the traditional buildings were slightly cool (-0.78) but warm up towards the early after noon.

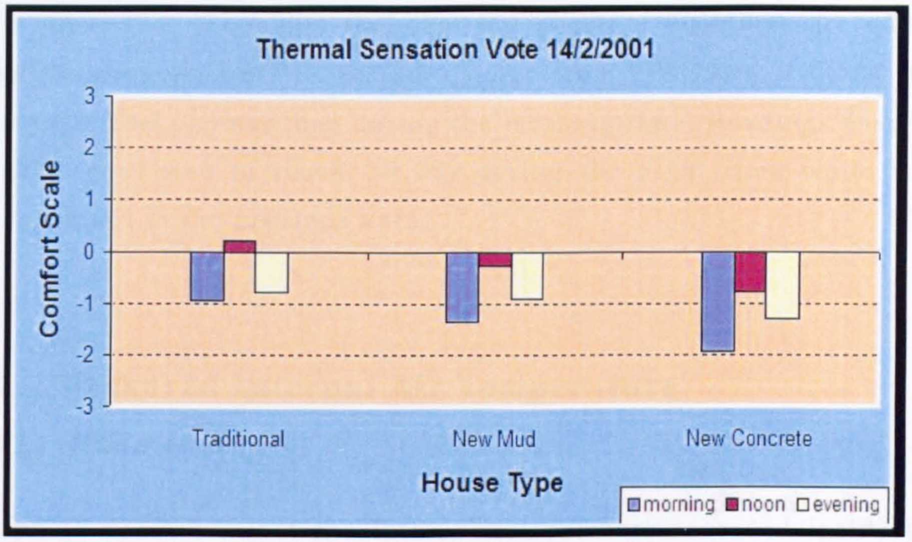

Figure 8-4: The second sensation vote in winter

New mud buildings residents indicated that this type of building has similar results to those seen in the previous vote with a little increase of perceived discomfort due to cold during the morning and early after noon periods. Compared to the previous surveys the participants feel that the building becomes cooler in the mornings and express the feeling of more than slightly cool (-1.35) while in previous vote it was (-1.10). Similar early after noon time results show that a little feeling of discomfort is apparent and the perceived sensation results decreased from (-0.13) to (-0.28). All the perceived levels of comfort results indicated a change in the results leaning towards cold.

In general the inhabitants of concrete buildings expressed feelings that this type of building is the coldest among the all buildings. Figure (8-4) shows that the comfort sensation results decreases from (-1.83) in the previous vote to reach (-1.92) in the morning time. During the day it is clear that occupants feel that the concrete buildings are cooler than the previous vote as results change from (+0.35) to (-0.78) but obviously feel warmer than during the morning time. Readings pass the slightly cool line to reach (-1.28) during the night time while they were (-1.16) in the previous vote.

8.2.2 Measured Internal Air Temperature

8.2.2.1 Winter season

Graph (8-5) shows that the internal temperature recorded inside the traditionally built buildings was between 21 °C and 25 °C while the new mud building and the concrete constructed building had an internal air temperature between 23 °C and 25 °C and between 23 °C and 28 °C respectively. The New mud case study registered quite a steady temperature reading for the period under investigation, which was not logical and lead to an investigation into the operation of the data logger and its set up. It was found that for some unknown reason the data logger only started to record the internal air temperature during the last few hours of the last day. It was decided to include the results that were recorded and illustrate that this unit failed to register the correct internal temperature in the case of the new mud building study.

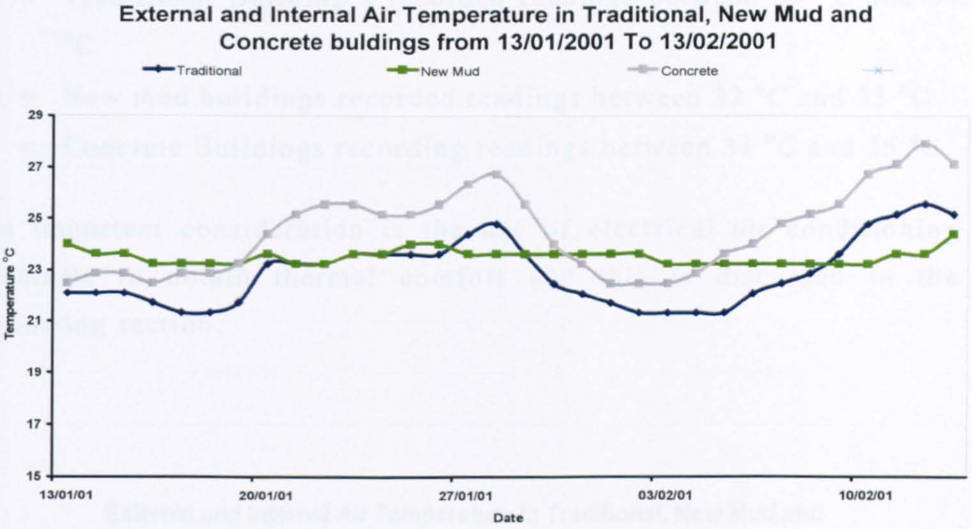

Figure 8-5: Measured internal air temperature in all houses in winter season.

It was also recorded that the air conditioning was switched on for an average of five to ten hours per day in winter to warm the house for the concrete type case study.

8.2.2.2 Summer season

This season is important because the air temperature reaches its maximum so all case studies are more affected by the sun and solar radiation. Internal air temperatures recorded in all case studies were approximately between 30 °C and 35 °C. From graph (8-6) below it was found that the recorded internal temperature varied from one building to the other as follows:

- Traditional Building s recorded readings between 30 °C and 34 °C
- New mud buildings recorded readings between 32 °C and 35 °C
- Concrete Buildings recording readings between 31 °C and 35 °C

An important consideration is the use of electrical air conditioning elements to obtain thermal comfort and this is discussed in the following section.

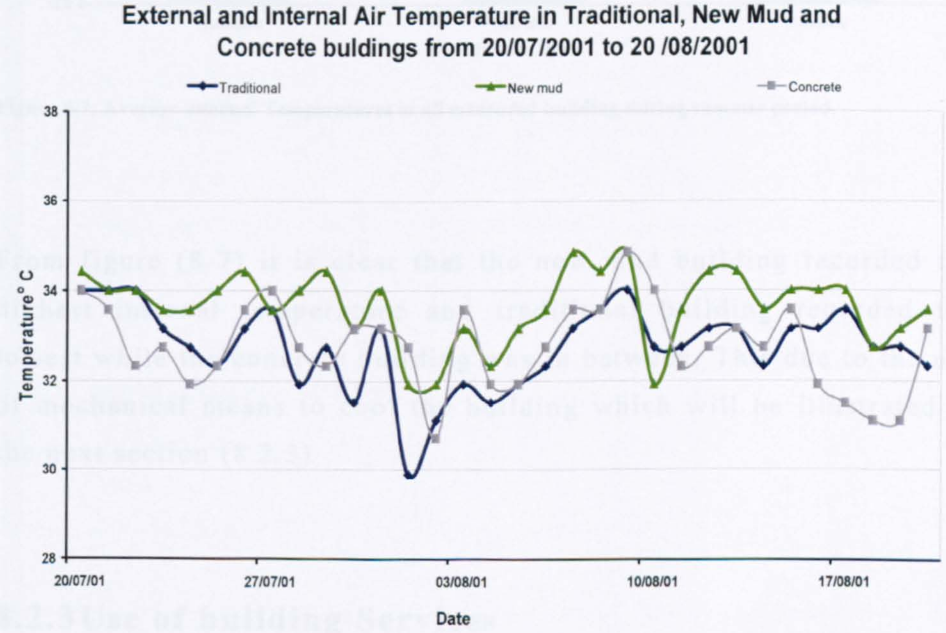

Figure 8-6: Measured internal air temperature in all houses in summer season.

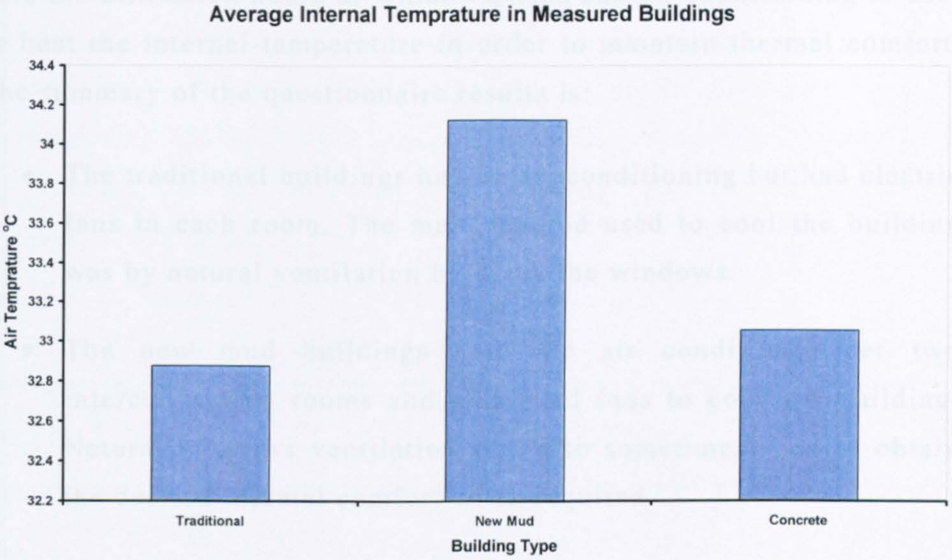

Figure 8-7: Average internal Temperatures in all measured building during summer period.

From figure (8-7) it is clear that the new mud building recorded the highest internal temperature and traditional building recorded the lowest while the concrete building was in between. This due to the use of mechanical means to cool the building which will be illustrated in the next section (8.2.3)

8.2.3 Use of building Services

During the period when measurements were taken, a questionnaire was given to the occupants of the participating residences and they were asked to fill in daily log with the main aim of quantifying the use of natural ventilation, fans and air conditioning. Occupants were asked to register the electrical equipment fitted in their houses and accurately note the utilisation hours of windows, fans and air conditioning to cool or heat the internal temperature in order to maintain thermal comfort. The summary of the questionnaire results is:

- The traditional buildings had no air conditioning but had electric fans in each room. The main method used to cool the building was by natural ventilation by using the windows.
- The new mud buildings had one air conditioner per two interconnecting rooms and also used fans to cool the building. Natural windows ventilation was also sometimes used to obtain the desired thermal comfort when required.
- The concrete buildings used air conditioning and fans in all of the rooms in the building. Occupants indicated that it is impossible to live in this type of house without using air conditioning to cool or warm the building as required.

8.2.4 Preference Survey

8.2.4.1 Winter season

From table (8-1) the following can be concluded:

In traditional buildings respondents indicated that no change is needed to the internal environment during the whole day, this indicates their satisfaction with their perceived thermal comfort and this building types response to the external climate.

New mud building respondents express their need for a warmer environment during the morning hours while they need the building to be cooler towards midday. At night they indicated that no change is needed to achieve perceived levels of comfort. Voters residing in concrete buildings expressed their general dissatisfaction with their internal environment. They indicated that they need their buildings to be warmer in the morning and evening but require a cooler environment around midday.

Type of Building	Time of the Day	Warmer	No Change	Cooler
Traditional	- Morning	-	√	-
	- Early after noon	-	√	-
	- Evening	-	√	-
New Mud	- Morning	√	-	-
	- Early after noon	-	-	√
	- Evening	-	√	-
New Concrete	- Morning	√	-	-
	- Early after noon	-	-	√
	- Evening	√	-	-

Table 8-1: Preferences votes in winter season

8.2.4.2 Summer season

As this period of time considered as a hot period results are expected to vary from the previous votes. Table (8-2) illustrates the results of the preferences survey for the summer period. The following can be concluded from the respondents.

Traditional voters expressed their needs for a cooler building during the midday hours while no change was needed in the morning and evening time.

A similar result as above was seen in the responses of the new mud building residents whereby only a cooler environment was required for the midday period.

As it was in the winter time, concrete building residents indicated their general dissatisfaction with the internal environment. They voted that they require a cooler building during the whole day because of the high external temperature.

Type of Building	Time of the Day	Warmer	No Change	Cooler
Traditional	- Morning	-	√	-
	- Early after noon	-	-	√
	- Evening	-	√	-
New Mud	- Morning	-	√	-
	- Early after noon	-	-	√
	- Evening	-	√	-
New Concrete	- Morning	-	-	√
	- Early after noon	-	-	√
	- Evening	-	-	√

Table 8-2: Preferences votes in summer season

8.2.5Cooling loads in case studies

To calculate the energy load it was important to know the type of air conditioning used in all building types and how many hours they were switched on. The air conditions fitted in all houses were found to be of the Carrier brand fitted in the wall with 2.5 kW power consumption.

Table (8-3) illustrates the results of the survey carrier out on the occupants of the studied buildings. These results are for the period of from the 1st of August to the 31st of August.

	Traditional Building	New Mud Building	Concrete Building
Number of A/C	0	2	5
Hours switched on in August	0	24	345
Total cooling load kWh	0	120	4312.5

Table 8-3: Calculated cooling load according to survey respondents

It is clear from table (8-3) that the concrete building has the largest power consumption required to obtain comfort. Results of the calculated cooling load for the concrete building will be compared in the next chapter with cooling load by Ecotect.

8.3 Conclusion

Traditional buildings often mitigated the effects of the exterior climate, even if 'perceived comfort' was not always achieved at all times of the day or in all seasons. Modern construction offers the technical possibilities to reach very good comfort through heating, cooling and other kinds of air conditioning.

From the conducted field study it can be concluded that there was a variation of responses according to the building type. In summer, traditional building occupants were less dissatisfied than the new mud and concrete buildings occupants. Concrete buildings were found to be the hottest among all buildings. In winter, it was found that traditional building occupants responded with less dissatisfaction than the occupants of the other buildings. Also concrete buildings were found to be perceived as the coldest among all buildings.

The monitored buildings indicated that the internal temperatures were almost in the same range for all building types. However the use of air conditioning varied according to the house type. It was noted that traditional buildings did not use air conditioning whereas new mud buildings used two air conditioners and concrete buildings used five air conditioners.

In terms of cooling loads the calculations for the monitored month (August) show that traditional building consumed zero KWh in August, whereas new mud building consumed 120 kWh for the whole month and concrete building consumed 4312.5 KWh for the same period.

From this chapter it can be concluded that the modern concrete building are perceived to be the worst in terms of thermal comfort and their excessive use of power to achieve thermal comfort and their design and material of construction need to be investigated and developed further. As the name indicates, concrete is the main material of construction and these types of buildings are normally designed and built with air conditioning installed as standard. Therefore, this type of concrete building will be investigated and simulated in the next chapter.

9. Thermal Modelling

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9.1 Introduction

This chapter is based on the results of the previous chapter and is also considered to be a continuation of the previous case study work. This chapter will describe the simulation process of the case study (concrete building), which was chosen as a result of the findings shown in the previous chapter. It will also illustrate the method that was chosen to compile the final recommendations on the building materials and passive design techniques. Results of the simulation will be compared against the actual results of the concrete building.

In this chapter a comparison of the calculated cooling loads of the concrete building from the previous chapter with the results calculated utilising the thermal modelling tool for the same specification of building and for the same month as the conducted field study.

9.2 Checking Ecotect

1. In terms of thermal modelling

A single room was drawn in Ecotect and the weather climate data of Seiyun was uploaded to the model Figure (9-5). The hourly IDRT of this room was calculated. The same room was exported from Ecotect to Energy Plus format and tested using Energy Plus. In order to check the performance of Ecotect against Energy Plus the room was simulated for four periods of the year. The results of these simulations are shown in Graphs 9.6 to 9.9. Figure 9.5 shows a 3D view of the tested room.

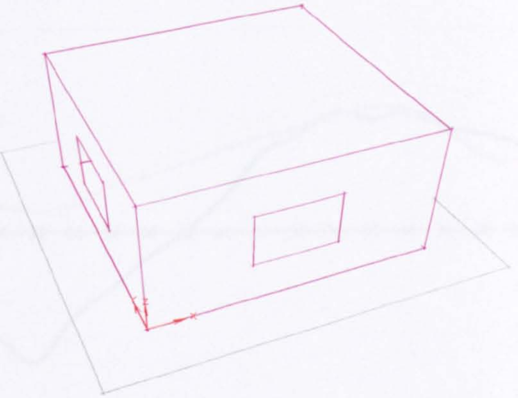

Figure 9-1: Isometric view of the tested room, by the author using Ecotect.

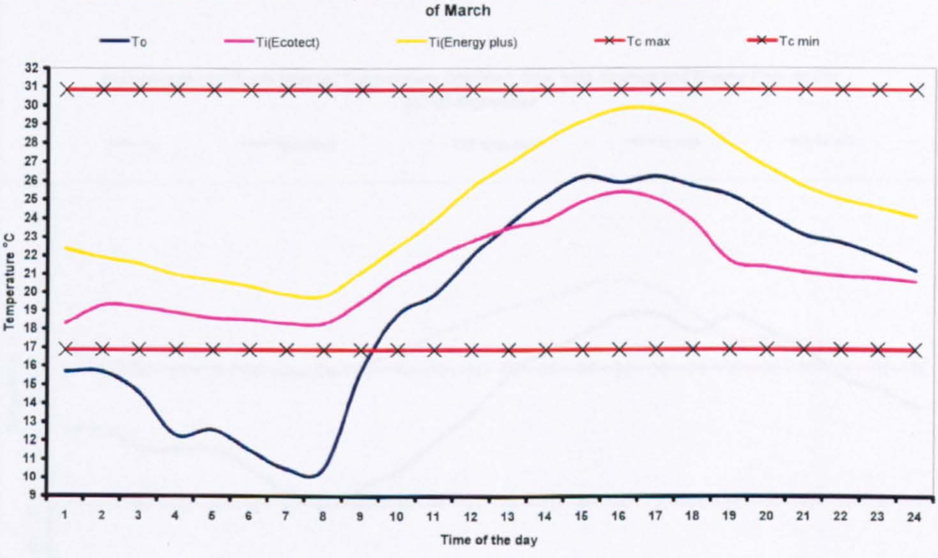

Figure 9-2: Results obtained from Ecotect and Energy Plus in vernal equinox.

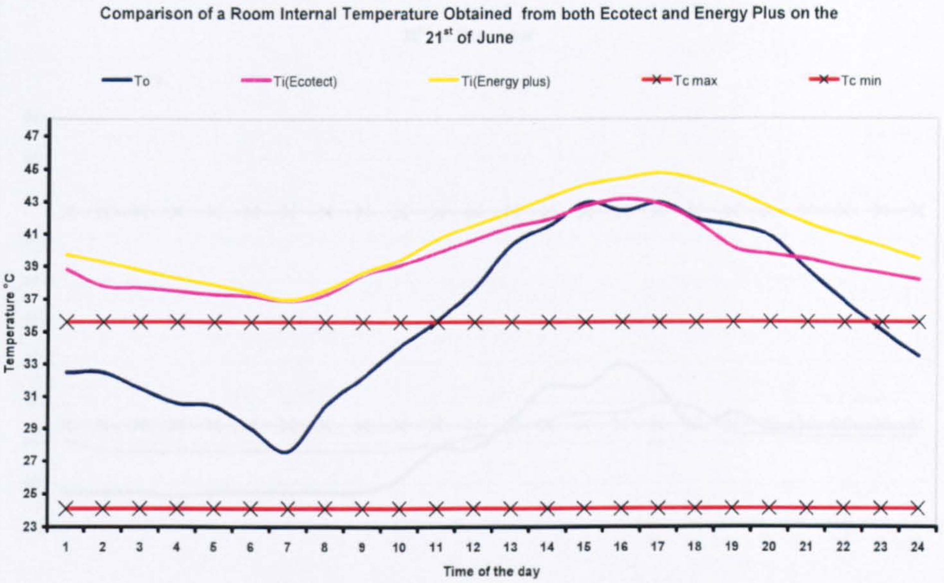

Figure 9-3: Results obtained from Ecotect and Energy Plus in summer solstice

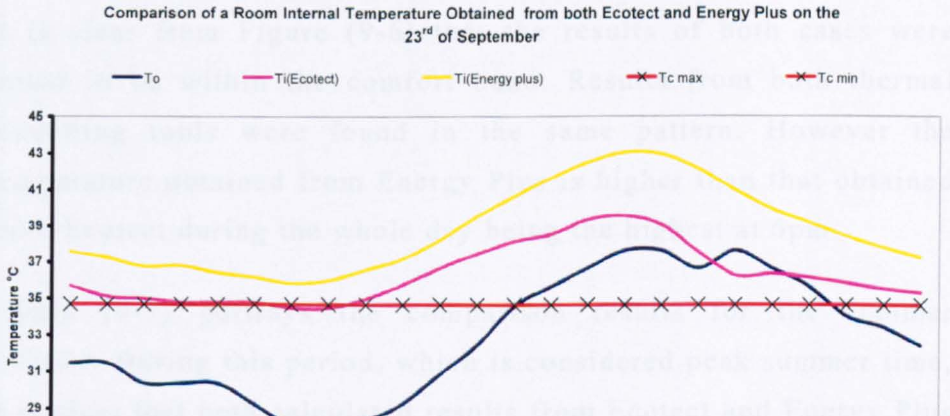

Figure 9-4: Results obtained from Ecotect and Energy Plus in autumnal equinox.

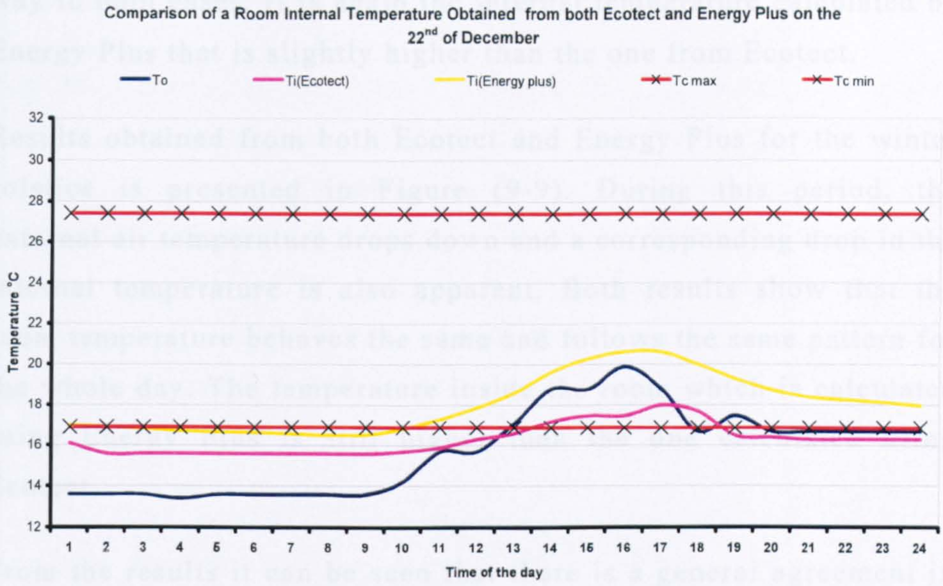

Figure 9-5 Results obtained from Ecotect and Energy Plus in winter solstice

Discussion of the simulations

It is clear from Figure (9-6) that the results of both cases were found to be within the comfort band. Results from both thermal modelling tools were found in the same pattern. However the temperature obtained from Energy Plus is higher than that obtained from Ecotect during the whole day being the highest at 6pm.

Figure (9-7) portrays the comparison results for the summer solstice. During this period, which is considered peak summer time, it is clear that both calculated results from Ecotect and Energy Plus were found to be outside the comfort band. In summer solstice, results obtained from both modelling tools were found in the same pattern but closer to each other compared with those obtained for the period during the vernal equinox.

From Figure (9-8) both calculated results are found to lie outside the comfort band and the internal temperature behaves in the same way in both cases. It is again the internal temperature calculated by Energy Plus that is slightly higher than the one from Ecotect.

Results obtained from both Ecotect and Energy Plus for the winter solstice is presented in Figure (9-9). During this period, the external air temperature drops down and a corresponding drop in the internal temperature is also apparent. Both results show that the room temperature behaves the same and follows the same pattern for the whole day. The temperature inside the room which is calculated using Energy Plus is still higher than the one calculated using Ecotect.

From the results it can be seen that there is a general agreement in the shape of the temperature profile between the results of both Ecotect and Energy Plus. The variation in results during the summer solstice, autumnal equinox and winter solstice were 3%, 6% and 9% respectively. However in the vernal equinox the disagreement reached on average 13%. It must be noted that Ecotect predicts the IDRT while Energy Plus predicts the air temperature. The IDRT is defined as:

$$T_{res} = \frac{1}{2} T_{air} + \frac{1}{2} T_{mrt}$$

Also Ecotect does not trace the sun rays into the space and thus does not fully take into account the effect of thermal mass or the increase in internal surface temperature. This is suggested by the occurrence of the difference near sunset i.e. when heat which was stored in the building elements started radiating into the space. It is also shown quite clearly by the simulations for June (where the sun is high in the sky and thus limited solar penetration) and September when the sun is lower in the sky giving more solar penetration. In June the differences between the programmes are lower than September.

2. In terms of Energy loads

For the month of the survey (August), the concrete building consumed approximately 4312.5 KWh (refer to chapter 8). The corresponding cooling load during the same month as calculated by ECOTECT was 4624.05 kWh as shown in Table (9-9) (With a variation of 7%). A 7% variation in the predicted loads is regarded as being small enough to believe that Ecotect can reasonably predict the cooling loads.

	Concrete building	
	Heating Load (KWh)	**Cooling Load (KWh)**
January	1199.84	1.94
February	548.14	0.99
March	116.67	11.11
April	2	642.31
May	2.23	2989.93
June	2.16	4128.52
July	2.23	4602.76
August	2.23	4624.05
September	2.16	3371.26
October	2.23	1656.69
November	22.38	11.31
December	1029.18	1.51
Total	2931.45	22042.38

Table 9-1: Monthly Heating and Cooling Loads for the concrete building obtained from Ecotect.

It must also be remembered that Energy Plus is a programme developed in the USA primarily for the US market and it has not been fully analysed for use in other climates and therefore there may be giving higher results. However given that the parametric analysis to be carried out will compare the performance of the various options against each other only in Ecotect, then it is felt that Ecotect gives results which are reliable.

9.3 Simulation arrangement

The concrete case study - as described in chapter seven - was simulated. This case study was introduced and drawn using the thermal modelling tool (more detail in part 9.2.1). The weather data file was then uploaded to the model to analyse thermal comfort. The outcome of the simulation will be an hourly IDRT, which can be exported to excel files for graphical interpretation and comparison

Each suggested measure was applied to the case study and simulated to obtain the best combination of materials (more details in section 9.2.2). From this simulation five recommended enhancement combinations were obtained. These recommended combinations were then simulated to calculate the resultant internal temperature and will be compared with the case study (more detail in part 9.4).

Finally the thermal modelling tool calculated the heating and cooling loads for the case study and all recommended combinations. Results of cooling loads obtained by using Ecotect for the concrete building will be also compared with the cooling load calculated during the field study (more details in 9.4.2).

9.3.1 Spatial analysis of modelled case study

The building was divided into nine separate thermal zones as shown in Figures (9-1). Only six of these zones were set to be occupied, and these were the reception, bedroom 1, bedroom 2, bedroom 3, bedroom 4 and the hall. In this way the results will only incorporate the user comfort in these zones without taking into consideration other zones such as toilets and kitchen.

Case study					
Outside wall	**Inner walls**	**Glazing**	**Shading**	**Roof**	**Height**
150mm concrete	100mm concrete	Single	Off	Off	2.6m

Table 9-2: Illustration of the case study (concrete building) parameters.

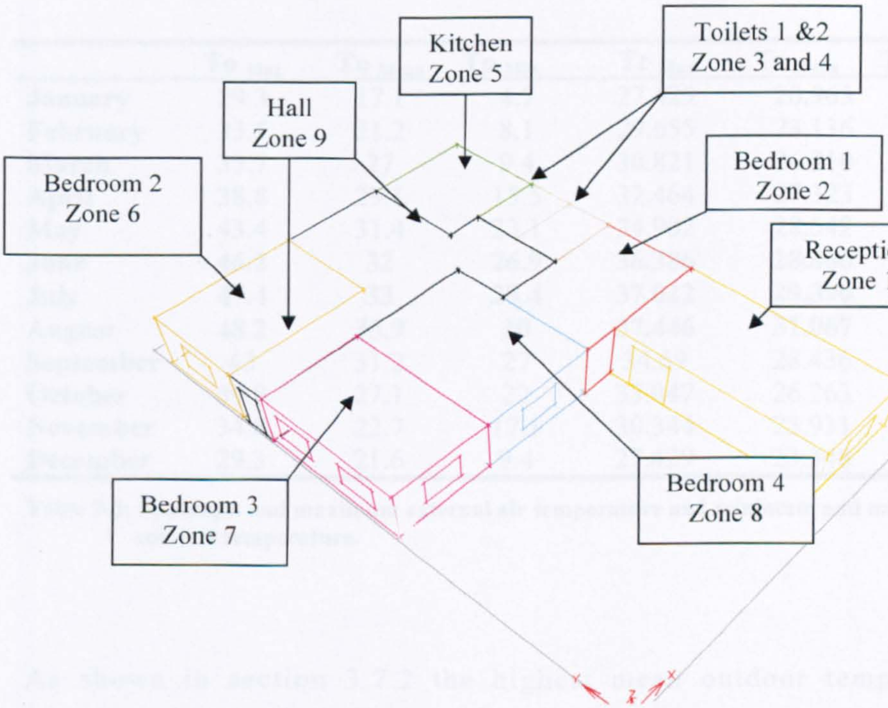

Figure 9-6: An isometric view of the base case building, by the author using Ecotect.

Table (9-2) illustrates the maximum and minimum external air temperatures and both the upper and lower comfort bands determined by Humphrey's et al adaptive model [Humphrey & Nicol, 1994] (refer to chapter 3). It can be seen that the maximum comfort band during June, July and August exceeded 35^{o}C. This model has been developed from a global field-study. It has been noted by the authors that their research will "lead to thermal comfort standards that are sympathetic to the climates and the cultures of the world and sustainable in the energy that they require" implying by such the need for further work to reach models that are more related to different climates. An example is the study by Heidari [2000] who derived a similar model for Iran to that of Humphrey's et al (refer to section 3.9.6).

	To$_{Max}$	To$_{Mean}$	To$_{Min}$	Tc$_{Max}$	Tc$_{Mean}$	Tc$_{Min}$
January	29.3	17.1	4.7	27.429	20.963	14.391
February	33.5	21.2	8.1	29.655	23.136	16.193
March	35.7	27	9.4	30.821	26.210	16.882
April	38.8	29.1	15.5	32.464	27.323	20.115
May	43.4	31.4	23.1	34.902	28.542	24.143
June	**46.2**	**32**	**26.9**	**36.386**	**28.860**	**26.157**
July	**47.4**	**33**	**28.4**	**37.022**	**29.390**	**29.072**
August	**48.2**	**33.9**	**30**	**37.446**	**31.067**	**30.768**
September	43	31.2	27	34.69	28.436	27.376
October	39.9	27.1	22	33.047	26.263	23.56
November	34.8	22.7	17.1	30.344	23.931	20.963
December	29.3	21.6	9.4	27.429	23.348	16.882

Table 9-3: Minimum and maximum external air temperature and minimum and maximum comfort temperature.

As shown in section 3.7.2 the highest mean outdoor temperature reported by Humphreys and Nicol [1994] in their global study is 34^{o}C resulting in an indoor comfort temperature of 31^{0}C. The mean outdoor temperature recorded at Seiyun approaches 34^{0}C in three months of the year (as shown in Table (9-2)), which indicates that the internal comfort temperature of 30^{0}C would be acceptable. This is backed up by the results of the study carried out in Pakistan

(Humphreys and Nicol [1994]) where the climate was similar to that of Seiyun and at indoor mean comfort temperature of 30^0C 90% of occupants felt comfortable. It is thus believed that in this case applying the adaptive model is applicable for most of the year. It is to be noted that further studies in other parts of Yemen should investigate the applicability of such model before any analysis is carried out.

9.3.2 Tested passive measures

It is important to mention that all measures tested in this study were based on two sections in this thesis. First was based on recommendations obtained from the weather tool and from Mahoney tables (chapter 7) and second was obtained from the design principles chapter (chapter 2).

The effect of 23 passive measures was investigated. Table (9-3) lists and describes the passive suggested measures. The parameters of each measure that will be introduced to the Ecotect are attached in (Appendix C).

Measure	Passive measure
m1	Outside wall 200mm concrete
m2	Outside wall 400mm concrete
m3	Outside wall 250mm mud
m4	Outside wall 500mm mud
m5	Inner walls 200mm concrete
m6	Inner walls 250mm mud
m7	Inner walls 400mm concrete
m8	Inner walls 500mm mud
m9	Outside and inner 200mm concrete
m10	Outside and inner 250mm mud
m11	Outside and inner 400mm concrete
m12	Outside and inner 500mm mud
m13	Outside 400mm concrete and inner 200mm concrete
m14	Outside 400mm concrete and inner 250mm mud
m15	Outside 500mm mud and inner 200mm concrete
m16	Outside 500mm mud and inner 250mm mud
m17	Outside double wall (500mm mud and 250mm mud with air gap of 100) and inside 250 mud
m18	Glazing is double
m19	Shading is on
m20	Shutters are on
m21	Light roof structure on top of the building
M21b	Light roof structure on top of the building with large opening on north side
m22	Spaces height is 4.5m

Table 9-4: Tested passive design measures.

From simulation results of suggested measures, five combinations were developed and earmarked for further simulation. Tables (9-4, 5, 6, 7 and 8) describe the recommended combinations.

Recommended combination 1					
Outside wall	**Inner walls**	**Glazing**	**Shading**	**Roof**	**Height**
500mm mud	250mm mud	Single	No	Wooden structure	4.5m

Table 9-5: Tested building materials in the first recommended combination

Figure (9-2) shows an isometric first recommended building.

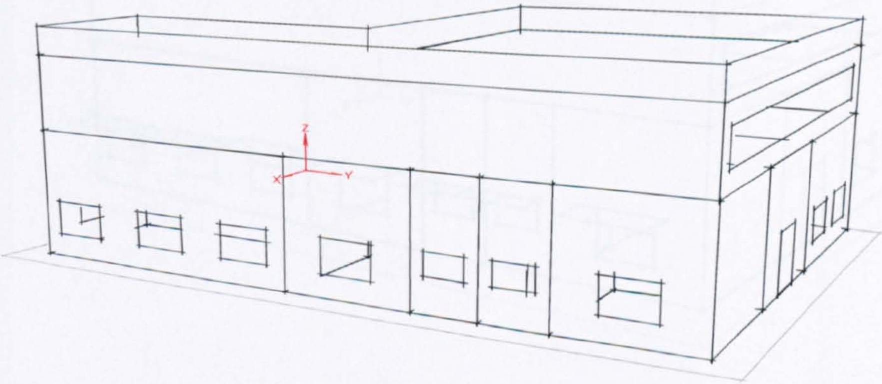

Figure 9-7: Isometric view of recommended combination one, by the author using Ecotect.

Recommended combination 2					
Outside wall	**Inner walls**	**Glazing**	**Shading**	**Roof**	**Height**
500mm mud	250mm mud	double	on	Wooden structure	4.5m

Table 9-6: Tested building materials in the second recommended combination

Figure (9-3) shows an isometric view of the second recommended combination building. Shading devices and double glazed windows are the only two elements that were added to this combination when compared with the first recommended combination.

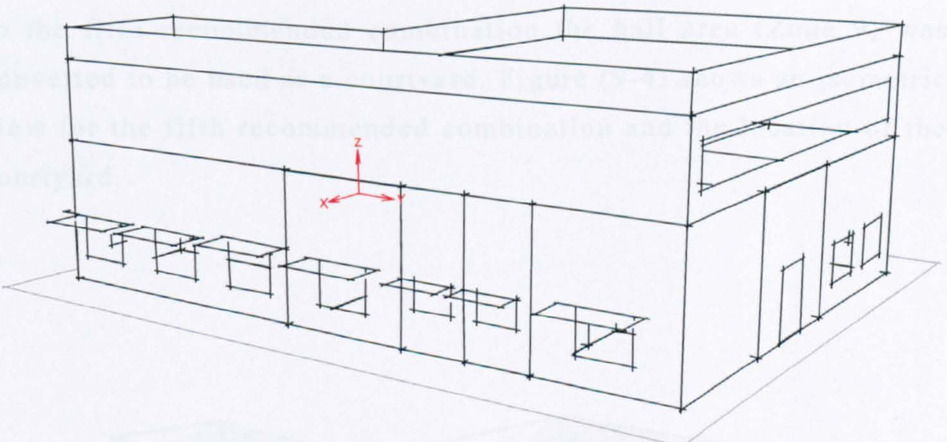

Figure 9-8: Isometric view of the recommended combination two, by the author using Ecotect.

Recommended combination 3
Same As Combination 2 but small openings at body height

Table 9-7: Recommended Combination 3

Recommended combination 4
Same As Combination 3 but high thermal mass roof used instead of wooden structure on top the buildings

Table 9-8: Recommended Combination 4

Recommended combination 5
Same As Combination 4 but the hall area was converted to a Courtyard

Table 9-9: Recommended Combination 5

In the fifth recommended combination the hall area (Zone 9) was converted to be used as a courtyard. Figure (9-4) shows an isometric view for the fifth recommended combination and the location of the courtyard.

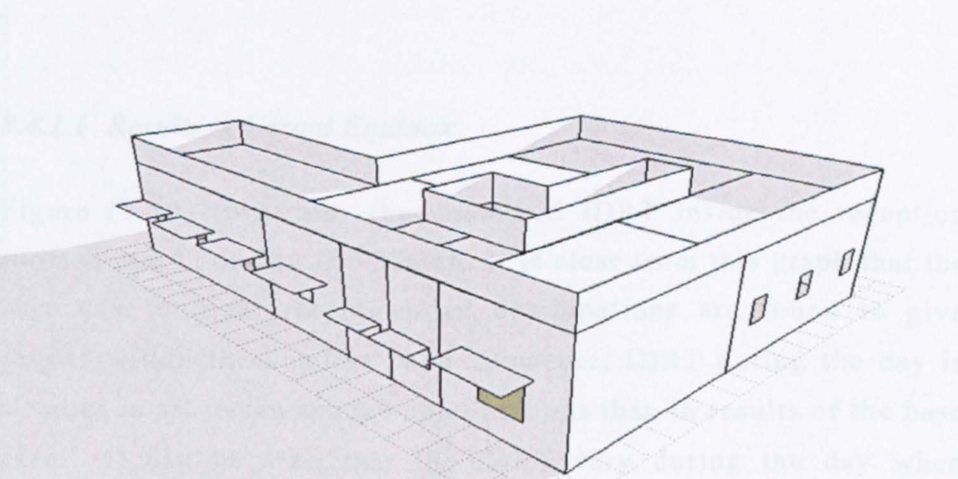

Figure 9-9: An isometric view of the recommended combination five, by the author using Ecotect.

9.4 Results and discussion

9.4.1 Internal Air Temperature

In this section both graphical and statistical analysis methods were used to draw out a conclusion to which passive combination or set of combinations are to be considered more effective inside each zone of the case study. Each graph illustrates the simulated IDRT inside each of the simulated zones without introducing any of the proposed measures (base case) and with each measure separately introduced. On the same graph the simulated internal temperatures inside the base case introduced to it one of the proposed passive combinations are presented separately (please refer to Appendix D for the raw data). This is repeated for the six zones four times of the year; vernal equinox, summer solstice, Autumnal equinox and Winter solstice. For each day the mean internal temperature and the standard deviation (SD) were reported in a table. The SD was used as an indication for the staidness of the temperature over the simulated day. One-way ANOVA test and LSD Post Hoc analysis were applied at 5% level of confidence to the data in order to compare the mean internal temperatures at each case.

9.4.1.1 Results in Vernal Equinox

Figure (9-10) illustrates the simulated IDRT inside the reception room (Zone 1) during 19th March. It is clear from this graph that the base case and all recommended combinations are found to give results within the comfort band. However, IDRT during the day is steadier in all recommended combinations than in results of the base case. It can be seen that the IDRT vary during the day when combination one was used in a similar manner as it vary when combination two was used. On the other hand, the IDRT when recommended combinations three, four and five were used were found to be almost the same throughout the whole day. It was also apparent that the IDRT in all combinations followed similar pattern as the external temperature.

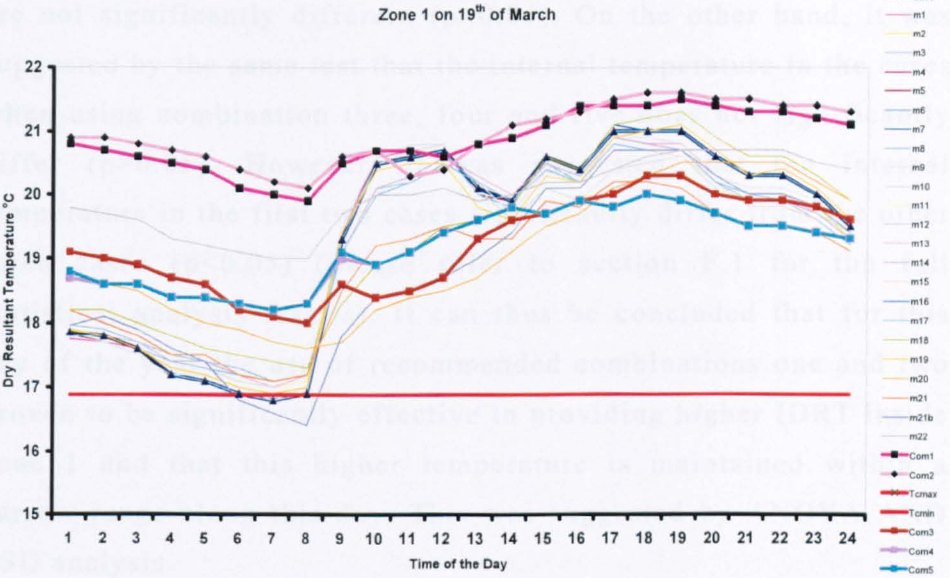

Figure 9-10: Dry resultant temperature inside the reception room in vernal equinox.

Table (9-10) illustrates the mean IDRT and the SD when each recommended combination was introduced to the base case. It is clear that the first and second recommended combinations provide a warmer internal temperature than the other three combinations with the least variation during the day.

	Recommended combinations				
	Com1	**Com2**	**Com3**	**Com4**	**Com5**
Mean	20.846	20.950	19.213	19.167	19.175
SD	0.472	0.476	0.730	0.599	0.595
No	24	24	24	24	24

Table 9-10: Mean internal dry resultant temperature and standard deviation in Zone 1 in 19th of March.

Applying the ANOVA test (F=62.46, $p<0.0005$) on the data suggested that the IDRT are significantly unequal when all five combinations were introduced to the base case. Applying the LSD Pot Hoc test (a=0.05) on the same data suggested that in the cases of introducing combination one and two the internal temperatures are not significantly different ($p>0.05$). On the other hand, it was suggested by the same test that the internal temperature in the cases when using combination three, four and five does not significantly differ ($p>0.05$). However, it was suggested that the internal temperature in the first two cases significantly differ from the other three cases ($p<0.05$) (please refer to section F.1 for the full statistical analysis results). It can thus be concluded that for this day of the year the use of recommended combinations one and two proven to be significantly effective in providing higher IDRT inside zone 1 and that this higher temperature is maintained within a narrow range along this day. This was suggested by ANOVA AND LSD analysis.

Figure (9-11) illustrates the IDRT in Bedroom 1 (Zone 2). In this zone, IDRT is steadier for all of the recommended combinations during the day than in the purely concrete building. The recommended combinations provide the occupants with lower IDRT than the concrete building during the peak external air temperature times. The recommended combination three was found to be warmer during night

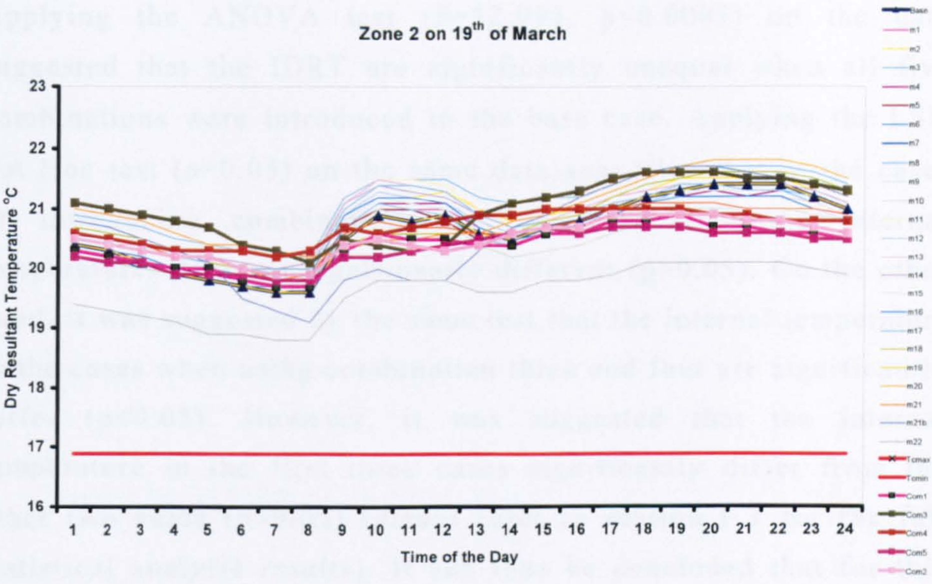

Figure 9-11: Dry resultant temperature inside the bedroom 1 in vernal equinox.

From table (9-11) it is clear that the third and fourth recommended combinations provide a warmer internal temperature than the other three combinations. The lowest SD was found in the fourth recommended combination during the day.

	Recommended combinations				
	Com1	Com2	Com3	Com4	Com5
Mean	20.388	20.496	20.975	20.696	20.338
SD	0.348	0.311	0.488	0.271	0.315
n	24	24	24	24	24

Table 9-11: Mean internal dry resultant temperature and standard deviation in Zone 2 in 19th of March

Applying the ANOVA test (F=12.991, $p<0.0005$) on the data suggested that the IDRT are significantly unequal when all five combinations were introduced to the base case. Applying the LSD Pot Hoc test (a=0.05) on the same data suggested that in the cases of introducing combination one, two and five the internal temperatures does not significantly different ($p>0.05$). On the other hand, it was suggested by the same test that the internal temperature in the cases when using combination three and four are significantly differ ($p<0.05$). However, it was suggested that the internal temperature in the first three cases significantly differ from the other two cases ($p<0.05$) (please refer to section F.1 for the full statistical analysis results). It can thus be concluded that for this day of the year the use of recommended combination three and four proven to be significantly effective in providing higher IDRT inside zone 2 and that this higher temperature is maintained within a narrow range along this day when the fourth recommended combination was used.

Figure (9-12) shows the IDRT inside bedroom 2 (Zone 6). The IDRT in this zone is different from the previous zones. Variation between minimum and maximum internal temperature during the day is high and reaches a difference of approximately 5 ^{o}C during the day in the concrete building while it reaches 4^{o}C in the recommended combinations one and two. The recommended combinations three, four and five are steadier and the fifth recommended combination provides the best IDRT during the whole day.

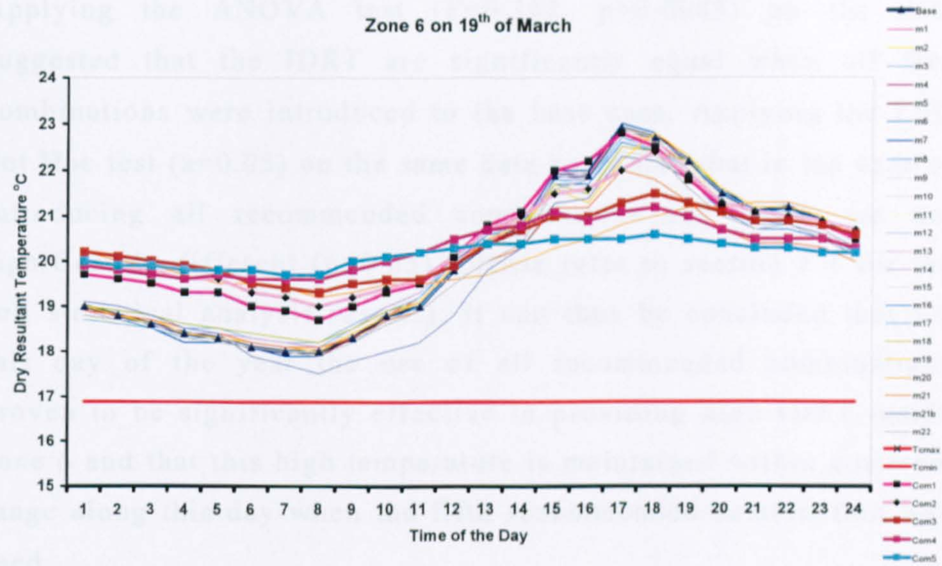

Figure 9-12: Dry resultant temperature inside the bedroom 2 in vernal equinox.

Table (9-12) shows that the mean IDRT ranges almost the same in all recommended combinations and there is no significant difference in IDRT between all recommended combinations. The lowest SD was found in the fifth recommended combination during the day.

	Recommended combinations				
	Com1	Com2	Com3	Com4	Com5
Mean	20.392	20.442	20.346	20.304	20.167
SD	1.241	1.019	0.692	0.556	0.287
No	24	24	24	24	24

Table 9-12: Mean internal dry resultant temperature and standard deviation in Zone 6 in 19th of March

Applying the ANOVA test (F=0.382, p>0.0005) on the data suggested that the IDRT are significantly equal when all five combinations were introduced to the base case. Applying the LSD Pot Hoc test (a=0.05) on the same data suggested that in the case of introducing all recommended combinations the IDRT are not significantly different (p>0.05) (please refer to section F.1 for the full statistical analysis results). It can thus be concluded that for this day of the year the use of all recommended combinations proven to be significantly effective in providing high IDRT inside zone 6 and that this high temperature is maintained within a narrow range along this day when the fifth recommended combination was used.

The IDRT in bedroom 3 (Zone 7) is shown in Figure (9-13). In this zone all recommended combinations provide a better IDRT than the concrete building. Variation in the internal temperature during the day in the concrete building is high and reaches differences of 6 °C. This high difference in internal temperature causes occupants significant discomfort during the day. All recommended combinations are steadier than the concrete building but the fourth and fifth recommended combinations show the most stability among all recommended combinations.

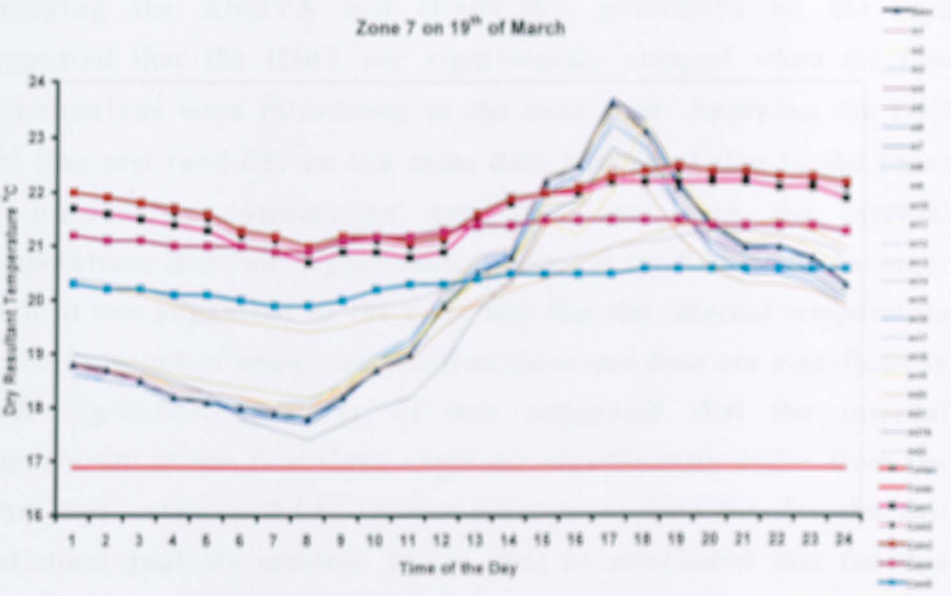

Figure 9-13: Dry resultant temperature inside the bedroom 3 in vernal equinox.

From table (9-13) it is clear that the second and third recommended combinations provide a warmer internal temperature than the other three combinations. The lowest SD during the day was found when the fourth recommended combination was used.

	Recommended combinations				
	Com1	Com2	Com3	Com4	Com5
Mean	21.583	21.750	21.817	21.258	20.338
SD	0.539	0.508	0.492	0.204	0.245
No	24	24	24	24	24

Table 9-13: Mean internal dry resultant temperature and standard deviation in Zone 7 in 19th of March

Applying the ANOVA test ($F=49.285$, $p<0.0005$) on the data suggested that the IDRT are significantly unequal when all five combinations were introduced to the base case. Applying the LSD Pot Hoc test ($a=0.05$) on the same data suggested that in the cases of introducing combination one, two and three the internal temperatures does not significantly different ($p>0.05$). On the other hand, it was suggested by the same test that the internal temperature in the cases when using combination three and four are significantly differ ($p<0.05$). However, it was suggested that the internal temperature in the first three cases are significantly differ from the other two cases ($p<0.05$) (please refer to section F.1 for the full statistical analysis results). It can thus be concluded that for this day of the year the use of recommended combination one, two and three proven to be significantly effective in providing higher IDRT inside zone 7 and that this higher temperature is maintained within a narrow range along this day when the third recommended combination was used.

In bedroom 4 (Zone 8) the IDRT is steadier throughout the whole day (Figure 9-14) in the concrete building and all recommended combinations. The first and second recommended combinations recorded almost the same IDRT for this zone and were warmer than the concrete building for the whole day. Recommended combinations four and five were found to have superior stability than the others.

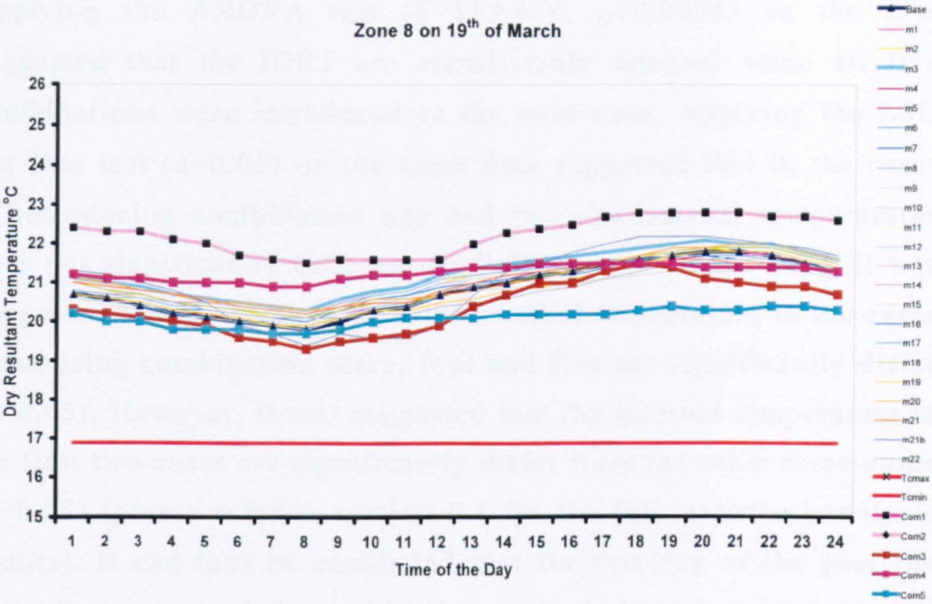

Figure 9-14: Dry resultant temperature inside the bedroom 4 in vernal equinox

From table (9-14) it is clear that the first and second recommended combinations provide a warmer internal temperature than the other three combinations while the lowest SD was found when the fourth recommended combination was used.

	Recommended combinations				
	Com1	Com2	Com3	Com4	Com5
Mean	22.225	22.225	20.396	21.258	20.096
SD	0.474	0.474	0.681	0.204	0.227
No	24	24	24	24	24

Table 9-14: Mean internal dry resultant temperature and standard deviation in Zone 8 in 19th of March

Applying the ANOVA test (F=115.409, p<0.0005) on the data suggested that the IDRT are significantly unequal when all five combinations were introduced to the base case. Applying the LSD Pot Hoc test (a=0.05) on the same data suggested that in the cases of introducing combination one and two the internal temperatures does not significantly different (p>0.05). On the other hand, it was suggested by the same test that the internal temperature in the cases when using combination three, four and five are significantly differ (p<0.05). However, it was suggested that the internal temperature in the first two cases are significantly differ from the other three cases (p<0.05) (please refer to section F.1 for the full statistical analysis results). It can thus be concluded that for this day of the year the use of recommended combination one and two proven to be significantly effective in providing higher IDRT inside zone 8 and that this higher temperature is not maintained within a narrow range along this day.

In the hall area (Zone 9) the recommended combination five will not be shown in Figure (9-15) since this zone was converted to be used as a courtyard. Recommended combinations one and two provided for a warmer environment while the fourth recommended combination was the steadiest.

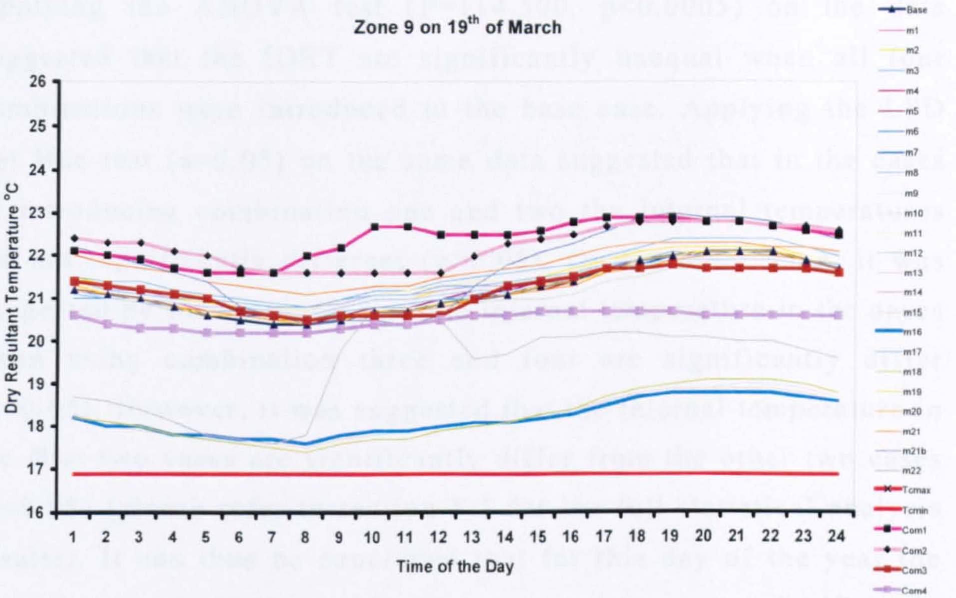

Figure 9-15: Dry resultant temperature inside the hall area in vernal equinox

From table (9-15) it is clear that the first and second recommended combinations provide a warmer internal temperature than the other three combinations. The lowest variation during the day was found when fourth recommended combination was used.

	Recommended combinations			
	Com1	**Com2**	**Com3**	**Com4**
Mean	22.379	22.229	21.208	20.488
SD	0.453	0.468	0.459	0.185
No	24	24	24	24

Table 9-15: Mean internal dry resultant temperature and standard deviation in Zone 9 in 19th of March

Applying the ANOVA test ($F=114.500$, $p<0.0005$) on the data suggested that the IDRT are significantly unequal when all four combinations were introduced to the base case. Applying the LSD Pot Hoc test ($a=0.05$) on the same data suggested that in the cases of introducing combination one and two the internal temperatures are not significantly different ($p>0.05$). On the other hand, it was suggested by the same test that the internal temperature in the cases when using combination three and four are significantly differ ($p<0.05$). However, it was suggested that the internal temperature in the first two cases are significantly differ from the other two cases ($p<0.05$) (please refer to section F.1 for the full statistical analysis results). It can thus be concluded that for this day of the year the use of recommended combination one proven to be significantly effective in providing higher IDRT inside zone 9 and that this higher temperature is maintained within the narrowest range along this day.

For each zone the combination, which has its internal temperature inside the comfort band for most of the time and provide better IDRT with low range in mean IDRT was chosen as the best combination for this zone from the thermal comfort and statistical point of views. The combination which results in a greater comfort factor for the building as a whole was chosen to be the best combination on average for this season.

Table (9-10) is a matrix that illustrates the discussed results in vernal equinox. The best combination for the remaining three seasons was found in the same manner.

	Recommended combinations				
	C1	C2	C3	C4	C5
Zone 1	x	x			
Zone 2			x	x	
Zone 6					x
Zone 7			x		
Zone 8	x	x			
Zone 9	x	x			
Decision	X	X			

Table 9-16: The best recommended combination for each zone during the Vernal Equinox

It can be seen from the above table that the first and second recommended combinations were found to be the best combinations on average during the vernal equinox.

9.4.1.2 Results in Summer Solstice

The summer solstice occurs on the 21st of June. The external air temperature for this month is high and it is considered as a summer period. The influences of recommended combinations of passive design elements show a significant difference in internal temperature than for the concrete building study. The heat penetration are varied for different zones and also varied from the concrete building reaction to the simulation of the recommended combinations.

Figure (9-16) shows the IDRT in the reception area (Zone 1) on the 21st of June. The recommended combinations one, two and three are inside the comfort band from the early hours of the day until 1 pm while the concrete building results are outside the comfort band most of the day. The IDRT of the concrete building is not steady and quickly increases just after sunrise. It can be said that the simulated buildings implementing the recommended combinations display a steady increase according to the external air temperature through out the day. Recommended combinations four and five were found to be within inside the comfort range for the whole of the day.

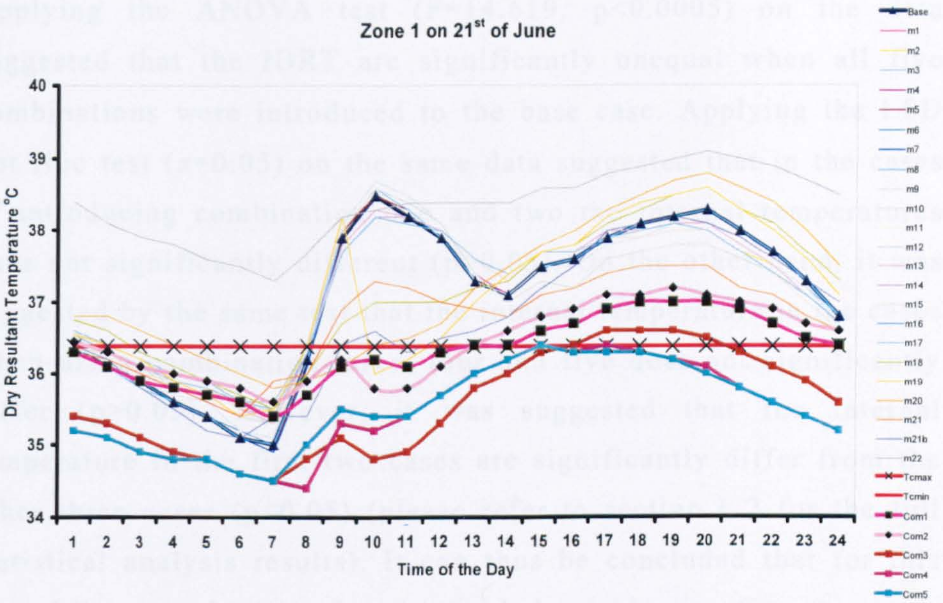

Figure 9-16: Dry resultant temperature inside the reception room in summer solstice

Table (9-17) illustrates the mean IDRT and the SD when each recommended combination was introduced to the base case. It is clear that the fourth and fifth recommended combinations provide a cooler internal temperature than the other three combinations with the least variation during the day when the fifth recommended combination was used.

	Recommended combinations				
	Com1	Com2	Com3	Com4	Com5
Mean	36.321	36.431	35.592	35.492	35.525
SD	0.476	0.506	0.716	0.642	0.594
No	24	24	24	24	24

Table 9-17: Mean internal dry resultant temperature and standard deviation in Zone 1 in 21st of June.

Applying the ANOVA test ($F=14.619$, $p<0.0005$) on the data suggested that the IDRT are significantly unequal when all five combinations were introduced to the base case. Applying the LSD Pot Hoc test ($a=0.05$) on the same data suggested that in the cases of introducing combination one and two the internal temperatures does not significantly different ($p>0.05$). On the other hand, it was suggested by the same test that the internal temperature in the cases when using combination three, four and five does not significantly differ ($p>0.05$). However, it was suggested that the internal temperature in the first two cases are significantly differ from the other three cases ($p<0.05$) (please refer to section F.2 for the full statistical analysis results). It can thus be concluded that for this day of the year the use of recommended combination five proven to be significantly effective in providing lower IDRT inside zone 1 and that this lower temperature is maintained within a narrow range along this day.

In all of the simulated recommended combinations and the concrete building, bedroom 2 (zone 2) was found to be outside of the comfort band (Figure 9-17). Although the recommended combinations are closer to the upper comfort band and this demonstrates that there is an influence from using the thermal mass and other passive means of temperature manipulation. The IDRT increased in all simulated buildings just after the sun rise. The recommended combinations four and five provided the most stable results among all and did not exceed $1^{o}C$ difference between the maximum and lower IDRT.

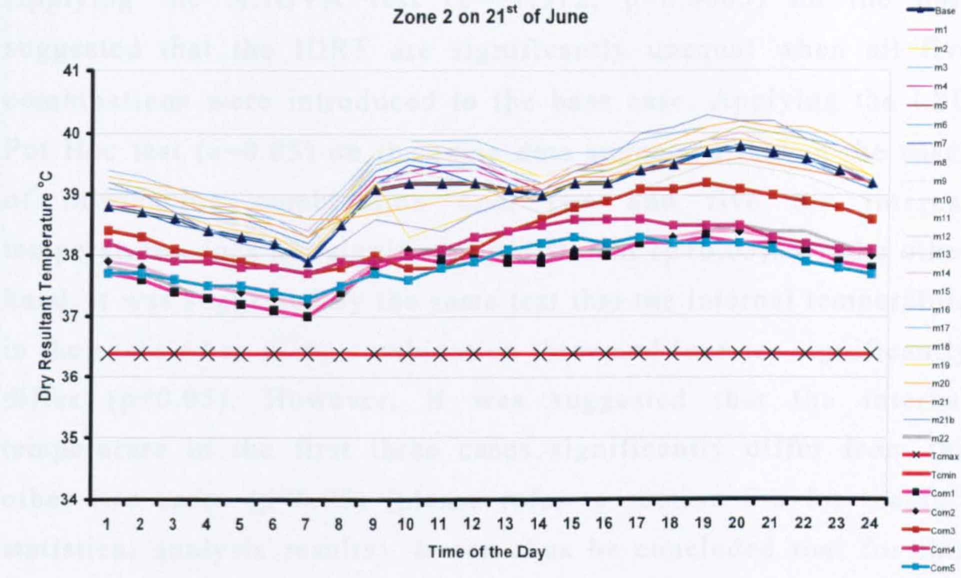

Figure 9-17: Dry resultant temperature inside the bedroom 1 in summer solstice

From table (9-18) it is clear that the first and fifth recommended combinations provide a cooler internal temperature than the other three combinations with the least variation during the day when the fifth recommended combination was used.

	Recommended combinations				
	Com1	**Com2**	**Com3**	**Com4**	**Com5**
Mean	37.796	37.942	38.425	38.183	37.850
SD	0.378	0.351	0.513	0.290	0.312
No	24	24	24	24	24

Table 9-18: Mean internal dry resultant temperature and standard deviation in Zone 2 in 21st of June.

Applying the ANOVA test ($F=11.572$, $p<0.0005$) on the data suggested that the IDRT are significantly unequal when all five combinations were introduced to the base case. Applying the LSD Pot Hoc test ($a=0.05$) on the same data suggested that in the cases of introducing combination one, two and five the internal temperatures does not significantly different ($p>0.05$). On the other hand, it was suggested by the same test that the internal temperature in the cases when using combination three and four are significantly differ ($p<0.05$). However, it was suggested that the internal temperature in the first three cases significantly differ from the other two cases ($p<0.05$) (please refer to section F.2 for the full statistical analysis results). It can thus be concluded that for this day of the year the use of recommended combination five proven to be significantly effective in providing low IDRT inside zone 2 and that this lower temperature is maintained within a narrow range along this day.

Bedroom 3 (Zone 6) indicates better results than bedroom 1. Figure (9-18) shows that the recommended combinations one and two are within the comfort range from 5am until noon while the concrete building is outside the comfort range for the whole of the day. The IDRT increased for both recommended combinations one and two as soon as the external air temperature increased and surpassed the other three recommended combinations. The fifth recommended combination was the most stable among all other recommended combinations and did not exceed $1^{o}C$ above the maximum comfort temperature. The increase in the internal temperature of all buildings within this zone starts in noon time. The late increase in internal temperature can be attributed to the fact that this zone has a northerly orientation.

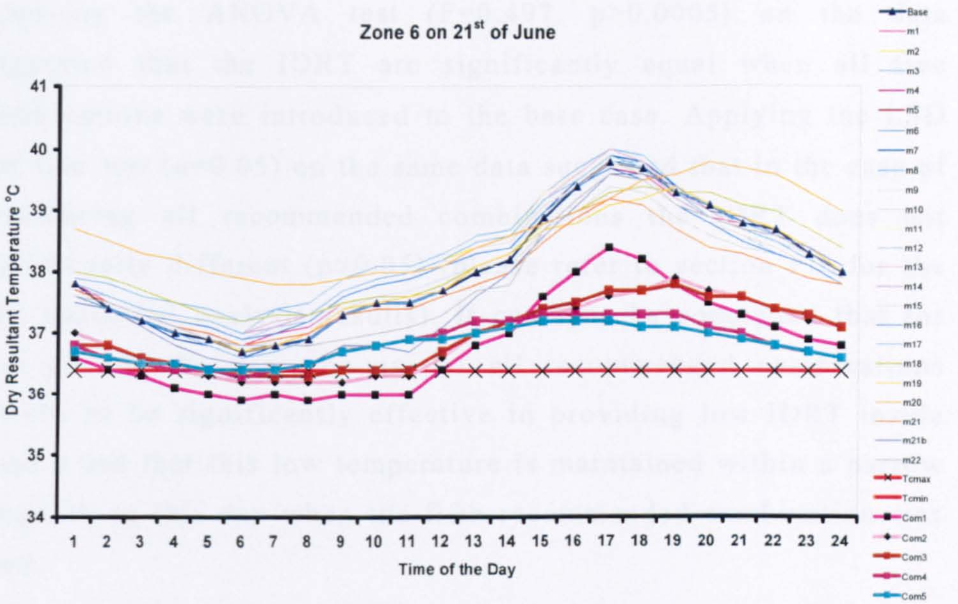

Figure 9-18: Dry resultant temperature inside the bedroom 2 in summer solstice

From table (9-19) it is clear that the first and fifth recommended combinations provide a cooler internal temperature than the other three combinations with the least variation during the day when the fifth recommended combination was used.

	Recommended combinations				
	Com1	**Com2**	**Com3**	**Com4**	**Com5**
Mean	36.792	36.925	36.967	36.850	36.800
SD	0.791	0.576	0.532	0.343	0.273
No	24	24	24	24	24

Table 9-19: Mean internal dry resultant temperature and standard deviation in Zone 6 in 21st of June.

Applying the ANOVA test (F=0.497, p>0.0005) on the data suggested that the IDRT are significantly equal when all five combinations were introduced to the base case. Applying the LSD Pot Hoc test (a=0.05) on the same data suggested that in the case of introducing all recommended combinations the IDRT does not significantly different (p>0.05) (please refer to section F.2 for the full statistical analysis results). It can thus be concluded that for this day of the year the use of all recommended combinations proven to be significantly effective in providing low IDRT inside zone 6 and that this low temperature is maintained within a narrow range along this day when the fifth recommended combination was used.

In bedroom 3 (Zone 7) the concrete building and recommended combinations one, two, three and four outside the comfort range while the fifth recommended combination is the only one found to be within the comfort zone (9-19). The concrete building responded similarly to zone 6 while the recommended combinations had an improved responds and were found closer to the comfort band. During the period that the concrete building registered the highest internal temperature, the recommended combinations recorded internal temperatures of 36.2°C and 38°C. The internal heat penetration of the recommended combinations is more stable than the concrete building throughout the whole of the day.

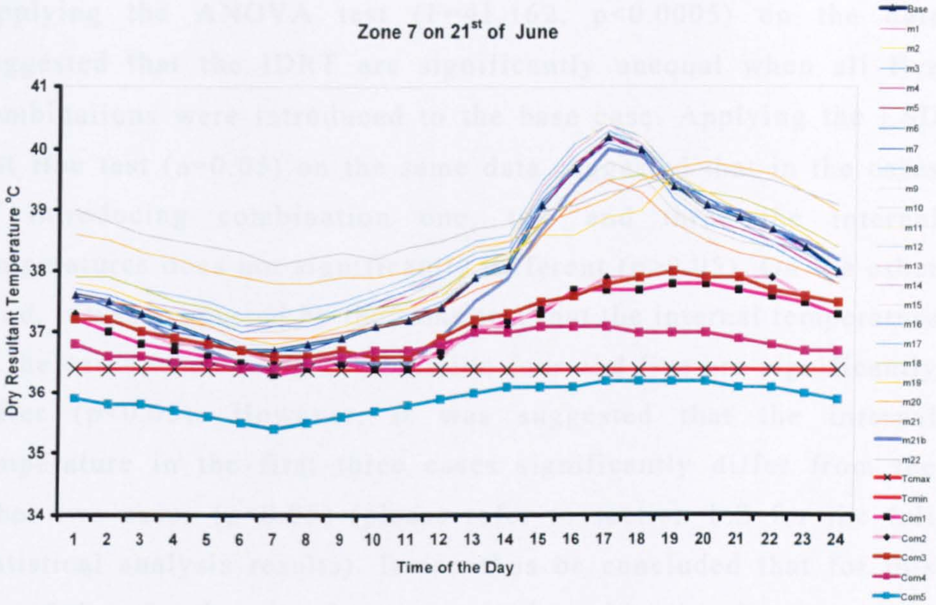

Figure 9-19: Dry resultant temperature inside the bedroom 3 in summer solstice

From table (9-20) it is clear that the fifth recommended combination provide a cooler internal temperature than the other four combinations with the least variation during the day.

	Recommended combinations				
	Com1	**Com2**	**Com3**	**Com4**	**Com5**
Mean	37.075	37.213	37.238	36.771	35.892
SD	0.529	0.530	0.490	0.229	0.250
No	24	24	24	24	24

Table 9-20: Mean internal dry resultant temperature and standard deviation in Zone 7 in 21st of June.

Applying the ANOVA test ($F=41.162$, $p<0.0005$) on the data suggested that the IDRT are significantly unequal when all five combinations were introduced to the base case. Applying the LSD Pot Hoc test ($a=0.05$) on the same data suggested that in the cases of introducing combination one, two and three the internal temperatures does not significantly different ($p>0.05$). On the other hand, it was suggested by the same test that the internal temperature in the cases when using combination four and five are significantly differ ($p<0.05$). However, it was suggested that the internal temperature in the first three cases significantly differ from the other two cases ($p<0.05$) (please refer to section F.2 for the full statistical analysis results). It can thus be concluded that for this day of the year the use of recommended combination five proven to be significantly effective in providing lower IDRT inside zone 7 and that this lower temperature is maintained within a narrow range along this day.

The IDRT in bedroom 4 (Zone 8) is shown in Figure (9-20). The concrete building and all recommended combinations were not found within the comfort band and recorded a steady increase in the internal temperature. Recommended combinations three, four and five are closer to the comfort band but the fifth recommended combination is the closest to the maximum comfort temperature. When the concrete building reaches its maximum internal temperature of 41.1 ^{o}C the recommended combinations reach their maximum temperature ranging from 37^{o}C for the fifth recommended combination and 39.3 ^{o}C for the first and second recommended combinations.

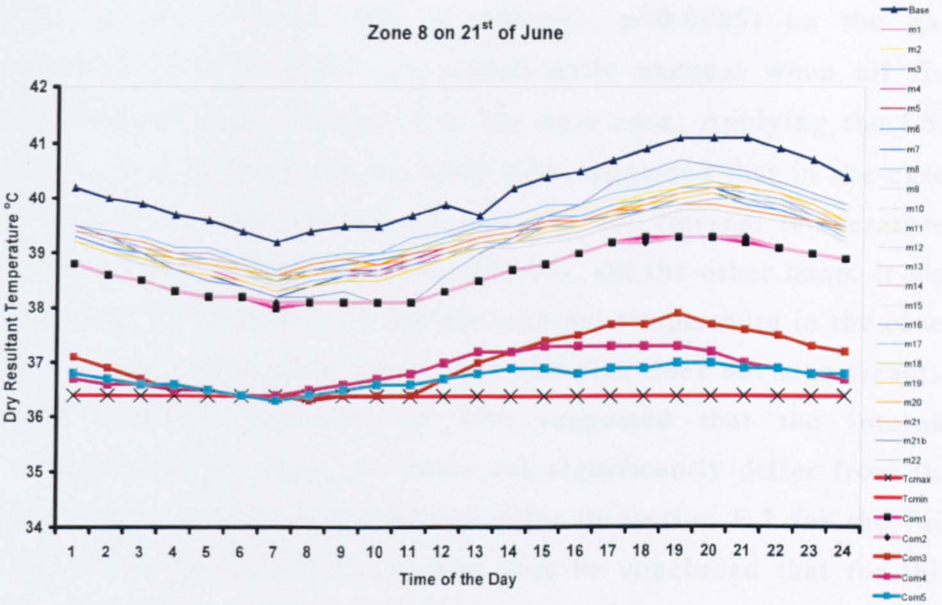

Figure 9-20: Dry resultant temperature inside the bedroom 4 in summer solstice

From table (9-21) it is clear that the fifth recommended combination provide a cooler internal temperature than the other four combinations with the least variation during the day.

	Recommended combinations				
	Com1	**Com2**	**Com3**	**Com4**	**Com5**
Mean	38.650	38.654	37.017	36.867	36.721
SD	0.455	0.449	0.530	0.327	0.200
No	24	24	24	24	24

Table 9-21: Mean internal dry resultant temperature and standard deviation in Zone 8 in 21st of June.

Applying the ANOVA test (F=138.643, $p<0.0005$) on the data suggested that the IDRT are significantly unequal when all five combinations were introduced to the base case. Applying the LSD Pot Hoc test (a=0.05) on the same data suggested that in the cases of introducing combination one and two the internal temperatures does not significantly different ($p>0.05$). On the other hand, it was suggested by the same test that the internal temperature in the cases when using combination three, four and five does not significantly differ ($p>0.05$). However, it was suggested that the internal temperature in the first two cases are significantly differ from the other three cases ($p<0.05$) (please refer to section F.2 for the full statistical analysis results). It can thus be concluded that for this day of the year the use of recommended combination five proven to be significantly effective in providing lower IDRT inside zone 1 and that this lower temperature is maintained within a narrow range along this day.

Figure (9-21) shows the internal temperature in the hall area (Zone 9) for the concrete building and all recommended combinations. The recommended combinations one and two registered a better resultant internal dry temperature compared with the concrete building and other recommended combinations. They were found to indicate results closest to the maximum comfort temperature while the rest of the recommended combinations were outside the comfort range.

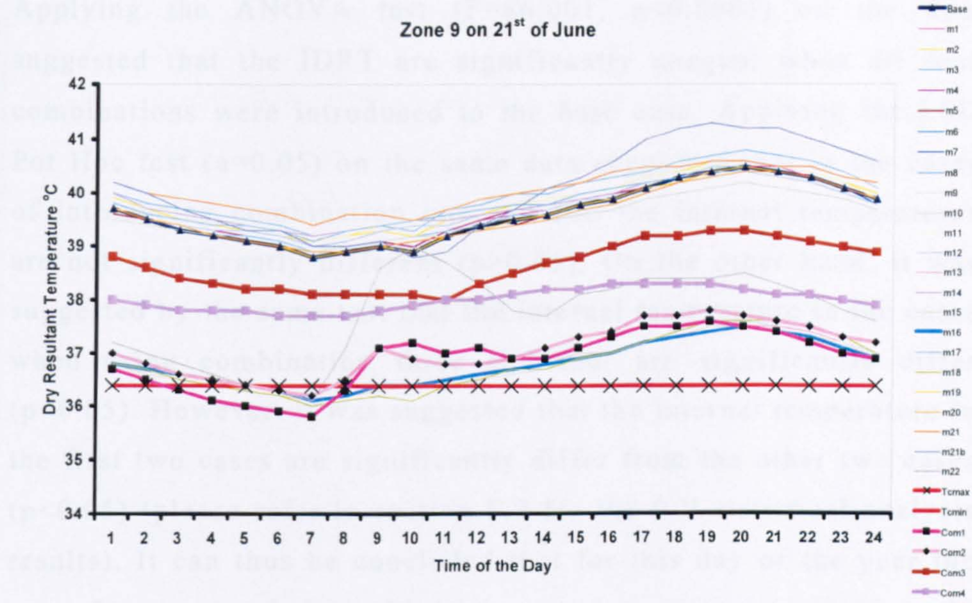

Figure 9-21: Dry resultant temperature inside the hall area in summer solstice

From table (9-22) it is clear that the first recommended combination provide a cooler internal temperature than the other three combinations while the least variation during the day was found when the fifth recommended combination was used.

	Recommended combinations			
	Com1	Com2	Com3	Com4
Mean	36.867	37.046	38.642	38.004
SD	0.546	0.483	0.451	0.205
No	24	24	24	24

Table 9-22: Mean internal dry resultant temperature and standard deviation in Zone 9 in 21st of June.

Applying the ANOVA test (F=86.001, p<0.0005) on the data suggested that the IDRT are significantly unequal when all four combinations were introduced to the base case. Applying the LSD Pot Hoc test (a=0.05) on the same data suggested that in the cases of introducing combination one and two the internal temperatures are not significantly different (p>0.05). On the other hand, it was suggested by the same test that the internal temperature in the cases when using combination three and four are significantly differ (p<0.05). However, it was suggested that the internal temperature in the first two cases are significantly differ from the other two cases (p<0.05) (please refer to section F.2 for the full statistical analysis results). It can thus be concluded that for this day of the year the use of recommended combination one proven to be significantly effective in providing lower IDRT inside zone 9 and that this lower temperature is not maintained within the narrowest range along this day.

Table (9-23) is a matrix that illustrates the discussed results in summer solstice.

	Recommended combinations				
	C1	**C2**	**C3**	**C4**	**C5**
Zone 1					x
Zone 2					x
Zone 6					x
Zone 7					x
Zone 8					x
Zone 9	x				
Decision					X

Table 9-23: The best recommended combination for the Summer Solstice.

It can be seen from the above table that the fifth recommended combination was found to be the best combination on average during the summer solstice.

9.4.1.3 *Results in Autumnal Equinox*

The autumnal equinox occurs on the 23rd of September. External air temperature during this month is still high but less than during the summer solstice. The recommended combinations provide better IDRT in this solstice than the previous one. They are found within the comfort band most of the time and in most of the zones.

In the reception area (Zone 1), the recommended combinations provide results which were found to be within the comfort band with varied IDRT Figure (9-22). A steady heat penetration was found in all recommended combinations throughout the day while a sudden increase of 3 °C is found in the concrete building between the hours 8am to 10am. The fourth and fifth recommended combinations registered similar and provided the lowest IDRT.

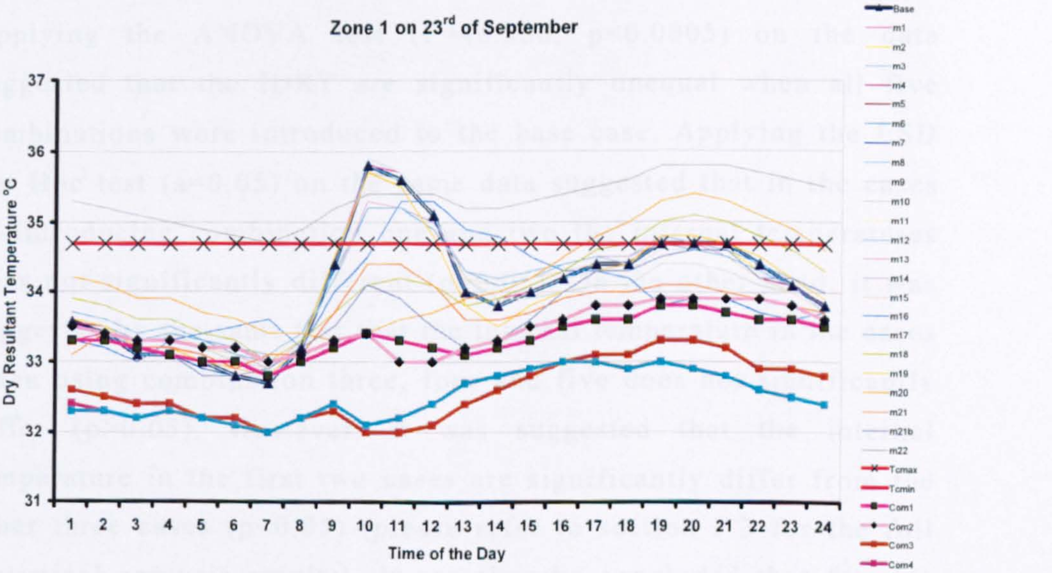

Figure 9-22: Dry resultant temperature inside the reception room in autumnal equinox

From Table (9-24) it is clear that the third, fourth and fifth recommended combinations provide a cooler internal temperature than the other two combinations with the least variation during the day when the fourth and fifth recommended combinations were used.

	Recommended combinations				
	Com1	**Com2**	**Com3**	**Com4**	**Com5**
Mean	33.338	33.454	32.596	32.513	32.508
SD	0.273	0.312	0.432	0.330	0.332
No	24	24	24	24	24

Table 9-24: Mean internal dry resultant temperature and standard deviation in Zone 1 in 23rd of September.

Applying the ANOVA test (F=46.358, $p<0.0005$) on the data suggested that the IDRT are significantly unequal when all five combinations were introduced to the base case. Applying the LSD Pot Hoc test (a=0.05) on the same data suggested that in the cases of introducing combination one and two the internal temperatures does not significantly different ($p>0.05$). On the other hand, it was suggested by the same test that the internal temperature in the cases when using combination three, four and five does not significantly differ ($p>0.05$). However, it was suggested that the internal temperature in the first two cases are significantly differ from the other three cases ($p<0.05$) (please refer to section F.3 for the full statistical analysis results). It can thus be concluded that for this day of the year the use of recommended combination five proven to be significantly effective in providing lower IDRT inside zone 1 and that this lower temperature is maintained within a narrow range along this day.

Figure (9-23) shows the simulation results of the IDRT in bedroom1 (Zone 2). The recommended combinations one, two and five are found within the comfort range for almost seven hours and are just above the maximum comfort temperature for the rest of the day. The concrete building doses not fall within the range of the maximum comfort temperature for the whole day. The internal heat penetration is varied in all simulated buildings.

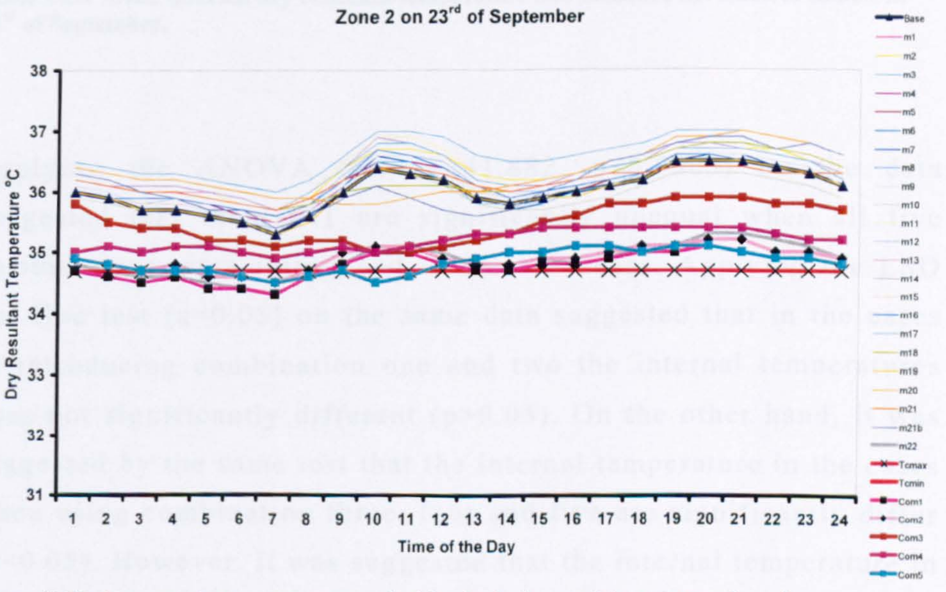

Figure 9-23: Dry resultant temperature inside the bedroom 1 in autumnal equinox.

From Table (9-25) it is clear that the first recommended combinations provide a cooler internal temperature than the other four combinations with the least variation during the day.

	Recommended combinations				
	Com1	**Com2**	**Com3**	**Com4**	**Com5**
Mean	20.846	20.950	19.213	19.167	19.175
SD	0.472	0.476	0.730	0.599	0.595
No	24	24	24	24	24

Table 9-25: Mean internal dry resultant temperature and standard deviation in Zone 2 in 23rd of September.

Applying the ANOVA test ($F=41.882$, $p<0.0005$) on the data suggested that the IDRT are significantly unequal when all five combinations were introduced to the base case. Applying the LSD Pot Hoc test ($a=0.05$) on the same data suggested that in the cases of introducing combination one and two the internal temperatures does not significantly different ($p>0.05$). On the other hand, it was suggested by the same test that the internal temperature in the cases when using combination three, four and five are significantly differ ($p<0.05$). However, it was suggested that the internal temperature in the first two cases are significantly differ from the other three cases ($p<0.05$) (please refer to section F.3 for the full statistical analysis results). It can thus be concluded that for this day of the year the use of recommended combination one proven to be significantly effective in providing lower IDRT inside zone 2 and that this lower temperature is maintained within a narrow range along this day.

In bedroom 2 (Zone 6) the third, fourth and fifth recommended combinations were found to conform to the perceived comfort band while the first and second recommended combinations were not within the comfort range from 3:30 pm until 6pm. The fourth and fifth recommended combinations indicate the most stable results for the IDRT among all other recommended combinations (Figure 9-24).

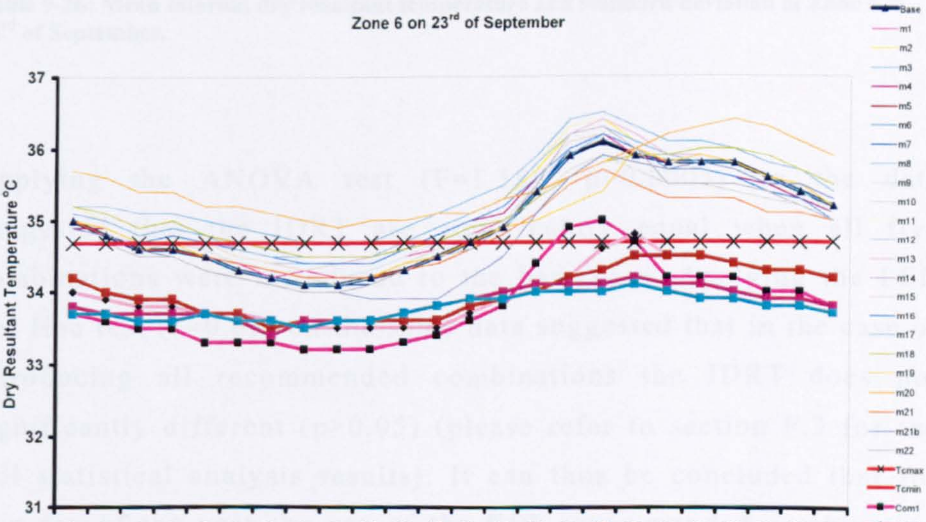

Figure 9-24: Dry resultant temperature inside the bedroom 2 in autumnal equinox

From table (9-26) it is clear that the fifth recommended combination provides a cooler internal temperature than the other four combinations with the least variation during the day.

	Recommended combinations				
	Com1	**Com2**	**Com3**	**Com4**	**Com5**
Mean	33.804	33.975	33.992	33.838	33.779
SD	0.547	0.400	0.336	0.214	0.169
No	24	24	24	24	24

Table 9-26: Mean internal dry resultant temperature and standard deviation in Zone 6 in 23rd of September.

Applying the ANOVA test (F=1.186, p>0.0005) on the data suggested that the IDRT are significantly equal when all five combinations were introduced to the base case. Applying the LSD Pot Hoc test (a=0.05) on the same data suggested that in the case of introducing all recommended combinations the IDRT does not significantly different (p>0.05) (please refer to section F.3 for the full statistical analysis results). It can thus be concluded that for this day of the year the use of the fifth recommended combination proven to be significantly effective in providing low IDRT inside zone 6 and that this lower temperature is maintained within a narrow range along this day.

The IDRT in bedroom 3 (Zone 7) gave better results than the previous zone in all recommended combinations (Figure 9-25). During the period when the concrete building was outside the comfort band from 12pm onwards, all recommended combinations were found within the comfort band for the whole day.

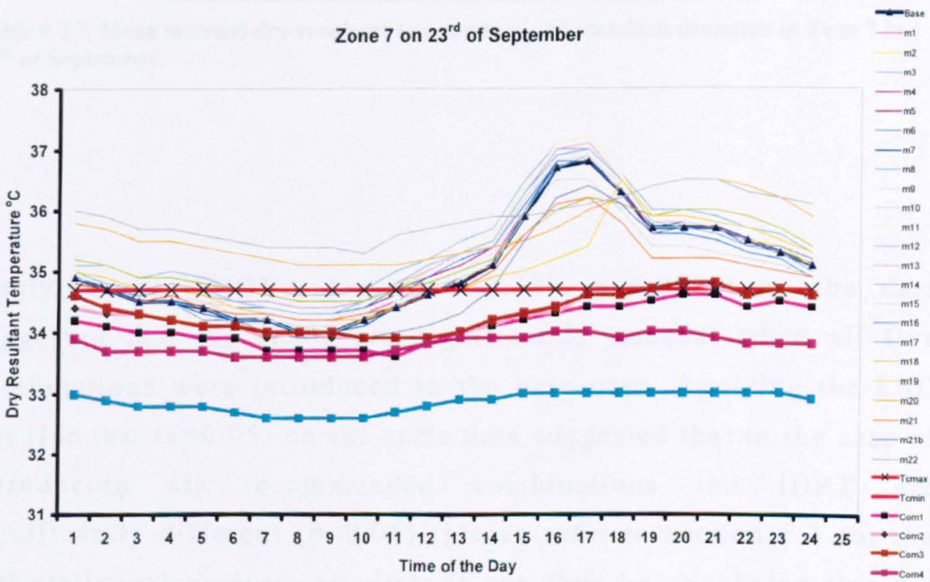

Figure 9-25: Dry resultant temperature inside the bedroom 3 in autumnal equinox

From table (9-27) it is clear that the fifth recommended combination provide a cooler internal temperature than the other three combinations with a narrow variation during the day.

	Recommended combinations				
	Com1	**Com2**	**Com3**	**Com4**	**Com5**
Mean	34.113	34.288	34.321	33.796	32.858
SD	0.318	0.310	0.311	0.143	0.153
No	24	24	24	24	24

Table 9-27: Mean internal dry resultant temperature and standard deviation in Zone 7 in 23rd of September.

Applying the ANOVA test ($F=130.283$, $p<0.0005$) on the data suggested that the IDRT are significantly unequal when all five combinations were introduced to the base case. Applying the LSD Pot Hoc test ($a=0.05$) on the same data suggested that in the case of introducing all recommended combinations the IDRT are significantly different ($p<0.05$) (please refer to section F.3 for the full statistical analysis results). It can thus be concluded that for this day of the year the use of the fifth recommended combination proven to be significantly effective in providing lower IDRT inside zone 7 and that this lower temperature is maintained within a narrow range along this day.

Results of IDRT in bedroom 4 (Zone 8) are shown in (Figure 9-26). It is clear that the recommended combinations three, four and five provide a better internal temperature and results fall within the comfort band. The fifth recommended combination provided the lowest IDRT reading of 32.4°C, while for the same period it was found to be 35.6°C in the concrete building. Heat penetration is steadier in all recommended combinations than for the concrete building.

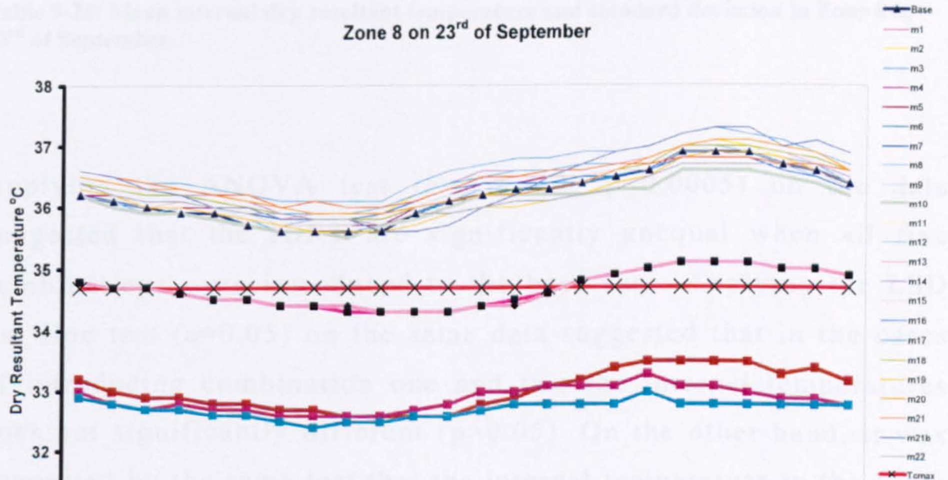

Figure 9-26: Dry resultant temperature inside the bedroom 4 in autumnal equinox

From Table (9-28) it is clear that the fourth and fifth recommended combinations provide a cooler internal temperature than the other three combinations with the least variation during the day when the fifth recommended combination was used.

	Recommended combinations				
	Com1	**Com2**	**Com3**	**Com4**	**Com5**
Mean	34.675	34.675	33.029	32.875	32.713
SD	0.286	0.285	0.329	0.203	0.145
No	24	24	24	24	24

Table 9-28: Mean internal dry resultant temperature and standard deviation in Zone 8 in 23rd of September.

Applying the ANOVA test ($F=355.321$, $p<0.0005$) on the data suggested that the IDRT are significantly unequal when all five combinations were introduced to the base case. Applying the LSD Pot Hoc test ($a=0.05$) on the same data suggested that in the cases of introducing combination one and two the internal temperatures does not significantly different ($p>0.05$). On the other hand, it was suggested by the same test that the internal temperature in the cases when using combination three, four and five are significantly differ ($p<0.05$). However, it was suggested that the internal temperature in the first two cases are significantly differ from the other three cases ($p<0.05$) (please refer to section F.3 for the full statistical analysis results). It can thus be concluded that for this day of the year the use of recommended combination five proven to be significantly effective in providing lower IDRT inside zone 8 and that this lower temperature is maintained within a narrow range along this day.

For the Hall area (Zone 9), both recommended combinations one and two were found to be within the comfort range for the whole day, while both the third and fourth recommended combinations and the concrete building were found to be outside the comfort zone (Figure 9-27). The IDRT was stable in all recommended combinations and the concrete building.

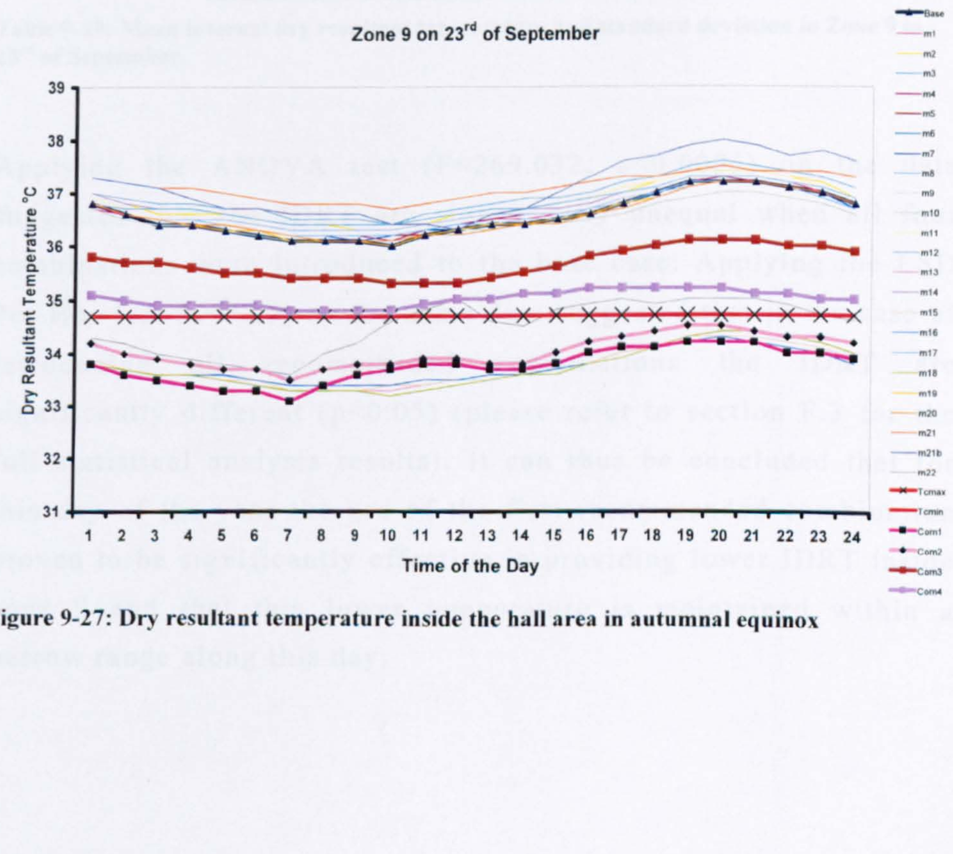

Figure 9-27: Dry resultant temperature inside the hall area in autumnal equinox

From table (9-29) it is clear that the first recommended combination provides a cooler internal temperature than the other three combinations while the least variation during the day was found when the fourth recommended combination was used.

	Recommended combinations			
	Com1	**Com2**	**Com3**	**Com4**
Mean	33.758	34.025	35.679	35.008
SD	0.313	0.291	0.281	0.141
No	24	24	24	24

Table 9-29: Mean internal dry resultant temperature and standard deviation in Zone 9 in 23rd of September.

Applying the ANOVA test ($F=269.032$, $p<0.0005$) on the data suggested that the IDRT are significantly unequal when all four combinations were introduced to the base case. Applying the LSD Pot Hoc test ($a=0.05$) on the same data suggested that in the case of introducing all recommended combinations the IDRT are significantly different ($p<0.05$) (please refer to section F.3 for the full statistical analysis results). It can thus be concluded that for this day of the year the use of the first recommended combination proven to be significantly effective in providing lower IDRT inside zone 9 and that this lower temperature is maintained within a narrow range along this day.

Table (9-23) is a matrix that illustrates the discussed results in the autumnal equinox.

	Recommended combinations				
	C1	**C2**	**C3**	**C4**	**C5**
Zone 1					x
Zone 2	x				
Zone 6					x
Zone 7					x
Zone 8					x
Zone 9					x
Decision					X

Table 9-30: The best recommended combination for Autumnal Equinox

It can be seen from the above table that the fifth combination is found to be the best combination on average during the autumnal equinox.

9.4.1.4 Results in Winter Solstice

The 22^{nd} of December is the winter solstice. During this month the external air temperature drops down therefore, the IDRT drops in all zones in all building types. The temperature drop is varied in all zones and also for all different recommended combinations. The IDRT in the concrete building for the bulk of the time and for almost all of the zones was outside the range of comfort. Passive design elements added to the recommended combination buildings provided a warmer internal temperature.

Results of internal temperature in reception (Zone 1) are shown in (Figure 9-28). It is apparent that the concrete building, the third, fourth and fifth ere found outside the comfort band. The IDRT is high during the day while all recommended combinations seem to possess a more stable heat penetration. As in all of the previous situations, the increase of the internal temperature is steadier in recommended combinations buildings than in the concrete building.

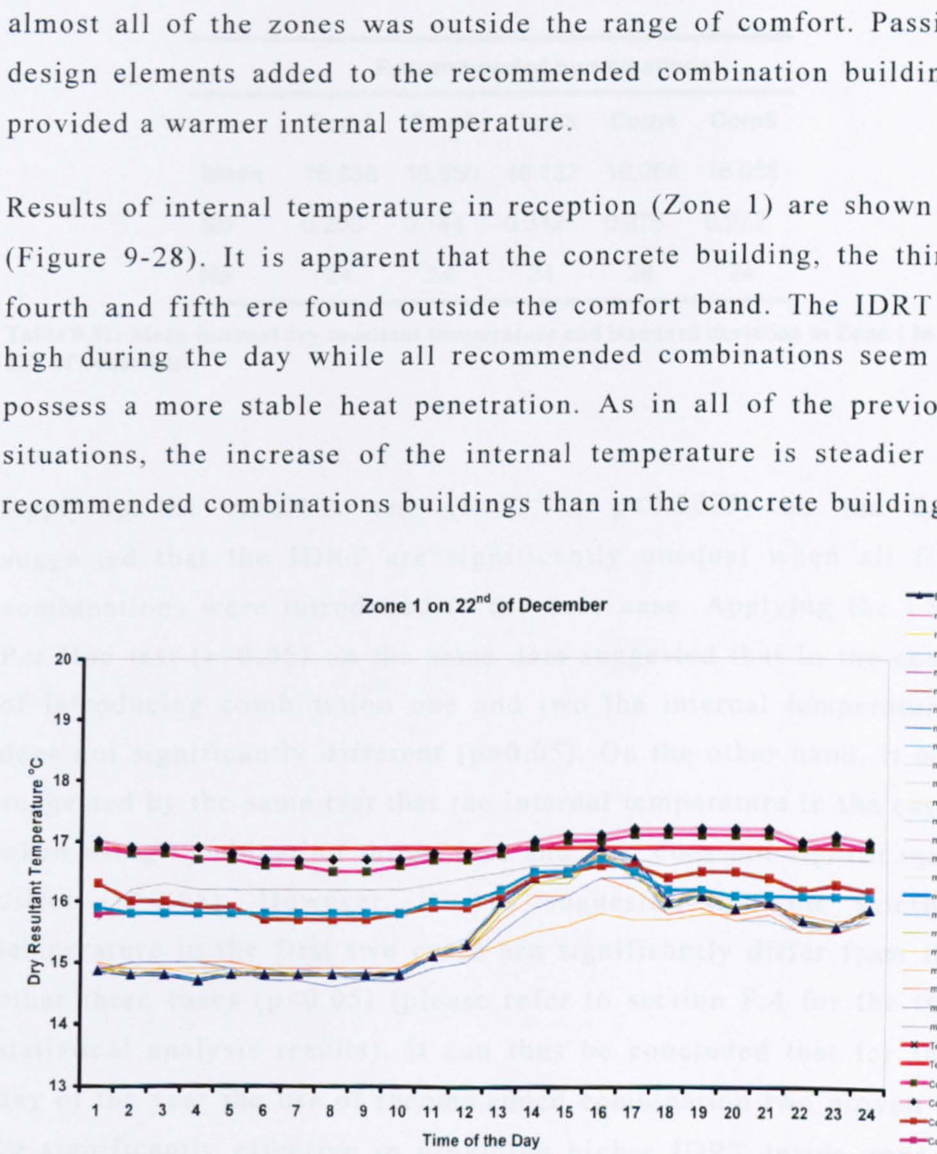

Figure 9-28: Dry resultant temperature inside the reception room in winter solstice

Table (9-31) illustrates the mean IDRT and the SD when each recommended combination was introduced to the base case. It is clear that the second recommended combination provide a warmer internal temperature than the other three combinations with the least variation during the day.

	Recommended combinations				
	Com1	**Com2**	**Com3**	**Com4**	**Com5**
Mean	16.838	16.950	16.133	16.054	16.058
SD	0.200	0.184	0.312	0.275	0.272
No	24	24	24	24	24

Table 9-31: Mean internal dry resultant temperature and standard deviation in Zone 1 in 22nd of December.

Applying the ANOVA test (F=75.30, p<0.0005) on the data suggested that the IDRT are significantly unequal when all five combinations were introduced to the base case. Applying the LSD Pot Hoc test (a=0.05) on the same data suggested that in the cases of introducing combination one and two the internal temperatures does not significantly different (p>0.05). On the other hand, it was suggested by the same test that the internal temperature in the cases when using combination three, four and five does not significantly differ (p>0.05). However, it was suggested that the internal temperature in the first two cases are significantly differ from the other three cases (p<0.05) (please refer to section F.4 for the full statistical analysis results). It can thus be concluded that for this day of the year the use of recommended combination two proven to be significantly effective in providing higher IDRT inside zone 1 and that this higher temperature is maintained within a narrow range along this day.

The simulated results inside bedroom 1 (Zone 2) were better than in Zone 1 and the IDRT in this zone was found to be warmer (Figure 9-29). The concrete building entered the comfort range just after midday while all recommended combinations were found to be within the comfort band for the whole of the day providing warmer spaces for the occupants. Resultant internal dry temperatures in all of the recommended combinations were stable within this zone. The small openings at body height provided the warmest internal temperature followed by the results of the high thermal mass roof.

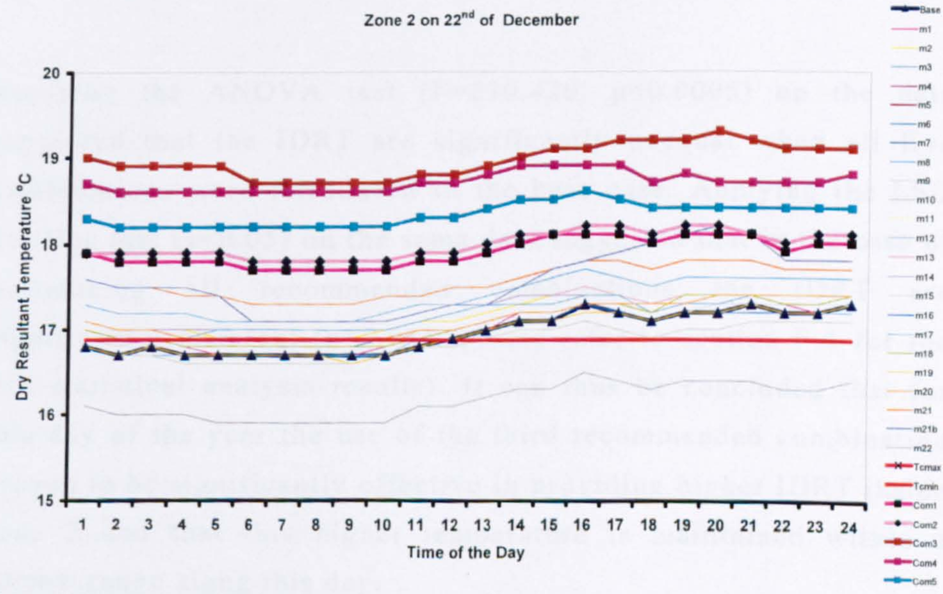

Figure 9-29: Dry resultant temperature inside the bedroom 1 in winter solstice

From table (9-32) it is clear that the third recommended combination provide a warmer internal temperature than the other four combinations while the least variation during the day was found when the fourth recommended combination was used.

	Recommended combinations				
	Com1	**Com2**	**Com3**	**Com4**	**Com5**
Mean	17.900	17.988	18.967	18.708	18.333
SD	0.153	0.145	0.193	0.110	0.124
No	24	24	24	24	24

Table 9-32: Mean internal dry resultant temperature and standard deviation in Zone 2 in 22nd of December.

Applying the ANOVA test (F=230.420, p<0.0005) on the data suggested that the IDRT are significantly unequal when all five combinations were introduced to the base case. Applying the LSD Pot Hoc test (a=0.05) on the same data suggested that in the case of introducing all recommended combinations the IDRT are significantly different (p<0.05) (please refer to section F.4 for the full statistical analysis results). It can thus be concluded that for this day of the year the use of the third recommended combination proven to be significantly effective in providing higher IDRT inside zone 2 and that this higher temperature is maintained within a narrow range along this day.

It can be demonstrated from Figure (9-30) that the increase in the IDRT in bedroom 2 (Zone 6) is different from the previous zones. A late increase in the IDRT was found just after midday. All recommended combinations were found within the comfort band except the recommended combinations one and two which were not within the range from 5am until midday. IDRT inside all recommended combinations was steadier than for the concrete building; while the fifth combination was found to be the steadiest.

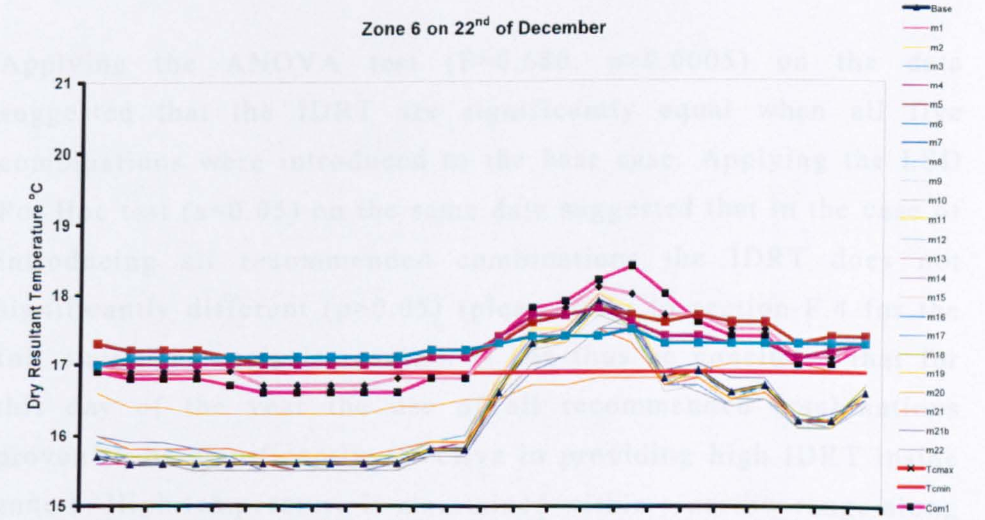

Figure 9-30: Dry resultant temperature inside the bedroom 2 in winter solstice

From table (9-33) it is clear that the third, fourth and fifth recommended combinations provide a warmer internal temperature than the other two combinations while the least variation during the day was found when the fifth recommended combination was used.

	Recommended combinations				
	Com1	**Com2**	**Com3**	**Com4**	**Com5**
Mean	17.167	17.192	17.329	17.225	17.225
SD	0.560	0.450	0.271	0.263	0.133
No	24	24	24	24	24

Table 9-33: Mean internal dry resultant temperature and standard deviation in Zone 6 in 22nd of December.

Applying the ANOVA test (F=0.680, p>0.0005) on the data suggested that the IDRT are significantly equal when all five combinations were introduced to the base case. Applying the LSD Pot Hoc test (a=0.05) on the same data suggested that in the case of introducing all recommended combinations the IDRT does not significantly different (p>0.05) (please refer to section F.4 for the full statistical analysis results). It can thus be concluded that for this day of the year the use of all recommended combinations proven to be significantly effective in providing high IDRT inside zone 6. High temperature is maintained within a narrow range along this day when the fifth recommended combination was used.

In bedroom 3 (Zone 7), all recommended combinations showed a steady increase of the IDRT when compared with the concrete building (Figure 9-31). All recommended combinations were found to be within the comfort range except the fifth recommended combination. Recommended combinations one, two, three and four were found to give IDRT of between 17°C and 18°C. The IDRT inside all recommended combinations was steadier than for the concrete building.

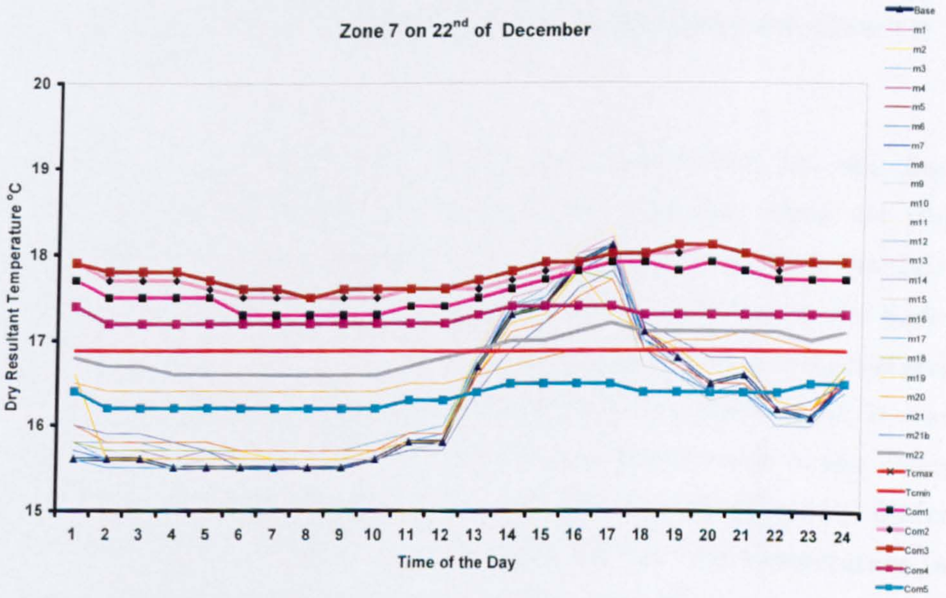

Figure 9-31: Dry resultant temperature inside the bedroom 3 in winter solstice

From table (9-34) it is clear that the second and third recommended combinations provide a warmer internal temperature than the other three combinations while the least variation during the day was found when the third recommended combination was used.

	Recommended combinations				
	Com1	**Com2**	**Com3**	**Com4**	**Com5**
Mean	17.583	17.750	17.804	17.275	16.342
SD	0.210	0.196	0.176	0.079	0.125
No	24	24	24	24	24

Table 9-34: Mean internal dry resultant temperature and standard deviation in Zone 7 in 22nd of December.

Applying the ANOVA test (F=320.553, p<0.0005) on the data suggested that the IDRT are significantly unequal when all five combinations were introduced to the base case. Applying the LSD Pot Hoc test (a=0.05) on the same data suggested that in the cases of introducing combination two and three the internal temperatures does not significantly different (p>0.05). On the other hand, it was suggested by the same test that the internal temperature in the cases when using combination one, four and five are significantly differ (p<0.05). However, it was suggested that the internal temperature in the first two cases are significantly differ from the other three cases (p<0.05) (please refer to section F.4 for the full statistical analysis results). It can thus be concluded that for this day of the year the use of recommended combination three proven to be significantly effective in providing higher IDRT inside zone 7 and that this lower temperature is maintained within a narrow range along this day.

Bedroom 4 (Zone 8) was found warmer throughout the day in recommended combinations one and two than the recommended combinations three, four and five (Figure 9-32). All recommended combinations were found to be within the comfort range and the IDRT indicated improved results in recommended combinations one and two. The recommended combinations one and two recorded the same IDRT in this zone for most of the day and was found to be between 18.9°C and 19.4°C.

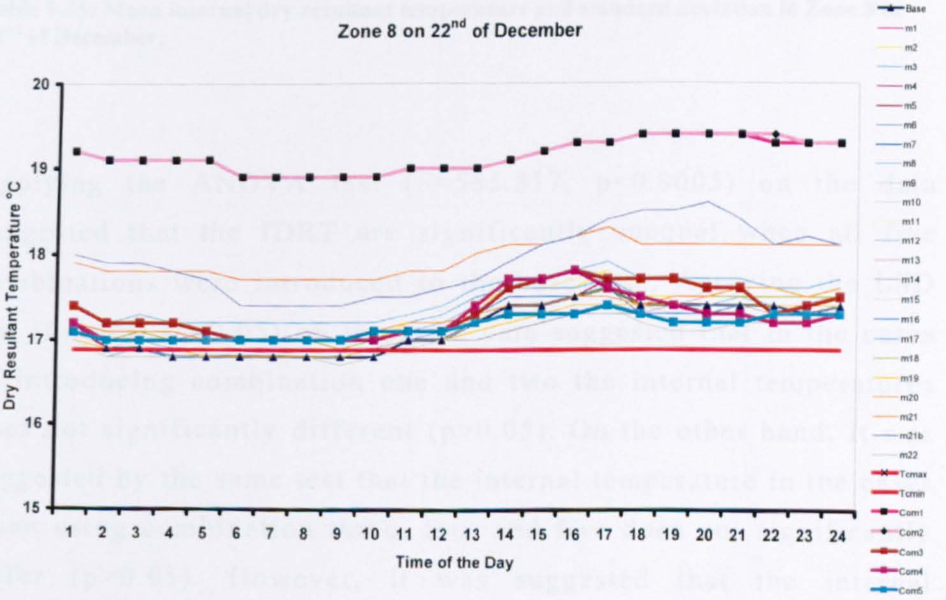

Figure 9-32: Dry resultant temperature inside the bedroom 4 in winter solstice

From table (9-35) it is clear that the first and second recommended combinations provide a warmer internal temperature than the other three combinations with the least variation during the day when the first recommended combination was used.

	Recommended combinations				
	Com1	**Com2**	**Com3**	**Com4**	**Com5**
Mean	19.146	19.150	17.342	17.242	17.154
SD	0.182	0.187	0.278	0.260	0.135
No	24	24	24	24	24

Table 9-35: Mean internal dry resultant temperature and standard deviation in Zone 8 in 22nd of December.

Applying the ANOVA test (F=565.817, $p<0.0005$) on the data suggested that the IDRT are significantly unequal when all five combinations were introduced to the base case. Applying the LSD Pot Hoc test (a=0.05) on the same data suggested that in the cases of introducing combination one and two the internal temperatures does not significantly different ($p>0.05$). On the other hand, it was suggested by the same test that the internal temperature in the cases when using combination three, four and five does not significantly differ ($p>0.05$). However, it was suggested that the internal temperature in the first two cases are significantly differ from the other three cases ($p<0.05$) (please refer to section F.4 for the full statistical analysis results). It can thus be concluded that for this day of the year the use of recommended combination one proven to be significantly effective in providing higher IDRT inside zone 8 and that this higher temperature is maintained within a narrow range along this day.

Simulated results of IDRT in the hall area (Zone9) are shown in Figure (9-33). The concrete building and all the recommended combinations were found to be within the comfort range. A steady increase of IDRT was found in this zone for all of the simulated buildings.

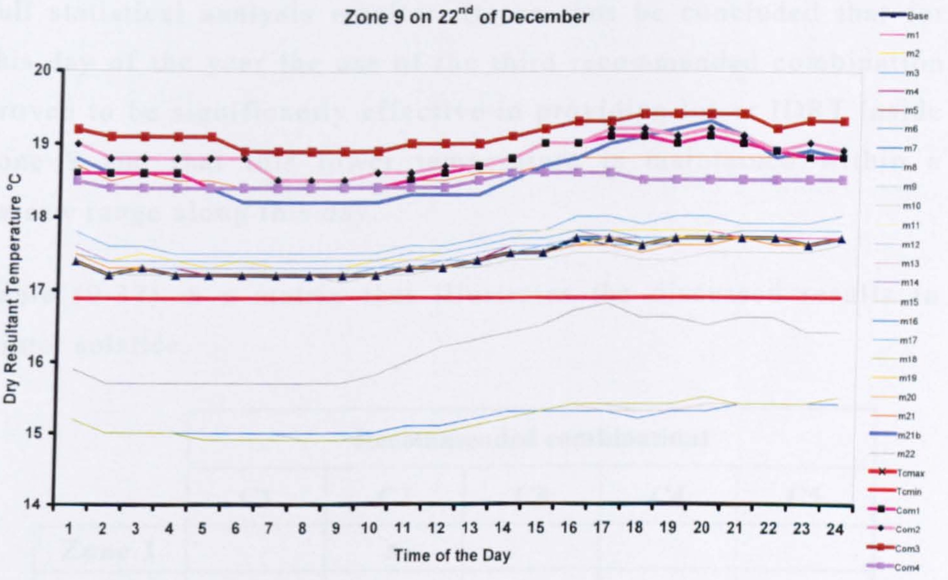

Figure 9-33: Dry resultant temperature inside the bedroom 1 in winter solstice

From table (9-36) it is clear that the third recommended combination provides a warmer internal temperature than the other three combinations with the low variation during the day.

	Recommended combinations			
	Com1	**Com2**	**Com3**	**Com4**
Mean	18.717	18.854	19.142	18.471
SD	0.258	0.223	0.179	0.075
No	24	24	24	24

Table 9-36: Mean internal dry resultant temperature and standard deviation in Zone 9 in 22nd of December.

Applying the ANOVA test (F=20.820, p<0.0005) on the data suggested that the IDRT are significantly unequal when all four combinations were introduced to the base case. Applying the LSD Pot Hoc test (a=0.05) on the same data suggested that in the case of introducing all recommended combinations the IDRT are significantly different (p<0.05) (please refer to section F.4 for the full statistical analysis results). It can thus be concluded that for this day of the year the use of the third recommended combination proven to be significantly effective in providing lower IDRT inside zone 9 and that this lower temperature is maintained within a narrow range along this day.

Table (9-37) is a matrix that illustrates the discussed results in winter solstice.

	Recommended combinations				
	C1	**C2**	**C3**	**C4**	**C5**
Zone 1		x			
Zone 2			x		
Zone 6					x
Zone 7			x		
Zone 8	x				
Zone 9			x		
Decision			X		

Table 9-37: The best recommended combination for the Winter Solstice.

It can be seen from the above discussion that the third combination is the best combination on average during the autumnal equinox.

It is clear from all the discussed results that the fifth recommended combination was found to be the best combination to be used during the two hot simulated days of June and September. It was also found that the recommended combinations one, two found to be the best to be used in the simulated day of March while the third recommended combination was found to be the best combination to be used in the simulated day of December.

9.4.2 Cooling and Heating loads

The calculated results of the Cooling and heating loads for the concrete building and all combinations were obtained using Ecotect software. Using the Humphrey's equation (equation 3-3) for heated or cooled buildings, the internal comfort temperatures were set between 18 °C and 26 °C. When the calculated internal temperature was found outside those limits Ecotect calculated the heating or cooling energy required to bring the internal temperature either up to 18°C or down to 26°C.

9.4.2.1 The Concrete building

It was found that a maximum heating load of 7.37 kW is needed at 6.00 am on the 6th of December, while the maximum cooling load of 11.75 kW is required at 16.00 on the 30th of July.

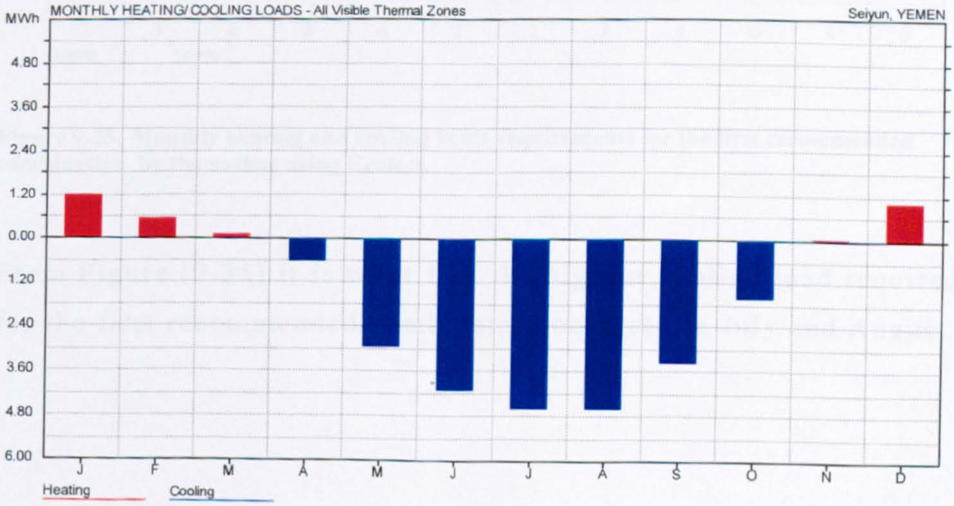

Figure 9-34: Monthly heating and cooling loads for the Concrete building, by the author using Ecotect.

From Figure (9-34) it is clear that the highest cooling load required in the concrete building occurs in July and August.

9.4.2.2 The Recommended Combinations

9.4.2.2.1 Recommended Combination One

It was found that the maximum heating load of 8.70 kW is needed at 6.00 on the 31st December while the maximum cooling load of 19.47 kW is needed at 15.00 on 30th July.

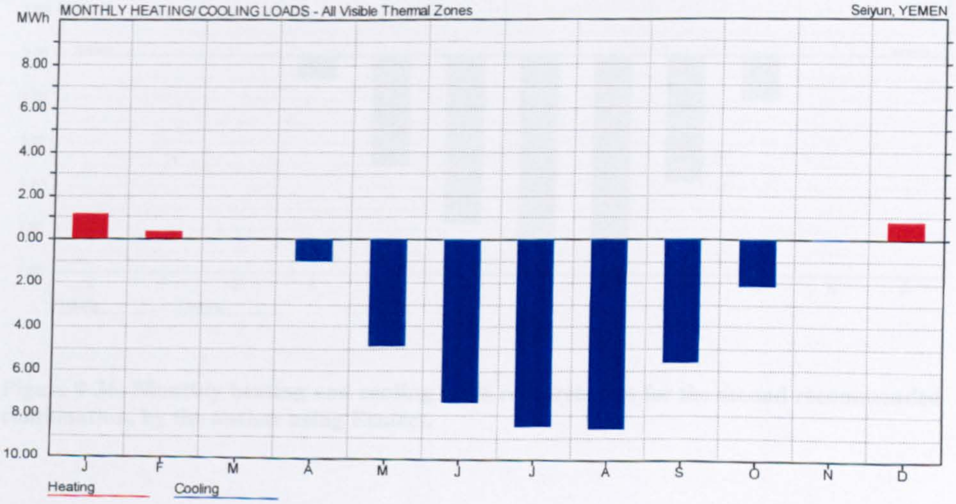

Figure 9-35: Monthly heating and cooling loads requirements for the first recommended combination, by the author using Ecotect.

From Figure (9-35) it is clear that the highest cooling load required for the first recommended combination occurred in July and August.

9.4.2.2.2 Recommended Combination Two

It was found that the maximum heating load of 6.15 kW is needed at 6.00 on the 31st December while the maximum cooling load of 18.08 kW is needed at 17.00 on 30th July.

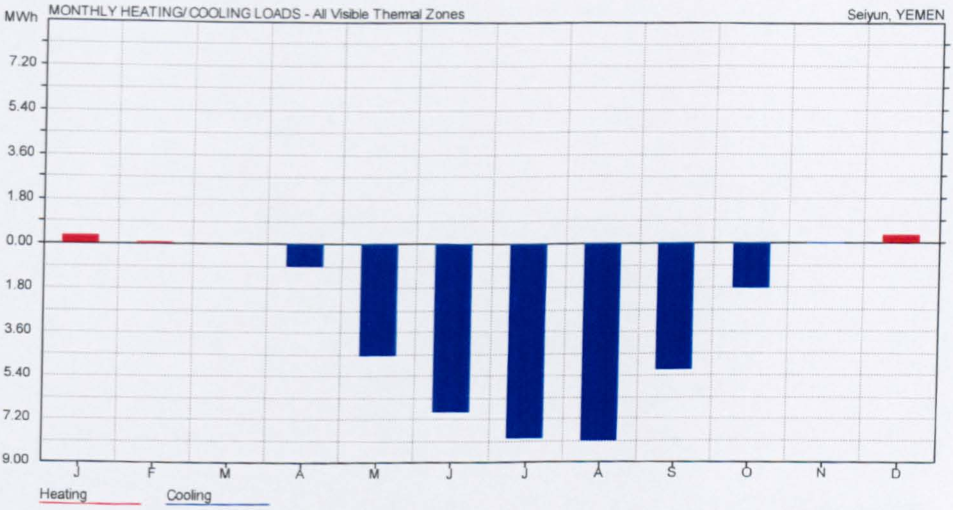

Figure 9-36: Monthly heating and cooling loads requirements for the second recommended combination, by the author using Ecotect.

From Figure (9-36) it is clear that the highest cooling load required for the second recommended combination occurred in August then July.

9.4.2.2.3 Recommended Combination Three

It was found that the maximum heating load of 1.56 kW is needed at 6.00 on the 31st December while the maximum cooling load of 7.71 kW is needed at 13.00 on 30th July.

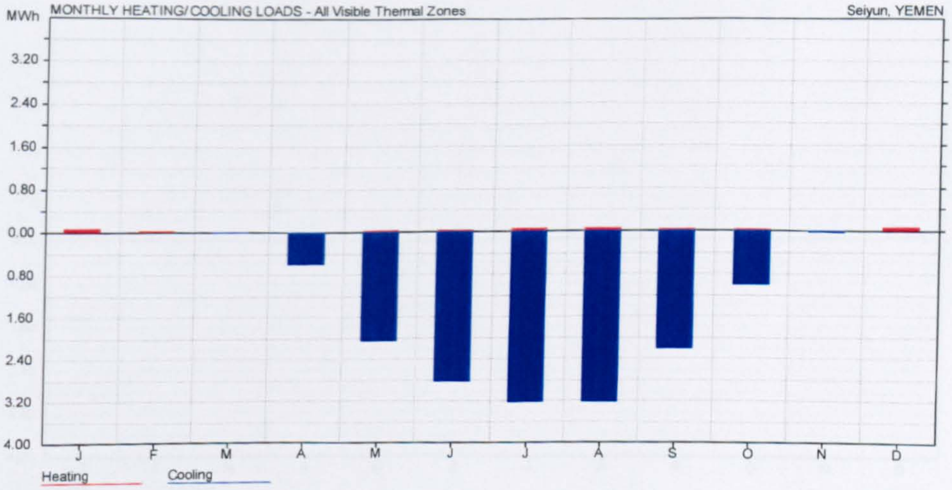

Figure 9-37: Monthly heating and cooling loads requirements for the third recommended combination, by the author using Ecotect.

From Figure (9-37) it is clear that the highest cooling load required for the third recommended combination again occurred in July and August.

9.4.2.2.4 Recommended Combination Four

It was found that the maximum heating load of 1.56 kW is needed at 6.00 on the 31st December while the maximum cooling load of 6.94 kW is needed at 13.00 on 30th July.

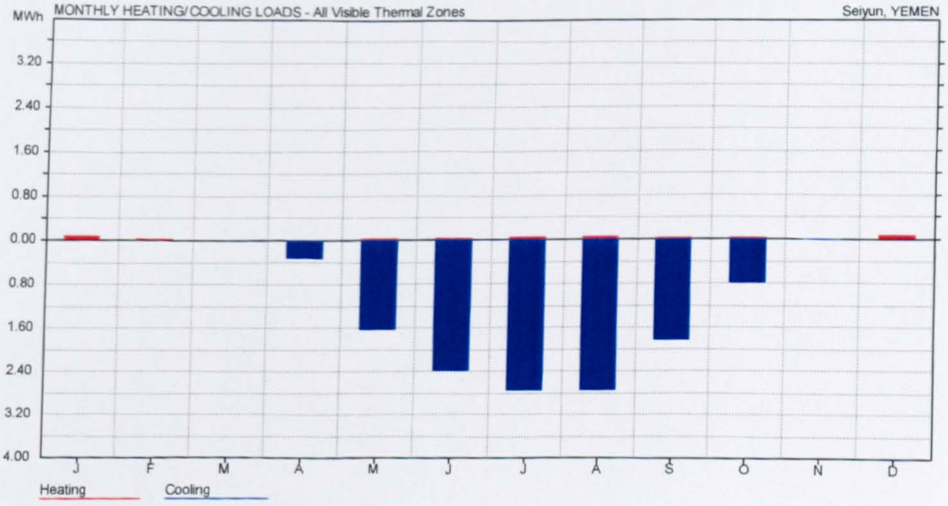

Figure 9-38: Monthly heating and cooling loads requirements for the fourth recommended combination, by the author using Ecotect.

From Figure (9-38) it is clear that the highest cooling load required for the fourth recommended combination occurred in July and August.

9.4.2.2.5 Recommended Combination Five

It was found that the maximum heating load of 3.07 kW is needed at 6.00 on the 6th December while the maximum cooling load of 7.38 kW is needed at 14.00 on 6th August.

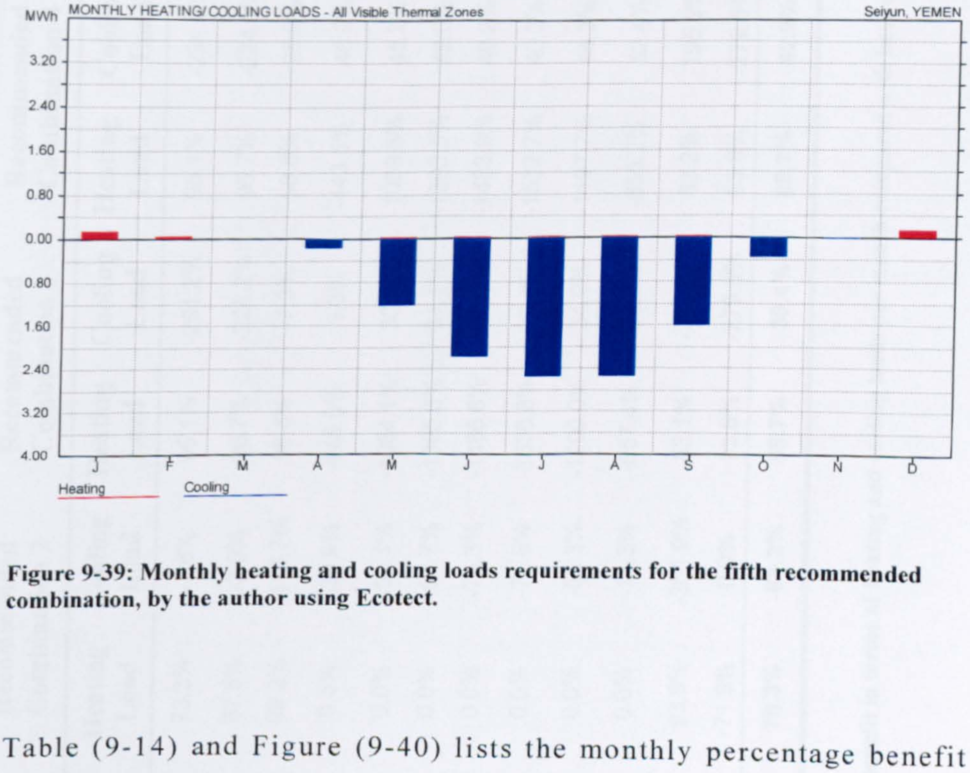

Figure 9-39: Monthly heating and cooling loads requirements for the fifth recommended combination, by the author using Ecotect.

Table (9-14) and Figure (9-40) lists the monthly percentage benefit in terms of heating and cooling loads for each recommended combination in comparison to the base case. It can be seen that the fifth recommended combination required the lowest cooling loads while the third and the fourth required the lowest heating loads.

	Recommended Combination 1		Recommended Combination 2		Recommended Combination 3		Recommended Combination 4		Recommended Combination 5	
	Heating Load	**Cooling Load**	**Heating Load**	**Cooling Load**	**Heating Load**	**Cooling Load**	**Heating Load**	**Cooling Load**	**Heating Load**	**Cooling Load**
January	7.3%	-2.6%	73.3%	-2.6%	95.1%	-291.2%	95.1%	-291.2%	87.8%	-157.7%
February	41.3%	-6.1%	87.5%	-3.0%	96.7%	-224.2%	96.7%	-224.2%	91.4%	-127.3%
March	91.0%	-115.3%	99.2%	-116.7%	98.8%	-7.9%	98.8%	25.9%	99.8%	26.0%
April	0.5%	-55.4%	0.5%	-39.9%	-445.5%	3.3%	-443.5%	48.0%	-117.0%	70.9%
May	0.0%	-64.3%	0.0%	-52.1%	-1064.1%	30.8%	-1059.6%	45.2%	-418.4%	58.8%
June	0.0%	-79.6%	0.0%	-67.7%	-1395.8%	31.1%	-1393.5%	42.0%	-582.9%	47.0%
July	0.0%	-84.9%	0.0%	-73.3%	-1486.5%	29.6%	-1483.9%	40.2%	-627.8%	44.3%
August	0.0%	-86.6%	0.0%	-74.8%	-1536.3%	29.8%	-1532.7%	40.3%	-651.6%	44.8%
September	0.0%	-66.8%	0.0%	-53.3%	-1200.0%	34.0%	-1197.7%	45.3%	-484.7%	52.2%
October	0.0%	-29.9%	0.0%	-11.8%	-657.4%	38.0%	-655.2%	52.4%	-215.2%	78.0%
November	94.2%	-420.4%	93.9%	-361.9%	83.1%	-265.0%	83.2%	-195.9%	95.1%	-95.0%
December	22.4%	-2.0%	71.9%	0.0%	93.8%	-279.5%	93.8%	-279.5%	85.7%	-155.0%
Total	**22.9%**	**-73.9%**	**76.3%**	**-61.2%**	**88.7%**	**30.4%**	**88.7%**	**42.9%**	**85.5%**	**51.3%**

Table 9-38: Percentage benefit in terms of heating and cooling loads per month compared with base case building.

Figure (9-40) illustrates the heating and cooling loads for all recommended combinations.

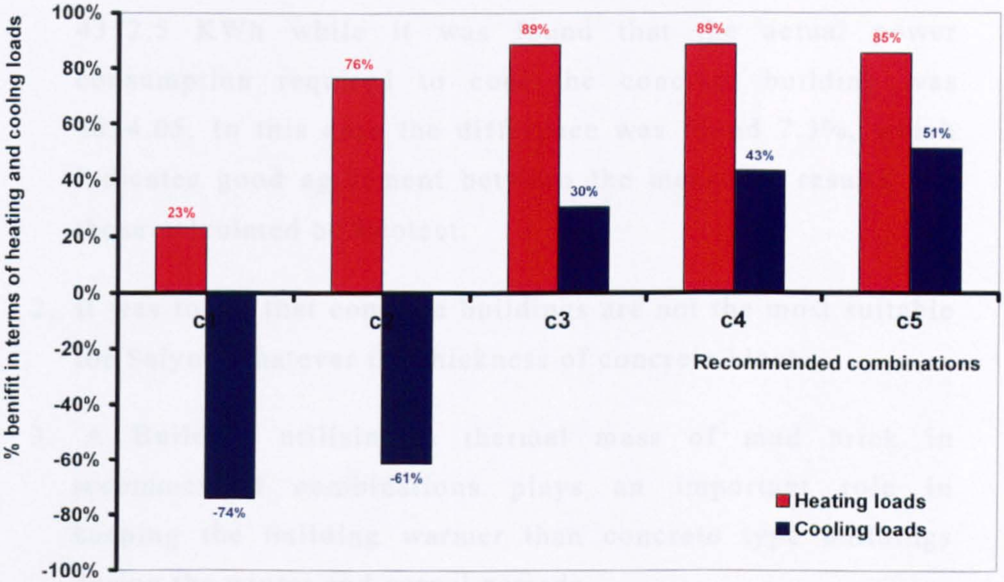

Figure 9-40: Benefits in heating and cooling loads in all recommended combinations.

C1 = use of internal and external thermal mass mud, light structure on top of the building and height of 4.5m

C2 = use of internal and external thermal mass mud, light structure on top of the building, height of 4.5m, double glazing and shading devices

C3 = C2 + small openings at body height

C4 = C3 high thermal mass roof instead of light roof structure on to of the building

C5 = C4 + courtyard created instead of zone 9

9.5 Conclusion

The following conclusions can be drawn from this chapter:

1. From the field study, the calculated cooling load for the month of August for the concrete building was found to be 4312.5 KWh while it was found that the actual power consumption required to cool the concrete building was 4624.05. In this case the difference was found 7.3%, which indicates good agreement between the measured results and those calculated by Ecotect.

2. It was found that concrete buildings are not the most suitable for Seiyun whatever the thickness of concrete blocks..

3. A Building utilising a thermal mass of mud brick in recommended combinations plays an important role in keeping the building warmer than concrete type buildings during the winter and vernal periods.

4. All rooms facing east are heated quickly in concrete buildings. Shading devices and window size reduction attenuates the solar penetration at the east façade which therefore diminishes the rate of heating.

5. Orientation plays an important role in this case study; east façades should be as short as possible to prevent early solar heating or should be provided with passive shading while the northern was façade found to be the coolest.

6. Sheltered outside windows are important elements in this type of climate which seem to prevent heating of the internal space in early or late hours of the day during summer.

7. Re-planning the case study (reducing length in eastern and western façades) and utilising some additional internal passive measures such as internal water cooling will reduce the internal temperature of the building.

8. Reducing the size of windows and creating a courtyard was found have a greater beneficial effect than creating a light structure on top of the building.

9. The results of the thermal simulation showed that the fifth combination is the best combination in terms of both thermal comfort and energy efficiency.

10. In terms of cooling loads it is found that the use of courtyard reduces the cooling load by just more than 51% and reduces the heating load by just more than 85% compared with the concrete building (base case).

Conclusion

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10.1 Introduction

This thesis is perhaps one of the first to study the relationship between thermal comfort and energy consumption in domestic buildings in the city of Seiyun in Yemen (refer to chapter four).

Part one of this thesis set the background for the research and indicated the gap in the body of knowledge. It set the scene with respect to housing types found in Yemen - in particular in Seiyun - and its context within an expanding economy. Part two investigated the climatic context to be considered in the later parts of the work. Part three presented the detailed methodology and both the field investigation and the parametric analysis.

The main aim of this work was firstly to establish whether or not the current trend in housing design in Seiyun is producing comfortable conditions that at the same time are energy efficient. Secondly, to test several passive strategies and measures, which may improve the comfort levels and reduce overall energy consumption (refer to chapter six).

The research used the following three tasks to reach the main aim:

1. Analysis of the climatic context of the case study using both Mahony tables and the Weather Tool.
2. A field study into the thermal comfort conditions to be found in three existing types of dwellings in Seiyun; traditional mud houses, contemporary new mud houses and contemporary concrete houses. This field study included a questionnaire distributed to 342 subjects, and the monitoring of the internal air temperature inside the three case studies during the four months of January, February, July and August

3. The utilisation of the field study results to carry out a parametric analysis using a thermal simulation programme known as Ecotect to determine the most efficient passive strategies and measures. Results obtained from Ecotect were compared with values obtained from both the Energy Plus and the actual field monitoring and suggested a reasonable corroboration, indicating a high degree of validity using Ecotect in the research context.

10.2 General Conclusion

10.2.1 Climatic analysis

The climatic analysis showed that the use of the following passive strategies and measures might increase the thermal comfort and decrease the energy consumption:

1. Exposed mass and night purge ventilation (55% benefit in term of thermal comfort)

2. High thermal mass (49% benefit in term of thermal comfort)

3. Indirect evaporative cooling (40% benefit in terms of thermal comfort)

4. Heavy roof structure

5. Very small openings at body height

6. Compact courtyard planning

10.2.2 Questionnaire

The questionnaire showed the following:

1. On average occupants of the concrete building type expressed their dissatisfaction with the internal environment. However in general it was found that this type is the most preferred type despite the high running costs associated with the use of air conditioning.
2. Occupants of traditional mud and new mud type houses were more satisfied with their internal environment.

10.2.3 Monitoring

The monitoring showed that:

1. The internal temperatures recorded inside the three case studies were found to be similar and the only differences were the use of mechanical means to acquire thermal comfort.
2. The concrete type house had the highest cooling load demand followed by the new mud type and the traditional mud type respectively.

10.2.4 Thermal modelling

The thermal simulation results showed that better internal air temperatures and lower heating / cooling loads inside the concrete type house were obtained by the introduction of a combination of passive measures. The benefit in terms of temperature and loads varied according to the applied combination of measures. The combination that proved to be the best from the internal temperature and heating & cooling loads point of view (reduced the cooling load by more than 51% and heating load by more than 81%) was combination number five:

a. High thermal mass in both the internal and external walls
b. High thermal mass roof
c. Small openings at body height
d. The use of shading devices
e. The use of double glazed windows
f. The use of a courtyard

10.3 Limitation and further work

1. This study was conducted in one Yemeni climatic region out of five existing definable regions due to the time limitation and expense. It is recommended that the different housing types are simulated in other regions. This will allow the investigation of the passive design measures in other climatic regions of Yemen.

2. The field study was carried out in winter and summer seasons only. It is recommend in further studies to run the field study throughout the remaining two seasons. It is also recommended to monitor the three case studies for a whole year to allow a comprehensive comparison between simulated and real life

results. This will allow future researchers to confidently use the computer simulation.

3. The results of this study were limited to the building type and the circumstances of the investigated case studies.
4. This study is limited to single storey and domestic buildings. It is important to extend the investigation to other housing types and to non-residential buildings such as commercial and or educational buildings which would also be beneficial.
5. A comfort band was determined by using Humphrey's and Nicol, equation as a thermal comfort adaptive model for Yemen or Seiyun could not be found. It is recommended that further work be carried out to validate these adaptive equations with relation to Seiyun or research that can obtain thermal adaptive equations for Seiyun.

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Appendices

Appendix A

Questionnaires 1, 2

1. General questionnaire (English)

In the name of God

1. Building type: ○ Traditional mud ○ New mud ○ New concrete
2. Number of floors: ○ One floor ○ Two floors ○ More than two floors
3. Number of rooms:
4. number of occupation:
5. Number of air conditions:
6. Number of fans:
7. What do you feel inside the building in the following times:

	Cold	Cool	Slightly cool	Normal	Slightly worm	Worm	Hot
Morning							
Noon							
Night							

8. What do you prefer your internal environment to be:

	Cooler	No changes	Wormer
Morning			
Noon			
Night			

9. In general are you satisfied with your building preference : ○ Yes ○ No
10. In your opinion what was the Hottest / Coldest day:
11. Please state any comments or recommendations regarding the building performance and respond to climate.

(Arabic)

بسم الله الرحمن الرحيم

1 . نوع المبنى : ○مبنى قديم مبني بالطين ○مبنى جديد مبني بالطين ○ مبنى جديد مبني بالأسمنت

2 . المبنى مكون من طابق واحد ○ طابقين○ أكثر من طابقين ○

3 . كم عدد الغرف الموجودة بالمترل : ________.

4 . كم عدد ساكني المترل : ________ .

5 . كم عدد المكيفات الموجودة بالمترل : ________.

6 . كم عدد المراوح الموجودة بالمترل : ________.

7 . ما هو إحساسك داخل المبنى في الأوقات الآتية :

	بارد جداً	بارد	بارد نوعاً ما	طبيعي	دافئ نوعاً ما	حار	حار جداً
في الصباح							
في الظهيرة							
في المساء							

8 . عندما تكون في المترل كيف تريد أن يكون الوضع داخل المترل :

	أكثر برودة	لا تغير	أكثر دفئا
في الصباح			
في الظهيرة			
في المساء			

9 . بشكل عام هل أنت راضي عن المناخ الداخلي للمترل : ○ نعم لا ○

10. ماهو اليوم الذي كان أشد حرا خلال الأسبوع: __________.

11. يرجى ذكر أي ملاحظات أو اقتراحات إضافية تعتقد أنها متعلقة بتقييم المناخ الداخلي للمباني السكنية خلال الأسبوع.

____

____

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____

2. Monitored houses questionnaire (English)

In the name of God

1. Building type: ○ Traditional mud ○ New mud ○ New concrete
2. Number of floors: ○ One floor ○ Two floors ○ More than two floors
3. How many hours did you switch the following building services on to cool / heat the building:

	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Monday
Air conditions							
Fan							
Windows							

4. What do you feel inside the building in the following times:

	Cold	Cool	Slightly cool	Normal	Slightly worm	Worm	Hot
Morning							
Noon							
Night							

5. What do you prefer your internal environment to be:

	Cooler	No changes	Wormer
Morning			
Noon			
Night			

6. In general are you satisfied with your building preference : ○ Yes ○ No
7. In your opinion what was the hottest / coldest day:
8. Please state any comments or recommendations regarding the building performance and respond to climate.

(Arabic)

بسم الله الرحمن الرحيم

1 . نوع المبنى : ○ مبنى قديم مبني بالطين ○ مبنى جديد مبني بالطين ○ مبنى جديد مبني بالأسمنت

2 . المبنى مكون من ○ طابق واحد ○ طابقين ○ أكثر من طابقين

3 . كم عدد الساعات التي تم فيها تشغيل الآتي :

	الثلاثاء	الاربعاء	الخميس	الجمعة	السبت	الأحد	الاثنين
المكيف							
المروحة							
فتح النوافذ							

4 . ما هو إحساسك داخل المبنى في الأوقات الآتية :

	بارد جدا	بارد	بارد نوعا ما	طبيعي	دافئ نوعا ما	حار	حار جدا
في الصباح							
في الظهيرة							
في المساء							

5 . عندما تكون في المنزل كيف تريد أن يكون الوضع داخل المنزل :

	أكثر برودة	لا تغير	أكثر دفئا
في الصباح			
في الظهيرة			
في المساء			

6 . بشكل عام هل أنت راضي عن المناخ الداخلي للمنزل : ○ نعم ○ لا

7 . ماهو اليوم الذي كان أشد حرا خلال الأسبوع: ____________.

8 . يرجى ذكر أي ملاحظات أو اقتراحات إضافية تعتقد أنها متعلقة بتقييم المناخ الداخلي للمباني السكنية.

____

____

Appendix B)

Mahoney tables

Seiyun ,Yemen

Indicator totals from data sheet

H1	H2	H3	A1	A2	A3
0	0	0	12	6	0

Layout

			0–10			☐	Orientation north and south (long axis east–west)
			11–12		5–12		
					0–4	☒	Compact courtyard planning

Spacing

11–12						☐	Open spacing for breeze penetration
2–10						☐	As above, but protection from hot and cold wind
0–1						☒	Compact layout of estates

Air movement

3–12						☐	Rooms single banked, permanent provision for air movement
1–2			0–5				
			6–12			☐	Rooms double banked, temporary provision for air movement
0	2–12						
	0–1					☒	No air movement requirement

Openings

			0–1		0	☐	Large openings, 40–80%
			11–12		0–1	☒	Very small openings, 10–20%
Any other conditions						☐	Medium openings, 20–40%

Walls

			0–2			☐	Light walls, short time-lag
			3–12			☒	Heavy external and internal walls

Roofs

			0–5			☐	Light, insulatted roofs
			6–12			☒	Heavy roofs, over 8h time-lag

Outdoor sleeping

				2–12		☒	Space for outdoor sleeping required

Rain protection

		3–12				☐	Protection from heavy rain necessary

Size of opening

			0–1		0	☐	Large openings, 40–80%
					1–12	☐	Medium openings, 25–40%
			2–5				
			6–10			☐	Small openings, 15–25%
			11–12		0–3	☒	Very small openings, 10–20%
					4–12	☐	Medium openings, 25–40%

Position of openings

3–12						☐	In north and south walls at body height on windward side
1–2			0–5				
			6–12			☒	As above, openings also in internal walls
0	2–12						

Protection of openings

					0–2	☒	Exclude direct sunlight
		2–12				☐	Provide protection from rain

Walls and floors

			0–2			☐	Light, low thermal capacity
			3–12			☒	Heavy, over 8h time-lag

Roofs

10–12			0–2			☐	Light, reflective surface, cavity
			3–12			☐	Light, well insulated
0–9			0–5				
			6–12			☒	Heavy, over 8h time-lag

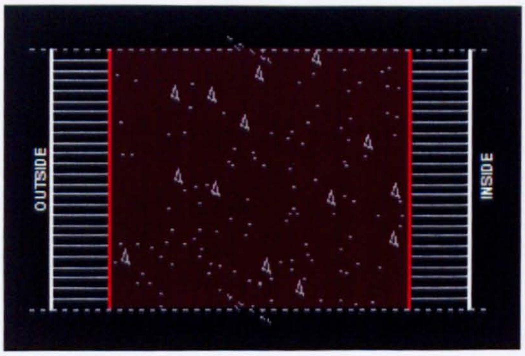
External features

				1–12		☒	Space for outdoor sleeping
		1–12				☐	Adequate rainwater drainage

Appendix C

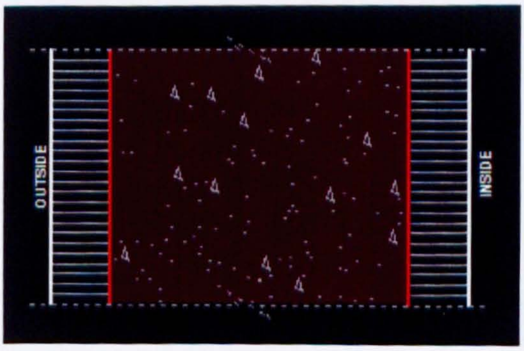
Building material parameters

Concrete blocks_100mm



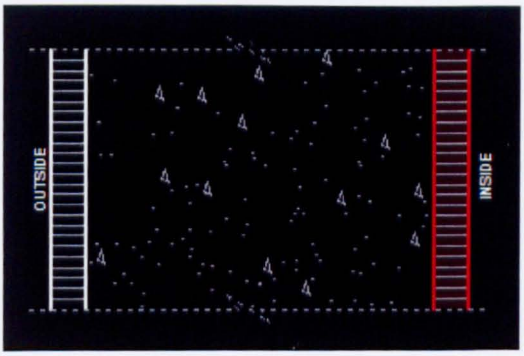
U-Value	1.74
Admittance	3.53
Solar absorption	0.1
Transparency	0
Thermal decrement	0.73
Time lag	2.65

Concrete blocks_150mm



U-Value	1.39
Admittance	3.67
Solar absorption	0.1
Transparency	0
Thermal decrement	0.55
Time lag	4.25

Concrete blocks_200mm

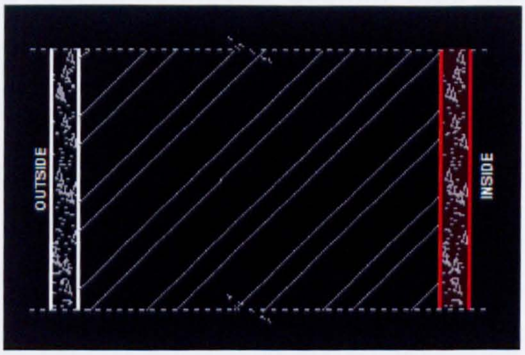


U-Value	1.14
Admittance	3.69
Solar absorption	0.1
Transparency	0
Thermal decrement	0.38
Time lag	5.7

Concrete blocks_400mm

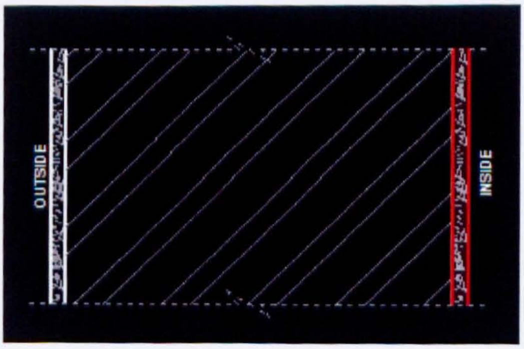
U-Value	0.68
Admittance	3.67
Solar absorption	0.1
Transparency	0
Thermal decrement	0.08
Time lag	11.88

Mud blocks_250mm



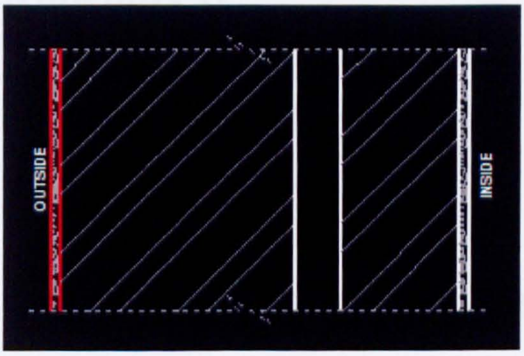
U-Value	0.21
Admittance	4.36
Solar absorption	0.1
Transparency	0
Thermal decrement	0.3
Time lag	8.12

Mud blocks_500mm



U-Value	0.11
Admittance	4.34
Solar absorption	0.1
Transparency	0
Thermal decrement	0.05
Time lag	16

Double Mud blocks_500mm_mud blocks_250mm



U-Value	0.07
Admittance	3.49
Solar absorption	0.1
Transparency	0
Thermal decrement	0.01
Time lag	17.82

Appendix D

Ecotect Results

19-Mar

Zone 1 (Reception)

Base	m1	m2	m3	m4	m5	m6	m7	m8	m9	m10	m11	m12	m13	m14	m15	m16	m17	m18	m19	m20	m21	m21b	m22	Com1	Com2	Tcmax	Tcmin	Com3	Com4	Com5	To
17.86	17.75	17.89	17.97	17.90	17.83	17.80	17.80	17.80	17.80	17.90	17.90	17.90	17.90	17.90	17.90	23.50	17.80	18.20	17.90	18.70	18.20	17.96	19.79	20.8	20.9	30.821	16.882	19.1	18.7	18.8	15.7
17.80	17.70	17.80	17.90	17.80	17.70	17.70	17.70	17.70	17.70	17.80	17.80	17.80	17.80	17.80	17.80	23.50	17.80	18.20	17.80	18.60	18.00	18.1	19.70	20.7	20.9	30.821	16.882	19	18.6	18.6	15.7
17.60	17.60	17.70	17.70	17.70	17.50	17.50	17.50	17.50	17.50	17.70	17.60	17.60	17.70	17.70	17.60	23.30	17.60	18.00	17.60	18.50	17.80	17.9	19.60	20.6	20.8	30.821	16.882	18.9	18.6	18.6	14.6
17.20	17.30	17.40	17.50	17.40	17.20	17.20	17.20	17.20	17.20	17.40	17.40	17.40	17.40	17.40	17.40	23.40	17.40	17.80	17.30	18.20	17.50	17.6	19.30	20.5	20.7	30.821	16.882	18.7	18.4	18.4	12.3
17.10	17.20	17.40	17.40	17.40	17.10	17.10	17.10	17.10	17.20	17.30	17.30	17.30	17.30	17.40	17.30	23.30	17.30	17.60	17.20	18.00	17.50	17.4	19.20	20.4	20.6	30.821	16.882	18.6	18.4	18.4	12.6
16.90	17.00	17.20	17.30	17.20	16.90	16.90	16.90	16.90	17.00	17.10	17.20	17.20	17.20	17.20	17.20	22.70	17.20	17.50	17.00	17.90	17.20	16.8	19.10	20.1	20.4	30.821	16.882	18.2	18.3	18.3	11.5
16.80	16.80	17.10	17.10	17.10	16.80	16.80	16.80	16.80	16.80	17.00	17.00	17.10	17.00	17.10	17.10	23.10	17.10	17.40	16.90	17.70	17.10	16.6	19.00	20	20.2	30.821	16.882	18.1	18.2	18.2	10.5
16.90	17.00	17.20	17.20	17.20	16.90	16.90	16.90	16.90	17.00	17.10	17.10	17.20	17.20	17.20	17.20	23.00	17.20	17.30	17.00	17.60	17.20	16.4	19.00	19.9	20.1	30.821	16.882	18	18.3	18.3	10.5
19.30	19.40	19.10	19.10	19.10	19.30	19.30	19.30	19.30	19.50	19.40	19.10	19.10	19.10	19.10	19.10	24.00	19.10	18.30	19.40	17.70	18.50	17.8	19.70	20.5	20.6	30.821	16.882	18.6	19	19.1	15.7
20.50	20.60	20.10	20.10	20.00	20.50	20.50	20.50	20.50	20.60	20.50	20.10	20.00	20.10	20.10	20.00	24.50	20.00	18.90	20.40	18.20	19.20	18.4	20.00	20.7	20.7	30.821	16.882	18.4	18.9	18.9	18.8
20.60	20.70	20.30	20.20	20.20	20.60	20.60	20.60	20.60	20.80	20.70	20.30	20.20	20.30	20.30	20.20	25.10	20.20	19.10	20.50	18.40	19.30	18.5	20.00	20.7	20.3	30.821	16.882	18.5	19.1	19.1	19.9
20.70	20.80	20.60	20.50	20.50	20.70	20.70	20.70	20.70	20.80	20.80	20.60	20.50	20.60	20.60	20.50	25.40	20.50	19.50	20.50	18.50	19.50	18.7	20.10	20.6	20.4	30.821	16.882	18.7	19.4	19.4	22
20.10	20.20	20.30	20.20	20.20	20.00	20.00	20.10	20.00	20.20	20.10	20.30	20.20	20.30	20.20	20.20	24.90	20.20	19.60	19.80	18.70	19.30	19	19.90	20.8	20.8	30.821	16.882	19.3	19.6	19.6	23.7
19.90	19.70	20.00	19.90	19.90	19.90	19.80	19.90	19.80	19.70	19.60	20.00	19.90	20.00	19.90	19.90	24.70	19.90	19.80	19.60	19.10	19.30	19.4	20.00	20.9	21.1	30.821	16.882	19.6	19.8	19.8	25.2
20.60	20.40	20.50	20.50	20.40	20.60	20.60	20.60	20.60	20.40	20.10	20.50	20.40	20.50	20.50	20.40	24.60	20.40	20.60	20.30	19.50	19.90	20.1	20.20	21.1	21.2	30.821	16.882	19.7	19.7	19.7	26.2
20.40	20.30	20.30	20.20	20.20	20.40	20.40	20.40	20.40	20.30	19.90	20.30	20.20	20.30	20.30	20.20	24.90	20.20	20.40	20.20	19.70	19.80	20.1	20.20	21.4	21.3	30.821	16.882	19.9	19.9	19.9	25.9
21.00	20.90	20.90	20.80	20.80	21.10	21.00	21.10	21.00	20.90	20.40	20.90	20.80	20.90	20.90	20.80	25.40	20.80	21.10	20.90	20.10	20.20	20.7	20.40	21.4	21.5	30.821	16.882	20	19.8	19.8	26.2
21.00	20.80	20.80	20.70	20.70	21.00	21.00	21.00	21.00	20.90	20.50	20.80	20.70	20.80	20.80	20.70	24.90	20.70	21.20	21.00	20.30	20.20	20.7	20.60	21.4	21.6	30.821	16.882	20.3	20	20	25.7
21.00	20.80	20.80	20.70	20.70	21.00	21.00	21.00	21.00	20.80	20.60	20.80	20.60	20.80	20.70	20.60	25.20	20.70	21.30	21.10	20.50	20.10	20.7	20.70	21.5	21.6	30.821	16.882	20.3	19.9	19.9	25.2
20.50	20.30	20.30	20.20	20.20	20.60	20.60	20.60	20.60	20.30	20.10	20.30	20.20	20.30	20.20	20.20	24.80	20.20	20.90	20.70	20.50	19.70	20.3	20.70	21.4	21.5	30.821	16.882	20	19.7	19.7	24.1
20.30	20.10	20.00	20.00	19.90	20.30	20.30	20.30	20.30	20.10	19.90	20.00	19.80	20.00	19.90	19.80	25.00	19.90	20.60	20.30	20.50	19.50	20	20.70	21.3	21.5	30.821	16.882	19.9	19.5	19.5	23.1
20.30	20.10	20.00	19.90	19.90	20.30	20.30	20.30	20.30	20.10	19.90	20.00	19.80	20.00	19.90	19.80	24.30	19.90	20.60	20.40	20.50	19.50	20	20.70	21.3	21.4	30.821	16.882	19.9	19.5	19.5	22.7
20.00	19.90	19.80	19.70	19.60	20.00	20.00	20.00	20.00	19.90	19.70	19.70	19.60	19.70	19.70	19.60	24.10	19.60	20.30	20.10	20.20	19.40	19.8	20.50	21.2	21.4	30.821	16.882	19.8	19.4	19.4	22
19.50	19.40	19.30	19.40	19.20	19.50	19.50	19.50	19.50	19.40	19.40	19.30	19.20	19.30	19.30	19.20	24.00	19.20	19.90	19.60	19.90	19.10	19.4	20.40	21.1	21.3	30.821	16.882	19.6	19.3	19.3	21.2

Zone 2 (Bed room1)

Base	m1	m2	m3	m4	m5	m6	m7	m8	m9	m10	m11	m12	m13	m14	m15	m16	m17	m18	m19	m20	m21	m21b	m22	Tcmax	Tcmin	Com1	Com2	Com3	Com4	Com5	To
20.40	20.40	20.60	20.90	20.40	20.30	20.30	20.30	20.30	20.40	20.20	20.50	20.30	20.50	20.60	20.30	20.40	20.50	20.70	20.40	21.00	20.60	20.80	19.40	30.821	16.882	20.3	20.5	21.1	20.6	20.2	15.7
20.30	20.30	20.50	20.80	20.30	20.20	20.20	20.20	20.20	20.30	20.10	20.40	20.20	20.40	20.50	20.20	20.30	20.40	20.60	20.30	20.90	20.50	20.7	19.30	30.821	16.882	20.2	20.4	21	20.5	20.1	15.7
20.10	20.20	20.40	20.70	20.20	20.10	20.10	20.00	20.10	20.20	20.00	20.30	20.10	20.40	20.40	20.20	20.20	20.30	20.50	20.10	20.80	20.40	20.5	19.20	30.821	16.882	20.1	20.3	20.9	20.4	20.1	14.6
19.90	20.00	20.20	20.50	20.00	19.90	19.90	19.90	19.90	20.00	19.90	20.20	20.00	20.20	20.20	20.00	20.00	20.20	20.30	19.90	20.60	20.20	20.3	19.10	30.821	16.882	20	20.2	20.8	20.3	19.9	12.3
19.80	19.90	20.10	20.40	19.90	19.80	19.80	19.80	19.80	20.00	19.80	20.10	20.00	20.20	20.20	20.00	20.00	20.10	20.10	19.80	20.40	20.20	20.1	18.90	30.821	16.882	20	20.2	20.7	20.3	19.9	12.6
19.70	19.80	20.00	20.30	19.80	19.70	19.70	19.70	19.70	19.80	19.70	20.00	19.90	20.10	20.10	19.90	19.90	20.00	20.00	19.70	20.40	20.00	19.5	18.90	30.821	16.882	19.8	20	20.4	20.3	19.9	11.5
19.60	19.70	19.90	20.20	19.70	19.60	19.70	19.60	19.60	19.70	19.60	20.00	19.80	20.00	20.00	19.80	19.90	20.00	19.90	19.60	20.30	19.80	19.3	18.80	30.821	16.882	19.7	19.9	20.3	20.2	19.8	10.5
19.60	19.70	19.90	20.20	19.80	19.60	19.70	19.60	19.70	19.80	19.70	20.00	19.90	20.00	20.10	19.80	19.90	20.00	19.90	19.60	20.20	19.90	19.1	18.80	30.821	16.882	19.7	19.9	20.1	20.3	19.8	10.5
20.50	20.70	20.90	21.20	20.70	20.70	20.70	20.70	20.70	20.80	20.60	21.10	20.90	21.10	21.10	20.90	20.90	21.00	20.40	20.50	20.30	20.60	19.8	19.50	30.821	16.882	20.3	20.4	20.5	20.7	20.2	15.7
20.90	21.00	21.30	21.50	21.10	21.00	21.10	21.10	21.10	21.20	21.00	21.50	21.30	21.50	21.40	21.20	21.20	21.40	20.60	20.90	20.50	20.80	20	19.80	30.821	16.882	20.6	20.5	20.4	20.6	20.2	18.8
20.80	21.00	21.20	21.50	21.10	21.00	21.00	21.00	21.00	21.10	20.90	21.50	21.20	21.40	21.30	21.20	21.20	21.40	20.60	20.80	20.50	20.70	19.8	19.80	30.821	16.882	20.5	20.4	20.3	20.7	20.3	19.9
20.90	21.00	21.30	21.50	21.10	20.80	20.90	20.90	20.90	21.00	20.80	21.40	21.10	21.30	21.20	21.10	21.10	21.30	20.60	20.90	20.60	20.70	19.8	19.80	30.821	16.882	20.5	20.3	20.4	20.8	20.4	22
20.60	20.70	21.00	21.20	20.80	20.50	20.50	20.50	20.50	20.60	20.40	21.00	20.80	20.90	20.90	20.70	20.70	20.90	20.60	20.60	20.60	20.60	20.3	19.60	30.821	16.882	20.4	20.4	20.9	20.9	20.5	23.7
20.50	20.50	20.80	21.10	20.60	20.40	20.40	20.40	20.40	20.40	20.20	20.70	20.60	20.70	20.70	20.50	20.50	20.70	20.60	20.50	20.80	20.60	20.7	19.60	30.821	16.882	20.4	20.6	21.1	20.9	20.6	25.2
20.70	20.70	20.90	21.20	20.70	20.60	20.60	20.60	20.60	20.60	20.30	20.80	20.70	20.80	20.80	20.60	20.60	20.80	20.80	20.70	20.90	20.70	20.9	19.80	30.821	16.882	20.6	20.7	21.2	21	20.7	26.2
20.80	20.80	21.00	21.20	20.80	20.80	20.70	20.70	20.70	20.80	20.40	20.90	20.70	21.00	20.90	20.80	20.70	20.90	20.90	20.80	21.10	20.80	21.2	19.80	30.821	16.882	20.6	20.7	21.3	21	20.6	25.9
21.00	21.00	21.20	21.40	21.00	21.00	21.00	21.00	21.00	21.00	20.60	21.20	21.00	21.20	21.10	21.00	20.90	21.10	21.20	21.00	21.30	21.00	21.4	19.90	30.821	16.882	20.8	20.9	21.5	21	20.7	26.2
21.20	21.20	21.30	21.60	21.10	21.20	21.10	21.20	21.10	21.20	20.80	21.30	21.10	21.30	21.20	21.10	21.10	21.20	21.40	21.20	21.50	21.10	21.6	20.10	30.821	16.882	20.8	20.9	21.6	21	20.7	25.7
21.30	21.30	21.50	21.70	21.20	21.30	21.30	21.30	21.30	21.30	21.00	21.40	21.20	21.40	21.40	21.20	21.20	21.40	21.50	21.30	21.70	21.10	21.7	20.10	30.821	16.882	20.9	20.9	21.6	21	20.7	25.2
21.40	21.40	21.50	21.70	21.30	21.30	21.30	21.30	21.30	21.30	21.00	21.40	21.20	21.40	21.40	21.20	21.20	21.40	21.60	21.40	21.80	21.10	21.7	20.10	30.821	16.882	20.7	20.9	21.6	20.9	20.6	24.1
21.40	21.40	21.50	21.70	21.20	21.30	21.30	21.30	21.30	21.30	21.00	21.40	21.20	21.40	21.40	21.20	21.20	21.30	21.60	21.40	21.80	21.00	21.6	20.10	30.821	16.882	20.7	20.8	21.5	20.9	20.6	23.1
21.40	21.40	21.50	21.70	21.30	21.30	21.30	21.30	21.30	21.30	21.00	21.40	21.20	21.40	21.40	21.20	21.20	21.30	21.60	21.40	21.80	21.00	21.5	20.10	30.821	16.882	20.6	20.8	21.5	20.8	20.6	22.7
21.20	21.20	21.30	21.60	21.10	21.20	21.10	21.20	21.10	21.20	20.90	21.30	21.00	21.30	21.30	21.10	21.00	21.20	21.50	21.20	21.70	21.00	21.4	20.00	30.821	16.882	20.6	20.7	21.4	20.8	20.5	22
21.00	21.00	21.10	21.40	20.90	21.00	20.90	21.00	20.90	21.00	20.80	21.10	20.80	21.10	21.10	20.90	20.90	21.00	21.30	21.00	21.50	20.90	21.2	19.90	30.821	16.882	20.5	20.6	21.3	20.8	20.5	21.2

Zone 6 (Bed room2)

Base	m1	m2	m3	m4	m5	m6	m7	m8	m9	m10	m11	m12	m13	m14	m15	m16	m17	m18	m19	m20	m21	m21b	m22	Tcmax	Tcmin	Com1	Com2	Com3	Com4	Com5	To
19.00	19.00	18.90	18.90	18.90	18.80	18.80	18.70	18.80	18.80	18.80	18.80	18.70	18.80	18.90	18.70	18.70	18.70	19.00	19.00	20.20	18.90	19.10	18.80	30.821	16.882	19.7	19.9	20.2	19.9	20	15.7
18.80	18.60	18.80	18.80	18.70	18.70	18.70	18.60	18.60	18.70	18.70	18.60	18.60	18.70	18.70	18.60	18.60	18.60	18.90	18.80	20.00	18.80	19.00	18.70	30.821	16.882	19.6	19.8	20.1	19.8	19.9	15.7
18.60	18.60	18.60	18.70	18.60	18.50	18.50	18.50	18.50	18.60	18.60	18.50	18.50	18.60	18.60	18.50	18.50	18.50	18.80	18.70	19.90	18.70	18.80	18.60	30.821	16.882	19.5	19.8	20	19.7	19.9	14.6
18.40	18.40	18.40	18.50	18.40	18.30	18.30	18.20	18.30	18.30	18.40	18.30	18.30	18.40	18.40	18.30	18.30	18.30	18.60	18.40	19.70	18.50	18.50	18.30	30.821	16.882	19.3	19.6	19.9	19.6	19.8	12.3
18.30	18.40	18.40	18.50	18.40	18.20	18.20	18.20	18.20	18.30	18.40	18.30	18.30	18.40	18.40	18.30	18.30	18.30	18.50	18.30	19.50	18.40	18.40	18.20	30.821	16.882	19.3	19.6	19.8	19.7	19.8	12.6
18.10	18.20	18.30	18.30	18.20	18.10	18.10	18.10	18.10	18.10	18.20	18.20	18.20	18.20	18.30	18.20	18.20	18.20	18.40	18.20	19.50	18.20	17.90	18.10	30.821	16.882	19	19.3	19.5	19.6	19.8	11.5
18.00	18.10	18.20	18.20	18.10	18.00	18.00	17.90	18.00	18.00	18.10	18.10	18.10	18.10	18.20	18.10	18.10	18.10	18.30	18.10	19.40	18.10	17.70	18.00	30.821	16.882	18.9	19.2	19.4	19.6	19.7	10.5
18.00	18.00	18.10	18.20	18.10	17.90	17.90	17.90	17.90	18.00	18.00	18.00	18.00	18.10	18.10	18.10	18.10	18.10	18.20	18.00	19.20	18.10	17.50	17.90	30.821	16.882	18.7	19	19.3	19.6	19.7	10.5
18.30	18.40	18.50	18.60	18.50	18.30	18.20	18.20	18.20	18.40	18.40	18.50	18.50	18.50	18.50	18.50	18.50	18.50	18.50	18.40	19.30	18.30	17.80	18.20	30.821	16.882	19	19.2	19.5	19.8	20	15.7
18.80	18.80	19.00	19.00	18.90	18.70	18.70	18.70	18.70	18.80	18.80	19.00	18.90	19.00	19.00	18.90	18.90	18.90	18.90	18.80	19.50	18.70	18.00	18.60	30.821	16.882	19.3	19.4	19.6	20	20.1	18.8
19.00	19.20	19.30	19.30	19.20	19.00	19.00	19.00	19.00	19.10	19.10	19.30	19.20	19.30	19.30	19.20	19.20	19.20	19.10	19.10	19.50	18.90	18.20	18.90	30.821	16.882	19.5	19.6	19.6	20.2	20.2	19.9
19.80	20.00	20.10	20.10	20.00	19.80	19.80	19.80	19.80	20.00	19.90	20.10	20.00	20.10	20.10	20.10	20.00	20.10	19.90	19.90	19.60	19.50	18.80	19.50	30.821	16.882	20.1	20.1	19.9	20.5	20.3	22
20.40	20.50	20.70	20.70	20.60	20.40	20.40	20.50	20.40	20.60	20.40	20.80	20.60	20.70	20.70	20.60	20.60	20.60	20.40	20.50	19.70	20.00	19.80	20.00	30.821	16.882	20.8	20.7	20.4	20.7	20.4	23.7
20.70	20.70	20.90	20.90	20.80	20.80	20.70	20.80	20.70	20.70	20.60	20.90	20.80	20.90	20.80	20.80	20.70	20.80	20.70	20.80	20.00	20.30	20.30	20.40	30.821	16.882	21.1	21	20.7	20.8	20.4	25.2
21.90	21.80	21.90	21.90	21.80	21.90	21.90	22.00	21.90	21.90	21.60	22.00	21.80	22.00	21.90	21.80	21.70	21.80	21.70	21.60	20.30	21.20	21.30	21.60	30.821	16.882	22	21.5	21	21.1	20.5	26.2
21.90	21.80	21.80	21.80	21.70	21.90	21.90	22.00	21.90	21.90	21.50	21.90	21.70	21.90	21.80	21.80	21.70	21.80	21.50	21.30	20.50	21.20	21.40	21.80	30.821	16.882	22.2	21.6	21	20.9	20.5	25.9
22.90	22.80	22.80	22.70	22.70	23.00	22.90	23.00	22.90	22.90	22.40	22.90	22.70	22.90	22.70	22.70	22.60	22.70	22.50	22.20	20.80	22.00	22.30	22.80	30.821	16.882	22.8	22	21.3	21.1	20.5	26.2
22.70	22.60	22.60	22.50	22.40	22.80	22.70	22.80	22.70	22.70	22.30	22.70	22.40	22.60	22.50	22.50	22.40	22.50	22.40	22.80	21.00	21.80	22.20	22.40	30.821	16.882	22.5	22.4	21.5	21.2	20.6	25.7
22.20	22.10	22.00	22.00	21.90	22.20	22.20	22.30	22.20	22.10	21.80	22.10	21.90	22.00	21.90	21.90	21.80	21.90	22.20	22.30	21.20	21.30	21.80	21.60	30.821	16.882	21.8	21.9	21.3	21	20.5	25.2
21.50	21.40	21.30	21.30	21.20	21.50	21.50	21.60	21.50	21.40	21.10	21.30	21.10	21.30	21.20	21.20	21.10	21.20	21.60	21.60	21.20	20.70	21.20	21.00	30.821	16.882	21.2	21.3	21.1	20.7	20.4	24.1
21.10	21.00	20.90	20.90	20.80	21.10	21.10	21.10	21.10	21.00	20.70	20.90	20.70	20.90	20.80	20.80	20.70	20.80	21.20	21.20	21.30	20.40	20.90	20.70	30.821	16.882	20.9	21.1	20.9	20.5	20.3	23.1
21.20	21.00	20.90	20.90	20.80	21.20	21.10	21.20	21.10	21.00	20.80	20.90	20.70	20.90	20.80	20.80	20.70	20.80	21.20	21.20	21.30	20.40	20.80	20.80	30.821	16.882	20.9	21	20.9	20.5	20.3	22.7
20.90	20.80	20.70	20.70	20.60	20.90	20.90	20.90	20.90	20.80	20.60	20.70	20.50	20.70	20.60	20.60	20.50	20.60	21.00	21.00	21.10	20.30	20.60	20.50	30.821	16.882	20.8	20.9	20.8	20.5	20.2	22
20.50	20.40	20.30	20.30	20.20	20.40	20.40	20.40	20.40	20.40	20.20	20.20	20.10	20.20	20.20	20.10	20.10	20.10	20.50	20.50	20.90	20.00	20.20	20.10	30.821	16.882	20.5	20.7	20.6	20.3	20.2	21.2

Zone 7 (Bed room4)

Base	m1	m2	m3	m4	m5	m6	m7	m8	m9	m10	m11	m12	m13	m14	m15	m16	m17	m18	m19	m20	m21	m21b	m22	Tcmax	Tcmin	Com1	Com2	Com3	Com4	Com5	To
18.80	18.80	18.70	18.80	18.80	18.70	18.70	18.60	18.60	18.70	18.70	18.60	18.60	18.70	18.70	18.60	18.60	18.70	19.00	19.00	20.30	18.80	19.00	20.40	30.821	16.882	21.7	22	22	21.2	20.3	15.7
18.70	18.70	18.60	18.70	18.60	18.60	18.50	18.50	18.50	18.60	18.60	18.50	18.50	18.60	18.60	18.50	18.50	18.50	18.90	18.90	20.20	18.70	18.90	20.30	30.821	16.882	21.6	21.9	21.9	21.1	20.2	15.7
18.50	18.50	18.50	18.60	18.50	18.40	18.40	18.40	18.40	18.40	18.50	18.40	18.40	18.50	18.50	18.40	18.40	18.40	18.80	18.70	20.10	18.60	18.70	20.20	30.821	16.882	21.5	21.8	21.8	21.1	20.2	14.6
18.20	18.30	18.30	18.40	18.30	18.20	18.10	18.10	18.10	18.20	18.30	18.20	18.20	18.20	18.30	18.20	18.20	18.20	18.60	18.40	19.90	18.40	18.50	20.00	30.821	16.882	21.4	21.6	21.7	21	20.1	12.3
18.10	18.20	18.30	18.30	18.20	18.10	18.10	18.10	18.10	18.20	18.20	18.20	18.20	18.20	18.30	18.20	18.20	18.20	18.50	18.30	19.70	18.30	18.30	19.80	30.821	16.882	21.3	21.5	21.6	21	20.1	12.6
18.00	18.10	18.20	18.20	18.10	18.00	18.00	17.90	18.00	18.00	18.10	18.10	18.10	18.10	18.20	18.10	18.10	18.10	18.40	18.20	19.60	18.20	17.80	19.80	30.821	16.882	21	21.2	21.3	21	20	11.5
17.90	18.00	18.00	18.10	18.00	17.90	17.90	17.80	17.80	17.90	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.30	18.10	19.50	18.00	17.60	19.70	30.821	16.882	20.9	21.1	21.2	20.9	19.9	10.5
17.80	17.90	18.00	18.10	18.00	17.80	17.80	17.70	17.80	17.90	17.90	17.90	17.90	17.90	18.00	17.90	18.00	18.00	18.20	18.00	19.40	18.00	17.40	19.60	30.821	16.882	20.7	20.9	21	20.9	19.9	10.5
18.20	18.30	18.40	18.50	18.40	18.10	18.10	18.10	18.10	18.30	18.30	18.40	18.30	18.40	18.40	18.40	18.40	18.40	18.40	18.40	19.50	18.30	17.70	19.80	30.821	16.882	20.9	21.1	21.2	21.1	20	15.7
18.70	18.80	18.90	19.00	18.90	18.70	18.70	18.70	18.70	18.80	18.80	18.90	18.90	18.90	18.90	18.90	18.90	18.90	18.90	18.80	19.70	18.70	18.00	19.90	30.821	16.882	20.9	21.1	21.2	21.2	20.2	18.8
19.00	19.20	19.30	19.30	19.20	19.00	19.00	19.00	19.00	19.20	19.10	19.30	19.20	19.30	19.30	19.20	19.20	19.30	19.10	19.10	19.70	18.90	18.20	20.00	30.821	16.882	20.8	21	21.1	21.2	20.3	19.9
19.90	20.00	20.10	20.20	20.10	19.90	19.80	19.90	19.80	20.00	19.90	20.20	20.10	20.20	20.10	20.10	20.10	20.10	19.90	19.80	19.80	19.50	18.80	20.20	30.821	16.882	20.9	21.1	21.2	21.3	20.3	22
20.50	20.60	20.80	20.80	20.70	20.50	20.50	20.50	20.50	20.60	20.50	20.80	20.70	20.80	20.70	20.70	20.60	20.70	20.40	20.40	19.90	20.00	19.80	20.40	30.821	16.882	21.5	21.6	21.6	21.4	20.4	23.7
20.80	20.80	20.90	20.90	20.80	20.80	20.80	20.90	20.80	20.80	20.60	21.00	20.80	21.00	20.90	20.90	20.80	20.90	20.70	20.70	20.20	20.30	20.40	20.50	30.821	16.882	21.8	21.8	21.9	21.4	20.5	25.2
22.20	22.20	22.20	22.20	22.10	22.30	22.20	22.30	22.20	22.20	21.90	22.30	22.10	22.30	22.20	22.20	22.00	22.10	21.80	21.50	20.40	21.40	21.60	20.70	30.821	16.882	22	22	22	21.5	20.5	26.2
22.50	22.50	22.50	22.40	22.30	22.60	22.50	22.60	22.50	22.50	22.10	22.60	22.30	22.50	22.40	22.40	22.30	22.40	21.80	21.20	20.70	21.70	21.90	20.80	30.821	16.882	22	22.1	22.1	21.5	20.5	25.9
23.60	23.50	23.50	23.40	23.30	23.70	23.60	23.70	23.60	23.60	23.00	23.60	23.30	23.60	23.40	23.40	23.20	23.40	22.70	22.00	21.00	22.50	22.80	21.00	30.821	16.882	22.2	22.2	22.3	21.5	20.5	26.2
23.10	23.00	23.00	22.90	22.80	23.20	23.10	23.30	23.20	23.10	22.70	23.10	22.80	23.00	22.90	22.90	22.80	22.90	22.50	23.30	21.20	22.10	22.50	21.10	30.821	16.882	22.2	22.4	22.4	21.5	20.6	25.7
22.10	22.00	21.90	21.90	21.70	22.10	22.10	22.20	22.10	22.00	21.70	21.90	21.70	21.90	21.80	21.80	21.70	21.80	22.10	22.30	21.40	21.20	21.70	21.20	30.821	16.882	22.2	22.4	22.5	21.5	20.6	25.2
21.40	21.20	21.10	21.10	21.00	21.40	21.30	21.40	21.30	21.20	20.90	21.10	20.90	21.10	21.00	21.00	20.90	21.00	21.50	21.50	21.40	20.60	21.10	21.30	30.821	16.882	22.2	22.3	22.4	21.4	20.6	24.1
21.00	20.90	20.70	20.70	20.60	21.00	20.90	21.00	20.90	20.80	20.60	20.70	20.50	20.70	20.60	20.60	20.50	20.60	21.10	21.10	21.40	20.30	20.80	21.30	30.821	16.882	22.2	22.3	22.4	21.4	20.6	23.1
21.00	20.90	20.70	20.80	20.60	21.00	21.00	21.00	21.00	20.90	20.60	20.70	20.50	20.70	20.70	20.60	20.50	20.60	21.20	21.20	21.50	20.30	20.70	21.20	30.821	16.882	22.1	22.3	22.3	21.4	20.6	22.7
20.80	20.70	20.50	20.60	20.40	20.80	20.70	20.80	20.70	20.70	20.50	20.50	20.30	20.50	20.50	20.40	20.30	20.40	21.00	21.00	21.30	20.20	20.50	21.10	30.821	16.882	22.1	22.2	22.3	21.4	20.6	22
20.30	20.30	20.10	20.20	20.00	20.30	20.20	20.30	20.20	20.20	20.10	20.10	19.90	20.10	20.00	20.00	19.90	20.00	20.50	20.50	21.00	19.90	20.10	20.90	30.821	16.882	21.9	22.1	22.2	21.3	20.6	21.2

Zone 8 (Bed room 3)

Base	m1	m2	m3	m4	m5	m6	m7	m8	m9	m10	m11	m12	m13	m14	m15	m16	m17	m18	m19	m20	m21	m21b	m22	Tcmax	Tcmin	Com1	Com2	Com3	Com4	Com5	To
20.7	20.8	21	21.1	20.8	20.6	20.7	20.6	20.6	20.7	20.6	20.8	20.6	20.8	20.8	20.6	20.8	20.7	21	20.7	21.1	21.00	21.30	20.8	30.821	16.882	22.4	22.4	20.3	21.2	20.2	15.7
20.6	20.6	20.8	21	20.6	20.5	20.5	20.5	20.5	20.6	20.4	20.7	20.5	20.7	20.7	20.5	20.6	20.6	20.8	20.6	21	20.90	21.20	20.7	30.821	16.882	22.3	22.3	20.2	21.1	20	15.7
20.4	20.5	20.6	20.9	20.5	20.4	20.4	20.4	20.4	20.5	20.3	20.6	20.4	20.6	20.7	20.5	20.5	20.6	20.7	20.5	20.8	20.80	21.00	20.6	30.821	16.882	22.3	22.3	20.1	21.1	20	14.6
20.2	20.3	20.4	20.7	20.3	20.2	20.2	20.2	20.2	20.3	20.1	20.4	20.3	20.4	20.5	20.3	20.3	20.4	20.5	20.3	20.7	20.70	20.80	20.5	30.821	16.882	22.1	22.1	20	21	19.8	12.3
20.1	20.2	20.4	20.6	20.2	20.2	20.1	20.1	20.1	20.3	20.1	20.4	20.3	20.4	20.5	20.3	20.3	20.4	20.4	20.2	20.5	20.60	20.50	20.3	30.821	16.882	22	22	19.9	21	19.8	12.6
20	20.1	20.3	20.5	20.1	20.0	20.0	20.0	20.0	20.1	20	20.3	20.2	20.3	20.4	20.2	20.2	20.3	20.3	20.1	20.5	20.40	19.90	20.2	30.821	16.882	21.7	21.7	19.6	21	19.8	11.5
19.9	20	20.1	20.4	20.0	19.9	20.0	19.9	19.9	20.0	19.9	20.2	20.1	20.2	20.3	20.1	20.1	20.2	20.2	19.9	20.4	20.30	19.70	20.1	30.821	16.882	21.6	21.6	19.5	20.9	19.7	10.5
19.8	19.9	20.1	20.3	19.9	19.8	19.9	19.8	19.9	19.9	19.8	20.1	20	20.1	20.2	20.0	20.0	20.1	20.1	19.9	20.3	20.20	19.40	20.1	30.821	16.882	21.5	21.5	19.3	20.9	19.7	10.5
20	20.2	20.4	20.6	20.2	20.1	20.1	20.1	20.1	20.2	20.1	20.4	20.3	20.4	20.5	20.3	20.3	20.4	20.3	20.1	20.4	20.40	19.70	20.1	30.821	16.882	21.6	21.6	19.5	21.1	19.8	15.7
20.3	20.4	20.6	20.8	20.5	20.4	20.4	20.4	20.4	20.5	20.3	20.7	20.6	20.7	20.7	20.6	20.6	20.7	20.5	20.3	20.6	20.50	19.60	20.2	30.821	16.882	21.6	21.6	19.6	21.2	20	18.8
20.4	20.5	20.7	20.9	20.6	20.5	20.5	20.5	20.5	20.6	20.4	20.8	20.7	20.8	20.8	20.7	20.7	20.8	20.5	20.3	20.6	20.50	19.60	20.2	30.821	16.882	21.6	21.6	19.7	21.2	20.1	19.9
20.7	20.8	21	21.2	20.9	20.7	20.8	20.8	20.8	20.9	20.7	21.1	21	21.1	21.1	20.9	20.9	21.1	20.7	20.5	20.7	20.80	19.90	20.4	30.821	16.882	21.6	21.6	19.9	21.3	20.1	22
20.9	21	21.2	21.4	21.0	20.9	20.9	20.9	20.9	21.0	20.8	21.3	21.1	21.2	21.2	21.1	21.0	21.2	20.8	20.6	20.8	21.00	20.70	20.5	30.821	16.882	22	22	20.4	21.4	20.1	23.7
21	21.1	21.3	21.5	21.1	21.0	21.1	21.1	21.1	21.1	20.9	21.4	21.2	21.3	21.3	21.2	21.1	21.3	21	20.8	21	21.20	21.30	20.6	30.821	16.882	22.3	22.3	20.7	21.4	20.2	25.2
21.2	21.2	21.4	21.6	21.3	21.2	21.2	21.2	21.2	21.2	20.9	21.5	21.3	21.4	21.4	21.3	21.2	21.4	21.2	20.9	21.1	21.30	21.50	20.8	30.821	16.882	22.4	22.4	21	21.5	20.2	26.2
21.3	21.3	21.5	21.7	21.3	21.3	21.3	21.3	21.3	21.3	21	21.5	21.3	21.5	21.4	21.3	21.2	21.4	21.3	21.1	21.3	21.40	21.80	20.9	30.821	16.882	22.5	22.5	21	21.5	20.2	25.9
21.5	21.5	21.6	21.8	21.4	21.5	21.4	21.5	21.4	21.5	21.1	21.6	21.4	21.6	21.5	21.4	21.4	21.6	21.5	21.3	21.5	21.50	22.00	21.1	30.821	16.882	22.7	22.7	21.3	21.5	20.2	26.2
21.6	21.6	21.7	21.9	21.5	21.5	21.5	21.5	21.5	21.5	21.2	21.7	21.4	21.6	21.6	21.5	21.4	21.6	21.7	21.5	21.7	21.50	22.20	21.3	30.821	16.882	22.8	22.8	21.5	21.5	20.7	25.7
21.7	21.7	21.8	22	21.6	21.6	21.6	21.7	21.6	21.6	21.3	21.7	21.5	21.7	21.7	21.6	21.5	21.7	21.8	21.7	21.9	21.60	22.20	21.5	30.821	16.882	22.8	22.8	21.4	21.5	20.4	25.2
21.8	21.8	21.9	22.1	21.7	21.6	21.6	21.7	21.6	21.6	21.3	21.7	21.5	21.7	21.7	21.6	21.5	21.7	21.9	21.8	21.9	21.60	22.20	21.6	30.821	16.882	22.8	22.8	21.1	21.4	20.3	24.1
21.8	21.8	21.8	22	21.7	21.7	21.6	21.6	21.6	21.7	21.3	21.7	21.5	21.7	21.7	21.6	21.5	21.7	21.9	21.8	22	21.50	22.10	21.6	30.821	16.882	22.8	22.8	21	21.4	20.3	23.1
21.7	21.7	21.8	22	21.6	21.7	21.6	21.6	21.6	21.7	21.4	21.7	21.5	21.8	21.7	21.6	21.5	21.6	21.9	21.8	22	21.50	22.00	21.5	30.821	16.882	22.7	22.7	20.9	21.4	20.4	22.7
21.5	21.6	21.6	21.8	21.4	21.5	21.4	21.5	21.4	21.6	21.3	21.6	21.4	21.6	21.6	21.5	21.4	21.5	21.7	21.6	21.8	21.40	21.90	21.4	30.821	16.882	22.7	22.7	20.9	21.4	20.4	22
21.3	21.3	21.4	21.6	21.2	21.3	21.2	21.3	21.2	21.3	21.1	21.4	21.2	21.4	21.4	21.2	21.2	21.3	21.5	21.4	21.6	21.30	21.70	21.2	30.821	16.882	22.6	22.6	20.7	21.3	20.3	21.2

Zone 9 (Hall)

Base	m1	m2	m3	m4	m5	m6	m7	m8	m9	m10	m11	m12	m13	m14	m15	m16	m17	m18	m19	m20	m21	m21b	m22	Tcmax	Tcmin	Com1	Com2	Com3	Com4	To
21.2	21.2	21.5	21.5	21.2	21.0	21.0	21.1	21.1	18.3	21.2	21.3	21.2	18.2	21.4	18.2	18.2	21.4	18.2	21.3	21.2	22.0	22.20	18.70	30.821	16.882	22.1	22.4	21.4	20.6	15.7
21.1	21.1	21.3	21.4	21.1	21.0	21.0	21.0	21.0	18.0	21.0	21.2	21.0	18.0	21.2	18.0	18.0	21.2	18.1	21.1	21.1	21.8	22.00	18.60	30.821	16.882	22	22.3	21.3	20.4	15.7
21	21	21.2	21.4	21.0	20.9	20.9	20.9	20.9	18.0	20.9	21.1	21.0	18.0	21.2	17.9	18.0	21.1	18.0	21.0	21.0	21.7	21.80	18.40	30.821	16.882	21.9	22.3	21.2	20.3	14.6
20.8	20.9	21	21.2	20.8	20.8	20.8	20.8	20.8	17.8	20.7	21.0	20.9	17.8	21.0	17.8	17.8	21.0	17.8	20.8	20.8	21.6	21.60	18.10	30.821	16.882	21.7	22.1	21.1	20.3	12.3
20.6	20.7	20.9	21.1	20.7	20.7	20.7	20.7	20.7	17.8	20.7	21.0	20.8	17.8	21.0	17.8	17.8	21.0	17.7	20.6	20.7	21.4	21.40	17.80	30.821	16.882	21.6	22	21	20.2	12.6
20.5	20.6	20.8	21	20.6	20.6	20.7	20.6	20.7	17.7	20.6	20.9	20.8	17.7	20.9	17.7	17.7	20.9	17.6	20.6	20.6	21.3	20.80	17.70	30.821	16.882	21.6	21.7	20.7	20.2	11.5
20.4	20.5	20.7	20.9	20.5	20.5	20.6	20.6	20.6	17.6	20.5	20.8	20.7	17.6	20.8	17.6	17.7	20.8	17.5	20.5	20.5	21.2	20.60	17.60	30.821	16.882	21.6	21.6	20.6	20.2	10.5
20.4	20.5	20.6	20.8	20.5	20.4	20.5	20.5	20.5	17.5	20.5	20.7	20.6	17.5	20.8	17.5	17.6	20.8	17.4	20.4	20.5	21.1	20.40	17.80	30.821	16.882	22	21.6	20.5	20.2	10.5
20.5	20.6	20.8	21	20.7	20.6	20.7	20.7	20.7	17.7	20.6	21.0	20.8	17.7	20.9	17.7	17.8	21.0	17.6	20.5	20.6	21.2	20.50	19.80	30.821	16.882	22.2	21.6	20.6	20.3	15.7
20.7	20.8	21	21.2	20.8	20.8	20.8	20.8	20.8	17.8	20.7	21.1	21.0	17.9	21.1	17.9	17.9	21.1	17.7	20.7	20.7	21.3	20.50	20.80	30.821	16.882	22.7	21.6	20.6	20.4	18.8
20.7	20.8	21	21.2	20.8	20.8	20.9	20.9	20.9	17.9	20.8	21.2	21.0	17.9	21.1	17.9	17.9	21.1	17.7	20.7	20.7	21.3	20.40	20.80	30.821	16.882	22.7	21.6	20.6	20.4	19.9
20.9	21	21.2	21.4	21.0	20.9	21.0	21.0	21.0	18.0	20.9	21.3	21.1	18.0	21.2	18.0	18.0	21.3	17.9	20.9	20.8	21.5	20.60	20.50	30.821	16.882	22.5	21.6	20.6	20.5	22
21	21.1	21.3	21.5	21.2	21.0	21.0	21.1	21.1	18.0	20.9	21.4	21.2	18.1	21.3	18.1	18.1	21.3	18.0	21.0	21.0	21.6	21.30	19.60	30.821	16.882	22.5	22	21	20.6	23.7
21.1	21.2	21.4	21.6	21.2	21.1	21.1	21.2	21.1	18.1	21.0	21.4	21.2	18.1	21.3	18.1	18.1	21.4	18.1	21.1	21.1	21.7	21.80	19.70	30.821	16.882	22.5	22.3	21.3	20.6	25.2
21.3	21.3	21.5	21.7	21.4	21.2	21.3	21.3	21.3	18.2	21.0	21.5	21.3	18.3	21.4	18.3	18.2	21.5	18.3	21.3	21.2	21.8	22.10	20.10	30.821	16.882	22.6	22.4	21.4	20.7	26.2
21.4	21.5	21.7	21.8	21.5	21.4	21.4	21.4	21.4	18.4	21.1	21.6	21.5	18.4	21.5	18.4	18.3	21.6	18.4	21.4	21.3	22.0	22.30	20.10	30.821	16.882	22.8	22.5	21.5	20.7	25.9
21.7	21.7	21.9	22	21.7	21.6	21.6	21.7	21.6	18.6	21.4	21.9	21.7	18.6	21.7	18.6	18.5	21.8	18.7	21.6	21.6	22.2	22.60	20.20	30.821	16.882	22.9	22.7	21.7	20.7	26.2
21.9	21.9	22.1	22.2	21.9	21.8	21.8	21.8	21.8	18.8	21.5	22.0	21.8	18.8	21.9	18.8	18.7	21.9	18.9	21.9	21.7	22.3	22.90	20.20	30.821	16.882	22.9	22.8	21.7	20.7	25.7
22	22.1	22.2	22.4	22.0	22.0	21.9	22.0	21.9	18.9	21.7	22.1	21.9	18.9	22.0	18.9	18.8	22.1	19.0	22.0	21.9	22.3	23.00	20.10	30.821	16.882	22.9	22.8	21.8	20.7	25.2
22.1	22.1	22.2	22.4	22.1	22.0	21.9	22.0	21.9	18.9	21.7	22.1	21.9	18.9	22.0	18.9	18.8	22.0	19.1	22.1	22.0	22.3	22.90	20.10	30.821	16.882	22.8	22.8	21.7	20.6	24.1
22.1	22.1	22.2	22.4	22.1	22.0	21.9	22.0	21.9	19.0	21.7	22.1	21.9	18.9	22.0	18.9	18.8	22.1	19.1	22.1	22.0	22.3	22.90	20.00	30.821	16.882	22.8	22.8	21.7	20.6	23.1
22.1	22.1	22.2	22.4	22.0	22.0	21.9	22.0	21.9	19.0	21.7	22.1	21.9	18.9	22.0	18.9	18.8	22.0	19.1	22.1	22.0	22.2	22.80	20.00	30.821	16.882	22.7	22.7	21.7	20.6	22.7
21.9	21.9	22	22.2	21.9	21.9	21.8	21.9	21.8	18.9	21.7	22.0	21.8	18.8	21.9	18.8	18.7	21.9	19.0	21.9	21.9	22.2	22.60	19.80	30.821	16.882	22.6	22.7	21.7	20.6	22
21.7	21.7	21.8	22	21.7	21.7	21.6	21.7	21.6	18.7	21.5	21.8	21.6	18.6	21.8	18.6	18.6	21.8	18.8	21.7	21.7	22.1	22.40	19.60	30.821	16.882	22.5	22.6	21.6	20.6	21.2

21-Jun

Zone 1 (Reception)

Base	m1	m2	m3	m4	m5	m6	m7	m8	m9	m10	m11	m12	m13	m14	m15	m16	m17	m18	m19	m20	m21	m21b	m22	Tcmax	Tcmin	Com1	Com2	Com3	Com4	Com5	To
36.35	36.35	36.35	36.60	36.35	36.35	36.35	36.35	36.35	36.35	36.45	36.35	36.35	36.35	36.35	36.35	32.40	36.55	36.75	36.55	36.80	36.30	36.4	38.40	36.386	26.157	36.3	36.45	35.4	35.2	35.2	32.5
36.10	36.20	36.30	36.40	36.30	36.10	36.10	36.10	36.10	36.20	36.30	36.30	36.30	36.30	36.30	36.30	32.10	36.30	36.60	36.40	36.80	36.20	36.2	38.10	36.386	26.157	36.1	36.3	35.3	35.1	35.1	32.5
35.90	35.90	36.10	36.20	36.10	35.80	35.90	35.80	35.80	35.90	36.10	36.10	36.10	36.10	36.10	36.00	32.10	36.10	36.30	36.20	36.60	36.00	35.8	37.90	36.386	26.157	35.9	36.1	35.1	34.9	34.9	31.5
35.60	35.70	35.90	36.00	35.90	35.60	35.60	35.60	35.60	35.70	35.80	35.90	35.90	35.90	35.90	35.90	31.90	35.90	36.10	35.90	36.40	35.80	35.5	37.80	36.386	26.157	35.8	36	34.9	34.8	34.8	30.6
35.40	35.60	35.80	35.90	35.80	35.40	35.40	35.40	35.40	35.60	35.70	35.80	35.80	35.80	35.80	35.80	32.00	35.80	35.90	35.70	36.20	35.60	35.2	37.60	36.386	26.157	35.7	35.9	34.8	34.8	34.8	30.4
35.10	35.20	35.50	35.60	35.50	35.10	35.20	35.10	35.10	35.20	35.40	35.50	35.50	35.50	35.50	35.50	32.10	35.60	35.70	35.40	36.00	35.40	35.1	37.50	36.386	26.157	35.6	35.8	34.6	34.6	34.6	29
35.00	35.10	35.30	35.60	35.50	34.90	35.00	34.90	35.00	35.10	35.30	35.30	35.40	35.30	35.40	35.50	32.40	35.50	35.50	35.50	35.80	35.90	35.4	37.30	36.386	26.157	35.4	35.6	34.5	34.5	34.5	27.6
36.20	36.30	36.30	36.40	36.30	36.20	36.20	36.10	36.20	36.30	36.40	36.30	36.30	36.30	36.30	36.30	32.50	36.30	36.00	36.40	35.90	36.00	35.4	37.70	36.386	26.157	35.7	35.9	34.8	34.4	35	30.4
37.90	38.10	37.70	37.70	37.70	38.00	38.00	38.00	38.00	38.10	38.00	37.80	37.70	37.80	37.70	37.70	33.00	37.70	36.70	38.20	36.10	36.90	36.4	38.20	36.386	26.157	36.1	36.2	35.1	35.3	35.5	32.2
38.50	38.70	38.20	38.20	38.20	38.50	38.60	38.60	38.60	38.70	38.60	38.30	38.20	38.30	38.20	38.20	33.70	38.20	37.00	36.00	36.40	37.30	36.6	38.30	36.386	26.157	36.2	35.8	34.8	35.2	35.4	34.1
38.20	38.50	38.10	38.20	38.10	38.30	38.30	38.30	38.30	38.50	38.40	38.20	38.10	38.20	38.20	38.10	33.90	38.10	37.00	36.20	36.50	37.20	36.3	38.40	36.386	26.157	36.1	35.8	34.9	35.4	35.4	35.7
37.90	38.10	38.00	38.00	38.00	37.90	37.90	37.90	37.90	38.10	38.10	38.00	38.00	38.00	38.00	38.00	33.60	38.00	37.00	36.50	36.70	37.00	36.5	38.40	36.386	26.157	36.3	36.1	35.3	35.7	35.7	37.7
37.30	37.40	37.60	37.60	37.60	37.30	37.30	37.30	37.30	37.30	37.40	37.60	37.60	37.60	37.60	37.60	32.90	37.60	37.20	37.00	37.20	36.90	36.6	38.40	36.386	26.157	36.4	36.4	35.8	36	36	40.4
37.10	37.10	37.40	37.40	37.40	37.10	37.10	37.10	37.10	37.10	37.00	37.40	37.30	37.40	37.40	37.30	32.50	37.40	37.30	37.40	37.50	36.80	36.8	38.40	36.386	26.157	36.4	36.6	36	36.2	36.2	41.6
37.50	37.50	37.70	37.70	37.70	37.50	37.50	37.50	37.50	37.50	37.30	37.70	37.70	37.70	37.70	37.70	32.80	37.70	37.70	37.70	37.80	37.10	37.2	38.60	36.386	26.157	36.6	36.8	36.3	36.4	36.4	43
37.60	37.50	37.70	37.70	37.70	37.60	37.60	37.60	37.60	37.50	37.20	37.70	37.70	37.70	37.70	37.70	32.80	37.70	37.80	37.80	38.00	37.20	37.5	38.60	36.386	26.157	36.7	36.9	36.4	36.3	36.3	42.5
37.90	37.80	37.90	38.00	37.90	37.90	37.90	37.90	37.90	37.80	37.60	38.00	37.90	38.00	37.90	37.90	32.90	37.90	38.10	38.20	38.30	37.40	38	38.80	36.386	26.157	36.9	37.1	36.6	36.4	36.3	43
38.10	37.90	38.00	38.00	37.90	38.10	38.10	38.10	38.10	37.90	37.70	38.00	37.90	38.00	38.00	37.90	33.10	38.00	38.30	38.40	38.50	37.50	38.1	38.90	36.386	26.157	37	37.1	36.6	36.3	36.3	42
38.20	38.10	38.10	38.10	38.00	38.20	38.20	38.20	38.20	38.10	37.80	38.10	38.00	38.10	38.10	38.00	33.00	38.10	38.50	38.50	38.70	37.50	38.2	39.00	36.386	26.157	37	37.2	36.6	36.2	36.2	41.6
38.30	38.10	38.00	38.10	38.00	38.30	38.30	38.30	38.30	38.10	37.80	38.10	38.00	38.10	38.00	38.00	33.10	38.00	38.60	38.60	38.80	37.50	38.1	39.10	36.386	26.157	37	37.1	36.5	36.1	36	40.9
38.00	37.80	37.70	37.80	37.70	38.00	38.00	38.00	38.00	37.80	37.60	37.80	37.70	37.80	37.70	37.70	33.00	37.70	38.30	38.30	38.60	37.20	37.9	39.00	36.386	26.157	36.9	37	36.3	35.8	35.8	38.8
37.70	37.50	37.50	37.50	37.40	37.70	37.70	37.70	37.70	37.50	37.40	37.50	37.40	37.50	37.40	37.40	33.00	37.40	38.10	38.00	38.40	37.10	37.6	38.90	36.386	26.157	36.7	36.9	36.1	35.6	35.6	36.9
37.30	37.20	37.10	37.20	37.00	37.30	37.30	37.30	37.30	37.20	37.10	37.10	37.00	37.10	37.10	37.00	32.90	37.10	37.70	37.60	38.00	36.80	37.3	38.70	36.386	26.157	36.5	36.7	35.9	35.4	35.4	35.1
36.80	36.70	36.70	36.80	36.60	36.80	36.80	36.80	36.80	36.70	36.70	36.70	36.60	36.70	36.70	36.60	32.80	36.70	37.30	37.10	37.50	36.60	37	38.50	36.386	26.157	36.4	36.6	35.6	35.2	35.2	33.5

Zone 2 (Bed room1)

Base	m1	m2	m3	m4	m5	m6	m7	m8	m9	m10	m11	m12	m13	m14	m15	m16	m17	m18	m19	m20	m21	m21b	m22	Tcmax	Tcmin	Com1	Com2	Com3	Com4	Com5	To
38.80	38.80	39.10	39.40	38.90	38.80	38.80	38.80	38.80	38.90	38.80	39.10	38.90	39.10	39.10	38.90	38.90	39.10	39.20	38.90	39.30	39.20	39.2	37.80	36.386	26.157	37.7	37.9	38.4	38.2	37.7	32.5
38.70	38.80	39.00	39.30	38.80	38.70	38.70	38.70	38.70	38.80	38.70	39.00	38.80	39.00	39.00	38.80	38.80	39.00	39.10	38.80	39.20	39.00	39	37.70	36.386	26.157	37.6	37.8	38.3	38	37.7	32.5
38.60	38.70	38.90	39.10	38.70	38.60	38.60	38.50	38.60	38.70	38.60	38.80	38.70	38.90	38.90	38.70	38.70	38.80	38.90	38.70	39.10	38.90	38.7	37.50	36.386	26.157	37.4	37.6	38.1	37.9	37.6	31.5
38.40	38.50	38.70	39.00	38.50	38.40	38.40	38.40	38.40	38.50	38.40	38.70	38.60	38.80	38.80	38.60	38.60	38.70	38.80	38.50	38.90	38.70	38.4	37.30	36.386	26.157	37.3	37.5	38	37.9	37.5	30.6
38.30	38.40	38.70	38.90	38.50	38.30	38.30	38.30	38.30	38.50	38.40	38.70	38.50	38.70	38.80	38.50	38.60	38.70	38.70	38.40	38.80	38.60	38.2	37.20	36.386	26.157	37.2	37.4	37.9	37.8	37.5	30.4
38.20	38.30	38.50	38.80	38.40	38.20	38.20	38.20	38.20	38.30	38.20	38.50	38.40	38.60	38.60	38.40	38.40	38.60	38.50	38.30	38.70	38.50	38.1	37.10	36.386	26.157	37.1	37.3	37.8	37.8	37.4	29
37.90	38.00	38.30	38.60	38.10	37.90	38.00	37.90	38.00	38.10	38.00	38.30	38.20	38.30	38.40	38.10	38.20	38.30	38.30	38.00	38.60	38.30	37.9	37.00	36.386	26.157	37	37.2	37.7	37.7	37.3	27.6
38.50	38.60	38.90	39.10	38.70	38.50	38.60	38.50	38.60	38.70	38.50	38.90	38.80	38.90	39.00	38.70	38.80	38.90	38.60	38.60	38.60	38.70	38.2	37.30	36.386	26.157	37.4	37.5	37.8	37.9	37.5	30.4
39.10	39.20	39.50	39.70	39.30	39.20	39.20	39.20	39.20	39.40	39.10	39.70	39.50	39.60	39.60	39.40	39.40	39.60	38.90	39.20	38.70	39.10	38.6	37.90	36.386	26.157	37.8	37.9	38	37.9	37.7	32.2
39.20	39.30	39.60	39.90	39.40	39.40	39.40	39.50	39.40	39.60	39.40	39.90	39.70	39.80	39.80	39.60	39.60	39.80	39.00	38.30	38.80	39.20	38.5	38.10	36.386	26.157	38	38.1	37.8	38	37.6	34.1
39.20	39.40	39.70	39.90	39.50	39.30	39.30	39.40	39.30	39.50	39.30	39.80	39.60	39.80	39.70	39.60	39.50	39.70	39.00	38.50	38.90	39.20	38.4	38.10	36.386	26.157	37.9	38	37.8	38.1	37.8	35.7
39.20	39.40	39.70	39.90	39.50	39.20	39.20	39.20	39.20	39.40	39.20	39.70	39.50	39.60	39.60	39.50	39.50	39.70	39.10	38.70	38.90	39.20	38.7	38.10	36.386	26.157	38	38.1	38.1	38.3	37.9	37.7
39.10	39.20	39.50	39.70	39.30	38.90	39.00	39.00	39.00	39.00	38.90	39.40	39.20	39.30	39.40	39.20	39.20	39.40	39.10	38.90	39.10	39.10	38.9	38.00	36.386	26.157	37.9	38	38.4	38.4	38.1	40.4
39.00	39.10	39.30	39.60	39.10	38.90	38.90	38.90	38.90	39.00	38.70	39.30	39.10	39.20	39.20	39.00	39.00	39.20	39.10	39.00	39.20	39.10	39.1	37.90	36.386	26.157	37.9	38	38.6	38.5	38.2	41.6
39.20	39.30	39.50	39.70	39.30	39.20	39.20	39.20	39.20	39.20	38.90	39.50	39.30	39.50	39.40	39.30	39.20	39.40	39.30	39.20	39.40	39.30	39.4	38.10	36.386	26.157	38	38.1	38.8	38.6	38.3	43
39.20	39.30	39.50	39.70	39.30	39.20	39.20	39.20	39.20	39.30	38.90	39.50	39.30	39.50	39.40	39.30	39.20	39.40	39.40	39.20	39.50	39.30	39.6	38.10	36.386	26.157	38	38.2	38.9	38.6	38.2	42.5
39.40	39.40	39.60	39.90	39.40	39.40	39.40	39.40	39.40	39.50	39.10	39.60	39.40	39.70	39.60	39.50	39.40	39.60	39.60	39.50	39.70	39.40	40	38.20	36.386	26.157	38.2	38.3	39.1	38.6	38.3	43
39.50	39.60	39.70	40.00	39.60	39.60	39.50	39.60	39.50	39.60	39.30	39.70	39.50	39.70	39.70	39.50	39.50	39.70	39.80	39.60	39.90	39.50	40.1	38.30	36.386	26.157	38.2	38.3	39.1	38.5	38.2	42
39.70	39.70	39.90	40.10	39.70	39.70	39.70	39.70	39.70	39.80	39.50	39.90	39.70	39.90	39.90	39.70	39.70	39.80	39.90	39.80	40.10	39.50	40.3	38.40	36.386	26.157	38.3	38.4	39.2	38.5	38.2	41.6
39.80	39.80	40.00	40.20	39.80	39.80	39.80	39.80	39.80	39.80	39.50	40.00	39.70	40.00	39.90	39.70	39.70	39.90	40.10	39.90	40.20	39.60	40.2	38.50	36.386	26.157	38.2	38.4	39.1	38.5	38.2	40.9
39.70	39.70	39.90	40.10	39.70	39.70	39.70	39.70	39.70	39.70	39.40	39.90	39.60	39.80	39.80	39.60	39.60	39.80	40.00	39.80	40.10	39.50	40.2	38.40	36.386	26.157	38.2	38.3	39	38.3	38.1	38.8
39.60	39.60	39.80	40.00	39.60	39.60	39.60	39.60	39.60	39.60	39.30	39.70	39.50	39.70	39.70	39.50	39.50	39.70	39.90	39.70	40.10	39.40	39.9	38.40	36.386	26.157	38.1	38.2	38.9	38.2	37.9	36.9
39.40	39.40	39.60	39.80	39.40	39.30	39.30	39.30	39.30	39.40	39.10	39.50	39.30	39.50	39.50	39.30	39.30	39.50	39.70	39.50	39.90	39.30	39.8	38.20	36.386	26.157	37.9	38.1	38.8	38.1	37.8	35.1
39.20	39.20	39.30	39.60	39.10	39.10	39.10	39.10	39.10	39.10	38.90	39.30	39.10	39.30	39.30	39.10	39.10	39.20	39.50	39.30	39.60	39.20	39.5	38.00	36.386	26.157	37.8	38	38.6	38.1	37.7	33.5

Zone 6 (Bed room2)

Base	m1	m2	m3	m4	m5	m6	m7	m8	m9	m10	m11	m12	m13	m14	m15	m16	m17	m18	m19	m20	m21	m21b	m22	Tcmax	Tcmin	Com1	Com2	Com3	Com4	Com5	To
37.80	37.80	37.70	37.90	37.70	37.60	37.60	37.50	37.50	37.70	37.70	37.80	37.60	37.80	37.70	37.60	37.70	37.80	38.00	37.70	38.70	37.70	37.50	37.60	36.386	26.157	36.6	37	36.8	36.8	36.7	32.5
37.40	37.50	37.60	37.80	37.50	37.40	37.40	37.40	37.40	37.50	37.50	37.60	37.50	37.60	37.60	37.50	37.50	37.60	37.90	37.50	38.50	37.50	37.40	37.50	36.386	26.157	36.4	36.8	36.8	36.6	36.6	32.5
37.20	37.30	37.40	37.60	37.30	37.20	37.20	37.20	37.20	37.30	37.30	37.40	37.30	37.40	37.40	37.30	37.30	37.40	37.70	37.30	38.30	37.30	37.10	37.30	36.386	26.157	36.3	36.6	36.6	36.5	36.5	31.5
37.00	37.10	37.30	37.50	37.20	37.00	37.00	36.90	37.00	37.10	37.10	37.20	37.20	37.30	37.30	37.20	37.20	37.30	37.50	37.10	38.20	37.10	36.80	37.10	36.386	26.157	36.1	36.4	36.5	36.4	36.5	30.6
36.90	37.00	37.20	37.40	37.10	36.80	36.80	36.80	36.80	37.00	37.00	37.20	37.10	37.20	37.20	37.10	37.10	37.20	37.30	36.90	38.00	37.00	36.60	36.90	36.386	26.157	36	36.3	36.4	36.4	36.4	30.4
36.70	36.80	37.00	37.20	36.90	36.60	36.60	36.60	36.60	36.70	36.80	37.00	36.90	37.00	37.00	36.90	36.90	37.00	37.20	36.70	37.90	36.80	36.50	36.80	36.386	26.157	35.9	36.2	36.3	36.3	36.4	29
36.80	37.00	37.10	37.40	37.00	36.80	36.70	36.80	36.70	36.90	36.90	37.20	37.10	37.20	37.10	37.00	37.00	37.40	37.30	36.80	37.80	36.90	36.50	36.80	36.386	26.157	36	36.2	36.3	36.4	36.4	27.6
36.90	37.10	37.30	37.50	37.20	36.90	36.90	36.90	36.90	37.00	37.00	37.30	37.20	37.30	37.30	37.20	37.20	37.30	37.30	37.00	37.80	37.00	36.50	36.80	36.386	26.157	35.9	36.2	36.3	36.5	36.5	30.4
37.30	37.50	37.70	37.90	37.60	37.30	37.30	37.30	37.30	37.50	37.40	37.70	37.60	37.70	37.70	37.60	37.60	37.70	37.50	37.40	37.90	37.30	36.80	36.90	36.386	26.157	36	36.2	36.4	36.7	36.7	32.2
37.50	37.60	37.90	38.10	37.80	37.50	37.50	37.50	37.50	37.60	37.60	37.90	37.80	37.90	37.90	37.80	37.80	37.90	37.60	37.50	38.00	37.40	36.80	37.00	36.386	26.157	36	36.3	36.4	36.8	36.8	34.1
37.50	37.70	38.00	38.10	37.90	37.50	37.50	37.50	37.50	37.70	37.60	38.00	37.90	38.00	38.00	37.90	37.90	38.00	37.60	37.60	38.00	37.40	36.70	37.10	36.386	26.157	36	36.3	36.4	36.9	36.9	35.7
37.70	37.90	38.20	38.30	38.10	37.70	37.70	37.70	37.70	37.90	37.80	38.20	38.10	38.20	38.20	38.10	38.10	38.20	37.80	37.70	38.10	37.60	37.10	37.30	36.386	26.157	36.4	36.6	36.7	37	36.9	37.7
38.00	38.10	38.40	38.60	38.30	38.10	38.10	38.10	38.10	38.10	38.10	38.50	38.40	38.50	38.50	38.40	38.30	38.50	38.10	38.10	38.40	37.80	37.60	37.70	36.386	26.157	36.8	37	37	37.2	37	40.4
38.20	38.30	38.60	38.70	38.40	38.30	38.30	38.30	38.30	38.30	38.10	38.60	38.50	38.60	38.60	38.50	38.40	38.60	38.30	38.30	38.60	38.00	38.00	37.80	36.386	26.157	37	37.2	37.2	37.2	37.1	41.6
38.90	39.00	39.20	39.30	39.00	39.00	39.00	39.00	39.00	39.00	38.70	39.30	39.10	39.20	39.20	39.10	39.00	39.20	38.80	38.70	38.80	38.50	38.60	38.70	36.386	26.157	37.6	37.3	37.4	37.3	37.2	43
39.40	39.40	39.50	39.70	39.40	39.40	39.40	39.50	39.40	39.40	39.00	39.60	39.40	39.60	39.50	39.40	39.40	39.50	39.00	38.80	39.00	38.90	39.10	39.20	36.386	26.157	38	37.4	37.5	37.3	37.2	42.5
39.80	39.80	39.90	40.00	39.70	39.80	39.80	39.90	39.80	39.80	39.40	40.00	39.80	40.00	39.90	39.80	39.70	39.90	39.30	39.10	39.20	39.20	39.60	39.60	36.386	26.157	38.4	37.6	37.7	37.3	37.2	43
39.70	39.60	39.70	39.90	39.60	39.80	39.80	39.80	39.80	39.70	39.30	39.80	39.60	39.80	39.70	39.60	39.50	39.70	39.40	39.20	39.50	39.10	39.60	39.50	36.386	26.157	38.2	37.7	37.7	37.3	37.1	42
39.30	39.20	39.30	39.40	39.10	39.30	39.30	39.40	39.30	39.30	38.90	39.30	39.10	39.30	39.20	39.10	39.10	39.30	39.30	39.40	39.60	38.70	39.40	39.10	36.386	26.157	37.8	37.9	37.8	37.3	37.1	41.6
39.10	38.90	38.90	39.10	38.80	39.10	39.10	39.10	39.10	39.00	38.60	39.00	38.80	39.00	38.90	38.80	38.80	38.90	39.30	39.10	39.80	38.40	39.00	38.90	36.386	26.157	37.5	37.7	37.6	37.1	37	40.9
38.80	38.80	38.70	38.90	38.60	38.80	38.80	38.80	38.80	38.80	38.40	38.70	38.60	38.70	38.70	38.60	38.50	38.70	39.10	38.90	39.70	38.30	38.90	38.70	36.386	26.157	37.3	37.6	37.6	37	36.9	38.8
38.70	38.60	38.50	38.70	38.40	38.60	38.60	38.60	38.60	38.50	38.30	38.50	38.30	38.50	38.50	38.40	38.30	38.50	39.00	38.70	39.60	38.10	38.60	38.60	36.386	26.157	37.1	37.4	37.4	36.8	36.8	36.9
38.30	38.30	38.20	38.40	38.10	38.30	38.30	38.30	38.30	38.30	38.10	38.20	38.10	38.20	38.20	38.10	38.10	38.20	38.70	38.40	39.30	37.90	38.40	38.30	36.386	26.157	36.9	37.2	37.3	36.7	36.7	35.1
38.00	37.90	37.90	38.10	37.80	37.90	37.90	37.90	37.90	37.90	37.80	37.90	37.80	37.90	37.90	37.80	37.80	37.90	38.40	38.00	39.00	37.80	38.10	38.00	36.386	26.157	36.8	37.1	37.1	36.6	36.6	33.5

Zone 7 (Bed room4)

Base	m1	m2	m3	m4	m5	m6	m7	m8	m9	m10	m11	m12	m13	m14	m15	m16	m17	m18	m19	m20	m21	m21b	m22	Tcmax	Tcmin	Com1	Com2	Com3	Com4	Com5	To
37.60	37.70	37.80	37.90	37.70	37.60	37.60	37.60	37.60	37.70	37.70	37.80	37.60	37.80	37.80	37.60	37.70	37.80	37.90	37.80	38.60	37.50	37.50	39.00	36.386	26.157	37.2	37.3	37.2	36.8	35.9	32.5
37.50	37.60	37.70	37.90	37.60	37.50	37.50	37.40	37.50	37.60	37.60	37.70	37.50	37.70	37.70	37.50	37.60	37.70	37.90	37.70	38.50	37.50	37.50	38.80	36.386	26.157	37	37.2	37.2	36.6	35.8	32.5
37.30	37.40	37.50	37.70	37.40	37.30	37.30	37.20	37.20	37.40	37.40	37.50	37.40	37.50	37.50	37.40	37.40	37.50	37.70	37.50	38.30	37.40	37.20	38.60	36.386	26.157	36.8	37	37	36.6	35.8	31.5
37.10	37.20	37.40	37.60	37.20	37.10	37.10	37.00	37.10	37.20	37.20	37.30	37.20	37.30	37.40	37.20	37.30	37.30	37.50	37.30	38.20	37.20	36.90	38.50	36.386	26.157	36.7	36.8	36.9	36.5	35.7	30.6
36.90	37.10	37.30	37.50	37.20	36.90	36.90	36.90	36.90	37.10	37.10	37.30	37.20	37.30	37.30	37.20	37.20	37.30	37.40	37.10	38.00	37.10	36.70	38.40	36.386	26.157	36.6	36.8	36.8	36.5	35.6	30.4
36.70	36.80	37.10	37.30	37.00	36.70	36.70	36.70	36.70	36.80	36.90	37.00	37.00	37.10	37.10	37.00	37.00	37.10	37.20	36.90	37.90	36.90	36.50	38.30	36.386	26.157	36.5	36.7	36.7	36.4	35.5	29
36.70	36.80	37.10	37.30	37.00	36.70	36.70	36.70	36.70	36.80	36.80	37.00	37.00	37.10	37.10	37.00	37.10	37.20	37.20	36.80	37.80	36.90	36.40	38.10	36.386	26.157	36.3	36.5	36.6	36.4	35.4	27.6
36.80	36.90	37.10	37.40	37.10	36.70	36.80	36.70	36.80	36.90	36.90	37.10	37.10	37.10	37.20	37.10	37.10	37.20	37.20	36.90	37.80	36.90	36.40	38.20	36.386	26.157	36.4	36.6	36.6	36.5	35.5	30.4
36.90	37.10	37.30	37.50	37.30	36.90	36.90	36.90	36.90	37.10	37.00	37.30	37.30	37.30	37.40	37.30	37.30	37.40	37.30	37.10	37.90	37.00	36.50	38.30	36.386	26.157	36.5	36.6	36.7	36.6	35.6	32.2
37.10	37.30	37.50	37.70	37.40	37.10	37.10	37.10	37.10	37.30	37.20	37.50	37.50	37.50	37.60	37.50	37.50	37.60	37.40	37.30	37.90	37.10	36.50	38.20	36.386	26.157	36.4	36.6	36.6	36.7	35.7	34.1
37.20	37.40	37.70	37.90	37.60	37.30	37.30	37.30	37.30	37.50	37.40	37.70	37.70	37.70	37.80	37.60	37.70	37.80	37.50	37.40	38.00	37.20	36.50	38.40	36.386	26.157	36.4	36.6	36.6	36.7	35.8	35.7
37.40	37.70	38.00	38.20	37.90	37.40	37.50	37.50	37.50	37.70	37.60	38.00	37.90	38.00	38.00	37.90	37.90	38.00	37.70	37.60	38.10	37.40	36.90	38.50	36.386	26.157	36.7	36.6	36.9	36.8	35.9	37.7
37.90	38.00	38.30	38.50	38.20	37.90	37.90	37.90	37.90	38.00	37.90	38.30	38.20	38.30	38.30	38.20	38.20	38.30	38.10	38.10	38.40	37.70	37.50	38.70	36.386	26.157	37	37.1	37.2	37	36	40.4
38.10	38.20	38.40	38.60	38.30	38.10	38.10	38.10	38.10	38.20	38.00	38.50	38.30	38.40	38.40	38.30	38.30	38.40	38.20	38.30	38.50	37.90	37.90	38.80	36.386	26.157	37.2	37.1	37.3	37	36.1	41.6
39.10	39.10	39.30	39.50	39.20	39.10	39.10	39.20	39.10	39.20	38.90	39.40	39.20	39.40	39.30	39.20	39.20	39.30	38.80	38.60	38.80	38.60	38.70	39.00	36.386	26.157	37.3	37.4	37.5	37.1	36.1	43
39.70	39.70	39.90	40.10	39.80	39.80	39.80	39.80	39.80	39.80	39.40	40.00	39.80	40.00	39.90	39.80	39.70	39.90	39.20	38.60	39.00	39.20	39.40	39.10	36.386	26.157	37.7	37.6	37.6	37.1	36.1	42.5
40.20	40.20	40.30	40.40	40.10	40.30	40.30	40.30	40.30	40.30	39.80	40.50	40.20	40.40	40.30	40.20	40.10	40.30	39.50	38.90	39.20	39.50	40.00	39.30	36.386	26.157	37.7	37.9	37.8	37.1	36.2	43
40.00	40.00	40.10	40.20	39.90	40.10	40.10	40.10	40.10	40.00	39.60	40.20	39.90	40.10	40.00	39.90	39.90	40.00	39.60	39.00	39.50	39.30	39.90	39.40	36.386	26.157	37.7	37.9	37.9	37	36.2	42
39.40	39.40	39.40	39.60	39.30	39.50	39.50	39.50	39.50	39.40	39.00	39.50	39.30	39.40	39.40	39.30	39.20	39.40	39.40	39.60	39.70	38.80	39.50	39.60	36.386	26.157	37.8	38	38	37	36.2	41.6
39.10	39.00	39.00	39.20	38.90	39.10	39.10	39.20	39.10	39.00	38.70	39.00	38.90	39.00	39.00	38.90	38.80	39.00	39.30	39.30	39.80	38.50	39.10	39.70	36.386	26.157	37.8	37.9	37.9	37	36.2	40.9
38.90	38.80	38.80	39.00	38.70	38.90	38.90	38.90	38.90	38.80	38.50	38.80	38.60	38.80	38.80	38.60	38.60	38.80	39.20	39.00	39.70	38.30	39.00	39.60	36.386	26.157	37.7	37.9	37.9	36.9	36.1	38.8
38.70	38.60	38.60	38.80	38.50	38.70	38.70	38.70	38.70	38.60	38.40	38.60	38.40	38.60	38.60	38.40	38.40	38.50	39.00	38.90	39.60	38.20	38.70	39.50	36.386	26.157	37.6	37.9	37.7	36.8	36.1	36.9
38.40	38.40	38.30	38.50	38.20	38.40	38.30	38.40	38.30	38.30	38.10	38.30	38.10	38.30	38.30	38.10	38.10	38.30	38.70	38.60	39.30	38.00	38.50	39.30	36.386	26.157	37.5	37.6	37.6	36.7	36	35.1
38.00	38.00	38.00	38.20	37.90	38.00	38.00	38.00	38.00	38.00	37.90	38.00	37.80	38.00	38.00	37.80	37.80	38.00	38.40	38.20	39.00	37.80	38.20	39.10	36.386	26.157	37.3	37.5	37.5	36.7	35.9	33.5

Zone 8 (Bed room 3)

Base	m1	m2	m3	m4	m5	m6	m7	m8	m9	m10	m11	m12	m13	m14	m15	m16	m17	m18	m19	m20	m21	m21b	m22	Tcmax	Tcmin	Com1	Com2	Com3	Com4	Com5	To
40.2	39.2	39.4	39.5	39.2	39.2	39.2	39.2	39.2	39.3	39.2	39.4	39.2	39.4	39.5	39.2	39.3	39.4	39.4	39.2	39.4	39.40	39.50	39.4	36.386	26.157	38.8	38.8	37.1	36.7	36.8	32.5
40	39.1	39.2	39.4	39.1	39.0	39.0	39.0	39.0	39.1	39	39.2	39.1	39.2	39.3	39.1	39.1	39.2	39.2	39	39.2	39.30	39.30	39.2	36.386	26.157	38.6	38.6	36.9	36.6	36.7	32.5
39.9	38.9	39.1	39.3	38.9	38.8	38.8	38.8	38.8	38.9	38.8	39.1	38.9	39.1	39.1	39.0	39.0	39.1	39	38.9	39.1	39.20	39.00	39.1	36.386	26.157	38.5	38.5	36.7	36.6	36.6	31.5
39.7	38.8	38.9	39.1	38.8	38.7	38.7	38.7	38.7	38.8	38.7	38.9	38.8	39	39	38.8	38.9	38.9	38.9	38.7	38.9	39.00	38.70	39.0	36.386	26.157	38.3	38.3	36.5	36.5	36.6	30.6
39.6	38.7	38.9	39.1	38.7	38.6	38.6	38.6	38.6	38.7	38.6	38.9	38.8	38.9	39	38.8	38.8	38.9	38.8	38.6	38.8	38.90	38.50	38.9	36.386	26.157	38.2	38.2	36.5	36.5	36.5	30.4
39.4	38.5	38.7	38.9	38.6	38.5	38.5	38.4	38.5	38.6	38.5	38.7	38.6	38.8	38.8	38.6	38.7	38.8	38.7	38.5	38.7	38.80	38.40	38.8	36.386	26.157	38.2	38.2	36.4	36.4	36.4	29
39.2	38.3	38.5	38.7	38.4	38.3	38.3	38.2	38.3	38.4	38.3	38.5	38.5	38.6	38.6	38.4	38.5	38.6	38.5	38.3	38.6	38.60	38.20	38.6	36.386	26.157	38	38.1	36.4	36.4	36.3	27.6
39.4	38.5	38.7	38.9	38.6	38.4	38.5	38.4	38.5	38.6	38.4	38.8	38.7	38.8	38.8	38.6	38.7	38.8	38.6	38.4	38.6	38.80	38.20	38.7	36.386	26.157	38.1	38.1	36.3	36.5	36.4	30.4
39.5	38.6	38.8	39	38.7	38.5	38.6	38.6	38.6	38.7	38.5	38.9	38.8	38.9	38.9	38.8	38.8	38.9	38.7	38.5	38.7	38.90	38.30	38.7	36.386	26.157	38.1	38.1	36.4	36.6	36.5	32.2
39.5	38.6	38.8	39	38.7	38.7	38.7	38.7	38.7	38.8	38.7	39	38.9	39	39	38.9	38.9	39	38.6	38.5	38.8	38.80	38.10	38.6	36.386	26.157	38.1	38.1	36.4	36.7	36.6	34.1
39.7	38.8	39.1	39.3	38.9	38.7	38.8	38.8	38.8	38.9	38.7	39.1	39	39.1	39.1	39.0	39.0	39.1	38.9	38.7	38.9	39.00	38.10	38.9	36.386	26.157	38.1	38.1	36.4	36.8	36.6	35.7
39.9	39	39.2	39.4	39.1	38.9	38.9	38.9	38.9	39.0	38.9	39.3	39.2	39.3	39.3	39.1	39.1	39.3	39	38.9	39	39.10	38.60	39.0	36.386	26.157	38.3	38.3	36.7	37	36.7	37.7
39.7	39.2	39.4	39.6	39.3	39.1	39.1	39.1	39.2	39.2	39.1	39.5	39.3	39.4	39.5	39.3	39.3	39.5	39.2	39.1	39.2	39.30	39.00	39.1	36.386	26.157	38.5	38.5	37	37.2	36.8	40.4
40.2	39.3	39.5	39.7	39.4	39.2	39.2	39.2	39.2	39.3	39.1	39.5	39.4	39.5	39.5	39.4	39.4	39.5	39.3	39.2	39.3	39.40	39.30	39.2	36.386	26.157	38.7	38.7	37.2	37.2	36.9	41.6
40.4	39.5	39.7	39.9	39.6	39.4	39.5	39.5	39.5	39.5	39.2	39.8	39.6	39.7	39.6	39.6	39.5	39.7	39.5	39.4	39.5	39.60	39.70	39.3	36.386	26.157	38.8	38.8	37.4	37.3	36.9	43
40.5	39.5	39.7	39.9	39.6	39.5	39.5	39.5	39.5	39.6	39.3	39.8	39.6	39.7	39.7	39.6	39.6	39.7	39.6	39.5	39.6	39.60	39.90	39.4	36.386	26.157	39	39	37.5	37.3	36.8	42.5
40.7	39.7	39.9	40.1	39.8	39.7	39.7	39.7	39.7	39.8	39.5	40	39.8	39.9	39.9	39.8	39.7	39.9	39.8	39.7	39.8	39.80	40.30	39.6	36.386	26.157	39.2	39.2	37.7	37.3	36.9	43
40.9	39.9	40.1	40.2	39.9	39.8	39.8	39.9	39.9	39.9	39.6	40	39.9	40	40	39.9	39.8	40	40	39.9	39.9	39.80	40.50	39.8	36.386	26.157	39.3	39.2	37.7	37.3	36.9	42
41.1	40.1	40.2	40.4	40.1	40.0	40.0	40.1	40.0	40.1	39.8	40.2	40	40.2	40.1	40.1	40.0	40.2	40.2	40	40.1	39.90	40.70	39.9	36.386	26.157	39.3	39.3	37.9	37.3	37	41.6
41.1	40.2	40.3	40.5	40.2	40.1	40.1	40.2	40.1	40.2	39.8	40.3	40.1	40.3	40.2	40.1	40.1	40.2	40.3	40.1	40.2	39.90	40.60	40.0	36.386	26.157	39.3	39.3	37.7	37.2	37	40.9
41.1	40.1	40.2	40.4	40.0	40.0	40.0	40.0	40.0	40.1	39.7	40.2	40	40.1	40.1	40.0	39.9	40.1	40.2	40	40.2	39.80	40.50	40.0	36.386	26.157	39.2	39.3	37.6	37	36.9	38.8
40.9	40	40.1	40.2	39.9	39.9	39.8	39.9	39.8	39.9	39.6	40	39.8	40	40	39.9	39.8	40	40.1	39.9	40.1	39.70	40.30	39.9	36.386	26.157	39.1	39.1	37.5	36.9	36.9	36.9
40.7	39.7	39.8	40	39.7	39.6	39.6	39.6	39.6	39.7	39.5	39.8	39.6	39.8	39.8	39.6	39.6	39.7	39.9	39.7	39.9	39.60	40.10	39.7	36.386	26.157	39	39	37.3	36.8	36.8	35.1
40.4	39.5	39.6	39.8	39.4	39.4	39.3	39.3	39.3	39.4	39.2	39.5	39.3	39.5	39.5	39.4	39.4	39.5	39.6	39.4	39.6	39.50	39.90	39.5	36.386	26.157	38.9	38.9	37.2	36.7	36.8	33.5

Zone 9 (Hall)

Base	m1	m2	m3	m4	m5	m6	m7	m8	m9	m10	m11	m12	m13	m14	m15	m16	m17	m18	m19	m20	m21	m21b	m22	Tcmax	Tcmin	Com1	Com2	Com3	Com4	To
39.7	39.6	39.9	40	39.6	39.6	39.7	39.7	39.7	36.8	39.5	39.7	39.7	36.8	40.0	36.8	36.8	39.8	36.8	39.7	39.7	40.2	40.20	37.20	36.386	26.157	36.7	37	38.8	38	32.5
39.5	39.5	39.7	39.8	39.5	39.5	39.5	39.5	39.5	36.6	39.4	39.6	39.5	36.6	39.7	36.6	36.7	39.6	36.7	39.5	39.5	40.0	40.00	37.00	36.386	26.157	36.5	36.8	38.6	37.9	32.5
39.3	39.4	39.5	39.7	39.4	39.4	39.4	39.3	39.4	36.5	39.3	39.5	39.4	36.5	39.6	36.5	36.6	39.5	36.5	39.4	39.4	39.9	39.70	36.80	36.386	26.157	36.3	36.6	38.4	37.8	31.5
39.2	39.3	39.4	39.6	39.3	39.2	39.2	39.2	39.2	36.4	39.2	39.4	39.3	36.4	39.5	36.4	36.5	39.4	36.4	39.2	39.2	39.8	39.50	36.60	36.386	26.157	36.1	36.5	38.3	37.8	30.6
39.1	39.2	39.3	39.5	39.2	39.1	39.2	39.1	39.2	36.3	39.1	39.4	39.3	36.3	39.4	36.3	36.4	39.4	36.3	39.1	39.1	39.7	39.30	36.40	36.386	26.157	36	36.4	38.2	37.8	30.4
39	39.1	39.2	39.4	39.1	39.0	39.1	39.0	39.1	36.2	39.0	39.3	39.2	36.2	39.3	36.2	36.3	39.3	36.2	39.0	39.0	39.6	39.30	36.30	36.386	26.157	35.9	36.3	38.2	37.7	29
38.8	38.9	39.1	39.2	38.9	38.9	38.9	38.9	38.9	36.0	38.9	39.1	39.0	36.1	39.2	36.1	36.1	39.1	36.0	38.8	38.9	39.4	39.00	36.10	36.386	26.157	35.8	36.2	38.1	37.7	27.6
38.9	39	39.2	39.3	39.0	39.0	39.0	39.0	39.0	36.2	39.0	39.2	39.1	36.2	39.3	36.2	36.2	39.3	36.1	38.9	38.9	39.6	39.00	37.10	36.386	26.157	36.3	36.5	38.1	37.7	30.4
39	39.1	39.3	39.4	39.1	39.1	39.1	39.1	39.1	36.3	39.1	39.4	39.3	36.3	39.4	36.3	36.4	39.4	36.2	39.0	39.0	39.6	39.10	38.60	36.386	26.157	37.1	37.1	38.1	37.8	32.2
38.9	39	39.2	39.3	39.0	39.2	39.2	39.2	39.2	36.4	39.2	39.5	39.4	36.4	39.5	36.4	36.4	39.5	36.1	38.9	39.1	39.5	38.80	39.00	36.386	26.157	37.2	36.9	38.1	37.9	34.1
39.2	39.3	39.5	39.7	39.3	39.2	39.3	39.3	39.3	36.5	39.2	39.6	39.4	36.5	39.5	36.5	36.5	39.6	36.4	39.2	39.2	39.7	38.90	38.70	36.386	26.157	37	36.8	38	38	35.7
39.4	39.5	39.6	39.8	39.5	39.3	39.4	39.4	39.4	36.5	39.3	39.7	39.6	36.6	39.6	36.6	36.6	39.7	36.5	39.3	39.3	39.9	39.40	38.30	36.386	26.157	37.1	36.8	38.3	38	37.7
39.5	39.6	39.8	40	39.7	39.4	39.6	39.6	39.6	36.6	39.4	39.8	39.7	36.7	39.7	36.7	36.7	39.8	36.7	39.5	39.4	40.0	39.70	37.80	36.386	26.157	36.9	36.9	38.5	38.1	40.4
39.6	39.7	39.9	40	39.7	39.6	39.6	39.6	39.6	36.7	39.5	39.9	39.7	36.8	39.8	36.8	36.8	39.8	36.7	39.6	39.5	40.1	40.10	37.70	36.386	26.157	36.9	37.1	38.7	38.2	41.6
39.8	39.9	40	40.2	39.9	39.8	39.8	39.8	39.8	37.0	39.6	40.0	39.9	37.0	39.9	37.0	36.9	40.0	36.9	39.8	39.7	40.2	40.30	38.10	36.386	26.157	37.1	37.3	38.8	38.2	43
39.9	39.9	40.1	40.3	40.0	39.9	39.9	39.9	39.9	37.0	39.7	40.1	39.9	37.0	40.0	37.0	37.0	40.1	37.0	39.9	39.8	40.4	40.60	38.20	36.386	26.157	37.3	37.4	39	38.3	42.5
40.1	40.1	40.3	40.4	40.1	40.1	40.1	40.1	40.1	37.2	39.9	40.3	40.1	37.2	40.2	37.2	37.2	40.2	37.2	40.1	40.0	40.5	41.00	38.40	36.386	26.157	37.5	37.7	39.2	38.3	43
40.3	40.3	40.4	40.6	40.3	40.2	40.2	40.3	40.2	37.3	40.0	40.4	40.2	37.3	40.3	37.3	37.3	40.3	37.4	40.2	40.2	40.5	41.20	38.40	36.386	26.157	37.5	37.7	39.2	38.3	42
40.4	40.5	40.6	40.7	40.4	40.4	40.4	40.4	40.4	37.5	40.1	40.5	40.3	37.5	40.4	37.5	37.4	40.5	37.6	40.4	40.3	40.6	41.30	38.40	36.386	26.157	37.6	37.8	39.3	38.3	41.6
40.5	40.5	40.6	40.8	40.5	40.4	40.4	40.5	40.4	37.6	40.2	40.6	40.4	37.5	40.5	37.5	37.5	40.5	37.6	40.5	40.4	40.6	41.20	38.50	36.386	26.157	37.5	37.7	39.3	38.2	40.9
40.4	40.5	40.5	40.7	40.4	40.4	40.3	40.4	40.3	37.5	40.1	40.5	40.3	37.5	40.4	37.4	37.4	40.4	37.6	40.4	40.4	40.5	41.20	38.30	36.386	26.157	37.4	37.6	39.2	38.1	38.8
40.3	40.3	40.4	40.6	40.3	40.3	40.2	40.3	40.2	37.4	40.0	40.4	40.2	37.4	40.3	37.3	37.3	40.3	37.5	40.3	40.3	40.5	41.00	38.10	36.386	26.157	37.2	37.5	39.1	38.1	36.9
40.1	40.1	40.2	40.4	40.1	40.1	40.0	40.1	40.0	37.2	39.9	40.2	40.0	37.2	40.1	37.2	37.1	40.1	37.3	40.1	40.1	40.3	40.80	37.80	36.386	26.157	37	37.3	39	38	35.1
39.9	39.9	40	40.1	39.8	39.8	39.8	39.8	39.8	37.0	39.7	39.9	39.8	36.9	39.9	36.9	36.9	39.9	37.0	39.9	39.9	40.2	40.60	37.60	36.386	26.157	36.9	37.2	38.9	37.9	33.5

23-Sep

Zone 1 (Reception)

Base	m1	m2	m3	m4	m5	m6	m7	m8	m9	m10	m11	m12	m13	m14	m15	m16	m17	m18	m19	m20	m21	m21b	m22	Tcmax	Tcmin	Com1	Com2	Com3	Com4	Com5	To
33.57	33.30	33.60	33.70	33.55	33.50	33.50	33.50	33.50	33.50	33.60	33.60	33.60	33.60	33.60	33.60	33.30	33.60	33.90	33.60	34.20	33.10	33.5	35.30	34.69	27.376	33.3	33.50	32.6	32.4	32.3	31.5
33.40	33.40	33.50	33.60	33.50	33.40	33.40	33.40	33.40	33.40	33.50	33.50	33.50	33.50	33.50	33.50	33.20	33.50	33.80	33.50	34.10	33.40	33.4	35.20	34.69	27.376	33.3	33.4	32.5	32.3	32.3	31.5
33.10	33.20	33.30	33.40	33.30	33.10	33.10	33.10	33.10	33.20	33.30	33.30	33.30	33.30	33.30	33.30	33.00	33.30	33.60	33.20	33.90	33.20	33.2	35.10	34.69	27.376	33.2	33.3	32.4	32.2	32.2	30.4
33.10	33.20	33.40	33.50	33.40	33.10	33.10	33.10	33.10	33.20	33.30	33.40	33.40	33.40	33.40	33.40	33.30	33.40	33.60	33.20	33.90	33.20	33.1	35.00	34.69	27.376	33.1	33.3	32.4	32.3	32.3	30.4
33.00	33.00	33.30	33.30	33.20	33.00	33.00	32.90	33.00	33.00	33.20	33.20	33.20	33.20	33.30	33.20	33.40	33.30	33.40	33.00	33.70	33.10	32.8	34.90	34.69	27.376	33	33.2	32.2	32.2	32.2	30.4
32.80	32.80	33.10	33.20	33.10	32.80	32.80	32.80	32.80	32.80	33.00	33.10	33.10	33.10	33.10	33.10	33.50	33.10	33.30	32.90	33.60	32.90	32.8	34.80	34.69	27.376	33	33.2	32.2	32.1	32.1	29.3
32.70	32.70	33.00	33.10	33.00	32.70	32.70	32.70	32.70	32.70	32.90	32.90	33.00	32.90	33.00	33.00	33.60	33.00	33.00	32.80	33.40	33.10	32.9	34.70	34.69	27.376	32.8	33	32	32	32	28
33.20	33.30	33.30	33.40	33.30	33.20	33.20	33.20	33.20	33.30	33.30	33.30	33.30	33.30	33.30	33.30	33.20	33.30	33.30	33.20	33.40	33.10	33.2	34.90	34.69	27.376	33	33.1	32.2	32.2	32.2	27.2
34.40	34.50	34.20	34.30	34.20	34.40	34.40	34.40	34.40	34.50	34.50	34.20	34.20	34.20	34.20	34.20	34.00	34.20	33.70	34.50	33.30	33.70	33.5	35.20	34.69	27.376	33.2	33.3	32.3	32.4	32.4	28.3
35.80	35.80	35.20	35.20	35.20	35.80	35.80	35.80	35.80	35.90	35.70	35.30	35.20	35.30	35.20	35.20	34.50	35.20	34.10	35.70	33.40	34.40	34.1	35.40	34.69	27.376	33.4	33.4	32	32.1	32.1	29.3
35.60	35.70	35.20	35.20	35.20	35.60	35.60	35.60	35.60	35.70	35.60	35.20	35.20	35.20	35.20	35.20	35.30	35.20	34.20	35.50	33.60	34.40	33.9	35.40	34.69	27.376	33.3	33	32	32.2	32.2	30.9
35.10	35.20	35.00	35.00	34.90	35.10	35.10	35.10	35.10	35.20	35.10	35.00	34.90	35.00	35.00	34.90	35.30	34.90	34.10	34.80	33.70	34.10	33.5	35.40	34.69	27.376	33.2	33	32.1	32.4	32.4	32.5
34.00	34.20	34.30	34.30	34.30	34.00	34.00	34.00	34.00	34.20	34.20	34.30	34.30	34.30	34.30	34.20	34.90	34.30	33.80	33.80	33.90	33.60	33.2	35.20	34.69	27.376	33.1	33.2	32.4	32.7	32.7	34.6
33.80	33.90	34.10	34.20	34.10	33.80	33.80	33.80	33.80	33.80	33.90	34.10	34.10	34.10	34.10	34.10	34.80	34.10	33.90	33.50	34.00	33.60	33.3	35.20	34.69	27.376	33.2	33.3	32.6	32.8	32.8	35.7
34.00	34.00	34.20	34.30	34.20	34.00	34.00	34.00	34.00	34.00	33.90	34.20	34.20	34.20	34.20	34.20	34.50	34.20	34.10	33.80	34.20	33.70	33.6	35.30	34.69	27.376	33.3	33.5	32.8	32.9	32.9	36.7
34.20	34.20	34.40	34.40	34.30	34.20	34.20	34.20	34.20	34.20	34.00	34.40	34.30	34.40	34.40	34.30	34.30	34.40	34.30	34.00	34.50	33.90	34	35.40	34.69	27.376	33.5	33.6	33	33	33	37.7
34.40	34.30	34.50	34.50	34.40	34.40	34.40	34.40	34.40	34.30	34.10	34.50	34.40	34.50	34.50	34.40	34.30	34.50	34.60	34.30	34.80	34.00	34.3	35.50	34.69	27.376	33.6	33.8	33.1	33	33	37.7
34.40	34.30	34.50	34.50	34.40	34.40	34.40	34.40	34.40	34.30	34.10	34.50	34.40	34.50	34.50	34.40	34.20	34.40	34.70	34.40	35.00	34.00	34.3	35.60	34.69	27.376	33.6	33.8	33.1	32.9	32.9	36.7
34.70	34.60	34.70	34.80	34.70	34.70	34.70	34.70	34.70	34.60	34.40	34.70	34.70	34.70	34.70	34.70	33.80	34.70	35.00	34.80	35.30	34.10	34.5	35.80	34.69	27.376	33.8	33.9	33.3	33	33	37.7
34.70	34.60	34.70	34.70	34.60	34.70	34.70	34.70	34.70	34.60	34.40	34.70	34.60	34.70	34.70	34.60	33.90	34.60	35.10	34.80	35.40	34.10	34.6	35.80	34.69	27.376	33.8	33.9	33.3	32.9	32.9	36.7
34.70	34.50	34.60	34.60	34.50	34.70	34.70	34.70	34.70	34.50	34.30	34.50	34.50	34.50	34.50	34.50	33.90	34.50	35.00	34.70	35.30	34.00	34.6	35.80	34.69	27.376	33.7	33.9	33.2	32.8	32.8	35.7
34.40	34.30	34.30	34.40	34.20	34.40	34.40	34.40	34.40	34.30	34.10	34.30	34.20	34.30	34.30	34.20	33.70	34.30	34.80	34.50	35.10	33.90	34.2	35.70	34.69	27.376	33.6	33.9	32.9	32.6	32.6	34.1
34.10	34.10	34.10	34.20	34.10	34.10	34.10	34.10	34.10	34.10	34.00	34.10	34.00	34.10	34.10	34.00	33.60	34.10	34.60	34.20	34.90	33.80	34.2	35.60	34.69	27.376	33.6	33.8	32.9	32.5	32.5	33.5
33.80	33.70	33.80	33.90	33.70	33.80	33.80	33.80	33.80	33.70	33.70	33.70	33.70	33.80	33.80	33.70	33.70	33.70	34.30	33.90	34.60	33.70	34	35.50	34.69	27.376	33.5	33.6	32.8	32.4	32.4	32.5

Zone 2 (Bed room1)

Base	m1	m2	m3	m4	m5	m6	m7	m8	m9	m10	m11	m12	m13	m14	m15	m16	m17	m18	m19	m20	m21	m21b	m22	Tcmax	Tcmin	Com1	Com2	Com3	Com4	Com5	To
36.00	36.10	36.20	36.50	36.00	36.00	35.90	35.90	35.90	36.10	35.90	36.20	36.00	36.20	36.20	36.00	36.00	36.20	36.30	36.00	36.40	36.20	36.3	34.80	34.69	27.376	34.7	34.9	35.8	35	34.9	31.5
35.90	36.00	36.10	36.40	35.90	35.90	35.80	35.80	35.80	36.00	35.80	36.10	35.90	36.10	36.10	35.90	35.90	36.10	36.20	35.90	36.30	36.10	36.2	34.70	34.69	27.376	34.6	34.8	35.5	35.1	34.8	31.5
35.70	35.80	36.00	36.30	35.80	35.70	35.70	35.70	35.70	35.80	35.70	36.00	35.80	36.00	36.10	35.80	35.90	36.00	36.00	35.70	36.20	36.00	36	34.60	34.69	27.376	34.5	34.7	35.4	35	34.7	30.4
35.70	35.80	36.00	36.30	35.80	35.70	35.70	35.70	35.70	35.80	35.70	36.00	35.90	36.00	36.10	35.80	35.90	36.00	36.00	35.70	36.20	36.00	35.9	34.60	34.69	27.376	34.6	34.8	35.4	35.1	34.7	30.4
35.60	35.70	35.90	36.20	35.80	35.60	35.60	35.60	35.60	35.70	35.60	36.00	35.80	36.00	36.00	35.80	35.80	35.90	35.90	35.60	36.10	35.90	35.7	34.50	34.69	27.376	34.4	34.6	35.2	35.1	34.7	30.4
35.50	35.60	35.80	36.10	35.60	35.50	35.50	35.50	35.50	35.60	35.50	35.80	35.70	35.90	35.90	35.70	35.70	35.80	35.80	35.50	36.00	35.80	35.7	34.40	34.69	27.376	34.4	34.6	35.2	35	34.6	29.3
35.30	35.40	35.70	36.00	35.50	35.30	35.40	35.30	35.40	35.40	35.30	35.70	35.50	35.70	35.70	35.50	35.60	35.70	35.70	35.30	35.90	35.70	35.4	34.30	34.69	27.376	34.3	34.5	35.1	34.9	34.5	28
35.60	35.70	35.90	36.20	35.70	35.60	35.60	35.60	35.60	35.70	35.50	36.00	35.80	36.00	36.00	35.80	35.80	36.00	35.80	35.50	35.90	35.90	35.6	34.60	34.69	27.376	34.6	34.7	35.2	35	34.6	27.2
36.00	36.10	36.40	36.60	36.20	36.10	36.10	36.10	36.10	36.20	36.00	36.50	36.30	36.40	36.40	36.20	36.20	36.40	36.00	36.00	35.80	36.20	35.9	34.80	34.69	27.376	34.8	35	35.2	35.1	34.7	28.3
36.40	36.50	36.70	37.00	36.50	36.50	36.50	36.60	36.50	36.60	36.40	36.90	36.70	36.90	36.90	36.70	36.70	36.80	36.10	36.40	35.80	36.40	36.1	35.10	34.69	27.376	35	35.1	35	35	34.5	29.3
36.30	36.50	36.70	37.00	36.50	36.40	36.40	36.50	36.50	36.60	36.30	36.90	36.60	36.80	36.80	36.60	36.60	36.80	36.10	36.30	35.90	36.40	35.9	35.10	34.69	27.376	35	35.1	35	35.1	34.6	30.9
36.20	36.40	36.60	36.90	36.40	36.20	36.20	36.20	36.20	36.40	36.10	36.70	36.50	36.60	36.60	36.40	36.40	36.60	36.10	36.20	36.00	36.30	35.7	35.00	34.69	27.376	34.8	34.9	35.1	35.2	34.8	32.5
35.90	36.00	36.30	36.60	36.10	35.80	35.80	35.80	35.80	35.90	35.80	36.30	36.10	36.20	36.20	36.00	36.10	36.20	36.00	35.90	36.00	36.10	35.6	34.80	34.69	27.376	34.7	34.8	35.2	35.3	34.9	34.6
35.80	35.90	36.20	36.50	36.00	35.70	35.80	35.70	35.80	35.80	35.70	36.10	36.00	36.10	36.10	35.90	35.90	36.10	36.00	35.80	36.10	36.00	35.7	34.80	34.69	27.376	34.7	34.8	35.3	35.3	35	35.7
35.90	36.00	36.20	36.50	36.00	35.80	35.80	35.80	35.80	35.90	35.70	36.20	36.00	36.20	36.10	36.00	36.00	36.20	36.10	35.90	36.20	36.10	36	34.90	34.69	27.376	34.8	34.9	35.5	35.4	35	36.7
36.00	36.10	36.30	36.60	36.10	36.00	36.00	36.00	36.00	36.10	35.80	36.30	36.10	36.30	36.30	36.10	36.10	36.30	36.20	35.90	36.30	36.20	36.2	34.80	34.69	27.376	34.8	34.9	35.6	35.4	35.1	37.7
36.10	36.20	36.40	36.70	36.20	36.20	36.10	36.10	36.10	36.20	35.90	36.40	36.20	36.40	36.40	36.20	36.20	36.40	36.30	36.10	36.50	36.30	36.5	34.90	34.69	27.376	34.9	35	35.8	35.4	35.1	37.7
36.20	36.30	36.50	36.80	36.30	36.30	36.30	36.30	36.30	36.30	36.10	36.50	36.30	36.50	36.50	36.30	36.30	36.50	36.50	36.20	36.60	36.30	36.6	35.10	34.69	27.376	35	35.1	35.8	35.4	35	36.7
36.50	36.60	36.70	37.00	36.60	36.50	36.50	36.50	36.50	36.60	36.30	36.80	36.60	36.80	36.80	36.60	36.60	36.70	36.70	36.50	36.90	36.40	36.8	35.10	34.69	27.376	35	35.1	35.9	35.4	35.1	37.7
36.50	36.60	36.80	37.00	36.60	36.50	36.50	36.60	36.50	36.60	36.30	36.80	36.60	36.80	36.80	36.60	36.60	36.70	36.80	36.50	36.90	36.40	36.9	35.30	34.69	27.376	35.1	35.2	35.9	35.4	35.1	36.7
36.50	36.60	36.70	37.00	36.50	36.50	36.50	36.60	36.50	36.60	36.30	36.80	36.50	36.70	36.70	36.50	36.50	36.70	36.80	36.50	37.00	36.40	36.9	35.30	34.69	27.376	35	35.2	35.9	35.4	35	35.7
36.40	36.50	36.70	36.90	36.40	36.40	36.40	36.40	36.40	36.50	36.20	36.60	36.40	36.60	36.60	36.40	36.40	36.60	36.70	36.40	36.90	36.30	36.7	35.20	34.69	27.376	34.9	35	35.8	35.3	34.9	34.1
36.30	36.40	36.50	36.80	36.30	36.30	36.30	36.30	36.30	36.40	36.10	36.50	36.30	36.50	36.50	36.30	36.30	36.50	36.60	36.30	36.80	36.30	36.8	35.10	34.69	27.376	34.9	35	35.8	35.2	34.9	33.5
36.10	36.10	36.30	36.60	36.10	36.10	36.10	36.10	36.10	36.10	35.90	36.30	36.10	36.30	36.30	36.10	36.10	36.20	36.40	36.10	36.60	36.30	36.6	34.90	34.69	27.376	34.8	34.9	35.7	35.2	34.8	32.5

Zone 6 (Bed room2)

Base	m1	m2	m3	m4	m5	m6	m7	m8	m9	m10	m11	m12	m13	m14	m15	m16	m17	m18	m19	m20	m21	m21b	m22	Tcmax	Tcmin	Com1	Com2	Com3	Com4	Com5	To
35.00	35.00	35.10	35.20	34.90	35.00	35.00	34.90	35.00	35.00	34.90	35.20	35.00	35.10	35.10	35.00	35.00	35.10	35.20	35.00	35.70	35.00	34.90	34.70	34.69	27.376	33.7	34	34.2	33.8	33.7	31.5
34.80	34.90	35.00	35.20	34.90	34.80	34.80	34.80	34.80	34.90	34.80	35.00	34.80	35.00	35.00	34.90	34.90	35.00	35.10	34.90	35.60	34.80	34.80	34.70	34.69	27.376	33.6	33.9	34	33.7	33.7	31.5
34.60	34.70	34.80	35.10	34.70	34.60	34.60	34.60	34.60	34.70	34.60	34.80	34.70	34.80	34.80	34.70	34.70	34.80	34.90	34.70	35.40	34.60	34.60	34.50	34.69	27.376	33.5	33.8	33.9	33.7	33.6	30.4
34.60	34.70	34.90	35.10	34.70	34.60	34.60	34.60	34.60	34.70	34.70	34.90	34.80	34.90	34.90	34.80	34.80	34.90	35.00	34.70	35.40	34.60	34.50	34.50	34.69	27.376	33.5	33.8	33.9	33.7	33.6	30.4
34.50	34.60	34.80	35.00	34.70	34.50	34.50	34.50	34.50	34.60	34.60	34.80	34.70	34.80	34.80	34.70	34.70	34.80	34.80	34.50	35.20	34.50	34.30	34.30	34.69	27.376	33.3	33.7	33.7	33.7	33.7	30.4
34.30	34.40	34.60	34.90	34.50	34.30	34.30	34.30	34.30	34.40	34.40	34.60	34.50	34.60	34.70	34.50	34.60	34.60	34.70	34.40	35.20	34.40	34.20	34.20	34.69	27.376	33.3	33.7	33.7	33.6	33.6	29.3
34.20	34.20	34.50	34.80	34.40	34.20	34.20	34.20	34.20	34.30	34.30	34.50	34.40	34.50	34.60	34.40	34.50	34.50	34.60	34.30	35.10	34.30	34.10	34.10	34.69	27.376	33.3	33.6	33.5	33.4	33.6	28
34.10	34.30	34.50	34.70	34.40	34.10	34.10	34.10	34.10	34.20	34.20	34.40	34.40	34.40	34.50	34.30	34.40	34.50	34.50	34.20	35.00	34.20	34.00	34.00	34.69	27.376	33.2	33.5	33.6	33.6	33.5	27.2
34.10	34.20	34.50	34.70	34.40	34.10	34.10	34.10	34.10	34.20	34.10	34.40	34.40	34.40	34.50	34.40	34.40	34.50	34.50	34.20	34.90	34.20	34.00	34.00	34.69	27.376	33.2	33.5	33.6	33.6	33.6	28.3
34.20	34.30	34.50	34.70	34.40	34.20	34.20	34.10	34.20	34.30	34.20	34.50	34.40	34.50	34.50	34.40	34.40	34.50	34.50	34.20	35.00	34.20	33.90	34.10	34.69	27.376	33.2	33.5	33.6	33.6	33.6	29.3
34.30	34.50	34.70	34.90	34.60	34.30	34.30	34.30	34.30	34.50	34.40	34.70	34.60	34.70	34.70	34.60	34.60	34.70	34.60	34.40	35.00	34.30	33.90	34.30	34.69	27.376	33.3	33.5	33.6	33.7	33.7	30.9
34.50	34.60	34.90	35.10	34.80	34.50	34.50	34.50	34.50	34.70	34.60	34.90	34.80	34.90	34.90	34.80	34.80	34.90	34.70	34.50	35.10	34.40	33.90	34.50	34.69	27.376	33.4	33.5	33.6	33.8	33.8	32.5
34.70	34.80	35.10	35.30	35.00	34.70	34.70	34.70	34.70	34.90	34.80	35.10	35.00	35.10	35.10	35.00	35.00	35.10	34.90	34.70	35.10	34.60	34.20	34.60	34.69	27.376	33.6	33.7	33.8	33.9	33.9	34.6
34.90	35.00	35.30	35.50	35.10	34.90	34.90	34.90	34.90	35.00	34.90	35.30	35.20	35.30	35.30	35.20	35.20	35.30	35.00	34.90	35.30	34.80	34.50	34.90	34.69	27.376	33.8	33.9	33.9	34	33.9	35.7
35.40	35.50	35.70	35.90	35.60	35.40	35.40	35.40	35.40	35.50	35.30	35.80	35.60	35.80	35.80	35.60	35.60	35.80	35.30	35.00	35.40	35.10	35.10	35.50	34.69	27.376	34.4	34	34	34.1	34	36.7
35.90	36.00	36.20	36.40	36.00	35.90	35.90	36.00	35.90	36.00	35.70	36.30	36.10	36.20	36.20	36.10	36.00	36.20	35.60	35.20	35.60	35.50	35.60	36.20	34.69	27.376	34.9	34.2	34.2	34.1	34	37.7
36.10	36.20	36.40	36.50	36.20	36.20	36.20	36.20	36.20	36.20	35.90	36.40	36.20	36.40	36.30	36.20	36.20	36.30	35.80	35.40	35.80	35.70	35.90	36.30	34.69	27.376	35	34.6	34.3	34.1	34	37.7
35.90	35.90	36.10	36.30	36.00	36.00	36.00	36.00	36.00	36.00	35.70	36.20	36.00	36.20	36.10	36.00	36.00	36.10	35.90	36.00	36.00	35.50	35.80	36.00	34.69	27.376	34.7	34.8	34.5	34.2	34.1	36.7
35.80	35.80	35.90	36.10	35.70	35.80	35.80	35.80	35.80	35.80	35.50	35.90	35.80	35.90	35.90	35.80	35.70	35.90	35.90	35.80	36.20	35.30	35.70	35.50	34.69	27.376	34.2	34.5	34.5	34.1	34	37.7
35.80	35.80	35.90	36.10	35.70	35.80	35.80	35.90	35.80	35.80	35.50	35.90	35.70	35.90	35.80	35.70	35.70	35.80	36.00	35.90	36.30	35.30	35.80	35.50	34.69	27.376	34.2	34.5	34.5	34.1	33.9	36.7
35.80	35.70	35.80	36.00	35.60	35.80	35.80	35.80	35.80	35.70	35.40	35.80	35.60	35.80	35.80	35.60	35.60	35.80	36.00	35.80	36.40	35.30	35.70	35.50	34.69	27.376	34.2	34.4	34.4	34	33.9	35.7
35.60	35.60	35.60	35.80	35.50	35.60	35.60	35.60	35.60	35.60	35.30	35.60	35.40	35.60	35.60	35.40	35.40	35.60	35.90	35.60	36.30	35.10	35.50	35.40	34.69	27.376	34	34.3	34.3	33.9	33.8	34.1
35.40	35.40	35.50	35.70	35.30	35.40	35.40	35.40	35.40	35.40	35.20	35.50	35.30	35.50	35.40	35.30	35.30	35.40	35.70	35.50	36.10	35.10	35.50	35.20	34.69	27.376	34	34.3	34.3	33.9	33.8	33.5
35.20	35.10	35.20	35.40	35.10	35.10	35.10	35.10	35.10	35.10	35.00	35.20	35.00	35.20	35.20	35.00	35.00	35.20	35.50	35.20	35.90	35.00	35.30	35.00	34.69	27.376	33.8	34.2	34.2	33.8	33.7	32.5

Zone 7 (Bed room4)

Base	m1	m2	m3	m4	m5	m6	m7	m8	m9	m10	m11	m12	m13	m14	m15	m16	m17	m18	m19	m20	m21	m21b	m22	Tcmax	Tcmin	Com1	Com2	Com3	Com4	Com5	To
34.90	35.00	35.00	35.10	34.90	34.90	34.90	34.90	34.90	34.90	34.80	35.00	34.90	35.00	35.00	34.90	34.90	35.00	35.20	35.00	35.80	34.80	34.90	36.00	34.69	27.376	34.2	34.4	34.6	33.9	33	31.5
34.70	34.80	34.90	35.10	34.70	34.70	34.70	34.70	34.70	34.80	34.70	34.90	34.70	34.90	34.90	34.70	34.70	34.80	35.10	34.90	35.70	34.70	34.70	35.90	34.69	27.376	34.1	34.3	34.4	33.7	32.9	31.5
34.50	34.60	34.70	34.90	34.60	34.50	34.50	34.50	34.50	34.60	34.50	34.70	34.60	34.70	34.70	34.60	34.60	34.70	34.90	34.70	35.50	34.50	34.50	35.70	34.69	27.376	34	34.3	34.3	33.7	32.8	30.4
34.50	34.60	34.80	35.00	34.60	34.50	34.50	34.50	34.50	34.60	34.60	34.80	34.60	34.80	34.80	34.60	34.70	34.70	34.90	34.70	35.50	34.60	34.50	35.70	34.69	27.376	34	34.2	34.2	33.7	32.8	30.4
34.40	34.50	34.70	34.90	34.50	34.40	34.40	34.30	34.40	34.50	34.50	34.60	34.50	34.70	34.70	34.50	34.60	34.60	34.80	34.60	35.40	34.40	34.20	35.60	34.69	27.376	33.9	34.1	34.1	33.7	32.8	30.4
34.20	34.30	34.50	34.70	34.40	34.20	34.20	34.20	34.20	34.30	34.30	34.50	34.40	34.50	34.50	34.40	34.40	34.50	34.70	34.40	35.30	34.30	34.20	35.50	34.69	27.376	33.9	34.1	34.1	33.6	32.7	29.3
34.20	34.20	34.40	34.70	34.30	34.20	34.20	34.20	34.20	34.20	34.20	34.40	34.30	34.40	34.50	34.30	34.40	34.40	34.60	34.30	35.20	34.30	34.00	35.40	34.69	27.376	33.7	33.9	34	33.6	32.6	28
34.00	34.10	34.30	34.60	34.20	34.00	34.00	34.00	34.00	34.10	34.10	34.30	34.20	34.30	34.40	34.20	34.30	34.30	34.50	34.20	35.10	34.20	33.90	35.40	34.69	27.376	33.7	34	34	33.6	32.6	27.2
34.00	34.10	34.30	34.60	34.20	34.00	34.00	34.00	34.00	34.10	34.00	34.30	34.20	34.30	34.40	34.20	34.30	34.30	34.50	34.20	35.10	34.20	33.90	35.40	34.69	27.376	33.7	33.9	34	33.6	32.6	28.3
34.20	34.30	34.50	34.70	34.40	34.20	34.20	34.10	34.20	34.30	34.20	34.50	34.40	34.50	34.50	34.40	34.40	34.50	34.50	34.20	35.10	34.30	33.90	35.30	34.69	27.376	33.7	33.9	33.9	33.6	32.6	29.3
34.40	34.50	34.70	35.00	34.60	34.40	34.40	34.40	34.40	34.60	34.50	34.80	34.70	34.80	34.80	34.70	34.70	34.80	34.70	34.40	35.10	34.40	34.00	35.60	34.69	27.376	33.6	33.9	33.9	33.7	32.7	30.9
34.60	34.80	35.00	35.20	34.90	34.60	34.70	34.60	34.70	34.80	34.70	35.10	34.90	35.00	35.10	34.90	34.90	35.10	34.80	34.60	35.20	34.60	34.10	35.70	34.69	27.376	33.8	33.9	33.9	33.8	32.8	32.5
34.80	35.00	35.30	35.50	35.10	34.80	34.90	34.90	34.90	35.00	34.90	35.30	35.20	35.30	35.30	35.20	35.20	35.30	35.00	34.70	35.30	34.70	34.30	35.80	34.69	27.376	34	34	34	33.9	32.9	34.6
35.10	35.20	35.50	35.70	35.40	35.10	35.10	35.10	35.10	35.30	35.10	35.60	35.40	35.50	35.50	35.40	35.40	35.50	35.20	34.90	35.40	35.00	34.70	35.90	34.69	27.376	34.1	34.1	34.2	33.9	32.9	35.7
35.90	36.00	36.30	36.50	36.10	36.00	36.00	36.00	36.00	36.10	35.90	36.40	36.20	36.30	36.30	36.20	36.10	36.30	35.60	35.00	35.50	35.60	35.50	35.90	34.69	27.376	34.2	34.3	34.3	33.9	33	36.7
36.70	36.70	37.00	37.10	36.80	36.70	36.70	36.80	36.70	36.80	36.50	37.10	36.80	37.00	37.00	36.80	36.80	36.90	36.00	35.20	35.70	36.10	36.20	36.00	34.69	27.376	34.3	34.3	34.4	34	33	37.7
36.80	36.90	37.00	37.20	36.90	36.90	36.90	36.90	36.90	36.90	36.50	37.20	36.90	37.10	37.00	36.90	36.80	37.00	36.20	35.40	36.00	36.20	36.40	36.10	34.69	27.376	34.4	34.6	34.6	34	33	37.7
36.30	36.30	36.50	36.60	36.30	36.40	36.40	36.40	36.40	36.40	36.00	36.60	36.30	36.50	36.50	36.30	36.30	36.50	36.10	36.50	36.20	35.80	36.10	36.20	34.69	27.376	34.4	34.6	34.6	33.9	33	36.7
35.70	35.70	35.80	36.00	35.60	35.70	35.70	35.70	35.70	35.70	35.40	35.80	35.60	35.80	35.80	35.60	35.60	35.80	35.90	35.90	36.40	35.20	35.60	36.40	34.69	27.376	34.5	34.7	34.7	34	33	37.7
35.70	35.70	35.80	36.00	35.60	35.70	35.70	35.80	35.70	35.70	35.40	35.80	35.60	35.80	35.70	35.60	35.60	35.70	36.00	35.90	36.50	35.20	35.70	36.50	34.69	27.376	34.6	34.8	34.8	34	33	36.7
35.70	35.60	35.70	35.90	35.50	35.70	35.70	35.70	35.70	35.60	35.30	35.70	35.50	35.70	35.70	35.50	35.50	35.60	36.00	35.80	36.50	35.20	35.70	36.50	34.69	27.376	34.6	34.7	34.8	33.9	33	35.7
35.50	35.50	35.50	35.70	35.30	35.50	35.50	35.50	35.50	35.50	35.20	35.50	35.30	35.50	35.50	35.30	35.30	35.40	35.90	35.70	36.40	35.10	35.40	36.30	34.69	27.376	34.4	34.6	34.6	33.8	33	34.1
35.30	35.30	35.40	35.60	35.20	35.30	35.30	35.30	35.30	35.30	35.10	35.30	35.20	35.30	35.30	35.20	35.20	35.30	35.70	35.50	36.20	35.00	35.40	36.20	34.69	27.376	34.5	34.7	34.7	33.8	33	33.5
35.10	35.00	35.10	35.30	34.90	35.00	35.00	35.00	35.00	35.00	34.90	35.00	34.90	35.10	35.10	34.90	34.90	35.00	35.40	35.30	35.90	34.90	35.20	36.10	34.69	27.376	34.4	34.6	34.6	33.8	32.9	32.5

Zone 8 (Bed room 3)

Base	m1	m2	m3	m4	m5	m6	m7	m8	m9	m10	m11	m12	m13	m14	m15	m16	m17	m18	m19	m20	m21	m21b	m22	Tcmax	Tcmin	Com1	Com2	Com3	Com4	Com5	To
36.2	36.3	36.4	36.6	36.2	36.2	36.2	36.2	36.2	36.4	36.2	36.4	36.2	36.4	36.4	36.3	36.3	36.4	36.4	36.3	36.5	36.60	36.60	36.4	34.69	27.376	34.8	34.8	33.2	33	32.9	31.5
36.1	36.2	36.3	36.5	36.2	36.1	36.1	36.1	36.1	36.2	36	36.3	36.1	36.3	36.3	36.2	36.2	36.3	36.3	36.2	36.4	36.50	36.50	36.2	34.69	27.376	34.7	34.7	33	32.8	32.8	31.5
36	36	36.2	36.4	36.0	36.0	36.0	35.9	35.9	36.0	35.9	36.2	36	36.2	36.2	36.0	36.1	36.2	36.2	36	36.3	36.40	36.30	36.1	34.69	27.376	34.7	34.7	32.9	32.7	32.7	30.4
35.9	36	36.2	36.4	36.0	36.0	36.0	35.9	36.0	36.1	35.9	36.2	36.1	36.2	36.2	36.1	36.1	36.2	36.2	36	36.3	36.30	36.20	36.1	34.69	27.376	34.6	34.6	32.9	32.8	32.7	30.4
35.9	35.9	36.1	36.3	36.0	35.9	35.9	35.9	35.9	36.0	35.8	36.1	36	36.1	36.2	36.0	36.0	36.1	36.1	35.9	36.2	36.20	36.00	36.0	34.69	27.376	34.5	34.5	32.8	32.7	32.6	30.4
35.7	35.8	36	36.2	35.9	35.8	35.8	35.7	35.8	35.8	35.7	36	35.9	36	36.1	35.9	35.9	36	36	35.8	36.1	36.20	36.00	35.9	34.69	27.376	34.5	34.5	32.8	32.7	32.6	29.3
35.6	35.7	35.9	36.1	35.7	35.6	35.6	35.6	35.6	35.7	35.6	35.9	35.7	35.8	35.9	35.7	35.8	35.9	35.9	35.7	36	36.00	35.80	35.9	34.69	27.376	34.4	34.4	32.7	32.6	32.5	28
35.6	35.7	35.9	36.1	35.7	35.6	35.6	35.6	35.6	35.7	35.6	35.9	35.8	35.9	35.9	35.7	35.8	35.9	35.8	35.6	35.9	36.10	35.80	35.8	34.69	27.376	34.4	34.4	32.7	32.6	32.4	27.2
35.6	35.7	35.9	36.1	35.7	35.6	35.6	35.6	35.6	35.7	35.5	35.9	35.8	35.9	35.9	35.7	35.8	35.9	35.8	35.6	35.9	36.00	35.80	35.8	34.69	27.376	34.3	34.4	32.6	32.6	32.5	28.3
35.6	35.7	35.9	36.1	35.7	35.7	35.7	35.7	35.7	35.8	35.7	36	35.9	36	36	35.9	35.9	36	35.8	35.6	35.9	36.00	35.60	35.7	34.69	27.376	34.3	34.3	32.6	32.6	32.5	29.3
35.9	36	36.2	36.4	36.0	35.9	35.9	35.9	35.9	36.0	35.8	36.2	36.1	36.2	36.2	36.1	36.1	36.2	36	35.7	36	36.10	35.60	35.9	34.69	27.376	34.3	34.3	32.6	32.7	32.6	30.9
36.1	36.2	36.4	36.6	36.2	36.1	36.1	36.1	36.1	36.2	36	36.4	36.3	36.4	36.4	36.3	36.3	36.4	36.1	35.9	36.1	36.30	35.70	35.9	34.69	27.376	34.3	34.3	32.6	32.8	32.6	32.5
36.2	36.3	36.5	36.7	36.4	36.2	36.2	36.2	36.3	36.3	36.2	36.6	36.4	36.5	36.6	36.4	36.4	36.5	36.2	36	36.2	36.50	36.00	36.0	34.69	27.376	34.4	34.4	32.8	33	32.7	34.6
36.3	36.4	36.6	36.8	36.4	36.3	36.3	36.3	36.3	36.4	36.2	36.6	36.5	36.6	36.6	36.5	36.4	36.6	36.3	36	36.2	36.50	36.20	36.1	34.69	27.376	34.5	34.4	32.9	33	32.8	35.7
36.3	36.4	36.6	36.8	36.5	36.3	36.3	36.4	36.4	36.4	36.2	36.6	36.5	36.6	36.6	36.5	36.4	36.6	36.3	36.1	36.3	36.60	36.50	36.1	34.69	27.376	34.6	34.6	33.1	33.1	32.8	36.7
36.4	36.5	36.7	36.9	36.5	36.4	36.4	36.4	36.4	36.5	36.2	36.7	36.5	36.7	36.6	36.5	36.5	36.7	36.4	36.2	36.4	36.60	36.70	36.2	34.69	27.376	34.8	34.8	33.2	33.1	32.8	37.7
36.5	36.5	36.7	36.9	36.6	36.5	36.5	36.5	36.5	36.6	36.3	36.7	36.6	36.7	36.7	36.6	36.5	36.7	36.6	36.4	36.6	36.70	36.90	36.3	34.69	27.376	34.9	34.9	33.4	33.1	32.8	37.7
36.6	36.6	36.8	37	36.6	36.6	36.6	36.6	36.6	36.6	36.3	36.8	36.6	36.8	36.7	36.6	36.6	36.7	36.7	36.5	36.8	36.70	37.00	36.5	34.69	27.376	35	35	33.5	33.3	33	36.7
36.9	36.9	37	37.2	36.9	36.8	36.8	36.8	36.8	36.9	36.6	37	36.8	37	37	36.8	36.8	37	37	36.8	37	36.80	37.20	36.7	34.69	27.376	35.1	35.1	33.5	33.1	32.8	37.7
36.9	36.9	37.1	37.3	36.9	36.8	36.8	36.9	36.8	36.9	36.6	37	36.8	37	37	36.9	36.8	37	37	36.9	37.1	36.80	37.30	36.7	34.69	27.376	35.1	35.1	33.5	33.1	32.8	36.7
36.9	36.9	37	37.2	36.8	36.8	36.8	36.8	36.8	36.9	36.6	37	36.8	37	36.9	36.8	36.8	36.9	37	36.9	37.1	36.80	37.30	36.7	34.69	27.376	35.1	35.1	33.5	33	32.8	35.7
36.7	36.7	36.9	37.1	36.7	36.7	36.7	36.7	36.7	36.7	36.5	36.8	36.7	36.9	36.8	36.7	36.6	36.8	36.9	36.8	37	36.70	37.00	36.7	34.69	27.376	35	35	33.3	32.9	32.8	34.1
36.6	36.6	36.7	36.9	36.6	36.6	36.5	36.5	36.5	36.6	36.4	36.7	36.5	36.7	36.7	36.6	36.5	36.7	36.8	36.6	36.9	36.70	37.10	36.6	34.69	27.376	35	35	33.4	32.9	32.8	33.5
36.4	36.4	36.5	36.7	36.3	36.3	36.3	36.3	36.3	36.4	36.2	36.5	36.3	36.5	36.5	36.3	36.3	36.4	36.6	36.4	36.6	36.60	36.90	36.4	34.69	27.376	34.9	34.9	33.2	32.8	32.8	32.5

Zone 9 (Hall)

Base	m1	m2	m3	m4	m5	m6	m7	m8	m9	m10	m11	m12	m13	m14	m15	m16	m17	m18	m19	m20	m21	m21b	m22	Tcmax	Tcmin	Com1	Com2	Com3	Com4	To
36.8	36.7	37	37	36.8	36.8	36.8	36.7	36.8	33.8	36.7	36.9	36.8	33.9	37.0	33.9	33.8	36.8	33.8	36.8	36.8	37.3	37.30	34.30	34.69	27.376	33.8	34.2	35.8	35.1	31.5
36.6	36.6	36.8	36.9	36.6	36.6	36.6	36.5	36.6	33.7	36.5	36.7	36.6	33.7	36.8	33.7	33.7	36.7	33.7	36.6	36.6	37.2	37.20	34.20	34.69	27.376	33.6	34	35.7	35	31.5
36.4	36.5	36.6	36.8	36.5	36.5	36.5	36.4	36.5	33.6	36.4	36.7	36.5	33.6	36.7	33.6	33.6	36.7	33.6	36.5	36.5	37.1	37.10	34.00	34.69	27.376	33.5	33.9	35.7	34.9	30.4
36.4	36.5	36.6	36.8	36.5	36.5	36.5	36.4	36.5	33.6	36.4	36.7	36.5	33.6	36.7	33.6	33.6	36.7	33.6	36.4	36.4	37.1	36.90	33.90	34.69	27.376	33.4	33.8	35.6	34.9	30.4
36.3	36.4	36.6	36.7	36.4	36.4	36.4	36.4	36.4	33.5	36.3	36.6	36.5	33.5	36.6	33.5	33.6	36.6	33.5	36.3	36.4	37.0	36.70	33.80	34.69	27.376	33.3	33.7	35.5	34.9	30.4
36.2	36.3	36.5	36.7	36.3	36.3	36.3	36.3	36.3	33.4	36.2	36.5	36.4	33.5	36.5	33.5	33.5	36.5	33.4	36.3	36.3	36.9	36.70	33.70	34.69	27.376	33.3	33.7	35.5	34.9	29.3
36.1	36.2	36.4	36.5	36.2	36.1	36.2	36.2	36.2	33.3	36.1	36.4	36.3	33.3	36.4	33.3	33.4	36.4	33.3	36.1	36.2	36.8	36.60	33.60	34.69	27.376	33.1	33.5	35.4	34.8	28
36.1	36.2	36.4	36.5	36.2	36.1	36.2	36.2	36.2	33.3	36.1	36.4	36.3	33.3	36.4	33.3	33.4	36.4	33.3	36.1	36.1	36.8	36.60	34.00	34.69	27.376	33.4	33.7	35.4	34.8	27.2
36.1	36.2	36.3	36.5	36.2	36.1	36.2	36.1	36.2	33.3	36.1	36.4	36.3	33.3	36.4	33.3	33.4	36.4	33.3	36.1	36.1	36.8	36.60	34.20	34.69	27.376	33.6	33.8	35.4	34.8	28.3
36	36.1	36.3	36.4	36.1	36.2	36.2	36.2	36.2	33.3	36.1	36.4	36.3	33.3	36.4	33.4	33.4	36.4	33.2	36.0	36.1	36.7	36.40	34.60	34.69	27.376	33.7	33.8	35.3	34.8	29.3
36.2	36.3	36.4	36.6	36.3	36.2	36.3	36.3	36.3	33.4	36.2	36.5	36.4	33.4	36.5	33.4	33.5	36.5	33.3	36.2	36.2	36.8	36.40	34.80	34.69	27.376	33.8	33.9	35.3	34.9	30.9
36.3	36.4	36.6	36.7	36.4	36.3	36.4	36.3	36.4	33.5	36.3	36.6	36.5	33.5	36.6	33.5	33.5	36.6	33.4	36.3	36.2	36.9	36.30	35.00	34.69	27.376	33.8	33.9	35.3	35	32.5
36.4	36.5	36.7	36.8	36.5	36.3	36.4	36.4	36.4	33.5	36.3	36.7	36.6	33.6	36.7	33.6	33.6	36.7	33.5	36.4	36.3	37.0	36.60	34.60	34.69	27.376	33.7	33.8	35.4	35	34.6
36.4	36.5	36.7	36.9	36.6	36.4	36.5	36.5	36.5	33.6	36.4	36.7	36.6	33.6	36.7	33.6	33.6	36.7	33.6	36.4	36.4	37.0	36.70	34.50	34.69	27.376	33.7	33.8	35.5	35.1	35.7
36.5	36.6	36.8	36.9	36.6	36.5	36.5	36.5	36.5	33.7	36.4	36.8	36.6	33.7	36.7	33.7	33.7	36.8	33.6	36.5	36.4	37.1	37.00	34.80	34.69	27.376	33.8	34	35.6	35.1	36.7
36.6	36.7	36.9	37	36.7	36.6	36.6	36.7	36.7	33.8	36.5	36.9	36.7	33.8	36.8	33.8	33.8	36.9	33.8	36.6	36.6	37.2	37.30	34.90	34.69	27.376	34	34.2	35.8	35.2	37.7
36.8	36.9	37	37.2	36.9	36.8	36.8	36.8	36.8	34.0	36.6	37.1	36.9	34.0	37.0	34.0	33.9	37.0	33.9	36.8	36.7	37.3	37.60	35.00	34.69	27.376	34.1	34.3	35.9	35.2	37.7
37	37	37.2	37.3	37.0	36.9	36.9	37.0	37.0	34.1	36.8	37.2	37.0	34.1	37.1	34.1	34.1	37.1	34.1	36.9	36.9	37.3	37.70	34.90	34.69	27.376	34.1	34.4	36	35.2	36.7
37.2	37.2	37.4	37.5	37.2	37.1	37.1	37.2	37.1	34.3	36.9	37.4	37.2	34.3	37.3	34.3	34.2	37.3	34.3	37.1	37.1	37.4	37.90	35.00	34.69	27.376	34.2	34.5	36.1	35.2	37.7
37.2	37.3	37.4	37.6	37.3	37.2	37.2	37.2	37.2	34.3	37.0	37.4	37.2	34.3	37.3	34.3	34.3	37.3	34.4	37.2	37.2	37.5	38.00	35.00	34.69	27.376	34.2	34.5	36.1	35.2	36.7
37.2	37.3	37.4	37.5	37.2	37.2	37.2	37.2	37.2	34.3	37.0	37.4	37.2	34.3	37.3	34.3	34.2	37.3	34.4	37.2	37.2	37.4	37.90	35.00	34.69	27.376	34.2	34.4	36.1	35.1	35.7
37.1	37.2	37.3	37.4	37.1	37.1	37.1	37.1	37.1	34.2	36.9	37.3	37.1	34.2	37.2	34.2	34.1	37.2	34.3	37.1	37.1	37.4	37.70	34.90	34.69	27.376	34	34.3	36	35.1	34.1
37	37	37.2	37.3	37.0	37.0	36.9	37.0	36.9	34.1	36.8	37.1	37.0	34.1	37.1	34.1	34.0	37.1	34.2	37.0	37.0	37.4	37.80	34.70	34.69	27.376	34	34.3	36	35	33.5
36.8	36.8	36.9	37.1	36.8	36.8	36.7	36.7	36.7	33.9	36.6	36.9	36.8	33.9	36.9	33.9	33.8	36.9	34.0	36.8	36.8	37.3	37.60	34.60	34.69	27.376	33.9	34.2	35.9	35	32.5

22-Dec

Zone 1 (Reception)

Base	m1	m2	m3	m4	m5	m6	m7	m8	m9	m10	m11	m12	m13	m14	m15	m16	m17	m18	m19	m20	m21	m21b	m22	Tcmax	Tcmin	Com1	Com2	Com3	Com4	Com5	To
14.87	14.88	14.90	14.90	14.79	14.88	14.90	14.90	14.88	14.90	14.80	14.88	14.90	14.95	14.89	14.92	24.50	15.00	14.89	14.90	15.00	14.87	14.89	15.70	27.429	16.882	16.9	17	16.3	15.8	15.9	13.6
14.80	14.80	14.90	14.90	14.90	14.80	14.80	14.80	14.80	14.80	14.90	14.90	14.90	14.90	14.90	14.90	24.50	14.90	14.90	14.80	14.90	15.00	15.00	16.20	27.429	16.882	16.8	16.9	16	15.8	15.8	13.6
14.80	14.80	14.90	14.90	14.90	14.80	14.80	14.80	14.80	14.80	14.90	14.90	14.90	14.90	14.90	14.90	24.50	14.90	14.90	14.90	14.90	15.00	15.00	16.30	27.429	16.882	16.8	16.9	16	15.8	15.8	13.6
14.70	14.80	14.80	14.80	14.80	14.70	14.70	14.70	14.70	14.80	14.80	14.80	14.80	14.80	14.80	14.80	23.90	14.80	14.80	14.80	14.90	15.00	15.00	16.20	27.429	16.882	16.7	16.9	15.9	15.8	15.8	13.4
14.80	14.80	14.90	14.90	14.90	14.80	14.80	14.80	14.80	14.80	14.80	14.80	14.90	14.90	14.90	14.90	23.90	14.90	14.80	14.80	14.90	15.00	14.90	16.20	27.429	16.882	16.7	16.8	15.9	15.8	15.8	13.6
14.80	14.80	14.90	14.90	14.90	14.80	14.80	14.80	14.80	14.80	14.80	14.80	14.90	14.90	14.90	14.90	23.50	14.90	14.90	14.80	14.90	14.90	14.70	16.20	27.429	16.882	16.6	16.7	15.7	15.8	15.8	13.6
14.80	14.80	14.90	14.90	14.90	14.80	14.80	14.80	14.80	14.80	14.80	14.80	14.90	14.90	14.90	14.90	23.50	14.90	14.80	14.80	14.90	14.90	14.70	16.20	27.429	16.882	16.6	16.7	15.7	15.8	15.8	13.6
14.80	14.80	14.80	14.90	14.90	14.80	14.80	14.80	14.80	14.80	14.80	14.80	14.90	14.80	14.80	14.90	23.80	14.90	14.80	14.80	14.90	14.90	14.60	16.20	27.429	16.882	16.5	16.7	15.7	15.8	15.8	13.6
14.80	14.80	14.80	14.90	14.90	14.70	14.70	14.70	14.70	14.80	14.80	14.80	14.90	14.80	14.80	14.90	24.10	14.90	14.80	14.80	14.90	14.90	14.70	16.20	27.429	16.882	16.5	16.7	15.7	15.8	15.8	13.6
14.80	14.90	14.90	14.90	14.90	14.80	14.80	14.80	14.80	14.90	14.90	14.90	14.90	14.90	14.90	14.90	24.70	14.90	14.90	14.90	14.90	14.90	14.70	16.20	27.429	16.882	16.6	16.7	15.8	15.8	15.8	14.2
15.10	15.20	15.20	15.20	15.20	15.10	15.10	15.10	15.10	15.20	15.20	15.20	15.20	15.20	15.20	15.20	25.20	15.20	15.10	15.20	15.10	15.10	14.90	16.30	27.429	16.882	16.7	16.8	15.9	16	16	15.7
15.30	15.40	15.30	15.30	15.30	15.30	15.30	15.30	15.30	15.40	15.30	15.30	15.30	15.30	15.30	15.30	25.70	15.30	15.20	15.30	15.10	15.20	15.00	16.40	27.429	16.882	16.7	16.8	15.9	16	16	15.7
16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	25.60	16.00	15.80	15.90	15.30	15.70	15.50	16.50	27.429	16.882	16.8	16.9	16.1	16.2	16.2	17.1
16.40	16.50	16.50	16.40	16.40	16.40	16.40	16.50	16.40	16.50	16.40	16.50	16.40	16.50	16.50	16.40	25.50	16.40	16.30	16.30	15.50	16.10	15.90	16.60	27.429	16.882	16.9	17	16.4	16.5	16.5	18.8
16.50	16.50	16.50	16.40	16.40	16.50	16.50	16.50	16.50	16.50	16.40	16.50	16.40	16.50	16.50	16.40	25.30	16.40	16.30	16.40	15.60	16.10	16.10	16.60	27.429	16.882	17	17.1	16.5	16.5	16.5	18.8
16.90	16.80	16.80	16.80	16.80	16.90	16.90	16.90	16.90	16.80	16.70	16.80	16.80	16.80	16.80	16.80	25.10	16.80	16.80	16.80	15.80	16.40	16.40	16.70	27.429	16.882	17	17.1	16.6	16.7	16.7	19.9
16.70	16.70	16.60	16.50	16.50	16.70	16.70	16.70	16.70	16.70	16.50	16.60	16.50	16.60	16.60	16.50	25.20	16.50	16.50	16.40	15.70	16.20	16.40	16.70	27.429	16.882	17.1	17.2	16.6	16.5	16.5	18.8
16.00	15.90	15.80	15.80	15.80	16.00	16.00	16.00	16.00	15.90	15.80	15.80	15.80	15.80	15.80	15.80	25.00	15.80	15.90	16.00	15.70	15.80	16.10	16.60	27.429	16.882	17.1	17.2	16.4	16.2	16.2	16.7
16.10	16.00	15.90	15.90	15.90	16.10	16.10	16.10	16.10	16.00	15.90	15.90	15.90	15.90	15.90	15.90	24.50	15.90	16.10	16.20	15.80	15.90	16.20	16.70	27.429	16.882	17.1	17.2	16.5	16.2	16.2	17.5
15.90	15.80	15.70	15.70	15.70	15.90	15.90	15.90	15.90	15.80	15.70	15.70	15.70	15.70	15.70	15.70	24.60	15.70	15.90	15.90	15.80	15.70	16.10	16.70	27.429	16.882	17.1	17.2	16.5	16.1	16.1	16.7
16.00	15.90	15.80	15.80	15.70	16.00	16.00	16.00	16.00	15.90	15.70	15.80	15.70	15.80	15.80	15.70	24.60	15.70	16.00	16.00	15.90	15.80	16.00	16.80	27.429	16.882	17.1	17.2	16.4	16.1	16.1	16.7
15.70	15.60	15.50	15.50	15.50	15.70	15.70	15.70	15.70	15.60	15.50	15.50	15.50	15.50	15.50	15.50	24.40	15.50	15.70	15.70	15.80	15.50	15.60	16.70	27.429	16.882	16.9	17	16.2	16.1	16.1	16.7
15.60	15.60	15.50	15.50	15.50	15.60	15.60	15.60	15.60	15.60	15.60	15.50	15.50	15.50	15.50	15.50	24.30	15.50	15.60	15.60	15.70	15.50	15.60	16.70	27.429	16.882	17	17.1	16.3	16.1	16.1	16.7
15.90	15.80	15.80	15.80	15.80	15.90	15.90	15.90	15.90	15.80	15.90	15.80	15.80	15.80	15.80	15.80	24.20	15.80	15.90	15.90	15.80	15.70	15.70	16.70	27.429	16.882	16.9	17	16.2	16.1	16.1	16.7

Zone 2 (Bed room1)

Base	m1	m2	m3	m4	m5	m6	m7	m8	m9	m10	m11	m12	m13	m14	m15	m16	m17	m18	m19	m20	m21	m21b	m22	Tcmax	Tcmin	Com1	Com2	Com3	Com4	Com5	To
16.80	16.90	17.10	17.30	17.00	16.80	16.80	16.80	16.80	16.90	16.80	17.10	16.90	17.10	17.10	16.90	17.00	17.10	17.00	16.80	17.10	17.60	17.6	16.10	27.429	16.882	17.9	17.9	19	18.7	18.3	13.6
16.70	16.80	17.00	17.20	16.90	16.70	16.70	16.70	16.70	16.80	16.70	17.00	16.80	17.00	17.00	16.80	16.90	17.00	16.90	16.70	17.00	17.50	17.5	16.00	27.429	16.882	17.8	17.9	18.9	18.6	18.2	13.6
16.60	16.80	17.00	17.20	16.90	16.70	16.70	16.70	16.70	16.80	16.70	17.00	16.90	17.00	17.00	16.90	16.90	17.00	16.90	16.80	17.00	17.50	17.5	16.00	27.429	16.882	17.8	17.9	18.9	18.6	18.2	13.6
16.70	16.80	17.00	17.20	16.80	16.70	16.70	16.70	16.70	16.80	16.60	17.00	16.80	17.00	17.00	16.80	16.80	16.90	16.80	16.70	16.90	17.40	17.5	16.00	27.429	16.882	17.8	17.9	18.9	18.6	18.2	13.4
16.70	16.70	16.90	17.10	16.80	16.70	16.70	16.70	16.70	16.80	16.60	17.00	16.80	17.00	17.00	16.80	16.80	17.00	16.80	16.70	16.90	17.40	17.4	15.90	27.429	16.882	17.8	17.9	18.9	18.6	18.2	13.6
16.70	16.70	16.90	17.10	16.80	16.70	16.70	16.70	16.70	16.80	16.60	17.00	16.80	17.00	17.00	16.80	16.80	17.00	16.80	16.70	16.90	17.30	17.1	15.90	27.429	16.882	17.7	17.8	18.7	18.6	18.2	13.6
16.70	16.70	16.90	17.10	16.80	16.70	16.70	16.70	16.70	16.80	16.60	17.00	16.80	17.00	17.00	16.80	16.80	17.00	16.80	16.70	16.90	17.30	17.1	15.90	27.429	16.882	17.7	17.8	18.7	18.6	18.2	13.6
16.70	16.70	16.90	17.10	16.80	16.70	16.70	16.70	16.70	16.80	16.60	17.00	16.80	17.00	17.00	16.80	16.80	17.00	16.80	16.70	16.90	17.30	17.1	15.90	27.429	16.882	17.7	17.8	18.7	18.6	18.2	13.6
16.70	16.70	16.90	17.10	16.80	16.70	16.70	16.70	16.70	16.80	16.60	17.00	16.80	17.00	17.00	16.80	16.80	17.00	16.80	16.60	16.90	17.30	17.1	15.90	27.429	16.882	17.7	17.8	18.7	18.6	18.2	13.6
16.70	16.80	17.00	17.20	16.80	16.70	16.70	16.70	16.70	16.80	16.70	17.00	16.90	17.00	17.00	16.80	16.90	17.00	16.80	16.70	16.90	17.40	17.1	15.90	27.429	16.882	17.7	17.8	18.7	18.6	18.2	14.2
16.80	16.90	17.10	17.30	16.90	16.80	16.90	16.90	16.90	16.90	16.80	17.10	17.00	17.10	17.10	17.00	17.00	17.10	16.90	16.80	17.00	17.40	17.2	16.10	27.429	16.882	17.8	17.9	18.8	18.7	18.3	15.7
16.90	16.90	17.10	17.30	17.00	16.90	16.90	16.90	16.90	17.00	16.80	17.20	17.00	17.20	17.20	17.00	17.00	17.20	17.00	16.90	17.00	17.50	17.3	16.10	27.429	16.882	17.8	17.9	18.8	18.7	18.3	15.7
17.00	17.00	17.20	17.40	17.10	17.00	17.00	17.00	17.00	17.10	16.90	17.30	17.10	17.30	17.30	17.10	17.10	17.30	17.10	17.00	17.10	17.50	17.3	16.20	27.429	16.882	17.9	18	18.9	18.8	18.4	17.1
17.10	17.20	17.30	17.50	17.20	17.10	17.10	17.10	17.10	17.20	17.00	17.40	17.20	17.40	17.40	17.20	17.20	17.30	17.20	17.10	17.20	17.60	17.5	16.30	27.429	16.882	18	18.1	19	18.9	18.5	18.8
17.10	17.20	17.40	17.60	17.20	17.10	17.10	17.10	17.10	17.20	17.00	17.40	17.20	17.40	17.40	17.20	17.20	17.30	17.20	17.10	17.20	17.70	17.7	16.30	27.429	16.882	18.1	18.1	19.1	18.9	18.5	18.8
17.30	17.30	17.50	17.70	17.30	17.20	17.20	17.30	17.20	17.30	17.10	17.50	17.30	17.50	17.40	17.30	17.30	17.40	17.30	17.20	17.30	17.80	17.8	16.50	27.429	16.882	18.1	18.2	19.1	18.9	18.6	19.9
17.20	17.30	17.40	17.60	17.30	17.20	17.20	17.20	17.20	17.20	17.00	17.40	17.20	17.40	17.40	17.20	17.20	17.40	17.30	17.20	17.30	17.80	17.9	16.40	27.429	16.882	18.1	18.2	19.2	18.9	18.5	18.8
17.10	17.20	17.30	17.50	17.20	17.10	17.10	17.10	17.10	17.10	16.90	17.30	17.10	17.30	17.20	17.10	17.10	17.20	17.20	17.10	17.30	17.70	18	16.30	27.429	16.882	18	18.1	19.2	18.7	18.4	16.7
17.20	17.30	17.40	17.60	17.30	17.20	17.20	17.20	17.20	17.20	17.00	17.40	17.20	17.40	17.30	17.20	17.20	17.30	17.40	17.20	17.30	17.80	18.1	16.40	27.429	16.882	18.1	18.2	19.2	18.8	18.4	17.5
17.20	17.30	17.40	17.60	17.30	17.20	17.20	17.20	17.20	17.30	17.00	17.40	17.20	17.40	17.30	17.20	17.20	17.30	17.40	17.20	17.40	17.80	18.2	16.40	27.429	16.882	18.1	18.2	19.3	18.7	18.4	16.7
17.30	17.30	17.40	17.60	17.30	17.30	17.30	17.30	17.30	17.30	17.10	17.40	17.20	17.40	17.40	17.30	17.20	17.40	17.40	17.30	17.40	17.80	18.1	16.40	27.429	16.882	18.1	18.1	19.2	18.7	18.4	16.7
17.20	17.30	17.40	17.60	17.20	17.20	17.20	17.20	17.20	17.30	17.10	17.40	17.20	17.40	17.40	17.20	17.20	17.30	17.30	17.20	17.40	17.70	17.8	16.30	27.429	16.882	17.9	18	19.1	18.7	18.4	16.7
17.20	17.20	17.40	17.60	17.20	17.20	17.20	17.20	17.20	17.30	17.10	17.40	17.20	17.40	17.40	17.20	17.20	17.30	17.30	17.20	17.40	17.70	17.8	16.30	27.429	16.882	18	18.1	19.1	18.7	18.4	16.7
17.30	17.30	17.40	17.60	17.30	17.20	17.20	17.20	17.20	17.30	17.10	17.40	17.30	17.40	17.40	17.30	17.30	17.40	17.40	17.30	17.40	17.70	17.8	16.40	27.429	16.882	18	18.1	19.1	18.8	18.4	16.7

Zone 6 (Bed room2)

Base	m1	m2	m3	m4	m5	m6	m7	m8	m9	m10	m11	m12	m13	m14	m15	m16	m17	m18	m19	m20	m21	m21b	m22	Tcmax	Tcmin	Com1	Com2	Com3	Com4	Com5	To
15.70	15.60	15.80	15.90	15.80	15.70	15.70	15.70	15.70	15.70	15.70	15.80	15.70	15.80	15.60	15.70	15.70	15.80	15.80	15.80	16.60	16.00	16.00	15.80	27.429	16.882	16.9	17	17.3	17	17	13.6
15.60	15.60	15.70	15.80	15.70	15.60	15.60	15.60	15.60	15.60	15.60	15.70	15.60	15.70	15.70	15.60	15.70	15.70	15.70	15.60	16.40	15.80	15.90	15.60	27.429	16.882	16.8	16.9	17.2	17	17.1	13.6
15.60	15.70	15.70	15.80	15.70	15.60	15.60	15.60	15.60	15.60	15.60	15.70	15.60	15.70	15.70	15.70	15.70	15.70	15.70	15.60	16.40	15.80	15.90	15.60	27.429	16.882	16.8	16.9	17.2	17	17.1	13.6
15.60	15.60	15.70	15.70	15.60	15.50	15.50	15.50	15.50	15.60	15.50	15.60	15.60	15.60	15.70	15.60	15.60	15.60	15.70	15.60	16.30	15.80	15.80	15.50	27.429	16.882	16.8	16.9	17.2	17	17.1	13.4
15.60	15.60	15.70	15.70	15.60	15.60	15.50	15.50	15.50	15.60	15.60	15.70	15.60	15.70	15.70	15.60	15.60	15.70	15.70	15.60	16.30	15.80	15.70	15.50	27.429	16.882	16.7	16.9	17.1	17	17.1	13.6
15.60	15.60	15.70	15.70	15.60	15.60	15.50	15.50	15.50	15.60	15.60	15.70	15.60	15.70	15.70	15.60	15.60	15.70	15.70	15.60	16.30	15.70	15.50	15.50	27.429	16.882	16.6	16.7	17	17	17.1	13.6
15.60	15.60	15.70	15.70	15.60	15.50	15.50	15.50	15.50	15.60	15.60	15.70	15.60	15.70	15.70	15.60	15.60	15.70	15.70	15.60	16.30	15.70	15.50	15.50	27.429	16.882	16.6	16.7	17	17	17.1	13.6
15.60	15.60	15.70	15.70	15.60	15.50	15.50	15.50	15.50	15.60	15.50	15.70	15.60	15.70	15.70	15.60	15.60	15.70	15.70	15.60	16.30	15.70	15.50	15.50	27.429	16.882	16.6	16.7	17	17	17.1	13.6
15.60	15.60	15.70	15.70	15.60	15.50	15.50	15.50	15.50	15.60	15.50	15.70	15.60	15.70	15.70	15.60	15.60	15.70	15.70	15.60	16.30	15.70	15.50	15.50	27.429	16.882	16.6	16.7	17	17	17.1	13.6
15.60	15.70	15.70	15.80	15.70	15.60	15.60	15.60	15.60	15.60	15.60	15.70	15.70	15.70	15.70	15.70	15.70	15.70	15.70	15.60	16.40	15.80	15.60	15.50	27.429	16.882	16.6	16.8	17	17	17.1	14.2
15.80	15.80	15.90	15.90	15.80	15.80	15.80	15.80	15.80	15.80	15.80	15.90	15.80	15.90	15.90	15.80	15.80	15.90	15.80	15.80	16.40	15.90	15.70	15.70	27.429	16.882	16.8	16.8	17.1	17.1	17.2	15.7
15.80	15.80	15.90	16.00	15.90	15.80	15.80	15.80	15.80	15.80	15.80	15.90	15.80	15.90	15.90	15.80	15.80	15.90	15.80	15.80	16.50	15.90	15.70	15.70	27.429	16.882	16.8	16.8	17.1	17.1	17.2	15.7
16.60	16.70	16.80	16.80	16.70	16.70	16.60	16.70	16.60	16.70	16.60	16.80	16.70	16.80	16.70	16.70	16.70	16.70	16.70	16.60	16.50	16.50	16.40	16.50	27.429	16.882	17.4	17.3	17.3	17.4	17.3	17.1
17.30	17.30	17.40	17.40	17.30	17.30	17.30	17.30	17.30	17.40	17.20	17.50	17.30	17.40	17.40	17.40	17.30	17.40	17.30	17.30	16.70	17.00	16.90	17.00	27.429	16.882	17.8	17.7	17.6	17.7	17.4	18.8
17.40	17.40	17.50	17.50	17.40	17.40	17.40	17.40	17.40	17.40	17.30	17.50	17.40	17.50	17.40	17.40	17.40	17.40	17.40	17.30	16.70	17.10	17.10	17.10	27.429	16.882	17.9	17.8	17.7	17.7	17.4	18.8
17.90	17.90	18.00	18.00	17.90	18.00	17.90	18.00	17.90	17.90	17.70	18.00	17.90	18.00	17.90	17.90	17.80	17.90	17.90	17.80	16.80	17.50	17.50	17.50	27.429	16.882	18.2	18.1	17.8	17.8	17.4	19.9
17.70	17.70	17.70	17.70	17.60	17.70	17.70	17.70	17.70	17.70	17.50	17.80	17.60	17.70	17.70	17.60	17.60	17.60	17.50	17.70	16.80	17.30	17.50	17.70	27.429	16.882	18.4	18	17.7	17.6	17.5	18.8
16.80	16.70	16.80	16.80	16.70	16.80	16.80	16.80	16.80	16.70	16.60	16.80	16.70	16.80	16.70	16.70	16.70	16.70	16.70	16.80	16.80	16.70	16.90	16.80	27.429	16.882	18	17.7	17.6	17.4	17.3	16.7
16.90	16.80	16.80	16.90	16.80	16.90	16.90	16.90	16.90	16.80	16.70	16.80	16.70	16.80	16.80	16.80	16.70	16.80	16.90	16.90	16.90	16.80	17.00	16.60	27.429	16.882	17.6	17.7	17.7	17.4	17.3	17.5
16.60	16.50	16.50	16.60	16.40	16.60	16.50	16.60	16.60	16.50	16.40	16.50	16.40	16.50	16.50	16.40	16.40	16.50	16.60	16.60	17.00	16.50	16.80	16.40	27.429	16.882	17.4	17.5	17.6	17.3	17.3	16.7
16.70	16.60	16.60	16.60	16.50	16.70	16.70	16.70	16.70	16.60	16.50	16.60	16.50	16.60	16.60	16.50	16.50	16.50	16.70	16.70	17.00	16.60	16.80	16.50	27.429	16.882	17.4	17.5	17.6	17.3	17.3	16.7
16.20	16.20	16.20	16.20	16.10	16.20	16.20	16.20	16.20	16.20	16.10	16.10	16.10	16.10	16.10	16.10	16.10	16.10	16.30	16.20	17.00	16.20	16.20	16.20	27.429	16.882	17	17.1	17.3	17.1	17.3	16.7
16.20	16.20	16.20	16.20	16.10	16.10	16.10	16.10	16.10	16.20	16.10	16.10	16.10	16.10	16.10	16.10	16.10	16.10	16.20	16.10	16.90	16.20	16.30	16.10	27.429	16.882	17	17.1	17.4	17.2	17.3	16.7
16.60	16.60	16.60	16.70	16.50	16.60	16.60	16.60	16.60	16.60	16.50	16.60	16.50	16.60	16.60	16.50	16.50	16.60	16.70	16.60	16.90	16.50	16.50	16.40	27.429	16.882	17.3	17.3	17.4	17.3	17.3	16.7

Zone 7 (Bed room4)

Base	m1	m2	m3	m4	m5	m6	m7	m8	m9	m10	m11	m12	m13	m14	m15	m16	m17	m18	m19	m20	m21	m21b	m22	Tcmax	Tcmin	Com1	Com2	Com3	Com4	Com5	To
15.60	15.70	15.80	15.80	15.70	15.60	15.60	15.60	15.60	15.60	15.60	15.80	15.70	15.80	15.80	15.70	15.70	15.80	15.80	16.60	16.50	16.00	16.00	16.80	27.429	16.882	17.7	17.9	17.9	17.4	16.4	13.6
15.60	15.60	15.70	15.80	15.60	15.50	15.50	15.50	15.50	15.60	15.60	15.60	15.60	15.70	15.70	15.60	15.60	15.60	15.70	15.60	16.40	15.80	15.90	16.70	27.429	16.882	17.5	17.7	17.8	17.2	16.2	13.6
15.60	15.60	15.70	15.80	15.60	15.50	15.50	15.50	15.50	15.60	15.60	15.60	15.60	15.70	15.70	15.60	15.60	15.60	15.70	15.60	16.40	15.80	15.90	16.70	27.429	16.882	17.5	17.7	17.8	17.2	16.2	13.6
15.50	15.60	15.60	15.70	15.60	15.50	15.50	15.50	15.50	15.50	15.50	15.60	15.60	15.60	15.60	15.60	15.60	15.60	15.70	15.60	16.40	15.80	15.80	16.60	27.429	16.882	17.5	17.7	17.8	17.2	16.2	13.4
15.50	15.60	15.70	15.70	15.60	15.50	15.50	15.50	15.50	15.60	15.50	15.60	15.60	15.60	15.70	15.60	15.60	15.60	15.70	15.60	16.40	15.80	15.70	16.60	27.429	16.882	17.5	17.6	17.7	17.2	16.2	13.6
15.50	15.60	15.70	15.70	15.60	15.50	15.50	15.50	15.50	15.60	15.50	15.60	15.60	15.60	15.60	15.60	15.60	15.60	15.70	15.60	16.40	15.70	15.50	16.60	27.429	16.882	17.3	17.5	17.6	17.2	16.2	13.6
15.50	15.60	15.60	15.70	15.60	15.50	15.50	15.50	15.50	15.60	15.50	15.60	15.60	15.60	15.60	15.60	15.60	15.60	15.70	15.60	16.40	15.70	15.50	16.60	27.429	16.882	17.3	17.5	17.6	17.2	16.2	13.6
15.50	15.60	15.60	15.70	15.60	15.50	15.50	15.50	15.50	15.50	15.50	15.60	15.60	15.60	15.60	15.60	15.60	15.60	15.70	15.60	16.40	15.70	15.50	16.60	27.429	16.882	17.3	17.5	17.5	17.2	16.2	13.6
15.50	15.60	15.60	15.70	15.60	15.50	15.50	15.50	15.50	15.50	15.50	15.60	15.60	15.60	15.60	15.60	15.60	15.60	15.70	15.60	16.40	15.70	15.50	16.60	27.429	16.882	17.3	17.5	17.6	17.2	16.2	13.6
15.60	15.60	15.70	15.80	15.70	15.60	15.60	15.60	15.60	15.60	15.60	15.70	15.70	15.70	15.70	15.60	15.70	15.70	15.70	15.70	16.40	15.70	15.60	16.60	27.429	16.882	17.3	17.5	17.6	17.2	16.2	14.2
15.80	15.80	15.90	15.90	15.80	15.70	15.70	15.70	15.70	15.80	15.70	15.90	15.80	15.90	15.90	15.80	15.80	15.90	15.90	15.80	16.50	15.90	15.70	16.70	27.429	16.882	17.4	17.6	17.6	17.2	16.3	15.7
15.80	15.90	15.90	16.00	15.90	15.80	15.80	15.80	15.80	15.90	15.80	15.90	15.90	15.90	15.90	15.90	15.90	15.90	15.90	15.80	16.50	15.90	15.70	16.80	27.429	16.882	17.4	17.6	17.6	17.2	16.3	15.7
16.70	16.70	16.80	16.80	16.70	16.70	16.70	16.70	16.70	16.80	16.60	16.90	16.80	16.80	16.80	16.80	16.70	16.80	16.70	16.60	16.60	16.60	16.40	16.90	27.429	16.882	17.5	17.6	17.7	17.3	16.4	17.1
17.30	17.30	17.40	17.40	17.30	17.30	17.30	17.40	17.30	17.40	17.20	17.50	17.40	17.50	17.40	17.40	17.30	17.40	17.30	17.20	16.70	17.10	16.90	17.00	27.429	16.882	17.6	17.7	17.8	17.4	16.5	18.8
17.40	17.50	17.60	17.60	17.40	17.50	17.50	17.50	17.50	17.50	17.30	17.60	17.50	17.60	17.50	17.50	17.40	17.50	17.40	17.30	16.80	17.20	17.20	17.00	27.429	16.882	17.7	17.8	17.9	17.4	16.5	18.8
17.90	17.90	18.00	18.00	17.90	18.00	17.90	18.00	18.00	18.00	17.80	18.10	17.90	18.00	18.00	17.90	17.80	17.90	17.80	17.80	16.90	17.50	17.60	17.10	27.429	16.882	17.8	17.9	17.9	17.4	16.5	19.9
18.10	18.10	18.20	18.20	18.00	18.20	18.10	18.20	18.10	18.20	17.90	18.30	18.10	18.20	18.10	18.10	18.00	18.10	17.70	17.30	16.90	17.70	17.80	17.20	27.429	16.882	17.9	18	18	17.4	16.5	18.8
17.10	17.00	16.90	17.10	17.00	17.10	17.00	17.00	17.10	16.90	16.70	17.10	17.00	17.10	17.00	16.90	16.90	17.00	16.90	17.10	16.90	16.90	17.20	17.10	27.429	16.882	17.9	18	18	17.3	16.4	16.7
16.80	16.80	16.80	16.80	16.70	16.80	16.80	16.80	16.80	16.80	16.60	16.80	16.70	16.80	16.70	16.70	16.60	16.70	16.90	16.90	17.00	16.70	17.00	17.10	27.429	16.882	17.8	18	18.1	17.3	16.4	17.5
16.50	16.50	15.50	16.50	16.40	16.50	16.50	16.50	16.50	16.50	16.30	16.40	16.40	16.40	16.40	16.40	16.40	16.40	16.60	16.60	17.00	16.50	16.80	17.10	27.429	16.882	17.9	18.1	18.1	17.3	16.4	16.7
16.60	16.60	15.50	16.60	16.50	16.60	16.60	16.60	16.60	16.60	16.40	16.50	16.40	16.50	16.50	16.50	16.40	16.50	16.70	16.70	17.10	16.50	16.80	17.10	27.429	16.882	17.8	18	18	17.3	16.4	16.7
16.20	16.20	16.10	16.20	16.10	16.20	16.20	16.20	16.20	16.20	16.00	16.10	16.00	16.10	16.10	16.10	16.10	16.10	16.30	16.30	17.00	16.20	16.20	17.10	27.429	16.882	17.7	17.8	17.9	17.3	16.4	16.7
16.10	16.20	16.10	16.20	16.10	16.10	16.10	16.10	16.10	16.20	16.10	16.10	16.00	16.10	16.10	16.10	16.10	16.10	16.20	16.20	16.90	16.20	16.30	17.00	27.429	16.882	17.7	17.9	17.9	17.3	16.5	16.7
16.50	16.50	16.60	16.50	16.40	16.60	16.50	16.50	16.50	16.50	16.40	16.50	16.50	16.50	16.50	16.40	16.50	16.40	16.70	16.60	16.90	16.50	16.50	17.10	27.429	16.882	17.7	17.9	17.9	17.3	16.5	16.7

Zone 8 (Bed room 3)

Base	m1	m2	m3	m4	m5	m6	m7	m8	m9	m10	m11	m12	m13	m14	m15	m16	m17	m18	m19	m20	m21	m21b	m22	Tcmax	Tcmin	Com1	Com2	Com3	Com4	Com5	To
17.2	17.2	17.2	17.4	17.1	17.1	17.1	17.0	17.0	17.0	17	17.2	17	17.2	17.2	17.1	17.2	17.1	17.1	17	17.2	17.90	18.00	17.2	27.429	16.882	19.2	19.2	17.4	17.2	17.1	13.6
16.9	16.9	17.1	17.2	16.9	16.9	16.9	16.8	16.8	16.9	16.8	17	16.9	17.1	17.1	16.9	17.0	17	17	16.9	17.1	17.80	17.90	17.0	27.429	16.882	19.1	19.1	17.2	17	17	13.6
16.9	17	17.1	17.3	17.0	16.9	16.9	16.8	16.9	16.9	16.8	17.1	16.9	17.1	17.1	17.0	17.0	17.1	17.1	16.9	17.1	17.80	17.90	17.0	27.429	16.882	19.1	19.1	17.2	17	17	13.6
16.8	16.9	17	17.2	16.9	16.8	16.8	16.8	16.8	16.9	16.8	17	16.9	17	17	16.9	16.9	17	17	16.9	17.1	17.80	17.80	16.9	27.429	16.882	19.1	19.1	17.2	17	17	13.4
16.8	16.9	17	17.2	16.9	16.8	16.8	16.8	16.8	16.9	16.8	17	16.9	17	17.1	16.9	16.9	17	17	16.8	17	17.80	17.70	16.9	27.429	16.882	19.1	19.1	17.1	17	17	13.6
16.8	16.9	17	17.2	16.9	16.8	16.8	16.8	16.8	16.9	16.8	17	16.9	17	17	16.9	16.9	17	17	16.8	17	17.70	17.40	16.9	27.429	16.882	18.9	18.9	17	17	17	13.6
16.8	16.9	17	17.2	16.9	16.8	16.8	16.8	16.8	16.9	16.8	17	16.9	17	17	16.9	16.9	17	17	16.8	17	17.70	17.40	16.9	27.429	16.882	18.9	18.9	17	17	17	13.6
16.8	16.9	17	17.2	16.9	16.8	16.8	16.8	16.8	16.9	16.8	17	16.9	17	17.1	16.9	16.9	17	17	16.8	17	17.70	17.40	16.9	27.429	16.882	18.9	18.9	17	17	17	13.6
16.8	16.9	17	17.2	16.9	16.8	16.8	16.8	16.8	16.9	16.7	17	16.9	17	17	16.9	16.9	17	16.9	16.8	17	17.70	17.40	16.9	27.429	16.882	18.9	18.9	17	17	17	13.6
16.8	16.9	17	17.2	16.9	16.9	16.9	16.9	16.9	16.9	16.8	17.1	17	17.1	17.1	16.9	17.0	17.1	17	16.9	17.1	17.70	17.50	16.9	27.429	16.882	18.9	18.9	17	17	17.1	14.2
17	17	17.2	17.3	17.0	17.0	17.0	17.0	17.0	17.1	16.9	17.2	17.1	17.2	17.2	17.1	17.1	17.2	17.1	17	17.2	17.80	17.50	17.0	27.429	16.882	19	19	17.1	17.1	17.1	15.7
17	17.1	17.2	17.4	17.1	17.1	17.1	17.1	17.1	17.1	17	17.3	17.2	17.3	17.3	17.1	17.1	17.3	17.1	17	17.2	17.80	17.60	17.0	27.429	16.882	19	19	17.1	17.1	17.1	15.7
17.2	17.3	17.4	17.6	17.3	17.3	17.3	17.3	17.3	17.3	17.2	17.5	17.4	17.5	17.5	17.4	17.3	17.5	17.3	17.1	17.3	18.00	17.70	17.0	27.429	16.882	19	19	17.3	17.4	17.2	17.1
17.4	17.4	17.6	17.7	17.4	17.4	17.4	17.4	17.4	17.5	17.3	17.6	17.5	17.6	17.6	17.5	17.5	17.6	17.4	17.2	17.4	18.10	17.90	17.1	27.429	16.882	19.1	19.1	17.6	17.7	17.3	18.8
17.4	17.4	17.6	17.7	17.4	17.4	17.4	17.4	17.4	17.5	17.3	17.6	17.5	17.6	17.6	17.5	17.5	17.6	17.4	17.3	17.4	18.10	18.10	17.2	27.429	16.882	19.2	19.2	17.7	17.7	17.3	18.8
17.5	17.5	17.6	17.8	17.5	17.5	17.5	17.5	17.5	17.5	17.3	17.7	17.5	17.6	17.6	17.5	17.5	17.6	17.5	17.4	17.5	18.20	18.20	17.3	27.429	16.882	19.3	19.3	17.8	17.8	17.3	19.9
17.6	17.7	17.8	17.9	17.7	17.6	17.6	17.6	17.6	17.6	17.4	17.8	17.6	17.7	17.7	17.6	17.6	17.7	17.6	17.4	17.5	18.30	18.40	17.3	27.429	16.882	19.3	19.3	17.7	17.6	17.4	18.8
17.4	17.4	17.5	17.7	17.4	17.3	17.3	17.3	17.3	17.4	17.2	17.5	17.4	17.5	17.5	17.4	17.3	17.5	17.4	17.4	17.4	18.10	18.50	17.3	27.429	16.882	19.4	19.4	17.7	17.5	17.3	16.7
17.4	17.4	17.5	17.7	17.4	17.3	17.3	17.3	17.3	17.3	17.1	17.4	17.3	17.4	17.4	17.3	17.3	17.4	17.5	17.4	17.5	18.10	18.50	17.4	27.429	16.882	19.4	19.4	17.7	17.4	17.2	17.5
17.4	17.4	17.5	17.7	17.4	17.3	17.3	17.3	17.3	17.4	17.1	17.4	17.3	17.5	17.4	17.3	17.3	17.4	17.5	17.4	17.5	18.10	18.60	17.4	27.429	16.882	19.4	19.4	17.6	17.3	17.2	16.7
17.4	17.4	17.5	17.7	17.4	17.4	17.4	17.4	17.4	17.4	17.2	17.5	17.4	17.5	17.5	17.4	17.4	17.5	17.5	17.4	17.6	18.10	18.40	17.4	27.429	16.882	19.4	19.4	17.6	17.3	17.2	16.7
17.4	17.4	17.5	17.6	17.3	17.4	17.3	17.4	17.3	17.4	17.2	17.5	17.3	17.5	17.5	17.4	17.3	17.4	17.5	17.4	17.6	18.10	18.10	17.3	27.429	16.882	19.3	19.4	17.3	17.2	17.3	16.7
17.3	17.4	17.5	17.6	17.3	17.3	17.3	17.3	17.3	17.4	17.2	17.5	17.3	17.5	17.5	17.4	17.3	17.4	17.5	17.4	17.5	18.10	18.20	17.3	27.429	16.882	19.3	19.3	17.4	17.2	17.3	16.7
17.4	17.4	17.5	17.7	17.4	17.4	17.4	17.4	17.4	17.4	17.3	17.5	17.4	17.5	17.5	17.4	17.4	17.5	17.5	17.4	17.6	18.10	18.10	17.4	27.429	16.882	19.3	19.3	17.5	17.3	17.3	16.7

Zone 9 (Hall)

Base	m1	m2	m3	m4	m5	m6	m7	m8	m9	m10	m11	m12	m13	m14	m15	m16	m17	m18	m19	m20	m21	m21b	m22	Tcmax	Tcmin	Com1	Com2	Com3	Com4	To
17.4	17.5	17.6	17.8	17.5	17.4	17.4	17.4	17.4	15.2	17.4	17.6	17.5	15.2	17.6	15.2	15.2	17.5	15.2	17.4	17.5	18.7	18.80	15.90	27.429	16.882	18.6	19	19.2	18.5	13.6
17.2	17.3	17.4	17.6	17.3	17.2	17.2	17.2	17.2	15.0	17.2	17.4	17.3	15.0	17.4	15.0	15.0	17.4	15.0	17.2	17.3	18.5	18.60	15.70	27.429	16.882	18.6	18.8	19.1	18.4	13.6
17.3	17.3	17.5	17.6	17.3	17.2	17.3	17.2	17.3	15.0	17.2	17.4	17.3	15.0	17.4	15.0	15.0	17.4	15.0	17.3	17.3	18.6	18.60	15.70	27.429	16.882	18.6	18.8	19.1	18.4	13.6
17.2	17.3	17.4	17.5	17.3	17.2	17.2	17.2	17.2	15.0	17.2	17.4	17.3	15.0	17.4	15.0	15.0	17.4	15.0	17.2	17.2	18.5	18.60	15.70	27.429	16.882	18.6	18.8	19.1	18.4	13.4
17.2	17.2	17.3	17.5	17.2	17.2	17.2	17.2	17.2	15.0	17.2	17.4	17.3	15.0	17.4	15.0	15.0	17.4	14.9	17.2	17.2	18.5	18.40	15.70	27.429	16.882	18.4	18.8	19.1	18.4	13.6
17.2	17.2	17.4	17.5	17.2	17.2	17.2	17.2	17.2	15.0	17.2	17.4	17.3	15.0	17.4	15.0	15.0	17.4	14.9	17.2	17.2	18.4	18.20	15.70	27.429	16.882	18.4	18.8	18.9	18.4	13.6
17.2	17.2	17.3	17.5	17.2	17.2	17.2	17.2	17.2	15.0	17.2	17.4	17.3	15.0	17.4	15.0	15.0	17.4	14.9	17.2	17.2	18.4	18.20	15.70	27.429	16.882	18.4	18.5	18.9	18.4	13.6
17.2	17.2	17.3	17.5	17.2	17.2	17.2	17.2	17.2	14.9	17.2	17.4	17.3	15.0	17.4	15.0	15.0	17.4	14.9	17.2	17.2	18.4	18.20	15.70	27.429	16.882	18.4	18.5	18.9	18.4	13.6
17.2	17.2	17.3	17.5	17.2	17.2	17.2	17.2	17.2	14.9	17.1	17.4	17.3	15.0	17.4	15.0	15.0	17.4	14.9	17.2	17.2	18.4	18.20	15.70	27.429	16.882	18.4	18.5	18.9	18.4	13.6
17.2	17.2	17.4	17.5	17.3	17.2	17.3	17.2	17.3	15.0	17.2	17.4	17.3	15.0	17.4	15.0	15.0	17.4	14.9	17.2	17.2	18.4	18.20	15.80	27.429	16.882	18.4	18.6	18.9	18.4	14.2
17.3	17.3	17.4	17.6	17.3	17.3	17.3	17.3	17.3	15.1	17.2	17.5	17.4	15.1	17.5	15.1	15.1	17.5	15.0	17.3	17.3	18.5	18.30	16.00	27.429	16.882	18.5	18.6	19	18.4	15.7
17.3	17.3	17.5	17.6	17.4	17.3	17.4	17.4	17.4	15.1	17.3	17.5	17.4	15.1	17.5	15.1	15.1	17.5	15.0	17.3	17.3	18.5	18.30	16.20	27.429	16.882	18.6	18.7	19	18.4	15.7
17.4	17.4	17.5	17.7	17.4	17.4	17.4	17.4	17.4	15.2	17.3	17.6	17.5	15.2	17.6	15.2	15.2	17.6	15.1	17.4	17.4	18.6	18.30	16.30	27.429	16.882	18.7	18.7	19	18.5	17.1
17.5	17.6	17.7	17.8	17.6	17.5	17.5	17.5	17.5	15.3	17.4	17.7	17.6	15.3	17.7	15.3	15.3	17.7	15.2	17.5	17.5	18.6	18.50	16.40	27.429	16.882	18.8	18.8	19.1	18.6	18.8
17.5	17.6	17.7	17.8	17.6	17.5	17.6	17.6	17.6	15.3	17.4	17.8	17.6	15.3	17.7	15.3	15.3	17.7	15.3	17.5	17.5	18.7	18.70	16.50	27.429	16.882	19	19	19.2	18.6	18.8
17.7	17.7	17.8	18	17.7	17.6	17.6	17.7	17.6	15.4	17.5	17.8	17.7	15.4	17.8	15.4	15.3	17.8	15.4	17.6	17.6	18.8	18.80	16.70	27.429	16.882	19	19	19.3	18.6	19.9
17.7	17.7	17.8	18	17.7	17.6	17.6	17.6	17.6	15.4	17.5	17.8	17.7	15.3	17.7	15.3	15.3	17.8	15.4	17.7	17.6	18.8	19.00	16.80	27.429	16.882	19.1	19.2	19.3	18.6	18.8
17.6	17.7	17.8	17.9	17.7	17.5	17.6	17.6	17.6	15.3	17.4	17.7	17.6	15.3	17.7	15.3	15.2	17.7	15.4	17.6	17.5	18.8	19.10	16.60	27.429	16.882	19.1	19.2	19.4	18.5	16.7
17.7	17.7	17.8	18	17.7	17.6	17.5	17.6	17.6	15.3	17.4	17.7	17.6	15.3	17.7	15.3	15.3	17.7	15.4	17.7	17.6	18.8	19.20	16.60	27.429	16.882	19	19.1	19.4	18.5	17.5
17.7	17.8	17.8	18	17.7	17.6	17.6	17.6	17.6	15.4	17.5	17.8	17.6	15.4	17.7	15.4	15.3	17.7	15.5	17.7	17.6	18.8	19.30	16.50	27.429	16.882	19.1	19.2	19.4	18.5	16.7
17.7	17.7	17.8	17.9	17.7	17.7	17.7	17.7	17.7	15.4	17.5	17.8	17.7	15.4	17.8	15.4	15.4	17.8	15.4	17.7	17.7	18.8	19.10	16.60	27.429	16.882	19	19.1	19.4	18.5	16.7
17.7	17.7	17.8	17.9	17.7	17.7	17.6	17.7	17.6	15.4	17.5	17.8	17.6	15.4	17.8	15.4	15.4	17.8	15.4	17.7	17.6	18.8	18.80	16.60	27.429	16.882	18.9	18.9	19.2	18.5	16.7
17.6	17.7	17.8	17.9	17.6	17.6	17.6	17.6	17.6	15.4	17.5	17.8	17.6	15.4	17.8	15.4	15.4	17.8	15.4	17.6	17.6	18.8	18.90	16.40	27.429	16.882	18.8	19	19.3	18.5	16.7
17.7	17.7	17.8	18	17.7	17.7	17.7	17.7	17.7	15.4	17.6	17.8	17.7	15.4	17.8	15.4	15.4	17.8	15.5	17.7	17.7	18.8	18.80	16.40	27.429	16.882	18.8	18.9	19.3	18.5	16.7
17.7	17.7	17.8	18	17.7	17.7	17.7	17.7	17.7	15.4	17.6	17.8	17.7	15.4	17.8	15.4	15.4	17.8	15.5	17.7	17.7	18.8	18.80	16.40	27.429	16.882	18.8	18.9			

Appendix E

Historical Mean Monthly Air Temperature and Relative Humidity of the Main Climatic Regions in Yemen.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Coastal region	25.4	25.9	27.1	28.6	31.8	32.5	31.8	32.0	30.9	29.6	26.7	26.5
Temperate region	2.3	6.1	10.9	11.1	13.9	14.6	15.8	14.9	12.3	9.0	4.6	4.5
Dry region	16.3	21.2	25.2	28.2	31.3	32.5	33.9	32.9	30.1	26.1	21.4	21.0

Mean Monthly Air Temperature

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Coastal region	65	72	74	72	71	66	63	62	69	67	63	68
Temperate region	41	39	59	43	42	34	46	56	34	35	41	43
Dry region	23	19	30	15	15	11	18	21	17	20	21	24

Mean Monthly Relative Humidity

	To$_{Max}$	To$_{Mean}$	To$_{Min}$
January	29.3	17.1	4.7
February	33.5	21.2	8.1
March	35.7	27	9.4
April	38.8	29.1	15.5
May	43.4	31.4	23.1
June	46.2	32	26.9
July	47.4	33	28.4
August	48.2	33.9	30
September	43	31.2	27
October	39.9	27.1	22
November	34.8	22.7	17.1
December	29.3	21.6	9.4

Monthly Maximum, Mean and Minimum Air temperature of Seiyun

Appendix F

Statistic Results.

F.1. Vernal Equinox (19th of March)

Zone 1

ANOVA

Z1

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	84.688	4	21.172	62.455	.000
Within Groups	38.984	115	.339		
Total	123.672	119			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: Z1
LSD

(I) VAR7	(J) VAR7	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1.00	2.00	-.1042	.168	.537	-.4371	.2288
	3.00	1.6333*	.168	.000	1.3004	1.9663
	4.00	1.6792*	.168	.000	1.3462	2.0121
	5.00	1.6708*	.168	.000	1.3379	2.0038
2.00	1.00	.1042	.168	.537	-.2288	.4371
	3.00	1.7375*	.168	.000	1.4046	2.0704
	4.00	1.7833*	.168	.000	1.4504	2.1163
	5.00	1.7750*	.168	.000	1.4421	2.1079
3.00	1.00	-1.6333*	.168	.000	-1.9663	-1.3004
	2.00	-1.7375*	.168	.000	-2.0704	-1.4046
	4.00	4.583E-02	.168	.786	-.2871	.3788
	5.00	3.750E-02	.168	.824	-.2954	.3704
4.00	1.00	-1.6792*	.168	.000	-2.0121	-1.3462
	2.00	-1.7833*	.168	.000	-2.1163	-1.4504
	3.00	-4.583E-02	.168	.786	-.3788	.2871
	5.00	-8.333E-03	.168	.961	-.3413	.3246
5.00	1.00	-1.6708*	.168	.000	-2.0038	-1.3379
	2.00	-1.7750*	.168	.000	-2.1079	-1.4421
	3.00	-3.750E-02	.168	.824	-.3704	.2954
	4.00	8.333E-03	.168	.961	-.3246	.3413

*. The mean difference is significant at the .05 level.

Zone 2

ANOVA

Z2

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	6.537	4	1.634	12.991	.000
Within Groups	14.467	115	.126		
Total	21.004	119			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: Z2
LSD

					95% Confidence Interval	
(I) VAR7	(J) VAR7	Mean Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
1.00	2.00	-.1083	.102	.292	-.3111	9.448E-02
	3.00	-.5875*	.102	.000	-.7903	-.3847
	4.00	-.3083*	.102	.003	-.5111	-.1055
	5.00	5.000E-02	.102	.626	-.1528	.2528
2.00	1.00	.1083	.102	.292	-9.448E-02	.3111
	3.00	-.4792*	.102	.000	-.6820	-.2764
	4.00	-.2000	.102	.053	-.4028	2.809E-03
	5.00	.1583	.102	.125	-4.448E-02	.3611
3.00	1.00	.5875*	.102	.000	.3847	.7903
	2.00	.4792*	.102	.000	.2764	.6820
	4.00	.2792*	.102	.007	7.636E-02	.4820
	5.00	.6375*	.102	.000	.4347	.8403
4.00	1.00	.3083*	.102	.003	.1055	.5111
	2.00	.2000	.102	.053	-2.809E-03	.4028
	3.00	-.2792*	.102	.007	-.4820	-7.636E-02
	5.00	.3583*	.102	.001	.1555	.5611
5.00	1.00	-5.000E-02	.102	.626	-.2528	.1528
	2.00	-.1583	.102	.125	-.3611	4.448E-02
	3.00	-.6375*	.102	.000	-.8403	-.4347
	4.00	-.3583*	.102	.001	-.5611	-.1555

*. The mean difference is significant at the .05 level.

Zone 6

ANOVA

Z6

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.053	4	.263	.382	.821
Within Groups	79.339	115	.690		
Total	80.392	119			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: Z6
LSD

(I) VAR7	(J) VAR7	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1.00	2.00	-5.000E-02	.240	.835	-.5249	.4249
	3.00	4.583E-02	.240	.849	-.4291	.5208
	4.00	8.750E-02	.240	.716	-.3874	.5624
	5.00	.2250	.240	.350	-.2499	.6999
2.00	1.00	5.000E-02	.240	.835	-.4249	.5249
	3.00	9.583E-02	.240	.690	-.3791	.5708
	4.00	.1375	.240	.567	-.3374	.6124
	5.00	.2750	.240	.254	-.1999	.7499
3.00	1.00	-4.583E-02	.240	.849	-.5208	.4291
	2.00	-9.583E-02	.240	.690	-.5708	.3791
	4.00	4.167E-02	.240	.862	-.4333	.5166
	5.00	.1792	.240	.456	-.2958	.6541
4.00	1.00	-8.750E-02	.240	.716	-.5624	.3874
	2.00	-.1375	.240	.567	-.6124	.3374
	3.00	-4.167E-02	.240	.862	-.5166	.4333
	5.00	.1375	.240	.567	-.3374	.6124
5.00	1.00	-.2250	.240	.350	-.6999	.2499
	2.00	-.2750	.240	.254	-.7499	.1999
	3.00	-.1792	.240	.456	-.6541	.2958
	4.00	-.1375	.240	.567	-.6124	.3374

Zone 7

ANOVA

Z7

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	35.179	4	8.795	49.285	.000
Within Groups	20.521	115	.178		
Total	55.700	119			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: Z7
LSD

(I) VAR7	(J) VAR7	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	-.1667	.122	.174	-.4082	7.488E-02
	3.00	-.2333	.122	.058	-.4749	8.215E-03
	4.00	.3250*	.122	.009	8.345E-02	.5665
	5.00	1.2458*	.122	.000	1.0043	1.4874
2.00	1.00	.1667	.122	.174	-7.488E-02	.4082
	3.00	-6.667E-02	.122	.586	-.3082	.1749
	4.00	.4917*	.122	.000	.2501	.7332
	5.00	1.4125*	.122	.000	1.1710	1.6540
3.00	1.00	.2333	.122	.058	-8.215E-03	.4749
	2.00	6.667E-02	.122	.586	-.1749	.3082
	4.00	.5583*	.122	.000	.3168	.7999
	5.00	1.4792*	.122	.000	1.2376	1.7207
4.00	1.00	-.3250*	.122	.009	-.5665	-8.345E-02
	2.00	-.4917*	.122	.000	-.7332	-.2501
	3.00	-.5583*	.122	.000	-.7999	-.3168
	5.00	.9208*	.122	.000	.6793	1.1624
5.00	1.00	-1.2458*	.122	.000	-1.4874	-1.0043
	2.00	-1.4125*	.122	.000	-1.6540	-1.1710
	3.00	-1.4792*	.122	.000	-1.7207	-1.2376
	4.00	-.9208*	.122	.000	-1.1624	-.6793

*. The mean difference is significant at the .05 level.

Zone 8

ANOVA

Z8

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	94.191	4	23.548	115.409	.000
Within Groups	23.464	115	.204		
Total	117.655	119			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: Z8
LSD

(I) VAR7	(J) VAR7	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	.0000	.130	1.000	-.2583	.2583
	3.00	1.8292*	.130	.000	1.5709	2.0875
	4.00	.9667*	.130	.000	.7084	1.2250
	5.00	2.1125*	.130	.000	1.8542	2.3708
2.00	1.00	.0000	.130	1.000	-.2583	.2583
	3.00	1.8292*	.130	.000	1.5709	2.0875
	4.00	.9667*	.130	.000	.7084	1.2250
	5.00	2.1125*	.130	.000	1.8542	2.3708
3.00	1.00	-1.8292*	.130	.000	-2.0875	-1.5709
	2.00	-1.8292*	.130	.000	-2.0875	-1.5709
	4.00	-.8625*	.130	.000	-1.1208	-.6042
	5.00	.2833*	.130	.032	2.504E-02	.5416
4.00	1.00	-.9667*	.130	.000	-1.2250	-.7084
	2.00	-.9667*	.130	.000	-1.2250	-.7084
	3.00	.8625*	.130	.000	.6042	1.1208
	5.00	1.1458*	.130	.000	.8875	1.4041
5.00	1.00	-2.1125*	.130	.000	-2.3708	-1.8542
	2.00	-2.1125*	.130	.000	-2.3708	-1.8542
	3.00	-.2833*	.130	.032	-.5416	-2.504E-02
	4.00	-1.1458*	.130	.000	-1.4041	-.8875

*. The mean difference is significant at the .05 level.

Zone 9

ANOVA

Z9

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	57.401	3	19.134	114.500	.000
Within Groups	15.374	92	.167		
Total	72.775	95			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: Z9
LSD

					95% Confidence Interval	
(I) VAR7	(J) VAR7	Mean Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
1.00	2.00	.1500	.118	.207	-8.437E-02	.3844
	3.00	1.1708*	.118	.000	.9365	1.4052
	4.00	1.8917*	.118	.000	1.6573	2.1260
2.00	1.00	-.1500	.118	.207	-.3844	8.437E-02
	3.00	1.0208*	.118	.000	.7865	1.2552
	4.00	1.7417*	.118	.000	1.5073	1.9760
3.00	1.00	-1.1708*	.118	.000	-1.4052	-.9365
	2.00	-1.0208*	.118	.000	-1.2552	-.7865
	4.00	.7208*	.118	.000	.4865	.9552
4.00	1.00	-1.8917*	.118	.000	-2.1260	-1.6573
	2.00	-1.7417*	.118	.000	-1.9760	-1.5073
	3.00	-.7208*	.118	.000	-.9552	-.4865

*. The mean difference is significant at the .05 level.

F.2. Summer Solstice (21st of June)

Zone 1

ANOVA

Z1

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	20.589	4	5.147	14.619	.000
Within Groups	40.490	115	.352		
Total	61.079	119			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: Z1
LSD

(I) VAR7	(J) VAR7	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	-.1104	.171	.520	-.4497	.2289
	3.00	.7292*	.171	.000	.3899	1.0685
	4.00	.8292*	.171	.000	.4899	1.1685
	5.00	.7958*	.171	.000	.4565	1.1351
2.00	1.00	.1104	.171	.520	-.2289	.4497
	3.00	.8396*	.171	.000	.5003	1.1789
	4.00	.9396*	.171	.000	.6003	1.2789
	5.00	.9063*	.171	.000	.5670	1.2455
3.00	1.00	-.7292*	.171	.000	-1.0685	-.3899
	2.00	-.8396*	.171	.000	-1.1789	-.5003
	4.00	.1000	.171	.560	-.2393	.4393
	5.00	6.667E-02	.171	.698	-.2726	.4060
4.00	1.00	-.8292*	.171	.000	-1.1685	-.4899
	2.00	-.9396*	.171	.000	-1.2789	-.6003
	3.00	-.1000	.171	.560	-.4393	.2393
	5.00	-3.333E-02	.171	.846	-.3726	.3060
5.00	1.00	-.7958*	.171	.000	-1.1351	-.4565
	2.00	-.9063*	.171	.000	-1.2455	-.5670
	3.00	-6.667E-02	.171	.698	-.4060	.2726
	4.00	3.333E-02	.171	.846	-.3060	.3726

*. The mean difference is significant at the .05 level.

Zone 2

ANOVA

Z2

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	6.580	4	1.645	11.572	.000
Within Groups	16.346	115	.142		
Total	22.926	119			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: Z2
LSD

					95% Confidence Interval	
(I) VAR7	(J) VAR7	Mean Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
1.00	2.00	-.1458	.109	.183	-.3614	6.975E-02
	3.00	-.6292*	.109	.000	-.8447	-.4136
	4.00	-.3875*	.109	.001	-.6031	-.1719
	5.00	-5.417E-02	.109	.620	-.2697	.1614
2.00	1.00	.1458	.109	.183	-6.975E-02	.3614
	3.00	-.4833*	.109	.000	-.6989	-.2678
	4.00	-.2417*	.109	.028	-.4572	-2.609E-02
	5.00	9.167E-02	.109	.401	-.1239	.3072
3.00	1.00	.6292*	.109	.000	.4136	.8447
	2.00	.4833*	.109	.000	.2678	.6989
	4.00	.2417*	.109	.028	2.609E-02	.4572
	5.00	.5750*	.109	.000	.3594	.7906
4.00	1.00	.3875*	.109	.001	.1719	.6031
	2.00	.2417*	.109	.028	2.609E-02	.4572
	3.00	-.2417*	.109	.028	-.4572	-2.609E-02
	5.00	.3333*	.109	.003	.1178	.5489
5.00	1.00	5.417E-02	.109	.620	-.1614	.2697
	2.00	-9.167E-02	.109	.401	-.3072	.1239
	3.00	-.5750*	.109	.000	-.7906	-.3594
	4.00	-.3333*	.109	.003	-.5489	-.1178

*. The mean difference is significant at the .05 level.

Zone 6

ANOVA

Z6

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.570	4	.142	.497	.738
Within Groups	32.957	115	.287		
Total	33.527	119			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: Z6
LSD

					95% Confidence Interval	
(I) VAR7	(J) VAR7	Mean Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
1.00	2.00	-.1333	.155	.390	-.4394	.1728
	3.00	-.1750	.155	.260	-.4811	.1311
	4.00	-5.833E-02	.155	.707	-.3644	.2478
	5.00	-8.333E-03	.155	.957	-.3144	.2978
2.00	1.00	.1333	.155	.390	-.1728	.4394
	3.00	-4.167E-02	.155	.788	-.3478	.2644
	4.00	7.500E-02	.155	.628	-.2311	.3811
	5.00	.1250	.155	.420	-.1811	.4311
3.00	1.00	.1750	.155	.260	-.1311	.4811
	2.00	4.167E-02	.155	.788	-.2644	.3478
	4.00	.1167	.155	.452	-.1894	.4228
	5.00	.1667	.155	.283	-.1394	.4728
4.00	1.00	5.833E-02	.155	.707	-.2478	.3644
	2.00	-7.500E-02	.155	.628	-.3811	.2311
	3.00	-.1167	.155	.452	-.4228	.1894
	5.00	5.000E-02	.155	.747	-.2561	.3561
5.00	1.00	8.333E-03	.155	.957	-.2978	.3144
	2.00	-.1250	.155	.420	-.4311	.1811
	3.00	-.1667	.155	.283	-.4728	.1394
	4.00	-5.000E-02	.155	.747	-.3561	.2561

Zone 7

ANOVA

Z7

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	30.146	4	7.536	41.162	.000
Within Groups	21.055	115	.183		
Total	51.201	119			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: Z7
LSD

(I) VAR7	(J) VAR7	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	-.1375	.124	.268	-.3822	.1072
	3.00	-.1625	.124	.191	-.4072	8.217E-02
	4.00	.3042*	.124	.015	5.949E-02	.5488
	5.00	1.1833*	.124	.000	.9387	1.4280
2.00	1.00	.1375	.124	.268	-.1072	.3822
	3.00	-2.500E-02	.124	.840	-.2697	.2197
	4.00	.4417*	.124	.001	.1970	.6863
	5.00	1.3208*	.124	.000	1.0762	1.5655
3.00	1.00	.1625	.124	.191	-8.217E-02	.4072
	2.00	2.500E-02	.124	.840	-.2197	.2697
	4.00	.4667*	.124	.000	.2220	.7113
	5.00	1.3458*	.124	.000	1.1012	1.5905
4.00	1.00	-.3042*	.124	.015	-.5488	-5.949E-02
	2.00	-.4417*	.124	.001	-.6863	-.1970
	3.00	-.4667*	.124	.000	-.7113	-.2220
	5.00	.8792*	.124	.000	.6345	1.1238
5.00	1.00	-1.1833*	.124	.000	-1.4280	-.9387
	2.00	-1.3208*	.124	.000	-1.5655	-1.0762
	3.00	-1.3458*	.124	.000	-1.5905	-1.1012
	4.00	-.8792*	.124	.000	-1.1238	-.6345

*. The mean difference is significant at the .05 level.

Zone 8

ANOVA

Z8

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	92.714	4	23.178	138.643	.000
Within Groups	19.226	115	.167		
Total	111.940	119			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: Z8
LSD

					95% Confidence Interval	
(I) VAR7	(J) VAR7	Mean Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
1.00	2.00	-4.167E-03	.118	.972	-.2380	.2296
	3.00	1.6333*	.118	.000	1.3995	1.8671
	4.00	1.7833*	.118	.000	1.5495	2.0171
	5.00	1.9292*	.118	.000	1.6954	2.1630
2.00	1.00	4.167E-03	.118	.972	-.2296	.2380
	3.00	1.6375*	.118	.000	1.4037	1.8713
	4.00	1.7875*	.118	.000	1.5537	2.0213
	5.00	1.9333*	.118	.000	1.6995	2.1671
3.00	1.00	-1.6333*	.118	.000	-1.8671	-1.3995
	2.00	-1.6375*	.118	.000	-1.8713	-1.4037
	4.00	.1500	.118	.206	-8.380E-02	.3838
	5.00	.2958*	.118	.014	6.203E-02	.5296
4.00	1.00	-1.7833*	.118	.000	-2.0171	-1.5495
	2.00	-1.7875*	.118	.000	-2.0213	-1.5537
	3.00	-.1500	.118	.206	-.3838	8.380E-02
	5.00	.1458	.118	.219	-8.797E-02	.3796
5.00	1.00	-1.9292*	.118	.000	-2.1630	-1.6954
	2.00	-1.9333*	.118	.000	-2.1671	-1.6995
	3.00	-.2958*	.118	.014	-.5296	-6.203E-02
	4.00	-.1458	.118	.219	-.3796	8.797E-02

*. The mean difference is significant at the .05 level.

Zone 9

ANOVA

Z9

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	50.089	3	16.696	86.001	.000
Within Groups	17.861	92	.194		
Total	67.950	95			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: Z9
LSD

					95% Confidence Interval	
(I) VAR7	(J) VAR7	Mean Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
1.00	2.00	-.1792	.127	.162	-.4318	7.345E-02
	3.00	-1.7750*	.127	.000	-2.0276	-1.5224
	4.00	-1.1375*	.127	.000	-1.3901	-.8849
2.00	1.00	.1792	.127	.162	-7.345E-02	.4318
	3.00	-1.5958*	.127	.000	-1.8485	-1.3432
	4.00	-.9583*	.127	.000	-1.2110	-.7057
3.00	1.00	1.7750*	.127	.000	1.5224	2.0276
	2.00	1.5958*	.127	.000	1.3432	1.8485
	4.00	.6375*	.127	.000	.3849	.8901
4.00	1.00	1.1375*	.127	.000	.8849	1.3901
	2.00	.9583*	.127	.000	.7057	1.2110
	3.00	-.6375*	.127	.000	-.8901	-.3849

*. The mean difference is significant at the .05 level.

F.3. Autumnal Equinox (23rd of September)

Zone 1

ANOVA

Z1

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	21.430	4	5.357	46.358	.000
Within Groups	13.290	115	.116		
Total	34.720	119			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: Z1
LSD

(I) VAR7	(J) VAR7	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	-.1167	.098	.237	-.3111	7.772E-02
	3.00	.7417*	.098	.000	.5473	.9361
	4.00	.8250*	.098	.000	.6306	1.0194
	5.00	.8292*	.098	.000	.6348	1.0236
2.00	1.00	.1167	.098	.237	-7.772E-02	.3111
	3.00	.8583*	.098	.000	.6639	1.0527
	4.00	.9417*	.098	.000	.7473	1.1361
	5.00	.9458*	.098	.000	.7514	1.1402
3.00	1.00	-.7417*	.098	.000	-.9361	-.5473
	2.00	-.8583*	.098	.000	-1.0527	-.6639
	4.00	8.333E-02	.098	.398	-.1111	.2777
	5.00	8.750E-02	.098	.374	-.1069	.2819
4.00	1.00	-.8250*	.098	.000	-1.0194	-.6306
	2.00	-.9417*	.098	.000	-1.1361	-.7473
	3.00	-8.333E-02	.098	.398	-.2777	.1111
	5.00	4.167E-03	.098	.966	-.1902	.1986
5.00	1.00	-.8292*	.098	.000	-1.0236	-.6348
	2.00	-.9458*	.098	.000	-1.1402	-.7514
	3.00	-8.750E-02	.098	.374	-.2819	.1069
	4.00	-4.167E-03	.098	.966	-.1986	.1902

*. The mean difference is significant at the .05 level.

Zone 2

ANOVA

Z2

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	8.374	4	2.094	41.882	.000
Within Groups	5.749	115	4.999E-02		
Total	14.123	119			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: Z2
LSD

(I) VAR7	(J) VAR7	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	-.1375*	.065	.035	-.2653	-9.653E-03
	3.00	-.7083*	.065	.000	-.8362	-.5805
	4.00	-.4333*	.065	.000	-.5612	-.3055
	5.00	-7.083E-02	.065	.275	-.1987	5.701E-02
2.00	1.00	.1375*	.065	.035	9.653E-03	.2653
	3.00	-.5708*	.065	.000	-.6987	-.4430
	4.00	-.2958*	.065	.000	-.4237	-.1680
	5.00	6.667E-02	.065	.304	-6.118E-02	.1945
3.00	1.00	.7083*	.065	.000	.5805	.8362
	2.00	.5708*	.065	.000	.4430	.6987
	4.00	.2750*	.065	.000	.1472	.4028
	5.00	.6375*	.065	.000	.5097	.7653
4.00	1.00	.4333*	.065	.000	.3055	.5612
	2.00	.2958*	.065	.000	.1680	.4237
	3.00	-.2750*	.065	.000	-.4028	-.1472
	5.00	.3625*	.065	.000	.2347	.4903
5.00	1.00	7.083E-02	.065	.275	-5.701E-02	.1987
	2.00	-6.667E-02	.065	.304	-.1945	6.118E-02
	3.00	-.6375*	.065	.000	-.7653	-.5097
	4.00	-.3625*	.065	.000	-.4903	-.2347

*. The mean difference is significant at the .05 level.

Zone 6

ANOVA

Z6

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.940	4	.235	1.816	.130
Within Groups	14.889	115	.129		
Total	15.829	119			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: Z6
LSD

					95% Confidence Interval	
(I) VAR7	(J) VAR7	Mean Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
1.00	2.00	-.1708	.104	.103	-.3766	3.491E-02
	3.00	-.1875	.104	.074	-.3932	1.825E-02
	4.00	-3.333E-02	.104	.749	-.2391	.1724
	5.00	2.500E-02	.104	.810	-.1807	.2307
2.00	1.00	.1708	.104	.103	-3.491E-02	.3766
	3.00	-1.667E-02	.104	.873	-.2224	.1891
	4.00	.1375	.104	.188	-6.825E-02	.3432
	5.00	.1958	.104	.062	-9.913E-03	.4016
3.00	1.00	.1875	.104	.074	-1.825E-02	.3932
	2.00	1.667E-02	.104	.873	-.1891	.2224
	4.00	.1542	.104	.140	-5.158E-02	.3599
	5.00	.2125*	.104	.043	6.754E-03	.4182
4.00	1.00	3.333E-02	.104	.749	-.1724	.2391
	2.00	-.1375	.104	.188	-.3432	6.825E-02
	3.00	-.1542	.104	.140	-.3599	5.158E-02
	5.00	5.833E-02	.104	.575	-.1474	.2641
5.00	1.00	-2.500E-02	.104	.810	-.2307	.1807
	2.00	-.1958	.104	.062	-.4016	9.913E-03
	3.00	-.2125*	.104	.043	-.4182	-6.754E-03
	4.00	-5.833E-02	.104	.575	-.2641	.1474

*. The mean difference is significant at the .05 level.

Zone 7

ANOVA

Z7

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	35.165	4	8.791	130.283	.000
Within Groups	7.760	115	6.748E-02		
Total	42.925	119			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: Z7
LSD

(I) VAR7	(J) VAR7	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	-.1750*	.075	.021	-.3235	-2.646E-02
	3.00	-.2083*	.075	.006	-.3569	-5.980E-02
	4.00	.3167*	.075	.000	.1681	.4652
	5.00	1.2542*	.075	.000	1.1056	1.4027
2.00	1.00	.1750*	.075	.021	2.646E-02	.3235
	3.00	-3.333E-02	.075	.658	-.1819	.1152
	4.00	.4917*	.075	.000	.3431	.6402
	5.00	1.4292*	.075	.000	1.2806	1.5777
3.00	1.00	.2083*	.075	.006	5.980E-02	.3569
	2.00	3.333E-02	.075	.658	-.1152	.1819
	4.00	.5250*	.075	.000	.3765	.6735
	5.00	1.4625*	.075	.000	1.3140	1.6110
4.00	1.00	-.3167*	.075	.000	-.4652	-.1681
	2.00	-.4917*	.075	.000	-.6402	-.3431
	3.00	-.5250*	.075	.000	-.6735	-.3765
	5.00	.9375*	.075	.000	.7890	1.0860
5.00	1.00	-1.2542*	.075	.000	-1.4027	-1.1056
	2.00	-1.4292*	.075	.000	-1.5777	-1.2806
	3.00	-1.4625*	.075	.000	-1.6110	-1.3140
	4.00	-.9375*	.075	.000	-1.0860	-.7890

*. The mean difference is significant at the .05 level.

Zone 8

ANOVA

Z8

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	94.804	4	23.701	355.321	.000
Within Groups	7.671	115	6.670E-02		
Total	102.475	119			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: Z8
LSD

					95% Confidence Interval	
(I) VAR7	(J) VAR7	Mean Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
1.00	2.00	7.105E-15	.075	1.000	-.1477	.1477
	3.00	1.6458*	.075	.000	1.4982	1.7935
	4.00	1.8000*	.075	.000	1.6523	1.9477
	5.00	1.9625*	.075	.000	1.8148	2.1102
2.00	1.00	-7.105E-15	.075	1.000	-.1477	.1477
	3.00	1.6458*	.075	.000	1.4982	1.7935
	4.00	1.8000*	.075	.000	1.6523	1.9477
	5.00	1.9625*	.075	.000	1.8148	2.1102
3.00	1.00	-1.6458*	.075	.000	-1.7935	-1.4982
	2.00	-1.6458*	.075	.000	-1.7935	-1.4982
	4.00	.1542*	.075	.041	6.486E-03	.3018
	5.00	.3167*	.075	.000	.1690	.4643
4.00	1.00	-1.8000*	.075	.000	-1.9477	-1.6523
	2.00	-1.8000*	.075	.000	-1.9477	-1.6523
	3.00	-.1542*	.075	.041	-.3018	-6.486E-03
	5.00	.1625*	.075	.031	1.482E-02	.3102
5.00	1.00	-1.9625*	.075	.000	-2.1102	-1.8148
	2.00	-1.9625*	.075	.000	-2.1102	-1.8148
	3.00	-.3167*	.075	.000	-.4643	-.1690
	4.00	-.1625*	.075	.031	-.3102	-1.482E-02

*. The mean difference is significant at the .05 level.

Zone 9

ANOVA

Z9

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	56.859	3	18.953	269.032	.000
Within Groups	6.481	92	7.045E-02		
Total	63.340	95			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: Z9
LSD

(I) VAR7	(J) VAR7	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	-.2667*	.077	.001	-.4188	-.1145
	3.00	-1.9208*	.077	.000	-2.0730	-1.7687
	4.00	-1.2500*	.077	.000	-1.4022	-1.0978
2.00	1.00	.2667*	.077	.001	.1145	.4188
	3.00	-1.6542*	.077	.000	-1.8063	-1.5020
	4.00	-.9833*	.077	.000	-1.1355	-.8312
3.00	1.00	1.9208*	.077	.000	1.7687	2.0730
	2.00	1.6542*	.077	.000	1.5020	1.8063
	4.00	.6708*	.077	.000	.5187	.8230
4.00	1.00	1.2500*	.077	.000	1.0978	1.4022
	2.00	.9833*	.077	.000	.8312	1.1355
	3.00	-.6708*	.077	.000	-.8230	-.5187

*. The mean difference is significant at the .05 level.

F-4. Winter Solstice (22nd of December)

Zone 1

ANOVA

Z1

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	19.227	4	4.807	75.030	.000
Within Groups	7.368	115	6.407E-02		
Total	26.595	119			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: Z1
LSD

(I) VAR7	(J) VAR7	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	-.1125	.073	.126	-.2572	3.223E-02
	3.00	.7042*	.073	.000	.5594	.8489
	4.00	.7833*	.073	.000	.6386	.9281
	5.00	.7792*	.073	.000	.6344	.9239
2.00	1.00	.1125	.073	.126	-3.223E-02	.2572
	3.00	.8167*	.073	.000	.6719	.9614
	4.00	.8958*	.073	.000	.7511	1.0406
	5.00	.8917*	.073	.000	.7469	1.0364
3.00	1.00	-.7042*	.073	.000	-.8489	-.5594
	2.00	-.8167*	.073	.000	-.9614	-.6719
	4.00	7.917E-02	.073	.281	-6.556E-02	.2239
	5.00	7.500E-02	.073	.307	-6.973E-02	.2197
4.00	1.00	-.7833*	.073	.000	-.9281	-.6386
	2.00	-.8958*	.073	.000	-1.0406	-.7511
	3.00	-7.917E-02	.073	.281	-.2239	6.556E-02
	5.00	-4.167E-03	.073	.955	-.1489	.1406
5.00	1.00	-.7792*	.073	.000	-.9239	-.6344
	2.00	-.8917*	.073	.000	-1.0364	-.7469
	3.00	-7.500E-02	.073	.307	-.2197	6.973E-02
	4.00	4.167E-03	.073	.955	-.1406	.1489

*. The mean difference is significant at the .05 level.

Zone 2

ANOVA

Z2

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	20.127	4	5.032	230.420	.000
Within Groups	2.511	115	2.184E-02		
Total	22.638	119			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: Z2
LSD

(I) VAR7	(J) VAR7	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1.00	2.00	-8.750E-02*	.043	.043	-.1720	-3.002E-03
	3.00	-1.0667*	.043	.000	-1.1512	-.9822
	4.00	-.8083*	.043	.000	-.8928	-.7238
	5.00	-.4333*	.043	.000	-.5178	-.3488
2.00	1.00	8.750E-02*	.043	.043	3.002E-03	.1720
	3.00	-.9792*	.043	.000	-1.0637	-.8947
	4.00	-.7208*	.043	.000	-.8053	-.6363
	5.00	-.3458*	.043	.000	-.4303	-.2613
3.00	1.00	1.0667*	.043	.000	.9822	1.1512
	2.00	.9792*	.043	.000	.8947	1.0637
	4.00	.2583*	.043	.000	.1738	.3428
	5.00	.6333*	.043	.000	.5488	.7178
4.00	1.00	.8083*	.043	.000	.7238	.8928
	2.00	.7208*	.043	.000	.6363	.8053
	3.00	-.2583*	.043	.000	-.3428	-.1738
	5.00	.3750*	.043	.000	.2905	.4595
5.00	1.00	.4333*	.043	.000	.3488	.5178
	2.00	.3458*	.043	.000	.2613	.4303
	3.00	-.6333*	.043	.000	-.7178	-.5488
	4.00	-.3750*	.043	.000	-.4595	-.2905

*. The mean difference is significant at the .05 level.

Zone 6

ANOVA

Z6

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.368	4	9.200E-02	.680	.607
Within Groups	15.551	115	.135		
Total	15.919	119			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: Z6
LSD

(I) VAR7	(J) VAR7	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1.00	2.00	-2.500E-02	.106	.814	-.2353	.1853
	3.00	-.1625	.106	.129	-.3728	4.777E-02
	4.00	-5.833E-02	.106	.584	-.2686	.1519
	5.00	-5.833E-02	.106	.584	-.2686	.1519
2.00	1.00	2.500E-02	.106	.814	-.1853	.2353
	3.00	-.1375	.106	.198	-.3478	7.277E-02
	4.00	-3.333E-02	.106	.754	-.2436	.1769
	5.00	-3.333E-02	.106	.754	-.2436	.1769
3.00	1.00	.1625	.106	.129	-4.777E-02	.3728
	2.00	.1375	.106	.198	-7.277E-02	.3478
	4.00	.1042	.106	.329	-.1061	.3144
	5.00	.1042	.106	.329	-.1061	.3144
4.00	1.00	5.833E-02	.106	.584	-.1519	.2686
	2.00	3.333E-02	.106	.754	-.1769	.2436
	3.00	-.1042	.106	.329	-.3144	.1061
	5.00	.0000	.106	1.000	-.2103	.2103
5.00	1.00	5.833E-02	.106	.584	-.1519	.2686
	2.00	3.333E-02	.106	.754	-.1769	.2436
	3.00	-.1042	.106	.329	-.3144	.1061
	4.00	.0000	.106	1.000	-.2103	.2103

Zone 7

ANOVA

Z7

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	34.634	4	8.658	320.553	.000
Within Groups	3.106	115	2.701E-02		
Total	37.740	119			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: Z7
LSD

					95% Confidence Interval	
(I) VAR7	(J) VAR7	Mean Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
1.00	2.00	-.1667*	.047	.001	-.2606	-7.269E-02
	3.00	-.2208*	.047	.000	-.3148	-.1269
	4.00	.3083*	.047	.000	.2144	.4023
	5.00	1.2417*	.047	.000	1.1477	1.3356
2.00	1.00	.1667*	.047	.001	7.269E-02	.2606
	3.00	-5.417E-02	.047	.256	-.1481	3.981E-02
	4.00	.4750*	.047	.000	.3810	.5690
	5.00	1.4083*	.047	.000	1.3144	1.5023
3.00	1.00	.2208*	.047	.000	.1269	.3148
	2.00	5.417E-02	.047	.256	-3.981E-02	.1481
	4.00	.5292*	.047	.000	.4352	.6231
	5.00	1.4625*	.047	.000	1.3685	1.5565
4.00	1.00	-.3083*	.047	.000	-.4023	-.2144
	2.00	-.4750*	.047	.000	-.5690	-.3810
	3.00	-.5292*	.047	.000	-.6231	-.4352
	5.00	.9333*	.047	.000	.8394	1.0273
5.00	1.00	-1.2417*	.047	.000	-1.3356	-1.1477
	2.00	-1.4083*	.047	.000	-1.5023	-1.3144
	3.00	-1.4625*	.047	.000	-1.5565	-1.3685
	4.00	-.9333*	.047	.000	-1.0273	-.8394

*. The mean difference is significant at the .05 level.

Zone 8

ANOVA

Z8

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	104.619	4	26.155	565.817	.000
Within Groups	5.316	115	4.622E-02		
Total	109.935	119			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: Z8
LSD

					95% Confidence Interval	
(I) VAR7	(J) VAR7	Mean Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
1.00	2.00	-4.167E-03	.062	.947	-.1271	.1188
	3.00	1.8042*	.062	.000	1.6812	1.9271
	4.00	1.9042*	.062	.000	1.7812	2.0271
	5.00	1.9917*	.062	.000	1.8687	2.1146
2.00	1.00	4.167E-03	.062	.947	-.1188	.1271
	3.00	1.8083*	.062	.000	1.6854	1.9313
	4.00	1.9083*	.062	.000	1.7854	2.0313
	5.00	1.9958*	.062	.000	1.8729	2.1188
3.00	1.00	-1.8042*	.062	.000	-1.9271	-1.6812
	2.00	-1.8083*	.062	.000	-1.9313	-1.6854
	4.00	1.000E-01	.062	.110	-2.294E-02	.2229
	5.00	.1875*	.062	.003	6.456E-02	.3104
4.00	1.00	-1.9042*	.062	.000	-2.0271	-1.7812
	2.00	-1.9083*	.062	.000	-2.0313	-1.7854
	3.00	-1.000E-01	.062	.110	-.2229	2.294E-02
	5.00	8.750E-02	.062	.161	-3.544E-02	.2104
5.00	1.00	-1.9917*	.062	.000	-2.1146	-1.8687
	2.00	-1.9958*	.062	.000	-2.1188	-1.8729
	3.00	-.1875*	.062	.003	-.3104	-6.456E-02
	4.00	-8.750E-02	.062	.161	-.2104	3.544E-02

*. The mean difference is significant at the .05 level.

Zone 9

ANOVA

Z9

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4.341	4	1.085	20.820	.000
Within Groups	4.848	93	5.213E-02		
Total	9.189	97			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: Z9
LSD

(I) VAR7	(J) VAR7	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	-.1333*	.066	.046	-.2642	-2.451E-03
	3.00	-.3917*	.066	.000	-.5225	-.2608
	4.00	.1792*	.066	.008	4.828E-02	.3100
2.00	1.00	.1333*	.066	.046	2.451E-03	.2642
	3.00	-.2583*	.066	.000	-.3892	-.1275
	4.00	.3125*	.066	.000	.1816	.4434
3.00	1.00	.3917*	.066	.000	.2608	.5225
	2.00	.2583*	.066	.000	.1275	.3892
	4.00	.5708*	.066	.000	.4400	.7017
4.00	1.00	-.1792*	.066	.008	-.3100	-4.828E-02
	2.00	-.3125*	.066	.000	-.4434	-.1816
	3.00	-.5708*	.066	.000	-.7017	-.4400

*. The mean difference is significant at the .05 level.

z1

19-Mar

	com1	com2	com3	com4	com5
com1		ns	s	s	s
com2	ns		s	s	s
com3	s	s		ns	ns
com4	s	s	ns		ns
com5	s	s	ns	ns	

(com1=com2) not equal to (com3=com4=com5)

com1,com2

21-Jun

	com1	com2	com3	com4	com5
com1		ns	s	s	s
com2	ns		s	s	s
com3	s	s		ns	ns
com4	s	s	ns		ns
com5	s	s	ns	ns	

(com1=com2) (com3=com4=com5)

23-Sep

	com1	com2	com3	com4	com5
com1		ns	s	s	s
com2	ns		s	s	s
com3	s	s		ns	ns
com4	s	s	ns		ns
com5	s	s	ns	ns	

(com1=com2) (com3=com4=com5)

22-Dec

	com1	com2	com3	com4	com5
com1		ns	s	s	s
com2	ns		s	s	s
com3	s	s		ns	ns
com4	s	s	ns		ns
com5	s	ns	ns	ns	

(com1=com2) (com3=com4) (com5)

z2

19-Mar

	com1	com2	com3	com4	com5
com1		ns	s	s	ns
com2	ns		s	ns	ns
com3	s	s		s	s
com4	s	ns	s		s
com5	ns	ns	s	s	

21-Jun

	com1	com2	com3	com4	com5
com1		ns	s	s	ns
com2	ns		s	s	ns
com3	s	s		s	s
com4	s	s	s		s
com5	ns	ns	s	s	

(com1=com2)(com3=com4) (com5)

23-Sep

	com1	com2	com3	com4	com5
com1		s	s	s	ns
com2	s		s	s	ns
com3	s	s		s	s
com4	s	s	s		s
com5	ns	ns	s	s	

(com1=com2)(com3=com4) (com5)

22-Dec

	com1	com2	com3	com4	com5
com1		s	s	s	s
com2	s		s	s	s
com3	s	s		s	s
com4	s	s	s		s
com5	s	s	s	s	

(com1=com2=com3=com4=com5)

z6

19-Mar

	com1	com2	com3	com4	com5
com1		ns	ns	ns	ns
com2	ns		ns	ns	ns
com3	ns	ns		ns	ns
com4	ns	ns	ns		ns
com5	ns	ns	ns	ns	

21-Jun

	com1	com2	com3	com4	com5
com1		ns	ns	ns	ns
com2	ns		ns	ns	ns
com3	ns	ns		ns	ns
com4	ns	ns	ns		ns
com5	ns	ns	ns	ns	

(com1=com2) (com3=com4=com5)

23-Sep

	com1	com2	com3	com4	com5
com1		ns	ns	ns	ns
com2	ns		ns	ns	ns
com3	ns	ns		ns	s
com4	ns	ns	ns		ns
com5	ns	ns	s	ns	

(com1=com2) (com3=com4=com5)

22-Dec

	com1	com2	com3	com4	com5
com1		ns	ns	ns	ns
com2	ns		ns	ns	ns
com3	ns	ns		ns	ns
com4	ns	ns	ns		ns
com5	ns	ns	ns	ns	

(com1=com2) (com3=com4=com5)

z7

19-Mar

	com1	com2	com3	com4	com5
com1		ns	ns	s	s
com2	ns		ns	s	s
com3	ns	ns		s	s
com4	s	s	s		s
com5	s	s	s	s	

21-Jun

	com1	com2	com3	com4	com5
com1		ns	ns	s	s
com2	ns		ns	s	s
com3	ns	ns		s	s
com4	s	s	s		s
com5	s	s	s	s	

(com1=com2) (com3=com4=com5)

23-Sep

	com1	com2	com3	com4	com5
com1		s	s	s	s
com2	s		ns	s	s
com3	s	ns		s	s
com4	s	s	s		s
com5	s	s	s	s	

(com1=com2) (com3=com4=com5)

22-Dec

	com1	com2	com3	com4	com5
com1		s	s	s	s
com2	s		ns	s	s
com3	s	ns		s	s
com4	s	s	s		s
com5	s	s	s	s	

(com1=com2) (com3=com4=com5)

z8

19-Mar

	com1	com2	com3	com4	com5
com1		ns	s	s	s
com2	ns		s	s	s
com3	s	s		s	s
com4	s	s	s		s
com5	s	s	s	s	

21-Jun

	com1	com2	com3	com4	com5
com1		ns	s	s	s
com2	ns		s	s	s
com3	s	s		ns	s
com4	s	s	ns		ns
com5	s	s	s	ns	

(com1=com2) (com3=com4=com5)

23-Sep

	com1	com2	com3	com4	com5
com1		ns	s	s	s
com2	ns		s	s	s
com3	s	s		s	s
com4	s	s	s		s
com5	s	s	s	s	

(com1=com2) (com3=com4=com5)

22-Dec

	com1	com2	com3	com4	com5
com1		ns	s	s	s
com2	ns		s	s	s
com3	s	s		ns	s
com4	s	s	ns		ns
com5	s	s	s	ns	

(com1=com2) (com3=com4=com5)

z9

19-Mar

	com1	com2	com3	com4
com1		ns	s	s
com2	ns		s	s
com3	s	s		s
com4	s	s	s	

21-Jun

	com1	com2	com3	com4
com1		ns	s	s
com2	ns		s	s
com3	s	s		s
com4	s	s	s	

(com1=com2) (com3=com4=com5)

23-Sep

	com1	com2	com3	com4
com1		s	s	s
com2	s		s	s
com3	s	s		s
com4	s	s	s	

(com1=com2) (com3=com4=com5)

22-Dec

	com1	com2	com3	com4
com1		s	s	s
com2	s		s	s
com3	s	s		s
com4	s	s	s	

(com1=com2) (com3=com4=com5)

بسم الله الرحمن الرحيم