

Duct Design and 3D Modeling of HVAC System for "Royal Oman Police" Building using Revit MEP

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Abstract—The main objective is duct designing and 3D modeling of Heating, Ventilation and Air-Conditioning (HVAC) system for ROYAL OMAN POLICE BUILDING. In this project HVAC controls the building temperature, humidity, cleanliness, proper distribution, noise level, comfort and energy efficient. Thermostat is used to control the temperature, humidifier is used to control the humidity, filters are used to control the cleanliness, sound attenuator is used to control the noise level .The main purpose of HVAC is to create the building environment to a comfort level. This project have cooling load calculation, this Cooling load was calculated by HOURLY ANALYSIS PROGRAM (HAP) Software. HAP is designed for consulting engineers, HVAC contractors for designing and analysis of building HVAC systems. It is a powerful tool for designing and sizing system components. 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, fresh air handling unit and fan coil unit based on requirements. REVIT MEP is a 3D Modeling software, it is used for draw the 3D Modeling of a HVAC system that is represented by HVAC layout. Now a days contractors wants 3D Modeling because it is easy to understand. REVIT MEP Software is mainly used for COMBINED SYSTEM DRAWING (CSD), in this drawing HVAC, PLUMBING, ELECTRICAL and FIRE FIGHTING layout are combined together. REVIT MEP is used to make the clear layout. This project was carried out on Duct Designing and 3D Modelling of HVAC system for ROYAL OMAN POLICE **BUILDING.**

Index Terms-duct designing, 3D modeling

I. INTRODUCTION

HVAC is mainly based on the principle of thermodynamics, heat and mass transfer and fluid dynamics. The main objective of HVAC is to create a comfortable thermal environment to the building. And also provide required amount of indoor air quality for the building. HVAC is purely for the mechanical engineers. HVAC is mainly used for large size buildings such as Malls, Theatres, 5-Star, 7-Star Hotels, Auditorium. It is also used for medium size hotel, apartments, villas and homes. HVAC has another advantage that is specially used for operation theatres in the hospitals because it requires 100% fresh air. So it is mandatory for Hospitals to provide HVAC for the operation theatres. Another specialty is mainly used for Clean room project. This clean room is that it must be very clean because there is a fine filters used to remove fine particulates. This is mainly used for hospitals, bio-medical laboratory, scientific research centre etc. Refrigeration is added to this that is known as Heating, Ventilation, Air-Conditioning and Refrigeration (HVAC&R).

Ventilation is one of the part of HVAC system. Ventilation plays a role of changing the indoor air of the rooms in a building by removing the indoor air and supplying the outdoor fresh air. It removes the smoke, dust, odors, heat, carbon dioxide and moisture from the indoor thereby supplying fresh air from the outdoor. It prevents stagnation of the interior air by removing unpleasant smells and excessive moisture that keeps the building indoor air comfortable. Ventilation can be done by either forced or naturally.

II. DESIGN CALCULATION

A) Cooling Load Calculation by HAP:

1) Hourly Analysis Program (HAP):

- HAP is designed for consulting engineers, design/build contractors, HVAC contractors, facility engineers and other professionals involved in the design and analysis of commercial building HVAC systems.
- This program is a powerful tool for designing systems and sizing system components.

2) HAP Procedure:

- Create a New project.
- Go to View, then select the preference in the list.
- Then a preference text box would open, in that box select the General and pick the S.I Metric and then click ok.
- The main components of HAP are listed below
 - > Weather
 - > Spaces
 - > Systems
 - \succ Plants
 - ➢ Building
 - Project libraries

Design Parameters Des	ign Temperatures	Desig	n Solar Simulation	
Begion: Middle East Location: Oman City: Masqat Lgsitude: Leggitude: Elegation: Summer Daily Bange Writer Design DB	▼ ▼ ▼ 23.6 -58.3 14.9 42.8 22.8 8.3 16.1	deg deg m ℃ ℃ ℃ ℃	Atmospheric Clearness Number Average Ground Reflectance Soil Conductivity Design Clg Calculation Months Time Zone (GMT +/-) Daytight Savings Tigge DST gegins DST geds DST gnds Data Source:	1.00 0.20 1.385 W/m/K Jan ▼ to Dec ▼ -3.0 hours C Yes C No Apr ▼ 1 Dct ▼ 31
Winter Coincident WB	10.6	*C	2001 ASHRAE Handbook	

Fig. 1. Weather properties



3) Spaces:

- Select the Spaces, then a space properties bar would open.
- Several components of spaces are
 - 1. General
 - 2. Internals
 - 3. Walls, Windows, Doors
 - 4. Roofs, Skylights
 - 5. Infiltration
 - 6. Floors
 - 7. Partitions

<u>N</u> ame	Laundary s	service GF	01		
<u>F</u> loor Area	485.0	rn²			
Avg Ceiling <u>H</u> eight	3.0	m			
Building <u>W</u> eight	341.8	kg/m²			_
			Light	Med.	Heavy
OA Ventilation Requ	uirements				
Space <u>U</u> sage	<user-defi< td=""><td>ined></td><td></td><td></td><td>-</td></user-defi<>	ined>			-
0A Requirement <u>1</u>	0.0		L/s/per	son	•
0A Requirement 2	0.00		L/(s-m²)		-
Spac	e usage defaul		SH 62 1-2	007	

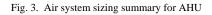
Fig. 2. Space properties

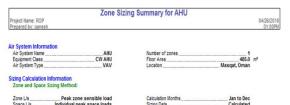
4) Systems:

Select the systems, then an Air system properties bar would open. Several Systems components are listed below"

- 1. General
- 2. System components
- 3. Zone components
- 4. Sizing data
- 5. Equipment

Air Sys	tem Sizir	ng Summary for AHU		
Project Name: ROP		A CARLES AND A CARLES AND A		04/26/2018
Prepared by: ganesh				12:51PM
Air System Information				
Air System Name AHU		Number of zones		
Equipment Class		Floor Area	485.0	m²
Air System Type		Location	Masqat, Oman	
Sizing Calculation Information				
Zone and Space Sizing Method:				
Zone L/s Peak zone sensible load		Calculation Months	lan to Dec	
Space Us Individual peak space loads		Sizing Data		
Space Da		Sizing Data	Calculated	
Central Cooling Coil Sizing Data				
Total coil load 62.8	kW	Load occurs at	Jul 1700	
Sensible coil load 53.2		0A DB / WB		°C
Coil L/s at Jul 1700 2612	Us	Entering DB / WB	27.7 / 17.6	°C
Max block L/s at Jul 1700 2905		Leaving DB / WB		
Sum of peak zone L/s 2905		Coll ADP		
Sensible heat ratio 0.847		Bypass Factor		
m²/kW 7.7		Resulting RH	46	%
W/m ² 129.6		Design supply temp.		
Water flow @ 6.0 °K rise 2.51	L/s	Zone T-stat Check	1 of 1	OK
-		Max zone temperature deviation	0.0	۳K
Supply Fan Sizing Data				
Actual max L/s at Jul 1700 2905	L/s	Fan motor BHP	5.43	BHP
Standard Us 2900	L/s	Fan motor kW	4.30	kW
Actual max L/(s-m ²)	L/(s-m ²)	Fan static	800	Pa
Outdoor Ventilation Air Data				
Design airflow L/s0	1/e	L/s/person	0.00	L/s/person
U(s-m ²) 0.00				
G(a-m)	w(and)			





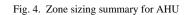
Zone Sizing Data

	Maximum Cooling Sensible	Design Air Flow	Minimum Air Flow	Time of Peak	Maximum Heating Load	Zone Floor Area	Zone
Zone Name	(kW)	(L/s)	(L/s)	Load	(kW)	(m ²)	L/(s-m2
Zone 1	38.5	2905	29	Jul 1700	4.5	485.0	5.99

Zone Terminal Sizing Data No Zone Terminal Sizing Data required for this system

Space Loads and Airflows

Zone Name / Space Name	Mult.	Cooling Sensible (kW)	Time of Load	Air Flow (L/s)	Heating Load (kW)	Floor Area (m ²)	Space L/(s-m ²)
Zone 1							
Laundary service GF 01	1	38.5	Jul 1700	2905	4.5	485.0	5.99



5) Selection of AHU:

Z

- Actual maximum load is 2905 l/s, so we select 4200 l/s AHU
- For example if the load is 1900 l/s, we select 3200 l/s AHU

6) Duct designing for laundry service GF 01:

- Area of the laundry service is 484.98 m².
- Airflow with 4200 l/s was supplied by the AHU (Air Handling Unit).
- Ductsizer is an application used to calculate the duct size.

7) Duct sizer:

i) Main duct:

- Flow rate 4200 l/s
- Duct size 1150 x 650
- Head loss 0.38 pa/m

Duct friction to be maintained at 0.3 to 0.5 pa/m

Duct velocity = Q/A

$$(4200 \text{ l/s} = 4.200 \text{ m}^3/\text{s})$$

4.2 m³/s / (1.150x0.650) m²
= 5.6 m/s.

Duct velocity to be maintained at 2.5 to 8 m/s.
Airflow per diffuser = Total airflow / Number of diffuser (2)
=
$$4200/15$$

$$= 280$$
 l/s.

• 4200	-560 - 280 = 3360 l/s
Flow rate	- 3360 l/s
Duct size	- 1050 x 600
Head loss	- 0.38 pa/m
Velocity	- 5.7 m/s

• 3360 - 280 - 280 = 2800 l/s Flow rate - 2800 l/s (1)



Duct size Head loss Velocity	- 1050 x 500 - 0.44 pa/m - 5.8 m/s
• 2800 - Flow rate Duct size	- 560 - 280 = 1960 l/s - 1960 l/s - 900 x 450
Head loss Velocity	- 0.43 pa/m - 5.3 m/s
• 1960 -	-280 - 280 = 1400 l/s
Flow rate	- 1400 l/s
Duct size	- 900 x 350
Head loss	- 0.45 pa/m
Velocity	- 4.9 m/s
• 1400 -	-560 - 280 = 560 l/s
Flow rate	- 560 l/s
Duct size	- 600 x 250
Head loss	- 0.5 pa/m
Velocity	- 4.16 m/s

ii) Branch duct:

Number of supply ceiling diffuser in branch duct is • two.

• 280	1/s + 280 1/s = 560 1/s.
Flow rate	- 560 l/s
Duct size	- 600 x 250
Head loss	- 0.5 pa/m
Velocity	- 4.16 m/s

Number of supply ceiling diffuser in branch duct is one.

• Ai	rflow is 280 l/s
Flow rate	- 280 l/s
Duct size	- 500 x 200
Head loss	- 0.38 pa/m
Velocity	- 3.13 m/s

- Number of supply ceiling diffuser in branch duct is one.
- Airflow is 280 l/s, duct size is 500 x 200

8) External Static Pressure (ESP):

Procedure to be followed in ESP calculation:

- 1. Finding the longest critical path of the duct system.
- Based on the longest path, we need to calculate the 2. pressure drop occurring in straight duct, duct fittings, grills, dampers and diffusers etc.
- Have to consider a safety factor of 10%. 3.

9) Procedure for 3D modelling by Revit MEP:

- 1. File creation
- 2. Level creation (LL)
- 3. Service creation

Duct System:

- Supply air duct (SAD) i.
- ii. Return air duct (RAD)

- Fresh air duct (FAD) iii.
- Exhaust air duct (EAD) iv.

Pipe System:

- i. Chilled water supply (CHWS)
- ii. Chilled water return (CHWR)
- iii. Layout creation
- Families creation iv.
- **Insulation Presentation** v.
- Interference check vi.
- Layout creation 4.
- Families creation 5.
- Insulation 6.
- 7. Presentation
- Interference check 8.

0	esignT	ools DuctSiz	er —	
Exit	Print	Clear Uni	ts About	
2	0°C Air	STP		· 🕂
F	luid der	nsity	1.2014	kg/m³
F	luid vis	cosity	0.0643	kg/m·h
S	pecific	Heat	1.0048	kJ/kg*C
E	nergy f	actor	1.21	W/*C·L/s
🗹 FI	low rate	4200	L/s	
₽н	ead los	s 0.000) Pa/m	
Πv	elocity		m/s	
	quivale liamete		mm	
D	uct size	e 1150	mm X	650) mm
Ε	quivale	nt Diamete	935.69	mm
F	low Are	a	0.6876	m ²
F	luid vel	ocity	6.108	m/s
R	eynold	s Number	384,497	
F	iction I	actor	0.01605	
v	elocity	Pressure	22.4178	Pa
н	ead Lo	\$\$	0.385	Pa/m
			Mc	Air Conditioning

www.mcguay.com

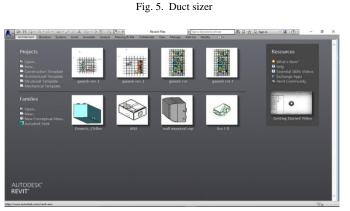


Fig. 6. REVIT (Architecture)



III. RESULT

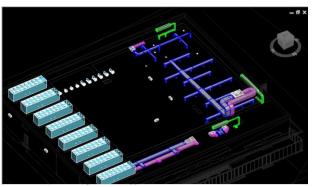


Fig. 7. 3D layout of ROP

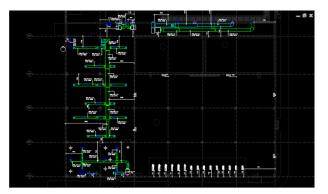


Fig. 8. 2D layout of ROP

IV. CONCLUSION

Cooling load calculation is done by Hourly Analysis Program HAP. Duct designing and 3D modelling by Revit MEP.

1) Supply air duct (SAD), 2) Return air duct (RAD), 3) Fresh air duct (FAD), 4) Exhaust air duct (EAD). Equipment Selection based on cooling load and zone such as Air handling unit (AHU). The following results are projected. Cooling load calculation was done by HAP Software. Duct Designing and 3D Modelling of HVAC system for ROYAL OMAN POLICE BUILDING was done by REVIT Software. The coordination flaws and errors are minimized while using Revit MEP and information is propagated in a much more efficient manner.

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