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HEAT LOAD ESTIMATION AND DUCT DESIGN FOR 4TH FLOOR, BLOCK 1 OF M.J.C.E.T.

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ABSTRACT

Heating, ventilation and air conditioning is defined as simultaneous control of temperature, humidity, radiant energy, air motion and air quality within a space for purpose of satisfying the requirements of comfort.
The (HVAC) heating, ventilation, and air-conditioning system is the most useful system installed in a building and is responsible for a substantial component of the total building energy use. A proper HVAC system will provide the accurate comfort and will run efficiently. Proper sizing of a HVAC system is the selection of equipment and the design of the air distribution system to meet the accurate predicted heating and cooling loads of the building.
Our aim in this project is to estimate heating and cooling load calculations, Duct designing by equal friction method, selection of type of AC unit as per capacity requirement for the 4th FLOOR, BLOCK 1, M.J.CE.T, Hyderabad, India.

Keywords*: HVAC, Duct, Equal friction method etc.*

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1. INTRODUCTION

Heating, ventilating and air conditioning (HVAC) is defined as the simultaneous control of temperature, humidity, radiant energy, air motion and air quality within a space for the purpose of satisfying the requirements of comfort or a process. Not included in the definition, but often required, it is the control of pressure in the conditioned space relative to adjacent areas. Another factor that becomes important in many applications is the noise level associated with the air conditioning equipment. HVAC systems use less energy and include environmentally friendly methods and components to reduce the system's impact on the world's fuel supplies while providing healthy indoor environments. Cleanliness, air quality, providing comfort, lowering energy usage is the major parameter that cannot be obtained without HVAC. For simplicity and to obtain the best possible condition i.e. human comfort zone the acronym HVAC (Heating, Ventilating and Air Conditioning) is used and thus HVAC plays a vital role in the ergonomics.

2. Environmental Criteria for Buildings

A building or a space within a building may be used in many different ways. For each of these applications the HVAC designer must determine the general criteria from personal experience or study and then add the special requirements of the user. The ASHRAE handbooks contain chapters on many common applications. The discussions that follow are limited to some of the more common applications. In every environment there are concerns for temperature, relative humidity, sound level, air quality and noise. In general, the higher the standard to be met, the more expensive the system will be to install and, probably, to operate. The architectural design of the building provides the basis for those heating and cooling loads. The orientation, amount and type of glass and shading factors are crucial for the proper calculation of solar loads and day lighting effects.

Structural and architectural factors determine the space and weight-carrying capacity available for HVAC equipment as well as piping and ductwork. Electrical requirements for the HVAC equipment must be carefully and completely communicated to the electrical designer. The characteristics of the electrical system—voltage, frequency, reliability, etc.—affect the HVAC design and specifications.

3. CIVIL PLAN, AIR CONDITIONING LOADS

An accurate survey of the load components of the space to be air- conditioned is a basic requirement for a realistic estimate of the cooling loads. The completeness and accuracy of this survey is the very foundation of the estimation and its importance cannot be ignored. Mechanical and architectural drawings, complete field sketches and in some cases photographs of important aspects are part of a good survey.

The following physical aspects must be considered:-
1. ORIENTATION OF BUILDING: - Location of the space to be air conditioned with respect to
   i. Compass Point: Sun and wind effects.
   ii. Nearby permanent structures, shading effects.
   iii. Reflective surfaces: Water, sand, parking lots etc.
2. USE OF SPACE: - Office, hospital, departmental store, machine shop, factory, restaurant etc.
3. PHYSICAL DIMENSIONS OF AIR CONDITIONED SPACE: - Length, width and height.
4. CEILING HEIGHT: - Floor to floor height, floor to ceiling height, clearance between suspended ceiling (false ceiling) and beams.
5. COLUMNS & BEAMS: - Size, Depth, Location etc.
6. CONSTRUCTION MATERIAL: - Materials and thickness of walls, roof, ceiling, floor and partitions, insulation with sketches.
7. SURROUNDING CONDITIONS: - Exterior colour of walls and roof shaded by adjacent building or exposed to sunlight, surrounding spaces conditioned or unconditioned.
8. WINDOWS: - Size and location, wood or metals sash, single or double hung, type of glass, single or multi pane.
9. DOORS: - Location, type, size and frequency of use.
10. STAIRWAYS, ELEVATORS AND ESCALATORS:-Location, temperature of space if open to unconditioned area.

SPECIFICATIONS:

Job name: Drawing Hall-1, 4th floor. Block 1, M.J.C.E.T
Location: HYDERABAD 17.86° N latitude $\simeq$ 20° N latitude, 21st May.
Material used: Medium type (for any residential complex).

GLASSES:
The glasses of windows and doors are heat absorbing with medium colour. The U-factor of the glass is 0.59
The size of the window is 6'x4'
WALLS:
The walls are 8" thick of solid brick type (common only). The wall has plastering on both sides and U-factor of the wall is 0.45
ROOF:
The roof is exposed to sun. The roof is 2" thick insulated and has a U-Factor of 0.12
PARTITION:
The partition is 8" thick of low concrete block type with plastering on both sides. It has a U-value of 0.41
NO. OF OCCUPANTS:
The maximum numbers of occupants in the drawing hall can be120 people.
Lights/ ft^2: 10watts/ ft^2
Electrical appliances: 0

3.1 Heating load parameters.

HEAT LOAD DUE TO CONDUCTION:-

The heat transferred by conduction through walls and ceiling to the air conditioned space is seldom steady. The steady state condition can be assumed if the temperature difference between the conditioned space and ambient air is large. This assumption introduces considerable error in calculation hence we introduce a factor 'U'.

HEAT LOAD DUE TO DIRECT SOLAR RADIATION:-

The glass has high transmissivity. So a considerable amount of heat is poured into air conditioned space by the sun through this glass. The amount of solar heat delivered into the air conditioned space varies from hour to hour.

INFILTRATION AIR LOAD:-

The outdoor air enters into the air conditioned space through windows and cracks and through doors when opened.

INTERNAL HEAT GAINS:-

The sensible and latent heat gains due to lights, appliances, machines, piping etc. within the conditioned space, form the components of the internal heat gains.

OCCUPANCY LOAD:-

The occupants in a conditioned space give heat at a metabolic rate that more or less depends on their rate of working. The relative proportion of the sensible and latent heats given out however depends on the ambient dry bulb temperature. The lower the dry bulb temperature, the greater the sensible heat emitted.

LIGHTING LOAD:-

Electric lights generate a sensible heat equal to the amount of electric power consumed. Most of the energy is liberated as heat and the rest as light which also eventually becomes heat after multiple reflections. After the wattage is known, the calculation of the heat gain is done.

APPLIANCES LOAD: -

Most appliances contribute both sensible and latent heats. The latent heat produced depends on the functions the appliances perform, such as drying, cooking etc.

3.2 HVAC DUCT DESIGN PROCEDURES

The general procedure for HVAC system duct design is as follows:

1. Study the building plans, arrange the supply and return outlets to provide proper distribution of air within each space. Adjust calculated air quantities for duct heat gains or losses and duct leakage. Also, adjust the supply, return, and/or exhaust air quantities to meet space pressurization requirements.
2. Select outlet sizes from manufacturers' data.
3. Sketch the duct system, connecting supply outlets and return intakes with the air-handling units/air conditioners. Space allocated for supply and return ducts often dictates system layout and ductwork shape.
4. Size the ducts by the equal friction method. Calculate system total pressure loss; then select the fan.
5. Lay out the system in detail. If duct routing and fittings vary significantly from the original design, recalculate the pressure losses. Reselect the fan if necessary.
6. Resize duct sections to approximately balance pressures at each junction.
7. Analyze the design for objectionable noise levels, and specify sound attenuators as necessary.

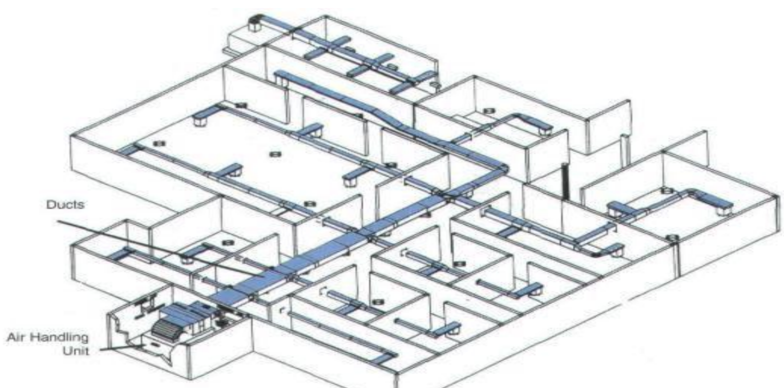

Fig. 44. A typical duct layout

Fig.:-Duct Layout

4. HEAT LOAD CALCULATION, EQUAL FRICTION METHOD, AC SELECTION AND VENTILATION

4.1 COOLING & DEHUMIDIFYING HEAT LOAD ESTIMATE E-20 FORM

INTERNAL SPACE SENSIBLE HEAT (R.S.H):

1. Walls = U-factor x ft² x Temp. diff.
2. Roof (exposed) = -same-
3. Sunglass = -same-
4. All glass = -same-
5. Partition = -same-
6. Ceiling = -same-
7. Floor = -same-
8. Outside air = CFM x Temp. diff x B.F x 1.08
9. People = No. of people x Sensible Heat
10. Lights = Watts x 3.41
11. Appliances = Watts x 3.41

12. Safety Factor = 7.5%

INTERNAL SPACE LATENT HEAT (R.L.H):

1. Outside air = CFM x gr/lb x B.F x 0.68
2. People = No. of people x Latent Heat
3. Leakage loss = 5%
4. Motors = Btu / h
5. Miscellaneous = Btu / h

ROOM TOTAL HEAT (R.T.H) = R.S.H + R.L.H
=R.T.H in (Btu/h)

 TONS OF REFRIGERATION (TR) = R.T.H/12000

4.2 HEAT LOAD ESTIMATION FOR DRAWING HALL -1:

Area=27x52=1404 ft²
Volume=27x52x11=15444 ft³
Formula: Q=U x A x TD

Glasses:

U=0.59

Area:

North=6x4x5=120
South=0
East=0
West=0

Temperature difference:

North=23°F
South=12°F
East=12°F
West=163°F

Q_{NG}=0.59x120x23=1629 Btu / h

Walls:

U=0.45

Area:

North=52x11=572
South=0
East=0
West=0

Temperature difference:

North=24°F

Q_{NW}=0.45x572x24=6178 Btu / h

Roof:

U=0.12
Area =27x52=1404 ft²
Temperature Difference=55°F

Q_{ROOF}=0.12x1404x55=9267 Btu / h

Partition:

No Partition

Fresh Air:

CFM= Volume X No.of air changes per hour/60
=15444x1/60
=258
CFM=CFM per person X No. of persons
=20x120
=2400
Maximum CFM=2400
$Q_{SENSIBLE\ HEAT}$ =CFMxTDxBFx1.08
=2400x31x0.17x1.08
=13660 Btu / h
$Q_{LATENT\ HEAT}$ =CFM x gr/lbxBFx0.68
=2400x36x0.17x0.68
=9988 Btu / h

People:
Sensible Heat=120x245
=29400 Btu / h
Latent Heat=120x205
=24600 Btu / h
Lights:
Watts/ ft²x area
=10 watts/ ft²x1544 ft²
=15440watts x 3.4
=47736 Btu / h
ROOM SENSIBLE HEAT:
HEAT DUE TO: 1629 Btu / h (WINDOWS)
6178 Btu / h (WALLS)
9267 Btu / h (ROOF)
13660 Btu / h (VENTILATION SENSIBLE HEAT)
29400 Btu / h (PEOPLE SENSIBLE HEAT)
47736 Btu / h (LIGHTS)

107870 Btu / h
+ 10% OF RSH

TOTAL RSH=118657 Btu / h
ROOM LATENT HEAT:
HEAT DUE TO 9988 Btu / h (VENTILATION LATENT HEAT)
24600 Btu / h (PEOPLE LATENT HEAT)

34588 Btu / h
+ 5% OF RLH

TOTAL RLH: 36318 Btu / h

ROOM TOTAL HEAT = ROOM SENSIBLE HEAT+ROOM TOTAL HEAT
= 118657 Btu / h + 36318 Btu / h
ROOM TOTAL HEAT = 154975 Btu / h

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CAPACITY = 154975 Btu / h / 12000

CAPACITY=13 TR

Equal Friction Method:

The following steps are adopted for duct designing by equal friction method:

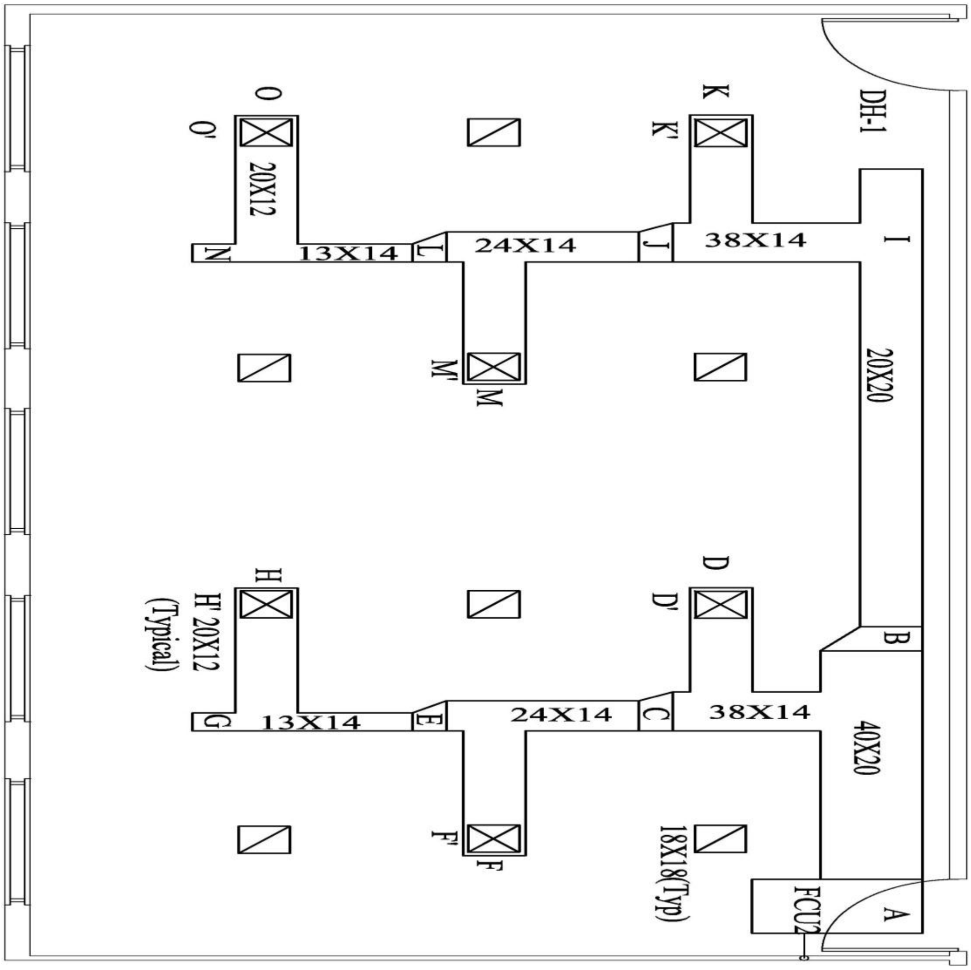
1. Sum up the CFM's backward from the last outlets; to find the CFM in each section.
2. Select a design velocity for the main from the fan. A velocity of 1500 ft/ min will be chosen, which should be reasonably quite for the application.
3. From the obtained figure, the equivalent round duct diameter is read.
4. The equivalent round duct diameter for each section is read from figure at the intersection of the design velocity and the CFM for the section.
5. The rectangular duct sizes are read from the figure. In actual installations, the duct proportions chosen would depend on space available.

In equal friction method for a given air quantity an initial velocity is selected to determine the friction rate. This friction rate is then maintained throughout the system and the equivalent round duct diameter is selected from the duct friction chart.

So, according to Equal fraction method following parameters are to be considered:

SECTION	CFM	F.P.M (VELOCITY)	FRICTION	RECTANGULAR DUCT
A-B (M.D)	5200	1000	0.08	40X20
B-C (B.D)	2600	700	0.06	38X14
C-D	866.6	600	0.02	20X12
D-D'	866.6	450	0.02	18X18
C-E (B.D)	1733.3	700	0.06	24X14
E-F	866.6	600	0.02	20X12
F-F'	866.6	450	0.02	18X18
E-G	866.6	700	0.03	13X14

G-H	866.6	600	0.02	20X12
H-H’	866.6	450	0.02	18X18
B-I	2600	900	0.07	20X20
I-J	2600	700	0.06	38X14
J-K	866.6	600	0.02	20X12
K-K’	866.6	450	0.02	18X18
J-L	1734	700	0.06	24X14
L-M	866.6	600	0.02	20X12
M-M’	866.6	450	0.02	18X18
L-N	866.6	700	0.03	13X14
N-O	866.6	600	0.02	20X12
O-O’	866.6	450	0.02	18X18


DH-1
O
O'
20X12
K
K'
38X14
I
N
13X14
L
24X14
J
20X20
M'
M
H
H' 20X12
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D'
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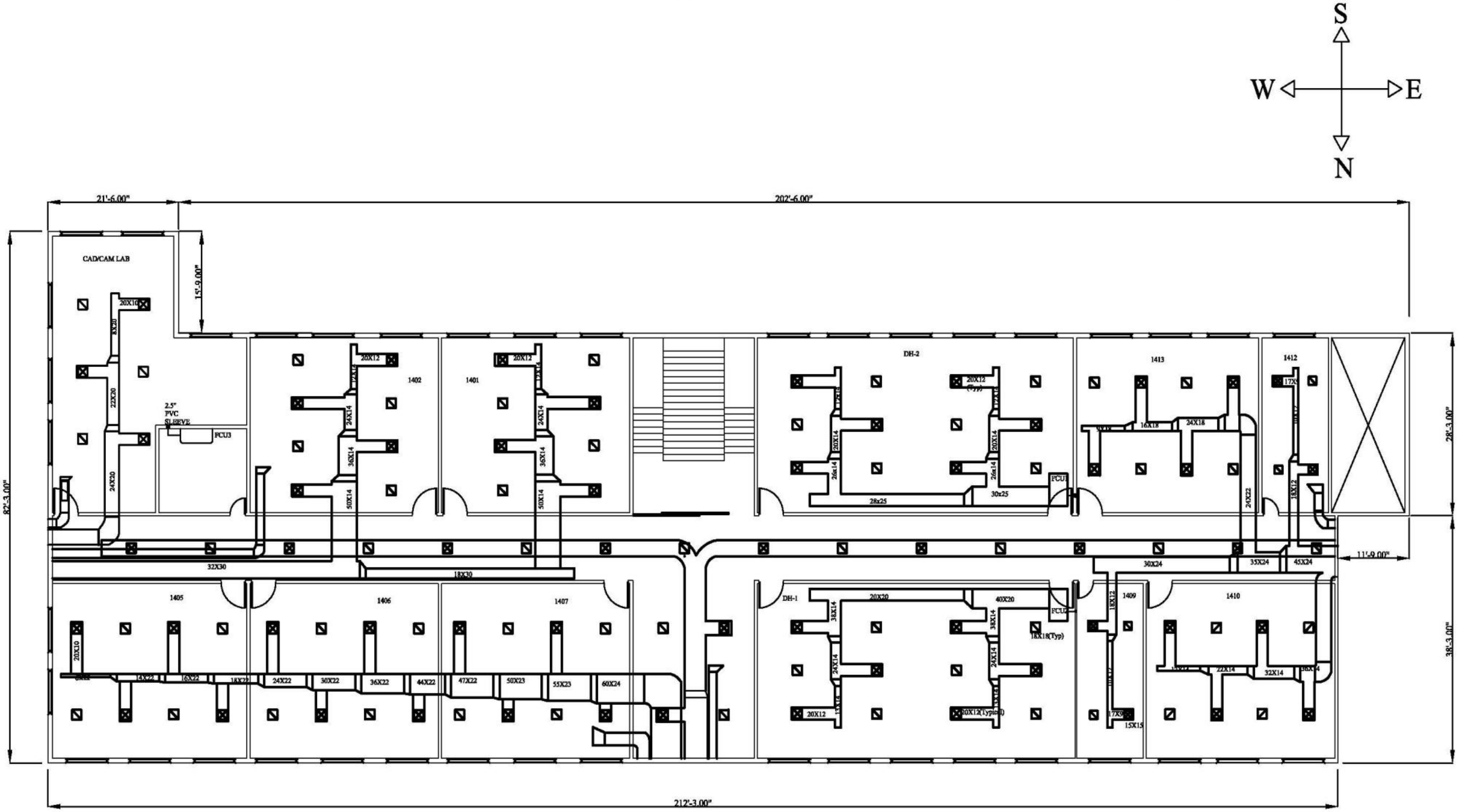
E
24X14
C
38X14
40X20
F'
F
18X18(Typ)
FCU2
A



4TH FLOOR PLAN

LEGENDS:

SAD= SUPPLY AIR DIFFUSER

RAD= RETURN AIR DIFFUSER

FCU= FAN COIL UNIT

PACU= PACKAGED AIR CONDITIONING UNIT

Project Title:

HEAT LOAD ESTIMATION AND DUCT DESIGN

Location :

4TH FLOOR, BLOCK 1, M.J.C.E.T, BANJARA HILLS, HYD.

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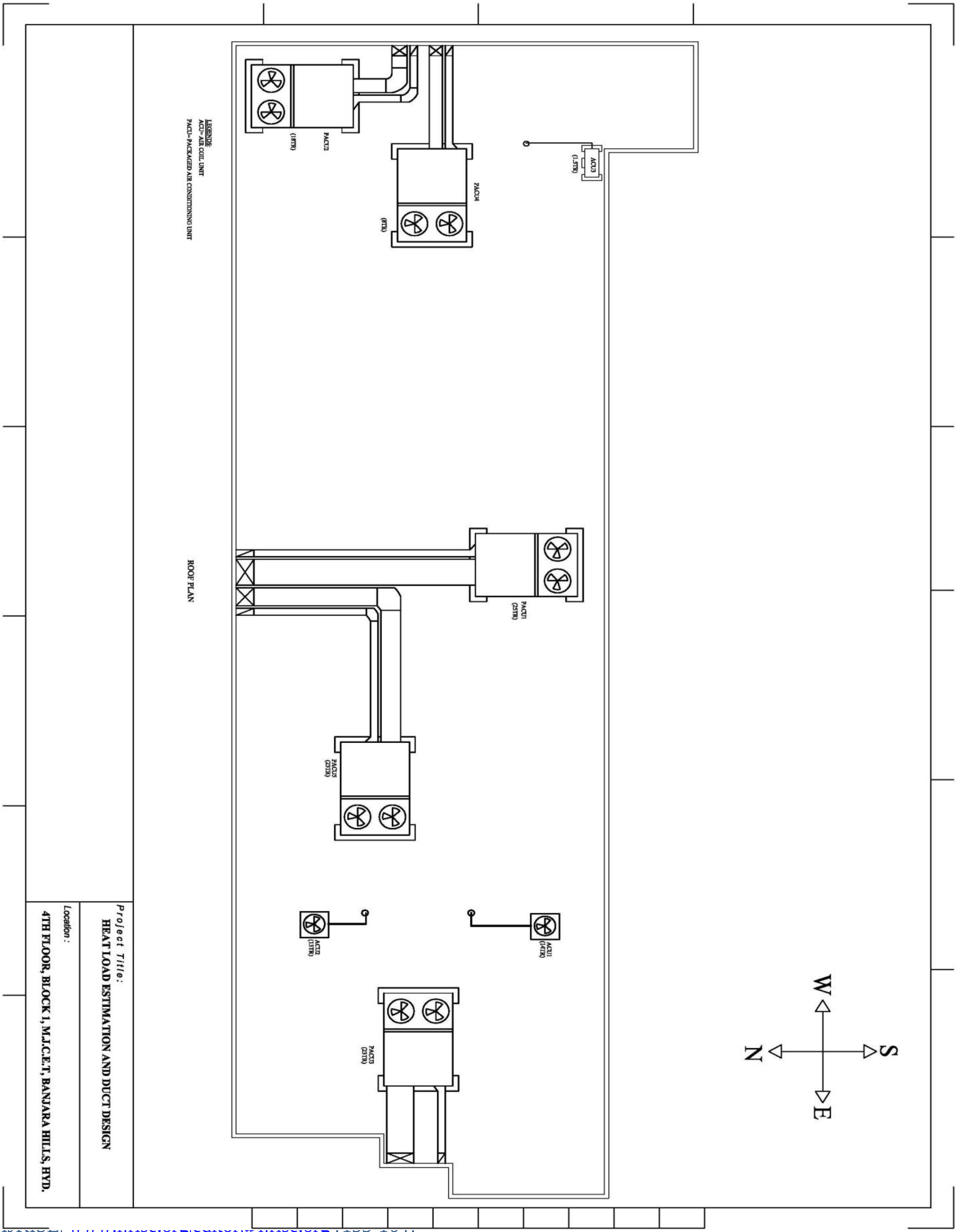

6. Results:

1. The heat load estimation for Drawing Hall -1 was calculated as 13TR.
2. The duct dimensions were designed by equal friction method.
3. As per capacity requirement, one FCU of 13 TR was selected.

7. Conclusion

Thus from the above parameters and study from HVAC following are the points to be concluded.

1. The maintained temperature range in the Conditioned space is 75°F and the Relative Humidity of air is maintained around 50%.
2. For this purpose we calculated the heat load as per the civil plan and specifications of the building
3. The Duct Layout was prepared and PACU'S and FCU's were located as per the requirements.
4. For the space to be properly conditioned, the following were selected:

FCU's:

i. One FCU of 13 TR for Drawing Hall -1
ii. One FCU of 14 TR for Drawing Hall -2

PACU's:

i. 25 TR for Room No.1405, 1406 and 1407
ii. 18 TR for Room No. 1401 and 1402
iii. 23 TR for Room No.1409,1410, 1412 and 1413
iv. 8 TR for Room No.1404
v. 23 TR for lobby capacity.

Thus, from this, we planned and designed the Central Air-conditioning for 4th floor, Block 1, M.J.C.E.T, Hyderabad, India.

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