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Duct Design and 3D Modeling of Central Air- Conditioning System for Commercial Building using Revit MEP

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Abstract - *The main objective of this project is designing the duct system using McQuay Software and 3D modeling of duct for central Air- conditioning system in a commercial building. The central air-conditioning system controls the building temperature, humidity, and cleanness, proper air distribution, noise level, & comfort level. Here cooling and heating load calculations are done manually by using E20 form. Also this project deals with duct designing for fresh air ventilation, exhaust air duct, return air duct and equipment selection such as Air handling unit, and fan coil unit based on requirement. REVIT MEP is 3D Modeling software, it is used for calculating the pressure losses and also to draw the 3D Modeling of a duct system that is represented by central air conditioning layout. Now a day's contractors require 3D Modeling because it is easy to understand the duct system. REVIT MEP Software is mainly used for drawing MECAHNICAL, ELECTRICAL, and PLUMBING layouts are combined together. REVIT MEP is used to make the clear layout of duct. This project was carried out on Duct Designing and 3D Modeling of Central air conditioning system for Commercial building.*

Key Words: E20Sheet, McQuay software, duct designing, Revit MEP.

1. INTRODUCTION

Central air conditioning is mainly based on the principle of thermodynamics, heat transfer and fluid dynamics. Central Air conditioning process is used to remove heat from indoor air is to create a requirement of a conditioned space by controlling its temperature, humidity, cleanliness and proper air distribution. Calculation of cooling load by taking into account people heat gain, walls, roofs, partition walls, light heat gain, infiltration, and ventilation heat gain are represented on MS-Excel E20 -sheet. Most of the air conditioning systems require some form of a duct i.e. a passage which carries cooled air from AHU to where the conditioned air is needed. Ducting plays a role of changing the air of a given space by removing the indoor air and supplying conditioned air. Effective design of duct system in central air conditioning provides lower power consumption and lower capital cost. Central air conditioning is mainly used for large size buildings such as Function hall, Malls, Theatres, and Auditorium.

Convention hall has been selected for calculation of cooling loads on the basis of floor area, humidity, and temperature of heat sources, occupancy, weather conditions, building structure and geographic location. These results will help in determining the heat load & duct design. The rectangular cross-section of the duct is selected to any space height restrictions and easy to fabricate.

2. Design calculation

Load estimations are needed throughout the air conditioning system in design process.

2.1 Cooling Load Calculation by E20spread Sheet

E20 (storage load factor/equivalent temperature difference method) spread sheet contains inserted formulas in tabular form.

2.2 Heating load estimation

For sensible and latent heat load calculations, factors considered below

1) Internal heat load

a. People

b. Equipment

c. Lighting

d. Floor

e. Portions wall

f. Ceiling

2) External heat load

a. Wall

b. Windows

c. Roof

Above radiation and transmission considered in both walls & windows

3) External to internal heat load

a. Infiltration air

b. Load on coil

2.3. **DESIGN CONSIDERATIONS**

Location & Thermal conditions:

Building location - hindupur, andhra pradesh.

a.Orientation Equal share of wall on all the sides

b. Application - commercial

c. Lattitude 13.81 ^{0} N, 77.49^0 E

d. Elevation(Altitude) - 621 m

Table -1: Summary of temperatures conditions

S.NO	Conditions	DBT (°F)	WBT (°F)	RH (%)	HR (Gr/lb)	DPT (°F)
1	Outdoor conditions	109	80	30	114	72
2	Room internal conditions	77	64	50	69	57
3	Difference	32	16	20	45	15

Room comfort conditions are 22 °c to 26 °c @ 30%

RH TO 70% RH

Daily range temperature (°F): maximum value of correction factor and daily range – 23

Heat load calculations are shown in **Fig-1**:E20 spread sheet.

3. Duct Sizing

The main goal of designing duct systems is satisfactory distribution of conditioned air to a given space. A well-designed ductwork system should deliver maximum interior comfort at the lowest operating cost while also preserving indoor air quality.

1. It should convey specified air flow rate to prescribed locations.

2. It should be economical in combined initial cost and operating cost.

3. It should not generate objectionable noise.

3.1. Duct sizing methods

Various methods of duct design are

a. Equal friction method

b. Constant velocity method, and

c. Static regains method.

3.2. Duct Design Criteria

Many factors are considered when designing a duct system.

a. Space availability

b. Installation cost

c. Air friction loss

d. Noise level

e. heat transfer and air leakages in duct.

3.3 Design of Duct Layout

On the basis of a particular airflow and velocity obtained from the selected AHU, the area of the duct is determined using the equal friction method by using McQuay software, as we are dealing with a moderate velocity system. The above process culminates with the establishment of a feasible duct network, estimation of the type, number and location of outlets & inlets .i.e. Diffusers, grills required in the cooling space to accomplish the goal of uniform cooling; keeping in mind the numerous principles guiding room air distribution for adequate comfort.

Steps in Duct Design

Following are the basic steps in Duct Design

a. First find out the air flow rate (cfm)

b. Based on cooling load and air flow rate select AHU system.

c. based on recommended initial velocity [Main duct air velocity: - 800-1200 fpm, Branch duct air velocity: - 600-900 fpm.

d. Continuity equation Q= A * V

Q= cfm, A= area, V= velocity

e. Determine Equivalent duct diameter corresponding air flow rate and velocity from ISHRAE table for rectangular shape.

f. Then initial friction rate is determined by using equation on the basis of air quantity and equivalent duct diameter.

g. Determine the static and dynamic pressure drop for fittings from ISHRAE table for duct fitting codes.

By using software MCQUAY duct calculation given below Based on height of the duct restricted according to the space constrains.

Duct shape and dimensions shown in **Fig-2 & Table -2.**

E20 sheet for heat load calculations:

PROJECT	NATIONAL REFRIGERATION
LOCATION	HINDUPUR
CLIENT	KRISHNA MURTHY
CONSULTANT	HAFEEZ
126.00	

Item	Area or Quantity			Sun Gain or Temp. Diff.			Factor (U)	Btu/Hour	Watts
	ROOM HEAT					Q= U*A*ΔT			
ROOM SENSIBLE HEAT									
Solar Gain Glass	Area			ΔT			U		
Glass N	75.00	SqFt	x	39.00		x	0.25	731.25	
Glass N	22.50	SqFt	x	39.00		x	0.25	219.38	
Glass		SqFt	x			x		0.00	
Glass SE		SqFt	x			x		0.00	
Glass S	75.00	SqFt	x	11.00		x	0.25	206.25	
Glass S	22.50	SqFt	x	11.00		x	0.25	61.88	
Glass W		SqFt	x			x		0.00	
Glass NW		SqFt	x			x		0.00	
Skylight		SqFt	x			x		0.00	
Solar & Transmission Gain Walls & Roof									
Wall N	2,436.50	SqFt	x	22.50	F	x	0.15	8,223.19	
Wall NE		SqFt	x		F	x		0.00	
Wall		SqFt	x		F	x		0.00	
Wall SE		SqFt	x		F	x		0.00	
Wall S	2,436.50	SqFt	x	36.50	F	x	0.15	13,339.84	
Wall SW		SqFt	x		F	x		0.00	
Wall W		SqFt	x		F	x		0.00	
Wall NW		SqFt	x		F	x		0.00	
Roof	9,547.75	SqFt	x	47.50	F	x	0.08	36,281.45	
Transmission Gain Except Walls & Roof									
All Glass	97.50	SqFt	x	34.00	F	x	0.50	1,657.50	
Partition	1,322.50	SqFt	x	27.00	F	x	0.09	3,213.68	
Ceiling		SqFt	x		F	x		0.00	
Floor	9,547.75	SqFt	x	27.00	F	x	0.21	54,135.74	
INFILTRATION AND BY PASSED AIR									
Infiltration	3.00	CFM	x	34.00	T.Diff	x	1.08	110.16	
Outside Air	7,500.00	CFM	x	34.00		x	1.08	110,160.00	

FLOOR	second floor				
SPACE REFERENCE	function hall				
AREA (SqFt) (WxH)	5,073.00				
Falce Ceiling Height (Ft)	20.00				
Volume (CuFt)	101,460.00				
Estimate for	Summer				
Design Conditions	DB (°F)	WB (°F)	RH (%)	SH (Gr/Lb)	
Ambient(Out Side)	109.00	80.00	30.00	114.00	
Room (InDoor)	75.00	64.00	50.00	69.00	
Difference Δ	34.00	16.00	20.00	45.00	
By Pass Factor (BF)				=	0.40
Contact Factor (CF = 1 BF)				=	0.60
CFM Ventilation					
CFM Per Person	15.00	No	=	500.00	= 7,500.00
CFM Per SqFt	0.33	Sqft	x	5,073.00	= 1,674.09
Air Change Per Hour (CFM)			=	2.00	
CFM Cu.ft	219,598.25 x	2.00		x1/60	= 7,319.94
CFM Infiltration					
Swinging		x		cfm/door =	0.00
Revolving Doors (People)		x		cfm/door =	0.00
Open Doors	2.00	x	1.00	cfm/door =	2.00
Crack (feet)		x		cfm/ft =	0.00
					2.00
Supply CFM from Machine					
Effective Room Sensible Heat Factor =					
Effective Room Sensible Heat/Eff Room Total Heat				=	0.73
Apparatus Dew Point (ADP)					
Indicated ADP (°F)				=	
Selected ADP (°F)				=	48.00
Dehumidified Rise					
(Room DB ADP) x CF				=	16.20
DEHUMIDIFIED AIR QUANTITY					
Effective Room Sensible Heat				= 23,467.33	CFM
Dehumidified Rise x 1.08					

Fig-1:E20 spread sheet

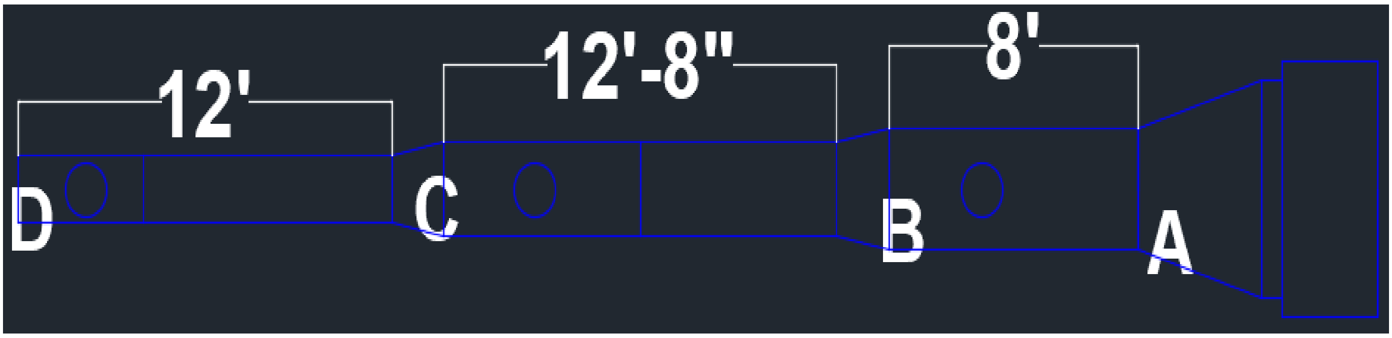

Fig-2: 2D Duct layout

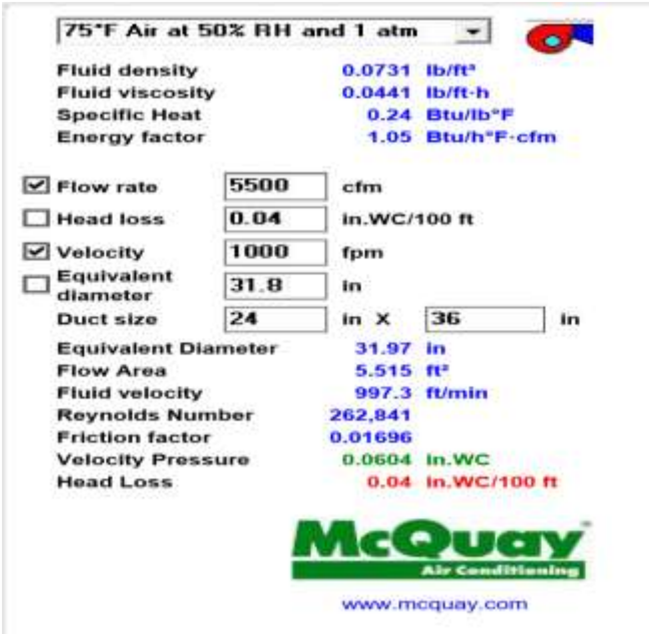

Fig -3: Duct sizer

Table -2: Duct dimensions

section	Airflow (cfm)	Velocity (fpm)	Dimensions W*H	diameter
A - B	5500	1000	36” * 24”	31”
B - C	3666	905	28” * 22”	28”
C - D	1833	763	20” * 18”	21”

3. Revit MEP

Revit MEP is software for the design, drawing, and scheduling of building project. It coordinates the MEP services. Load calculations and & energy analysis of building. It includes duct and pipe designing. In duct and pipe system it will show auto layout (routing) for different passible routes. All 3D modelling views, creating sectional views, plumbing fire protection design, detailing, dimensioning, annotation & documentation etc.

Procedure for 3D modelling by Revit MEP

1. New File creation

   a. Linking projects

   b. New templates

2. Level creation (LL)

   a. Preparing spaces

   b. Spaces in open area

Multi-level spaces:

   a. Zone on single level

   b. Zone on multiple levels

Analytical models:

a. Heating & cooling loads

b. Zone color schemes

3. Service creation

Adding Mechanical Equipment

Duct System:

a. Auto duct work

b. Duct sizing

c. Manually creating duct work

Piping system:

a. Creating a piping system

b. Adding piping using auto layout

c. sizing pipes

4. Insulation

5. Presentation

6. Interference check

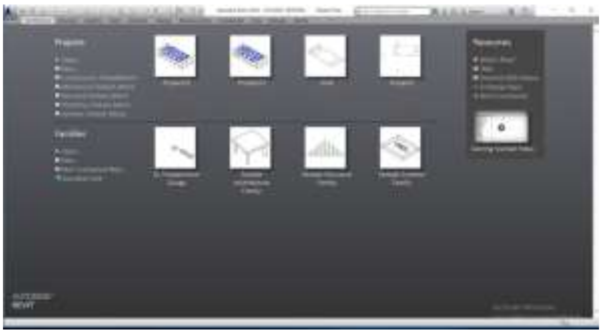

Fig -4: REVIT (Architecture)

4. Results

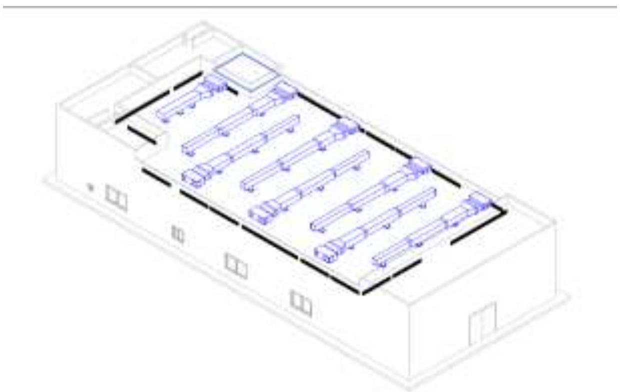

Fig.5. 3D layout of duct

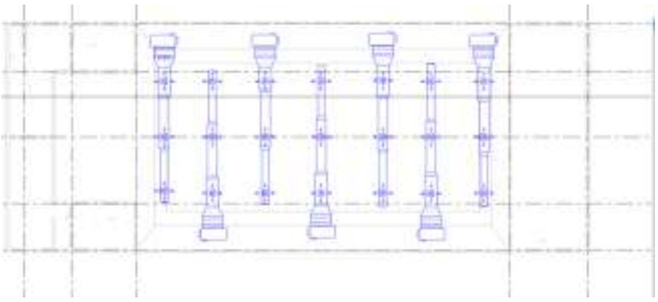

Fig.6. 2D layout of duct

Fig.7. Fabricated duct

3. CONCLUSIONS

Cooling load calculation is done by E20 (storage load factor/equivalent temperature difference method) MS-Excel Program. The result shows that the total cooling load for the commercial building required is 74.61 tons for summer. For designing of Duct system and 3D modeling duct by using Revit MEP software. Based on Air flow rate and velocity duct dimensions are calculated by using McQay software with equal friction method. Equipment Selection based on cooling load and zone such as Air handling unit.

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