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Chiller and AHU Design for A commercial Usage

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ABSTRACT

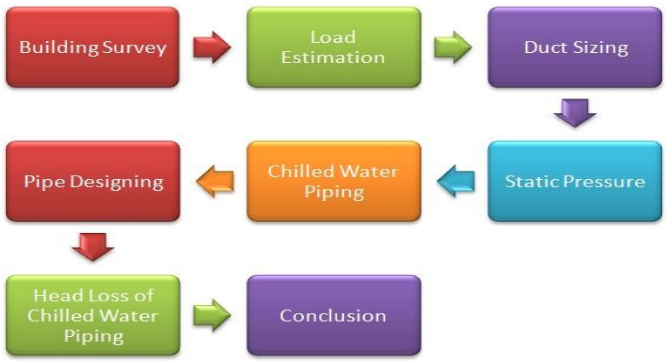
Central air conditioning is more reliable for easy operation with a lower maintenance cost. The effective design of central air conditioning can provide lower power consumption; low capital cost and improves aesthetics of a building. This paper establishes the results of cooling load calculation under different climate conditions by using HAP for a commercial building1. Heating and cooling due to people, lighting, infiltration, ventilation, and cooling load due to walls and roofs. Using ASHRAE and CARRIER Fundamental Hand Books. And here the study of air water vapor mixture, (called psychometrics) for human comfort in the air conditioning system for the city Hyderabad.

Keywords : Hourly Analysis Programme, Cubic Feet per Minute, Static Pressure, Gallons per minute, Head Loss of Chilled Water Pump.

I. INTRODUCTION

Heating, ventilating, and air conditioning (hvac):- relates to systems that perform processes designed to regulate the air conditions within buildings for the comfort and safety of occupants or for commercial and industrial processes or for storage of goods. hvac systems condition and move air to desired areas of an indoor environment to create and maintain desirable temperature, humidity, ventilation and air purity.

II. METHODS AND MATERIAL



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.

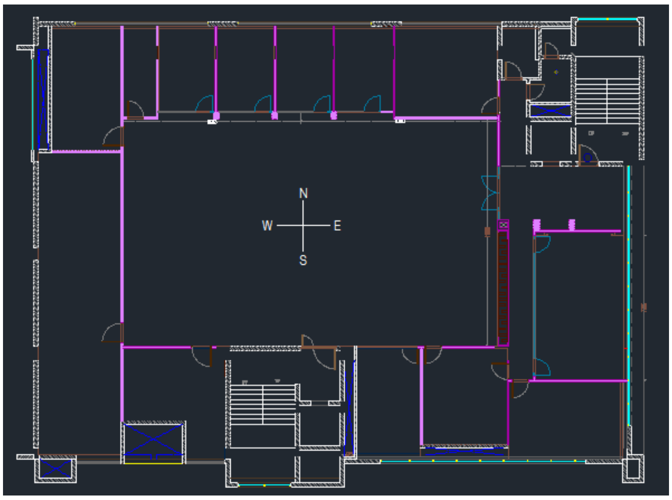
Orientation of Building- location of the space to be air-conditioned with respect to

- ✓ Compass points- sun and wind effects.
- ✓ Nearby permanent structures shading effects.
- ✓ Reflective surfaces- water, sand and parking lots etc.
- ✓ Use of 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 colour 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, 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.

Site Drawing



Heat Load Estimation

Here we are going to proceed the load calculation with Hourly Analysis Programme Version 4.9

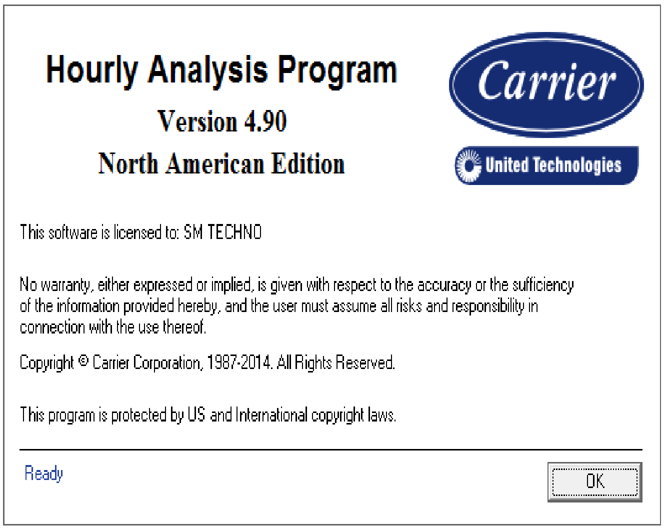


Figure 1. HAP Software

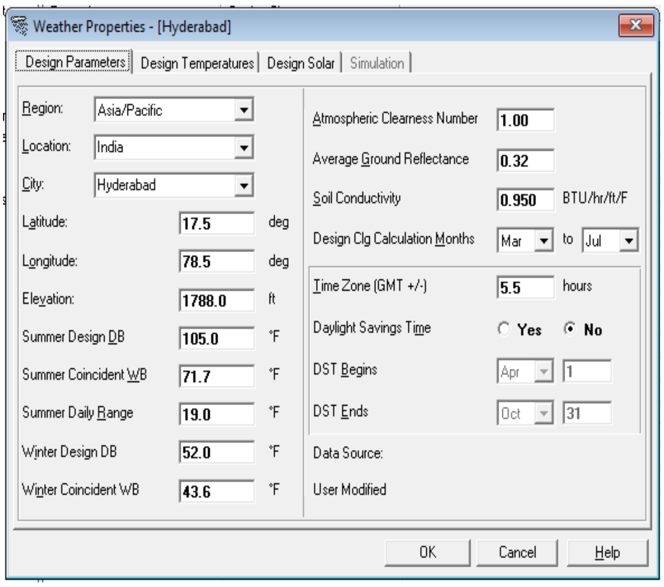


Figure 2. Software for weather Properties

Air Handling Unit 1 Heat Load Estimation

Air System Sizing Summary for GF AHU -- 001

Project Name: Faraz HAP update — 04-12-2017
Prepared by: SM TECHNO — 01:38AM

Air System Information

Air System Name	GF AHU -- 001		Number of zones	5	
Equipment Class	CW AHU		Floor Area	2157.0	ft²
Air System Type	VAV		Location	Hyderabad, India	

Sizing Calculation Information

Calculation Months	Mar to Jul	Zone CFM Sizing	Peak zone sensible load
Sizing Data	Calculated	Space CFM Sizing	Individual peak space loads

Central Cooling Coil Sizing Data

Total coil load	14.9	Tons	Load occurs at	Jun 1500	
Total coil load	179.3	MBH	OA DB / WB	104.0 / 71.7	°F
Sensible coil load	161.7	MBH	Entering DB / WB	97.1 / 68.8	°F
Coil CFM at Jun 1500	3604	CFM	Leaving DB / WB	52.8 / 51.8	°F
Max block CFM at Jun 1500	4184	CFM	Coil ADP	51.0	°F
Sum of peak zone CFM	4249	CFM	Bypass Factor	0.038	
Sensible heat ratio	0.902		Resulting RH	47	%
ft²/Ton	144.4		Design supply temp.	55.0	°F
BTU/(hr-ft²)	83.1		Zone T-stat Check	5 of 5	OK
Water flow @ 10.0 °F rise	35.88	gpm	Max zone temperature deviation	0.0	°F

Supply Fan Sizing Data

Actual max CFM at Jun 1500	4184	CFM	Fan motor BHP	3.44	BHP
Standard CFM	3921	CFM	Fan motor kW	2.73	kW
Actual max CFM/ft²	1.94	CFM/ft²	Fan static	3.00	in wg

Outdoor Ventilation Air Data

Design airflow CFM	932	CFM	CFM/person	15.03	CFM/person
CFM/ft²	0.43	CFM/ft²			

As shown above the load estimation for the area covered by AHU 1 is 14.9 Tr. Similarly, for the remaining two Air Handling Units the load estimation is as follows:

AHU 2: 8 Tr.
AHU 3: 20.1 Tr.

Duct Sizing

Duct designing is done by equal friction method in which the friction loss in WC feet/ 100feet.

The air flow quantity is and the friction is scaled in a manner to get the required size of the duct in a round shape by using ASHRAE Handbook Table no.1 (Friction chart book for Round Duct)

By comparing the round duct size and the height of the required rectangular duct in the ASHRAE Handbook Table no. 2 (Equivalent Rectangular Duct Dimensions).

Static Pressure for AHU 1

S.no.	Duct Section	Air Quantity CFM	Friction in wg/100'	Velocity (FPM)	Size of Round Duct Dia.	Size of Rectangular Duct
1	1 to A	5520	0.095	1413	26	24x24
2	A to B	3840	0.095	1294	22	20x18
3	B to C	2440	0.095	1159	20	18x18
4	C to D	1000	0.095	931	14	12x14
5	D to E	600	0.095	821	11	10x10

Static Pressure:

Pressure drop in straight duct,

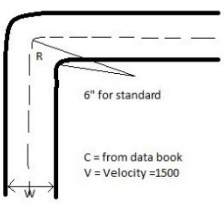
Total length of straight duct = 10+7.8+13.5+20.7+5.8 = **57.8**

Therefore, Pressure drop (Fr) = 0.095 of wg/100' of duct length

Therefore, Pressure drop in straight duct
= (57.8x0.095)/100
= 0.0549"of wg

Pressure drop in elbow

Requirements
1. R/W Ratio
2. H/W Ratio
3. C=loss co-efficient



$H_f = C \times (V/4000)^2$

For Elbow 1

R = 6 + 20/2 = 16
W= 20
H =18
R/W = 16/20 = 0.8
H/W = 18/20 = 0.9
Type of elbow – Short run rectangular standards
Now, from data book, page 56 table no. CR3-1.
We get, as per R/W & H/W
C=0.21
Therefore, H_f= $0.21(1413/4000)^2$ = 0.026" of wg

For Elbow 2

R = 6 + 14/2 = 13"
W = 14; H=12
R/W = 13/14 = 0.92
H/W = 12/14 = 0.85
From data book we get,
C=0.21
H_f = $0.21 (931/4000)^2$ = 0.0113 of wg

Pressure drop in diffuser

Standard pressure drop in terminal = 0.1" of wg
Pressure given due to velocity regain between first and last section of duct.

Static Regain = $R[(V_1/4000)^2 - (V_2/4000)^2]$

Where, R= Recovery factor
R=0.7 for complicated route
R = 0.9 for simple route

V_1 = 1413 & V_2= 821
= $0.7 [(1413/4000)^2 – (821/4000)^2]$
= 0.057" of wg

Static Pressure

- For straight duct = 0.0549
- For elbow 1 = 0.026
- For elbow 2 = 0.0113
- For last terminal (diffuser) = 0.1

Total = 0.1922" of wg
Considering 10% safety factor = 0.01922
External static pressure = 0.21142 of wg

Now,
For internal static pressure (by manufacturer)
Pressure drop in filter = 0.45
Pressure drop in evaporator coil = 0.2
Pressure drop in system = 0.1
Total = 0.75 of wg
Efficiency (η) 60%
Total Static Pressure = ESP + ISP

= 0.21142 + 0.75
= 0.96142 of wg

Now, Fan power in
BHP = [(CFM x Static Pressure)/ (6350 x η)]
= [(5520x0.96142)/(6350x0.6)]
= 1.39 HP

Similarly for the remaining other two air handling units the static pressure is calculated and are

Air Handling Unit 2: 0.89 HP = 1 HP
Air Handling Unit 3: 1.74 HP = 2 HP.

CHILLER SELECTION:

The selection of Chillers is depends upon the requirement of client and the requirement of the site.

There are two types of chillers Water cooled chillers and Air cooled chillers.

Here in this we are going to use a water cooled chiller.

The total tonnage of the three AHU's is:

AHU Name	Tonnage (Tr.)
AHU 1	14.9
AHU 2	8
AHU 3	20.1
TOTAL	43

The capacity of Chiller

Tonnage of Chiller	43 Tr.
Gallons per minute	43x2.4 = 104

Now the chilled water piping is drafted to attain the chilled water pipe sizing.

From ASHRAE Handbook Chart no. 3

Friction Loss for Closed Piping Systems.

Route	Flow (GPM)	Fluid Velocity (FPS)	Pipe Size (inches)	Head Loss (ft/100ft)
Chiller main line	105	10	2"	21.75
Branch to AHU 1	36	7	1.25"	19.483
Main line	69	7	2"	9.967
Branch to AHU 2	20	7	1.25"	9.092
Line to AHU 3	49	7	1.5	0.955

The chiller is placed at the roof of the building and the chilled water supply to the AHU's is done by aid of gravitational force and the chilled water return from the AHU's is done with aid of chilled water pump. The capacity of the chilled water pump is carried out by the head losses occurred in the chilled water piping and the fittings in chilled water piping.

WHP = (GPM x H x S) / (3960 x efficiency of the pump)

Where,

WHP is Water Horse Power
GPM is Gallons per Minute
H is Head Losses in pipes and fittings
S is Specific Gravity of water

Head Losses in Pipes and fittings

From ASHRAE Handbook Table No. 10 – Valve losses in equivalent feet of pipe (feet)

Nominal pipe or tube size (inches)	Globe Valve	Gate Valve	Strainer	Butterfly Valve	Elbow	Flexible Connection	TEE	
							Line flow	Branch Flow
2"	55	2.3	27	2.3	1.633	2	1.8	6.6
1.5"	43	1.8	10	1.8	0.955	2	1.5	5.2
1.25	38	1.5	9	1.5	1.019	2	1.3	4.4

Calculated Head Losses of chilled water piping and fittings

Total pressure drop in pipes and fittings	1.17893 feet
Pressure Drop in Chiller	10 feet
Pressure Drop in AHU	7 feet
Sub - Total	18.1783 feet
10% Safety Factor	1.817893’
Total Head Required H	20.89’

Applying the above all values in the formula

WHP = (GPM x H x S) / (3960 x efficiency of the pump)

WHP = (104 x 20.89 x 1) / (3960 x 0.6) = 0.91 HP = 1 HP

Here the calculated water Horse Power of the chilled water pump is 1 HP.

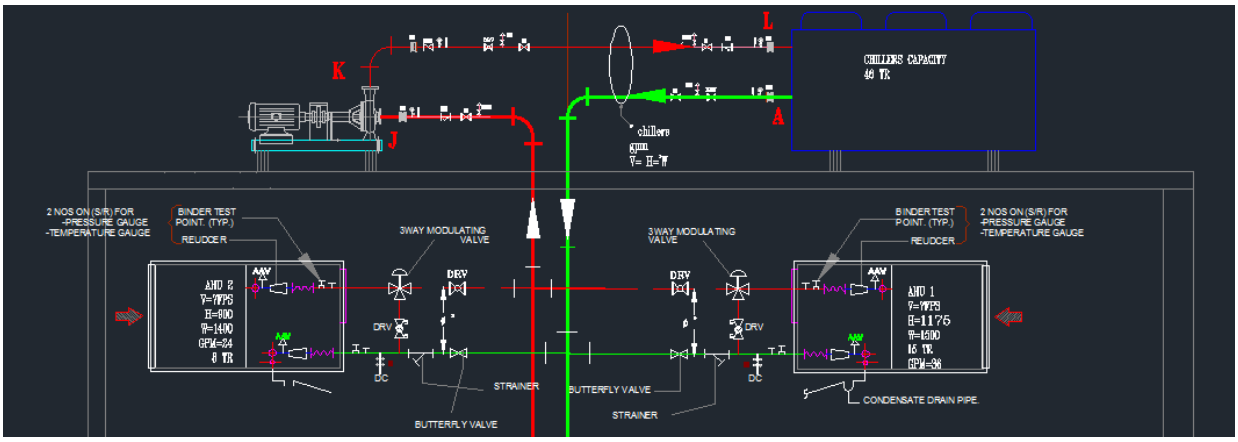


Figure 3. Chilled water piping routing and chilled water pump

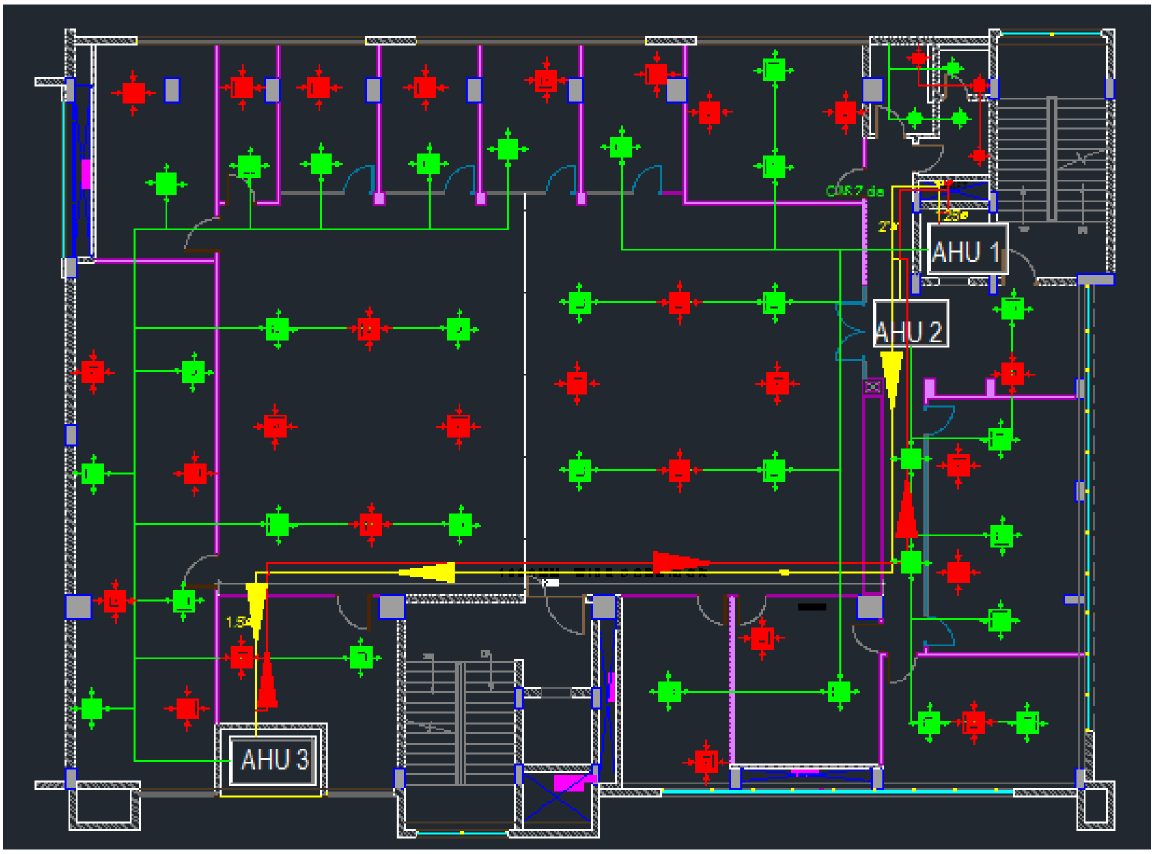


Figure 1. Drafted Drawing of HVAC output

Result

Designed Output Data

	AHU 1	AHU 2	AHU 3	Total
HAP (Tr.)	14.9	8	20	46
Static pressure of wg	0.96142	0.857	0.9038	2.72
Blower (HP)	1.5	1	2	4.5
Chilled water pump (HP)	---	---	---	1

III. CONCLUSION

Hence we meet the building demand for Heating Ventilation and Air Conditioning using AHU's and Chiller was found to be satisfactory using standards ASHRAE and CARRIER.

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