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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
  - Plants
  - Building
  - Project libraries

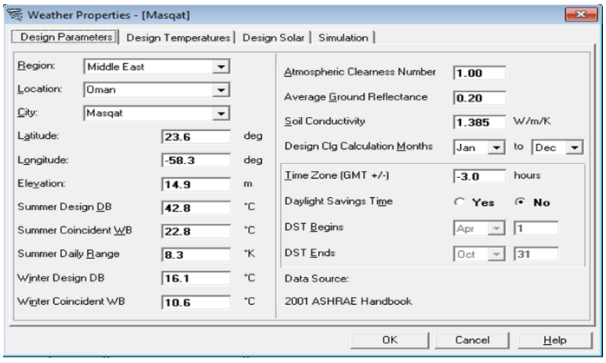

Fig. 1. Weather properties

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

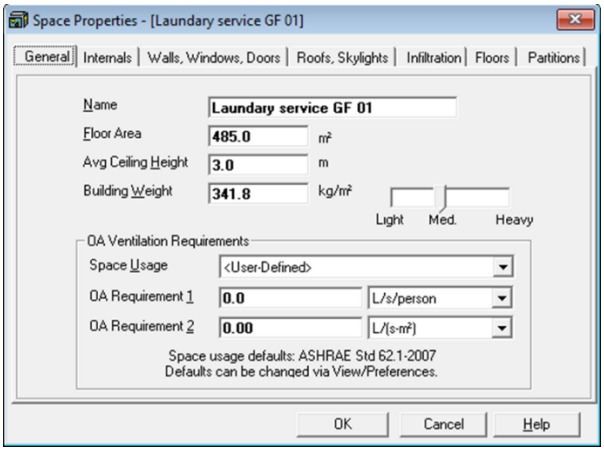

Fig. 2. Space properties

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

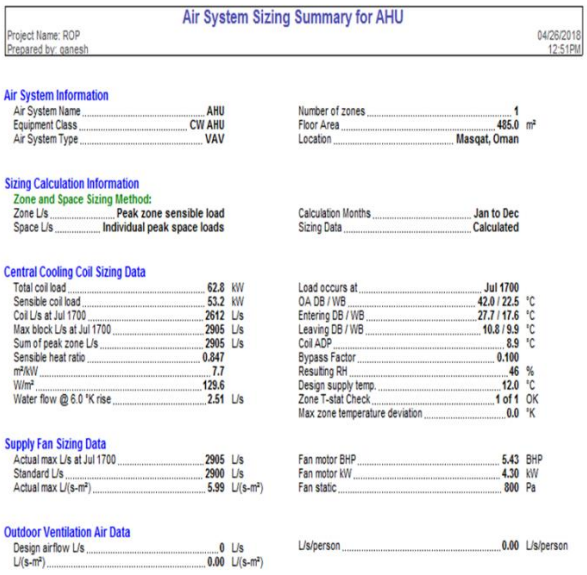

Fig. 3. Air system sizing summary for AHU

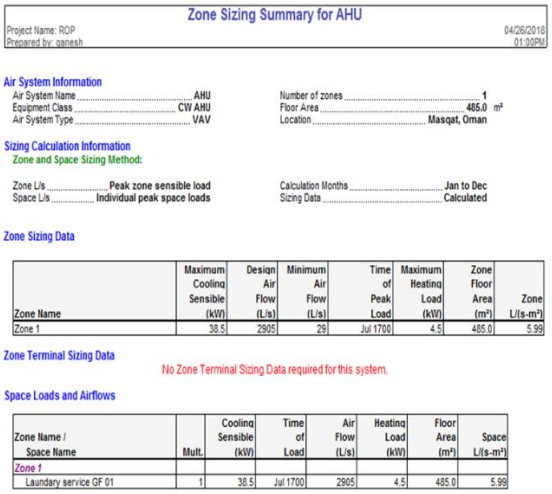

Fig. 4. Zone sizing summary for AHU

5) Selection of AHU:

- 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 m^2.
- 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 (1)

(4200 l/s = 4.200 m^3/s)

4.2 m^3/s / (1.150x0.650) m^2

= 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

Duct size - 1050 x 500
Head loss - 0.44 pa/m
Velocity - 5.8 m/s

- 2800 – 560 – 280 = 1960 l/s

Flow rate - 1960 l/s
Duct size - 900 x 450
Head loss - 0.43 pa/m
Velocity - 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 l/s +280 l/s = 560 l/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.
- Airflow 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.
2. Based on the longest path, we need to calculate the pressure drop occurring in straight duct, duct fittings, grills, dampers and diffusers etc.
3. Have to consider a safety factor of 10%.

9) Procedure for 3D modelling by Revit MEP:

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

Duct System:

i. Supply air duct (SAD)
ii. Return air duct (RAD)
iii. Fresh air duct (FAD)
iv. Exhaust air duct (EAD)

Pipe System:

i. Chilled water supply (CHWS)
ii. Chilled water return (CHWR)
iii. Layout creation
iv. Families creation
v. Insulation Presentation
vi. Interference check

4. Layout creation
5. Families creation
6. Insulation
7. Presentation
8. Interference check

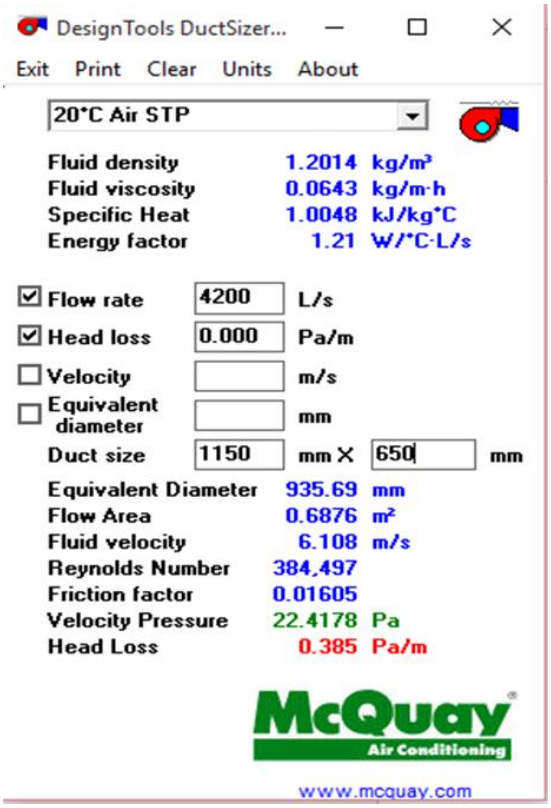

Fig. 5. Duct sizer

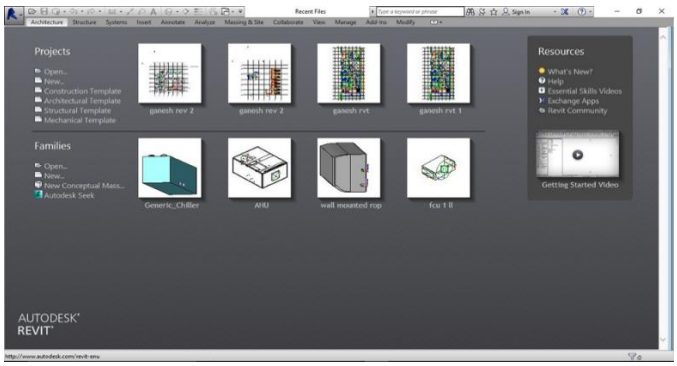

Fig. 6. REVIT (Architecture)

III. Result

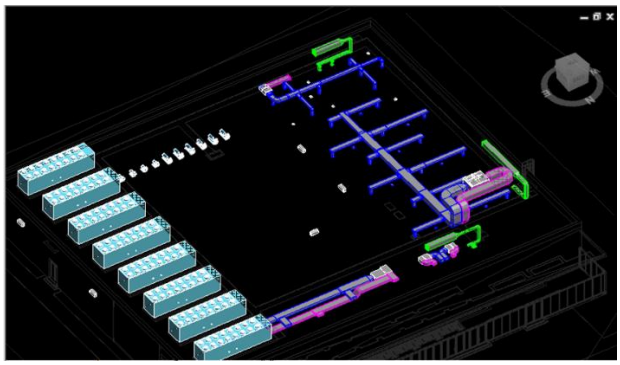

Fig. 7. 3D layout of ROP

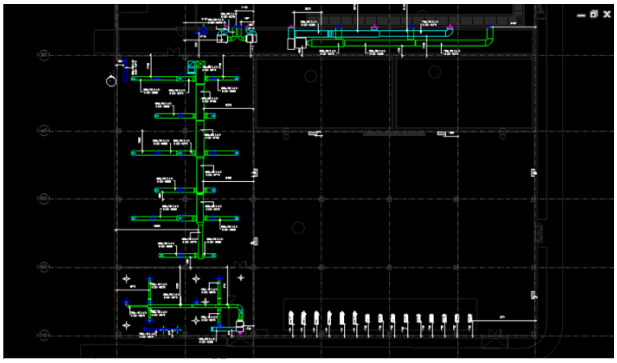

Fig. 8. 2D layout of ROP

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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