A PROJECT REPORT

ON

"DESIGN OF HVAC SYSTEM FOR BASEMENT OF AIKTC"

Submitted by

Ansari Rizwan Ahmed Iqbal Husain (13ME126)

Mukadam Awez Yaseen (13ME132)

Shaikh Rubel Mohammed Amin (12ME56)

In partial fulfillment for the award of the Degree

Of

BACHELOR OF ENGINEERING

IN

MECHANICAL ENGINEERING

UNDER THE GUIDANCE

Of

Prof. Ghazi Altamash

DEPARTMENT OF MECHANICAL ENGINEERING

ANJUMAN-I-ISLAM

KALSEKAR TECHNICAL CAMPUS NEW PANVEL,

NAVI MUMBAI – 410206

UNIVERSITY OF MUMBAI

ACADEMIC YEAR 2015-2016

ANJUMAN-I-ISLAM

KALSEKAR TECHNICAL CAMPUS NEW PANVEL

(Approved by AICTE, recg. By Maharashtra Govt. DTE,

Affiliated to Mumbai University)

PLOT #2&3, SECTOR 16, NEAR THANA NAKA, KHANDAGAON, NEW PANVEL,NAVI MUMBAI-410206,
Tel.: +91 22 27481247/48 * Website: www.aiktc.org

CERTIFICATE

This is to certify that the project entitled

"DESIGN OF HVAC SYSTEM FOR THE BASEMENT OF AKTC"

Submitted by

Ansari Rizwan Ahmed Iqbal Husain (13ME126)
Mukadam Awez Yaseen (13ME132)
Shaikh Rubel Mohammed Amin (12ME56)

To the Kalsekar Technical Campus, New Panvel is a record of bonafide work carried out by him under our supervision and guidance, for partial fulfillment of the requirements for the award of the Degree of Bachelor of Engineering in Mechanical Engineering as prescribed by **University Of Mumbai**, is approved.

Internal Examiner (Prof. Ghazi Altamash)

External Examiner

Head of Department (Prof. Ansari Zakir)

Principal

ANJUMAN-I-ISLAM
KALSEKAR TECHNICAL CAMPUS NEW PANVEL

(Approved by AICTE, recg. By Maharashtra Govt. DTE,

Affiliated to Mumbai University)

PLOT #2&3, SECTOR 16, NEAR THANA NAKA, KHANDAGAON, NEW PANVEL,NAVI MUMBAI-410206,
Tel.: +91 22 27481247/48 * Website: www.aiktc.org

APPROVAL OF DISSERTATION

This is to certify that the thesis entitled

"DESIGN OF HVAC SYSTEM FOR THE BASEMENT OF AKTC"

Submitted by

Ansari Rizwan Ahmed Iqbal Husain (13ME126)
Mukadam Awez Yaseen(13ME132)
Shaikh Rubel Mohammed Amin (12ME56)

In partial fulfillment of the requirements for the award of the Degree of Bachelor of Engineering in Mechanical Engineering, as prescribed by University of Mumbai approved.

(Internal Examiner) **(External Examiner)**

Prof. Ghazi Altamash

Date: __________

ACKNOWLEDGEMENT

After the completion of this work, we would like to give our sincere thanks to all those who helped us to reach our goal. It's a great pleasure and moment of immense satisfaction for us to express my profound gratitude to our guide **Prof. Ghazi Altamash** whose constant encouragement enabled us to work enthusiastically. His perpetual motivation, patience and excellent expertise in discussion during progress of the project work have benefited us to an extent, which is beyond expression.

We would also like to give our sincere thanks to **Prof. Ansari Zakir** Head Of Department, and **Prof. Shaikh Rizwan** Project coordinator from Department of Mechanical Engineering, Kalsekar Technical Campus, New Panvel, for their guidance, encouragement and support during a project.

I am thankful to **Dr. Abdul Razak Honnutagi**, Kalsekar Technical Campus New Panvel, for providing an outstanding academic environment, also for providing the adequate facilities.

Last but not the least I would also like to thank all the staffs of Kalsekar Technical Campus (Mechanical Engineering Department) for their valuable guidance with their interest and valuable suggestions brightened us.

Ansari Rizwan Ahmed Iqbal Husain (13ME126)
Mukadam Awez Yaseen (13ME132)
Shaikh Rubel Mohammed Amin (12ME56)

Contents

List of figures

Abstract

HVAC (Heating, Ventilation and Air conditioning) is technology of indoor and vehicular comfort. Its goal is to provide thermal comfort and acceptable indoor quantity of air. This project is to design a HVAC system for the basement of AIKTC to bring the environment of basement into the comfort zone for the people. So the people can work efficiently.

This report includes the design of HVAC system for the basement of AIKTC which contain the calculation of heat load, design of duct according season like summer and winter, selection of component & equipment for HVAC system and cost estimation.

Chapter 1

Introduction

Introduction

HVAC (heating, ventilating, and air conditioning; also heating, ventilation, and air conditioning) is the technology of indoor and vehicular environmental comfort. Its goal is to provide thermal comfort and acceptable indoor air quality. HVAC system design is a sub discipline of mechanical engineering, based on the principles of thermodynamics, fluid mechanics, and heat transfer. Refrigeration is sometimes added to the field's abbreviation as HVAC&R or HVACR, (heating, ventilating and air-conditioning & Refrigeration) or ventilating is dropped as in HACR (such as the designation of HACR-rated circuit breakers).

HVAC is important in the design of medium to large industrial and office buildings such as skyscrapers, onboard vessels, and in marine environments such as aquariums, where safe and healthy building conditions are regulated with respect to temperature and humidity , using fresh air from outdoors.

Ventilating or ventilation (the V in HVAC) is the process of "exchanging" or replacing air in any space to provide high indoor air quality which involves temperature control, oxygen replenishment, and removal of moisture, odors, smoke, heat, dust, airborne bacteria, and carbon dioxide. Ventilation removes unpleasant smells and excessive moisture, introduces outside air, keeps interior building air circulating, and prevents stagnation of the interior air.

Ventilation includes both the exchange of air to the outside as well as circulation of air within the building. It is one of the most important factors for maintaining acceptable indoor air quality in buildings. Methods for ventilating a building may be divided into mechanical/forced and natural types.

The three central functions of heating, ventilation, and air-conditioning are interrelated, especially with the need to provide thermal comfort and acceptable indoor air quality within reasonable installation, operation, and maintenance costs. HVAC systems can provide ventilation, reduce air infiltration, and maintain pressure relationships between spaces. The means of air delivery and removal from spaces is known as room air distribution.

1.1: Heating:-

Heaters are appliances whose purpose is to generate heat (i.e. warmth) for the building. This can be done via central heating. Such a system contains a boiler, furnace, or heat pump to heat water, steam, or air in a central location such as a furnace room in a home, or a mechanical room in a large building. The heat can be transferred by convection, conduction, or radiation.

1.2: Ventilation:-

Ventilation is the process of changing or replacing air in any space to control temperature or remove any combination of moisture, odors, smoke, heat, dust, airborne bacteria, or carbon dioxide, and to replenish oxygen. Ventilation includes both the exchange of air with the outside as well as circulation of air within the building. It is one of the most important factors for maintaining acceptable indoor air quality in buildings. Methods for ventilating a building may be divided into mechanical/forced and natural types.

1.2.1: Mechanical or forced ventilation:-

"Mechanical" or "forced" ventilation is provided by an air handler and used to control indoor air quality. Excess humidity, odors, and contaminants can often be controlled via dilution or replacement with outside air. However, in humid climates much energy is required to remove excess moisture from ventilation air.

Kitchens and bathrooms typically have mechanical exhausts to control odors and sometimes humidity. Factors in the design of such systems include the flow rate (which is a function of the fan speed and exhaust vent size) and noise level. Direct drive fans are available for many applications, and can reduce maintenance needs.

Ceiling fans and table/floor fans circulate air within a room for the purpose of reducing the perceived temperature by increasing evaporation of perspiration on the skin of the occupants. Because hot air rises, ceiling fans may be used to keep a room warmer in the winter by circulating the warm stratified air from the ceiling to the floor.

1.2.2: Natural ventilation:-

Natural ventilation is the ventilation of a building with outside air without using fans or other mechanical systems. It can be via operable windows, louvers, or trickle vents when spaces are small and the architecture permits. In more complex schemes, warm air is allowed to rise and flow out high building openings to the outside (stack effect), causing cool outside air to be drawn into low building openings. Natural ventilation schemes can use very little energy, but care must be taken to ensure comfort. In warm or humid climates, maintaining thermal comfort solely via natural ventilation may not be possible. Air conditioning systems are used, either as backups or supplements. Air-side economizers also use outside air to condition spaces, but do so using fans, ducts, dampers, and control systems to introduce and distribute cool outdoor air when appropriate.

An important component of natural ventilation is air change rate or air changes per hour: the hourly rate of ventilation divided by the volume of the space. For example, six air changes per hour means an amount of new air, equal to the volume of the space, is added every ten minutes. For human comfort, a minimum of four air changes per hour is typical, though warehouses might have only two. Too high of an air change rate may be uncomfortable, akin to a wind tunnel which have thousands of changes per hour. The highest air change rates are for crowded spaces, bars, night clubs, and commercial kitchens at around 30 to 50 air changes per hour.

Room pressure can be either positive or negative with respect to outside the room. Positive pressure occurs when there is more air being supplied than exhausted, and is common to reduce the infiltration of outside contaminants.

1.3: Air Conditioning:-

An air conditioning system, or a standalone air conditioner, provides cooling and humidity control for all or part of a building. Air conditioned buildings often have sealed windows, because open windows would work against the system intended to maintain constant indoor air conditions. Outside, fresh air is generally drawn into the system by a vent into the indoor heat exchanger section, creating positive air pressure. The percentage of return air made up of fresh air can usually be manipulated by adjusting the opening of this vent. Typical fresh air intake is about 10%.

Air conditioning and refrigeration are provided through the removal of heat. Heat can be removed through radiation, convection, or conduction. Refrigeration conduction media such as water, air, ice, and chemicals are referred to as refrigerants. A refrigerant is employed either in a heat pump system in which a compressor is used to drive thermodynamic refrigeration cycle, or in a free cooling system which uses pumps to circulate a cool refrigerant (typically water or a glycol mix).

Chapter 2

Literature Review

Literature Review

From the study of various technical papers, journals, reference books (of refrigeration and air conditioning) and different literature on HVAC system design by qualified and experience persons.

After studying various contents on RAC and HVAC system it is seeing that to design an effective HVAC system for the basement of AIKTC some basic steps are to be followed like:

- Calculation of heat load (which includes heat transfer across the wall, heat transfer across the glass of window, heat emitted through various appliances like tube light, fan, projector, etc. and emitted from the people).
- Determination of zone of space to be condition with respect to the comfort zone specified by ASHARAE.
- Various factors (Effective temperature, Moisture content of air, Air stratification, etc) That affect the comfort condition of human being should also be consider in order designing an effective HVAC system for the basement of AIKTC.
- Selection of different basic components (blower, compressor. Dehumidifier, etc) to form a HVAC system to achieve comfort condition in the basement of AIKTC. The component should be selected according to various parameter obtain during calculation steps (such as air flow rate, tonnage of refrigeration, etc.)
- Sizing of duct: depending upon the velocity of air passing through the duct, air flow rate, etc.
- After calculating heat load and size of duct required, layout is to be made. While deciding layout take care that each component should be place in proper sequence and should be occupied in space available.

Chapter 3

Problem Definition

Problem Definition

The basement of AIKTC is used for various purposes like class room, drawing hall, etc. As it is used for these applications so the people continuously come and go into the basement.

As basement does not contain windows as much as required for the proper ventilation, so the people who work into the basement does not feel comfortable and cannot work efficiently.

The purpose of this project is to design a proper HVAC system for the basement the of AIKTC so the people who work in the basement can work effectively and efficiently.

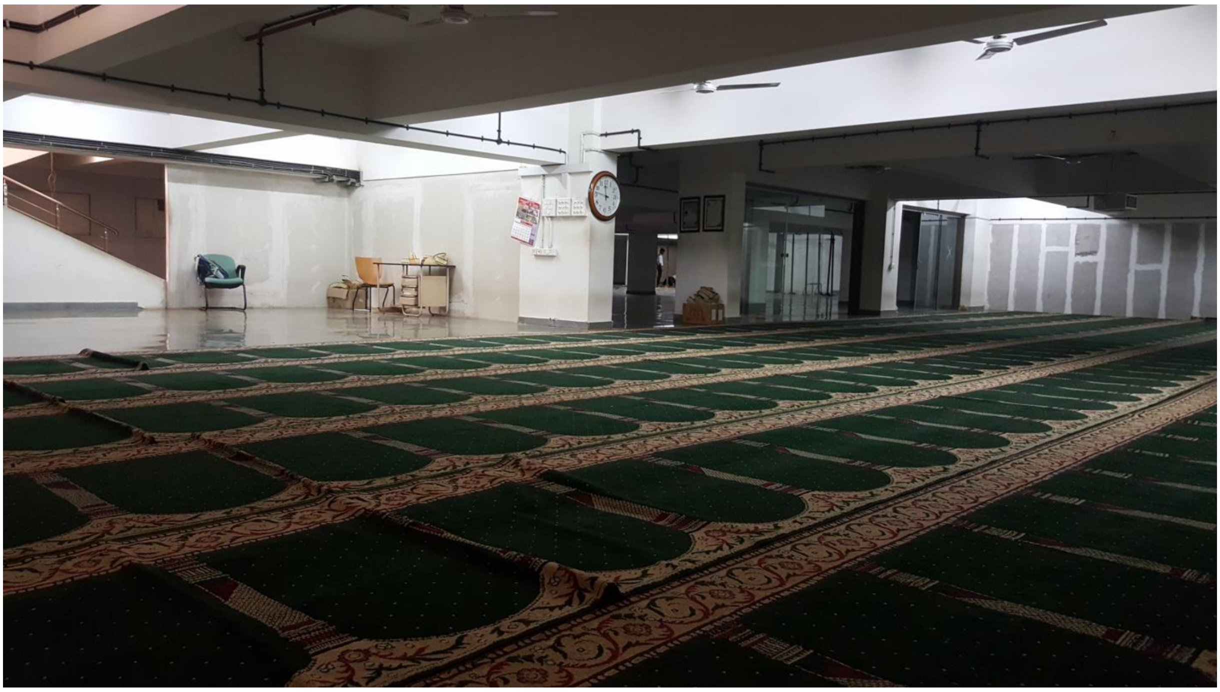


Fig.3.1: Basement area

Chapter 4

Objective of project

Objective of the Project

The objective of HVAC are to control the temperature and of air inside the designated “Air Conditioned” space along with control of moisture, filtration of air and containment of air borne particles, supply of outside fresh air for control of oxygen and carbon dioxide levels in the air conditioned space, and finally control of the movement of air or draught. All these factors comprise of a successful HVAC system. Air conditioning has changed over the years from just cooling of a space to the effective control of all the above parameters. So that the people working across the air conditioned area can work efficiently.

Chapter 5

Heat load Estimation

Heat Load Estimation

- Take measurement of area and making layout.

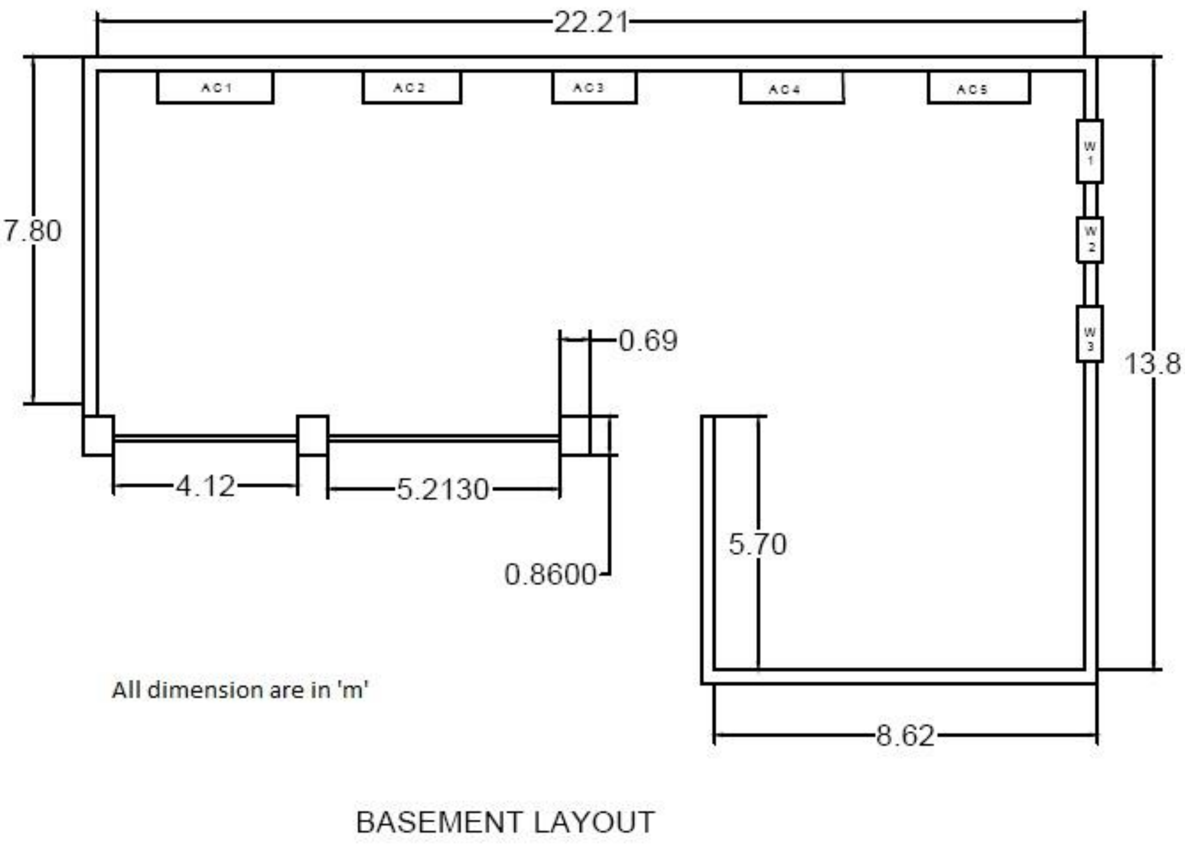


Fig 5.1: Basement layout

- No. of light : 30
- No. of fan : 17
- No. of people: 275

5.1: Calculation of heat load:-

5.1.1: For summer:-

1. Heat load of empty area (H_1) –

H_1 = volume / 3024

= 608.5313/3024

= 0.20123 kcal/hr

2. Heat transfer through wall (H_2) –

H_2 = area × heat transfer coeff. × temp. Difference

= 38.475 × 2.81 × 15.5

= 1682.33 kcal/hr

3. Heat through window (H_3) –

H_3 = area × heat transfer coeff. × temp. diff × no. of window

= 0.6075 × 19.529 × (38-33) × 3

= 177.958 kcal/hr

4. Heat emitted through lights (H_4) –

H_4 = Watt × no. of light × 0.86

= 36 × 30 × 0.86

= 928.8 kcal/hr

5. Heat emitted through projector (H_5) –

H_5 = 1315 BTU/hr

= 1315 × 0.2913

= 385.42 kcal/hr

6. Heat emitted trough fan (H_6) –

H_6 = 641 × H.P of motor × no. of fan

= 641 × (60÷746) × 17

= 876.434 kcal/hr

7. Heat through people (H_7) –

H_7 = (2000÷24) × 275

= 22916.67 cal/hr

= 22.91667 kcal/hr

8. Total heat load (H.L) –

H.L = $H_1+H_2+H_3+H_4+H_5+H_6+H_7$

=0.2013+1682.33+177.958+928.8+385.42+876.434+22.91

= 4074.05kcal/hr

5.1.2: For winter:-

1. Heat load of empty are (H_1) –

H_1 = volume / 3024

= 608.5313/3024

= 0.20123 kcal/hr

2. Heat transfer through wall (H_2) –

H_2 = area × heat transfer coeff. × temp. Difference

= 38.475 × 2.81 × 15.5

= 1682.33 kcal/hr

3. Heat transfer through window (H_3) –

H_3 = area × heat transfer coeff. × temp. diff × no. of window

= 0.6075 × 19.529 × (48.75 - 47.25) × 3

= 53.38 kcal/hr

4. Heat emitted through lights (H_4) –

H_4 = Watt × no. of light × 0.86

= 36 × 30 × 0.86

= 928.8 kcal/hr

5. Heat emitted through projector (H_5) –

H_5 = 1315 BTU/hr

= 1315 × 0.2913

= 385.42 kcal/hr

6. Heat emitted trough fan (H_6) –

H_6 = 641 × H.P of motor × no. of fan

= 641 × (60÷746) × 17

= 876.434 kcal/hr

7. Heat through people (H_7) –

H_7 = (2000÷24) × 275

= 22916.67 cal/hr

= 22.91667 kcal/hr

8. Total heat load (H) –

$$H.L = H_1+H_2+H_3+H_4+H_5+H_6+H_7$$

$$=0.2013+1682.33+53.38+928.8+385.42+876.434+22.91$$

$$= 3949.47 kcal/hr$$

Chapter 6

Human comfort

Human Comfort

Human comfort depends upon physiological and psychological condition. Thus it is difficult to define the term 'human comfort'. There are many definitions given for this term by different bodies. But the most accepted definition from is given by the American Society of Heating, Refrigeration and Air conditioning Engineers (ASHRAE) which state: "Human comfort is that condition of mind, which expresses satisfaction with the thermal environment."

6.1: Factors Affecting human comfort:-

In designing winter or summer air conditioning system, the designer should be well conversant with a number of factors which physiologically affect human comfort. The important factors are as follow:

1. Effective temperature
2. Heat production and regulation in human body
3. Heat and moisture losses from human body
4. Moisture content of air
5. Quality and quantity of air
6. Hot and cold surface
7. Air stratification

6.1.1: Effective Temperature:-

The degree of warmth or cold felt by human body depends mainly on the following three factors:

i. Dry bulb temperature
ii. Relative humidity
iii. Air velocity

In order to evaluate the combined effect of these factors, the term effective temperature is employed. It is defined as that index which correlates the combine effect of air temperature, relative humidity and air velocity on the human body. The numerical value of effective temperature is made equal to the temperature of still saturated air, which produces the same sensation of warmth or coolness as produced under the given condition.

6.1.2: Heat production and regulation of human body:-

The human body acts like a heat engine which gets its energy from combustion of food within the body. The process of combustion produces heat and energy due to the oxidation of products in the body by oxygen obtained from inhaled air. The rate of heat production depends upon individual's health, his physical activity and his environment. The rate at which the body produces heat is termed as metabolic rate. the heat production from a normal healthy person when asleep is about 60 watts and it is about 10 times more for a person carrying out sustained very hard work.

6.1.3: Heat and moisture losses from body:-

The heat is given off from the human body as either sensible or latent heat or both in order to design any air conditioning system for spaces which human bodies are to occupy, it is necessary to know the rate at which these two form of heat are given off under different condition of air temperature and bodily activity.

6.1.4: Moisture content of air:-

The moisture content of outside air during winter is generally low and it is above the average during summer, because the capacity of air to carry moisture is dependent upon its dry bulb temperature. Thus while designing an air conditioning system, the proper dry bulb temperature for either summer or winter must be selected in accordance with the practical consideration of relative humidities which are feasible.

6.1.5: Quality and quantity of air:-

The air in an occupied space should, at all times, be free from toxic, unhealthful or disagreeable fumes such as carbon dioxide. It should also be free from dust and odour. In order to obtain this condition, enough clean outside air must always be supplied to an occupied space to counteract or adequately dilute the sources of contamination.

6.1.6: Air Motion:-

The air motion which includes the distribution of air very important to maintain uniform temperature in the conditioned space ordinarily the air velocity in occupied zone should not exceed 8-12 m/min. the air velocities in the space above the occupied zone should be very high in order to produce good distribution of air in the occupied zone, provided that air in motion does not produce any objectionable noise.

6.1.7: cold and hot surface:-

The cold or hot object in a conditioned space may cause discomfort to the occupant. Thus, in the designing of an air conditioning system, the temperature of the surfaces to which the body may be exposed must be given considerable importance.

6.1.8: Air stratification:-

When air is heated, its density decreases and thus it rises to the upper part of the confined space. This result in a considerable variation in the temperatures between the floor and ceiling levels. The movement of the air to produce the temperature gradient from floor to ceiling is termed as air stratification. The air conditioning system must be designed to reduce the air stratification to a minimum.

Chapter 7

Analyzing & Design

7.1: Psychrometric chart:-

It is graphical representation of the various thermodynamic properties of moist air. The psychrometric chart is very useful for finding out the properties of air and eliminates lots of calculations. There is a slight variation in the prepared by different air conditioning manufacturers but basically they all are alike.

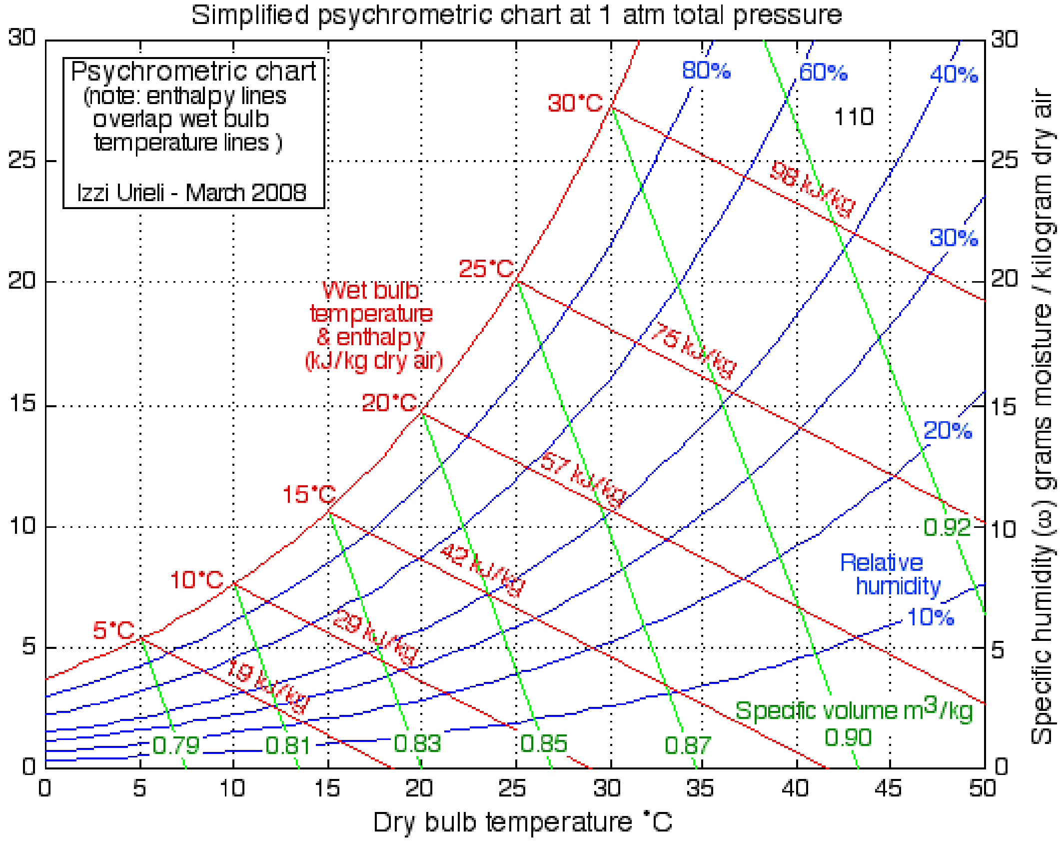


Fig7.1: Psychrometric chart

7.2: Condition of basement during summer season:-

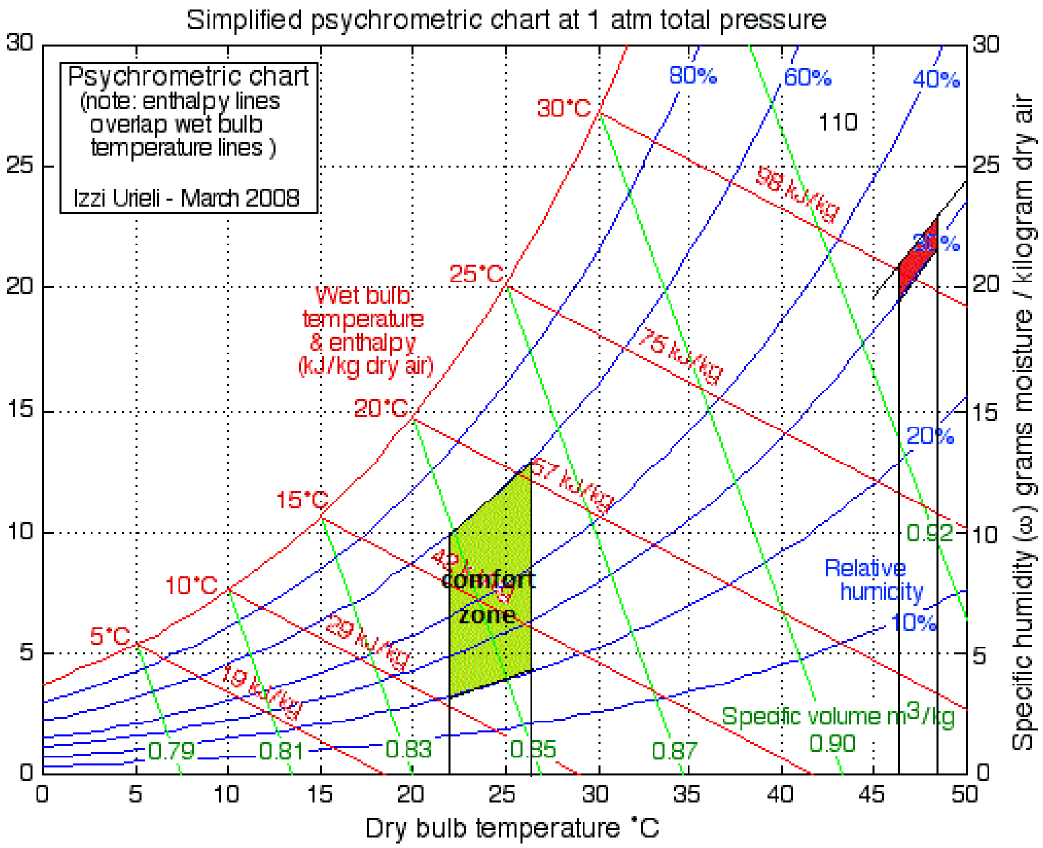


Fig 7.2: Basement condition for the summer season

- Form above chart it can be observed that the temperature of basement varies between 47° C to 48° C and the comfort condition is in between 22° C to 27° C.

7.3: Design of duct for summer:-

- Selecting the velocity of flow from standard table according to application.

$V = 350$ m/min

$= 6$ m/s

- Taking air flow rate

$Q = H.L / (\rho \times C_p \times (T_o - T_i))$

$Q = 4734.95 / (1.2 \times 1005 \times (48 - 46))$

$Q = 1.96\ m^3/s$

- Taking width of duct as

b= 0.3 m

- Area of duct

A = a x b

= a x 0.3

- Now,

Q = A x V

1.96 = a x 0.3 x 6

a = 1.08 m

- Equivalent circular duct

$$D_{eqv} = (1.3(a \times b)^{0.625}) \div (a + b)^{0.25}$$

$$= (1.3(1.08 \times 0.3)^{0.625}) \div (1.08 + 0.3)^{0.25}$$

$$= 0.62 \text{ m}$$

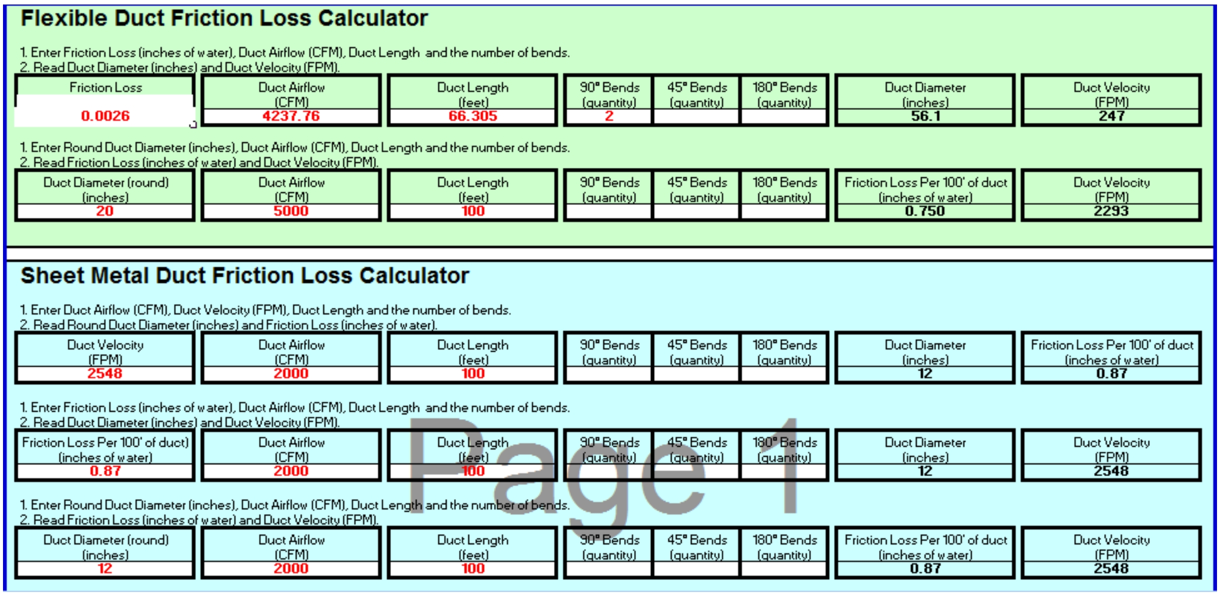
- Mass flow rate of air

$$H.L = m\, C_p\, (T_o - T_i)$$

$$4734.9 = m \times 1005 \times (48 - 46)$$

$$m = 2.35 \text{ kg/s}$$

- Verification



Flexible Duct Friction Loss Calculator

1. Enter Friction Loss (inches of water), Duct Airflow (CFM), Duct Length and the number of bends.
2. Read Duct Diameter (inches) and Duct Velocity (FPM).

Friction Loss	Duct Airflow (CFM)	Duct Length (feet)	90° Bends (quantity)	45° Bends (quantity)	180° Bends (quantity)	Duct Diameter (inches)	Duct Velocity (FPM)
0.0026	4237.76	66.305	2			56.1	247

1. Enter Round Duct Diameter (inches), Duct Airflow (CFM), Duct Length and the number of bends.
2. Read Friction Loss (inches of water) and Duct Velocity (FPM).

Duct Diameter (round) (inches)	Duct Airflow (CFM)	Duct Length (feet)	90° Bends (quantity)	45° Bends (quantity)	180° Bends (quantity)	Friction Loss Per 100' of duct (inches of water)	Duct Velocity (FPM)
20	5000	100				0.750	2293

Sheet Metal Duct Friction Loss Calculator

1. Enter Duct Airflow (CFM), Duct Velocity (FPM), Duct Length and the number of bends.
2. Read Round Duct Diameter (inches) and Friction Loss (inches of water).

Duct Velocity (FPM)	Duct Airflow (CFM)	Duct Length (feet)	90° Bends (quantity)	45° Bends (quantity)	180° Bends (quantity)	Duct Diameter (inches)	Friction Loss Per 100' of duct (inches of water)
2548	2000	100				12	0.87

1. Enter Friction Loss (inches of water), Duct Airflow (CFM), Duct Length and the number of bends.
2. Read Duct Diameter (inches) and Duct Velocity (FPM).

Friction Loss Per 100' of duct) (inches of water)	Duct Airflow (CFM)	Duct Length (feet)	90° Bends (quantity)	45° Bends (quantity)	180° Bends (quantity)	Duct Diameter (inches)	Duct Velocity (FPM)
0.87	2000	100				12	2548

1. Enter Round Duct Diameter (inches), Duct Airflow (CFM), Duct Length and the number of bends.
2. Read Friction Loss (inches of water) and Duct Velocity (FPM).

Duct Diameter (round) (inches)	Duct Airflow (CFM)	Duct Length (feet)	90° Bends (quantity)	45° Bends (quantity)	180° Bends (quantity)	Friction Loss Per 100' of duct (inches of water)	Duct Velocity (FPM)
12	2000	100				0.87	2548

Fig 7.3: Verification of duct size

7.4: Condition of basement during winter season:-

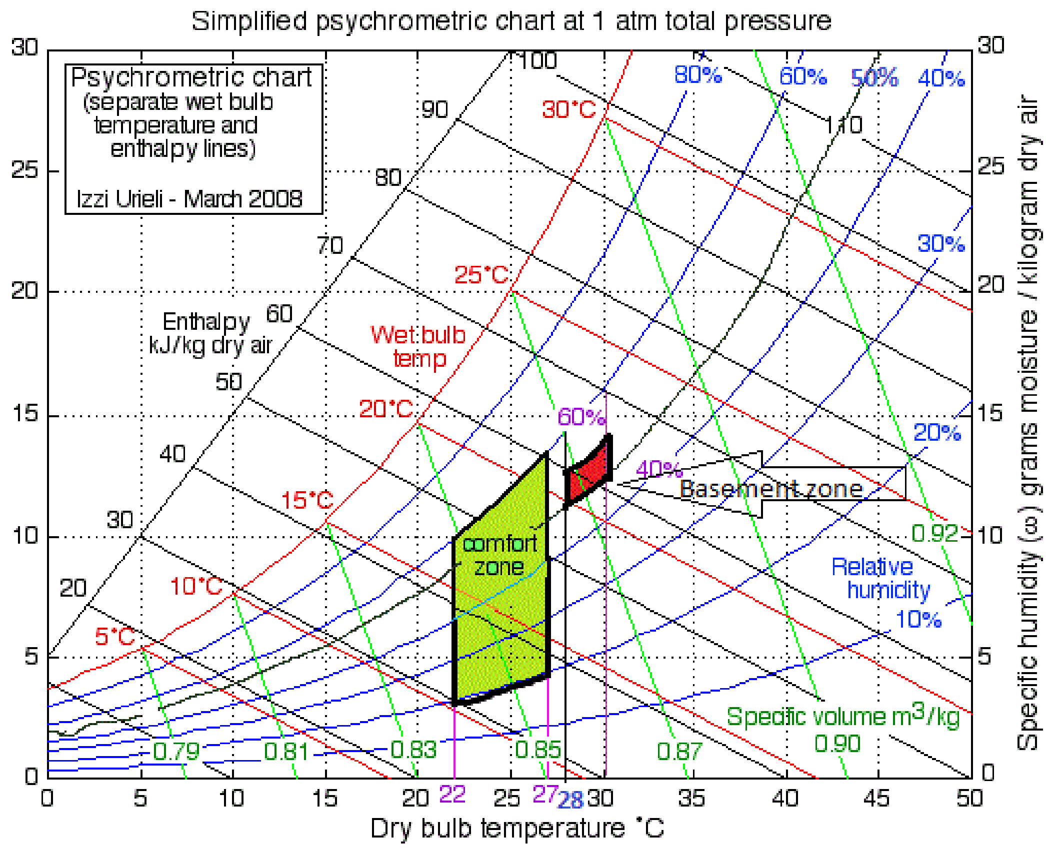


Fig 7.4: Basement condition for winter season

- Form above chart it can be observed that the temperature of basement varies between 28^{o} C to 30^{o} C and the comfort condition is in between 22^{o} C to 27^{o} C.
- So our objective is to bring the current basement condition into comfort zone.

7.5: Design of duct for winter:-

- Selecting the velocity of flow from standard table according to application.

$V = 350$ m/min

$= 6$ m/s

- Taking air flow rate

$Q = H.L/(\rho \times C_p \times (T_o - T_i))$

$Q = 4590.2 / (1.2 \times 1005 \times (30 - 28))$

$Q = 1.90\ m^3/s$

- Taking width of duct as

$b = 0.3$ m

- Area of duct

$A = a \times b$

$= a \times 0.3$

- Now,

$Q = A \times V$

$1.90 = a \times 0.3 \times 6$

$a = 1.15$ m

- Equivalent circular duct

$$D_{eqv.} = (1.3(a \times b)^{0.625}) \div (a + b)^{0.25}$$

$$=(1.3(1.15\times0.3)^{0.625}) \div(1.15+0.3)^{0.25}$$

$$= 1.08 \text{ m}$$

- Mass flow rate of air

$$H.L = m\, C_p\, (T_o - T_i)$$

$$4590.2 = m \times 1005 \times (30 - 28)$$

$$m = 2.28 \text{ kg/s}$$

- Verification of duct size

Flexible Duct Friction Loss Calculator

1. Enter Friction Loss (inches of water), Duct Airflow (CFM), Duct Length and the number of bends.
2. Read Duct Diameter (inches) and Duct Velocity (FPM).

Friction Loss	Duct Airflow (CFM)	Duct Length (feet)	90° Bends (quantity)	45° Bends (quantity)	180° Bends (quantity)	Duct Diameter (inches)	Duct Velocity (FPM)
0.0026	4237.76	66.305	2			56.1	247

1. Enter Round Duct Diameter (inches), Duct Airflow (CFM), Duct Length and the number of bends.
2. Read Friction Loss (inches of water) and Duct Velocity (FPM).

Duct Diameter (round) (inches)	Duct Airflow (CFM)	Duct Length (feet)	90° Bends (quantity)	45° Bends (quantity)	180° Bends (quantity)	Friction Loss Per 100' of duct (inches of water)	Duct Velocity (FPM)
20	5000	100				0.750	2293

Sheet Metal Duct Friction Loss Calculator

1. Enter Duct Airflow (CFM), Duct Velocity (FPM), Duct Length and the number of bends.
2. Read Round Duct Diameter (inches) and Friction Loss (inches of water).

Duct Velocity (FPM)	Duct Airflow (CFM)	Duct Length (feet)	90° Bends (quantity)	45° Bends (quantity)	180° Bends (quantity)	Duct Diameter (inches)	Friction Loss Per 100' of duct (inches of water)
2548	2000	100				12	0.87

1. Enter Friction Loss (inches of water), Duct Airflow (CFM), Duct Length and the number of bends.
2. Read Duct Diameter (inches) and Duct Velocity (FPM).

Friction Loss Per 100' of duct) (inches of water)	Duct Airflow (CFM)	Duct Length (feet)	90° Bends (quantity)	45° Bends (quantity)	180° Bends (quantity)	Duct Diameter (inches)	Duct Velocity (FPM)
0.87	2000	100				12	2548

1. Enter Round Duct Diameter (inches), Duct Airflow (CFM), Duct Length and the number of bends.
2. Read Friction Loss (inches of water) and Duct Velocity (FPM).

Duct Diameter (round) (inches)	Duct Airflow (CFM)	Duct Length (feet)	90° Bends (quantity)	45° Bends (quantity)	180° Bends (quantity)	Friction Loss Per 100' of duct (inches of water)	Duct Velocity (FPM)
12	2000	100				0.87	2548

Fig 7.5: verification of duct size (winter)

Chapter 8

Air Handling Unit

Air handling unit of HVAC system

An air handler, or air handling unit (often abbreviated to AHU), is a device used to regulate and circulate air as part of a heating, ventilating, and air-conditioning (HVAC) system. An air handler is usually a large metal box containing a blower, heating or cooling elements filter racks or chambers, sound attenuators, and dampers.[2] Air handlers usually connect to a ductwork ventilation system that distributes the conditioned air through the building and returns it to the AHU. Sometimes AHUs discharge (supply) and admit (return) air directly to and from the space served without ductwork.

Small air handlers, for local use, are called terminal units, and may only include an air filter, coil, and blower; these simple terminal units are called blower coils or fan coil units. A larger air handler that conditions 100% outside air, and no recirculated air, is known as a makeup air unit (MAU). An air handler designed for outdoor use, typically on roofs, is known as a packaged unit (PU) or rooftop unit (RTU).

Components of an AHU:-

8.1: Filter:-

Air filtration is almost always present in order to provide clean dust-free air to the building occupants. It may be via simple low-MERV pleated media, HEPA, electrostatic, or a combination of techniques. Gas-phase and ultraviolet air treatments may be employed as well.

Filtration is typically placed first in the AHU in order to keep all the downstream components clean. Depending upon the grade of filtration required, typically filters will be arranged in two (or more) successive banks with a coarse-grade panel filter provided in front of a fine-grade bag filter, or other "final" filtration medium. The panel filter is cheaper to replace and maintain, and thus protects the more expensive bag filters.

The life of a filter may be assessed by monitoring the pressure drop through the filter medium at design air volume flow rate. This may be done by means of a visual display using a pressure gauge, or by a pressure switch linked to an alarm point on the building control system. Failure to replace a filter may eventually lead to its collapse, as the forces exerted upon it by the fan overcome its inherent strength, resulting in collapse and thus contamination of the air handler and downstream ductwork.

8.2: Heating and/or cooling elements:-

Air handlers may need to provide heating, cooling, or both to change the supply air temperature, and humidity level depending on the location and the application. Such conditioning is provided by heat exchanger coil within the air handling unit air stream, such coils may be direct or indirect in relation to the medium providing the heating or cooling effect.

Direct heat exchangers include those for gas-fired fuel-burning heaters or a refrigeration evaporator, placed directly in the air stream. Electric resistance heaters and heat pumps can be used as well. Evaporative cooling is possible in dry climates.

Indirect coils use hot water or steam for heating, and chilled water for cooling (prime energy for heating and cooling is provided by central plant elsewhere in the building). Coils are typically manufactured from copper for the tubes, with copper or aluminum fins to aid heat transfer. Cooling coils will also employ eliminator plates to remove and drain condensate. The hot water or steam is provided by a central boiler, and the chilled water is provided by a central chiller. Downstream temperature sensors are typically used to monitor and control "off coil" temperatures, in conjunction with an appropriate motorized control valve prior to the coil.

8.3: Blower/ Fan:-

Air handlers typically employ a large squirrel cage blower driven by an AC induction electric motor to move the air. The blower may operate at a single speed, offer a variety of set speeds, or be driven by a Variable Frequency Drive to allow a wide range of air flow rates. Flow rate may also be controlled by inlet vanes or outlet dampers on the fan. Some residential air handlers in USA (central "furnaces" or "air conditioners") use a brushless DC electric motor that has variable speed capabilities.[1] Air handlers in Europe and Australia and New Zealand now commonly use backward curve fans without scroll or "plug fans". These are driven using high efficiency EC (electronically commutated) motors with built in speed control.

Multiple blowers may be present in large commercial air handling units, typically placed at the end of the AHU and the beginning of the supply ductwork (therefore also called "supply fans"). They are often augmented by fans in the return air duct ("return fans") pushing the air into the AHU.

Fig 8.1: Blower

8.4: AHU virtual model:-

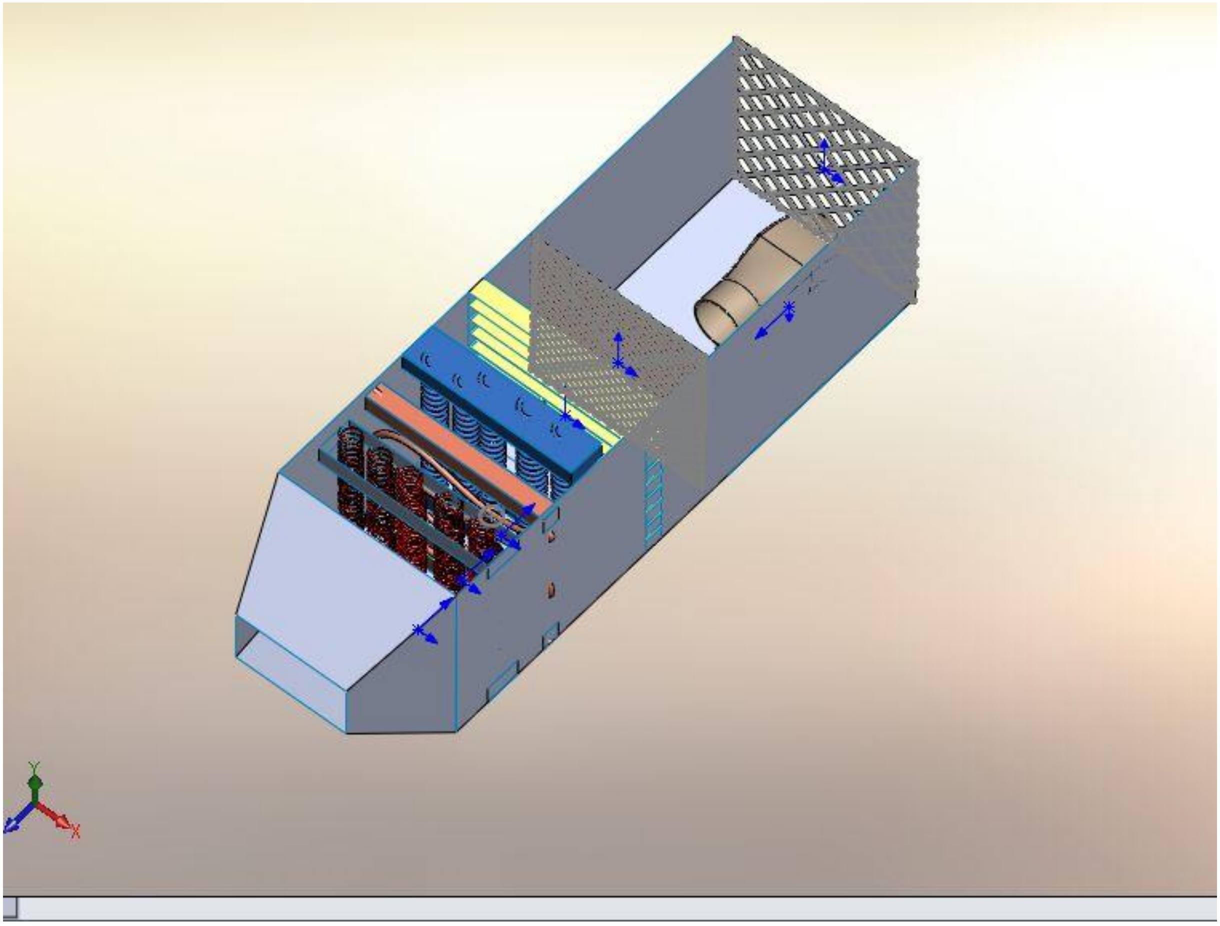


Fig 8.2: AHU

Chapter 9

Layout

Layout

9.1: Layout:-

The conditioned air (cooled or heated) from the air conditioning equipment must be properly distributed to rooms or spaces to be conditioned in order to provide comfort conditions. When the conditioned air cannot be supplied directly from the air conditioning equipment to the spaces to be conditioned, then the ducts are installed. The duct system conveys the conditioned air from the air conditioning equipment to the proper air distribution points or air supply outlets in the room and carries the return air from the room back to the air conditioning equipment for reconditioning and recirculation.

It may be noted that the duct system for proper distribution of condition air cost nearly 20 to 30 percent of the total cost of the equipments required and the power required by the fans form the substantial part of the running cost. Thus, it is necessary to design the air duct system in such a way that the capital cost of duct and the cost of running the fans is lowest.

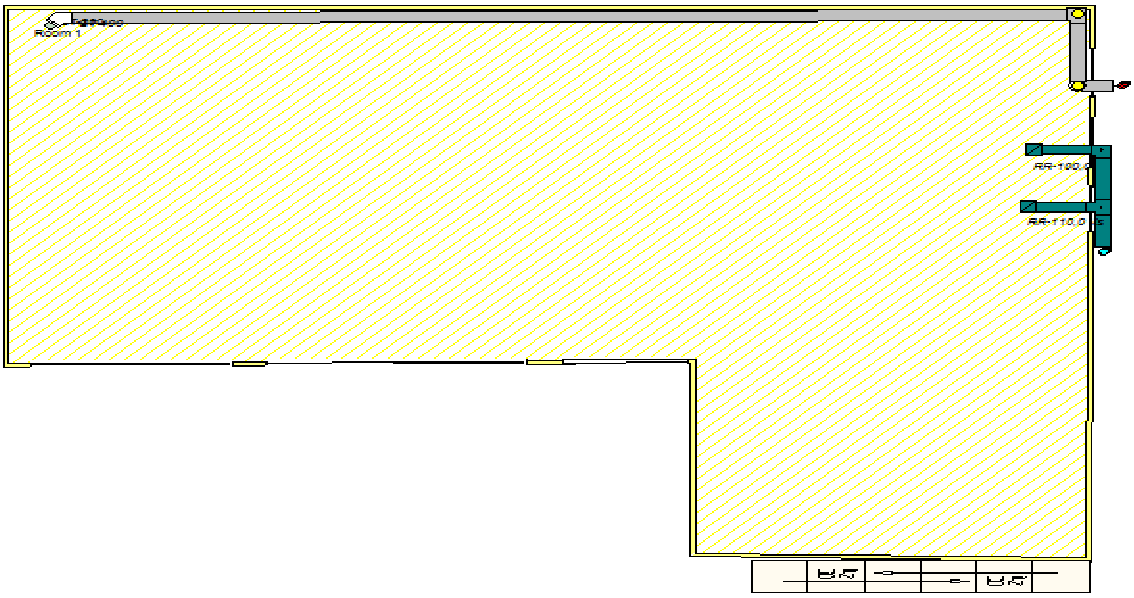


Fig 9.1: Layout (Top View)

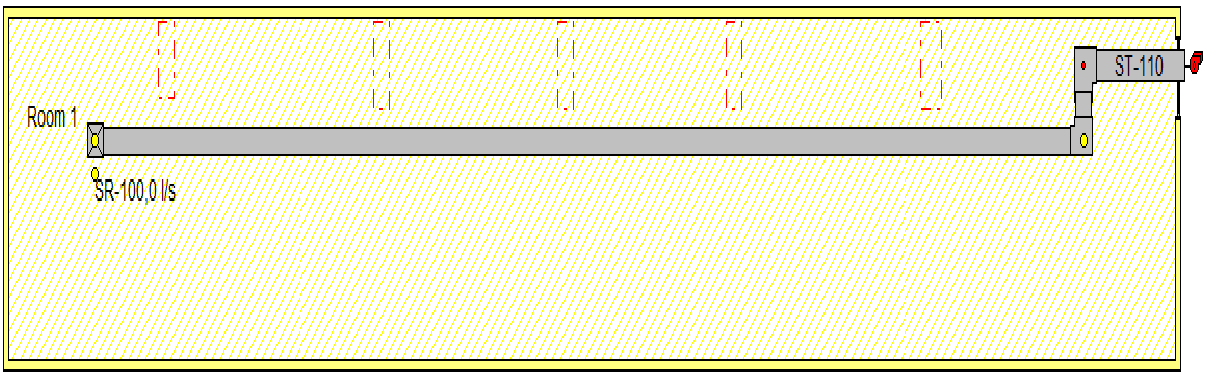


Fig 9.2 : layout (Front View)

Chapter 10

Component selection & Cost

10.1: Component selection:-

10.1.1: Blower:-

Table 10.1: Blower

Sr.No.	**Blower**	Air flow rate(m^3/s)	Cost(Rs.)
1	Blowtech	0 to 2.19	8500
2	Acme	0 to 47.19	13,000
3	Supertech	0 to 12.51	11,000
4	compliance	0 to 7.08	10,000

- On the basis of the air flow rate and the cost blowtech is selected. the

Blowtech blower specification:-

- Type : centrifugal
- RPM : 3500 rpm
- Power : 5 hp(230V, 50 Hz)
- Air flow rate : 0 to 2.19 m^3/s
- Static pressure range : 760 to 765 torr
- Blower diameter : 190 to 380 mm
- Material : steel.
- Feature : dampers, door

Fig 10.1: Blowtech blower

- In case if the number of people in the basement increases the heat load will also increase. So for effective working of the HVAC system we propose Compliance blower whose capacity is 0 to 7.08. It will take care of increase heat load.

10.1.2: Condenser:-

Table 10.2: condenser

Sr.No.	Condenser	Capacity(Kcal/h)	Cost(Rs.)
1	GSX130181	4517.20	7300
2	GSX140181	5125.65	9267
3	GSX160181	4824.82	8217
4	GSX160241	5030.45	8463

- On the basis of the capacity and the cost Goodman GSX130181 is selected.

Condenser specification:-

- Model : GSX130181
- Nominal capacity : 4517.20 kcal/h
- Efficiency : 13 SEER (Seasonal Energy Efficiency Ratio)
- Compressor required : Rotary compressor

10.1.3: Compressor:-

- For the effective working of above selected condenser the compressor required is rotary compressor of 208 V /230 V and single phase 50 Hz. So that Hitachi SHY 33MC2-S rotary compressor is selected.

Compressor Specification:-

- Cost : 8033 Rs.
- Capacity : 4675 kcal/h
- Power : 1.2 KW
- Current :6.2/5.8 Amp at 208/230 V

10.2: Duct material:-

- Galvanized steel: Galvanized mild steel is the standard and most common material used in fabricating ductwork. For insulation purposes, metal ducts are typically lined with faced fiberglass blankets (duct liner) or wrapped externally with fiberglass blankets (duct wrap).
- Aluminum: Aluminum ductwork is lightweight and quick to install. Also, custom or special shapes of ducts can be easily fabricated in the shop or on site.
- Based on the cost, availability, and requirement the galvanized steel is selected for the duct material.

10.3: Cost:-

Detail	cost
Component cost	32,333
Duct manufacturing cost	6400
Other cost	2500
Total cost	41,233

Chapter 11

Conclusion and Future Scope

Conclusion

The HVAC system for the basement of AIKTC is designed successfully by following basic steps obtained from various content on the HVAC system design. After installation of HVAC system proposed in this report, the people in the basement will feel comfortable. Because various factors that affect the human comfort (like effective temperature, air motion, etc.) will be achieve within the range. It will give comfort to people in the basement.

Further improvement in the propose design of HVAC system for the basement of AIKTC also has scope. Areas where further improvement is possible in the project are discussed in the future scope of this report.

Future Scope

The following things can be adopted in future in order to enhance the working of designed HVAC system.

11.1: Insulation:-

The heat emitted through the wall is 42.6% of the total heat load. This percentage of heat addition in the total heat load can be minimizing by providing insulation to the wall which emits heat in the conditioned space.

11.2: Elimination of fans:-

The heats emitted through the fans are 22.19% of the total heat load. This percentage of heat addition in the total heat load can be minimize by eliminating fans from conditioned space, after installing the HVAC system design in the basement of AIKTC.

11.3: Introduce LED lights:-

The heat emitted through the lights is 23.51% of the total heat load. This percentage of heat addition in the total heat load can be minimize by introducing LED lights in the condition spaces as LED emits less heat as compare to florescent lamp/lights.

11.4: Provision for future expansion:-

The area of the basement would be expanded in future so accordingly there will be a change in heat load so the size of duct will also change accordingly and as a result of this change there will be a need of high capacity blower which can be selected from above stated table.

References

- P.N.Ananthanarayan , “*Basic Refrigeration & Air Conditioning”,* Tata McGraw-Hill Publication, third edition, 2009
- P.N.Ananthanarayan, “*Basic Refrigeration & Air Conditioning”,* Tata McGraw-Hill Publication, fourth edition, 2013
- R.S.Khurmi, “ *Refrigeration & Air conditioning*”, S Chand Publication, fifth edition, 2015
- Arsha Viswambharan, "*Sustainable HVAC systems in commercial and Residential Buildings*", International Journal of Scientific and Research Publication, Volume 4, Issue 4, April-2014
- Lars sonderby Nielsen, " *Building Integrated System for Sustainable Heating and Cooling*", REHVA Journal, Feb-2012
- Sheetal Kumar Patidar, “*Modern trans in building an HVAC design tool*”, International Journal of Science Engineering and Technology Research, May-2002.
- Khayti Saxena, “HVAC Schematic System Design”, International Organization of scientific Research Journal Mechanical and Civil Engineering, Sept-2006

Appendix

H_1 : Heat load of empty area

H_2 : Heat transfer through wall

H_3 : Heat transfer through window

H_4 : Heat emitted from light

H_5 : Heat emitted from projector

H_6 : Heat emitted from fan

H_7 : Heat emitted from people

H.L : Total heat load

Q : discharge or air flow rate

ρ : Density of air

A : Area of duct

V : Velocity of air flowing through duct

a : Wirth of the duct

b : height of the duct

D_{eqv} : Equivalent diameter of circular duct

C_p : Specific heat at constant pressure

T_O : Outer temperature of basement

$T_{i.}$: Inside temperature of basement

m : mass flow rate of air