DESIGN OF AIR CONDITIONING SYSTEM BY USHIG HAP (Hourly Analysis Program)

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ABSTRACT

To study and evaluate the technical Designing of Heating, Ventilation & Air-conditioning (HVAC) system for a commercial High Rise Building has been designed

HVAC refers to the equipment, distribution network, and terminal that provide either collectively or individually the heating, ventilating, or air-conditioning processes to a building. HVAC system design is a major sub discipline of mechanical engineering, based on the principles of thermodynamics, heat transfer and fluid mechanics [3].

HVAC systems provide:

- Heating
- Cooling
- Air handling, ventilation, and air quality

Every air conditioning application has its own special 'needs' and provided its own challenges. Shopping malls, office complexes, hotels, Atm's, Airports and banks need uniform comfort cooling in every corners of their sprawling spaces and activities involving computers, electronics, aircraft products, precision manufacturing, communication networks and operation in hospitals, infect many areas of programming will come to a halt, so air conditioning is no longer a luxury but an essential part of modern part of modern living.

INTRODUCTION TO HVAC

HVAC (heating, ventilating, and air conditioning) refers to the equipment, distribution network, and terminals that provide either collectively or individually the heating, ventilating, or air-conditioning processes to a building. HVAC system design is a major sub discipline of mechanical engineering, based on the principles of thermodynamics, fluid mechanics, and heat transfer.

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HVAC accounts for 40 to 60 percent of the energy used in U.S. commercial and residential buildings. This represents an opportunity for energy savings using proven technologies and design concepts.

The American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) supplies technical information to engineers and other professionals. In addition, ASHRAE writes standards and guidelines in its field of expertise to guide industry in the delivery of goods and services to the public.

HEATING

There are different types of standard heating systems. Central heating is often used in cold climates to heat private houses and public buildings. Such a system contains a boiler, furnace, or heat pump to heat water, steam, or air, all in a central location such as

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a furnace room in a home or a mechanical room in a large building. The use of water as the heat transfer medium is known as hedonics.

The system also contains either ductwork, for forced air systems, or piping to distribute a heated fluid and radiators to transfer this heat to the air. The term *radiator* in this context is misleading since most heat transfer from the heat exchanger is by convection, not radiation. The radiators may be mounted on walls or buried in the floor to give under-floor heat.

VENTILATION

Ventilating is the process of "changing" or replacing air in any space to control temperature or remove moisture, odors, smoke, heat, dust, airborne bacteria, carbon-dioxide, and to replenish oxygen. 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 [6]

Methods for ventilating a building may be divided into mechanical/forced and natural types. Ventilation is used to remove unpleasant smells and excessive moisture, introduce outside air, to keep interior building air circulating, and to prevent stagnation of the interior air.

Mechanical or forced ventilation: A building ventilation system that uses powered fans or blowers to provide free air to rooms and its used to control indoor air quality, excess humidity, odours and contaminants can often be controlled via dilution or replacement with outside air. Kitchens and bathrooms typically have mechanical exhaust to control odour and sometimes humidity.

Natural ventilation: Natural ventilation is the ventilation of a building with outside air without the use of a fan or other mechanical system. It can be achieved with opened windows.

AIR-CONDITIONING

Air-conditioning is the process of removing heat from the space according to the human comfort conditions and its simultaneous control of temperature, humidity, air movement and the quality of air in space.

Early test on refrigeration discussed the application of using ice for preservation of food and the initial development of the concept of mechanical chemical refrigeration in 1978 in Scotland by Dr. William Cullen. It was in 1844 that Dr. John Gorrie (1803-1855), director of the U.S. Marine Hospital and Apalachicola, Florida, described his new refrigeration machine. In the world built and used for refrigeration and air-conditioning. Refrigeration engineering became a recognized profession and in 1904 some 70 members formed ASRE (American Society of Refrigeration Engineers). The real “Father of air-conditioning” was Willis H. Carrier (1876-1950) as noted by many industry professionals and historians.

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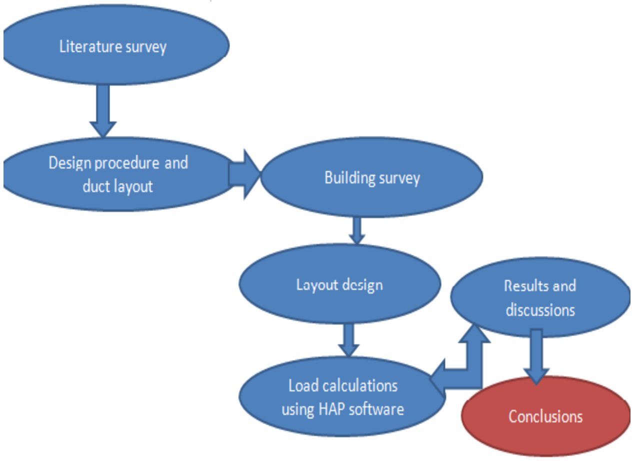
METHODOLOGY



DUCT

A duct can be described as a device used to provide an isolation path to carry an item from one place to other place without bringing the product in contact with the atmosphere before delivery point.

DUCT DESIGN PROCEDURE AND DUCT LAYOUT

DESIGN PROCEDURE:

- Computer-aided duct design and sizing programs are widely used for more precise calculation and optimum sizing of large and more complicated duct systems.
- Designer should verify local customs, local codes, local union agreements
- The designer proposes a preliminary duct layout to connect the supply outlets and return inlets with the fan(s)

DUCT SIZING METHODS

- Equal Friction (Pressure Drop) Method
- In this method, the size of duct is decided to give equal pressure drop (or friction loss) per meter length in all ducts.
- If the layout of the ducts is symmetrical giving the same length of the various runs, this method gives equal pressure loss in various branches.

PIPE DESIGNING

- It is a conduit, which carries the water from a boiler or chiller to the heat exchanger, where the heat exchange process is carried out.
- Pipe sizing is calculated from machine to air handling unit and fan coil units.
- For pipe sizing we need to two parameter gpm and velocity

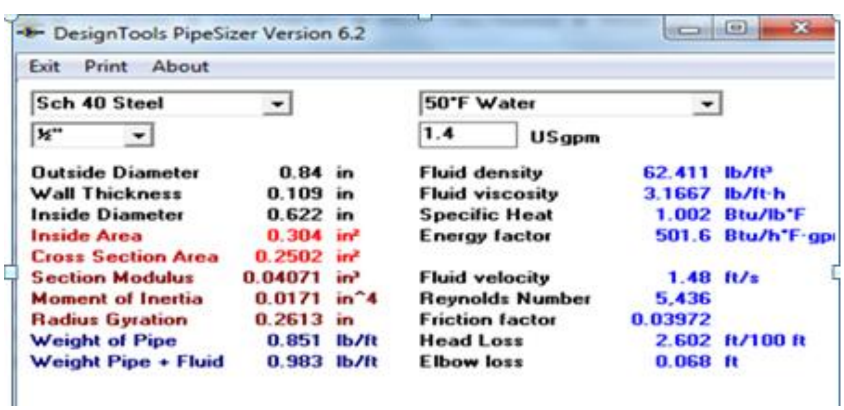


Figure: Pipe Sizing Software

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OVER ALL PIPING SYSTEM

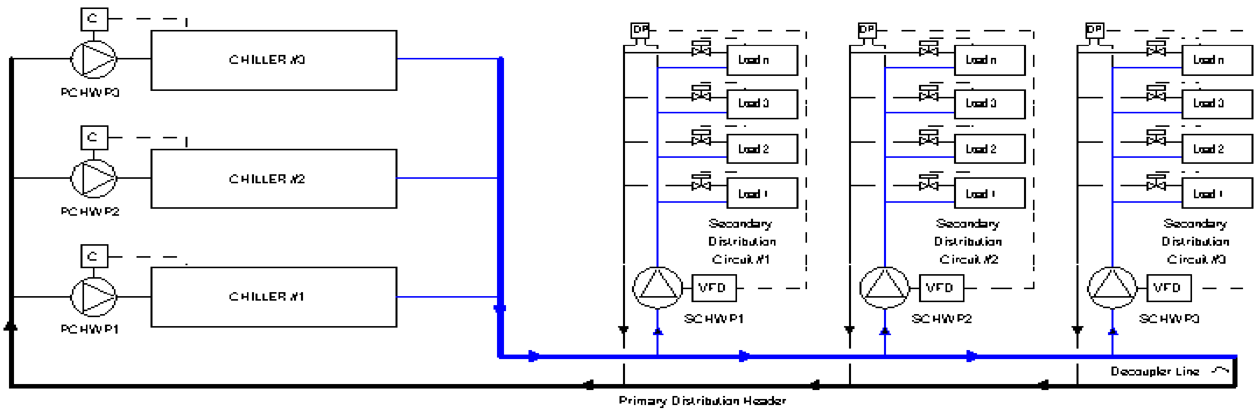

Figure: Overall Piping System

EXTERNAL STATIC PRESSURE CALCULATIONS (esp):

ESP For fan selection using ASHRAE duct fitting software

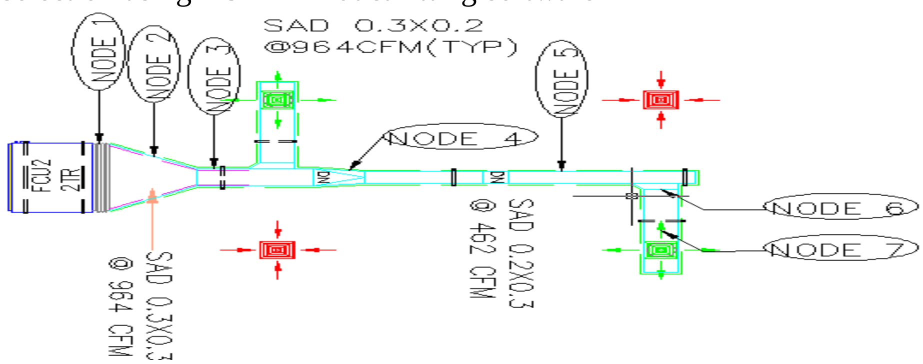

Figure: ASHRAE Duct Fitting for ESP

BUILDING SURVEY AND LOAD ESTIMATE

The primary function of air conditioning is to maintain conditions that are (1) Conductive to human comfort or (2) Required by a product, or process within a space. To perform this function equipment of the proper capacity must be installed and controlled throughout the year [2]

The equipment break load requirements, type of control are determined by the conditions to be maintained during peak and partial load. Generally it is impossible to measure either the actual peak or the partial load on any given space, these loads must be estimated. It is for this purpose that the data contained has been compiled.

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Before the load can be estimated, it is imperative that a comprehensive survey be made to assure accurate evaluation of the load components. If the building facilities and the actual instantaneous load with a given mass of the building are carefully studied and economical equipment selection and system design can result, and smooth, trouble free performance is then possible.

The heat gain or loss is the amount of heat instantaneously coming into or going out of the space. The actual load is defined as that amount of heat, which is instantaneously added or removed by the equipment. The instantaneous heat gain and the actual load on the equipment will rarely be equal, because of the thermal inertia or storage effect of the building structures surrounding a conditioned space.

BUILDING SURVEY

Space Characteristics and Heat Load Sources:

An accurate survey of the load components of the space to be air-conditioned is a basic requirement for a realistic estimation of cooling and heating loads, the compel and accuracy of this survey is the very foundation of the estimation, and its importance cannot be over emphasized [1]

Mechanical and architectural drawings, complete fields sketches and in some cases photographs of important aspects are part of a good survey. The following physical aspects must be considered.

Orientation of Building- location of the space to be air-conditioned with respect to

- Compass points- sun and wind effects.
- Nearby permanent structures- shading effects.
- Reflective surfaces- water, sand and parking lots etc.
- **Use if Space(s)-** Office, Hospital, departmental store, specialty shop, machine shop and factory assembly plant etc.
- **Physical Dimensions of spaces (s) -** Length, width and height.
- **Ceiling Height-** Floor to floor height, floor to ceiling, clearance between suspended ceiling and beams.
- **Columns and Beams-** size, depth also knee braces.
- **Construction Materials-** Materials and thickness of wall, roof ceiling, floor and partitions and their relative's position in the structure.
- **Surrounding Conditions-** Exterior color of walls and roof shaded by adjacent building or sunlight space- invented or vented, gravity or forced ventilation. Surrounding spaces conditioned or unconditioned- temperature of non-conditioned adjacent spaces, such as furnace or boiler room, and kitchens, floors on ground, crawl space and basement.
- **Window Sized and Location-** wood or material sash, single or double hung, type of glass single or multiple type of shading device. Dimension of reveals and over changes.
- **Doors-** Location, types, size and frequency of use.
- **Stairways, Elevators and Escalators-** Location temperature of space if open unconditioned area. Horsepower of machinery, ventilated or not.
- **People-** Number, duration of occupancy, nature of activity any special concentration. At times, it is required to estimate the number of people on the basis of square feet per person, or on average traffic
- **Ventilation-** CFM per person, CFM per sq. ft, scheduled ventilation (agreement with purchaser) Excessive smoking orders,

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code requirements. Exhaust fans-type size, speed and CFM delivery.

- **Thermal Storage-** includes system operating scheduled (12,16 or 24 hours) per day specially during peak outdoor conditions, permissible temperature swing in space during a design day, rugs on floor, nature of surface, materials, enclosing the space.
- **Continuous or Intermittent Operation-** whether system be required to operate every business day during cooling seasons, or only occasionally, such as churches and ballrooms, if intermittent operation determine duration if time available for pre-cooling or pull down.

HEATING LOAD ESTIMATE

(a)Source of Heat:

1. Outside Heat

2. Inside generated heat

3. Outside source heat

4. A/C Machine Heat

5. Visitors Heat

(b)Outside Heat:

1. Solar Heat

2. Machine AHU

3. Visitors Heat

4. Air Leakage

5. Fresh air

(c)Solar heat load come through radiation & conduction:

a) Radiation comes through glass window.

b) Conduction through Wall.

Air Conditioning system will be too much affected if we fix it North or East

(d)Orientation Layout of the building will be in consideration at the time of heat load calculation:

1. Types of wall used material.

2. Window fixed side & Material.

3. Ground Floor not affected Heat

4. 1st floor & above lower floor's Condition, roof material, floor Material.

5. Roof: - RCC, Asbestos sheet, false sealing material Leakage

6. Exposed sun

7. Infiltration

Leakage in side, Ventilation, IAQ [Indoor air quality] fresh air CFM/Person.

(e)Occupancy:

- Sensible heat from Visitors+ Latent heat added

(f)Heat load reduction:

1. Insulating the wall roof
2. Quality of glass [Double glass pane window reduce 40% to 60% heat load]
3. Ventilation blind
4. Using Sun film
5. Sun Shed
6. Doors leakage
7. Roof [Water spraying, Permanent water storing, Covering by cemented water tank.]
8. False ceiling.

Principal of Load Estimation

U Factor Value means: - Coefficient of heat transfer from hotter Zone to colder Zone [4]

Conduction method followed for heat transfer "U" Factor.

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Heat transfer by conduction=Area XΔT X U

Out Side Design Data

ΔT= Varies from place to place

Inside Design Data T=24^{o}C^{+}-1^{o}C RH:-50% {cooling in Summer}

Inside Design Data T=20^{o}C^{+}-1^{o}C RH:-35% {heating in winter}

(a)Air Movement:

4.5 -7.5 CM/Min Measured 5' above ground level

Outside Design:-Maximum enriched Temperature.

Inside Design: - Desired Temperature.

Load & Estimate determine size of ACR Equipment to maintain in side design condition during periods of maximum extreme outside temperature.

(b)Heat Gain:

Radiation Maximum through Glass.

Radiation due to solar gain.

Total Heat=Factor on Chart X Area

Solar Heat Gain = Factor X solar Heat gain through glass X Area [BTU/Hr] solar heat.

(c)Conduction:

Thermal Resistance

Conduction=Area XΔT X U

ΔT= Outside Temperature -Inside Temperature

Radiation=Area XΔT X U

Heat gain Add by People:-1. Sensible Heat 2. Latent heat.

Heat gain Add by Light,:-1.Incand Lamp, 2.Fluracent Lamp {Wattage X3.4}

(d)Infiltration:

Window Leakage- 22 BTU/Hr

Doors Leakage-65 BTU/Hr/Person X No of customer/Hr

Exhaust Fan = 1000 CFM, 10% Extra will Add Compare with Ventilation & Infiltration.

Specific Humidity = Gm/Kg of Dry Air

GrainX0.0648 = 1 gm [1 grain =1/0.0648 gm]

One Man required =60Sq Feet, Release =14 BTU/Hr,

Light Factor=3.4 BTU/Hr,

Air quantity standard CFM = 400 cfm/ Ton

360 CFM outside air carried by the person

Outside air add 20% Extra

Velocity X area of duct air throw= CFM Air Quantity

CALCULATION FOR HIGH RISE BUILDING

Heat Load Calculation using HAP (Hourly Analysis Program):

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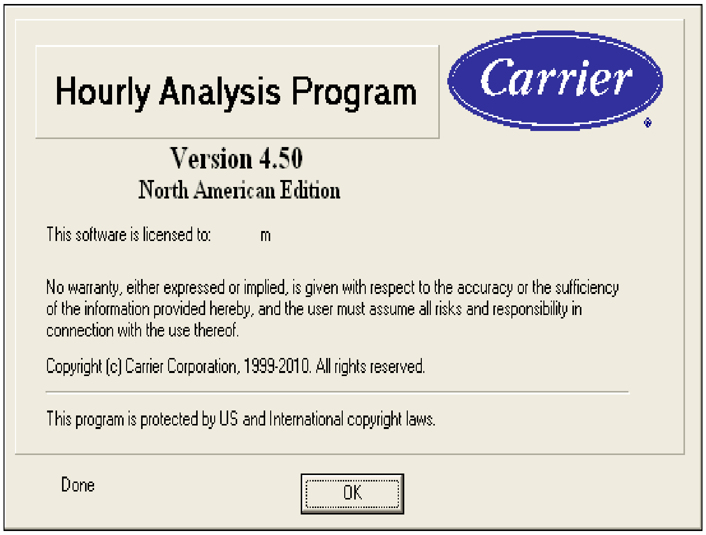

Fig: Hap Software

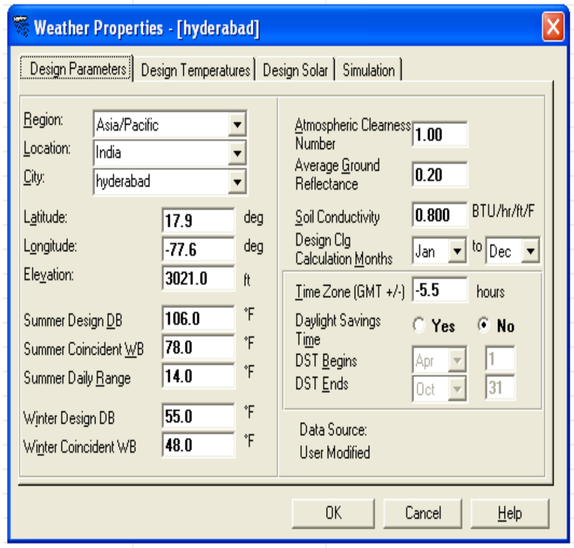

Fig:Software for Weather properties

HEAT LOAD CALCLUTION SHEET USING HAP SOFTWARE

Air System Information

Air System Name	**R FCU 7,8**		Number of zones	**1**	
Equipment Class	**CW AHU**		Floor Area	**1300.0**	ft²
Air System Type	**SZCAV**		Location	**Hyderabad, India**	

Sizing Calculation Information

Zone and Space Sizing Method:

Zone CFM	**Sum of space airflow rates**	Calculation Months	**Mar to Jun**
Space CFM	**Individual peak space loads**	Sizing Data	**Calculated**

Central Cooling Coil Sizing Data

Total coil load	**6.9**	Tons	Load occurs at	**Mar 1400**	
Total coil load	**83.2**	MBH	OA DB / WB	**100.4 / 74.9**	°F
Sensible coil load	**73.5**	MBH	Entering DB / WB	**77.7 / 63.6**	°F
Coil CFM at Mar 1400	**3640**	CFM	Leaving DB / WB	**56.9 / 55.5**	°F
Max block CFM	**3640**	CFM	Coil ADP	**54.5**	°F
Sum of peak zone CFM	**3640**	CFM	Bypass Factor	**0.100**	
Sensible heat ratio	**0.884**		Resulting RH	**49**	%
ft²/Ton	**187.5**		Design supply temp.	**55.0**	°F
BTU/(hr-ft²)	**64.0**		Zone T-stat Check	**1 of 1**	OK
Water flow @ 10.0 °F rise	**16.65**	gpm	Max zone temperature deviation	**0.0**	°F

Central Heating Coil Sizing Data

Max coil load	**6.6**	MBH	Load occurs at	**Des Htg**	
Coil CFM at Des Htg	**3640**	CFM	BTU/(hr-ft²)	**5.1**	
Max coil CFM	**3640**	CFM	Ent. DB / Lvg DB	**69.2 / 71.1**	°F
Water flow @ 20.0 °F drop	**0.66**	gpm			

Supply Fan Sizing Data

Actual max CFM	**3640**	CFM	Fan motor BHP	**0.00**	BHP
Standard CFM	**3260**	CFM	Fan motor kW	**0.00**	kW
Actual max CFM/ft²	**2.80**	CFM/ft²	Fan static	**0.00**	in wg

Outdoor Ventilation Air Data

Design airflow CFM	**228**	CFM	CFM/person	**11.40**	
CFM/ft²	**0.18**	CFM/ft²		CFM/person	

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- From load calculation we get 3640 CFM. & 6.9TR. We divide TR & CFM into two Machines (3.3tr, 1820cfm) &.we divide retail shop into 16 diffuser.
- In that there are 8 supply & 8 return. From each diffuser (supply) 455 cfm is supplied

SIMULATION OF HVAC DESIGNING

Air System Information

Air System Name	**lobby (b&p) FCU1,2,3**	Number of zones	**1**
Equipment Class	**CW AHU**	Floor Area	**212.6** ft²
Air System Type	**SZCAV**	Location	**Hyderabad, India**

Sizing Calculation Information

Zone and Space Sizing Method:

Zone CFM	**Sum of space airflow rates**	Calculation Months	**Mar to Jun**
Space CFM	**Individual peak space loads**	Sizing Data	**Calculated**

Central Cooling Coil Sizing Data

Total coil load	**1.3**	Tons	Load occurs at	**Jun 1700**	
Total coil load	**15.9**	MBH	OA DB / WB	**103.6 / 77.7**	°F
Sensible coil load	**13.1**	MBH	Entering DB / WB	**78.4 / 61.9**	°F
Coil CFM at Jun 1700	**498**	CFM	Leaving DB / WB	**51.1 / 49.7**	°F
Max block CFM	**498**	CFM	Coil ADP	**48.1**	°F
Sum of peak zone CFM	**498**	CFM	Bypass Factor	**0.100**	
Sensible heat ratio	**0.825**		Resulting RH	**41**	%
ft²/Ton	**160.3**		Design supply temp.	**50.0**	°F
BTU/(hr-ft²)	**74.9**		Zone T-stat Check	**1 of 1**	OK
Water flow @ 10.0 °F rise	**3.18**	gpm	Max zone temperature deviation	**0.0**	°F

Central Heating Coil Sizing Data

Max coil load	**0.6**	MBH	Load occurs at	**Des Htg**	
Coil CFM at Des Htg	**498**	CFM	BTU/(hr-ft²)	**2.9**	
Max coil CFM	**498**	CFM	Ent. DB / Lvg DB	**68.7 / 70.0**	°F
Water flow @ 20.0 °F drop	**0.06**	gpm			

Supply Fan Sizing Data

Actual max CFM	**498**	CFM	Fan motor BHP	**0.00**	BHP
Standard CFM	**446**	CFM	Fan motor kW	**0.00**	kW
Actual max CFM/ft²	**2.34**	CFM/ft²	Fan static	**0.00**	in wg

Outdoor Ventilation Air Data

Design airflow CFM	**43**	CFM	CFM/person	**7.13**	CFM/person
CFM/ft²	**0.20**	CFM/ft²			

ASHRAE Recommended Values

Table: Outdoor Air Requirements for ventilation

Application	**Estimated Max** Occupancy P/1000 ft^2**
Reception Area	30
Main Entry Lobby	10
Office Space	5
Data entry/Telephone	60
Health club/aerobics room	40
Supermarket	8

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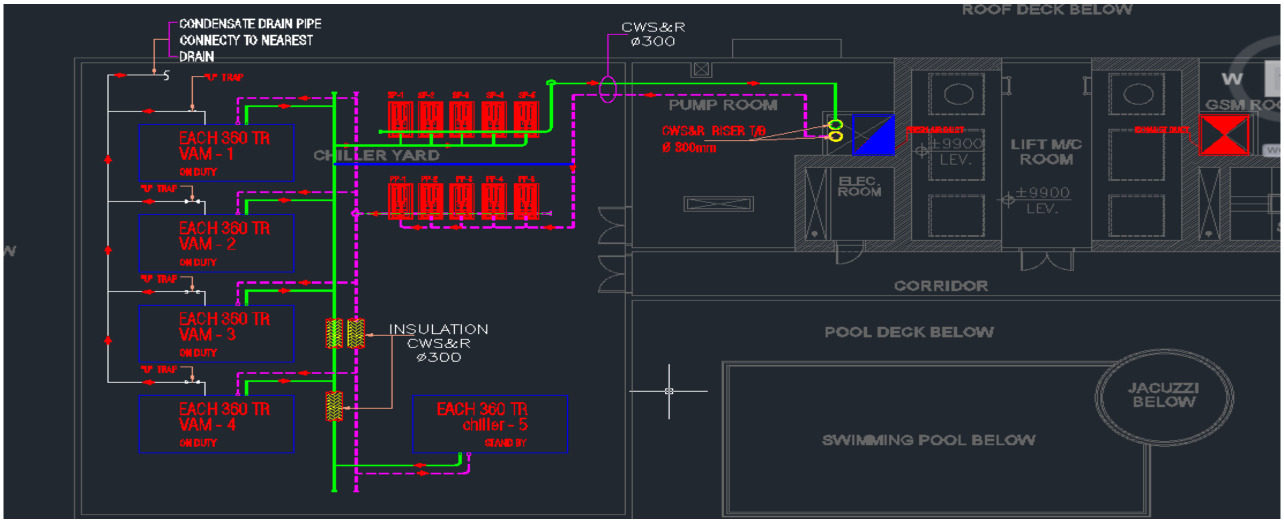

Fig: Plant Area Shop Drawing

Results

Air System Name	Mult.	System Cooling Coil Load (Tons)
2- C, OF L, P , IDF, FCU 57	13	4.0
2 corridor (3)	13	2.1
2- C OF FCU 55	13	2.6
2 lobby OFFICE(1)	13	1.0
2-O FCU 58	13	3.8
2-0 FCU 67	13	4.0
2-0 FCU 68	13	4.0
C FCU 36	1	2.4
C, OF L , P , IDF FCU 37	1	4.6
corridor (4)	1	2.4
C FCU 35	1	3.2
ELE ROOM G	1	0.3
EN,CO,RE,L	1	5.7
EN,CO,EL	1	6.9
Gen.gym FCU 316-317	1	21.6
GYM CO FCU 315	1	4.9
I D F ROOM1	1	1.1
I D F ROOM2	13	0.8
l v room 1	1	3.0
l v room 2	1	3.0

Conclusion

Based on the inputs & room data sheets and data Summary sheet the projected Ton will be calculated. To offset this load we propose to provide vapor absorption machine with a standby option. Three will be as duty Vapor Absorption Machine while other one will be as standby.

The vapor absorption machine and the pumps will be located in the plant room assigned for the purpose on the Roof Deck floor. The plant room will be duly ventilated. The FCU's will also be located on the Roof Deck Floor [7]

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It is proposed to incorporate a primary water distribution system in the AC system design. The Primary system will comprise of a set of Primary pumps which will circulate the water to the vapor absorption machine and they will circulate the water from the vapor absorption machine to the Various Zone FCU's are constant speed type. This way the pumps need not run at constant speed always and hence energy is saved.

REFERENCES

[1] ASHRAE HANDBOOK, Fundamentals Applications 2001.

[2] CARRIER Air Conditioning Co, Hand

[3] Tongshoob T, and Vitooraporn C, "A Probabilistic Approach for Cooling Load Calculation"
ASHRAE Thailand Chapter, ASHRAE Journal 2004-2005.

book of Air Conditioning System Design, McGraw-Hill, New York, 1996.

[4] C.P Arora, Refrigeration and Air-conditioning, 3rd Ed., Prentice Hall (2009).

John Wiley and Sons Inc.

[5] H.J Cowan, Energy conservation in multi-storeyed buildings, Pergamon Press.

[6] J.E Brombaugh, Heating Ventilation & Air-conditioning.

[7] R.S Khurmi & J.K Gupta, Refrigeration & Air-conditioning, S. Chand Publication.

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