Study on Improvement of Cooling Energy and Thermal Comfort of KlinikPergigianBatu Gajah

by

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CERTIFICATION OF APPROVAL

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Approved by,

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(Ir. Dr. Shaharin Anwar Sulaiman)

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TRONOH, PERAK
September 2011

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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MUHAMMAD NAZREE BIN ALEHAN

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ABSTRACT

Batu Gajah dental clinic was built in early 70’s where it provides services to the residents nearby. Recently, the patients and staff of the clinic complained about the level of comfort in the waiting area of the clinic whichwas said as very warm and uncomfortable. Besides, the monthly electricity consumption of the clinic increased significantly recently. Therefore, a study on the cooling energy of the clinic is required in order to identify rooms for improvements in thermal comfort and its energy consumption. The objective of the project is to studyand analyze the building thermal performance and various factors towards energy saving in the clinic. In this project, the study involvescalculations of the dental clinic’s cooling energy and measurement of the temperature at various points in the waiting area during various conditions. Interviews are conducted with patients at the waiting area, and it is found that among of them prefer to wait outside the clinic due to the hot condition in the indoor area. Detailed analysis on the current trend of operation isconducted to identify potential energy conservation measures. At the end of this report, several ideas are proposed.

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CHAPTER 1
INTRODUCTION

1.1 Background of Study

The Batu Gajah dental clinic is agovernment dental clinic which provides facilitiesto residents in dealing with gums and tooth problems. The dental clinic is located within the public hospital. The clinic was established in 1973at which there were only 2 dentists and 5 dental nurses. The building construction plan and materials werebased on the specifications and regulations of that particular time. The town of Batu Gajah is located in the central region of the state of Perak in Malaysia and it experiences an all year round hot and humid climate. With constant sun exposure throughout the year, the heat gain by the buildings in this area is considered as high.The application of air conditioning system would be considered as the best method to maintain the indoor thermal comfort condition.

Recently, the level of comfort in the waiting area of the clinic was reported to be below satisfactory and the monthly electricity bills were reported to be higher than the previous years. Air conditionerswere installedin the clinic building to obtain indoor thermal comfort in the building except for certain rooms including the waiting area, due to cost factor.In 2011, the monthly electricity bills for the dental clinic reached four digit figures. High electricity power consumption in the clinic may be attributed by the high power equipments such as the air conditioners, sterilizers, thermo sealer and water heater. The air conditioners require high electrical power to supply sufficient cool air to the room.

Figure1.1shows the trend of electricity consumption in Malaysia every year since late 60s. In early days, less electricity was consumedas compared to the present day due to the small growth of in economy particularly the industrial sector.Since the rapid industrialization of the country made by the former Prime Minister of Malaysia, Tun Dr. Mahathir Bin Mohammad, the number of factories and manufacturing hubs increased significantly in the 80s in order to compete with the developed countries. Since then, the national electricity consumption increases rapidly in parallel with the country's development in economy. The industrials sector alone takes almost 50% of total electricity consumed every year as shown in the Figure 1.2 (Saidur 2009).

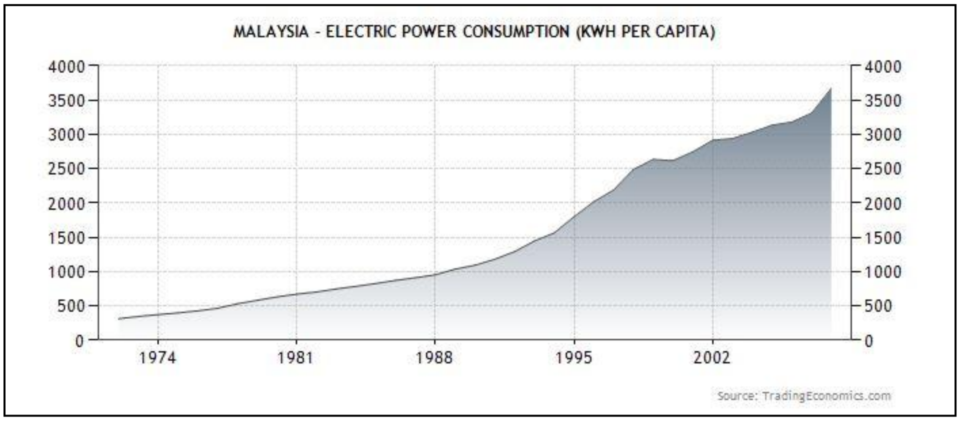


Figure 1.1: Electric power consumption trend in Malaysia (Trading Economics 2010).

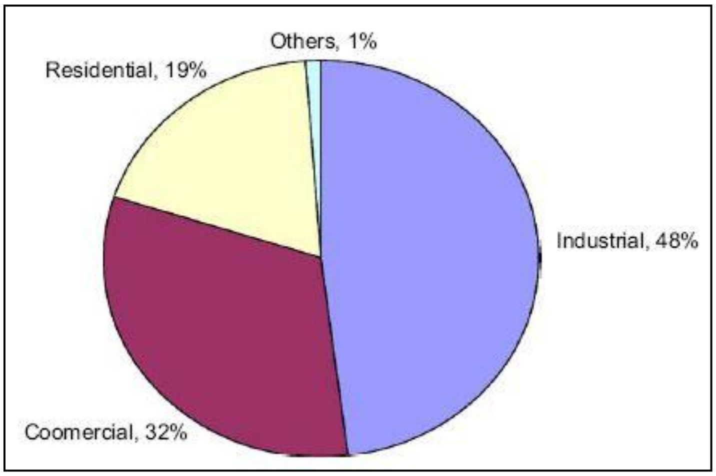
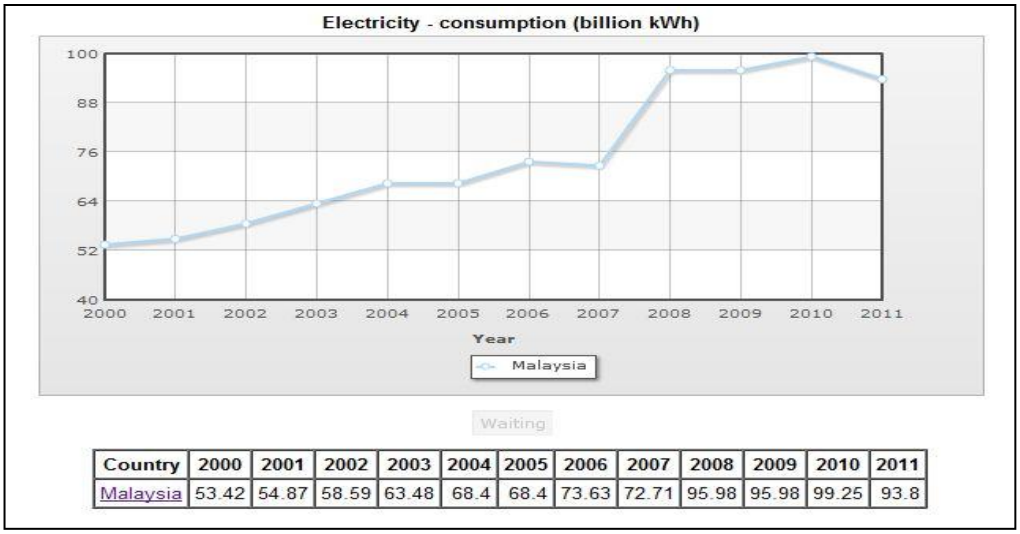


Figure 1.2: Statistics of energy used in Malaysia 2007 (Saidur 2009).



Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Malaysia	53.42	54.87	58.59	63.48	68.4	68.4	73.63	72.71	95.98	95.98	99.25	93.8

Figure 1.3: Electricity consumption trend in Malaysia 2000-2011(Index Mundi, 2011)

Figure 1.3 shows the actual amount of electricity consumed by Malaysia between 2000 and 2011. In conjunction with the increase of demand in electricity, global warming is expected to be worsening as the energy still mainly came from fossil fuels. Figure 1.4shows an example of of an air-cooled split unit conditioner used in small building, which include dental clinics. Taha, 2003concluded that air conditioner is one of the main electricity consumption in a residential building, which saw refrigerators as the top main consumptions.

Figure 1.4: Floor Ceiling Air Conditioner type

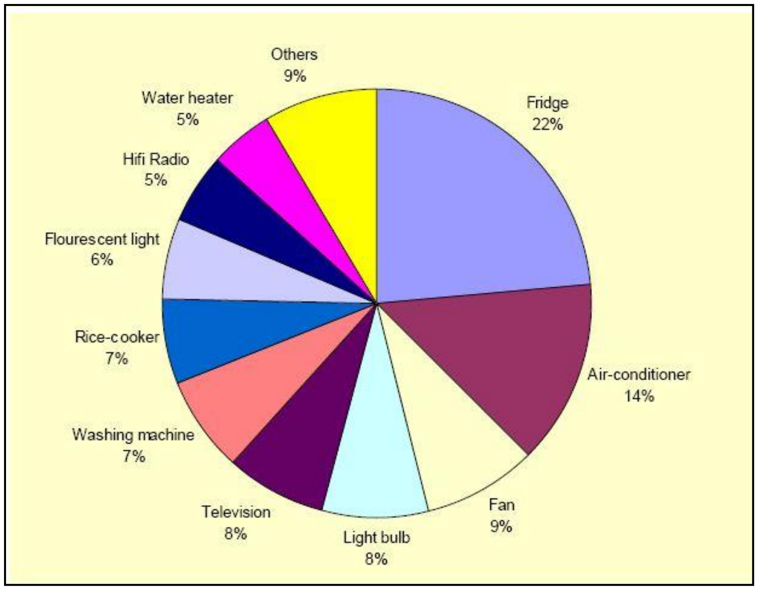


Figure 1.5: Statistic of energy consumption by electrical appliances in a typical residential building in Malaysia in the year of 2002 (Taha, 2003)

1.2 Problem Statement

Without any natural shading nearby the clinic, the clinic would be exposed to the sun radiation during the day time. The sun radiation will hit directly the waiting area's wall and will also penetrate through the large glazing. It is obvious the direction of the sun in the morning striking the waiting area walls as shown in the Figure 1.6. At 3.00 pm, the level of sun radiation on the wall decreases as impliedby the shades in Figure 1.7.There is no direct sun radiation on the wall during the noon.At the cause line, the patients and staff dissatisfaction is observed obvious during the noon time where they feel very hot and uncomfortable. At the very least, the heat gain from solar radiation decrease with the tinted glass windows implemented instead of normal louver type window glass system. There seems to be not much differentof using tinted glass in preventing direct sun radiation into the waiting area, because the clinic's staff will open the windowsfor natural ventilation. The waiting area was observed to be warm and uncomfortable based on the comments from the staff and patients. The increased amount of monthly electricity bills from three digits figure to four digits figure shown the electricity energy consumption at the clinic increased due to seven air conditioners installed. With such huge usage of air conditioner, any increase of the cooling load will cost a huge additional amount of energy consumed from the electricity.

Figure 1.6: Level of sun radiation at Batu Gajah Dental Clinic at 8am.

Figure 1.7: Level of sun radiation at Batu Gajah Dental Clinic at 3pm

1.3 Objectives and Scope of Study

The objectives of this research are to study the potentials forreduction of cooling energy and to study thermal comfort ofthe patients in the waiting are of the Batu Gajah Dental Clinic. The project divided into two scopes of studies, cooling energy consumption matters and thermal comfort matter. First is the thermal comfort matter which cover the aspect inside of the clinic, the waiting area, and next matter relates to the air conditioner covers the cooling energy consumption.

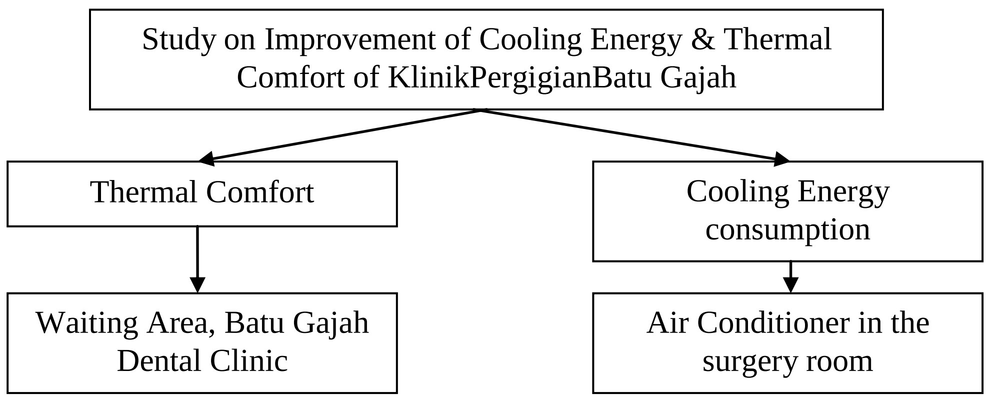


Figure 1.8: Project scope of studies

Temperatures measurements in the waiting area started by installing a lot of thermocouple at various points and record it and analyzing them. For the energy saving consumption, the measures are done by analyzing the cooling load of the overall clinic building first, the air conditioners operational practices of the system up till today, calculations and computer energy simulation (Energy Plus) of the building. This study will lead to the study of potential energy saving and thermal comfort within air-conditioning system in the clinic. Set of data collected determine the trend of the energy consumes by the clinic room's air-conditioning system in a period. This project related to energy audit and simulation of energy in a building which most of the time dealing with the Energy Plus software and manual calculations to determining the actual and theoretical results of cooling load.

CHAPTER 2
LITERATURE REVIEW AND THEORY

2.1 Thermal Comfort

Thermal comfort is a term that generally regarded as a desirable or positive state of a person. The feeling of comfort is a result of mixture sensations that varies depending on the person, lifestyle, and habits. For example, during winter, when you are from the outside region and coming in (from temperature of -5^{o}C to temperature 20^{o}C), warm sensation will be experienced and same goes to cool sensation, from hot to cold area. Thermal comfort mainly concerns the interior temperature of rooms, maintaining and distributing it evenly and the quality of air.

There are many levels of discussion regarding the meaning and nature of thermal comfort and there was much activity and debate in 1960s and 1970s on this topic (McIntyre, 1980). Much been achieved since 1970 in understanding the conditions that create thermal comfort. However, because of the need to take the understanding to a higher level in order to meet increased and new requirements, these discussions are again coming to the fore. Based on ASHRAE standard 55, a good thermal comfort achieved where eighty percent or more people in a room feel comfortable. 'Thermal comfort is that condition of mind which expresses satisfaction with the thermal environment' (Hall 2011). A less neutral and more positive concept related to thermal comfort is thermal pleasure. A contributor to good fengshui is a refreshing wind providing a stimulating and desirable environment. Thermal pleasure found in cool temperatures compensated for by the neat of the sun. Such conditions are usually beyond thermal comfort.

2.2 Cooling Energy

Air conditioners are there to make sure work to be done in comfortable conditions. However, when people in an office located in tropical and sunny Malaysia are seen walking around in sweaters more suited for autumn, this is a clear sign that the air conditioning is too cold. Hence, the cooling energy was wasted. Raising the temperature settings by 1^{o}C can visibly affect the total electricity bill at the end of the month, and probably without anyone even noticing the difference. While wearing sensible work attire, a cool 24-26^{o}C should be enough to keep everyone comfortable in the office and mean significant savings in electricity (Tenaga Nasional Berhad, 2011).

Prudent and efficient use of electricity is not only kinder to the environment but it is also kinder to the business, saving money and brings a lot of profit in term of doing business. For the Batu Gajah Dental Clinic, reducing the used of electricity reduced the amount of electricity. Even though the bills are under the government care, there are still a lot of alternatives can be done on the reduced cost.Reducing the electricity consumption requires surprisingly minor changes in the daily work habits especially for the air conditioner and perhaps some wiser decisions when operating the high power equipments in the clinic.The performance of cooling energy supplied by the conventional electricity company was rate by its power factor. Having a low power factor is like having a glass of carbonated drink with a lot of foam; the glass is full but not really satisfied the thirsty. Having low power factor means the machine is inefficient and requires more electricity to perform its tasks. By increasing the power factor up to 1.0 ratio, the machine will use less electricity to achieve the same results and naturally, this will reduce monthly electricity bill.

2.2 Studies related to thermal and air conditioner

There are quite a number of studies already conducted on the energy performance of a building in hot and humid climate as well as area of Hong Kong. For example a study conducted by Bojic (2000) on the thermal insulation of cooled spaces in high rise residential building in Hong Kong. The study investigates the effect of including thermal insulation layer in the wall component at the middle, in door side and the outdoor side of fabric components were evaluated and compared. From the study, it is found that a maximum yearly cooling load reduction by 10.5% can be achieved when a 50 mm thick thermal insulation layer was placed at the indoor side of the wall that enclosed the cooling area. Therefore,the dental clinic building components should comply with this insulation method.

Thermal comfort and indoor air quality (IAQ) of air-conditioned bedrooms in a hot and humid climate study from Sekhar (2010) also providing meaningful result for the study of this project. He reported the increasing level of carbon dioxide may decrease the human sleeping duration and environment which lead to uncomfortable during night time. This study involves 12 fans bedrooms and 12 air conditioned bedrooms in a hot and humid climate. Interview and sets of questionnaire related to thermal comfort prepared in before proceeding with the findings. Depends on the weather for the particular day which the room's relative humidity is definitely higher when it is raining compared to dry day. Low humidity will increase airborne dust and drying of mucous membrane and skin, while high humidity allows for growth of moulds easily and they pose a threat for allergy and asthma sufferers. As for the results for better bedrooms condition and thermal comfort, orienting the bedroom to towards the wind flow will generally provide good ventilation system. Besides that, mechanical ventilation (fans) improves thermal comfort and that windows are opened after a period of time of usage (5 to 6 hours) to ventilate the bedrooms better. The best method is to open the windows about half an hour after the air-conditioning unit is shut down and maintain a higher set point temperature (25^{o}C) and use fan to provide thermal comfort. The dental clinic could possibly apply these findings where the waiting area is the most important area for the patients to wait for their turn and need better ventilation for thermal comfort.

Eskin (2006) reported another study on the analysis of annual heating and cooling energy requirements for the office building in different climates in Turkey. The building material construction for the external wall selected in the simulation is based on the Turkish standards. For external wall outer partition consist of plaster layer, reinforced concrete material and gypsum plaster layer with paint. For internal partition, it is consist of concrete layer which cover by a gypsum plaster layer on both sides. From the simulation did on the study, it is found that the effect of windows area on energy requirement is most significant for all buildings in all cities for all aspect ratio up to 1.75. It is also found that a building with more glass quantity requires more energy compared to the building with much lesser glass quantity. This data shown that, a normal building consumes less cooling load amount than a glass wall building. By that, the dental clinic should not give huge amount of cooling load.

Kagvic (2007) reported a study related to thermal comfort and indoor air quality in a mechanically ventilated theatre. Level of indoor air quality and thermal comfort in a typical medium sized mechanically ventilated theatre analysis was carried out on a theatre in Belgrade. In order to optimize the energy consumption of the ventilation system while maintaining adequate Indoor Air Quality, a CO_2 operated control system for the ventilation system could be incorporated in the existing system. In such circumstances, people may complaint about discomfort where a larger than expected number of people are in the room, hence supply air is introduced to the space near the floor level at low velocity and at a temperature only slightly below the desired room temperature. From the studies, it is possible to apply it in the waiting area in the clinic where huge number of people is waiting for their turn and in need of comfort zone which they will feel comfortable while waiting.

Calvino (2009) reported that in order to achieve thermal comfort, it is not necessary to neglect the cost of energy where less energy usage could lead to thermal comfort in a room too. The performances of the two controllers' PID-fuzzy and ON-OFF controller are quantified and compared by means of two cost functions that are based on the quadratic forms of overall energy required by the thermal fluid and the deviation from the preferred set point of the predicted mean vote. It is found that the application of PID-fuzzy controller results in lower costs of energy input and lower deviation from set point of PMV. Instead of using less option of HVAC building conditioning system, ON-OFF controllers, it is better to use PID-fuzzy controllers which the user may control their desire temperature of the room for their own comfort. Same goes to the clinic; there is a way to reduce the energy usage from the air conditioning system which at the end providing excellent thermal comfort and good room condition for them before waiting for their turn.

The ultimate aim of air conditioning the interior environments of building is to provide a comfortable and healthy indoor environment for the occupants. Failure to provide satisfactory thermal conditions has resulted in discomfort and ill health. Cheong (2001) reported there are factors contributes to thermal comfort in a room, which are the air temperature, air velocity, relative humidity, concentration of carbon dioxide, predicted mean vote (PMV) index and the percentage dissatisfied (PPD) index. Then, the evaluations of thermal conditions in a room will be easily done. Based on ISO Standard 7730, indoor air temperature of 23^{o}C was at the lower limit of the range, it is appropriates for the user to increase the temperature to the derived comfort temperature of 25.8^{o}C in order to achieve the objectives with less energy used. Carbon dioxide sensors would also helps to monitor the concentration of CO_2 in the air and regulate the position of the damper opening of the fresh air intake duct.Implementing the sensors and methods is best for the recommendation to improve thermal comfort of the clinic with less energy consume.

Another research done in Turkey regarding building energy performance by Aktacir, Buyukalaca, Bulut and Yilmaz (2007) which is on the effect of outdoor design condition on design cooling load and design cooling capacities of air conditioning equipments. The analysis conducted by selecting a high school located in Andana, Turkey which gross area is about $1628m^2$. The building is condition by a constant air volume system, which consists of AHU, supply, and return fans, ducts and control units. For cooling load calculation, Radiant Time Series (RTS) method is used. Occupancy pattern and all internal loads such as lightings and appliances were considered in the load calculation. From the result obtained, it shows that half of the cooling load is weather dependent. As for the air-conditioning sizing in Turkey, it was consider as strictly adhere to the country's standard. Lastly, form the control point of view, it is highly recommended to use high efficiency equipment during running on part load for energy conserving purposes.

CHAPTER 3

METHODOLOGY

3.1 Overall Project Flow

For thermal comfort scope in the waiting area, data required are the systematic method based on Matthew R. Hall, "Materials for energy efficiency and thermal comfort in buildings". Cooling load calculation regarding the energy saving scope is taken from Pita (2001). For the overall Batu Gajah Dental Clinic simulation, Energy Plus is used. Several aspects were highlighted before project implementations. Cooling load calculation in a commercial building, energy plus simulation functions and usage, and gather all the building information related to the air conditioning system. Figure 3.1shows the process involved in this project from the beginning until the end of the project period.

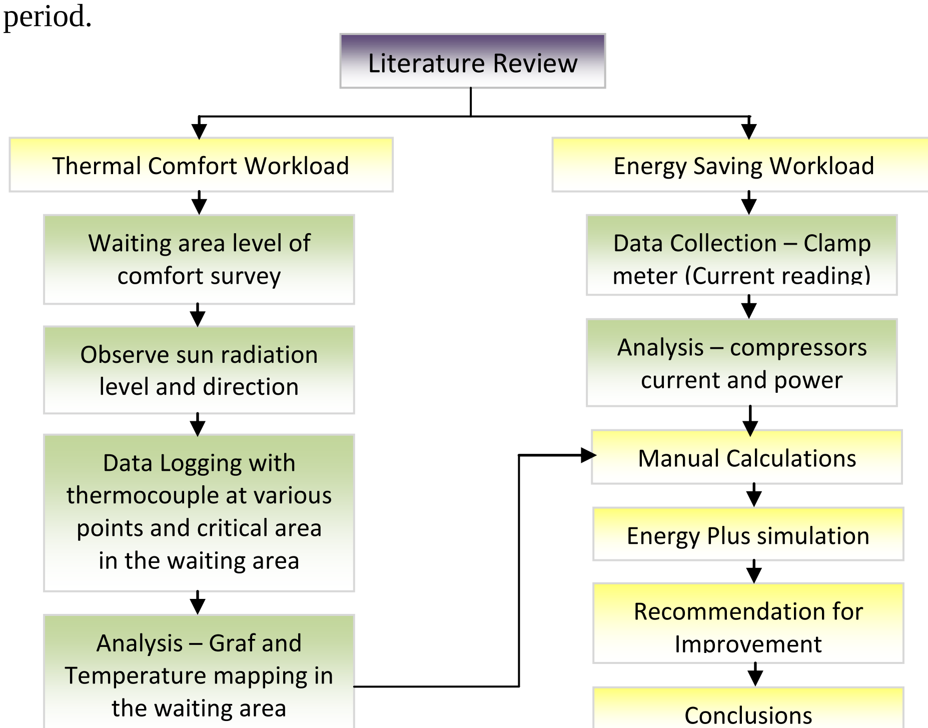


Figure 3.1: Flowchart of the project

3.2 Cooling Load Simulation Tool: Energy Plus

Energy plus is the official building simulation program by the United States Department of Energy. Energy plus is originally based on the previously popular energy simulation software BLAST (Building Loads Analysis and Systems Thermodynamics) and DOE-2. The software is created in order to model heating, cooling, lighting, ventilating and other energy related systems of a building. Based on a user's description of a building from the perspective of the building's physical make-up, associated mechanical systems, etc., EnergyPlus will calculate the heatingand cooling loads necessary to maintain thermal control set points, conditions throughout secondary HVAC system and coil loads, and the energy consumption of primary plantequipment as well as many other simulation details that are necessary to verify that thesimulation is performing as the actual building would.

The simulation program is based on the heat balance method, which allows for simultaneous calculation of radiant and convective effect at both interior and exterior surface during each time step. The heat balance method takes into account allheat balances on outdoor and indoor surfaces and transient heatconduction through building construction (Eskin, 2006). Figure shows how the Energy Plus comes out with the result of the energy simulation. Initially, user is required to provide all necessary building information such as envelop material properties.

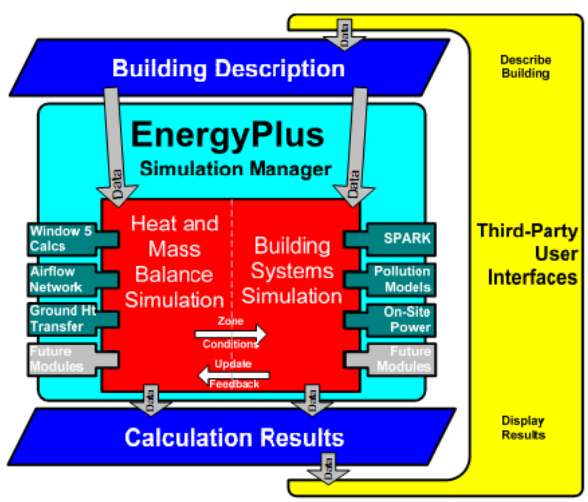


Figure 3.2: Energy Plus methodology schematic diagram
(Source: Energy Plus get started document)

Next, user is to model the building in three-dimensional drawing and defining those as either heat transfer surface or non-heat transfer surfaces. Heat transfer surfaces consist of the wall, roof, floor, door, and glazing. As for non-heat transfer surfaces are the roof overhangs, external shading from adjacent building etc. This is one of the unique features of the software, which can accounts for the external shadings effect on the zone cooling load.

Next, data such as internal heat gain from lightings, ventilation, infiltration, electrical equipments as well as from the occupants were defined in the software. One unique feature of the software is that scheduling can be applied to those internal heat gain such lightings schedule and so on. Finally, user should define the kind of output that desired as the simulation report. The report comes in two ways whether in Microsoft Excel format of HTML format for ease of viewing. Besides that, user is also able to specify how detail the software should perform the simulation. A more detailed simulation would require slightly longer time but in return a more accurate result.

3.3 Cooling Load Manual Calculation: CLTD Method

For manual cooling load calculation, CLTD method is used due to its relevancy and simplicity in estimating space peak cooling load to assist calculation. Sets of formula were used to estimate the amount of load occur during conduction process, radiation from the sun light, people, lighting and load from the electrical equipments equip in the building (Pita,2001).

The calculation is based on design data provided by ASHRAE for Sitiawanas it is the closest town with Batu Gajah which available in the Energy Plus software which enable for calculation comparison of both methods. Design dry bulb temperature and wet bulb temperature is 32.5°C and 26.9°C respectively. Daily temperature range of dry bulb (DB) temperature is 8.2°C. For indoor design condition, dry bulb temperature is 24°C with relative humidity of 50% (ASHRAE, 2001). From psychometric chart, humidity ratio value is obtained for both outdoor and indoor design condition. For outdoor design condition, humidity ratio is at 0.014kg of vapour/ kg of water while for indoor condition humidity ratio is 0.067 kg of vapour/ kg of water.

3.3.1 Batu Gajah Dental Clinic Profile

The Batu Gajah Dental Clinic is a typical building that applied air conditioning system in their operation rooms and office. The Batu Gajah Dental Clinic is located at the latitude of 4^{o}28’46’’N and longitude of 101^{o}2’1’’E. The small one storey building covers 53ft x 71ft, that consist of 19 rooms including four toilets, a waiting room, the surgery room for operations, two laboratories, stores, and staff rooms. In order to create a thermal comfort condition for the dentist to do surgery as well as the patients, air conditioning system is equipped in the surgery room.

There are five rooms installed with the air conditioners; three in the surgery room and one in the wet laboratory, staff room, doctor’s room, and at the counter. The air-conditioned rooms cover the area of the floor of 1340 square feet (see Figure A.3 in the appendixes for the overall dental clinic’s layout). The number of floor area covered are not precisely indicate that the area are totally cooled since the counter area there are also ceiling fans used by the staff in order to keep themselves comfortable. The rest of rooms are equipped with fans. For example in the waiting area, six fans operated consist of two big fans on the ceiling and the other four fans are at each room pillars. The air conditioning system in the surgery room operates independently and powered by the electricity provided by the conventional electricity company where the clinic needs to pay amount of money for the electricity bill monthly. The air conditioning system in the surgery room consists of three main air-cooled split unit air conditioners ofthree horsepower (2.24kW). Additional with the condition of the surgery room, it is fully enclosed which allows the air to circulate only within the room in order to maintain its temperature and to conserve energy.

Common practice in the clinic would be that the staff would switch on and off the air conditioners and set up the temperature blindly to the extreme cool set point temperature without considering the effect to the surgery room. The air-conditioning system in the clinic is not centralized.Figure 3.3 shows the overview of the clinic. In the waiting area, the patients and parents do suffer direct sun radiation during the day from

8 am until 11am through the windows that makes the room temperature increase andincrease the heat to the patient's body in the waiting area. Even though there is no direct sun radiation coming into the room during the noon onwards, the temperature inside the room was high and most of the patients and parents complained on their dissatisfaction about the level of comfort in the waiting area.

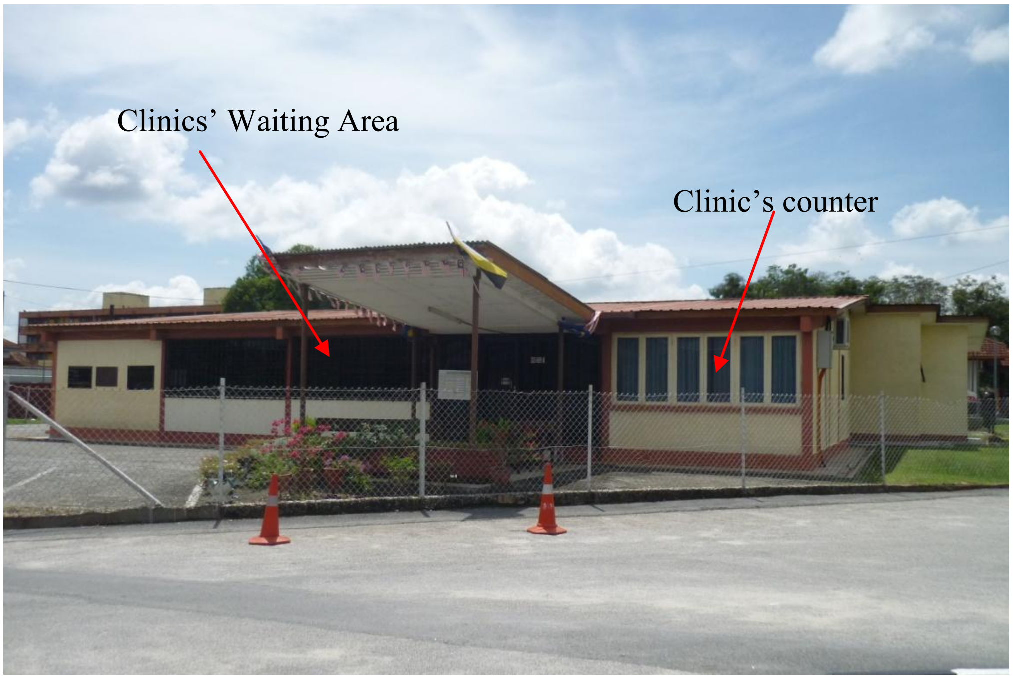


Figure 3.3: Front view of the Batu Gajah Dental Clinic.

3.3.2 Building description

Batu Gajah Dental Clinic is modelled for both manual calculation and Energy Plus simulation. The building consists of two big main rooms which are the surgery room and the waiting area. Figure A.1 and A.2 in the appendixes show overall floor lay out for the overall Batu Gajah Dental Clinic. Table 3.1 outlines building envelope material specifications.

Table 3.1: Overall clinic building dimensional and envelop details

Side	Wall Area (ft^2)	Wall Construction	Windows Dimensions	Windows Area(ft^2)	Windows Construction	Door Construction	Roof and ceiling Construction	Floor Construction
1 North	602.57	8in concrete block, no finish	4.30ft x 1.80ft	7.74	Single Glass (Heat absorbing)	NA	Steel Deck with no insulation	4in Concrete Deck
			1.61ft x 1.61ft	2.59	Single Glass (Heat absorbing)			
2 South	602.57	8in concrete block, no finish	4.30ft x 1.80ft	7.74	Single Glass (Heat absorbing)	Solid Wood 1½ in thick		
			1.80ft x 1.44ft	2.59	Single Glass (Heat absorbing)			
			1.80ft x 1.44ft	2.59	Single Glass (Clear)			
3 East	559.98	8in concrete block, no finish	4.30ft x 1.80ft	7.74	Single Glass (Heat absorbing)	Single Glass (Heat absorbing)		
	18.87	Single Glass (Heat absorbing)	4.04ft x 1.40ft	5.66	Single Glass (Clear)			
4 West	594.14	8in concrete block, no finish	1.80ft x 0.69ft	1.24	Single Glass (Clear)	Solid Wood 1½ in thick		
			1.61ft x 1.08ft	1.74	Single Glass (Heat absorbing)			
			4.30ft x 1.80ft	7.74	Single Glass (Heat absorbing)			

The building is in 62^{o}from the Northto the West referred to the side 1 of the building as illustrated in the figure below. The main entrance of the clinic is facing east which happen having maximum solar radiation came from the sun during the morning. Moreover, the clinic's waiting area located at the main entrance and it proves that the area is having low thermal comfort due to the sun radiation. Figures 3.6, 3.7, 3.8, 3.9 and Tables A.1, A.2, A.3, A.4(in the appendixes) describe in details the overall side of the buildings including the construction of windows, doors and walls.

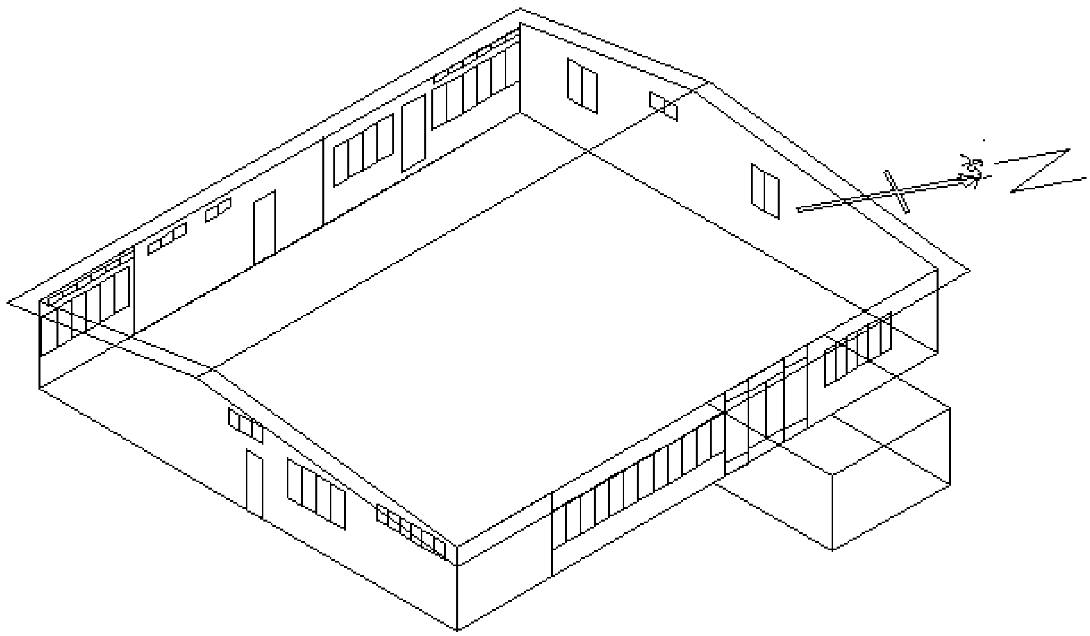


Figure 3.4: The overall notation of the Batu Gajah Dental Clinic in drawing.

Figure 3.5: The overall notation of the Batu Gajah Dental Clinic based on google map**.**

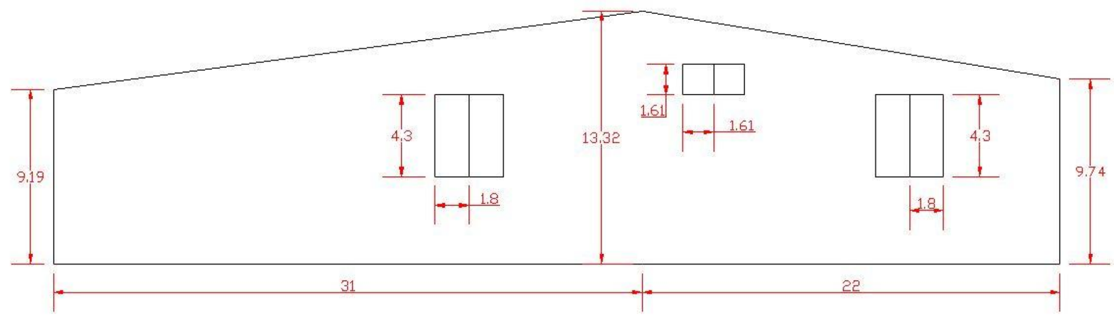


Figure 3.6: Side 1 of the building, facing North West drawing details dimensions in feet

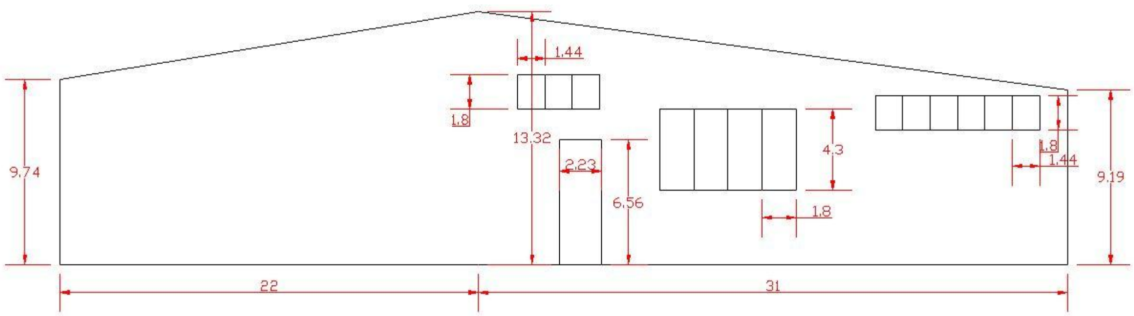


Figure 3.7: Side 2 of the building, facing South East drawing detailsdimensions in feet

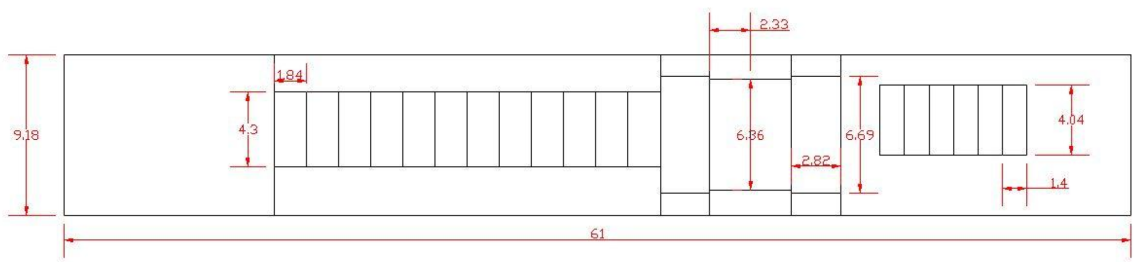


Figure 3.8: Side 3 of the building, facing North East drawing detailsdimensions in feet

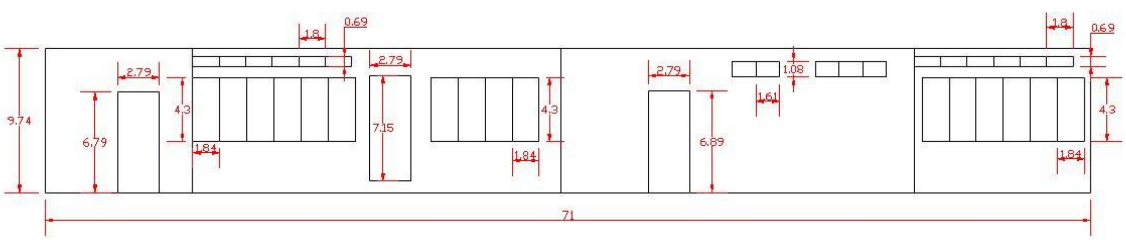


Figure 3.9: Side 4 of the building, facing South West drawing detailsdimensions in feet

Every side of the building contains windows without any internal and exterior shading upon reducing the effect of the solar radiation. The dimensions of the windows are various depend on the locations. Every walls of the clinic are exposed to the sun and wind hence assumption ofcalculation later explained which put the clinic under residential type building: single-family detached.

Table 3.2: Envelope Material Specifications.(Pita, 2001)

Construction	Season	U-Value(Btu/hr.ft^2.F)
4in concrete block, no finish	Summer	0.49
Single Glass(Heat absorbing)		1.01
Single Glass(Clear)		1.01
Steel Deck with no insulation		0.33
4in Concrete Deck for ground		0.59
Solid Wood 1½ in thick		0.47

3.3.3 Heat Gain Calculation

Manual calculation was done via Cooling Load Temperature Difference (CLTD) method of ASHRAE 2001, whichis for the commercial buildings.There are several methods in doing the calculation for the building, due to some restrictions and limitation on the materials and assumptions, ASHRAE 2001 was used for the ease of this project calculation. In fact, ASHRAE 2001 CLTD has overcome that particular restriction. This also would allow comparison the cooling loads from both methods.

The six main components of heat gain that contribute to the room cooling load consists of conduction through exterior walls, roof and glass, conduction through interior partitions, ceiling and floors, solar radiation through glass, lighting, people, and equipment. Firstly, heat gain via conduction is heat transferred from either exterior surface such as walls, roofs, floors, and glass or interior partition of a space. Heat gain by conduction calculated using this formula,

$$Q = U \text{ x } A \text{ x } CLTD_c \quad (3.1)$$

whereQ is the cooling load value (in Btu/hr), U is the overall heat transfer coefficient of the exterior surface (in Btu/hr.ft^2.F), A is the area of the surface (in ft^2) and CLTDcis the corrected value of Cooling Load Temperature Difference (CLTD). Table A.5 in the appendixes chapter shows the details of the heat gain via conduction.

These parameters value are obtained in the table of ASHRAE 1989 or 2001 (Pita, 2001)

$$CLTD_c = CLTD + LM + (78 - T_r) + (T_a - 85) \quad (3.2)$$

whereLM is the Latitude and Month CLTD correction, T_R is the Indoor relative temperature and $T_a$is the Outdoor relative temperature. The glass is exceptional from the LM calculationbut the bricks walls, roof, and the doors needed. The partitions inside the clinic neglected since the temperature differences between the rooms are very small.

Secondly, heat gain via solar radiation is calculated by using the formula below:

$$Q = SHGF \text{ x } A \text{ x } SC \text{ x } CLF \quad (3.3)$$

where Q is the Solar cooling load value (in Btu/hr), SHGF is the Solar Heat Gain Factor (in Btu/hr. F), A is the Glass area that is exposed directly to the sun light (in ft^2), SC is the Shading coefficient and CLF is the Cooling load factor. Table A.6 in the appendixes chapter shows the details of the heat gain via radiation.

Next, heat gain from the lightings. The factor Ballast Factor (BF) accounts for heat losses in the ballast in fluorescent lamps, or other special losses. Typical value of BF is 1.25 for fluorescent lighting. The load calculation is based on the following formulas:

$$Q = W \text{ x } BF \text{ x } CLF \quad (3.4)$$

whereQ is the Load (in Btu/hr), W is the lamp wattage (in W), BF is the Ballast factor and CLF is the Cooling load factor. Table A.7 in the appendixes chapter shows the details of the heat gain via lighting.

As for the calculation of heat gain from the electrical appliances, ASHRAE standard heat gain is taken based on types of equipments and multiple with the power of the equipments and its quantity available in building.In the clinic, there are a lot of high power equipment's, >1500W which in calculation need to be aware of the usage of those. Basically, rarely all the equipments are operated simultaneously in one time. There is a period where some of the equipments are been used and not.Table A.8 in the appendixes chapter shows the details of the heat gain via equipments.

Next, heat gain via occupants. It was assumed that the waiting area of the clinic is capable to have 52 peoplesat maximum including the staff and doctors of the clinic. Heat valuestaken fromPita E. G (Pita, 2001). Table A.9 in the appendixes chapter shows the details of the heat gain via people.

3.3.4 Energy Plus Simulation

Similar condition in the manual calculation is also being implemented in the simulation stage. Yearly simulation is done in order to identify peak load of the whole year. For yearly simulation, a set of weather data is required for the software to perform the simulation. In this case a weather set of Kuala Lumpur provided by Energy Plus is used. The weather data comprises the essential information of the whole 24 hours for the use of the simulation, for instance, outdoor dry bulb temperature, wind speed, location geometrical details (latitude, longitude, elevation, ground temperature) and so on. One of the main settings that should be defined by user is solution algorithm either using Conduction Transfer Function (CTF) or Conduction Finite Difference (CFD). For this case, CTF algorithm is selected as per outlined by ASHRAE 2001 heat balance guideline. As for the building material, the simulation is basically based on the experimental value of thermal resistance of the surfaces. This is due to unavailability of that particular data which means the simulation is performed in one dimensional steady state conduction. After all, every single step in performing the ideas and showing off the relevancy of the recommendation later in the discussion parts.

3.4 Thermal Comfort Scope

In this project, there are two different important scopes that need to be done. One of them is about the thermal comfort. Main focus about the thermal comfort study is the waiting area of the clinic. Thermal comfort is a term that is generally regarded as a desirable or positive state of a person. It is used in relation to how warm or cold a person feels and is clearly related to the environment a person occupies. (Matthew,2010). Thermal comfort usually related with the ‘psychological’ response of a person because different people, size, skin colour may feel differ about the room condition. In the field studies of tropical climates it is often concluded that thermal comfort conditions are at higher temperatures than those for people who live in temperate climates.

3.4.1 Thermal Comfort

One of the best ways to determining whether a group of people are comfortable in the waiting area is to ask them. Thermal sensation, comfort, pleasure, pain as well as behavioural responses, are all psychological phenomena. Methods for measuring psychological responses were range from psychological techniques (Guildford, 1954) and simple seven points scale often used in laboratory experiments. To the integration of techniques into questionnaires for practical surveys as well as behavioural measures.

The easiest ways to determine are by asking each one of the patients and people about their satisfaction waiting in the waiting area. Seven-point’sscales of Bedford (1936) were used as references for the survey. Basically, the questions provided are more related on their feeling waiting inside the room at different time. Furthermore, the set of questions is focussing more on the ventilation inside the room. 30 peoples were involved in this survey for the past three days. Different timing results were achieved which later concluded that the room should equip with equipment to capture the temperature of every points.

Table 3.3: The Bedford seven-points comfort scale

BEDFORD comfort scale	
Much too warm	7
Too warm	6
Comfortably warm	5
Comfortable	4
Comfortably cool	3
Too much	2
Much too cool	1

Other option is to follow the ASHRAE Standard 55 on doing the survey. The purpose of this standard is to ensure a room or building is comfortable for the majority (at least 80%) of the occupants. Therefore, survey the occupants is the effective way to evaluate the environmental conditions.

3.4.2 Thermocouple and data logging

The survey analysis in section 4.2.1confirmed that the patients were not satisfied with the level of comforts in the waiting area of the clinic. Observation inside the clinic was done followed by measurement of temperatures at each point in the waiting area. The data logger Omega-DAQPRO-5300recorded the reading inside the waiting area for two weekends. Two 8 channel data loggers were used to measure 16 points in the room with the aid of two laptops. Figure 3.10 show the placement of each thermocouple in the waiting area for two weekend temperature logging. The thermocouples are positioned one meter above the floor and placed at various locations within the patients sitting area. The critical area identified and temperature logging at different elevation was done as shown in Figure 3.12.

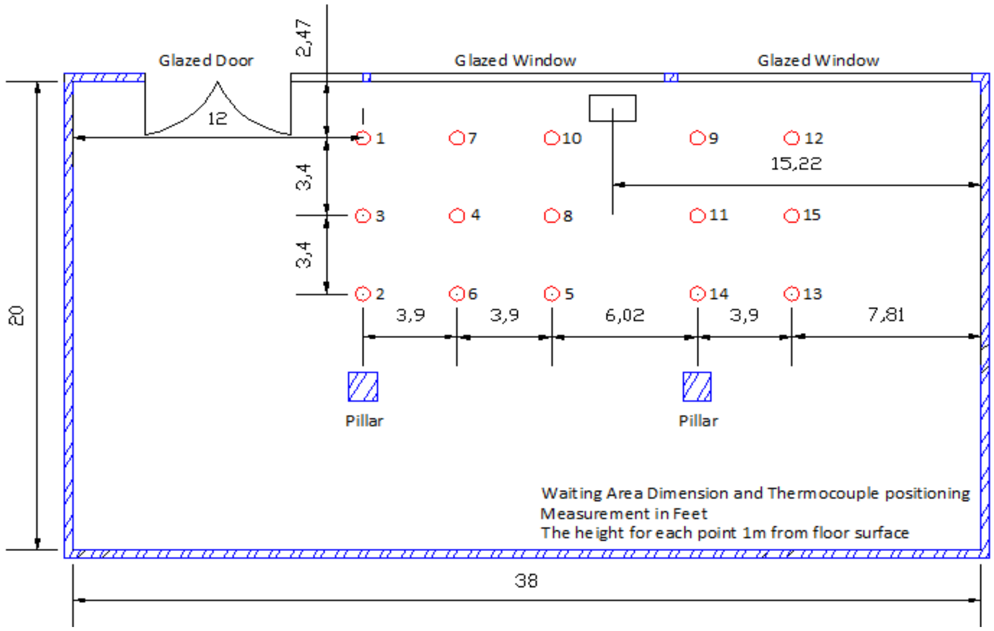


Figure 3.10: Final placement of the thermocouple for two weekend's temperature logging

Thermocouples were installed one meter above the floor and hanged.

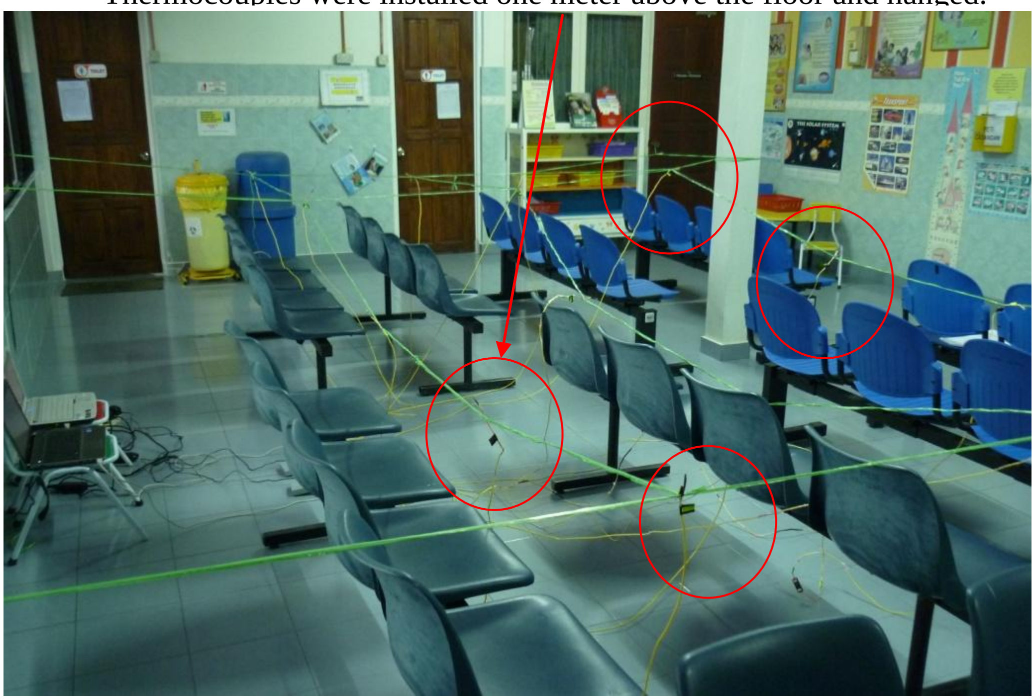


Figure 3.11: Overall view of the placement thermocouples in the waiting area for two weekend's temperature logging

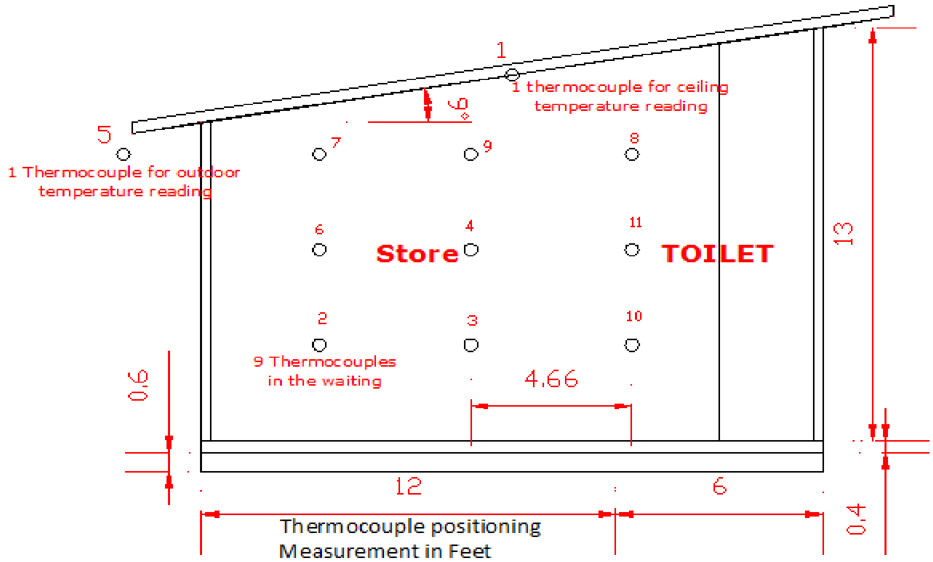


Figure 3.12: Side view of the finalised location of the thermocouple in the waiting area for the critical points of observation

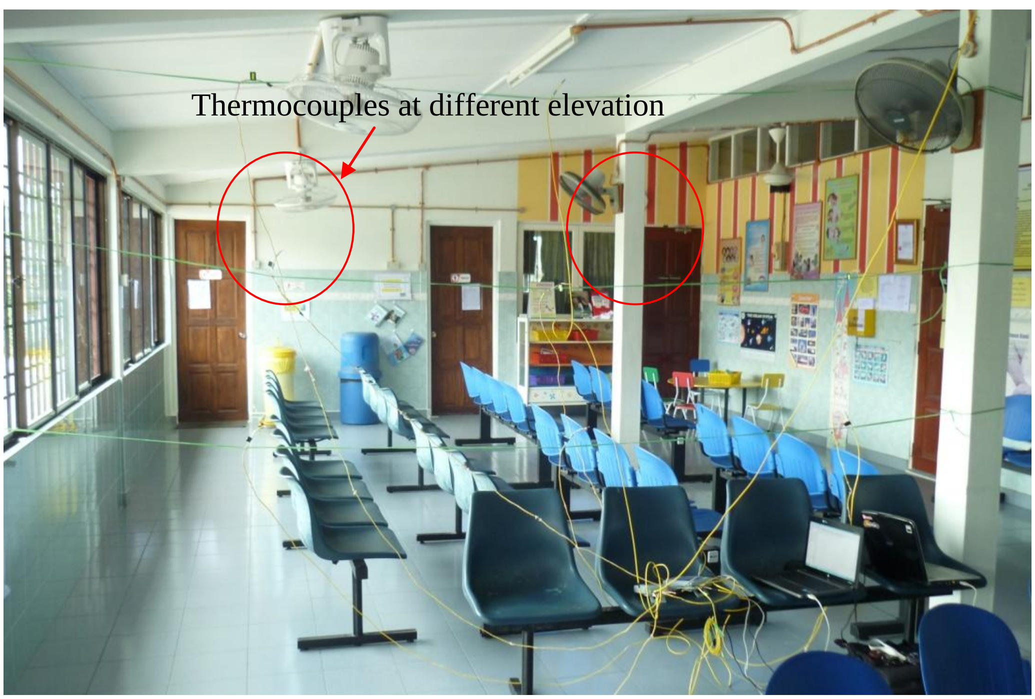


Figure 3.13: Overall view of the placement thermocouples in the waiting area at different elevations

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The observation took about two weeks to complete, during the first weekendwas the observationperiod, followed by recording and monitoring run without any fan switched on and windows closed. In the following weekend, the activity was implemented at the same location and position of the thermocouples but the fans were switched on and outside temperature recorded too. The thermocouples were mounted at locations where the patients would likely to sit at. In fact, the thermocouples need to be set up at elevation one meter above the ground and hanged so that they could capture the temperature at the region they covered. If the thermocouples were mounted on the floor, the temperature readings would not correspond to the area of interest of this project. The data was analyzed in order to find the most critical temperature area. At the most critical temperature area, one weekend of continuous recording was needed but this time the recording covers the whole elevation of the building at the critical point area where the temperature of ceiling recorded too. The temperature contour at 12 pm was obtained once the analysis of the data prepared.

3.5 Cooling Energy Saving Scope

Another scope covered for this project is in term of cooling energy saving. The main focus of this scope is to reduce the usage of the cooling energy through power per kilowatt used by the air conditioners. There are three main air conditioners equipped in the surgery which are important to maintain the comfort temperature for the doctors and patients at every station of surgery.

3.5.1 Measurement of Cooling Energy

Two main compressors with one having rated of power twice than the other act as the main ace to have air conditioners working. Evaluation throughout the day on the compressor is a must in order to know the performance trend of the compressors. Every compressor had its own performance trend according to the load required and capacity needed that day. Multimeter-LH1050 (LEM) installed at each compressors for current readings.The current readings were recorded and analyzed.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Peak Cooling Load Calculation

This section discusses the calculated peak load required by the zone to determine the load size of the equipments which then compared to the actual installed design load of the equipments.

4.1.1 CLTD Method and Heat Balance Method Comparison

Table 4.1: Complete ASHRAE 2001 heat Gain via conduction of the clinic

Side and Direction	Conduction Parts	Area (ft^2)	Qua	Total Area (ft^2)	U ($Btu/hr.ft^2.F$)	CLTD (F)	Load (Btu/hr)
1 (North)	Wall	602.57	1	602.57	0.49	9	2657.31
	Large Window	7.74	4	30.96	1.01	18	562.85
	Medium Window	2.59	2	5.18	1.01	18	47.12
2 (South)	Wall	602.57	1	602.57	0.49	14	4133.60
	Door	14.63	1	14.63	0.47	14	96.26
	Large Window	7.74	4	30.96	1.01	18	562.85
	Medium Window	2.59	6	15.55	1.01	18	282.74
	Medium Window	2.59	3	7.78	1.01	18	141.37
3 (East)	Wall	559.98	1	559.98	0.49	24	6585.36
	Roof	1907.47	1	1907.47	0.33	24	15107.16
	Wall (Glass)	18.87	2	37.73	1.01	18	685.96
	Door (Glass)	29.64	1	29.64	1.01	18	538.81
	Large Window	7.74	12	92.88	1.01	18	1688.56
	Large Window	5.66	6	33.94	1.01	18	616.96
4 (West)	Wall	594.14	1	594.14	0.49	14	4075.80
	Roof	1360.30	1	1360.3	0.33	14	6284.59
	Door (type 1)	18.94	1	18.94	0.47	14	124.65
	Door (type 2)	19.95	1	19.95	0.47	14	131.26
	Door (type 3)	19.22	1	19.22	0.47	14	126.49
	Small Window	1.24	12	14.90	1.01	18	270.95
	Medium Window	1.74	5	8.69	1.01	18	158.06
	Large Window	7.74	16	123.84	1.01	18	2251.41
			Total Overall Conduction Load (Btu/hr)				**47130**
			Total Overall Conduction Load (W)				**13813**

This section will compare all results from the CLTD and heat balance method for determining the zone cooling load of overall dental clinic building. All the factors for the calculation were taken from ASHRAE 2001 at reference date 15 June. Tables below summarizes the cooling load calculation via ASHRAE 2001 CLTD method to get peak cooling load by assuming the maximum solar heat gain factor, SHGF. In fact, there is no shading either interior or exterior at each side of the building. In fact, the building materials for the building is simple, 4 inch concrete for the wall, plaster cement, clear windows and wood door.

Table 4.2: Complete ASHRAE 2001 heat Gain via radiation of the clinic

Side and Direction	Conduction Parts	Area (ft^2)	Qua	Total Area (ft^2)	SHGF	SC	CLF	Load (Btu/hr)
1 (North)	Large Window	7.74	4	30.96	59	0.69	0.85	1071.32
	Medium Window	2.59	2	5.18	59	0.69	0.85	179.39
2 (South)	Large Window	7.74	4	30.96	226	0.69	0.63	3041.58
	Medium Window	2.59	6	15.55	226	0.69	0.63	1527.86
	Medium Window	2.59	3	7.78	226	0.94	0.63	1040.72
3 (East)	Wall (Glass)	18.87	2	37.73	238	0.69	0.26	1611.03
	Door (Glass)	29.64	1	29.64	238	0.69	0.26	1265.44
	Large Window	7.74	12	92.88	238	0.69	0.26	3965.72
	Large Window	5.66	6	33.94	238	0.94	0.26	1973.96
4 (West)	Small Window	1.24	12	14.90	238	0.94	0.45	1500.45
	Medium Window	1.74	5	8.69	238	0.69	0.45	642.48
	Large Window	7.74	16	123.84	238	0.69	0.45	9151.65
				Total Overall Radiation Load (Btu/hr)				**26971**
				Total Overall Radiation Load (W)				**7905**

Table 4.3: Complete ASHRAE 2001 heat Gain via lighting of the clinic

Light	Watt	BF	CLF	number	Factor	Load (Btu/hr)
Fluorescent Lamp	36	1.25	1	39	3.41	5984.55
Patients Chair Lamp	40	1.25	1	3	3.41	511.5
	Total Overall Radiation Load (Btu/hr)					**6496**
	Total Overall Radiation Load (W)					**1905**

Table 4.4: Complete ASHRAE 2001 heat Gain via people of the clinic

People	Heat value (Btu/hr)	number	CLF	Load (Btu/hr)
$Q_{sensible}$	245	15	1	3675
Q_{latent}	155	15	1	2325
		Total Overall Radiation Load (Btu/hr)		**6000**
		Total Overall Radiation Load (w)		**1758**

Table 4.5: Complete ASHRAE 2001 heat Gain via all electrical equipments

Area	Appliances	Rated Load (W)	Conversion Factor	Number	Load (Btu/hr)
Waiting Area	Television	90	3.41	1	306.9
	Wall Fan	50	3.41	4	682
	Ceiling Fan	75	3.41	2	511.5
Surgery Room	Wall Fan	50	3.41	1	170.5
	Refrigerator	160	3.41	1	545.6
	Station Main Power Unit	1500	3.41	3	15345
	Chair Lamp	40	3.41	3	409.2
	Patents chair	70	3.41	3	716.1
	Light cure unit	30	3.41	3	306.9
	Alginote Mixer	300	3.41	1	1023
	Amalgam Mixer	350	3.41	1	1193.5
X-Ray Room	X-Ray unit	1150	3.41	1	3921.5
	Wall Fan	50	3.41	1	170.5
Kawasankotor	Turbosid	1000	3.41	1	3410
	Thermo sealer	300	3.41	1	1023
	Wall fan	50	3.41	2	341
	Unltrasonic cleaner	140	3.41	1	477.4
Steril room	Autoclave normal type	2000	3.41	3	20460
	Autoclave vacuum type	2400	3.41	2	16368
	Wall fan	50	3.41	1	170.5
	Water distiller	1225	3.41	1	4177.25
Dry Laboratories	Ceiling fan	70	3.41	1	238.7
	Work station with blower and motor	1100	3.41	1	3751
Wet laboratories	Water heater	1200	3.41	1	4092
	Main Pacobath	1500	3.41	1	5115
	Secondary Pacobath	1100	3.41	1	3751
	Model trimer	800	3.41	1	2728
	Polishing Lathe	500	3.41	1	1705
	Wall fan	70	3.41	1	238.7
Doctors Room	Computer	40	3.41	1	136.4
	Printer	150	3.41	1	511.5
	Speaker for PC	35	3.41	1	119.35
Clinic Staff room	Computer	40	3.41	1	136.4
	Printer	150	3.41	1	511.5
	Speaker	35	3.41	1	119.35
	Wall Fan	50	3.41	1	170.5
Counter	Ceiling Fan	70	3.41	1	238.7
	Wall fan	50	3.41	2	341
		Total Overall Load (Btu/hr)			**95633**
		Total Overall Load (W)			**28045**

The number of equipments listed in Table 4.5 are not necessary been used at the same time. It might have certain equipment used seldom and rarely. For the total amount, cooling load from the equipment at the maximum is 28.05kW. In order to have significant in the results for comparison, the amount should be less than actual whereas the important equipments included in the calculation. In the end, cooling load value for the equipments is 1465 W only.

Table 4.6: Summary of complete ASHRAE 2001 total heat gain in clinic building

Heat Source	Heat Gain (Btu/hr)	Watt (W)	Percentage (%)
Conduction	44458	13030	55.62
Radiation	17973	5268	22.49
People	6000	1758	7.51
Lighting	6496	1904	8.13
Equipment	5000	1465	6.26
Total	**79928**	**23427**	**100**

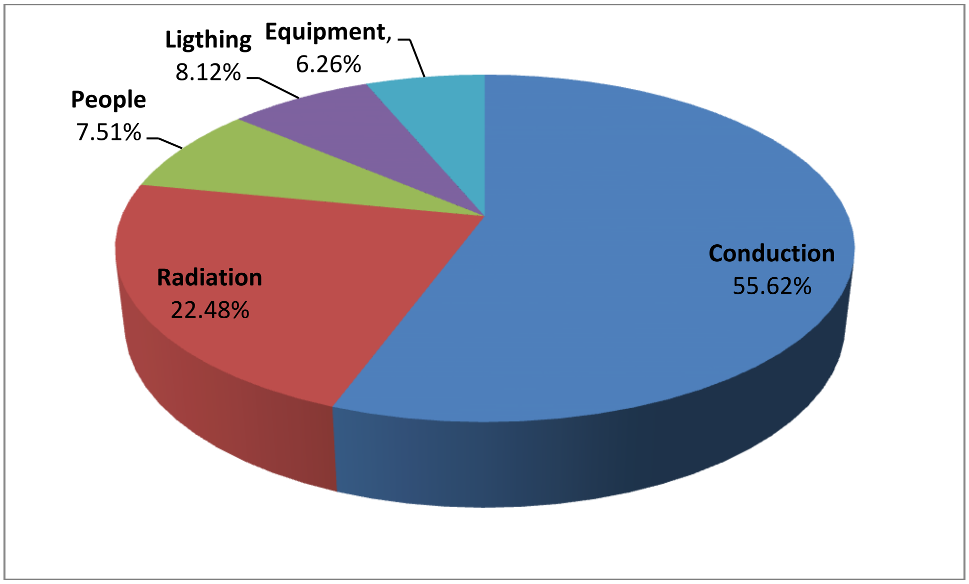

Figure 4.1: Cooling load distribution at maximum solar gain condition

Table 4.6 concludes the total heat gains value for the overall building of clinic. The value of cooling load gain from ASHRAE2001was huge and yet feasible with the design and equipments available in the clinic. Based on the Figure 4.1, if the comparison of the percentage include the total cooling load from the equipment, it will have the highest percentage of heat gain by the clinic was from the electrical equipments. Electrical equipments with huge power consumption were widely been used in many parts of the clinic especially in the sterile rooms which occupied with 5 autoclave where two of them are vacuum type autoclave that used a lot of power up to 2500W per machine. In fact, all the equipments were impossible to work in one time, so the total cooling load results were revise back and came out with new the percentage as shown in Table 4.6, which the conduction is the main cooling load consumption. The amount of cooling load calculated could be reducing if there is shading either natural or artificial nearby.

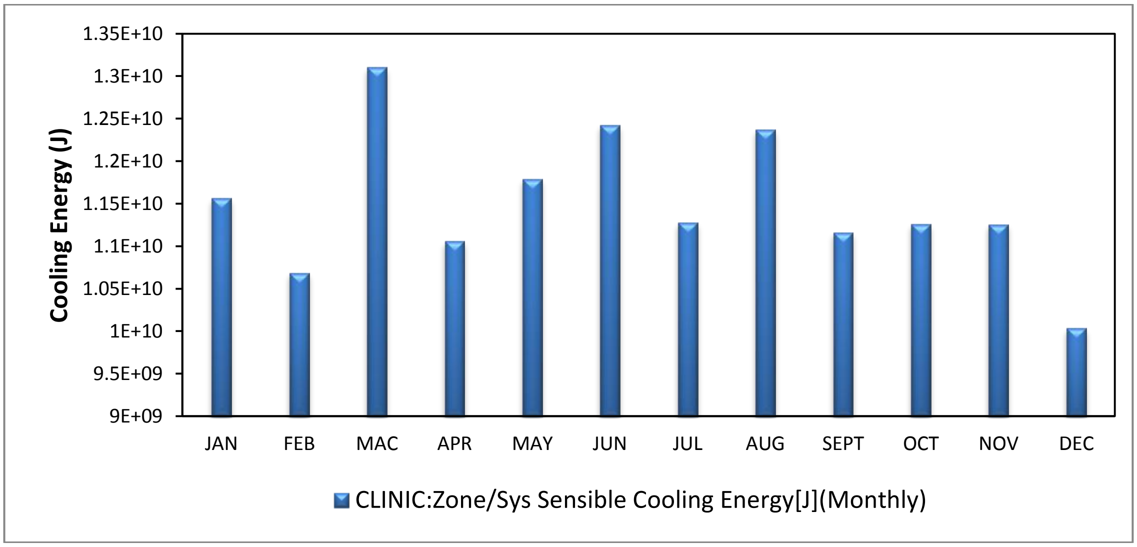

Figure 4.2: Energy Plus simulation on the whole clinic area

Cooling load trend for a year generated from energy plus, by considering the dimension of the building, elevation, direction towards the sun and the construction materials for the clinic. The up and down graph trend were referred to the weather data provided by Energy plus and with the desire latitude and longitude to the nearest area, Sitiawan. In order to provide the cooling load results by manual calculation, it needs a lot of reference on date, month, and need to be calculating one by one by replacing the variables. Users are easy to monitor the data and gained a huge data with time step from the first month until the end of the year by using Energy Plus. There are slightly difference results as to compare from the manual calculation and simulated around 5-8%.

4.2 Thermal Comfort Results and Findings

4.2.1 Level of Thermal Comfort Survey in the waiting area

One of the best ways of determining whether groups of people are comfortable is to ask them. Thermal sensation, comfort, pleasure, pain, as well as behavioral responses are all psychological phenomena. There are a number of subjective scales, which been used in the assessment of thermal environments; the most common of these are the seven-point scales of Bedford (1936) and ASHRAE (1966)(Hall 2010). The survey held from Wednesday, 12 October 2011 until Friday, 14th of October 2011 and 30 participants from various age participate in this survey. Survey form prepared in the appendixes. The survey is focusing on the level of comfort in the waiting area for patients and parents during waiting for their surgery turn. The expectation was met where every participant urge for a better comfort condition in the waiting area, which they complained they are not comfortably waiting in the room. The results may vary due to the different psychological state of individual.

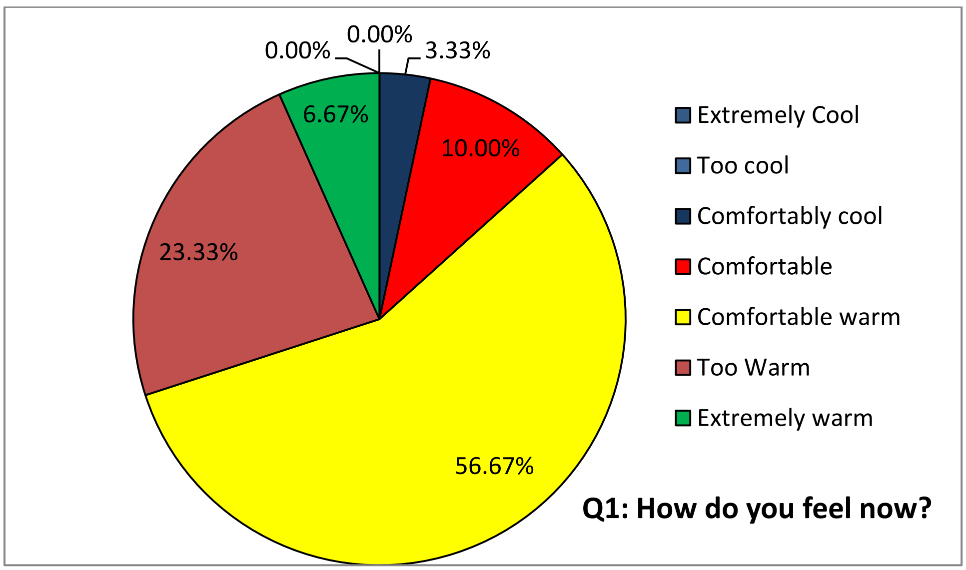

Figure 4.3: Feedback on how they feel waiting in the waiting area

The first question is implementing the seven-point Bedford comfort scale. This helps to answer the question in a specific and details manner. Different people have different psychological behavioral and they have their own different perspective of comfort.

Based on the pie chart above, majority (56.67%) of the survey participants feels comfortable warm waiting their turn in the clinic waiting area. Most of them experienced from the range time 9.00am until 3.00pm where the clinic occupied with peoples. In fact, no one stated there that the room was cooland it shows that the six fans provided in the waiting room are not enough to cool down the temperature inside the room. From the seven-point Bedford comfort scale overall, points 5 to 7 recorded the dissatisfaction of the participant on the level of comfort in the area, which is total percentage of 86.67%.

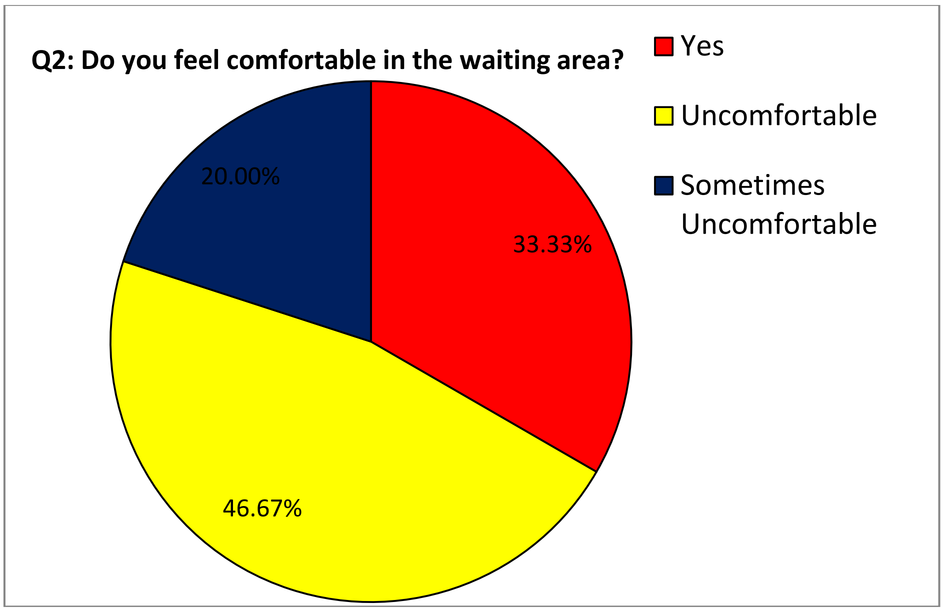

Figure 4.4: Feedback on waiting area level of comfort

Question 2 is actually a continuous question from the previous that highly proves the results and analysis for the question 1 where from the pie chart figure 4.3, 46.67% of the participant feels uncomfortable in the waiting area. This include also the 20% of the respondent who feels sometimes uncomfortable,which makes total 66.67% of them are uncomfortable waiting in the waiting area. This clearly linked the thermal comfort in a room with physical response. If a person is not familiar with the concept of thermal comfort then he or she may not be disposed to report discomfort. Satisfaction might be express because dissatisfaction is not the state of mind. It goes to the others too where the state of mind is ‘uncomfortable’ but satisfaction is expressed because the person is not used to nor expects any better. In field studies of tropical climates like Malaysia, it often concluded that thermal comfort condition are at higher temperatures than those peoples who live in temperate climates.

For question 3, the length time of waiting also plays huge impact on the survey. Longer duration time, effect the patients' level of comfort. From the survey, there are 3 respondents who wait for their turn just for only 5 minutes and they mentioned their satisfaction towards the level of comfort in the waiting area. Result from those 3 respondents is clearly stated in the question 1's pie chart, the results of 10% vote for comfortable and 3.33% comfortably cool. The level of thermal comfort decreasing due to the long waiting period, temperature effect on the body, cloth and surrounding.

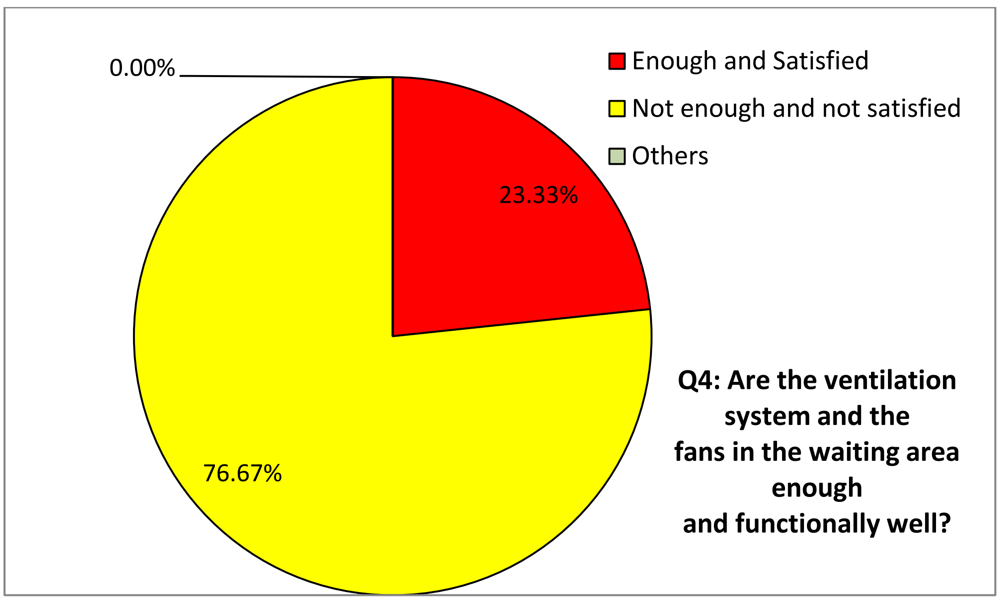

Figure 4.5: Feedback percentage on ventilation system in the waiting area

Based on the results generated on the Figure 4.5, 76.67% of the respondent dissatisfied with the ventilation system in the waiting area and the number of fans provided not enough. Six fans were provided with four small fans are located near to the windows where sun radiation was at maximum. The small fans speed are not enough to cool down the direct radiation received to the waiting area. This lead to patients' discomfort that wait for their turn and seat near to the windows area. There are two types of ventilation system namely natural and mechanical. Natural ventilation generated by the natural forces due to wind and gravity, refers to the ventilation arise flows through the openings in the building envelope. Mechanical ventilation system refers to fans and there are three basics types of mechanical system, which are; extract, supply and both. A building that is primarily natural ventilated may have local mechanical ventilation devices; extract fans in some room (Hall2010). It goes to the clinic, where overall envelope of the clinic especially in the waiting area, they used to slide the windows for the outside wind to flow through and cooled down the area with additional six wall fans but still respondent complaint about their dissatisfaction on the comfort matters.

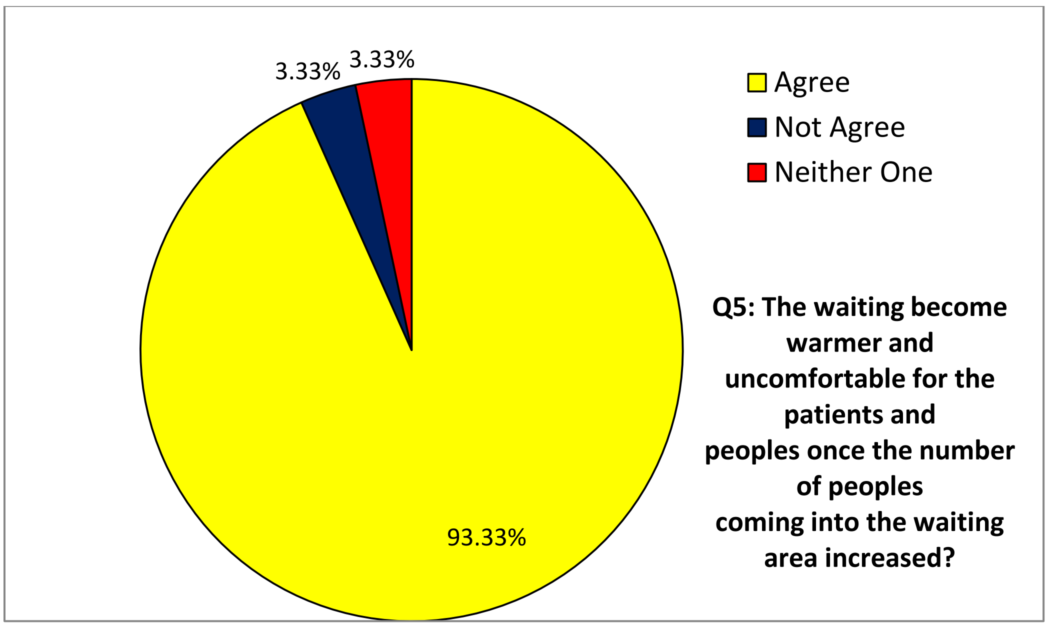

Figure 4.6: Feedback percentage about waiting area

Expected result came out 93.33% of the respondent agree with the situation given. The waiting area become warmer and uncomfortable for the patients and peoples once the number of peoples keeps increasing in the area. As the survey ended, most of the time within those three days, the number of patients is at the most during the noon, which is after lunch hour from 2 pm up to 4 pm. Increasing numbers of people express a sensitivity towards many points for example the scents, surrounding, temperature and behavioral.

The entire respondents agree with the question 6 in the survey form, which, the fans need to be replacing by air conditioner in order to have comfort zone for the patients and others in the waiting area. Reviewing all the feedback gained, they did mention about the current development at all clinics and hospitals nowadays where they are already equipped with air conditioner in the waiting area. Therefore, it means that this clinic should apply the same. In fact, air conditioner may reduce the pressure of the patients before entering to have their surgery. Furthermore, theincreases of earth temperature show a point to equip the waiting area with air conditioners.

4.2.2 Temperature Variation in the Waiting Area

The temperature variation helps to analyzethe thermal comfort in the waiting area, shown in Figure A.5. Three weekends variations with different perspectives provide different sets of data. Observation and monitoring were donein order to follow up the upcoming results, for example the direction of the sun to the waiting area and outdoor temperature range compared to the inside and in the ceiling area.

Based on the layout (see Figure A.4 in the appendixes), sets of mean temperature recorded and classified based on the position of the thermocouples (see Table 4.7). Sets of thermocouples located near to the counter area were the most critical temperature area recorded. In order to have more and better findings, another one week of temperature variation at the area implemented which this time the temperature and thermocouples were equipped at various elevations including the ceiling area. Figures 4.7 and 4.8 are actually plotted graphs shows exactly the temperature trend in the waiting at various situations. Figure 4.7 illustrate the first week temperature recording variation in the waiting area without switching on all the fans. As for the week two, Figure 4.8 illustrates temperature variation in the waiting area with all the fans switched on. Based from both weeks' temperature variations, mechanical ventilation such as fans keeps the room at lower temperature.

Table 4.7: Mean temperature recorded at various points within two weekends

Point	Mean Tempearature (°C)	
	Week 1 with Fans Off	Week 2 with Fans On
1	35.4	33.8
2	34.5	33.5
3	35.5	29.6
4	31.4	31.2
5	34.4	28.2
6	34.0	33.3
7	33.7	30.6
8	32.0	33.5
9	33.3	32.2
10	33.5	27.3
11	30.5	31.9
12	32.8	28.6
13	35.2	33.6
14	33.8	31.8
15	34.4	32.0
16	34.0	32.8

Labels:

Red	1st row to the window
Orange	2nd row to the window
Yellow	3rd row to the window
Green	Room Temperature

In conjunction with the results, the temperature recording and data logging be extend to the third week in order to identify the possibilities of high temperature came from the ceiling area. At various elevations, temperature variations were plot in the Figure 4.9. The ceiling area holds high temperature variation compared to other points. Consistent roof received direct sun radiation from 8 am in the morning was the main reason the high temperature variation in the ceiling area. There was no proper insulation in the ceiling to diffuse the effect from the direct radiation. In fact, poor ventilated space in the ceiling area, which at least the outside air may lower down the temperature effect from the ceiling area. Table 4.8 is basically shown the mean temperature experience by each thermocouple at different elevation of waiting area. High temperature inspected located near to the ceiling area. Figure 4.12 refers roughly to the temperature contour in the waiting area where the red area is actually the area with high temperature, turned into lighter colour when the elevation is near to the patients sitting position area.

Table 4.8: Mean temperature for the points at the critical area in waiting area

Point	**Mean Tempearature (^oC)**
	Week 3 with Fans On
1	32.56
2	26.53
3	28.23
4	30.34
5	23.09
6	32.37
7	32.16
8	33.19
9	32.83
10	24.94
11	31.98

Point 5 in the Table 4.8 indicates the thermocouple, which was located at the outside of the clinic without exposing it to the sun radiation. Point 1 was referring to the thermocouple located in the ceiling area. The heat gains were coming from the roof to the waiting area, which make the room hotter. The outside temperature recorded the lowest set of temperature compared to the temperature recorded in the waiting area. This means, if there is proper ventilation in the waiting area, the temperature inside the room should not exceed its maximum number. Besides that, the direct sun radiation striking the roof without any shading produced high temperature in the ceiling area.

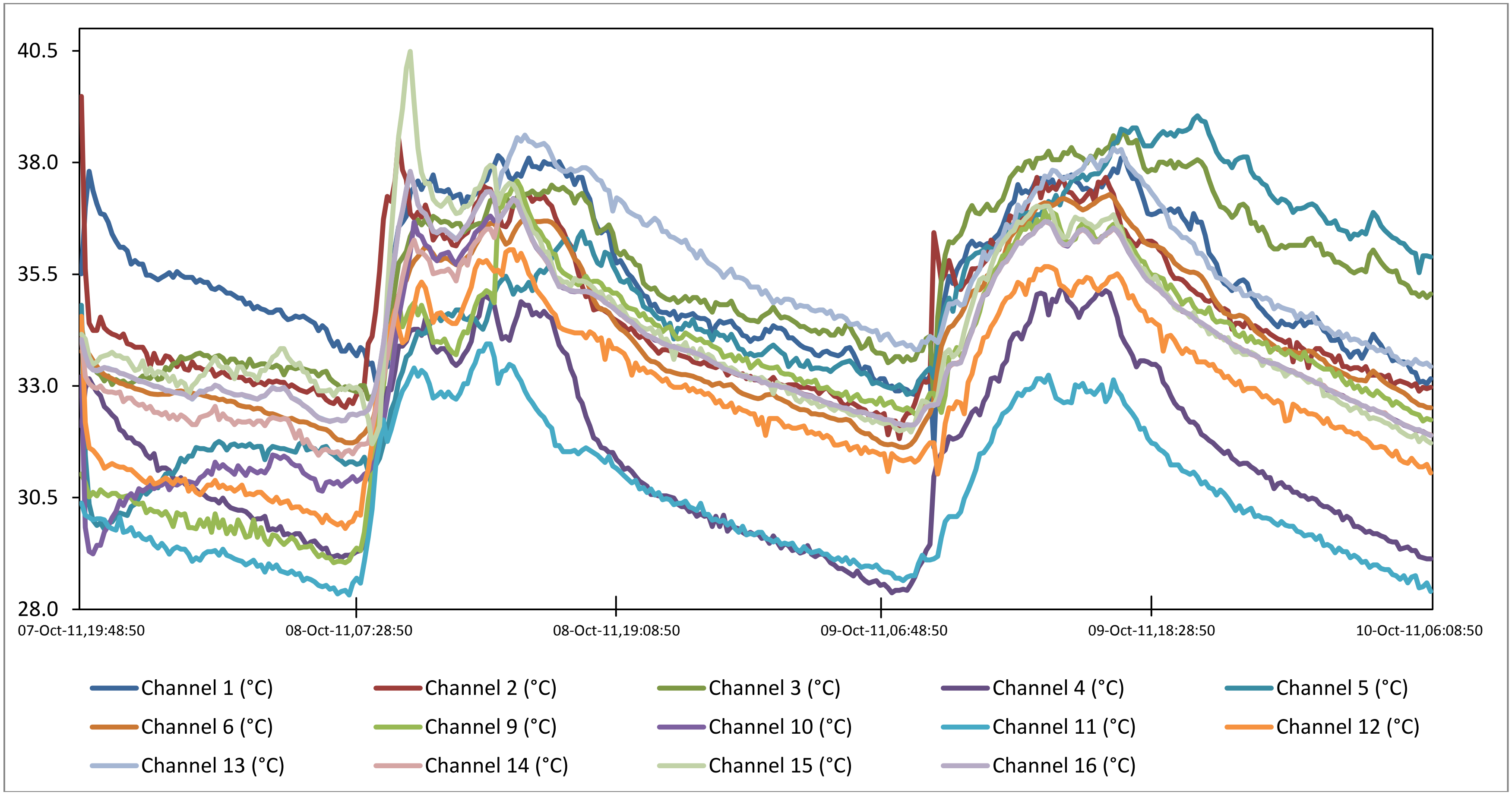

Figure 4.7:Temperature variation in waiting area for week one graph

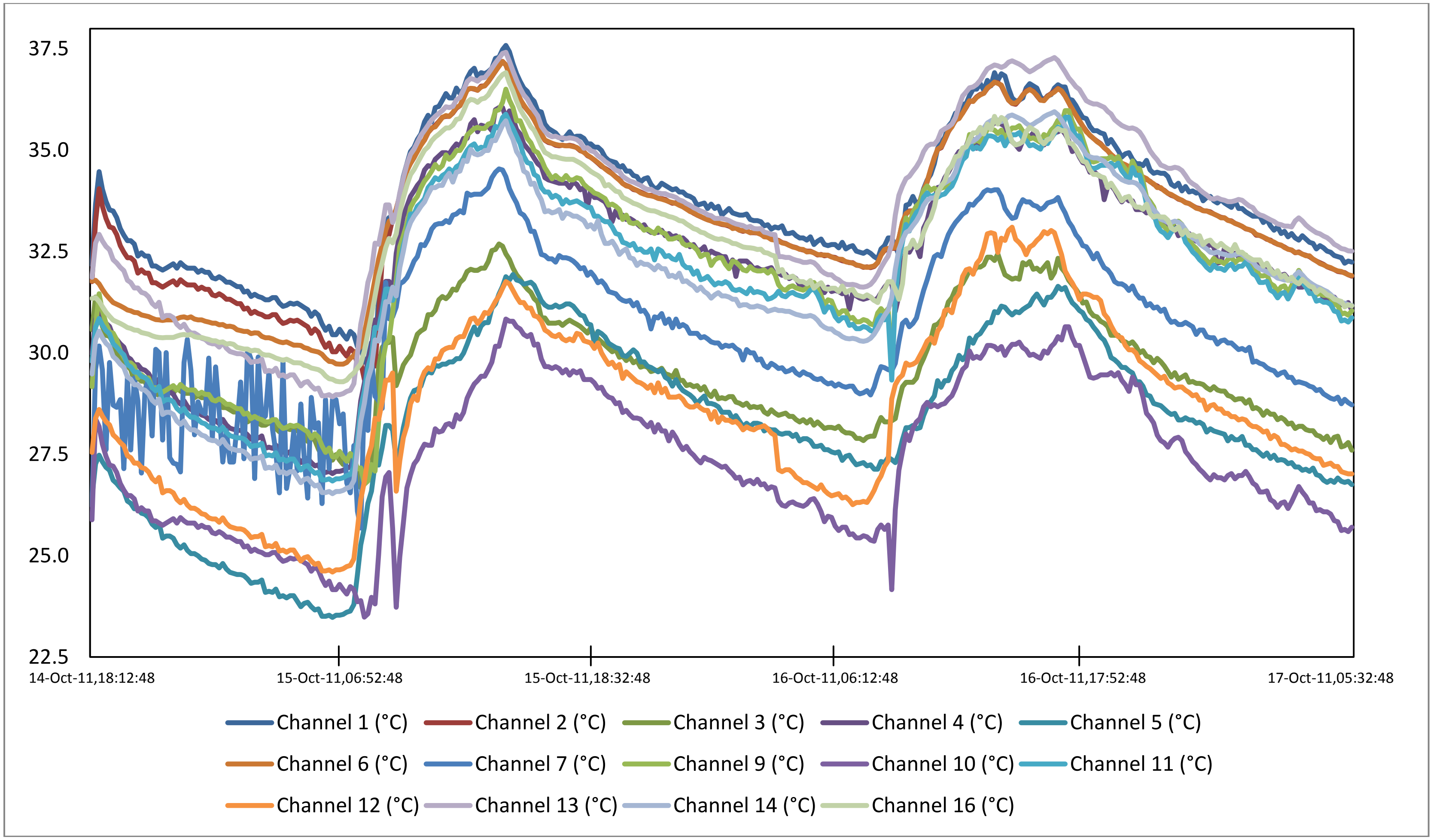

Figure 4.8: Temperature variation in waiting area for week two graph

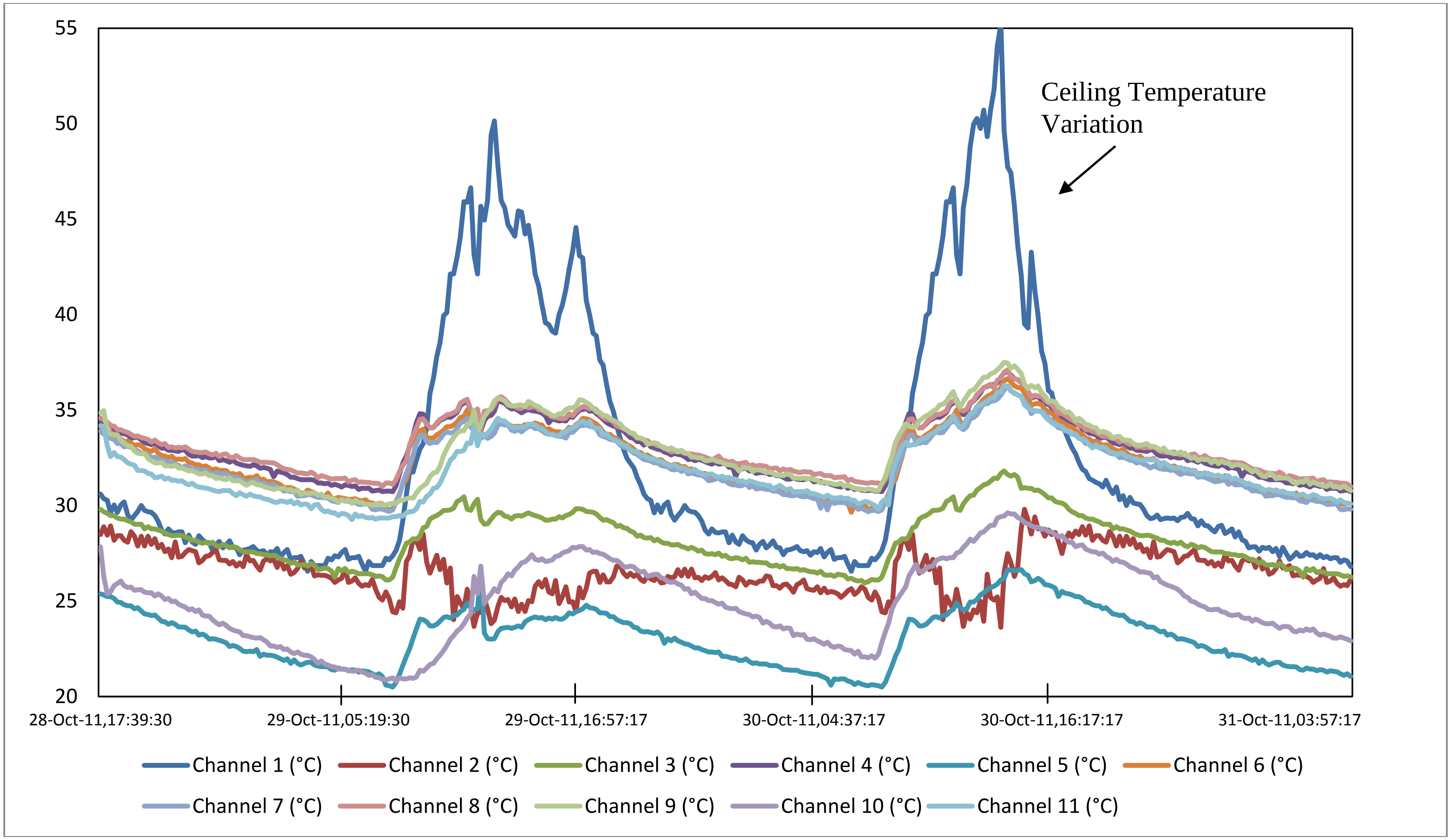

Figure 4.9: Temperature variation in critical region in waiting area

4.2.3 Temperature Analysis for the Waiting Area

Temperature mapping of the whole waiting area (see Figures 4.10 and 4.11) were prepared. The time taken for the temperature mapping was set to be at 12in the noon. In Figures 4.10 and 4.11, temperature mapsare show based on the temperature range at each point.The temperature in range 36°C to 37°C and above falls under one category which is high temperature, and then goes to second categories which is medium range temperature and lowest captured temperature. The area nearer to the counter at the left side of the picture is the critical area where there are the most high temperature recorded. In fact, the temperatures near to the window area were remained stable but still at the very high as to compare with the outdoor temperature recorded.

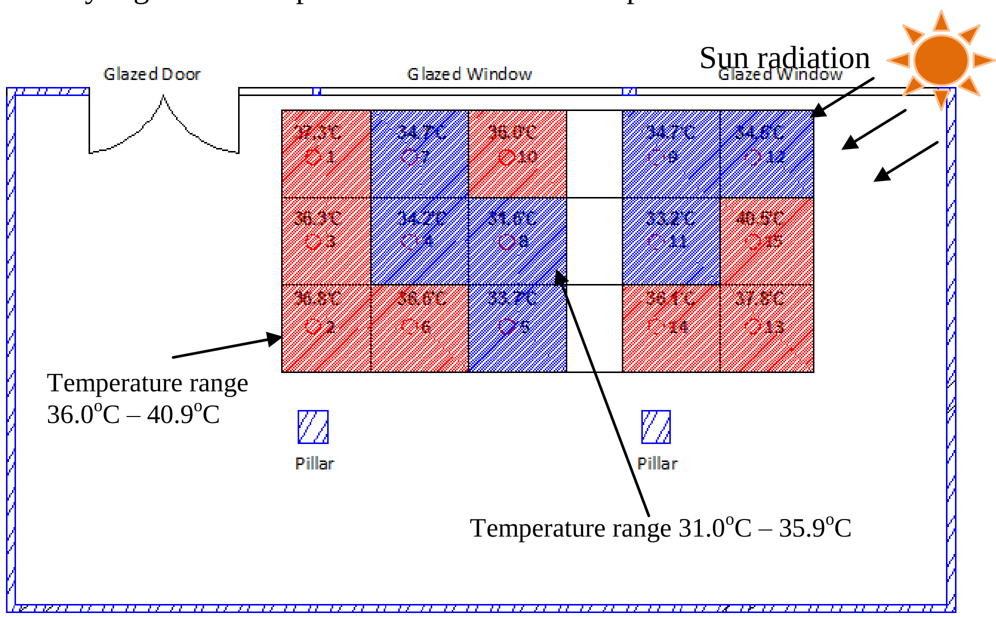

Figure 4.10: Temperature mapping in the waiting area for week 1 at 10 am with fans turned off

For week two temperature analysis (see Figure 4.11), the area with high temperatures were lesser than previous week observation (see Figure 4.10). There are six fans install in the waiting area and all of them were switch on during the temperature-recording period. Significant results obtained, the cool air from the fan cooled down the hot air circulating inside the waiting area, but the temperature remains steady as to compare to the previous week temperature gained, which had the difference range 3-4°C.

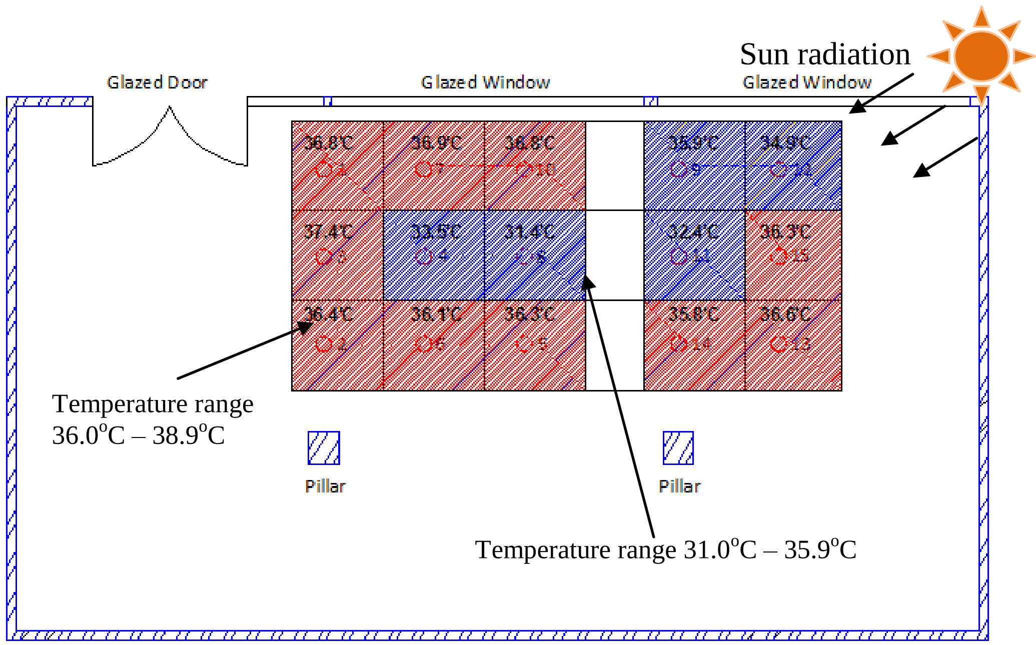

Figure 4.11: Temperature mapping in the waiting area for week 1 at 12 noon with fans turned off

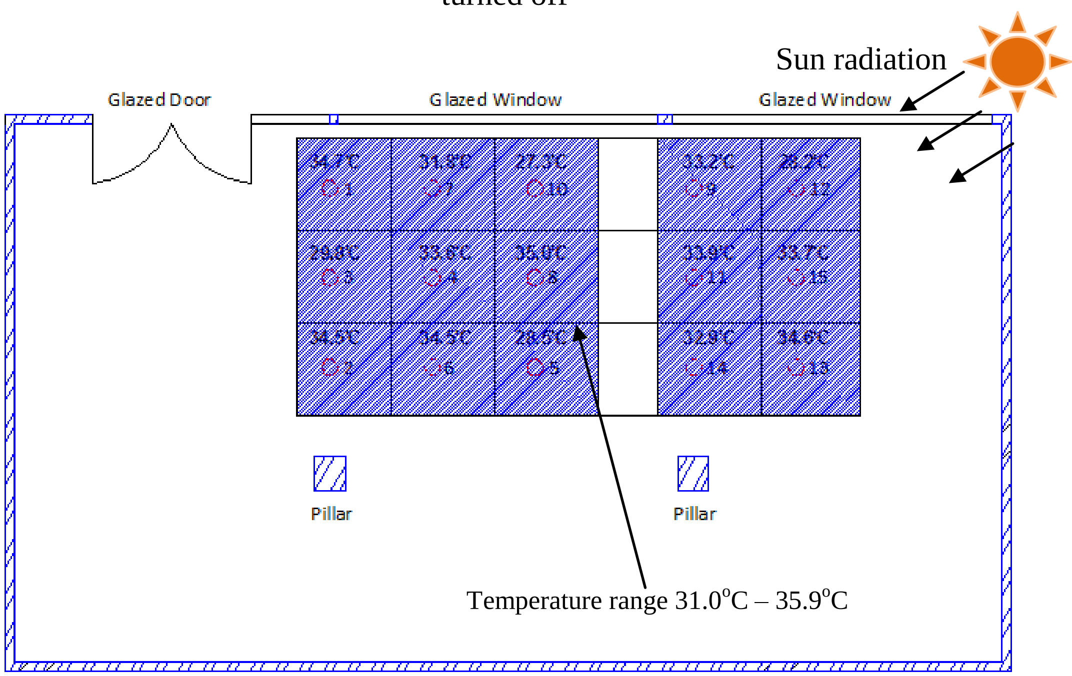

Figure 4.12: Temperature mapping in the waiting area for week 2 at 10 am with fans turned on

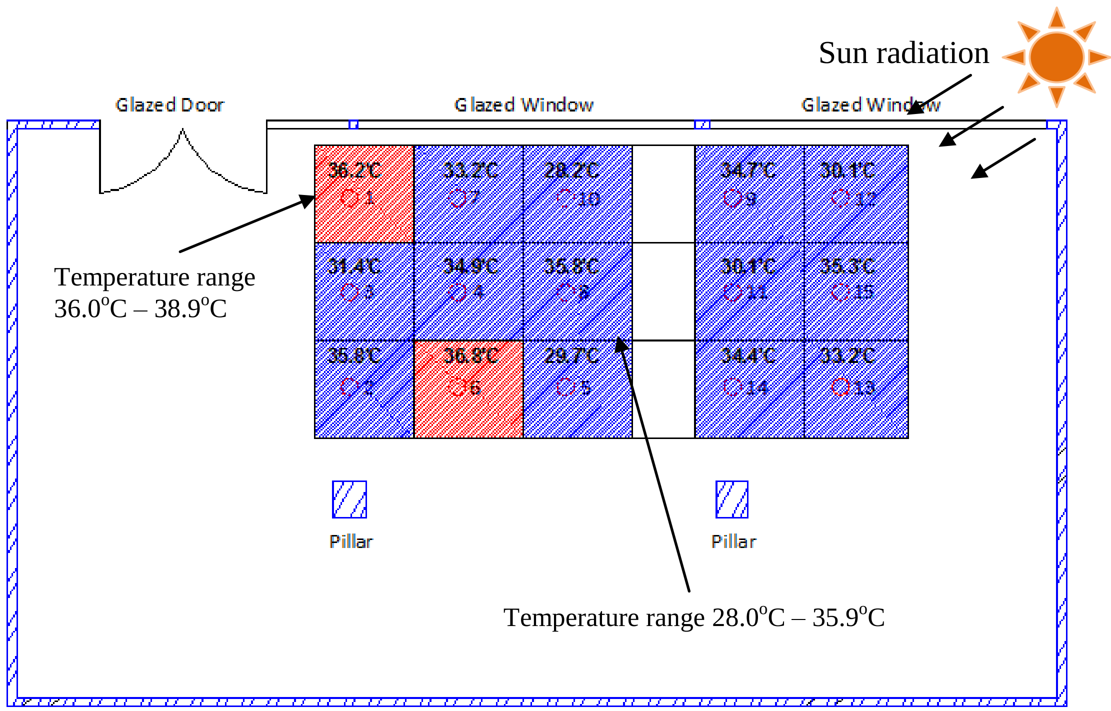

Figure 4.13: Temperature mapping in the waiting area for week 2 at 12 noon with fans turned on

Circled region in Figure 4.10 and 4.11 are basically referring to the different range of temperature recorded in the waiting area at 12 pm. The regions were categories into two; high temperatures region and moderate temperature regions. The high temperatures region ranges from 36°C to 37°C and the moderate temperature region ranges from 25°C to 35.9°C.

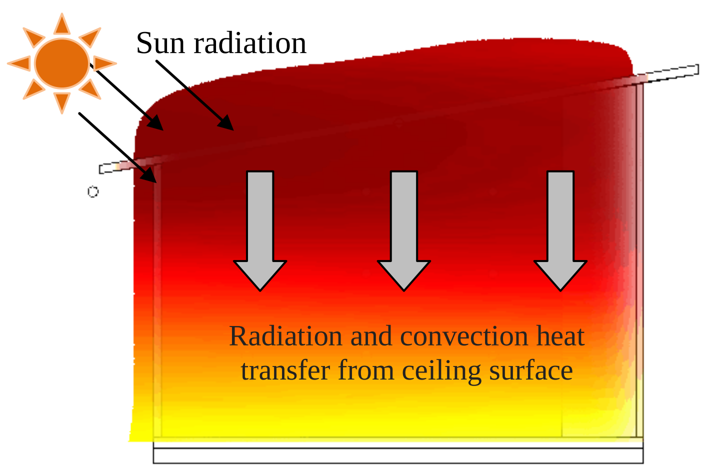

Figure 4.14: Temperature mapping based on elevation of waiting area

There are several significant observations and monitoring was done during 3 weeks data logging in the waiting area. From the graph temperature variation for the first week and second week (Figures 4.7 and 4.8), the area having the most critical temperature recorded is the location near to the counter area. There is no proper ventilation system at that area, to be precise the whole waiting area. The thermocouples located near to the windows area should be higher than the thermocouple at the counter area because they were exposed to the direct sun radiation and surrounding. Since the staffs are used to open up the windows during operating days, the temperatures are reduced due to the ventilation effect from outdoor air. The thermocouples at the counter area received little ventilation effect but probably still not effective enough to reduce its temperature from risen up.

A week of observation was performed which include the variation of temperature in the ceiling area, outdoor temperature variation and variation of temperature at different elevations recorded. It is true that there is a little direct sun radiation coming into the waiting area, but the effect lasts for only two hours in the morning. A huge temperature rise was recorded in the region close to the ceiling surface(see Figure 4.14) and was regarded as the main factor of the high temperature and low level of comfort in the waiting area. There is neither natural nor artificial shading nearby to block the sun radiation to the roof. The roof was heated up for the whole day, and furthermore the ceiling was installed without insulation to reduce the percentage of the radiation.

4.3 Savings in Cooling Energy Saving Results and Findings

4.3.1 Compressor Current and Power Relative to Time

Figure 4.13 shows there are two compressors operated for three air conditioners in the surgery room. One of the compressors provides power two times more than the other one. Each air conditioner powered up to 3 horsepower (2.24kW). The compressors are located in a room which is isolated due to noise produce from the compressors are destructing the doctors focus while surgeries. The compressors' current readings were recorded by using Multimeter-LH1050 (LEM).

Figure 4.15: The compressors for air-cooled split units

Observation and the data were recorded. As expected, there was a peak current produced by the compressors early in the morning and after lunch hour which they switch the air conditioners back. There are two line plotted resulted by the data recorded. The compressor operated for two air conditioners provide high current compare to the others.

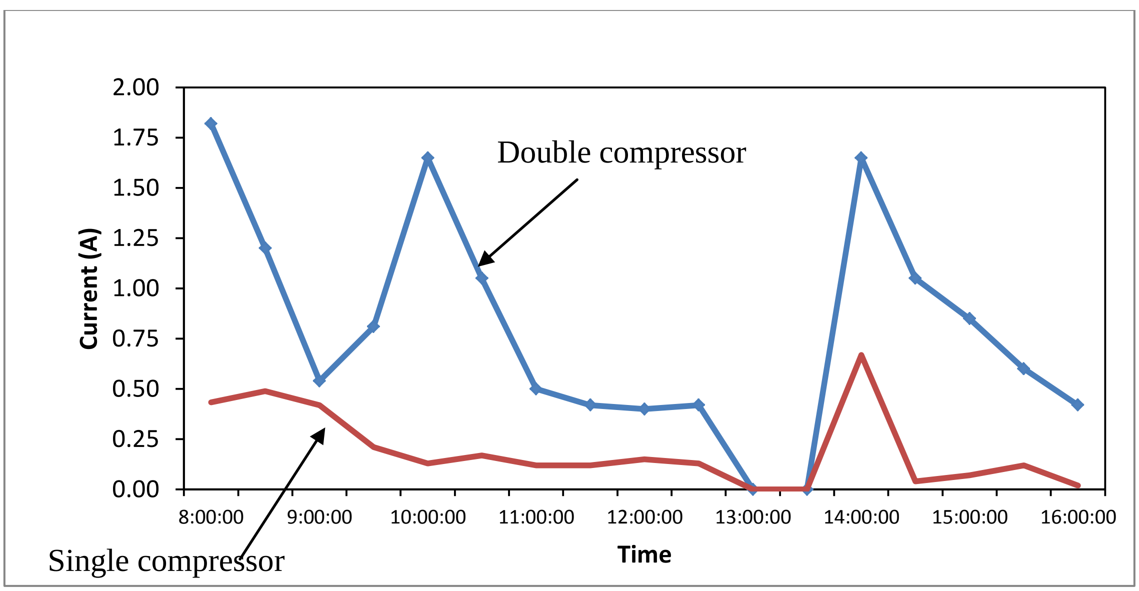

Figure 4.16: Compressors current versus time graph

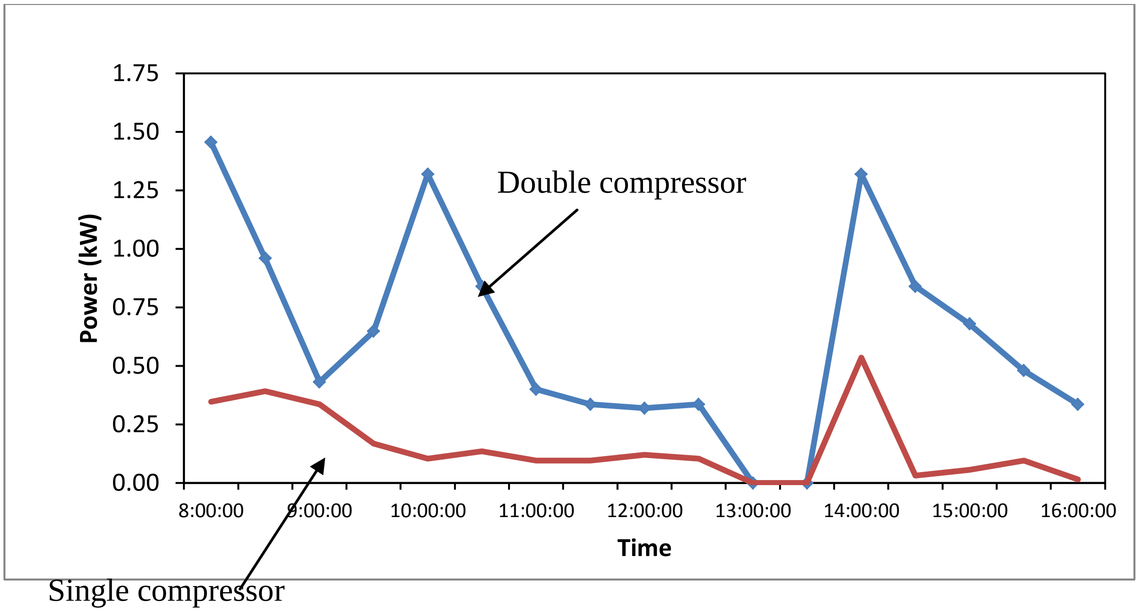

Figure 4.17: Compressors power versus time graph

In order to have power versus time graph, the current reading needs to be multiplied with the power factor prepared by the national electric supply company. The Batu Gajah dental clinic's power factor is observed to change every month depending on the kilo-volts used in a month. Here, the power factor would be the best at 0.80. The ideal power factor would be 1.0, but it is impossible to achieve the figure. Power factor is an index used to compute the efficiency level of electricity usage. The index is measured from 0 to 1 basically. A high index shows efficient usage of electricity and vice versa. A low power factor shortens the lifespan of electrical appliances and causes power system losses to the national electric supply company, TNB. Power factor that is less than 0.85 shows an inefficient use of electricity. For the clinic, a power factor of 0.80 is considered as low, which caused by inductive loads for example the transformers, induction motors and high intensity discharge (HID) lighting. As for the national electric supply company who provide the electricity to the clinic, there are several calculations in the monthly bills that really need the clinic to achieve power factor of 0.85 and above. Due to that, they included surcharge in the monthly bill for about 1.5-3.0% amount of the monthly bill based on the power factor achieve monthly.

4.4 Proposed Ideas for Improvement

Without any further studies, people might have said that equipping the waiting area with two air conditioners will solve the problems. This is not necessary a true statement. In some cases, the air conditioners maintain the thermal comfort, but the monthly cost of electricity will increasesharply. There are cheaper alternatives than buying and equip with air conditioners.

4.4.1 Applying Reflective Coated Window

One of the cheaper alternatives is by implementing reflective coated window to every window in the clinic. The reflective glass reducing the cooling load by reflecting much of the direct sun radiation, the half mirror effect can enhance the external appearance of a building beautifully. Reflective glass reduce the load on the cooling system by reflecting up to 30% of the sunlight’s energy by using tinted substrate glass for energy saving efficiency. In fact, it becomes like a mirror which changes with time, season and climate to create a unique appearance. As a suitable amount of sunlight passes through, it is possible to achieve an even degree of illumination and this creates a pleasant and relaxed atmosphere.

Figure 4.18: Example picture of reflective coated window (architecture.uterworld.com)

Table 4.9: Percentage reduction after implementing reflective coated window in terms of cooling load

Side	Before (Btu/hr)	After (Btu/hr)	% Reduction On cooling load
North West	2860	2342	18.1
South East	4584	3745	18.3
North East	24214	21214	12.4
South West	12799	10521	17.8
Total	44458	37822	14.9

Table 4.9 show the comparison in term of cooling load calculated before and after implementing the reflective coated window. Implementing reflective coated window helps the clinic to reduce the cooling load by 14.9 percent.

4.4.2 Venetian Blinds for Internal Shading

Implementing venetian blinds at each windows and glass doors reduce the cooling load by modulate the direct sun radiation striking from indoor area. It can operate manually and electrically controlled by means of automatic sun sensors, time controls, and manual switches. A part from the venetian blinds, there are aluminum slats, which held in position with the side guides and controlled by weatherproof lifting tapes. The slats function to modulate the direct solar radiation, completely closed and restricted to admit full radiation and heat.

Table 4.10: Percentage reduction after implementing venetian blind

Side	Before (Btu/hr)	After (Btu/hr)	% Reduction On cooling load
North West	1696	1303	23.2
South East	1489	1128	24.2
North East	7270	5494	24.4
South West	7517	5718	23.9
Total	17973	13645	24.1

Table 4.10 show the comparison result for the cooling load of the clinic before and after implementing the venetian blinds. The percentage reduction was as high as 24.1 percent, which is better than the reduction from the reflective coated window. The capability of the venetian blinds to block the direct sun radiation internally helps to maintain the thermal comfort level in the waiting area. Figure 4.19 explain the correlation of venetian blinds at various situations.

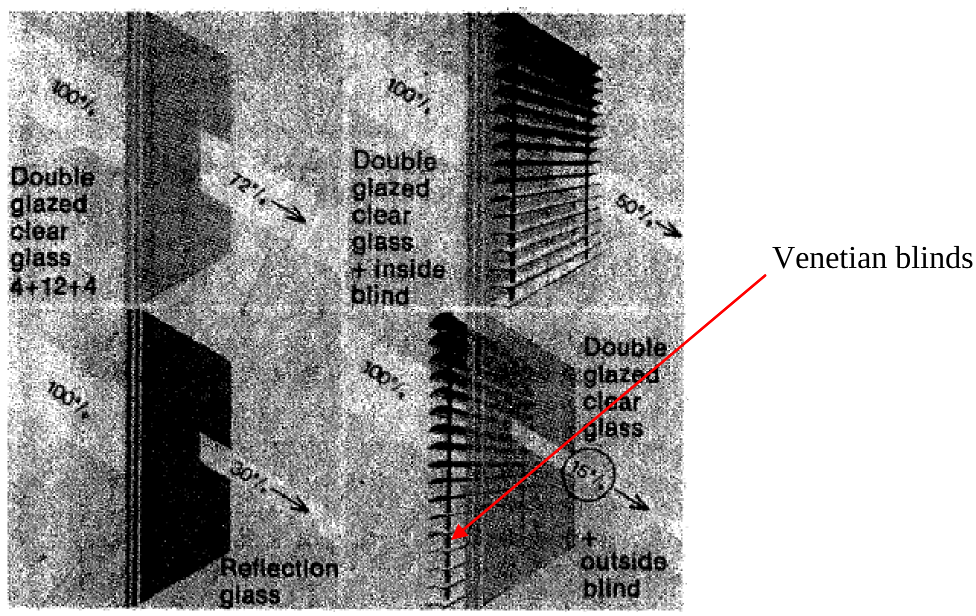

Figure 4.19: The significant using venetian blinds (ecolog-building.com)

4.4.3 Artificial and Natural Shading nearby the Clinic

There are two types of shading, natural and artificial. Natural shading is form from bushes, plants and trees which is the most environmentally efficient way to provide shade. Trees also help to cleanse the air by intercepting airborne particles, reducing heat and absorbing such pollutants as carbon monoxide, sulphur dioxide and nitrogen dioxide. In fact, this effect better thermal level for surrounding. Natural shading consists of trees, for example the big trees are needed to block the direct sun radiation to the clinic. Moreover, planting a tree is not enough to provide shade to overall of the clinic. Artificial shading is from the building nearby, and it has the same concept by providing shade to the clinic.

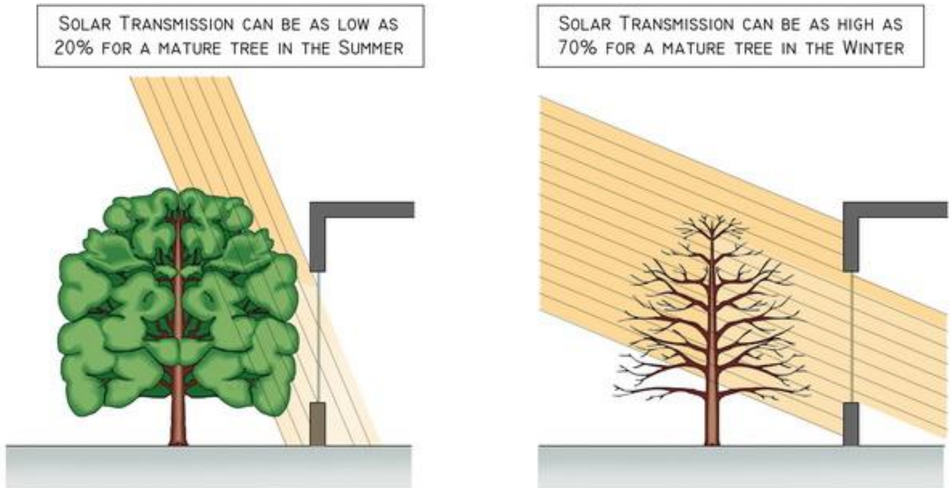

Figure 4.20: The significant of planting big tree near to the clinic, which provide shading and reduce the temperature from direct sun radiation (ecolog-building.com)

In Figure 4.20, in order to control sun penetration to the interior of buildings it is important to provide exterior shading**,** a big tree as a part of the architectural envelope design. Such shading can be attach to the building or achieve by the articulation and disposition of the building floors to create overhangs. The natural environment used to shade low-rise buildings. Deciduous trees can effectively shade the facade when heat avoidance desired, and permit solar penetration where passive solar gain sought.

4.4.4 Build Secondary Roof Top

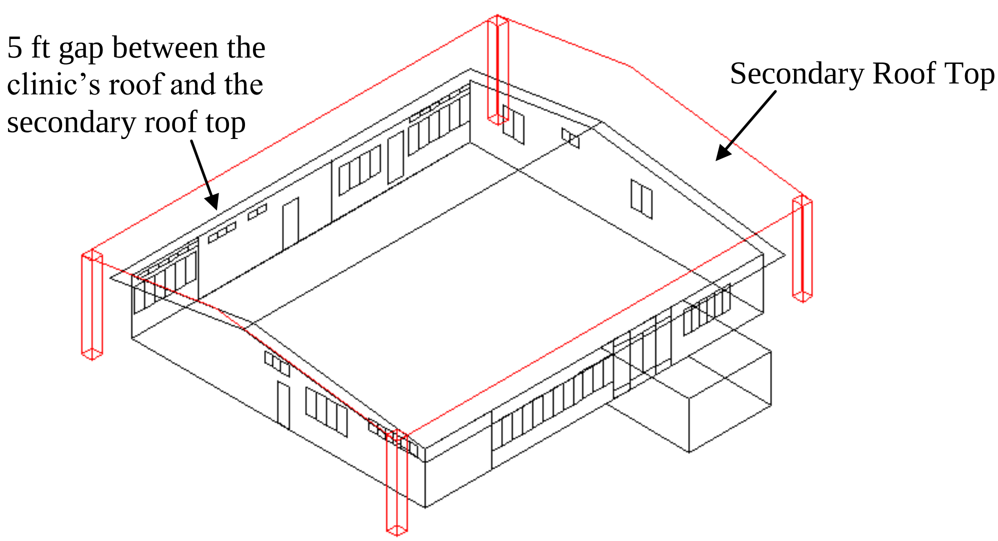

Figure 4.21: Overall view of the clinic with secondary rooftop

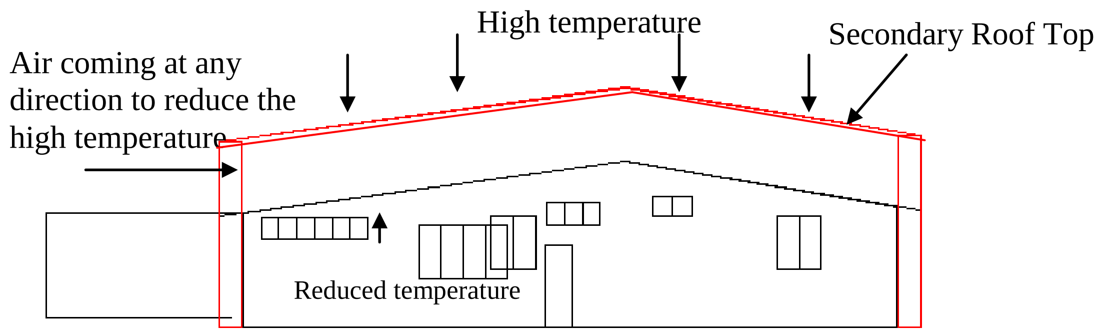

Figure 4.22: Side view of the clinic with secondary rooftop

Figures 4.21 & 4.22 show how secondary roof top helps to reduce the effect of sun radiation direct to the roof. Based on the findings in the section 4.2.3, the gap between the clinic's roof and the secondary roof helps to reduce the radiation and high temperature by ventilating the air to flow between the gaps. Ventilation of the roof space allows high heat energy trapped by convection to be released back into surrounding. This important airflow through the roof space draws hot air out of the roof and prevents heat to build up, and eventually transmits heat through the ceiling. Besides that, the secondary rooftop will provides extra shading for the clinic and its surrounding. The total cost and payback period estimated for implementing the secondary roof top is around RM7000.00 where in one year and half with reduction on the monthly bill RM450.00.

4.4.5 Thermal Insulation for Ceiling

The other cheap alternative for improvement of thermal comfort level is implementing insulation in the ceiling area. Without any insulation under the roof, cooling energy will cost a lot. There are several layers of insulations for the ceiling. One of them is shining and reflective insulation sheet, which helps to reflect the radiant heat up to 95 to 97% which resulted reduction in cooling cost. Additional bulk insulation above the ceilings will guarantee a cool clinic throughout a year and reduced electricity bills. These types of insulation will not deteriote when handled. It is a plastic, homogenous material having no loose particles throughout the lifetime of the product, not causing any hazardous to the health or the installer. Lifespan of this insulation sheet is 10 years.

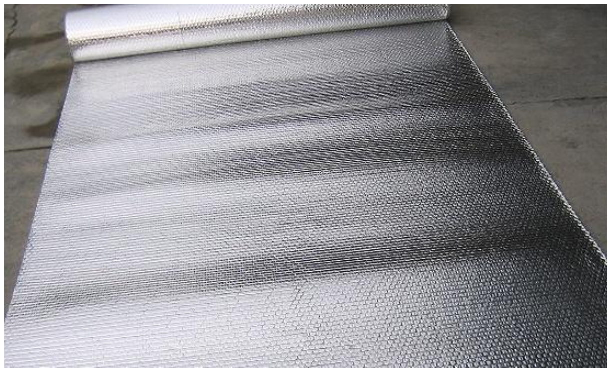

Figure 4.23: Picture of one of the component roof insulation for ceiling

With these thermal insulation sheet installed, it will reduce up to 50% of current monthly electricity bill. In fact, the thermal insulation sheet life span is about 10 years. So by taking monthly bill as RM1500.00 and life span of the thermal insulation is 8 years.

Total cost of thermal insulation and installation is RM5722.41 for total up 1947.41 ft^2, where a square feet of it is RM3.00 only. If the thermal insulation could save up to 30% of the monthly electricity bill, every month the clinic will save up to RM450, which a year it is RM5400.00. So payback period for the cost of installation the thermal insulation is one year and a month, plus the life span of the thermal insulation is 8 years. The clinic will save a lot from the electricity and it also reduced the temperature in the clinic.

4.4.6 Optimizing the Power Factor

The inefficient operation of power systems stems mainly from a low power factor. Power factor correction is cost-effective when utility penalties imposed. Low power factors can be by installing energy-efficient transformers and replacing existing motors with smaller and/or higher efficiency motors, or by installing variable-speed motor drives. Evaluating kWh, kW, and power factor charges separately can be useful in evaluating the impact of demand and power factor, penalties on the monthly electric bill. Savings from installation of correction devices often have paybacks less than two years. Although demand and power factor measures save little if any energy, the significant cost savings and relatively short payback periods make them attractive measures.

1.5% surcharge of the current bill is for every 0.01 less than 0.85 power factor and 3% surcharge for every 0.01 less than 0.75 power factor.

Current bill: Rm1500.00 with power factor 0.80

$$\text{surcharge} = \left[(0.85 - 0.80)/0.01\right] \text{ x } 1.5\% \text{ x RM}1500.00 = \text{RM}112.50$$

Current bill: Rm1500.00 with power factor 0.60

$$\text{surcharge} = \left[\left[\frac{(0.85 - 0.75)}{0.01}\right] \text{ x } 1.5\% \text{ x RM}1500.00\right] + \left[\frac{(0.75 - 0.60)}{0.01}\right] \text{ x } 3.0\% \text{ x RM}1500.00 = \text{RM}900.00$$

The surcharge keep increased as the power factor recorded is far less than the expected optimized 0.85. Thus, a lot savings in electrify monthly bill can be achieved by improvising the power factor. There are several ways to improve the power factor, such as installing capacitors, minimizing operations of idling or lightly loaded motors, avoid operating equipments above its rate voltage and replace standard motors as they burn out with energy efficient motors.

4.4.7 EMS Scheduling and Duty Cycling

In some cases, there is in need serious exposure to the staffs about how to conserve the energy and use them very well. This method would have increased their energy awareness. Controlled set point temperature also would be one of the effective conservation of energy exposed to the clinic’s staff. These devices can control anywhere from one to a virtually unlimited number of items of equipment.By concentrating the control of many items of equipment at a single point, the EMS allows the building operator to tailor building operation in order to satisfy occupant needs. Energy Management Systems are generally preprogrammed so that operation is relatively straightforward. Programming simply involves entering the appropriate parameter, the point number and the on and off times for the desired function which makes works easy for the staff.

Scheduling with an EMS is very much the same as it is with a time clock. Equipment is start and stop based on the time of day and the day of week. Unlike a time clock, however, multiple start or stops accomplished very easily and accurately, for example in the clinic, lights could be turned off during morning and afternoon break periods and during lunch or when there are no people around. It should be noted that this single function, if accurately programmed and depending on the type of facility served, can account for the largest energy savings attributable to an EMS. Most heating, ventilation and air conditioning, HVAC fan systems are designed for peak load conditions, and consequently these fans are usually moving much more air than is needed. Therefore, they could be shut down for short periods each hour, typically 15 minutes, without affecting occupant comfort. Turning equipment off for predetermined periods during occupied hours referred to as duty cycling, and can be accomplished very easily with an EMS. Duty cycling saves fan and pump energy but does not reduce the energy required for space heating or cooling since the thermal demand must still be met.

CHAPTER 5
CONCLUSIONS

5.1 Conclusions

In this paper, Batu Gajah Dental Clinic cooling load is fully analyzed. At the moment, the analysis is done only at the CLTD calculation part of the overall clinic building.Based on the simulation result, there is difference with 5-10% on the value. In fact, energy plus is more accurate than using manual calculation because the reading covers for the whole year which let user to set whether to have the record instead of total month or by 15 minutes gap from first January until the end of the year. The objective of this study is to study on improvement of cooling energy and thermal comfort of Batu Gajah Dental Clinic were achieved. For manual calculation, CLTD/SCL/CLF method is used due to its simplicity and relevancy for manual calculation. ASHRAE 2001 was used in the calculation as the main references. From the calculation of the overall heat gain in the clinic, the maximum cooling load is from the conduction, 44458 Btu/hr which is equals to 13.08kW.

After comparing with the other heat gain values, the conduction covers 55.6 percent of the total cooling loads of the clinic. Furthermore, there are a lot of high power (W) electricalequipments inside the clinic which most of them are machine used to sterile the tools and to store the medicine.The location of the clinic would also play a big role in determining the heat gain value of the clinic. No trees around the clinic to help blocking maximum sunlight to the roof, walls and doors. Besides that, the clinic was surrounded by small one story building that could not able to block sunlight at any direction. Shading at the external and internal would reduce the heat gain value of the total overall clinic by 15%.

As a conclusion, adding shading internallyby venetian blinds is the best choice on preventing direct sun radiation through the window. Moreover, applying reflective coated window at every window in the clinic will reduce the cooling load for the clinic up to 24.05 %. Build up a secondary roof is a good idea to help the ceiling area from radiated all day but the cost of building it would be costly and payback period for the building would be more than a year. Same goes to other propose ideas like the thermal insulation where costly and need a year and a month to have the payback. There is a lot of ways to save the energy; the most important part is basically how the staff had been exposed to the value of conserving the energy. Without proper exposure to the conservation energy practice, there is no use to save the energy instead of paying everything monthly highly. However, there is still much potential of the system to save energy especially in the system control side. Further work should be continued especially in coming with a valid simulation outcome for the cooling load simulation. Detail analysis on the current trend of operation must be done to obtain potential energy saving measures of the system.

5.2 Recommendations

The recommendations are needed to have better understanding about the problems faced by the clinic management in the future and analyzing the implemented ideas effect to the clinic. There are several recommendations for the future in order to improve the study of thermal comfort and cooling energy at Batu Gajah Dental Clinic. Implementing all the propose ideas and do analyzing by capturing again the temperature of the waiting area in regards to see the changes and its effectiveness. Hence, it need to follow the step that are required before starting the temperature recording, for example getting those feedback of the level of comfort in the waiting area once the ideas were implemented and followed by necessary action based on the feedback. The actual compressor's power reading will be manageable with permissions, so that the analysis of the cooling energy will be precise and details. Details simulation using Energy Plus will help users and the dental clinic's management to identify the best possible ideas and recommendations on improvising the thermal comfort and cooling energy in the whole are of Batu Gajah Dental Clinic.

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APPENDIXES

Table A.1: Side 1 dental clinic building envelope

Walls Area (ft^2)	**Windows**	**Windows Construction**	**Dimensions**	**Quantity**
602.57	Large Size Window	Single Glass(Heat absorbing)	4.30ft x 1.80ft	4
	Medium Size Window		1.61ft x 1.61ft	2

Table A.2: Side 2 dental clinic building envelope

Walls Area (ft^2)	**Windows**	**Windows Construction**	**Dimensions**	**Quantity**
602.57	Large Size Window	Single Glass (Heat absorbing)	4.30ft x 1.80ft	4
	Medium Size Window		1.61ft x 1.61ft	6
	Medium Size Window	Single Glass(Clear)	1.80ft x 1.44ft	3

Table A.3: Side 3 dental clinic building envelope

Walls Area (ft^2)	**Windows**	**Windows Construction**	**Dimensions**	**Quantity**
578.85	Large Size Window	Single Glass(Heat absorbing)	4.30ft x 1.80ft	12
	Large Size Window	Single Glass(Clear)	4.04ft x 1.40ft	6

Table A.4: Side 4 dental clinic building envelope

Walls Area (ft^2)	Windows	Windows Construction	Dimensions	Quantity
594.14	Large Size Window	Single Glass(Heat absorbing)	4.30 ft x 1.80 ft	16
	Medium Size Window		1.61ft x 1.08ft	5
	Small Size Window	Single Glass(Clear)	1.80ft x 0.69ft	12

Table A.5: Heat Gain via conduction construction table

Side and Direction	Conduction Parts	Area (ft^2)	Qua	Total Area (ft^2)	U ($Btu/hr.ft^2.F$)	CLTD (F)
1(North)	Wall	602.57	1	602.57	0.49	9
	Large Window	7.74	4	30.96	1.01	18
	Medium Window	2.59	2	5.18	1.01	18
2(South)	Wall	602.57	1	602.57	0.49	14
	Door	14.63	1	14.63	0.47	14
	Large Window	7.74	4	30.96	1.01	18
	Medium Window	2.59	6	15.55	1.01	18
	Medium Window	2.59	3	7.78	1.01	18
3(East)	Wall	559.98	1	559.98	0.49	24
	Roof	1907.47	1	1907.47	0.33	24
	Wall (Glass)	18.87	2	37.73	1.01	18
	Door (Glass)	29.64	1	29.64	1.01	18
	Large Window	7.74	12	92.88	1.01	18
	Large Window	5.66	6	33.94	1.01	18
4 (West)	Wall	594.14	1	594.14	0.49	14
	Roof	1360.30	1	1360.3	0.33	14
	Door (type 1)	18.94	1	18.94	0.47	14
	Door (type 2)	19.95	1	19.95	0.47	14
	Door (type 3)	19.22	1	19.22	0.47	14
	Small Window	1.24	12	14.90	1.01	18
	Medium Window	1.74	5	8.69	1.01	18
	Large Window	7.74	16	123.84	1.01	18

Table A.6: Heat Gain via radiation construction table

Side and Direction	Conduction Parts	Area (ft^2)	Qua	Total Area (ft^2)	SHGF	SC	CLF
1(North)	Large Window	7.74	4	30.96	59	0.69	0.85
	Medium Window	2.59	2	5.18	59	0.69	0.85
2 (South)	Large Window	7.74	4	30.96	226	0.69	0.63
	Medium Window	2.59	6	15.55	226	0.69	0.63
	Medium Window	2.59	3	7.78	226	0.94	0.63
3(East)	Wall (Glass)	18.87	2	37.73	238	0.69	0.26
	Door (Glass)	29.64	1	29.64	238	0.69	0.26
	Large Window	7.74	12	92.88	238	0.69	0.26
	Large Window	5.66	6	33.94	238	0.94	0.26
4 (West)	Small Window	1.24	12	14.90	238	0.94	0.45
	Medium Window	1.74	5	8.69	238	0.69	0.45
	Large Window	7.74	16	123.84	238	0.69	0.45

Table A.7: Heat Gain via lighting construction table

Light	Watt	BF	CLF	number	Factor
Fluorescent Lamp	36	1.25	1	39	3.41
Patents Chair Lamp	40	1.25	1	3	3.41

Table A.8: Heat Gain via electrical equipments in the rooms of the clinic

Area	Appliances	Rated Load (W)	Quantity
Waiting Area	Television	90	1
	Wall Fan	50	4
	Ceiling Fan	75	2
Surgery Room	Wall Fan	50	1
	Refrigerator	160	1
	Station Main Power Unit	1500	3
	Chair Lamp	40	3
	Patents chair	70	3
	Light cure unit	30	3
	Alginote Mixer	300	1
	Amalgam Mixer	350	1
X-Ray Room	X-Ray unit	1150	1

	Wall Fan	50	1
Kawasankotor	Turbosid	1000	1
	Thermo sealer	300	1
	Wall fan	50	2
	Unltrasonic cleaner	140	1
Steril room	Autoclave normal type	2000	3
	Autoclave vacuum type	2400	2
	Wall fan	50	1
	Water distiller	1225	1
Dry Laboratories	Ceiling fan	70	1
	Work station with blower and motor	1100	1
Wet laboratories	Water heater	1200	1
	Main Pacobath	1500	1
	Secondary Pacobath	1100	1
	Model trimer	800	1
	Polishing Lathe	500	1
	Wall fan	70	1
Doctors Room	Computer	40	1
	Printer	150	1
	Speaker for PC	35	1
Clinic Staff room	Computer	40	1
	Printer	150	1
	Speaker	35	1
	Wall Fan	50	1
Counter and recording room	Ceiling Fan	70	1
	Wall fan	50	2

Table A.9: Heat Gain via people in the clinic

People	Heat value (Btu/hr)	number	CLF
$Q_{sensible}$	245	52	1
Q_{latent}	155	52	1

Table A.10: Sample data for week one temperature variation sets of data (point 1 – 8)

Date and Time	Channel 1 (°C)	Channel 2 (°C)	Channel 3 (°C)	Channel 4 (°C)	Channel 5 (°C)	Channel 6 (°C)	Channel 7 (°C)	Channel 8 (°C)
07-Oct-11,19:48:50	35.508	39.480	34.356	32.106	34.807	33.774	30.351	32.143
07-Oct-11,19:58:50	36.993	35.619	33.816	32.943	31.459	33.794	33.726	32.136
07-Oct-11,20:08:50	37.803	34.404	33.654	33.159	30.352	33.703	34.293	32.162
07-Oct-11,20:18:50	37.371	34.242	33.465	32.997	29.988	33.570	33.699	32.208
07-Oct-11,20:28:50	37.074	34.242	33.303	32.862	29.876	33.437	31.728	32.247
07-Oct-11,20:38:50	36.858	34.539	33.249	32.781	29.932	33.335	33.888	32.273
07-Oct-11,20:48:50	36.831	34.296	33.114	32.538	29.792	33.244	32.835	32.299
07-Oct-11,20:58:50	36.669	34.215	33.222	32.457	29.932	33.203	32.781	32.312
07-Oct-11,21:08:50	36.399	34.161	33.033	32.349	29.960	33.162	32.970	32.331
07-Oct-11,21:18:50	36.237	34.134	33.141	32.268	30.072	33.111	31.269	32.344
07-Oct-11,21:28:50	36.102	34.080	33.087	32.025	30.156	33.060	33.537	32.357
07-Oct-11,21:38:50	36.102	34.161	33.114	31.971	30.128	33.040	31.728	32.364
07-Oct-11,21:48:50	36.021	33.945	33.033	31.836	30.100	32.999	33.510	32.377
07-Oct-11,21:58:50	35.724	33.918	33.060	31.836	30.296	32.989	32.943	32.383
07-Oct-11,22:08:50	35.805	33.864	33.114	31.728	30.352	32.938	31.161	32.390
07-Oct-11,22:18:50	35.724	33.864	33.141	31.701	30.492	32.917	33.213	32.396
07-Oct-11,22:28:50	35.724	33.864	33.222	31.620	30.660	32.897	33.483	32.403
07-Oct-11,22:38:50	35.481	33.729	33.195	31.458	30.576	32.856	32.079	32.416
07-Oct-11,22:48:50	35.481	33.432	33.168	31.377	30.660	32.825	34.212	32.435
07-Oct-11,22:58:50	35.427	33.729	33.276	31.485	30.800	32.815	34.131	32.435
07-Oct-11,23:08:50	35.373	33.513	33.141	31.107	30.716	32.805	31.971	32.442
07-Oct-11,23:18:50	35.427	33.513	33.168	31.161	30.884	32.815	34.131	32.442
07-Oct-11,23:28:50	35.481	33.675	33.411	31.161	31.024	32.815	31.539	32.435
07-Oct-11,23:38:50	35.535	33.648	33.357	31.107	31.054	32.815	31.404	32.429
07-Oct-11,23:48:50	35.427	33.540	33.492	30.945	31.027	32.846	31.377	32.422
07-Oct-11,23:58:50	35.562	33.432	33.519	30.864	31.162	32.876	31.188	32.416
08-Oct-11,00:08:50	35.481	33.567	33.654	30.945	31.378	32.887	33.888	32.409
08-Oct-11,00:18:50	35.427	33.378	33.600	30.810	31.297	32.866	34.455	32.416
08-Oct-11,00:28:50	35.427	33.351	33.627	30.729	31.432	32.887	33.699	32.416
08-Oct-11,00:38:50	35.427	33.540	33.654	30.729	31.432	32.836	32.106	32.429
08-Oct-11,00:48:50	35.319	33.405	33.708	30.675	31.621	32.815	32.916	32.435
08-Oct-11,00:58:50	35.373	33.405	33.735	30.594	31.594	32.815	32.673	32.435
08-Oct-11,01:08:50	35.319	33.351	33.681	30.567	31.594	32.785	32.619	32.442
08-Oct-11,01:18:50	35.319	33.378	33.681	30.486	31.567	32.764	33.996	32.448
08-Oct-11,01:28:50	35.184	33.378	33.600	30.459	31.567	32.734	31.998	32.455
08-Oct-11,01:38:50	35.157	33.216	33.654	30.459	31.702	32.734	33.780	32.455
08-Oct-11,01:48:50	35.211	33.270	33.681	30.378	31.756	32.693	32.673	32.468

Table A.11: Sample data for week one temperature variation sets of data (point 9 – 16)

Channel 9 (°C)	Channel 10 (°C)	Channel 11 (°C)	Channel 12 (°C)	Channel 13 (°C)	Channel 14 (°C)	Channel 15 (°C)	Channel 16 (°C)
31.026	33.210	30.378	34.558	34.049	34.052	34.158	34.039
30.837	29.835	30.108	32.182	33.692	33.215	34.050	33.692
30.513	29.295	30.054	31.615	33.448	33.053	33.645	33.437
30.621	29.241	30.000	31.561	33.356	32.972	33.483	33.356
30.540	29.430	30.027	31.453	33.335	32.945	33.537	33.346
30.675	29.430	30.027	31.345	33.356	32.999	33.645	33.376
30.594	29.727	30.000	31.156	33.407	32.891	33.672	33.417
30.540	29.862	29.855	31.210	33.397	32.864	33.699	33.376
30.594	30.051	29.801	31.264	33.366	32.864	33.753	33.356
30.594	30.186	29.774	31.210	33.346	32.837	33.672	33.346
30.513	30.429	30.054	31.183	33.284	32.864	33.672	33.284
30.513	30.321	29.720	31.183	33.264	32.648	33.618	33.274
30.540	30.510	29.747	31.129	33.233	32.729	33.618	33.233
30.486	30.591	29.828	31.129	33.193	32.729	33.483	33.203
30.378	30.483	29.639	31.048	33.152	32.621	33.348	33.162
30.351	30.699	29.693	30.967	33.121	32.567	33.375	33.101
30.378	30.645	29.585	30.886	33.101	32.594	33.564	33.091
30.162	30.699	29.558	30.832	33.070	32.486	33.267	33.070
30.243	30.780	29.612	30.940	33.029	32.540	33.402	33.029
30.189	30.699	29.450	30.805	32.999	32.405	33.240	32.989
30.189	30.753	29.369	30.832	32.989	32.405	33.321	32.978
30.108	30.780	29.477	30.886	32.938	32.351	33.294	32.958
30.189	30.861	29.369	30.940	32.907	32.405	33.240	32.887
30.054	30.672	29.234	30.886	32.897	32.270	33.105	32.887
29.855	30.807	29.342	30.805	32.856	32.351	33.213	32.866
30.162	30.780	29.396	30.913	32.846	32.243	32.997	32.846
30.108	30.834	29.342	30.859	32.825	32.351	33.105	32.846
30.135	30.861	29.342	30.913	32.805	32.297	33.051	32.815
29.828	30.861	29.234	30.643	32.764	32.216	32.808	32.744
29.828	30.834	29.072	30.751	32.703	32.135	32.997	32.723
29.801	30.807	29.153	30.616	32.795	32.135	33.078	32.805
30.000	30.942	29.099	30.562	32.887	32.297	33.213	32.866
29.855	30.996	29.234	30.670	32.876	32.324	33.240	32.856
30.027	31.104	29.288	30.778	32.927	32.351	33.402	32.927
29.720	31.023	29.288	30.778	32.938	32.405	33.510	32.938
30.135	31.293	29.315	30.886	33.009	32.540	33.645	33.019
29.828	31.158	29.207	30.724	32.989	32.243	33.456	32.978

Table A.12: Sample data for week two temperature variation sets of data (point 1 – 8)

Date and Time	Channel 1 (°C)	Channel 2 (°C)	Channel 3 (°C)	Channel 4 (°C)	Channel 5 (°C)	Channel 6 (°C)	Channel 7 (°C)	Channel 8 (°C)
14-Oct-11,18:12:48	32.175	31.755	30.570	29.981	26.428	31.774	26.229	29.340
14-Oct-11,18:22:48	33.660	33.240	31.380	30.818	27.265	31.794	29.604	32.715
14-Oct-11,18:32:48	34.470	34.050	30.948	31.034	27.481	31.703	30.171	33.282
14-Oct-11,18:42:48	34.038	33.618	30.651	30.872	27.319	31.570	29.577	32.688
14-Oct-11,18:52:48	33.741	33.321	30.435	30.737	27.184	31.437	27.606	30.717
14-Oct-11,20:02:48	33.525	33.105	30.408	30.656	27.103	31.335	29.766	32.877
14-Oct-11,20:12:48	33.498	33.078	30.246	30.413	26.860	31.244	28.713	31.824
14-Oct-11,20:22:48	33.336	32.916	29.976	30.332	26.779	31.203	28.659	31.770
14-Oct-11,20:32:48	33.066	32.646	29.814	30.224	26.671	31.162	28.848	31.959
14-Oct-11,20:42:48	32.904	32.484	29.679	30.143	26.590	31.111	27.147	30.258
14-Oct-11,20:52:48	32.769	32.349	29.679	29.900	26.347	31.060	29.415	32.526
14-Oct-11,21:02:48	32.769	32.349	29.598	29.846	26.293	31.040	27.606	30.717
14-Oct-11,21:12:48	32.688	32.268	29.301	29.711	26.158	30.999	29.388	32.499
14-Oct-11,21:22:48	32.391	31.971	29.382	29.711	26.158	30.989	28.821	31.932
14-Oct-11,21:32:48	32.472	32.052	29.301	29.603	26.050	30.938	27.039	30.150
14-Oct-11,21:42:48	32.391	31.971	29.301	29.576	26.023	30.917	29.091	32.202
14-Oct-11,21:52:48	32.391	31.971	29.058	29.495	25.942	30.897	29.361	32.472
14-Oct-11,22:02:48	32.148	31.728	29.058	29.333	25.780	30.856	27.957	31.068
14-Oct-11,22:12:48	32.148	31.728	29.004	29.252	25.699	30.825	30.090	33.201
14-Oct-11,22:22:48	32.094	31.674	28.950	29.360	25.807	30.815	30.009	33.120
14-Oct-11,22:32:48	32.040	31.620	29.004	28.982	25.429	30.805	27.849	30.960
14-Oct-11,22:42:48	32.094	31.674	29.058	29.036	25.483	30.815	30.009	33.120
14-Oct-11,22:52:48	32.148	31.728	29.112	29.036	25.483	30.815	27.417	30.528
14-Oct-11,23:02:48	32.202	31.782	29.004	28.982	25.429	30.815	27.282	30.393
14-Oct-11,23:12:48	32.094	31.674	29.139	28.820	25.267	30.846	27.255	30.366
14-Oct-11,23:22:48	32.229	31.809	29.058	28.739	25.186	30.876	27.066	30.177
14-Oct-11,23:32:48	32.148	31.728	29.004	28.820	25.267	30.887	29.766	32.877
14-Oct-11,23:42:48	32.094	31.674	29.004	28.685	25.132	30.866	30.333	33.444
14-Oct-11,23:52:48	32.094	31.674	29.004	28.604	25.051	30.887	29.577	32.688
15-Oct-11,00:02:48	32.094	31.674	28.896	28.604	25.051	30.836	27.984	31.095
15-Oct-11,00:12:48	31.986	31.566	28.950	28.550	24.997	30.815	28.794	31.905
15-Oct-11,00:22:48	32.040	31.620	28.896	28.469	24.916	30.815	28.551	31.662
15-Oct-11,00:32:48	31.986	31.566	28.896	28.442	24.889	30.785	28.497	31.608
15-Oct-11,00:42:48	31.986	31.566	28.761	28.361	24.808	30.764	29.874	32.985
15-Oct-11,00:52:48	31.851	31.431	28.734	28.334	24.781	30.734	27.876	30.987
15-Oct-11,01:02:48	31.824	31.404	28.788	28.334	24.781	30.734	29.658	32.769
15-Oct-11,01:12:48	31.878	31.458	28.734	28.253	24.700	30.693	28.551	31.662
15-Oct-11,01:22:48	31.824	31.404	28.653	28.361	24.808	30.703	27.309	30.420

Table A.13: Sample data for week two temperature variation sets of data (point 9 – 16)

Channel 9 (°C)	Channel 10 (°C)	Channel 11 (°C)	Channel 12 (°C)	Channel 13 (°C)	Channel 14 (°C)	Channel 15 (°C)	Channel 16 (°C)
29.166	25.888	29.794	27.550	31.870	29.483	29.662	31.342
30.651	28.373	30.631	28.387	32.707	30.320	29.682	31.362
31.461	28.183	30.847	28.603	32.923	30.536	29.591	31.271
31.029	27.751	30.685	28.441	32.761	30.374	29.458	31.138
30.732	27.454	30.550	28.306	32.626	30.239	29.325	31.005
30.516	27.238	30.469	28.225	32.545	30.158	29.223	30.903
30.489	27.211	30.226	27.982	32.302	29.915	29.132	30.812
30.327	27.049	30.145	27.901	32.221	29.834	29.091	30.771
30.057	26.779	30.037	27.793	32.113	29.726	29.050	30.730
29.895	26.617	29.956	27.712	32.032	29.645	28.999	30.679
29.760	26.482	29.713	27.469	31.789	29.402	28.948	30.628
29.760	26.482	29.659	27.415	31.735	29.348	28.928	30.608
29.679	26.401	29.524	27.280	31.600	29.213	28.887	30.567
29.382	26.104	29.524	27.280	31.600	29.213	28.877	30.557
29.463	26.185	29.416	27.172	31.492	29.105	28.826	30.506
29.382	26.104	29.389	27.145	31.465	29.078	28.805	30.485
29.382	26.104	29.308	27.064	31.384	28.997	28.785	30.465
29.139	25.861	29.146	26.902	31.222	28.835	28.744	30.424
29.139	25.861	29.065	26.821	31.141	28.754	28.713	30.393
29.085	25.807	29.173	26.929	31.249	28.862	28.703	30.383
29.031	25.753	28.795	26.551	30.871	28.484	28.693	30.373
29.085	25.807	28.849	26.605	30.925	28.538	28.703	30.383
29.139	25.861	28.849	26.605	30.925	28.538	28.703	30.383
29.193	25.915	28.795	26.551	30.871	28.484	28.703	30.383
29.085	25.807	28.633	26.389	30.709	28.322	28.734	30.414
29.220	25.942	28.552	26.308	30.628	28.241	28.764	30.444
29.139	25.861	28.633	26.389	30.709	28.322	28.775	30.455
29.085	25.807	28.498	26.254	30.574	28.187	28.754	30.434
29.085	25.807	28.417	26.173	30.493	28.106	28.775	30.455
29.085	25.807	28.417	26.173	30.493	28.106	28.724	30.404
28.977	25.699	28.363	26.119	30.439	28.052	28.703	30.383
29.031	25.753	28.282	26.038	30.358	27.971	28.703	30.383
28.977	25.699	28.255	26.011	30.331	27.944	28.673	30.353
28.977	25.699	28.174	25.930	30.250	27.863	28.652	30.332
28.842	25.564	28.147	25.903	30.223	27.836	28.622	30.302
28.815	25.537	28.147	25.903	30.223	27.836	28.622	30.302
28.869	25.591	28.066	25.822	30.142	27.755	28.581	30.261
28.815	25.537	28.174	25.930	30.250	27.863	28.591	30.271

Table A.14: Sample data for week three temperature variation sets of data (point 1 – 11)

Time(hh:mm:ss)	Channel 1 (°C)	Channel 2 (°C)	Channel 3 (°C)	Channel 4 (°C)	Channel 5 (°C)	Channel 6 (°C)	Channel 7 (°C)	Channel 8 (°C)	Channel 9 (°C)	Channel 10 (°C)	Channel 11 (°C)
28-Oct-11,17:39:30	30.594	28.478	29.801	34.428	25.373	34.158	33.888	34.59	34.86	27.83	34.185
28-Oct-11,17:49:30	30.351	28.883	29.666	34.374	25.319	34.104	33.726	34.482	34.968	26.291	34.131
28-Oct-11,17:59:30	30.27	28.451	29.585	34.239	25.238	33.942	33.699	34.374	33.888	25.373	33.132
28-Oct-11,18:09:30	29.612	28.937	29.477	34.212	25.238	33.807	33.51	34.185	33.726	25.481	32.565
28-Oct-11,18:19:30	30.027	28.181	29.477	33.996	25.13	33.726	33.456	34.158	33.699	25.805	32.781
28-Oct-11,18:29:30	29.639	28.424	29.342	33.942	24.941	33.537	33.24	33.969	33.699	25.913	32.565
28-Oct-11,18:39:30	30.027	28.424	29.288	33.78	24.914	33.483	33.24	33.969	33.402	26.048	32.538
28-Oct-11,18:49:30	30.189	28.181	29.288	33.753	24.806	33.348	33.078	33.888	33.267	25.805	32.403
28-Oct-11,18:59:30	29.531	28.073	29.207	33.699	24.752	33.375	33.105	33.834	33.132	25.697	32.241
28-Oct-11,19:09:30	29.234	28.64	29.153	33.51	24.752	33.294	33.051	33.726	33.105	25.724	32.16
28-Oct-11,19:19:30	29.477	28.397	29.018	33.564	24.59	33.132	32.943	33.618	32.862	25.562	32.106
28-Oct-11,19:29:30	29.693	27.884	29.018	33.591	24.644	33.186	32.862	33.645	32.727	25.589	31.836
28-Oct-11,19:39:30	30	28.397	29.018	33.429	24.482	33.132	32.754	33.564	32.7	25.589	31.836
28-Oct-11,19:49:30	29.747	27.884	28.775	33.294	24.32	32.97	32.7	33.51	32.727	25.454	31.809
28-Oct-11,19:59:30	29.666	28.397	28.883	33.24	24.293	32.889	32.673	33.456	32.457	25.427	31.674
28-Oct-11,20:09:30	29.639	27.965	28.775	33.186	24.239	32.835	32.511	33.321	32.349	25.427	31.647
28-Oct-11,20:19:30	29.477	28.262	28.775	33.267	24.266	32.97	32.538	33.429	32.241	25.265	31.458
28-Oct-11,20:29:30	29.18	27.776	28.721	33.132	24.104	32.754	32.457	33.294	32.241	25.373	31.485
28-Oct-11,20:39:30	28.721	27.965	28.667	32.997	23.942	32.619	32.376	33.186	32.268	25.265	31.539
28-Oct-11,20:49:30	28.505	27.587	28.559	32.997	23.915	32.592	32.349	33.24	32.079	25.076	31.377
28-Oct-11,20:59:30	28.775	27.722	28.478	32.889	23.78	32.511	32.214	33.051	32.079	25.13	31.431
28-Oct-11,21:09:30	28.586	27.263	28.424	32.889	23.861	32.592	32.295	33.078	32.052	24.968	31.323
28-Oct-11,21:19:30	28.559	28.1	28.424	32.862	23.78	32.403	32.16	33.024	32.106	24.995	31.323
28-Oct-11,21:29:30	28.613	27.29	28.451	32.835	23.645	32.43	32.106	33.051	31.971	24.833	31.269
28-Oct-11,21:39:30	28.613	27.344	28.424	32.916	23.645	32.403	31.971	33.024	31.971	24.752	31.296
28-Oct-11,21:49:30	28.046	27.533	28.343	32.889	23.618	32.457	32.079	33.078	31.89	24.671	31.161
28-Oct-11,21:59:30	28.451	27.695	28.289	32.673	23.483	32.268	31.998	32.943	31.809	24.536	31.08
28-Oct-11,22:09:30	28.1	27.641	28.181	32.592	23.375	32.214	31.917	32.835	31.836	24.59	31.161
28-Oct-11,22:19:30	27.965	27.587	28.181	32.592	23.429	32.133	31.89	32.808	31.755	24.455	31.026
28-Oct-11,22:29:30	28.424	26.993	28.073	32.619	23.213	32.133	31.89	32.781	31.647	24.536	30.972
28-Oct-11,22:39:30	28.208	27.128	28.019	32.511	23.267	32.025	31.836	32.781	31.647	24.266	30.945
28-Oct-11,22:49:30	28.073	27.344	28.073	32.565	23.186	32.079	31.863	32.808	31.701	24.212	30.918
28-Oct-11,22:59:30	28.046	27.371	27.992	32.484	22.997	31.971	31.728	32.7	31.566	24.212	30.864
28-Oct-11,23:09:30	27.668	27.533	28.073	32.484	23.024	31.863	31.62	32.646	31.566	24.023	30.81
28-Oct-11,23:19:30	27.965	27.695	27.911	32.565	22.997	31.917	31.728	32.727	31.404	23.861	30.756
28-Oct-11,23:29:30	28.127	27.155	27.83	32.349	22.943	31.836	31.674	32.565	31.458	23.753	30.729
28-Oct-11,23:39:30	27.776	27.128	27.965	32.403	22.889	31.836	31.647	32.673	31.377	23.834	30.783
28-Oct-11,23:49:30	27.938	27.128	27.911	32.349	22.808	31.836	31.674	32.7	31.35	23.726	30.783

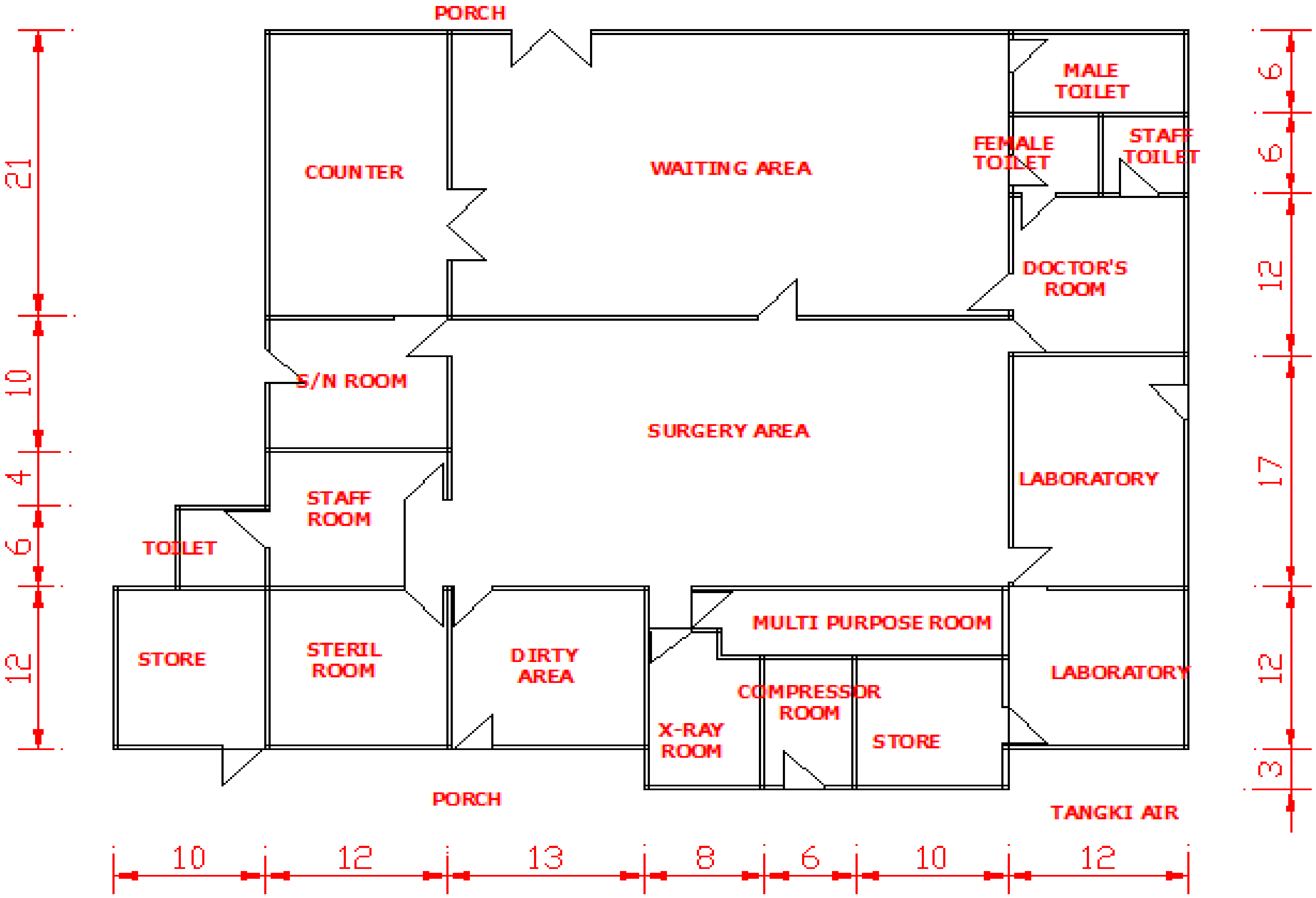

Figure A.1: Top view of Batu Gajah Dental Clinic

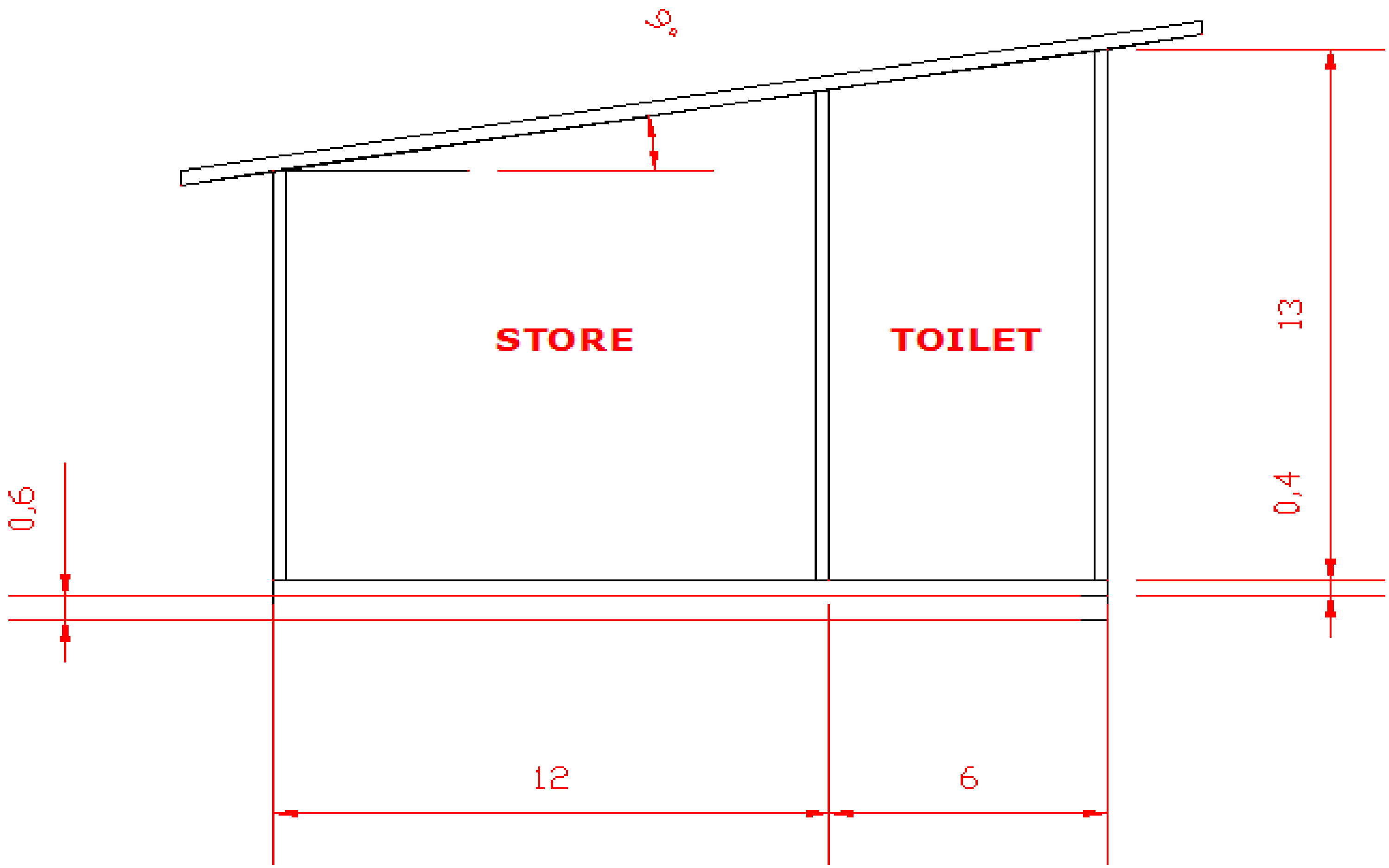

Figure A.2: Side view of Batu Gajah Dental Clinic

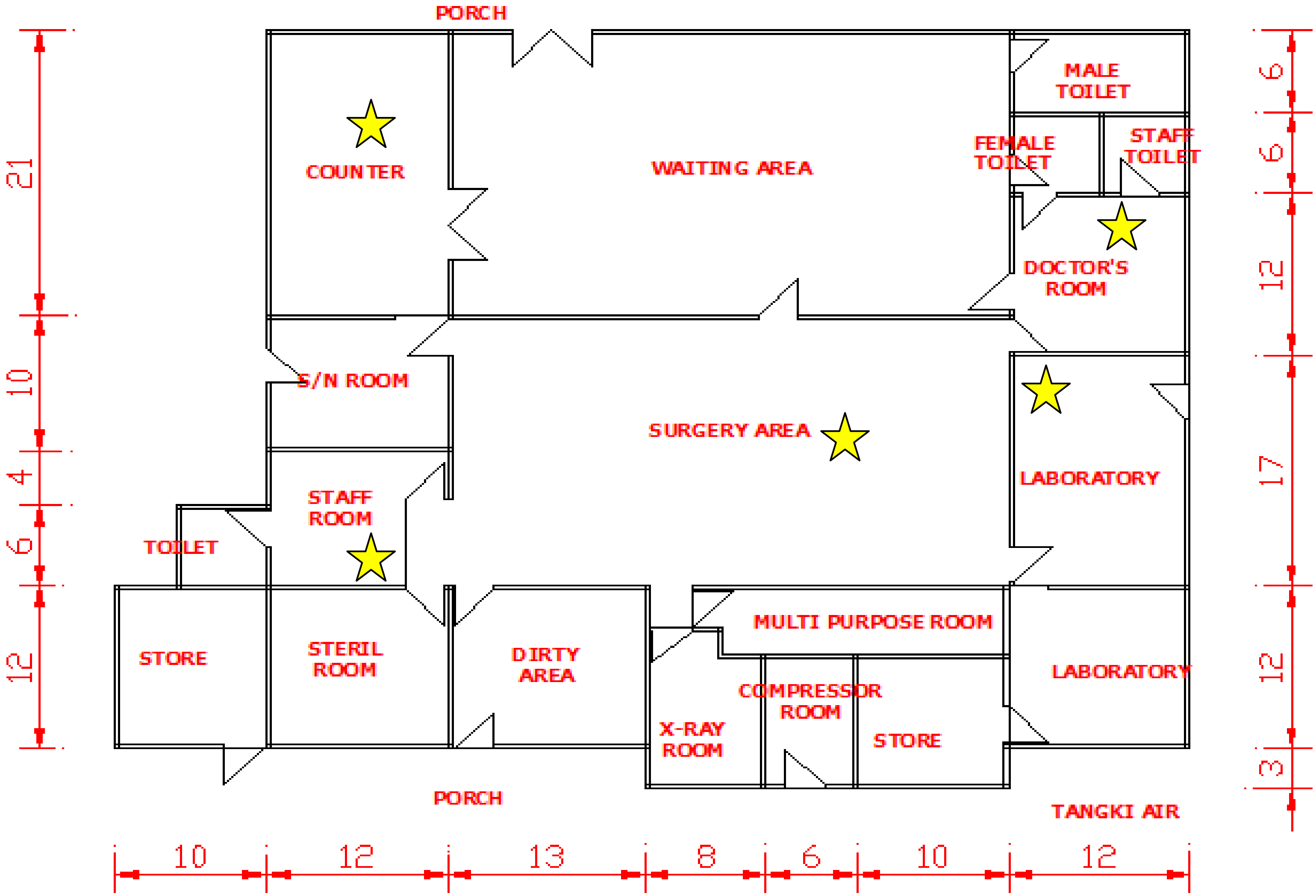

Figure A.3: Rooms in the dental clinic equipped with air conditioners

☆ = indicate rooms with air conditioners

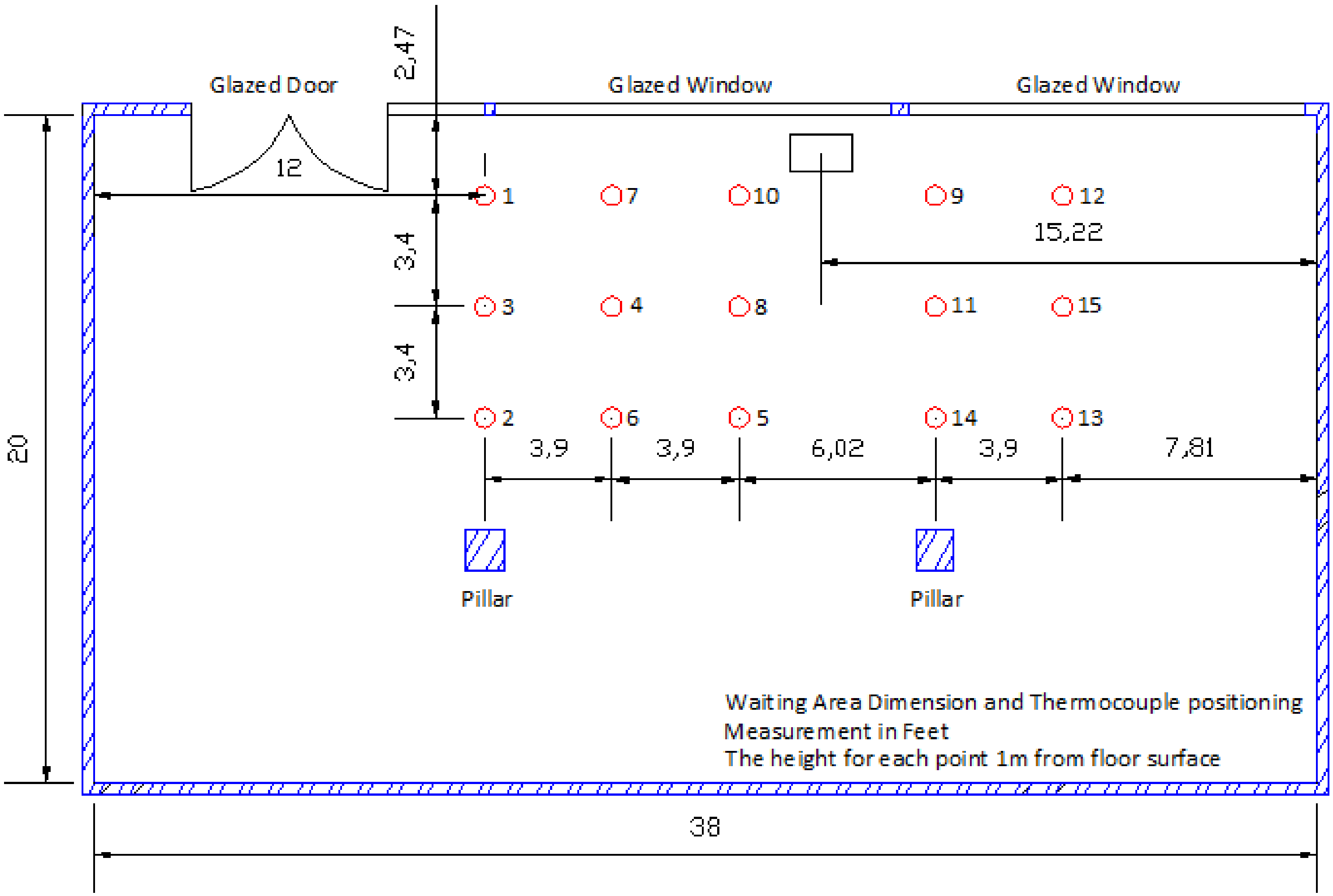

Figure A.4: Final placement of the thermocouple for 3 weeks temperature logging

Appendix A.1: Approved permission letter from the Ministry Of Health

BAHAGIAN KESIHATAN PERGIGIAN
KEMENTERIAN KESIHATAN MALAYSIA
ARAS 5, BLOK E10, KOMPLEKS E
PUSAT PENTADBIRAN KERAJAAN PERSEKUTUAN
62590 W.P PUTRAJAYA

TEL : 03 - 88833888 (OPERATOR)
03 - 88834215
03 - 88834216
FAX : 03 - 88886133

Our Ref. : (8)dlm.KKM-60(13 /9)/1 Jld 1

Date : 26 August 2011

Assoc. Prof. Ir. Dr. Shaharin Anwar bin Sulaiman
Department of Mechanical Engineering
Universiti Teknologi PETRONAS
31750 Tronoh
Perak

Dear Sir,

PERMISSION TO CONDUCT RESEARCH PROJECT *KLINIK PERGIGIAN BATU GAJAH*

With reference to your letter dated 25th August 2011, I am pleased to inform you that approval is granted for conduct or the research project at Klinik Pergigian Batu Gajah by your student, Muhammad Nazree bin Alehan.

We would appreciate if the above student can provide us his feedback concerning findings relevant to data collected from our facilities.

Thank you.

Yours Sincerely,

(DATO' DR. NORAIN BINTI ABU TALIB)
Principal of Director
Oral Health Division
Ministry of Health Malaysia

s.k. Timbalan Pengarah Kesihatan Negeri
(Pergigian) Perak

Dr. Yaw Siew Lian
Deputy Director
Oral Health Division
Ministry of Health Malaysia

(Sila catatkan rujukan surat ini apabila menjawab)

Appendix A.2: Thermal comfort survey form

Survey: Level of comfort in the waiting area of Clinic PergigianBatu Gajah

Date : ....
Time : ....

Please circle **only one answer** and do provide any comments if needed.

1) How do you feel now?
    1) Extremely cool
    2) Too cool
    3) Comfortably cool
    4) Comfortable
    5) Comfortably warm
    6) Too Warm
    7) Extremely warm

2) Do you feel comfortable in the waiting area?
    (1) Yes
    (2) Uncomfortable
    (3) Sometime uncomfortable
    (4) Others:……………………………………………………………………………………
    ……………………………….

3) Approximate time waiting your turn for the surgery.
    Comment: ………………….minutes or …………………….hours

4) Are the ventilation system and the fans in the waiting area enough and functionally well?
    (1) Enough and satisfied
    (2) Not enough and not satisfied
    (3) Others:……………………………………………………………………………………
    ……………………………….

5) The waiting become warmer and uncomfortable for the patients and peoples once the number of peoples coming into the waiting area increased?
    (1) Agree
    (2) Not Agree
    (3) Neither one
    (4) Others:……………………………………………………………………………………
    ……………………………….

6) Your opinion if all the fans were replaced by air conditioners?
    (1) Agree. Reasons:
    ………………………………………………………………………………………………
    ……………………………………..……………………………………………………
    (2) Not Agree. Reasons:
    ………………………………………………………………………………………………
    ……………………………………..……………………………………………………
    Others:……………………………………………………………………………………
    …………………………….

Note: *This survey is one of the steps required in this final year project conduct by the mechanical engineering final year student UniversitiTeknologiPetronas (UTP). The purpose of this survey is to identify the level of comfort in the waiting area of KlinikPergigianBatu Gajah. Thank you for the corporation on completing this survey.*

Appendix A.3: Energy Plus simulation result

Program Version:**EnergyPlus 2.2.0.023, 23/12/2011 11:22 AM**
Tabular Output Report in Format: **HTML**
Building: **Batu Gajah Dental Clinic**
Environment: **KUALA LUMPUR - MYS IWEC Data WMO#=486470**
Simulation Timestamp: **2011-12-23 11:22:58**

Table of Contents
Report: **Annual Building Utility Performance Summary**
For: **Entire Facility**
Timestamp: **2011-12-23 11:22:58**
Values gathered over 8760.00 hours

Site and Source Energy

	Total Energy (GJ)	Energy Per Total Building Area (MJ/m2)	Energy Per Conditioned Building Area (MJ/m2)
Total Site Energy	272.66	1077.77	1077.77
Net Site Energy	272.66	1077.77	1077.77
Total Source Energy	454.03	1794.70	1794.70
Net Source Energy	454.03	1794.70	1794.70

Building Area

	Area (m2)
Total Building Area	252.98
Net Conditioned Building Area	252.98