بِسْمِ ٱللَّهِ ٱلرَّحْمَٰنِ ٱلرَّحِيمِ

Sudan University of Science & Technology

Faculty of Engineering

Mechanical Engineering Department

(Power)

Selecting the best type of an air conditioning system for three floors building using (CHVAC) software

Thesis Submitted in Partial Fulfilment of the Requirements for the Degree of Bachelor of Engineering. (B.Eng. Honor)

Prepared By:

1. **Alwalid El fadol obaid Mohammed**
2. **Ayman Shams Eldin Eltayeb**
3. **Waddah abdul Rahman Mohammed**

Supervised By:

Dr. Ehab Abdel Raouf

October 2017

الآيـــــة

قال الله تعالى:

((وَقَضَى رَبُّكَ أَلاَّ تَعْبُدُواْ إِلاَّ إِيَّاهُ وَبِالْوَالِدَيْنِ إِحْسَانًا إِمَّا يَبْلُغَنَّ عِندَكَ الْكِبَرَ أَحَدُهُمَا أَوْ كِلاَهُمَا فَلاَ تَقُل لَّهُمَآ أُفٍّ وَلاَ تَنْهَرْهُمَا وَقُل لَّهُمَا قَوْلاً كَرِيمًا . وَاخْفِضْ لَهُمَا جَنَاحَ الذُّلِّ مِنَ الرَّحْمَةِ وَقُل رَّبِّ ارْحَمْهُمَا كَمَا رَبَّيَانِي صَغِيرًا. رَّبُّكُمْ أَعْلَمُ بِمَا فِي نُفُوسِكُمْ إِن تَكُونُواْ صَالِحِينَ فَإِنَّهُ كَانَ لِلأَوَّابِينَ غَفُورًا)).

الإسراء (23-25)

Dedication

"Success or failure is own decisions"

Every challenging work needs self-efforts as well as guidance of elders especially those who were very close to our heart.

My humble effort I dedicate to my " family and friends " whose affection, love, encouragement and prays of day and night make me able to get such success and honor.

Along with all hard working and respected Teachers

Acknowledgement

Much of this work would have been impossible without the support, help and suggestions from our families and Teachers. In particular, we wish to thank **Dr. Ehab Abdel Raouf** for his efforts to give us the keys of this knowledge step by step and for his encouragement also **Eng. Yousif Ahmed Abdelkarim** who are responsible for the practical part of this project and for his encouragement and support throughout the preparation of this project .

We also wish to remember all invisible hands of the teachers of **Mechanical Engineering (SUST)**. We are privileged to know them.

Abstract

The aim of the project was to find the suitable thermal environment and comfort for the people working within a three floors building, because there is no suitable thermal environment inside the building.

This was done by selecting the best type of an air conditioning system to operate inside the building after the cooling loads of the building were calculated using the Commercial heating, ventilating and air conditioning (CHVAC) program.

The total cooling load of the building was obtained at (250.68) kilowatts and the load values of each zones ranges from (1 - 45) kilowatts.

Comparative comparison was done between LG and Toshiba units in terms of price and annual energy consumption.

LG's split air conditioning units were selected as the best unit to operate within the building in terms of price and annual energy consumption.

التجريد

كان الهدف من البحث ايجاد البيئة والراحة الحرارية المناسبة للاشخاص العاملين داخل مبني مكون من ثلاثة طوابق وذلك لعدم وجود بيئة حرارية مناسبة داخل ذلك المبني .

تم ذلك باختيار افضل نظام تكييف لتشغيله داخل المبني بعد ان تم حساب الاحمال الحرارية للمبني باستخدام برنامج التدفئة والتهوية وتكييف الهواء التجاري.

تم الحصول علي اجمالي حمل حراري للمبني بما يعادل (250.68) كيلو واط وتتراوح قيم الاحمال الحرارية لكل فراغ من (1 - 45) كيلو واط.

نم اجراء مقارنه ما بين وحدات شركتي ال جي وتوشيبا من حيث السعر ومعدل الاستهلاك الكهربائي.

تم اختيار وحدات التكييف المنفصله لشركة ال جي كافضل وحده لتشغيلها داخل المبنى من حيث السعر ومعدل الاستهلاك الكهربائي.

Content

List of Tables

List of Figures

List of Symbols

NO.	Symbols	Meaning of Symbols
1	HVAC	Heat Ventilating and Air Conditioning
2	RH	Relative Humidity
3	W	Humidity Ratio
4	DPT	Dew Point Temperature
5	DBT	Dry Bulb Temperature
6	WBT	Wet bulb temperature
7	h	Enthalpy
8	Q	Heat Transfer Rate

9	m	Mass
10	T	Temperature
11	COP	Coefficient of Performance
12	AC	Air Conditioning
14	VRF	Variable refrigerant flow
15	VAV	Variable Air Volume
16	VRV	Variable refrigerant volume
17	T.R	Ton of Refrigeration
19	D.X	Direct expansion
21	CHVAC	Commercial Heat Ventilating and Air Conditioning
22	RHVAC	Residential Heat Ventilating and Air Conditioning
23	CLTD	Cooling Load Temperature Difference
24	RTS	Radiant Time Series
25	C	Complete
26	T-D	Temperature Difference
27	CFM	Cubic Foot per Minute
28	L/S	Liter per Second
29	Infil&vent	Infiltration and Ventilation
30	CO_2	Carbon dioxide
31	Sq.ft	Square per Foot
32	3D	Three Dimensions
33	m^2	Square meter
34	KW	Kilo Watt
35	Btu/h	British Temperature Unit per hour
36	KW/h	Kilo Watt per hour
37	E.Room	Electric Room

38	P.Room	Plotter and Printer Room
39	G.M.Room	General Manager Room
40	i.e	Example
41	N	North
42	WB	Wet Bulb
43	DB	Dry Bulb
44	Sq.m	Square meter
45	£	British Pound
46	ASHREA	American Society of Heating ,Refrigerating and Air Conditioning Engineers
47	HVAC&R	Heating Ventilating Air Conditioning and Refrigeration
48	ACCA	Air Conditioning Contractors of America

CHAPTER ONE

(INTRODUCTION)

1-1 Introduction:

Air conditioning is an applied geometrical science that examines the determination of ways to obtain an industrial medium that achieves comfort for humans regardless of the surrounding air condition.

In the past air conditioning was considered a luxury, now considered essential because it provides, Healthy atmosphere is suitable for increased production and air conditioning for human thermal comfort.

To achieve the reasons above by select the best air conditioning system, this depends on cooling load calculations.

The Cooling load calculations are carried out to estimate the required capacity of cooling systems, which can maintain the required conditions in the conditioned space.

1-2 problem statement:

There is no suitable thermal environment inside the building for human thermal comfort.

1-3 The importance of the project:

Healthy atmosphere is suitable for increased production, and ensure human thermal comfort.

1-4 Objective of the project:

Select the best air condoning system for three floors building which provide suitable atmosphere in the building.

1-5 Methodology:

Calculate the cooling loads by using (CHVAC) software and choose the best air conditioning system in the building.

1-6 Project layouts:

Month / Chapter	December-2016	January-2017	February-2017	March-2017	May-2017	July-2017	August-2017	September-2017
1 & 2	Introduction and Literature review							
3			Methodology					
4					Results and data analysis			
5							Conclusion and recommendations	

CHAPTER TWO

(LITERATURE REVIEW)

2-1 The meaning of air conditioning:

Is the process of altering the properties of air (primarily temperature and humidity) to more favorable conditions, more generally, air conditioning can refer to any form of technological cooling, heating, ventilation, or disinfection that modifies the condition of air.

An air conditioner (often referred to as AC) is a major or home appliance, system, or mechanism designed to change the air temperature and humidity within an area. The cooling is typically done using a simple refrigeration cycle, but sometimes evaporation is used.

2-2 History of Refrigeration and Air-conditioning:

Most evidence indicates that the Chinese were the first to store natural ice and snow to cool wine and other delicacies. Evidence indicates that ice cellars were used as early as 1000 Before Christ. in China. Early Greeks and Romans also used underground pits to store ice, which they covered with straw, weeds, and other materials to provide insulation and preserve it over a long period. The ancient people of Egypt and India cooled liquids in porous earthen jars. These jars were set out in the dry night air, and the evaporation of the liquids seeping through the porous walls provided the cooling. Some evidence indicates that ice was produced from the vaporization of water through the walls of these jars, radiating heat into the night air.

In 1823, Michael Faraday discovered that certain gases under constant pressure will condense when they cool. In 1834, Jacob Perkins, an American, developed a closed refrigeration system using liquid expansion and then compression to produce cooling. He used ether as a refrigerant, a hand-operated compressor, a water-cooled condenser, and an evaporator in a liquid cooler. He was awarded a British patent for this system.

Humidity control to accompany a new air-cooling system. He pioneered modern air-conditioning. In 1915, he, along with other engineers, founded Carrier Engineering, now known as Carrier Corporation. The Guardian Refrigerator Company had developed a refrigerator they called the "Guardian." General Motors purchased Guardian in 1919 and developed the refrigerator they named Frigidaire [1]

2-3 Previous studies:

2-3-1 Study and Design of Air Conditioning System for administration building in the Police School in Hems:

Presented by:

1- Omer elmasry
2- Mohamed sabt.

Supervised by:

Dr. Eng. Rateb Alkeng.

Publisher Country - Date:

Egypt – July 2013

Abstract:

The Department of Power Engineering at the Faculty of Mechanical and Electrical Engineering at Al-Baath University published a book which is a study and design of air conditioning system for administration building in the Police School in Hems Governorate.

The building consists of three floors containing administrative offices and bathrooms. The building is heated in winter and conditioned in summer by air to pass the air through air ducts made of galvanized sheet and bound to the two air handling units and then placing the units on the surface. As for the water coolers they are placed on the surface also, hot boilers are in the basement management.

2-3-2 Design and selection of an air conditioning system for International University of Africa Mosque:

Presented by:

1- Ahmed Mohammed Alhassan Abdellateef Mahir
2- Mohammed Yousif Altayeb Abdalla

Supervised by:

Dr.Obai Younis Taha

Publisher Country - Date:

SUDAN – July 2016

Abstract:

This project aim for designing and selecting appropriate air conditioning system technically and economically for International University of Africa Mosque in order to create and maintain a comfortable environment within the building. ELITE (CHVAC) software was used to calculate the building cooling loads system was selected according to American Society of Heating, Refrigerating and Air conditioning Engineers ASHREA standards. Results were obtained for the entire building, and the optimum system selected to ensure comfort condition economically. Free stand split system were selected with 30 units 80000BTU/H and 20 units 50000 BTU/H.

2-3-3 Selecting the best air conditioning system for Health Care Hospital using (HAP):

Prepared By:

1- Ahmed Abdulrahem Mohammed Hamad
2- Ahmed Mohammed Ali Ahmed Alawad
3- Awad Ali Hussein
4- Mohammed Eltayeb Elbashir

Supervised By:

Dr. Hassan Abdulateef Osman

Publisher Country - Date:

SUDAN – September 2015

Abstract:

This study aimed at designing and selecting the Air-Conditioning system for Health Care hospital in accordance with international specifications and to what extends do hospitals in Sudan implement these specifications, this study adopted the descriptive and analytic method. It is also based upon information collected from secondary sources, firstly a research plan was put, the literature review had been done by researcher, then the description of the hospital and data analysis had been discussed, after that it will be clear to estimating the thermal load with computer program called hourly analysis program (HAP) version 4.61and according to it the selection of the Air-Conditioning will take place.

2-4 types of an air conditioning system:

We can define two types of an air conditioning system:-

2-4-1 Comfort air conditioning system:

In institutional, commercial and residential buildings, air-conditioning systems are mainly for the occupants' health and comfort.

2-4-2 Industrial (processing) air conditioning system:

In manufacturing buildings, air-conditioning systems are provided for product processing, or for the health and comfort of workers as well as processing, and are called processing air-conditioning systems.

2-5 Cooling Loads

Cooling load calculations are carried out to estimate the required capacity of and cooling systems, which can maintain the required conditions in the conditioned space. To estimate the required cooling capacities, one has to have information regarding the design indoor and outdoor conditions, specifications of the building, and specifications of the conditioned space (such as the occupancy, activity level, various appliances and equipment used etc.) and any special requirements of the particular application [4].

2-5-1 Cooling loads definition in two types:

1) External cooling loads such as:

Walls

Windows

Ventilation and infiltration

Roofs

Floors

2) Internal cooling loads such as:

Lighting

Occupancy

Appliances

The total load of the conditioned space is the sum of external cooling loads and internal cooling loads.

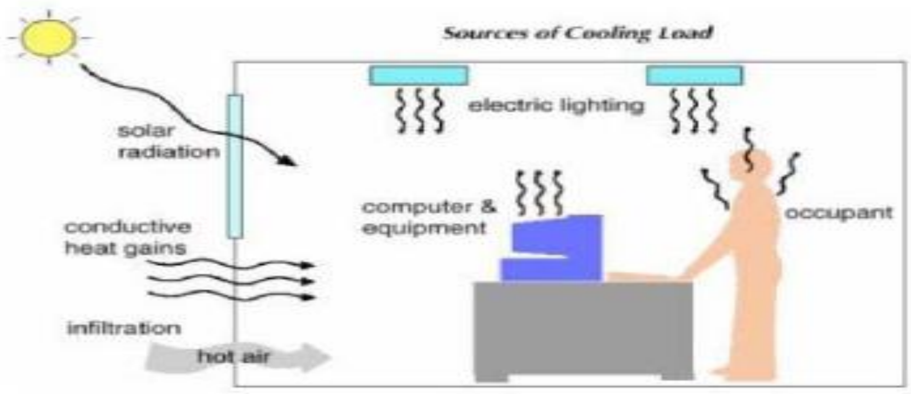


Figure (2.1): Sources of cooling loads as we classified

There is another load add on these cooling loads called system load

2-5-2 System load:

It is convection resulting from the passage of air distribution ducts inside the non-air conditioned spaces. There are other thermal loads is non-calculated as a result of air leakage between the links airway due to lack of provisions in the parts of the system, so we multiply the total cooling load in the safety factor value ranging from 5 to 20% [4].

2-5-3 External cooling loads:

2-5-3-1 Walls and roofs:

The heat gain through a wall is the sum of the relatively steady-state flow (often simply termed 'transmission') that occurs because the inside air temperature is less than that outside, and the unsteady-state gain resulting from the varying intensity of solar radiation on the outer surface of the wall. The phenomenon of unsteady-state heat flow through a wall is complicated by the fact that a wall has a thermal capacity, and so a certain amount of the heat passing through it is stored, being released to the interior (or exterior) at some later time.

Two environmental factors are to be considered when assessing the amount of heat entering the outer surface of a wall:

(a) The diurnal variation of air temperature, and

(b) The sinusoidal-type variation of solar intensity.

The heat gain through the roof is the same as the heat gain through the wall [4].

2-5-3-2 Windows:

The solar radiation which passes through a sheet of window glazing does not constitute an immediate load on the air conditioning system. This is because:

(a) Air is transparent to radiation of this kind, and

(b) A change of load on the air conditioning system is indicated by an alteration to the air temperature within the room.

For the temperature of the air in the room to rise, solar radiation entering through the window must first warm up the solid surfaces of the furniture, floor slab and walls, within the room. These surfaces are then in a position to liberate some of the heat to the air by convection. Not all the heat will be liberated immediately, because some of the energy is stored within the depth of the solid materials. There is, a decrement factor to be applied to the value of the instantaneous solar transmission through glass, and there is also a time lag to be considered. Also we must consider the window type [4].

2-5-3-3 Floor:

The heat gain from floor due to solar radiation through windows and heat transfer through walls and roofs, and the figure below show how floor give cooling load.

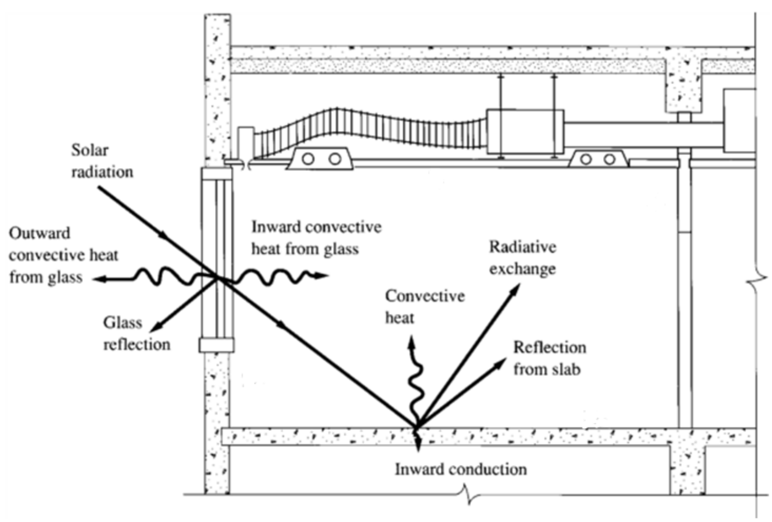


Figure (2.2): Convective and radiant heat in a conditioned space and the temperatures of the interior surfaces [3].

2-5-3-4 Infiltration and Ventilation Loads:

Infiltration is air leaks into the conditioned space through the clearance between the doors, windows and walls as a result of the external wind speed and temperature difference inside and outside the building and by opening the doors and windows, and the ventilation is the entering the amount of air into the space adapted to breathing people and to reduce the proportion of carbon dioxide and disposal of strange odors and pollution in place [4].

2-5-3-5 Infiltration Rate:

We put The air leakage into the building as a function of the degree of tightening of the doors and windows of the building and also according to the building has been divided into the premises sealed a new court buildings and doors and windows, and buildings average a medium-martial, and a weak buildings verdicts [4].

2-5-3-6 Ventilation Rate:

Ventilation is the Requirement person to fresh air needed for breathing and other vital processes and purification conditioned place of carbon dioxide resulting from the smoking, we put the amount of air needed to breathe per person as a function of the place activity [4].

2-5-4 Internal cooling loads:

2-5-4-1 Lighting:

Electric lighting is usually chosen to produce a certain standard of illumination and, in doing so, electrical energy is liberated. Most of the energy appears immediately as heat, but even the small proportion initially dissipated as light eventually becomes heat after multiple reflections and reactions with the surfaces inside the room.

The standard of illumination produced depends not only on the electrical power of the source but also on the method of light production, the area of the surfaces within the room, their color and their reflective properties. The consequence is that no straightforward relation exists between electrical power and standard of illumination. For example, fluorescent tube light fittings are more efficient than are tungsten filament lamps. This means that for a given room and furnishings, more electrical power, and hence more heat dissipation, is involved in maintaining a given standard of illumination if tungsten lamps are used [4].

2-5-4-2 Occupants:

Human beings give off heat at a metabolic rate which depends on their rate of working. The sensible and latent proportions of the heat liberated for any given activity depend on the value of the ambient dry-bulb temperature" the lower the dry-bulb temperature the larger the proportion of sensible heat dissipated [4].

2-5-4-3 Appliances:

For example In offices, the presence of personal computers with peripheral devices and the commonplace use of other electrically energized equipment, gives a significant contribution to the sensible heat gains [4].

2-6 Psychometric process

In the design and analysis of air conditioning plants, the fundamental requirement is to identify the various processes being performed on air. Once identified, the processes can be analyzed by applying the laws of conservation of mass and energy. All these processes can be plotted easily on a psychometric chart. This is very useful for quick visualization and also for identifying the changes taking place in important properties such as temperature, humidity ratio, enthalpy etc. The important processes that air undergoes in a typical air conditioning plant are discussed below. [6]

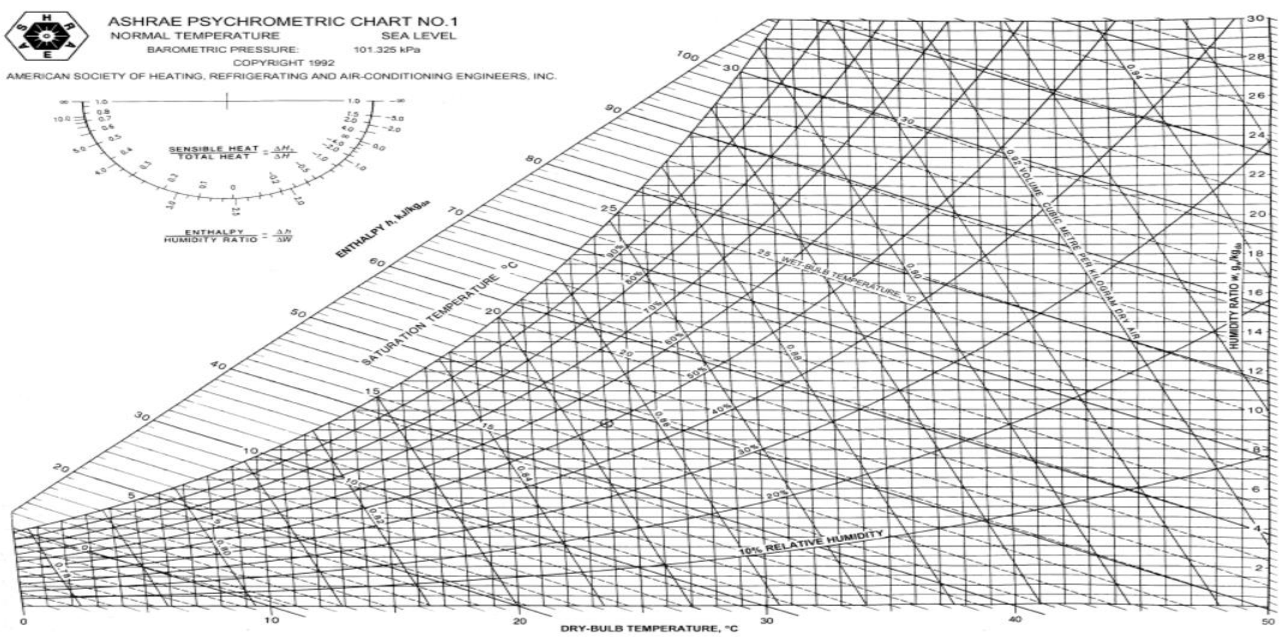


Figure (2.3): psychometric chart [7]

2-6-1 Atmospheric air

Makes up the environment in almost every type of air conditioning system ;Hence a thorough understanding of the properties of atmospheric air and the ability to analyze various processes involving air is fundamental to air conditioning design. [6]

2-6-2 Psychometric

Is the study of the properties of mixtures of air and water vapor

2-6-3 Psychometric chart

A Psychometric chart graphically represents the thermodynamic properties of moist air. Standard psychometric charts are bounded by the dry-bulb temperature line (abscissa) and the vapor pressure or humidity ratio (ordinate). The Left Hand Side of the psychometric chart is bounded by the saturation line. Figure shows the schematic of a psychometric chart. Psychometric charts are readily available for standard barometric pressure of 101.325 kPa at sea level and for normal temperatures (0-50°C). [6]

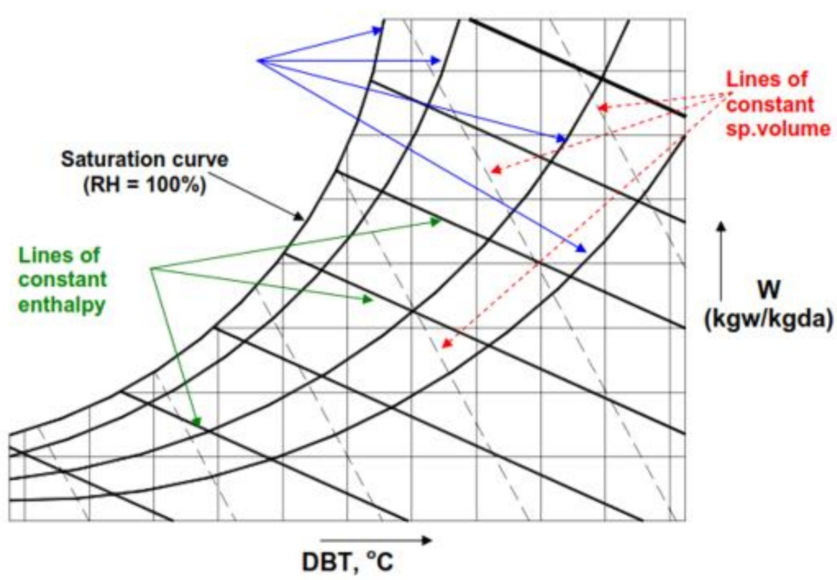


Figure (2.4): Schematic of a psychometric chart for a given barometric pressure. [6]

2-6-4 important psychometric processes:

a) Sensible cooling:

During this process, the moisture content of air remains constant but its temperature decreases as it flows over a cooling coil.

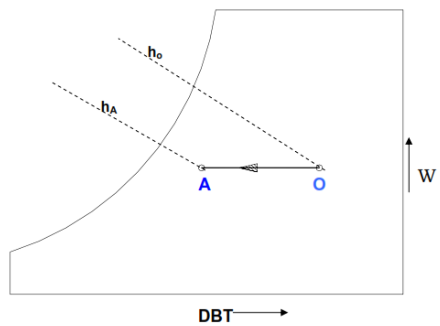


Figure (2.5): Sensible cooling process O-A on psychometric chart. [6]

b) Sensible heating (Process O-B):

During this process, the moisture content of air remains constant and its temperature increases

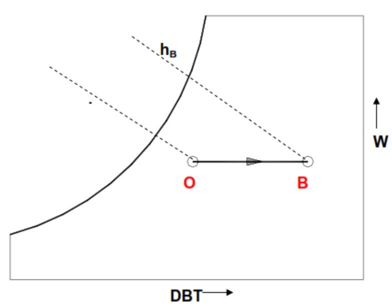


Figure (2.6): Sensible heating process on psychometric chart. [6]

c) Cooling and dehumidification (Process O-C):

When moist air is cooled below its dew-point by bringing it in contact with a cold surface as shown in Fig.2.8, some of the water vapor in the air condenses and leaves the air stream as liquid, as a result both the temperature and humidity ratio of air decreases as shown. This is the process air undergoes in a typical air conditioning system

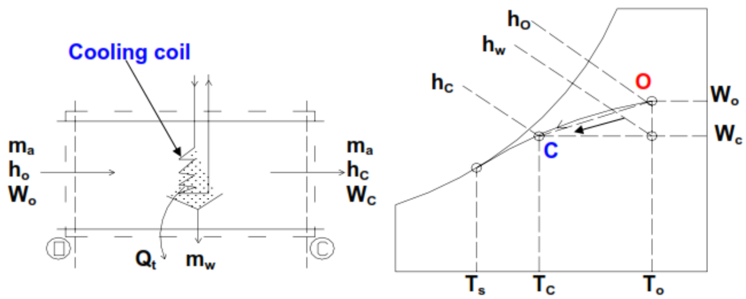


Figure (2.7): Cooling and dehumidification process (O-C). [6]

d) Heating and Humidification (Process O-D):

During winter it is essential to heat and humidity the room air for comfort. As shown in Fig.2.9, this is normally done by first sensibly heating the air and then adding water vapor to the air stream through steam nozzles as shown in the figure.

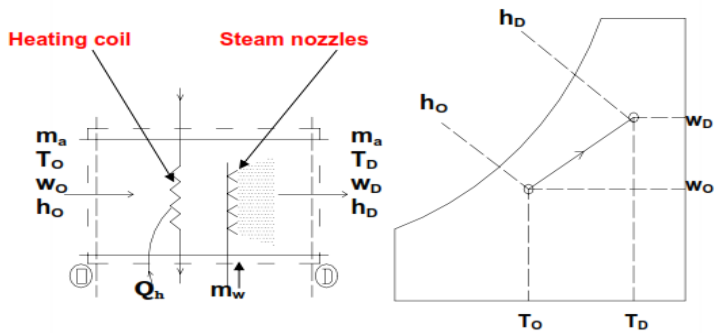


Figure (2.8): Heating and humidification process. [6]

e) Cooling & humidification (Process O-E):

As the name implies, during this process, the air temperature drops and its humidity increases. This process is shown in Fig. (2.9). as shown in the figure, this can be achieved by spraying cool water in the air stream. The temperature of water should be lower than the dry-bulb temperature of air but higher than its dew-point temperature to avoid condensation $(T_{DPT} < T_w < T_O)$.

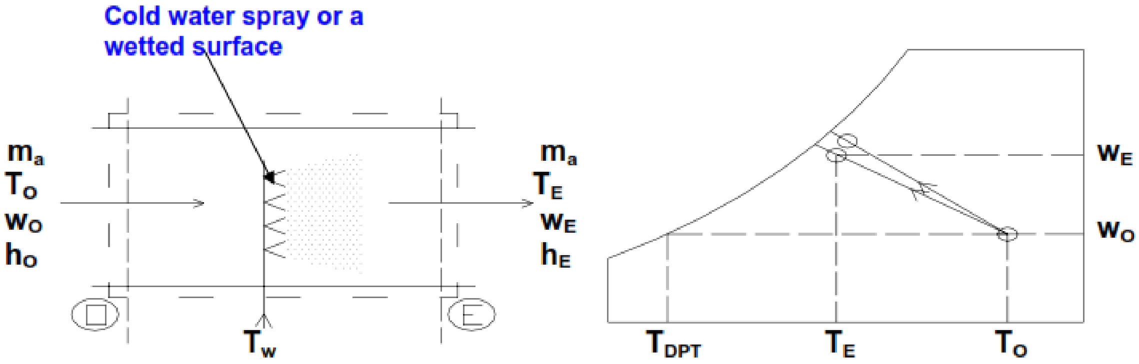


Figure (2.9): Cooling and humidification process. [6]

f) Heating and de-humidification (Process O-F):

This process can be achieved by using a hygroscopic material, which absorbs or adsorbs the water vapor from the moisture. If this process is thermally isolated, then the enthalpy of air remains constant, as a result the temperature of air increases as its moisture content decreases as shown in Fig.2.11.

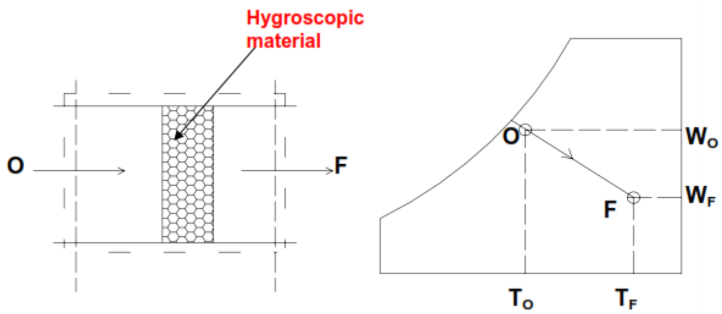


Figure (2.10): Chemical de-humidification process. [6]

g) Mixing of air streams:

Mixing of air streams at different states is commonly encountered in many processes, including in air conditioning. Depending upon the state of the individual streams, the mixing process can take place with or without condensation of moisture.

1) Without condensation:

Figure (2.11) shows an adiabatic mixing of two moist air streams during which no condensation of moisture takes place. As shown in the figure, when two air streams at state points 1 and 2 mix, the resulting mixture condition 3 can be obtained from mass and energy balance.

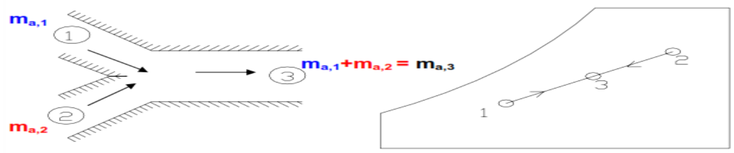


Figure (2.11): Mixing of two air streams without condensation. [6]

2) Mixing with condensation:

As shown in Fig.2.13, when very cold and dry air mixes with warm air at high relative humidity, the resulting mixture condition may lie in the two-phase region, as a result there will be condensation of water vapor and some amount of water will leave the system as liquid water. Due to this, the humidity ratio of the resulting mixture (point3) will be less than that at point 4. Corresponding to this will be an increase in temperature of air due to the release of latent heat of condensation. This process rarely occurs in an air conditioning system, but this is the phenomenon which results in the formation of fog or frost (if the mixture temperature is below 0°C). This happens in winter when the cold air near the earth mixes with the humid and warm air, which develops towards the evening or after rains. [6]

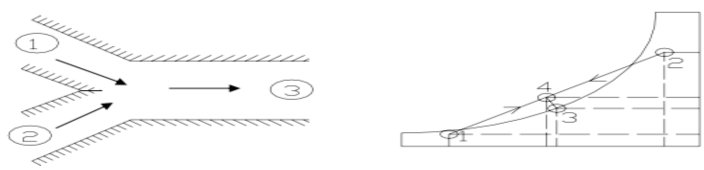


Figure (2.12): Mixing of two air streams with condensation. [6]

2-7 Air conditioning devices:

2-7-1 Window air conditioner:

These are small units of 1 TR to 3 TR cooling capacity meant for individual rooms. These may be installed on the outdoor facing wall of a room near the window or in the window frame. There is a partition in the middle of a window air conditioner, which divides it into an outer part and an inner part.

1) Component:

1) Compressor

2) Axial fan and centrifugal fan

3) Evaporator

4) Motor

5) Condenser

6) Expansion coil

2) Processes

The compressor and the air-cooled condenser are on the outer side of the partition. An axial fan sucks the outside air from its sides and throws it straight out over the condenser rejecting heat to the surroundings. The air when sucked flows over the compressor to cool it to some extent. The evaporator (a direct expansion coil) is on the inner side of the partition inside the room. The room air is sucked by a centrifugal fan, made to flow over the evaporator, cooled, dehumidified and recirculates in the room. A single motor with shaft on either side of it drives the condenser and the evaporator fans. There is a vent in the partition through which some fresh air is continuously introduced into the room. The water vapor that condenses on the direct expansion coil (condensate) is drained outside towards the condenser, where it is sprayed on the air-cooled condenser to obtain some evaporative cooling as well. The small motors are usually not very efficient; hence the (COP) of these smaller systems may be 20 to 30% less than those of the central systems. Moreover, there is no way of controlling the relative humidity precisely. Also, humidification is not possible and better filters cannot be used to clean the air properly [2].

3) Advantages

1) Small size

2) Easy to install

4) Disadvantages

The window air conditioner is usually very noisy with noise levels of 50 decibels or so. The noise emanates from the compressor and the fans [3].

Figure (2.13): Window Wall Mounted type

2-7-2 Split air conditioner:

Room air-conditioners have a cooling capacity between 1/2 to 2 tons. The split air conditioner is split at the level of partition. It has two distinct parts. The part containing the compressor and the air-cooled condenser along with a motor and a fan is mounted outside the building. This eliminates the compressor and condenser fan noise from entering the room. It is called condensing unit; it rejects heat to the surroundings and produces liquid refrigerant by condensation. The other part contains the direct expansion coil and a fan. This may be called cooling unit [2].

1) Component

1) Condenser

2) Evaporator

3) Compressor

4) Fans

5) Expansion coil

2) Processes

The liquid refrigerant from the condensing unit is brought into the room by a tube of up to 10 meter length and the vapor from the evaporator is taken out of the room by a tube of similar length and fed to the compressor. These two tubes combined together work as sub cooling heat exchanger. There is drop in pressure in both these tubes, as a result the pressure ratio of the compressor is higher for the split units and the (COP) is smaller. The condensate from the evaporator cannot be sprayed over the condenser to obtain evaporative cooling. Hence, the condenser temperature is higher which further reduces the (COP). Two separate motors are used for the two fans, which require more power. And worst of all, there is no scope of introducing fresh air into the room. The split air conditioner is recommended for private executive offices where low noise levels are required, or for interior rooms which do not have a wall facing outdoor on which window air conditioner can be mounted. The condensate from the direct expansion coil has to be drained outside by a pipe line which may get choked if not cleaned frequently [2]

3) Advantages

1) There are no supply, return, or exhaust ducts.

2) Individual air conditioning systems are the most compact, flexible, and lower in initial cost than others, except portable air conditioning units.

3) Building space is saved for mechanical rooms and duct shafts.

4) It is easier to match the requirements of an individual control zone.

5) They are quick to install.

4) Disadvantages

1) Temperature control is usually on /off, resulting in space temperature swing.

2) Air filters are limited to coarse or low-efficiency filters.

3) Local outdoor ventilation air intake is often affected by wind speed and wind direction.

4) Noise level is not suitable for critical applications.

5) More regular maintenance of coils and filters is required than for packaged and central systems [3].

Figure (2.14): split Type

2-7-3 Central Air Conditioning Systems:

The central air conditioning systems used for cooling capacities beyond 20 tons. Used when large buildings, hotels, theaters, airports, shopping malls etc. to be air conditioned completely. Common problems in this system like: Bad odor, Leaky ducts and low airflow, Low refrigerant, and Faulty wiring [2].

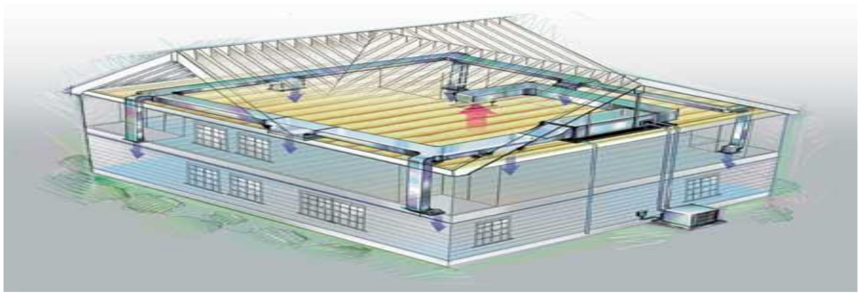


Figure (2.15): House conditioned by a central air conditioning system.

2-7-3-1 Forms of central plant systems air conditioning:

1. All Air System.
2. Air –Water System.
3. All Water System.
4. Variable Refrigerant Flow

2-7-3-2 All air systems:

As the name implies, in an all air system air is used as the media that transports energy from the conditioned space to the (AC) plant. In these systems air is processed in the (AC) plant and this processed air is then conveyed to the conditioned space through insulated ducts using blowers and fans. This air extracts the required amount of sensible and latent heat from the conditioned space. The return air from the conditioned space is conveyed back to the plant, where it again undergoes the required processing thus completing the cycle. No additional processing of air is required in the conditioned space. All air systems can be further classified into:

1. Single duct systems
2. Dual duct systems

The single duct systems can provide either cooling or heating using the same duct, but not both heating and cooling simultaneously. These systems can be further classified into:

1. Constant volume, single zone systems

2. Constant volume, multiple zone systems

3. Variable volume systems

The dual duct systems can provide both cooling and heating simultaneously.

These systems can be further classified into:

1. Dual duct, constant volume systems

2. Dual duct variable volume systems [5]

1) Advantages of all air systems:

1. All air systems offer the greatest potential for energy conservation by utilizing the outdoor air effectively.

2. By using high-quality controls it is possible to maintain the temperature and relative humidity of the conditioned space within ± 0.15oC (DBT) and ± 0.5%, respectively.

3. Using dual duct systems, it is possible to provide simultaneous cooling and heating. Changeover from summer to winter and vice versa is relatively simple in all air systems.

4. It is possible to provide good room air distribution and ventilation under all conditions of load.

5. Building pressurization can be achieved easily.

6. The complete air conditioning plant including the supply and return air fans can be located away from the conditioned space. Due to this it is possible to use a wide variety of air filters and avoid noise in the conditioned space. [5]

2) Disadvantages of all air systems:

1. They occupy more space and thus reduce the available floor space in the buildings. It could be difficult to provide air conditioning in high-rise buildings with the plant on the ground floor or basement due to space constraints.

2. Retrofitting May not always is possible due to the space requirement.

3. Balancing of air in large and particularly with variable air volume systems could be difficult. [5]

2-7-3-3 Air-water systems:

In air-water systems both air and water are used for providing required conditions in the conditioned space. The air and water are cooled a central plant. The air supplied to the conditioned space from the central plant is called as primary air, while the water supplied from the plant is called as secondary water. The complete system consists of a central plant for cooling of water and air, ducting system with fans for conveying air, water pipelines and pumps for conveying water and a room terminal. The room terminal may be in the form of a fan coil unit, an induction unit or a radiation panel. Air-water systems can simultaneously serve several conditioned spaces. [5]

1) Advantages of air-water systems:

1. Individual zone control is possible in an economic manner using room thermostats, which control either the secondary water flow rate or the secondary air (in fan coil units) or both.

2. It is possible to provide simultaneous cooling and heating using primary air and secondary water.

3. Space requirement is reduced, as the amount of primary supplied is less than that of an all air systems.

4. Positive ventilation can be ensured under all conditions.

5. Since no latent heat transfer is required in the cooling coil kept in the conditioned space, the coil operates dry and its life thereby increases and problems related to odors or fungal growth in conditioned space is avoided.

6. The conditioned space can sometimes be heated with the help of the heating coil and secondary air, thus avoiding supply of primary air during winter.

7. Service of indoor units is relatively simpler compared to all water systems [5]

2) Disadvantages of air-water systems:

1. Operation and control are complicated due to the need for handling and controlling both primary air and secondary water.

2. In general these systems are limited to perimeter zones.

3. The secondary water coils in the conditioned space can become dirty if the quality of filters used in the room units is not good.

4. Since a constant amount of primary air is supplied to conditioned space, and room control is only through the control of room cooling/heating coils, shutting down the supply of primary air to unoccupied spaces is not possible.

5. If there is abnormally high latent load on the building, then condensation may take place on the cooling coil of secondary water. [5]

2-7-3-4 All water systems:

In all water systems the fluid used in the thermal distribution system is water, i.e., water transports energy between the conditioned space and the air conditioning plant. When cooling is required in the conditioned space then cold water is circulated between the conditioned space and the plant, while hot water is circulated through the distribution system when heating is required. Since only water is transported to the conditioned space, provision must be there for supplying required amount of treated, outdoor air to the conditioned space for ventilation purposes. Depending upon the number of pipes used, the all water systems can be classified into a 2-pipe system or a 4-pipe system. A 2-pipe system is used for either cooling only or heating only application, but cannot be used for simultaneous cooling and heating. A 2-pipe system consists of two pipes – one for supply of cold/hot water to the conditioned space and the other for the return water. A cooling or heating coil provides the required cold or hot water. As the supply water flows through the conditioned space, required heat transfer between the water and conditioned space takes place, and the return water flows back to the cooling or heating coil.

A flow control valve controls the flow rate of hot or cold water to the conditioned space and thereby meets the required building heating or cooling load. The flow control valve is controlled by the zone thermostat. As already mentioned, a separate arrangement must be made for providing the required amount of ventilation air to the conditioned space. A 4-pipe system consists of two supply pipelines – one for cold water and one for hot water; and two return water pipelines. The cold and hot water are mixed in a required proportion depending upon the zone load, and the mixed water is supplied to the conditioned space. The return water is split into two streams, one stream flows to the heating coil while the other flows to the cooling coil. [5]

Heat transfer between the cold/hot water and the conditioned space takes place either by convection, conduction or radiation or a combination of these. The cold/hot water may flow through bare pipes located in the conditioned space or one of the following equipment can be used for transferring heat:

1. Fan coil units
2. Convectors
3. Radiators

A fan coil unit is located inside the conditioned space and consists of a heating and/or cooling coil, a fan, air filter, drain tray and controls. The basic components of a fan coil unit are: finned tube cooling coil, fan, air filter, insulated drain tray with provision for draining condensate water and connections for cold water lines. The cold water circulates through the finned tube coil while the blower draws warm air from the conditioned space and blows it over the cooling coil. As the air flows through the cooling coil it is cooled and dehumidified.

These are room air conditioners but use chilled water instead of refrigerant. Units can be floor or ceiling mounted.

The chilled water is piped to a finned heat exchanger as in a fan convector.

A fan blows room air across the heat exchanger and cool air is emitted into the room.

The room temperature can be controlled with low, medium and high fan speeds and chilled water flow is varied with a two-port or three-port motorized valve. [5]

A convector consists of a finned tube coil through which hot or cold fluid flows. Heat transfer between the coil and surrounding air takes place by natural convection only; hence no fans are used for moving air. Convectors are very widely used for heating applications, and very rarely are used for cooling applications.

In a radiator the heat transfer between the coil and the surrounding air is primarily by radiation. Some amount of heat is also transferred by natural convection. Radiators are widely used for heating applications, however, in recent times they are also being used for cooling applications.

1) Advantages of all water systems:

1. The thermal distribution system requires very less space compared to all air systems. Thus there is no penalty in terms of conditioned floor space. Also the plant size will be small due to the absence of large supply air fans.

2. Individual room control is possible, and at the same time the system offers all the benefits of a large central system.

3. Since the temperature of hot water required for space heating is small, it is possible to use solar or waste heat for winter heating.

4. It can be used for new as well existing buildings (retrofitting).

5. Simultaneous cooling and heating is possible with 4-pipe systems. [5]

2) Disadvantages of all water systems:

1. Requires higher maintenance compared to all air systems, particularly in the conditioned space.

2. draining of condensate water can be messy and may also create health problems if water stagnates in the drain tray. This problem can be eliminated, if dehumidification is provided by a central ventilation system, and the cooling coil is used only for sensible cooling of room air.

3. If ventilation is provided by opening windows or wall apertures, then, it is difficult to ensure positive ventilation under all circumstances, as this depends on wind and stack effects.

4. Control of humidity, particularly during summer is difficult using chilled water control valves. [5]

2-7-3-5 Variable Refrigerant Flow/Volume (VRF or VRV):

Variable Refrigerant Flow (VRF) also known as variable refrigerant volume (VRV) is a flexible method of modern air conditioning system.

The flow of refrigerant can be varied to match the cooling load as heat gains in a room fluctuate, also if reversible heat pumps are used, the heating output can be varied to match the varying heat loss in a room.

An expansion valve or control valve can reduce or stop the flow of refrigerant to each indoor unit, thus controlling its output to the room.

This type of system consists of a number of indoor units (up to 40) connected to one or more external condensing units. The overall refrigerant flow is varied using either an inverter controlled variable speed compressor, or multiple compressors of varying capacity in response to changes in the cooling or heating requirement within the air conditioned space.[5]

2-7-4 Packaged Air Conditioners Systems:

Figure (2.18): House conditioned by packaged air conditioning system.

Most future productions point to the increasing use of these systems. A single unit may serve the whole building through ductwork or without ductwork. Many units may be used in the same building connected to the same ductwork. These may be mounted on floor or on rooftop. Smaller units use hermetic compressors while larger units of 5 to 7.5 TR capacities use semi-sealed compressors so that these require minimum of maintenance [6].

The packaged air conditioners are used for cooling capacities in between 5 to 20 tons.

1) Types of Packaged Systems:

Packaged systems can be subdivided according to their configuration and operating characteristic into the following air conditioning systems:

1. Single-zone constant-volume packaged system

2. Single-zone (VAV) packaged system

3. (VAV) cooling packaged system

a) Single-Zone Constant-Volume Packaged System:

A single-zone, constant-volume packaged system is an air conditioning system that uses a packaged unit to supply and return a constant-volume flow rate of conditioned air to and from a single-zone conditioned space.

Single-zone packaged systems are widely used in residences, indoor stadiums, arenas, and many industrial applications.

A typical single-zone constant-volume packaged system consists of mainly an up flow gas furnace and a (DX) refrigeration system with: A supply fan, a gas furnace, Low and medium efficiency filters, (DX) coil, Supply and return ducts and a heating element humidifier and an exhaust / relief / return fan. [3]

b) Single-Zone (VAV) Packaged System:

In a single-zone (VAV) packaged system; zone temperature is maintained through variation of the opening of the inlet guide vanes at the supply fan inlet or the supply fan speed through a variable-speed drive. Therefore, the supply volume flow rate is varied to match the zone load variation. [3]

c) (VAV) Cooling Packaged System:

(VAV) cooling packaged system is a multi-zone air conditioning system that provides conditioned air without heating. It uses a packaged unit with (DX) cooling coils to condition the air and distribute it to various control zones through (VAV) boxes, ducts, distributing devices, and controls. The zone supply volume flow rate is modulated by the damper in the (VAV) box to match the variation of the zone sensible load to maintain a preset zone temperature. [3]

CHAPTER THREE

(METHODOLOGY)

3-1 History of Elite Software:

Elite Software is an (CHVAC) software development company almost as old as the computer industry itself. Founded in 1979, Elite Software has offered (HVAC), electrical, plumbing, and fire protection design software longer than anyone else in the industry.

Elite's flagship products, (CHVAC) and (RHVAC), were the first in the industry and remain the best to this day. The first program Elite Software ever developed, (CHVAC), was released in 1979 and was the first ASHRAE based software on the market. It was based on the (CLTD) method of the 1977 ASHRAE Handbook of Fundamentals. Elite's (RHVAC) program, released in 1984, was the first (ACCA) Manual J based software on the market and was based on the sixth edition of (ACCA) Manual J.

The Full Commercial (HVAC) Loads Calculation program (CHVAC) was designed to quickly and accurately calculate the maximum heating and cooling loads for buildings having unlimited zones and up to 100 air handlers. (CHVAC) uses the exact procedures and methods as described in the 1989 & 1993 ASHRAE Handbook of Fundamentals for the (CLTD) method, and the 2001 ASHRAE Handbook of Fundamentals for the (RTS) method.

Comprehensive reports list zone loads, outside air loads, tonnage requirements, supply air quantities, chilled water flow rates, and complete psychometric data including entering and leaving coil conditions. The program also provides features such as exterior and interior shading, internal operating load profiles, building rotation, reheat and sub-cooling calculations, positive and negative pressurization allowances.

The new building load and summary graphs provide the user with a quick graphical picture of the load distribution. The full screen editing, continuous on-line help, selectorized help and dynamic error checking make the program extremely friendly to a new user.

3-2 Two Persons behind Elite Software:

• Bill Smith - President and Founder

• Benito Flores-Meath - Senior Programmer & Network Administrator

3-3 (CHVAC) Program Basics:

Below are the basic elements of the (CHVAC) main window:

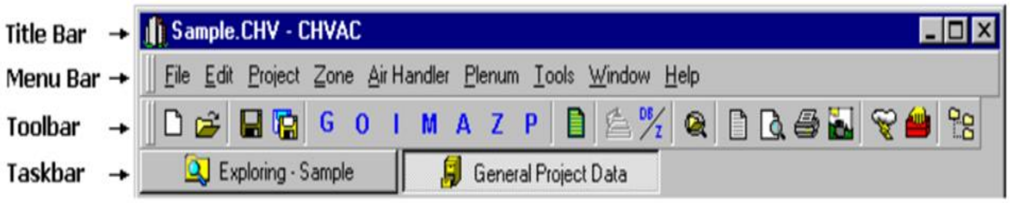


Figure (3.1): Basic elements of (CHVAC) main window

1) Title Bar: Displays the name of the current project, if a project is open. If no project is open, the caption just says, (CHVAC).

2) Menu Bar: The customizable menu provides access to all of the program's features.

3) Tool Bar: The customizable toolbar displays the items from the main menu that you will be using the most. If a project is open, most of the toolbar buttons will appear as they do in the above picture. If no project is open, several of the buttons will be grayed out.

4) Task Bar: Similar to the Windows taskbar displays a button for each open child window.

a) G: General Project Data Window

b) O: Operating Profiles Window

c) I: Indoor/Outdoor Design Conditions Window

d) M: Master Data Window

e) A: Air Handler Data Window

f) Z: Zone data Window

3-4 Program Windows:

3-4-1 General Project Data Window:

3-4-1-1 Client Window, Project Window and Company Window:

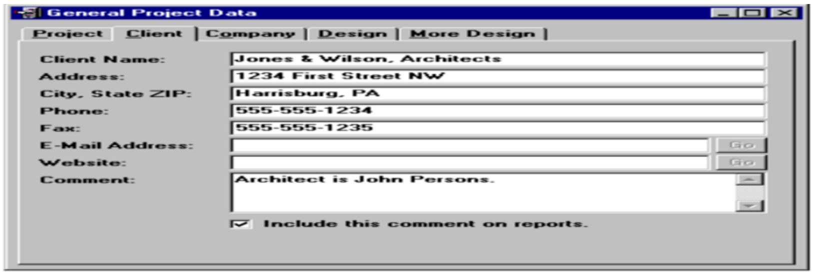


Figure (3.2): Client Window

Figure (3.3): Project Window

Figure (3.4): Company Window

These inputs are provided to let you document background information about the project, client and the company.

Note:

Units command in the project window: This input determines how (CHVAC) will interpret the information that you enter for the project.

3-4-1-2 Design Window:

Figure (3.5): Design Window

1) **Operating Profiles:** These inputs allow you to specify what operating load profile (whether for the people, lighting, or equipment) should be used by (CHVAC) to calculate the operating load per hour. If zero (0) is entered then no operating load

will be entered, and (CHVAC) will perform calculations on the basis of a 100% operating load per hour.

2) **Watts of Lighting per Square Foot (Lighting):** This input allows you to specify the Watts that you want to be added to each zone on a per square foot basis.

3) **Watts of Equipment per Square Foot (Equipment):** This input allows you to specify the Watts that you want to be added to each zone on a per square foot basis.

4) **Square feet per person:** This input allows you to indirectly specify the number of people in the zones by specifying the number of square feet per person.

5) **People diversity factor (%):** This input is used to account for people moving around in the building (by default is equal to 100%). Although the maximum number of people should be entered for each zone to insure enough supply air.

6) **Sensible heat per person:** This input accounts for sensible (dry bulb) heat contributed by people to the zones.

7) **Latent heat per person:** This input accounts for latent (wet bulb) heat contributed by people to the zones

8) **Opening hour:** This input indicates the solar hour (1-24) at which (HVAC) load calculations should be started

9) **Closing hour:** This input indicates the solar hour (1-24) at which (HVAC) load calculations should be halted

3-4-1-3 More Design Window:

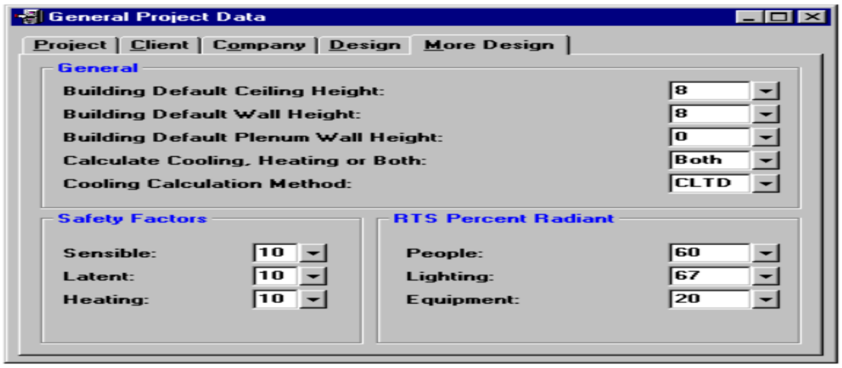


Figure (3.6): More Design Window

1) **Building Default Ceiling Height:** This input allows you to enter the average height of the ceiling in feet.

2) **Building Default Wall Height:** This input allows you to enter the average wall height for the building in feet, which acts as a default value for the building

3) **Building Default Plenum Wall Height:** This input applies only if return air plenums are going to be used in this building.

4) **Calculate Cooling, Heating or Both:** This input item allows you to specify what calculations should be performed for the project.

5) **Cooling Calculation Method:** Specifies which calculation method to use for cooling loads. The (RTS) method is described in the latest edition of the ASHRAE Handbook of Fundamentals, while the (CLTD) method is from earlier editions of the Handbook.

6) **Safety Factors:** These input items allow you to specify the percentage of the (HVAC) loads (whether it is sensible gain, latent gain, or winter heating loss) that should be added as a safety factor (always the safety factor is equal to 10 or 15).

3-4-2 Operating Profiles Window:

Opens the Operating Profiles window, which allows you to enter 24-hour in-use profiles for lighting, people and equipment.

You can enter a description for each profile to help you remember what each one should be used for.

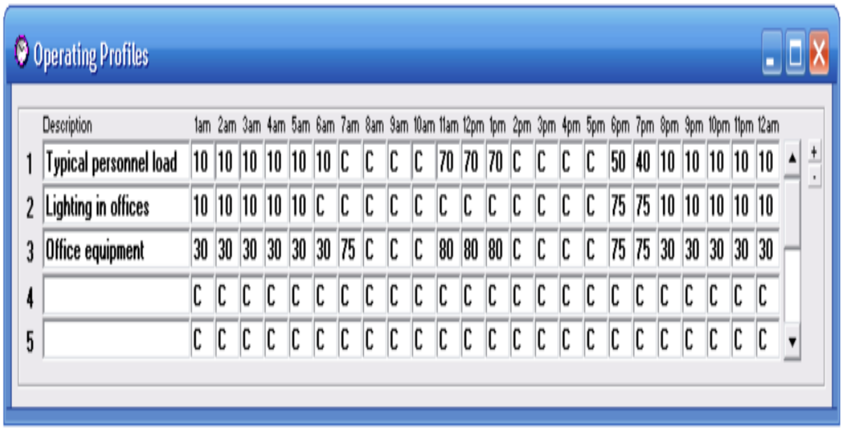


Figure (3.7): Operating Profiles Window

These inputs allow you to create people, lighting and equipment load profiles in order to reduce the cooling load for certain hours of the day. People load profiles can be thought of as occupancy schedules for the building while lighting and equipment load profiles can be thought of as operating schedules for the building.

3-4-3 Indoor/Outdoor Design Conditions Window:

Opens the Indoor/Outdoor Design Conditions window, where city weather data for the project is entered.

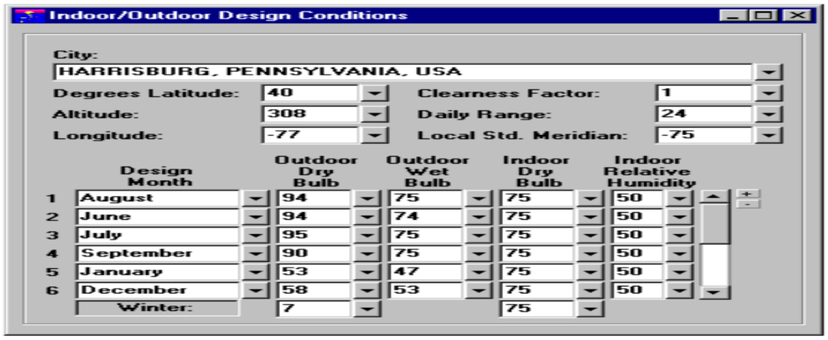


Figure (3.8): Indoor/Outdoor Design Conditions Window

1) City: Displays the city for the current project

2) Degrees Latitude: Specifies the latitude of the current city.

3) Clearness Factor: Specifies the relative amount of cloudiness of the sky at the current city, which is used to determine the solar gain for glass.

4) Altitude: Specifies the height above sea level of the current city, and allows (CHVAC) to predict the density of the air at the project location

5) Daily Range: Specifies the average difference between the daily high and daily low temperatures for a given location in the summer.

6) Longitude: The degree's longitude is used by the (RTS) calculations along with the local standard meridian in determining the sol-air temperatures throughout the day.

7) Local Standard Meridian: The local standard meridian is used by the (RTS) calculations in conjunction with the longitude in determining the sol-air temperatures throughout the day

8) Design Month: Specifies the cooling month(s) that you want the program to use in finding the peak cooling load.

9) Outdoor Dry Bulb Temperature (Outdoor Dry Bulb): Specifies the highest dry bulb temperature in degrees Fahrenheit expected during the design month specified.

10) Outdoor Wet Bulb Temperature (Outdoor Wet Bulb): Specifies the mean coincident wet bulb temperature in degrees Fahrenheit expected during the design month specified.

11) Indoor Dry Bulb Temperature (Indoor Dry Bulb): Specifies the indoor dry bulb temperature in degrees Fahrenheit that you want to maintain in the zone for cooling purposes during the specified design month.

12) Indoor Relative Humidity: Specifies the relative humidity in percent (i.e. 50 for 50%) that you want to maintain in the zone for cooling purposes during the specified month.

3-4-4 Master Data Window:

Opens the Master Data window, where global building material data for the project is entered. Note that this information is stored on a per project basis.

3-4-4-1 Roofs Window:

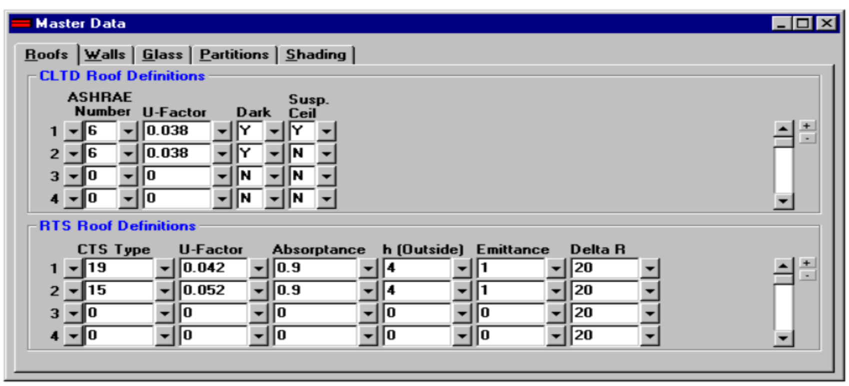


Figure (3.9): Master Data Window

The Roofs tab is used to define the Master Roof types. The characteristics of the roof are entered here, so that you only need to enter a number to indicate the appropriate roof on the Zone Data window.

a) CLTD Roof Definitions:

1) **ASHRAE Number:** In accordance with ASHRAE procedures you must select an ASHRAE roof number (1-13) that is most like this roof type. The ASHRAE roof number refers to the ability of the roof to store and radiate heat only.

2) **U-Factor:** Specifies the overall heat transfer coefficient of your roof

3) **Dark:** Enter a (Y) if the roof is dark colored or light colored and in an industrial area. Enter an (N) if the roof is light colored and in a rural area.

4) **Suspended Ceiling (Susp Ceil):** This entry is needed because the 1989 Handbook provides different cooling load temperature differences for each roof type depending on whether the roof is used with a suspended ceiling. Enter Y if the zone under this roof has a suspended ceiling, or enter an N if the zone under this roof does not have a suspended ceiling

3-4-4-2 Walls Window:

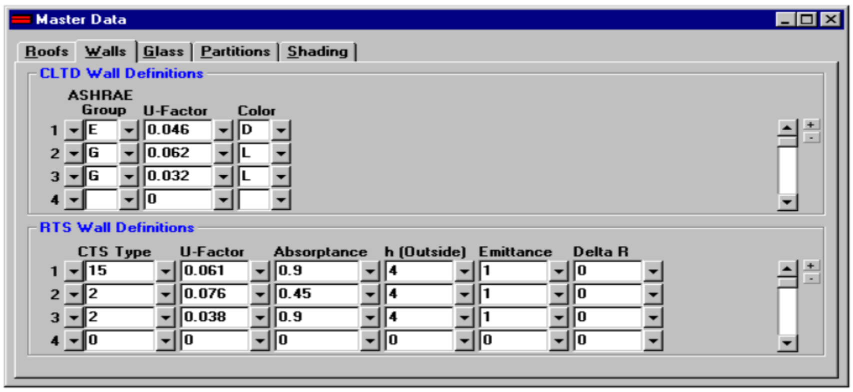


Figure (3.10): Walls Window

The Walls tab is used to define the Master Wall types. The characteristics of the wall are entered here, so that you only need to enter a number to indicate the appropriate wall on the Zone Data window.

a) CLTD Wall Definitions:

1) **ASHRAE Code:** In accordance with ASHRAE procedures you must select an ASHRAE wall group code (A-G) that is most like the actual exterior wall being defined. Your selection should be based mostly on the similarities of the ASHRAE wall construction and mass description with your wall.

2) **U-Factor:** This input allows you to enter the actual U-factor (overall heat transfer coefficient) of your wall section.

3) **Color:** This entry is used to account for the color of the wall (which affects the solar gain). Walls can be light, medium, or dark.

3-4-4-3 Glass Window:

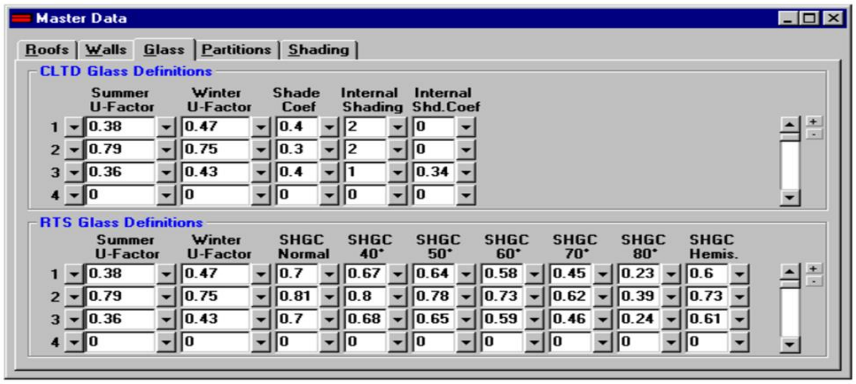


Figure (3.11): Glass Window

a) CLTD Glass Definitions:

1) **Summer U-Factor, Winter U-Factor:** Glass U-factors ideally should be obtained from the manufacturer of the specific glass to be used in the building.

2) **Shading Coefficient (Shade Coeff):** Glass shading coefficients should ideally be obtained from the manufacturer of the specific glass to be used in the building. Note that this shading coefficient is used if the glass does not have any interior shading (by default is equal to 1).

3-4-4-4 Partitions Window:

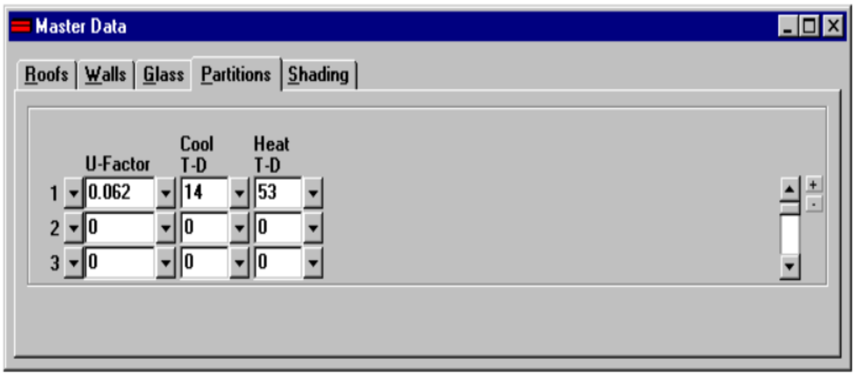


Figure (3.12): Partitions Window

A partition occurs when a wall, ceiling, or floor adjoins an unconditioned enclosed area. This entry is used when part of a zone adjoins an unconditioned, enclosed or partially vented space. (The temperature difference in summer is normally zero for floors over a vented space, since the cooling load is assumed to be zero.)

1) **U-Factor:** This input item allows you to enter the actual U-Factor (overall heat transfer coefficient) of your partition section.

2) **Cool T-D:** This input requires you to enter the temperature difference in degrees Fahrenheit across the partition for the case where the unconditioned side of the partition is at its hottest. Typically, an unconditioned space will be 3 to 10 degrees hotter than the zone.

3-4-5 Air Handler Data Window:

Opens the Air Handler Data window, where you can enter information for up to 100 different air handlers.

3-4-5-1 Main Window:

Figure (3.13): Main

1) **System Type:** If the air handling system is being used for cooling purposes then it will provide either a constant volume of air or it will be capable of varying the air volume handled. Choose 'Constant Volume' if the system provides a constant volume or choose (VAV) if the volume being provided is variable

2) **Occurrences of This Air Handler:** This entry is used to duplicate zones that access this air handler. Zones that used other air handlers would not be affected. Note that you can also duplicate individual zones at the zone level.

3) **Zone Exhaust May Not Exceed Supply:** The supply air is either calculated by the program or entered directly. In addition to the ventilation outside air, you are allowed to enter an exhaust air CFM for each zone

4) **Excess Supply Air:** This entry is used when the amount of supply air is specified is greater than required to meet the building loads. It simply tells (CHVAC) how you want to handle such a situation so that subcooling of zones is avoided.

5) **Cooling Coil:** If you would like to enter the leaving dry bulb temperature of the cooling coil, select the option 'Leaving dry bulb temperature' and enter it in the data field beside that option. A typical temperature is 55 degree Fahrenheit. If you would like to enter a relative humidity of the cooling coil, select the option 'Leaving

relative humidity' and enter it in the data field beside that option. A typical relative humidity is 95 percent. If you know the supply air the air system can provide, enter it in the data field beside the option 'Leaving cooling coil CFM'. (CHVAC) will then attempt to honor both the supply air specified and the temperature or relative humidity entered.

6) **Supply Fan:** Choose the 'Draw through' option if the supply air fan of the air handling unit draws air through the (cooling and/or heating) coil (and is located on the supply side). Choose the 'Blow through' option if the supply air fan of the air handling unit blows air through the (cooling and/or heating) coil (and is located on the return side). Choose the 'Package fan' option if the supply fan is part of a packaged unit or if no supply fan is used.

3-4-5-2 General Window:

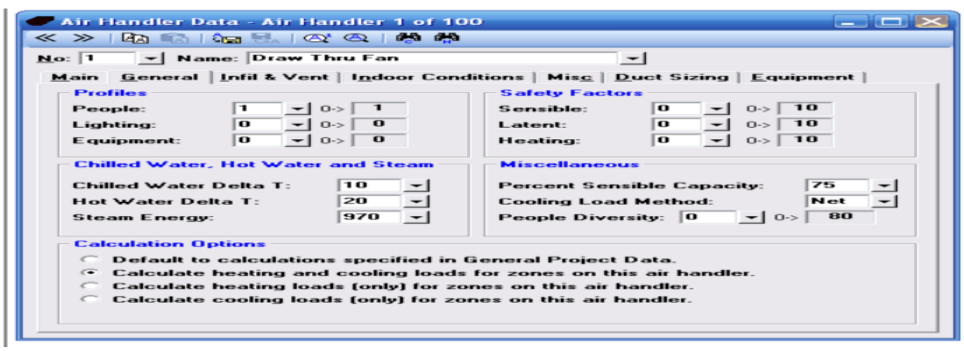


Figure (3.14): General Window

1) **Profiles:** These inputs allow you to specify what operating load profile (whether for the people, lighting, or equipment) should be used by (CHVAC) to calculate the operating load per hour. An entry of a whole number from one (1) to ten (10) indicates you want to use a load profile different from the one entered on the General Project Data window.

2) **Safety Factors:** These inputs allow you to specify what percentage of the (HVAC) loads (whether it's sensible gain, latent gain, or winter heating loss) should be added as a safety factor. An entry of a whole number from 1 to 50 indicates you want to use a safety factor different from the one entered on the General Project Data window.

3) **Calculation Options:** This input item allows you to specify what calculations should be performed for zones in this air handler.

3-4-5-3 Infil & vent Window:

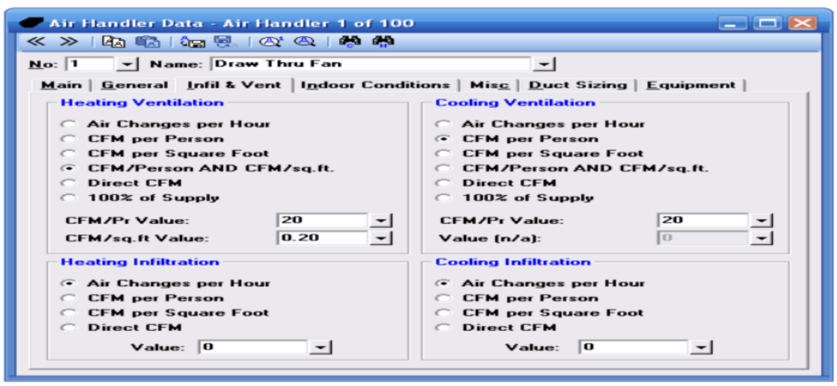


Figure (3.15): Infil & vent Window

(CHVAC) allows four different methods for adding outside air whether for ventilation or infiltration. Note that due to seasonal variations you can describe different summer (cooling) rates for both infiltration and ventilation. Ordinarily, a zone would not have both infiltration and ventilation, although (CHVAC) is capable of performing the calculations. Note that the outside air should typically be from six (6) to ten (10) percent of the total supply air for occupant comfort.

The addition of outside air imposes a load on the (HVAC) equipment that must be accounted for. If entered as infiltration rather than ventilation, the supply air requirement of the zones is increased as well. The additional heating and sensible cooling loads are determined using the design temperature differences while the latent cooling load is determined using the grains of moisture difference.

Typically, less ventilation air is needed in the winter than in the summer. The four methods are described below. Be sure that no matter which method you use, the fresh air circulating through the building is not less than 5 CFM per person to prevent CO_2 buildup.

1) **Air changes per hour:** Outside air is to be added on an air change per hour basis. If you enter in an air change per hour value, the program will multiply that value by the total volume of the structure and divide the result by 60 to determine the total CFM. Typical values ranges 0.1 to 1.0 air changes in one hour while 0.5 is most common.
2) **CFM per person:** Outside air is to be added on a CFM per person basis. Typical values range from 5 to 30 CFM per person for ventilation air while 10 CFM per person is most common.
3) **CFM per square foot**: Outside air is to be added on a CFM per square foot basis. Typical values range from 0.1 to 1.0 CFM per square foot.
4) **CFM per person AND CFM per square foot:** Outside air is added on the basis of a CFM per person value plus a CFM per square foot value. The second Value input (for CFM/sq.ft.) becomes enabled only when you select this option.
5) **Direct CFM:** This input allows you to define the exact CFM of outside air that is to be added.
6) **100% of supply:** Outside air comprises 100% of the total air supply. Note that this option is only available for Heating and Cooling Ventilation, and only on the Air Handler Data window. Also note that this is the only option that does not require a value to be entered into the Value field.

7) **Value:** Enter the number appropriate for the selected option. Note that due to seasonal variations, you can describe different summer (cooling) and winter (heating) rates for both infiltration and ventilation. Ordinarily, a system would not have both infiltration and ventilation although (CHVAC) is capable of performing the calculations. Enter a value corresponding to the option you have selected.

3-4-5-4 Indoor Conditions Window:

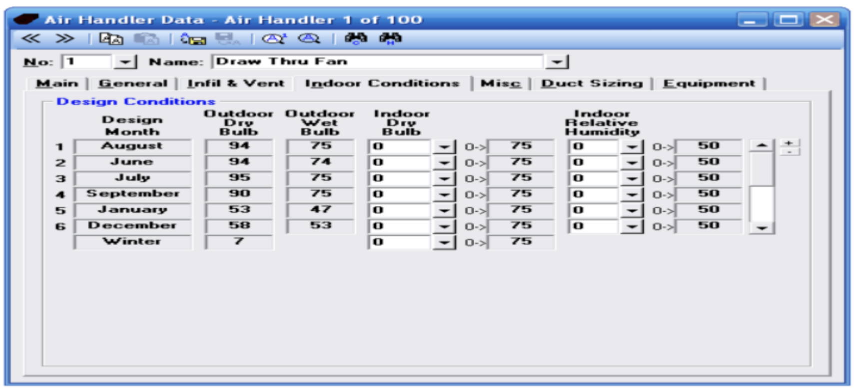


Figure (3.16): Indoor Conditions Window

1) **Design Month:** This is default information that can only be changed on the Indoor/Outdoor Design Conditions window.

2) **Outdoor Dry Bulb Temperature (Outdoor Dry Bulb):** This is default information that can only be changed on the Indoor/Outdoor Design Conditions window.

3) **Outdoor Wet Bulb Temperature (Outdoor Wet Bulb):** This is default information that can only be changed on the Indoor/Outdoor Design Conditions window.

4) **Indoor Dry Bulb Temperature (Indoor Dry Bulb):** Enter the new indoor design dry bulb temperature you want for this air handling system. If you leave this value as zero (0), the previously entered values (shown to the right) will be used. If

you enter a negative one (-1) as the value, then the indoor dry bulb temperature will be equal to zero (0). The valid range of values is from -1 to 150 degrees.

5) **Indoor Relative Humidity:** Enter the new indoor design dry bulb temperature you want for this air handling system. If you leave this value as zero (0), the previously entered values (shown in the gray box to the right of this input) will be used.

3-4-6 Zone data Window:

Opens the Zone Data window, where information about the structure is defined, including the zone dimensions, internal loads such as people and equipment, as well as the roofs, walls and glass.

3-4-6-1 Main Window:

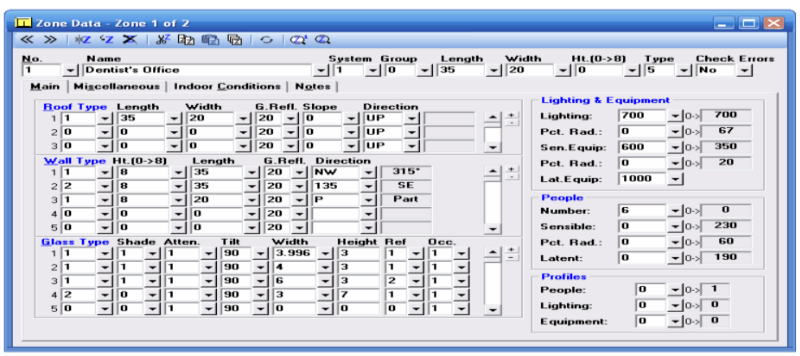


Figure (3.17): Zone Data Window

1) **No:** Displays the number of the current zone.

2) **Name:** Specifies the name of the zone.

3) **Group:** Specifies the optional (VAV) group number for this zone. This input allows you to group two or more zones together to be treated as a single space having its own peak time and airflow requirements.

4) **System:** Specifies the air handler number that this zone is supplied by.

5) **Length:** Specifies the length of the conditioned area of the zone. For a non-rectangular zone, you should enter the area in the length input and 1 in the width input. The product of the floor length and width entries should be equal to the actual floor area.

6) **Width:** Specifies the width of the conditioned area of the zone. For a non-rectangular zone, you should enter the area in the length input and 1 in the width input. The product of the floor length and width entries should be equal to the actual floor area.

7) **Height:** Specifies the ceiling height of the zone. You can leave this value as zero to use the default ceiling height shown on the General Project Data window.

8) **Type:** Specifies characteristics of the zone such as its mass, the presence of carpet and the percentage of glass area to wall area. For the (CLTD) method, this input is used only to set the room construction (Light, Medium or Heavy) in determining the solar heat gain for glass.

9) **Check Errors:** If set to yes, makes it so the program will evaluate the zone for input errors whenever you try to leave this zone, either by closing the Zone Data window, closing the program, going to another existing zone or creating a new zone.

a) Lighting & Equipment:

1) **Lighting Watts:** Specifies the Watts of lighting in the zone. You can leave this value as zero to default to using the 'Watts per square foot' entry on the General Project Data window.

2) **Pct. Rad. (Lighting Percent Sensible That Is Radiant)**: This input is required only when using the (RTS) cooling calculation method.

3) **Equipment Watts:** Specifies the Watts of equipment in the zone. You can leave this value as zero to default to using the 'Watts per square foot' entry on the General Project Data window.

4) **Pct. Rad. (Equipment Percent Sensible That Is Radiant):** This input is required only when using the (RTS) cooling calculation method.

5) **Latent Equipment Btu/h**: Specifies the latent heat due to swimming pools, fountains, cooking equipment, hair dryers, or other such items.

b) People:

1) **Number**: Specifies the number of people that will typically occupy this zone. Normally you should enter the maximum number of people you expect to occupy the zone during the cooling season.

2) **Sensible gain per person:** This value accounts for sensible (dry bulb) heat contributed by people to the zones. A default value is entered into the General Project Data window, which can be modified on a zone by zone basis. If a zero is entered for the people multipliers in the Zone Data window, the value entered into the General Project Data window will be used for that zone. The heat per person is multiplied by the number of people in each zone to determine the sensible and latent load due to people.

3) **Pct. Rad. (People Percent Sensible That Is Radiant):** This input is required only when using the (RTS) cooling calculation method

4) **Latent gain per person:** This value accounts for latent (wet bulb) heat contributed by people to the zones. A default value is entered into the General Project Data window, which can be modified on acon zone by zone basis. If a zero is entered for the people multipliers in the Zone Data window, the value entered into the General Project Data window will be used for that zone. The heat per person is

multiplied by the number of people in each zone to determine the sensible and latent load due to people.

c) Profiles:

1) People, Lighting, Equipment: These inputs allow you to specify what operating loads profile (whether for the people, lighting, or equipment) should be used by (CHVAC) to calculate the operating load per hour. An entry of a whole number from one (1) to ten (10) indicates you want to use a load profile different from the one entered on the General Project Data window or the Air Handler Data window.

d) Roofs:

1) Type: Specifies the master roof to reference from the Master Data window.

2) Length, Width: Specifies the dimensions of the roof. If the roof is not rectangular, enter its area for Length and 1 for Width. The product of the roof length and width entries should equal to the actual roof area.

3) Ground Reflectance: Specifies the percentage of sunlight being reflected up from the ground. This input affects the amount of solar heat gain produced by windows in the (CLTD) method, as well as that of walls and roofs in the (RTS) method.

4) Slope: If the roof is horizontal or if you are using the (CLTD) calculation method, then enter zero for the roof slope angle.

e) Walls & Partitions:

1) Type: Specifies the master wall or partition to reference from the Master Data window. Walls or floors that are more than 5 feet below grade should be entered as partitions. Partitions can also be used to account for extra heat losses or gains that affect the zone. Of course, a partition should always be specified when a zone adjoins an unconditioned zone.

2) **Height:** Specifies the height of the wall. You can leave this value as zero to default to the value entered for 'Default wall height' on the General Project Data window. This input is provided so that (CHVAC) can automatically compute the gross area of partitions and walls.

3) **Width:** Specifies the width (or length) of the wall. Note that (CHVAC) will automatically subtract the appropriate glass areas for each wall.

4) **Ground Reflectance:** Specifies the percentage of sunlight being reflected up from the ground. This input affects the amount of solar heat gain produced by windows in the (CLTD) method, as well as that of walls and roofs in the (RTS) method.

5) **Direction:** Specifies the direction the wall faces, or "P" for a partition, or "D" followed by the number of the containing wall for a door.

f) Glass:

1) **Type:** Specifies the master glass to reference from the Master Data window. This input is used for windows, horizontal skylights, glass walls, and glass doors.

2) **Shade:** Specifies the master shade number to use for this glass from the Master Data window. This input is used for windows, horizontal skylights, glass walls, and glass doors. If this glass does not have a shading device, leave it as zero.

3) **Tilt:** Specifies the tilt of the glass in degrees from the horizontal. For example, vertical glass would have a tilt of 90 degrees, while a horizontal skylight would have a tilt of 180 degrees. If you enter 180 degrees, the Reference input for this glass will refer to a roof.

4) **Width, Height:** Specifies the width and height of the glass section in decimal feet. The height and width are important when determining the effect of a shading device on a window. If you do not have any overhangs or fins on the window, then you can enter 1 for the width and enter the area for the height. If you do have shading devices on the window, make sure the width and height of the glass are correct.

5) **Reference (Ref):** Specifies the wall number upon which this glass section resides or the roof number if the glass is a skylight. If the glass is a skylight, the Glass Tilt must be 180 degrees. If there is a 100% glass wall then it should still be defined as glass and should reference a wall. That wall should have an area exactly equal to the net glass area

6) **Occurrences:** The normal value for this input is "1". But if you have a window or skylight that occurs several times in the same wall or roof you can enter the glass only once and enter the number of occurrences of the glass here. The maximum allowed value is 99.

After discuss how the program work we can use it in office building which is shown below:

3-5 Office Building:

3-5-1 maps:

Figure (3.18): Building 3D View

Figure (3.19): Building Dimensions (Ground Floor)

Figure (3.20): Building Dimension (First Floor)

Figure (3.21): Building Dimension (Second Floor)

3-5-2 office building information's:

[Back to appendix3]

CHAPTER FOUR

(DATA DISCUSION)

4-1 Introduction:

After entering all inputs for the building at the maximum load in the (CHVAC) program and running it, reports are given the following outputs:

1- Total air handler supply air: It is the rate of airflow that conditioning space needs.
2- Total air handler ventilation: It is the ventilation rate required by the conditioning space.
3- Total conditioned air space: It is the space to be conditioned.
4- Supply air per unit area: It is the air flow rate that each square meter of conditioning space needs.
5- Cooling capacity per area: It is the cooling capacity of the conditioning space in each square meter.
6- Area per cooling capacity: It is an inverted of cooling capacity per area.
7- Total cooling with outside air: It is the cooling capacity required by the conditioning space.

4-2 Program Reports:

The program gives separate reports for each conditioning space alone, Examples of these reports:

1- Report about the mosque on the ground floor of the building.[back to appendix4 mosque]
2- Report about the reception 0 on the ground floor of the building.[back to appendix4 reception 0]
3- Report about the g.m.room on the first floor of the building.[back to appendix4 g.m.room

4- Report about the office 2-6 on the second floor of the building.[back to appendix4 office 2-6]
5- Report about the e.room 2-1 on the second floor of the building.[back to appendix4 e.room 2-1]
6- Report about the p.room 2-1 on the second floor of the building.[back to appendix4 p.room 2-1]
7- Report about meeting room on the second floor of the building.[back to appendix4 meeting room]

The reports data differs from one area to another because the more loads the greater the required capacity and air flow rate These loads are increased by variations in walls (internal or external), Number of persons in the conditioning space, roofs exhibition for heat transfer and Data values in reports are increased as the area to be conditioned increases.

4-3 Selected Units:

Split Units selected as conditioning system in the building for the following reasons:

1- Central and packaged system can't be used because of the short wall (2.8 heights) and can't create a suspended celling.
2- Window units can't be used because of having an internal wall that window type can't fitted in it.

Split units selected based on the capacity and air flow rate from the data of the report so we form the following tables:

Table (4-1): ground floor

No.	Zone Name	Area	Total Capcity			Supply Air	
		m2	Ton	BTU/H	Kw	L/S	CFM
1	office 0-1	16	0.96	11520	3.38	163	360.4
2	office 0-2	14	0.77	9240	2.71	122	269.7
3	office 0-3	14	0.72	8640	2.53	110	243.2
4	office 0-4	22	1.3	15600	4.57	217	479.8
5	office 0-5	18	1.02	12240	3.59	178	393.6
6	office 0-6	28	1.72	20640	6.05	320	707.5
7	office 0-7	16	0.83	9960	2.92	129	285.2
8	office 0-8	16	0.91	10920	3.2	151	333.9
9	reception 0	196	8.54	102480	30	1150	2543
10	E.room 0-1	11	0.52	6240	1.83	77	170.2
11	P.room 0-1	14	0.87	10440	3.06	153	338.3
12	mosque	32	4	48000	14.1	553	1223
	Total	**397**	**22.2**	**265920**	**77.9**	**3323**	**7347**

Table (4-2): first floor

No.	Zone Name	Area	Total Capcity			Supply Air	
		m2	Ton	BTU/H	Kw	L/S	CFM
1	office 1-1	16	0.91	10920	3.2	151	333.9
2	office 1-2	14	0.77	9240	2.71	122	269.7
3	office 1-3	14	0.72	8640	2.53	110	243.2
4	office 1-4	22	1.3	15600	4.57	217	479.8
5	office 1-5	18	1.02	12240	3.59	178	393.6
6	office 1-6	28	1.72	20640	6.05	320	707.5
7	office 1-7	16	0.83	9960	2.92	129	285.2
8	office 1-8	16	0.91	10920	3.2	151	333.9
9	reception 1	196	8.54	102480	30	1150	2543
10	E.room 1-1	11	0.52	6240	1.83	77	170.2
11	P.room 1-1	14	0.87	10440	3.06	153	338.3
12	G.M.Room	32	2.21	26520	7.77	463	1024
	Total	**397**	**20.3**	**243840**	**71.5**	**3221**	**7122**

Table (4-3): second floor

No.	Zone Name	Area	Total Capcity			Supply Air	
		m2	Ton	BTU/H	Kw	L/S	CFM
1	office 2-1	16	1.3	15600	4.57	274	605.8
2	office 2-2	14	1.06	12720	3.73	217	479.8
3	office 2-3	14	1.01	12120	3.55	187	413.5
4	office 2-4	22	1.77	21240	6.23	369	815.9
5	office 2-5	18	1.35	16200	4.75	276	610.2
6	office 2-6	28	2.21	26520	7.77	460	1017
7	office 2-7	16	1.15	13800	4.04	213	470.9
8	office 2-8	16	1.25	15000	4.4	261	577.1
9	reception 2	196	12.7	152160	44.6	2233	4937
10	E.room 2-1	11	0.74	8880	2.6	135	298.5
11	P.room 2-1	14	1.15	13800	4.04	246	543.9
12	Meeting Room	32	3.49	41880	12.3	703	1554
	Total	**397**	**29.2**	**349920**	**103**	**5574**	**12324**

By using above tables we can select the units from the catalogues.

4-4 Definition of catalogue:

Is a special report of the company contains a list of all products and its specifications and prices.

4-4-1 Methods to select units from catalogues:

1- Table's data are used and compared to unit specifications in the catalogues.
2- Units are usually selected at a higher capacity and flow rate than required for the conditioning space; to ensure full and perfect conditioned for conditioning space.
3- When there are two or more units they can cover the capacity and the air flow rate, the units with the lowest operating cost and price are preferred.
4- The lower operating cost is preferred in unit selection even if the unit price is high because the building works continuously and the operating cost is a continuous cost throughout the year and the unit price is a one-time fee.

5- When there are relatively small spaces, it is preferable to use one unit instead of several units even if the operating cost is high; because of the small space and the lack of adequate facilities for the installation of units.

After following the above points, units were selected from catalogues of two different companies [back to appendix1 and appendix2] and placed in the following tables:

4-4-2 Selection of spilt type (LG Company):

Table (4-4): ground floor

No.	Zone Name	Area	Total Capcity			Supply Air		Unit Code	Model Number	Unit Quantity	Total capcity Rated	AIR flow max	TOTAL PRICE	TOTAL RUNNING COST (ANNUAL ENERGY CONSUMPTION)
		m2	Ton	BTU/H	Kw	L/S	CFM	indoor unit	outdoor unit	No.	KW	L/S	£	Kwh
1	office 0-1	16	0.96	11520	3.38	163	360.4	ASUW126MMS6	ASNW126MMS6	1	3.5	258.3	1071	132
2	office 0-2	14	0.77	9240	2.71	122	269.7	ASUW126MMS6	ASNW126MMS6	1	3.5	258.3	1071	132
3	office 0-3	14	0.72	8640	2.53	110	243.2	ASUW126MMS6	ASNW126MMS6	1	3.5	258.3	1071	132
4	office 0-4	22	1.3	15600	4.57	217	479.8	P18EL.NS2	P18EL.UL2	1	5	316.6	747	287
5	office 0-5	18	1.02	12240	3.59	178	393.6	P18EL.NS2	P18EL.UL2	1	5	316.6	747	287
6	office 0-6	28	1.72	20640	6.05	320	707.5	P24EL.NS2	P24EL.UUE	1	6.8	433.3	944	391
7	office 0-7	16	0.83	9960	2.92	129	285.2	ASUW126MMS6	ASNW126MMS6	1	3.5	258.3	1071	132
8	office 0-8	16	0.91	10920	3.2	151	333.9	ASUW126MMS6	ASNW126MMS6	1	3.5	258.3	1071	132
9	reception 0	196	8.54	102480	30	1150	2543	UJ30 NV2 1Ø	UU30W U42	4	31.2	1533.3	6044	1788
10	E.room 0-1	11	0.52	6240	1.83	77	170.2	ASUW096MMS6	ASNW096MMS6	1	2.5	258.3	915	95
11	P.room 0-1	14	0.87	10440	3.06	153	338.3	ASUW126MMS6	ASNW126MMS6	1	3.5	258.3	1071	132
12	mosque	32	4	48000	14.1	553	1223	UJ30 NV2 1Ø	UU30W U42	2	15.6	766.6	3022	894
	Total	397	22.2	265920	77.9	3323	7347			16	87.1	5174.5	18845	4534

Table (4-5): first floor

No.	Zone Name	Area	Total Capcity			Supply Air		Unit Code	Model number	Unit Quantity	Total capcity Rated	AIR flow max	TOTAL PRICE	TOTAL RUNNING COST (ANNUAL ENERGY CONSUMPTION)
		m2	Ton	BTU/H	Kw	L/S	CFM	indoor unit	outdoor unit	No.	KW	L/S	£	Kwh
1	office 1-1	16	0.91	10920	3.2	151	333.9	ASUW126MMS6	ASNW126MMS6	1	3.5	258.3	1071	132
2	office 1-2	14	0.77	9240	2.71	122	269.7	ASUW126MMS6	ASNW126MMS6	1	3.5	258.3	1071	132
3	office 1-3	14	0.72	8640	2.53	110	243.2	ASUW126MMS6	ASNW126MMS6	1	3.5	258.3	1071	132
4	office 1-4	22	1.3	15600	4.57	217	479.8	P18EL.NS2	P18EL.UL2	1	5	316.6	747	287
5	office 1-5	18	1.02	12240	3.59	178	393.6	P18EL.NS2	P18EL.UL2	1	5	316.6	747	287
6	office 1-6	28	1.72	20640	6.05	320	707.5	P24EL.NS2	P24EL.UUE	1	6.8	433.3	944	391
7	office 1-7	16	0.83	9960	2.92	129	285.2	ASUW126MMS6	ASNW126MMS6	1	3.5	258.3	1071	132
8	office 1-8	16	0.91	10920	3.2	151	333.9	ASUW126MMS6	ASNW126MMS6	1	3.5	258.3	1071	132
9	reception 1	196	8.54	102480	30	1150	2543	UJ30 NV2 1Ø	UU30W U42	4	31.2	1533.3	6044	1788
10	E.room 1-1	11	0.52	6240	1.83	77	170.2	ASUW096MMS6	ASNW096MMS6	1	2.5	258.3	915	95
11	P.room 1-1	14	0.87	10440	3.06	153	338.3	ASUW126MMS6	ASNW126MMS6	1	3.5	258.3	1071	132
12	G.M.Room	32	2.21	26520	7.77	463	1024	P18EL.NS2 + ASUW126MMS6	P18EL.UL2 + ASNW126MMS6	1 + 1	8.5	574.9	1818	419
	Total	397	20.3	243840	71.5	3221	7122			16	80	4982.8	17641	4059

Table (4-6): second floor

No.	Zone Name	Area	Total Capcity			Supply Air		Unit Code	Model Number	Unit Quantity	Total capcity Rated	AIR flow max	TOTAL PRICE	TOTAL RUNNING COST (ANNUAL ENERGY CONSUMPTION)
		m2	Ton	BTU/H	Kw	L/S	CFM	indoor unit	outdoor unit	No.	KW	L/S	£	Kwh
1	office 2-1	16	1.3	15600	4.57	274	605.8	P18EL.NS2	P18EL.UL2	1	5	316.6	747	287
2	office 2-2	14	1.06	12720	3.73	217	479.8	P18EL.NS2	P18EL.UL2	1	5	316.6	747	287
3	office 2-3	14	1.01	12120	3.55	187	413.5	P18EL.NS2	P18EL.UL2	1	5	316.6	747	287
4	office 2-4	22	1.77	21240	6.23	369	815.9	P24EL.NS2	P24EL.UUE	1	6.8	433.3	944	391
5	office 2-5	18	1.35	16200	4.75	276	610.2	P18EL.NS2	P18EL.UL2	1	5	316.6	747	287
6	office 2-6	28	2.21	26520	7.77	460	1017	P18EL.NS2 + ASUW126MMS6	P18EL.UL2 + ASNW126MMS6	1 + 1	8.5	574.9	1818	419
7	office 2-7	16	1.15	13800	4.04	213	470.9	P18EL.NS2	P18EL.UL2	1	5	316.6	747	287
8	office 2-8	16	1.25	15000	4.4	261	577.1	P18EL.NS2	P18EL.UL2	1	5	316.6	747	287
9	reception 2	196	12.7	152160	44.6	2233	4937	UJ30 NV2 1Ø	UU30W U42	6	46.8	2300	9066	2682
10	E.room 2-1	11	0.74	8880	2.6	135	298.5	ASUW126MMS6	ASNW126MMS6	1	3.5	258.3	1071	132
11	P.room 2-1	14	1.15	13800	4.04	246	543.9	P18EL.NS2	P18EL.UL2	1	5	316.6	747	287
12	Meeting Room	32	3.49	41880	12.3	703	1554	P24EL.NS2	P24EL.UUE	2	13.6	866.6	1888	782
	Total	397	29.2	349920	103	5574	12324			17	114.2	6649.3	20016	6415

4-4-3 Selection of spilt type (Toshiba Company):

Table (4-7): ground floor

No.	Zone Name	Area	Total Capcity			Supply Air		Unit Code	Model Number	Unit Quantity	Total capcity Rated	AIR flow max	TOTAL PRICE	TOTAL RUNNING COST (ANNUAL ENERGY CONSUMPTION)
		m2	Ton	BTU/H	Kw	L/S	CFM	indoor unit	outdoor unit	No.	KW	L/S	£	Kwh
1	office 0-1	16	0.96	11520	3.38	163	360.4	RAS-13PKVP-E	RAS-13PAVP-E	1	3.5	193	1545.6	385
2	office 0-2	14	0.77	9240	2.71	122	269.7	RAS-13PKVP-E	RAS-13PAVP-E	1	3.5	193	1545.6	385
3	office 0-3	14	0.72	8640	2.53	110	243.2	RAS-13PKVP-E	RAS-13PAVP-E	1	3.5	193	1545.6	385
4	office 0-4	22	1.3	15600	4.57	217	479.8	RAS-18SKV2-E	RAS-18SAV2-E1	1	5	265	1411.2	710
5	office 0-5	18	1.02	12240	3.59	178	393.6	RAS-16PKVP-E	RAS-16PAVP-E	1	4.5	207	1814.4	610
6	office 0-6	28	1.72	20640	6.05	320	707.5	RAS-13PKVP-E	RAS-13PAVP-E	2	7	386	3091.2	770
7	office 0-7	16	0.83	9960	2.92	129	285.2	RAS-13PKVP-E	RAS-13PAVP-E	1	3.5	193	1545.6	385
8	office 0-8	16	0.91	10920	3.2	151	333.9	RAS-13PKVP-E	RAS-13PAVP-E	1	3.5	193	1545.6	385
9	reception 0	196	8.54	102480	30	1150	2543	RAS-18SKV2-E	RAS-18SAV2-E1	6	30	1590	8467.2	4260
10	E.room 0-1	11	0.52	6240	1.83	77	170.2	RAS-07PKVP-E	RAS-07PAVP-E	1	2	170	1021.5	177
11	P.room 0-1	14	0.87	10440	3.06	153	338.3	RAS-13PKVP-E	RAS-13PAVP-E	1	3.5	193	1545.6	385
12	mosque	32	4	48000	14.1	553	1223	RAS-18SKV2-E	RAS-18SAV2-E1	3	15	795	4233.6	2130
	Total	397	22.2	265920	77.9	3323	7347			20	84.5	4571	29312.7	10967

Table (4-8): first floor

No.	Zone Name	Area	Total Capcity			Supply Air		Unit Code	Model Number	Unit Quantity	Total capcity Rated	AIR flow max	TOTAL PRICE	TOTAL RUNNING COST (ANNUAL ENERGY CONSUMPTION)
		m2	Ton	BTU/H	Kw	L/S	CFM	indoor unit	outdoor unit	No.	KW	L/S	£	Kwh
1	office 1-1	16	0.91	10920	3.2	151	333.9	RAS-13PKVP-E	RAS-13PAVP-E	1	3.5	193	1545.6	385
2	office 1-2	14	0.77	9240	2.71	122	269.7	RAS-13PKVP-E	RAS-13PAVP-E	1	3.5	193	1545.6	385
3	office 1-3	14	0.72	8640	2.53	110	243.2	RAS-13PKVP-E	RAS-13PAVP-E	1	3.5	193	1545.6	385
4	office 1-4	22	1.3	15600	4.57	217	479.8	RAS-18SKV2-E	RAS-18SAV2-E1	1	5	265	1411.2	710
5	office 1-5	18	1.02	12240	3.59	178	393.6	RAS-16PKVP-E	RAS-16PAVP-E	1	4.5	207	1814.4	610
6	office 1-6	28	1.72	20640	6.05	320	707.5	RAS-13PKVP-E	RAS-13PAVP-E	2	7	386	3091.2	770
7	office 1-7	16	0.83	9960	2.92	129	285.2	RAS-13PKVP-E	RAS-13PAVP-E	1	3.5	193	1545.6	385
8	office 1-8	16	0.91	10920	3.2	151	333.9	RAS-13PKVP-E	RAS-13PAVP-E	1	3.5	193	1545.6	385
9	reception 1	196	8.54	102480	30	1150	2543	RAS-18SKV2-E	RAS-18SAV2-E1	6	30	1590	8467.2	4260
10	E.room 1-1	11	0.52	6240	1.83	77	170.2	RAS-07PKVP-E	RAS-07PAVP-E	1	2	170	1021.5	177
11	P.room 1-1	14	0.87	10440	3.06	153	338.3	RAS-13PKVP-E	RAS-13PAVP-E	1	3.5	193	1545.6	385
12	G.M.Room	32	2.21	26520	7.77	463	1024	RAS-18SKV2-E + RAS-16PKVP-E	RAS-18SAV2-E1 + RAS-16PAVP-E	1 + 1	9.5	472	3225.6	1320
	Total	397	20.3	243840	71.5	3221	7122			17	79	4248	28304.7	10157

Table (4-9): second floor

No.	Zone Name	Area	Total Capcity			Supply Air		Unit Code	Model Number	Unit Quantity	Total capcity Rated	AIR flow max	TOTAL PRICE	TOTAL RUNNING COST (ANNUAL ENERGY CONSUMPTION)
		m2	Ton	BTU/H	Kw	L/S	CFM	indoor unit	outdoor unit	No.	KW	L/S	£	Kwh
1	office 2-1	16	1.3	15600	4.57	274	605.8	RAS-225SKV2-E	RAS-225SAV2-E	1	6	300	1591.8	998
2	office 2-2	14	1.06	12720	3.73	217	479.8	RAS-18SKV2-E	RAS-18SAV2-E1	1	5	265	1411.2	710
3	office 2-3	14	1.01	12120	3.55	187	413.5	RAS-16PKVP-E	RAS-16PAVP-E	1	4.5	207	1814.4	610
4	office 2-4	22	1.77	21240	6.23	369	815.9	RAS-13PKVP-E	RAS-13PAVP-E	2	7	386	3091.2	770
5	office 2-5	18	1.35	16200	4.75	276	610.2	RAS-225SKV2-E	RAS-225SAV2-E	1	6	300	1591.8	998
6	office 2-6	28	2.21	26520	7.77	460	1017	RAS-18SKV2-E + RAS-16PKVP-E	RAS-18SAV2-E1 + RAS-16PAVP-E	1 + 1	9.5	472	3225.6	1320
7	office 2-7	16	1.15	13800	4.04	213	470.9	RAS-18SKV2-E	RAS-18SAV2-E1	1	5	265	1411.2	710
8	office 2-8	16	1.25	15000	4.4	261	577.1	RAS-18SKV2-E	RAS-18SAV2-E1	1	5	265	1411.2	710
9	reception 2	196	12.7	152160	44.6	2233	4937	RAS-18SKV2-E	RAS-18SAV2-E1	9	45	2385	12700.8	6390
10	E.room 2-1	11	0.74	8880	2.6	135	298.5	RAS-13PKVP-E	RAS-13PAVP-E	1	3.5	193	1545.6	385
11	P.room 2-1	14	1.15	13800	4.04	246	543.9	RAS-18SKV2-E	RAS-18SAV2-E1	1	5	265	1411.2	710
12	Meeting Room	32	3.49	41880	12.3	703	1554	RAS-18SKV2-E	RAS-18SAV2-E1	3	15	795	4233.6	2130
	Total	397	29.2	349920	103	5574	12324			22	116.5	6098	35439.6	16441

4-5 Chooses two different companies:

Each conditioning engineer is working on a set of comparisons between companies and different units so that he can get the best results at the lowest cost. Therefore, LG and TOSHIBA have been chosen because they are one of the leading companies in the field of air conditioning in Sudan

4-5-1 The best choice between the two companies:

After doing a comparison between the two companies we find that LG is the most suitable to operate the building for the following reasons:

1- Because LG has external units operating under external operating conditions more suitable than Toshiba for the atmosphere of Sudan.

2- LG offers a range of units with different capacities compared to Toshiba, which has a limited range of units.

3- Operating costs and unit prices for LG are lower compared to Toshiba. Which, the total prices of units for the building when using LG units is equal to 56502 £ and it is less than using Toshiba units which is equal to 93057 £, also the total operating costs for the building by using LG units is equal to 15008 Kwh and it is less than using Toshiba units which is equal to 37565 Kwh.

4-6 psychometric chart:

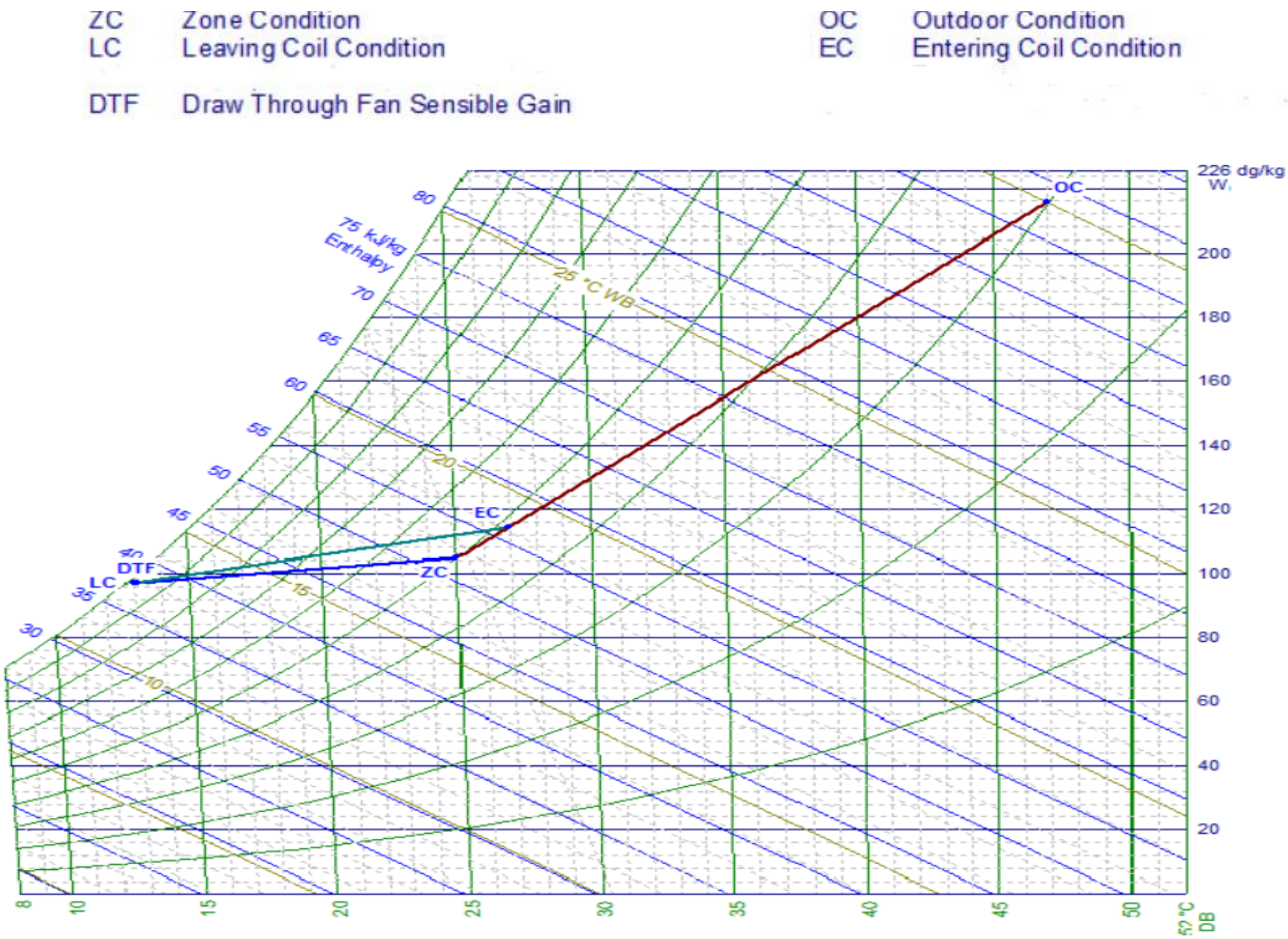


Figure (4.1): psychometric chart show the outdoor and indoor points

CHAPTER FIVE

(CONCLUSION AND RECOMMENDATIONS)

5-1 Conclusion:

- Calculated the cooling loads using the program (CHVAC) for a building consisting of three floors and obtained a total value of cooling loads of 250.68 kilowatts and the value of load for each conditioned space is between 1 to 45 kW.
- The equipment was then chosen to conditioning the building from the companies' catalogue's and to choose the most suitable equipment in terms of operating conditions, prices and energy consumption of that equipment.

5-2 Recommendations:

5-2-1 Recommendation for using central plant system:

It is preferable to use the central air conditioning system in the case of large area buildings and high wall heights instead of split unit air conditioning system to obtain some fresh air, a quiet operation and other advantages of the central air conditioning system featuring on the split unit system, so we recommend increasing the wall height

5-2-2 Recommendation to use mathematical method for load calculation:

It is preferable to use the program instead of using mathematical equations in the calculation of cooling loads in order to save time, effort and money and to reduce the potential errors in the use of mathematical methods, but we recommend to use mathematical method to make compare between two methods.

REFERENCES

References:

1) **William C. Whitman, William M. Johnson, John A. Tomczyk, Eugene Silberstein**," Refrigeration and Air Conditioning Technology, Seventh Edition", USA.[Date of publication not identified].

2) **Dr. Ramesh Chandra Arora**, "REFRIGERATION AND AIR CONDITIONING", Asoke K. Ghosh, New Delhi, 2010.

3) **Shan K. Wang**, "Handbook of air conditioning and refrigeration, Second Edition", Pamela A. Pelton, New York, 2000.

4) **د. رمضان**,"حسابات حمل التبريد",مصر [سنة النشر غير موجوده].

5) **G. L. TAYLOR,** "HVAC Inspection Notes", MCGRAW-HILL, New York, 2005.

6) **IIT KHARAGPUR, "**4O LESSONS ON REFRIGERATION AND AIR CONDITIONING", India, 2008.

7) **ASHRAE, "**ASHRAE Fundamentals", Atlanta, 2009.

APPENDIXE

Appendix 1:

LG unit's catalogue

LIBERO-S
P09RL / P12RL / P18EL / P24EL

SPECIFICATIONS						
Model	**Indoor Unit** / **Outdoor Unit**		**P09RL.NSB** / **P09RL.UA3**	**P12RL.NSB** / **P12RL.UA3**	**P18EL.NS2** / **P18EL.UL2**	**P24EL.NS2** / **P24EL.UUE**
Cooling Capacity	(Min/Rated/Max)	kW	0.89-2.50-3.70	0.90-3.50-4.04	0.90 - 5.00 - 5.53	0.90 - 6.80 - 7.42
Heating Capacity	(Min/Rated/Max)	kW	0.89-3.20-4.10	0.89 - 3.80 - 5.10	0.90 - 5.80 - 6.44	0.90 - 8.00 - 8.64
Annual Energy Consumption	Cooling/Heating	kWh	141 / 1179	201 / 1400	287 / 1435	391 / 2027
Energy Efficiency Class	Cooling/Heating		A++ / A	A++ / A	A++ / A+	A++ / A
Air Flow Rate	Indoor,Max	m3/min	12		19	26
	Outdoor,Max	m3/min	27		32	50
Operation Range	Cooling(Outdoor)	°C	-10-48		-10-48	-10-48
	Heating(Outdoor)	°C	-10-24		-10-24	-10-48
List Price	**Indoor**		£175	£190	£225	£283
	Outdoor		£311	£352	£522	£661
	System		£486	£542	£747	£944

Prestige
H09AL / H12AL

SPECIFICATIONS					
Unit				H09AL	H12AL
Model Outdoor Unit				ASUW096MMS6	ASUW126MMS6
Model Indoor Unit				ASNW096MMS6	ASNW126MMS6
Indoor Unit					
Capacity	Cooling	Min	W	300	300
		Rated	W	2500	3500
		Max	W	3800	4040
	Heating	Min	W	300	300
		Rated	W	3200	4000
		Max	W	6600	6800
	Heating -7°C	Rated	W	4300	4600
Power Input	Cooling	Rated	W	490	830
	Heating +7°C	Rated	W	570	770
Energy Label	Cooling			A+++	A+++
	Heating			A+++	A+++
Annual Energy Consumption	Cooling		kWh	95	132
	Heating		kWh	855	985
Air Flow Rate	Cooling	Sleep	m³/min	5.0	5.0
		Low	m³/min	8.5	8.5
		Medium	m³/min	11.5	11.5
		High	m³/min	14.5	14.5
		Max (Power)	m³/min	15.5	15.5
	Heating	Low	m³/min	9.5	9.5
		Medium	m³/min	12.5	12.5
		High	m³/min	16.5	16.5
Outdoor Unit					
Operation Range	Cooling	Min-Max	°CDB	-10-48	-10-48
	Heating	Min-Max	°CWB	-15-24	-15-24
Air Flow Rate		High	m³/min	40	40
List Price		**Indoor**		£368	£433
		Outdoor		£547	£638
		System		£915	£1,071

Large Capacity Standard Inverter (1Ø and 3Ø)
UJ30.NV2 / UJ36.NV2 NEW

SPECIFICATIONS						
Indoor				**UJ30 NV2 1Ø**	**UJ36 NV2 1Ø**	**UJ36 NV2 1Ø**
Capacity	Cooling	Min/Nom/Max	kW	3.5-7.8-8.5	4.0-9.5-10.5	4.0-9.5-10.5
	Heating	Min/Nom/Max	kW	4.0-8.4-9.2	4.4-10.5-11.5	4.4-10.5-11.5
Power Input (Set)	Cooling	Nom	kW	2.29	2.79	2.79
	Heating	Nom	kW	2.46	3.08	3.08
Power Input (Indoor)		Min/Max	W	50/140	60/160	60/160
Seasonal Energy Label	Cooling/Heating			A++/A	A/A	A/A
Annual Energy Consumption	Cooling/Heating		kWh	447/2,256	615/2,793	615/2,793
Air Flow Rate		High/Medium/Low	m³/min	23.0/20.0/17.0	26.0/23.0/19.0	26.0/23.0/19.0
Outdoor				**UU30W U42**	**UU36W UO2**	**UU37W UO2**
Airflow Rate		Nom	m³/min	58	90	90
Operation Range (Outdoor)	Cooling	Min-Max	°C DB	-15-48	-15-48	-15-48
	Heating	Min-Max	°C WB	-18-18	-18-18	-18-18
List Price		**Indoor**		£447	£490	£490
		Outdoor		£1064	£1294	£1370
		System		£1511	£1784	£1860

Appendix 2:

Toshiba catalogue units

Super DAISEIKAI

PKVP + PAVP			Performance data				
Outdoor unit			RAS-07PAVP-E	RAS-10PAVP-E	RAS-13PAVP-E	RAS-16PAVP-E	RAS-18PAVP-E
Indoor unit			RAS-07PKVP-E	RAS-10PKVP-E	RAS-13PKVP-E	RAS-16PKVP-E	RAS-18PKVP-E
Cooling capacity	kW		2	2,5	3,5	4,5	5
Cooling range (min. - max.)	kW		0,3 - 3,0	0,3 - 3,5	0,3 - 4,5	0,3 - 5,0	0,3 - 5,5
Power input (min. - rated - max.)	kW	CO	0,07 - 0,35 - 0,68	0,07 - 0,47 - 0,88	0,07 - 0,77 - 1,25	0,07 - 1,22 - 1,49	0,07 - 1,49 - 1,75
Annual energy consumption	kWh		177	237	385	610	745
Air Flow (h/l)	m^3/h - l/s	CO	612/288 - 170/80	624/306 - 173/85	696/318 - 193/88	744/372 - 207/103	804/408 - 223/113
Single price / Set price excl. VAT [EUR]					620,-- 1.220,-- / 1.840,--	680,-- 1.480,-- / 2.160,--	

Suzumi+

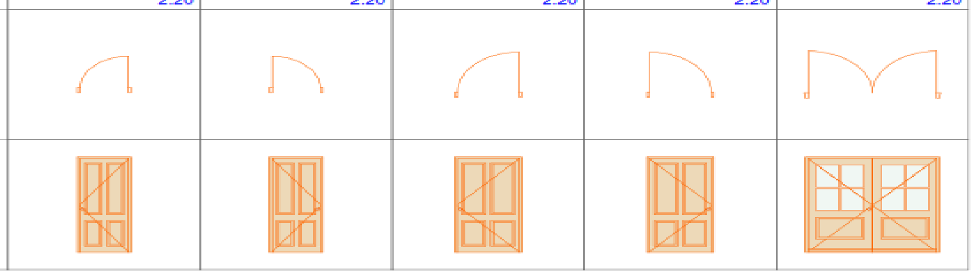
SKV2 + SAV2			Performance data				
Outdoor unit			RAS-10SAV2-E	RAS-13SAV2-E	RAS-16SAV2-E1	RAS-18SAV2-E1	RAS-22SAV2-E
Indoor unit			RAS-10SKV2-E	RAS-13SKV2-E	RAS-16SKV2-E1	RAS-18SKV2-E	RAS-22SKV2-E
Cooling capacity	kW		2,5	3,5	4,5	5	6
Cooling range (min. - max.)	kW		1,1 - 3,0	0,8 - 4,1	0,8 - 5,0	1,1 - 6,0	1,2 - 6,7
Power input (min. - rated - max.)	kW	CO	0,25 - 0,598 - 0,82	0,15 - 1,00 - 1,25	0,15 - 1,395 - 1,72	0,18 -1,42 - 2,00	0,20 - 1,995 - 2,65
Annual energy consumption	KWh		299	500	698	710	998
Air Flow	m^3/h - l/s	CO	516 - 143	570 - 158	684 - 190	954 - 265	1080 - 300
Single price / Set price excl. VAT [EUR]						435,-- 1.245,-- / 1.680,--	445,-- 1.450,-- / 1.895,--

Appendix 3:

Building dimensions

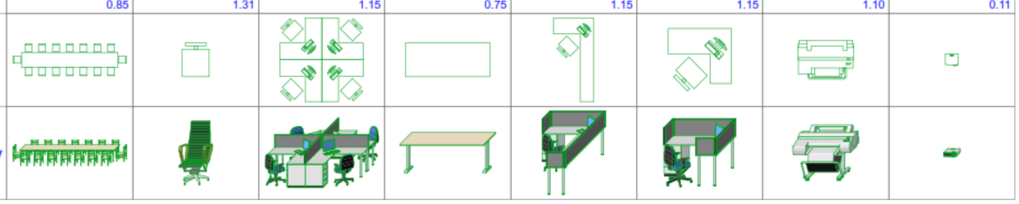
a) Door dimensions

Door List					
Door Name	Door 18	Door 18	Door 18	Door 18	Double Door 18
Quantity	9	12	17	18	1
Zone Number					
W x H Size	0.80x2.20	0.80x2.20	1.00x2.20	1.00x2.20	2.00x2.20
Orientation	L	R	L	R	R
Door sill height	0.00	0.00	0.00	0.00	0.00
Door head height	2.20	2.20	2.20	2.20	2.20
2D Symbol					
View from Side Opposite to Opening Side					



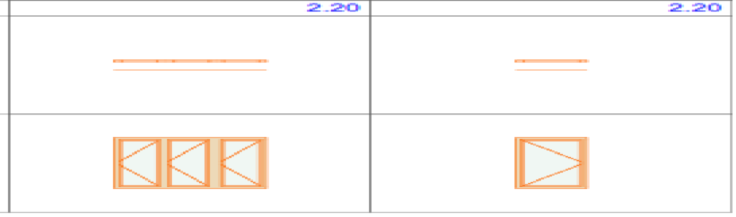
b) Appliance information

Object Inventory List								
Object Name	Dining Table Rectan...	Office Chair 03 18	Office Layout Island ...	Office Table 18	Office Workstation S...	Office Workstation S...	Plotter 18	Projector 18
Quantity	1	3	3	1	3	45	6	1
Length (A)	6.67	0.64	3.00	2.00	1.50	1.50	1.32	0.31
Width (B)	1.86	0.80	3.00	0.80	3.11	1.30	0.91	0.26
Height (Z Size)	0.85	1.31	1.15	0.75	1.15	1.15	1.10	0.11
2D Symbol								
3D Front Axonometry								



c) Windows dimensions and information

Window List		
Window Name	Triple Window 18	Window 18
Quantity	49	1
From Room Number		
W x H Size	1.50x1.30	0.70x1.30
Orientation		R
Window sill height	0.90	0.90
Window head height	2.20	2.20
2D Symbol		
View from Side Opposite to Opening Side		



d) Walls diminutions and information’s

Wall List							
Wall Type	Volume [...	Thickness [m]	Height [m]	Area [m2]	Perimeter [m]	Length on Outside Face [m]	Surface Area on Outside Face [...
Brick - Finish	20.28	0.25	2.80	15.30	125.00	61.25	79.08
Brick - Finish	2.37	0.25	2.80	0.66	7.05	2.25	10.50
Brick - Finish	0.88	0.25	2.80	0.38	3.71	1.50	3.50
Brick - Finish	1.92	0.25	2.80	0.76	7.20	2.76	7.70
Brick - Finish	2.94	0.25	2.80	1.41	12.75	5.64	15.75
Brick - Finish	0.99	0.25	2.80	0.47	4.39	2.02	4.95
Brick - Finish	6.30	0.25	2.80	4.14	36.00	16.50	25.08
Brick - Finish	6.30	0.25	2.80	2.28	21.00	9.00	25.20
Brick - Finish	1.06	0.25	2.80	0.50	4.60	2.13	5.25
Brick - Finish	4.74	0.25	2.80	1.77	16.05	6.75	18.90
Brick - Finish	3.32	0.25	2.80	1.18	10.50	4.76	13.30
Brick - Finish	1.75	0.25	2.80	0.56	5.00	2.25	7.00
Brick - Finish	2.11	0.25	2.80	1.16	9.75	4.63	10.75
Brick - Finish	41.34	0.25	2.80	16.92	144.00	67.50	189.00
Brick - Finish	13.68	0.25	2.80	4.86	42.00	19.50	54.60
Brick - Finish	7.11	0.25	2.80	2.64	23.13	9.75	27.39
Brick - Finish	2.48	0.25	2.80	1.09	9.25	4.38	12.25
Brick - Finish	2.73	0.25	2.80	1.13	9.71	4.75	11.90
Brick - Finish	23.61	0.25	2.80	9.78	82.26	39.00	103.41
Brick - Finish	13.95	0.25	2.80	6.45	53.67	25.62	57.07
Brick - Finish	28.11	0.25	2.80	13.32	110.10	52.50	133.26
Brick - Finish	13.98	0.25	2.80	7.02	58.05	28.50	53.88
Brick - Finish	11.94	0.25	2.80	5.88	48.00	23.50	57.00
Brick - Finish	17.91	0.25	2.80	8.52	70.05	33.75	83.40
Brick - Finish	38.37	0.25	2.80	18.00	148.26	73.50	170.25
Brick - Finish	80.54	0.25	2.80	36.00	292.26	145.50	355.64

e) Components by layers

Components by Layers		
Layer Name	Name	Volume [m3]
Shell - Roof		
	Timber - Roof	26.40
Structural - Bearing		
	Brick - Finish	350.71
	Concrete - Structural	373.26
	GENERIC - STRUC...	50.05
	Tile - Floor	46.59

f) All components

Components	
Name	Volume [m3]
Brick - Finish	350.71
Concrete - Structural	373.26
GENERIC - STRUCTU...	50.05
Tile - Floor	46.59
Timber - Roof	26.40

Appendix 4:

Software output reports

Office 2-6

Chvac - Full Commercial HVAC Loads Calculation Program
pReJkEr
Hell

Elite Software Development, Inc.
Air Conditioning For 3 Floors Building
Page 45

Air Handler #22 - Office 2-6 - Total Load Summary

Air Handler Description:	Office 2-6 Constant Volume - Proportion
Supply Air Fan:	Draw-Thru with program estimated horsepower of 0.06 kW
Fan Input:	0% motor and fan efficiency with 0 kPa across the fan
Sensible Heat Ratio:	0.90 --- This system occurs 1 time(s) in the building. ---

Air System Peak Time:	3pm in July.
Outdoor Conditions:	Clg: 47° DB, 30° WB, 21.25 grams moisture per kg dry air
Indoor Conditions:	Clg: 25° DB, 50% RH

Because of the diversity in zone, plenum and ventilation loads, the zone sensible peak time in May at 3pm is different from the total system peak time, hence the air system L/s was computed using a zone sensible load of 5,887.

Summer: Ventilation controls outside air, ----- Winter: Exhaust controls outside air.

Zone Space sensible loss:	0 Watts		
Infiltration sensible loss:	0 Watts	0 L/s	
Outside Air sensible loss:	0 Watts	0 L/s	
Supply Duct sensible loss:	0 Watts		
Return Duct sensible loss:	0 Watts		
Return Plenum sensible loss:	0 Watts		
Total System sensible loss:			0 Watts
Heating Supply Air: 0 / (.956 X 1.21 X 0) =		0 L/s	
Winter Vent Outside Air (0.0% of supply) =		0 L/s	
Zone space sensible gain:	5,709 Watts		
Infiltration sensible gain:	0 Watts		
Draw-thru fan sensible gain:	61 Watts		
Supply duct sensible gain:	0 Watts		
Reserve sensible gain:	0 Watts		
Total sensible gain on supply side of coil:			5,770 Watts
Cooling Supply Air: 5,949 / (.956 X 1.23 X 11) =		460 L/s	
Summer Vent Outside Air (5.2% of supply) =		24 L/s	
Return duct sensible gain:	0 Watts		
Return plenum sensible gain:	0 Watts		
Outside air sensible gain:	615 Watts	24 L/s	
Blow-thru fan sensible gain:	0 Watts		
Total sensible gain on return side of coil:			615 Watts
Total sensible gain on air handling system:			6,386 Watts
Zone space latent gain:	644 Watts		
Infiltration latent gain:	0 Watts		
Outside air latent gain:	732 Watts		
Total latent gain on air handling system:			1,376 Watts
Total system sensible and latent gain:			7,762 Watts

Check Figures

Total Air Handler Supply Air (based on a 11° TD):	460 L/s	
Total Air Handler Vent. Air (5.17% of Supply):	24 L/s	
Total Conditioned Air Space:	28 Sq.m	
Supply Air Per Unit Area:	16.4315 L/s/Sq.m	
Area Per Cooling Capacity:	3.6074 Sq.m/kW	12.7 Sq.m/Ton
Cooling Capacity Per Area:	0.2772 kW/Sq.m	0.0788 Tons/Sq.m
Heating Capacity Per Area:	0.00 Watts/Sq.m	
Total Heating Required With Outside Air:	0.00 kW	
Total Cooling With Outside Air:	7.76 kW	2.21 Tons

C:\Users\TOSHIBA\Desktop\wadda7.CHV

Tuesday, April 25, 2017, 03:59 PM

p. room 2-1

Air Handler #33 - P.Room 2-1 - Total Load Summary

Air Handler Description:	P.Room 2-1 Constant Volume - Proportion
Supply Air Fan:	Draw-Thru with program estimated horsepower of 0.03 kW
Fan Input:	0% motor and fan efficiency with 0 kPa across the fan
Sensible Heat Ratio:	0.91 --- This system occurs 1 time(s) in the building. ---
Air System Peak Time:	5pm in July.
Outdoor Conditions:	Clg: 45° DB, 30° WB, 22.10 grams moisture per kg dry air
Indoor Conditions:	Clg: 25° DB, 50% RH

Because of the diversity in zone, plenum and ventilation loads, the zone sensible peak time in May at 5pm is different from the total system peak time, hence the air system L/s was computed using a zone sensible load of 3,148.

Summer: Ventilation controls outside air, ----- Winter: Exhaust controls outside air.

Zone Space sensible loss:	0 Watts		
Infiltration sensible loss:	0 Watts	0 L/s	
Outside Air sensible loss:	0 Watts	0 L/s	
Supply Duct sensible loss:	0 Watts		
Return Duct sensible loss:	0 Watts		
Return Plenum sensible loss:	0 Watts		
Total System sensible loss:			0 Watts
Heating Supply Air: 0 / (.956 X 1.21 X 0) =		0 L/s	
Winter Vent Outside Air (0.0% of supply) =		0 L/s	
Zone space sensible gain:	3,047 Watts		
Infiltration sensible gain:	0 Watts		
Draw-thru fan sensible gain:	33 Watts		
Supply duct sensible gain:	0 Watts		
Reserve sensible gain:	0 Watts		
Total sensible gain on supply side of coil:			3,080 Watts
Cooling Supply Air: 3,181 / (.956 X 1.23 X 11) =		246 L/s	
Summer Vent Outside Air (4.7% of supply) =		12 L/s	
Return duct sensible gain:	0 Watts		
Return plenum sensible gain:	0 Watts		
Outside air sensible gain:	274 Watts	12 L/s	
Blow-thru fan sensible gain:	0 Watts		
Total sensible gain on return side of coil:			274 Watts
Total sensible gain on air handling system:			3,354 Watts
Zone space latent gain:	315 Watts		
Infiltration latent gain:	0 Watts		
Outside air latent gain:	386 Watts		
Total latent gain on air handling system:			701 Watts
Total system sensible and latent gain:			4,054 Watts

Check Figures

Total Air Handler Supply Air (based on a 11° TD):	246 L/s	
Total Air Handler Vent. Air (4.73% of Supply):	12 L/s	
Total Conditioned Air Space:	14 Sq.m	
Supply Air Per Unit Area:	17.9713 L/s/Sq.m	
Area Per Cooling Capacity:	3.3767 Sq.m/kW	11.9 Sq.m/Ton
Cooling Capacity Per Area:	0.2961 kW/Sq.m	0.0842 Tons/Sq.m
Heating Capacity Per Area:	0.00 Watts/Sq.m	
Total Heating Required With Outside Air:	0.00 kW	
Total Cooling With Outside Air:	4.05 kW	1.15 Tons

e. room 2-1

Air Handler #30 - E.Room 2-1 - Total Load Summary

Air Handler Description:	E.Room 2-1 Constant Volume - Proportion		
Supply Air Fan:	Draw-Thru with program estimated horsepower of 0.02 kW		
Fan Input:	0% motor and fan efficiency with 0 kPa across the fan		
Sensible Heat Ratio:	0.89	--- This system occurs 1 time(s) in the building. ---	
Air System Peak Time:	5pm in July.		
Outdoor Conditions:	Clg: 45° DB, 30° WB, 22.10 grams moisture per kg dry air		
Indoor Conditions:	Clg: 25° DB, 50% RH		

Because of the diversity in zone, plenum and ventilation loads, the zone sensible peak time in May at 5pm is different from the total system peak time, hence the air system L/s was computed using a zone sensible load of 1,889.

Summer: Ventilation controls outside air, ----- Winter: Exhaust controls outside air.

Zone Space sensible loss:	0 Watts		
Infiltration sensible loss:	0 Watts	0 L/s	
Outside Air sensible loss:	0 Watts	0 L/s	
Supply Duct sensible loss:	0 Watts		
Return Duct sensible loss:	0 Watts		
Return Plenum sensible loss:	0 Watts		
Total System sensible loss:			0 Watts
Heating Supply Air: 0 / (.956 X 1.21 X 0) =		0 L/s	
Winter Vent Outside Air (0.0% of supply) =		0 L/s	
Zone space sensible gain:	1,851 Watts		
Infiltration sensible gain:	0 Watts		
Draw-thru fan sensible gain:	18 Watts		
Supply duct sensible gain:	0 Watts		
Reserve sensible gain:	0 Watts		
Total sensible gain on supply side of coil:			1,869 Watts
Cooling Supply Air: 1,907 / (.956 X 1.23 X 12) =		135 L/s	
Summer Vent Outside Air (6.6% of supply) =		9 L/s	
Return duct sensible gain:	0 Watts		
Return plenum sensible gain:	0 Watts		
Outside air sensible gain:	210 Watts	9 L/s	
Blow-thru fan sensible gain:	0 Watts		
Total sensible gain on return side of coil:			210 Watts
Total sensible gain on air handling system:			2,078 Watts
Zone space latent gain:	242 Watts		
Infiltration latent gain:	0 Watts		
Outside air latent gain:	296 Watts		
Total latent gain on air handling system:			537 Watts
Total system sensible and latent gain:			2,616 Watts

Check Figures

Total Air Handler Supply Air (based on a 12° TD):	135 L/s	
Total Air Handler Vent. Air (6.60% of Supply):	9 L/s	
Total Conditioned Air Space:	11 Sq.m	
Supply Air Per Unit Area:	12.8770 L/s/Sq.m	
Area Per Cooling Capacity:	4.0140 Sq.m/kW	14.1 Sq.m/Ton
Cooling Capacity Per Area:	0.2491 kW/Sq.m	0.0708 Tons/Sq.m
Heating Capacity Per Area:	0.00 Watts/Sq.m	
Total Heating Required With Outside Air:	0.00 kW	
Total Cooling With Outside Air:	2.62 kW	0.74 Tons

g.m. room

Air Handler #35 - G.M.Room - Total Load Summary

Air Handler Description:	G.M.Room Constant Volume - Proportion		
Supply Air Fan:	Draw-Thru with program estimated horsepower of 0.06 kW		
Fan Input:	0% motor and fan efficiency with 0 kPa across the fan		
Sensible Heat Ratio:	0.91	--- This system occurs 1 time(s) in the building. ---	

Air System Peak Time:	5pm in July.
Outdoor Conditions:	Clg: 45° DB, 30° WB, 22.10 grams moisture per kg dry air
Indoor Conditions:	Clg: 25° DB, 50% RH

Because of the diversity in zone, plenum and ventilation loads, the zone sensible peak time in May at 5pm is different from the total system peak time, hence the air system L/s was computed using a zone sensible load of 5,920.

Summer: Ventilation controls outside air, ----- Winter: Exhaust controls outside air.

Zone Space sensible loss:	0 Watts		
Infiltration sensible loss:	0 Watts	0 L/s	
Outside Air sensible loss:	0 Watts	0 L/s	
Supply Duct sensible loss:	0 Watts		
Return Duct sensible loss:	0 Watts		
Return Plenum sensible loss:	0 Watts		
Total System sensible loss:			0 Watts
Heating Supply Air: 0 / (.956 X 1.21 X 0) =		0 L/s	
Winter Vent Outside Air (0.0% of supply) =		0 L/s	
Zone space sensible gain:	5,794 Watts		
Infiltration sensible gain:	0 Watts		
Draw-thru fan sensible gain:	62 Watts		
Supply duct sensible gain:	0 Watts		
Reserve sensible gain:	0 Watts		
Total sensible gain on supply side of coil:			5,856 Watts
Cooling Supply Air: 5,981 / (.956 X 1.23 X 11) =		463 L/s	
Summer Vent Outside Air (5.0% of supply) =		23 L/s	
Return duct sensible gain:	0 Watts		
Return plenum sensible gain:	0 Watts		
Outside air sensible gain:	539 Watts	23 L/s	
Blow-thru fan sensible gain:	0 Watts		
Total sensible gain on return side of coil:			539 Watts
Total sensible gain on air handling system:			6,395 Watts
Zone space latent gain:	621 Watts		
Infiltration latent gain:	0 Watts		
Outside air latent gain:	761 Watts		
Total latent gain on air handling system:			1,382 Watts
Total system sensible and latent gain:			7,777 Watts

Check Figures

Total Air Handler Supply Air (based on a 11° TD):	463 L/s	
Total Air Handler Vent. Air (4.96% of Supply):	23 L/s	
Total Conditioned Air Space:	32 Sq.m	
Supply Air Per Unit Area:	14.4562 L/s/Sq.m	
Area Per Cooling Capacity:	4.1146 Sq.m/kW	14.5 Sq.m/Ton
Cooling Capacity Per Area:	0.2430 kW/Sq.m	0.0691 Tons/Sq.m
Heating Capacity Per Area:	0.00 Watts/Sq.m	
Total Heating Required With Outside Air:	0.00 kW	
Total Cooling With Outside Air:	7.78 kW	2.21 Tons

reception0

Air Handler #25 - Reception 0 - Total Load Summary

Air Handler Description:	Reception 0 Constant Volume - Proportion
Supply Air Fan:	Draw-Thru with program estimated horsepower of 0.16 kW
Fan Input:	0% motor and fan efficiency with 0 kPa across the fan
Sensible Heat Ratio:	0.78 --- This system occurs 1 time(s) in the building. ---
Air System Peak Time:	5pm in July.
Outdoor Conditions:	Clg: 45° DB, 30° WB, 22.10 grams moisture per kg dry air
Indoor Conditions:	Clg: 25° DB, 50% RH

Because of the diversity in zone, plenum and ventilation loads, the zone sensible peak time in May at 5pm is different from the total system peak time, hence the air system L/s was computed using a zone sensible load of 16,072.

Summer: Ventilation controls outside air, ----- Winter: Exhaust controls outside air.

Zone Space sensible loss:	0 Watts		
Infiltration sensible loss:	0 Watts	0 L/s	
Outside Air sensible loss:	0 Watts	0 L/s	
Supply Duct sensible loss:	0 Watts		
Return Duct sensible loss:	0 Watts		
Return Plenum sensible loss:	0 Watts		
Total System sensible loss:			0 Watts
Heating Supply Air: 0 / (.956 X 1.21 X 0) =		0 L/s	
Winter Vent Outside Air (0.0% of supply) =		0 L/s	
Zone space sensible gain:	15,936 Watts		
Infiltration sensible gain:	0 Watts		
Draw-thru fan sensible gain:	153 Watts		
Supply duct sensible gain:	0 Watts		
Reserve sensible gain:	0 Watts		
Total sensible gain on supply side of coil:			16,089 Watts
Cooling Supply Air: 16,225 / (.956 X 1.23 X 12) =		1,150 L/s	
Summer Vent Outside Air (14.5% of supply) =		167 L/s	
Return duct sensible gain:	0 Watts		
Return plenum sensible gain:	0 Watts		
Outside air sensible gain:	3,916 Watts	167 L/s	
Blow-thru fan sensible gain:	0 Watts		
Total sensible gain on return side of coil:			3,916 Watts
Total sensible gain on air handling system:			20,006 Watts
Zone space latent gain:	4,508 Watts		
Infiltration latent gain:	0 Watts		
Outside air latent gain:	5,523 Watts		
Total latent gain on air handling system:			10,031 Watts
Total system sensible and latent gain:			30,037 Watts

Check Figures

Total Air Handler Supply Air (based on a 12° TD):	1,150 L/s	
Total Air Handler Vent. Air (14.48% of Supply):	167 L/s	
Total Conditioned Air Space:	196 Sq.m	
Supply Air Per Unit Area:	5.8694 L/s/Sq.m	
Area Per Cooling Capacity:	6.5253 Sq.m/kW	22.9 Sq.m/Ton
Cooling Capacity Per Area:	0.1532 kW/Sq.m	0.0436 Tons/Sq.m
Heating Capacity Per Area:	0.00 Watts/Sq.m	
Total Heating Required With Outside Air:	0.00 kW	
Total Cooling With Outside Air:	30.04 kW	8.54 Tons

meeting room

Air Handler #36 - Meeting Room - Total Load Summary

Air Handler Description:	Meeting Room Constant Volume - Proportion
Supply Air Fan:	Draw-Thru with program estimated horsepower of 0.10 kW
Fan Input:	0% motor and fan efficiency with 0 kPa across the fan
Sensible Heat Ratio:	0.89 --- This system occurs 1 time(s) in the building. ---
Air System Peak Time:	5pm in July.
Outdoor Conditions:	Clg: 45° DB, 30° WB, 22.10 grams moisture per kg dry air
Indoor Conditions:	Clg: 25° DB, 50% RH

Because of the diversity in zone, plenum and ventilation loads, the zone sensible peak time in May at 5pm is different from the total system peak time, hence the air system L/s was computed using a zone sensible load of 8,994.

Summer: Ventilation controls outside air, ----- Winter: Exhaust controls outside air.

Zone Space sensible loss:	0 Watts		
Infiltration sensible loss:	0 Watts	0 L/s	
Outside Air sensible loss:	0 Watts	0 L/s	
Supply Duct sensible loss:	0 Watts		
Return Duct sensible loss:	0 Watts		
Return Plenum sensible loss:	0 Watts		
Total System sensible loss:			0 Watts
Heating Supply Air: 0 / (.956 X 1.21 X 0) =		0 L/s	
Winter Vent Outside Air (0.0% of supply) =		0 L/s	
Zone space sensible gain:	8,751 Watts		
Infiltration sensible gain:	0 Watts		
Draw-thru fan sensible gain:	94 Watts		
Supply duct sensible gain:	0 Watts		
Reserve sensible gain:	0 Watts		
Total sensible gain on supply side of coil:			8,845 Watts
Cooling Supply Air: 9,087 / (.956 X 1.23 X 11) =		703 L/s	
Summer Vent Outside Air (5.8% of supply) =		41 L/s	
Return duct sensible gain:	0 Watts		
Return plenum sensible gain:	0 Watts		
Outside air sensible gain:	959 Watts	41 L/s	
Blow-thru fan sensible gain:	0 Watts		
Total sensible gain on return side of coil:			959 Watts
Total sensible gain on air handling system:			9,804 Watts
Zone space latent gain:	1,104 Watts		
Infiltration latent gain:	0 Watts		
Outside air latent gain:	1,353 Watts		
Total latent gain on air handling system:			2,457 Watts
Total system sensible and latent gain:			12,261 Watts

Check Figures

Total Air Handler Supply Air (based on a 11° TD):	703 L/s	
Total Air Handler Vent. Air (5.80% of Supply):	41 L/s	
Total Conditioned Air Space:	32 Sq.m	
Supply Air Per Unit Area:	21.9652 L/s/Sq.m	
Area Per Cooling Capacity:	2.6100 Sq.m/kW	9.2 Sq.m/Ton
Cooling Capacity Per Area:	0.3831 kW/Sq.m	0.1089 Tons/Sq.m
Heating Capacity Per Area:	0.00 Watts/Sq.m	
Total Heating Required With Outside Air:	0.00 kW	
Total Cooling With Outside Air:	12.26 kW	3.49 Tons

Mosque

Air Handler #34 - Mosque - Total Load Summary

Air Handler Description:	Mosque Constant Volume - Proportion
Supply Air Fan:	Draw-Thru with program estimated horsepower of 0.08 kW
Fan Input:	0% motor and fan efficiency with 0 kPa across the fan
Sensible Heat Ratio:	0.79 --- This system occurs 1 time(s) in the building. ---

Air System Peak Time:	5pm in July.
Outdoor Conditions:	Clg: 45° DB, 30° WB, 22.10 grams moisture per kg dry air
Indoor Conditions:	Clg: 25° DB, 50% RH

Because of the diversity in zone, plenum and ventilation loads, the zone sensible peak time in May at 5pm is different from the total system peak time, hence the air system L/s was computed using a zone sensible load of 7,731.

Summer: Ventilation controls outside air, ----- Winter: Exhaust controls outside air.

Zone Space sensible loss:	0 Watts		
Infiltration sensible loss:	0 Watts	0 L/s	
Outside Air sensible loss:	0 Watts	0 L/s	
Supply Duct sensible loss:	0 Watts		
Return Duct sensible loss:	0 Watts		
Return Plenum sensible loss:	0 Watts		
Total System sensible loss:			0 Watts
Heating Supply Air: 0 / (.956 X 1.21 X 0) =		0 L/s	
Winter Vent Outside Air (0.0% of supply) =		0 L/s	
Zone space sensible gain:	7,605 Watts		
Infiltration sensible gain:	0 Watts		
Draw-thru fan sensible gain:	74 Watts		
Supply duct sensible gain:	0 Watts		
Reserve sensible gain:	0 Watts		
Total sensible gain on supply side of coil:			7,679 Watts
Cooling Supply Air: 7,805 / (.956 X 1.23 X 12) =		553 L/s	
Summer Vent Outside Air (13.8% of supply) =		77 L/s	
Return duct sensible gain:	0 Watts		
Return plenum sensible gain:	0 Watts		
Outside air sensible gain:	1,798 Watts	77 L/s	
Blow-thru fan sensible gain:	0 Watts		
Total sensible gain on return side of coil:			1,798 Watts
Total sensible gain on air handling system:			9,477 Watts
Zone space latent gain:	2,070 Watts		
Infiltration latent gain:	0 Watts		
Outside air latent gain:	2,536 Watts		
Total latent gain on air handling system:			4,606 Watts
Total system sensible and latent gain:			14,084 Watts

Check Figures

Total Air Handler Supply Air (based on a 12° TD):	553 L/s	
Total Air Handler Vent. Air (13.83% of Supply):	77 L/s	
Total Conditioned Air Space:	32 Sq.m	
Supply Air Per Unit Area:	17.2914 L/s/Sq.m	
Area Per Cooling Capacity:	2.2721 Sq.m/kW	8.0 Sq.m/Ton
Cooling Capacity Per Area:	0.4401 kW/Sq.m	0.1251 Tons/Sq.m
Heating Capacity Per Area:	0.00 Watts/Sq.m	
Total Heating Required With Outside Air:	0.00 kW	
Total Cooling With Outside Air:	14.08 kW	4.00 Tons