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Heat Load Calculations and Duct Design for Commercial Building G+2

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ABSTRACT

The modern commercial or office building consists of the HVAC system which is Heating, Ventilation, Air-conditioned. In this report, we'll going to identify the purpose and goals of HVAC system, describe HVAC types, describe HVAC parts and describe how this part works together or its working cycle. outsides to air-conditioning there are ventilation systems like ceiling fan, fresh air supply and exhaust fan where ceiling fan is used is used to ventilate the air with rotating blades and exhaust fan is used to displace the inside air to the outside environment, fresh air supply is used to displace the inside air to the outside environment by supplying fresh air from the outside air. And also the design of duct by using the heat load calculations based on that how much amount of air to be carried out to gain the required cooling inside the area is determined and also creating the comfortable zone for the humans.

KEYWORDS: *rotating blades exhaust fan, HVAC system*

INTRODUCTION

HEATING

Heaters are appliances whose purpose to generate heat for the building , this can be done via central heating such a system contains a boiler , furnace, or heat pump to heat water ,steam, or air in a central location such as furnace

In the present day, as the population increases the need for comfortness also increases. The human being needs more comfortless because of inferior environment (like light, sound, machine which produce heat). Sound, light and heat affect human comfort a lot. They may adversely affect the human comfort positively or negatively. Researchers suggest that, human body is used to be comfortable at a temperature of 22oC to 25oC. When the temperature of room is lower or higher than this temperature, than the human body feels uncomfortable. This is because, the human body is structured in a way that, it should receive a certain amount of light, failure to which it can cause sunburns and other skin conditions.

There are many types of air conditioning system like window air conditioners, split air conditioners etc. but theseAC's system are used in small room or office where cooling load required is low. When the cooling load required is very high like multiplex building, hospital etc. central AC's system are used. In central AC's system the cooled air is directly not distributed to the rooms. The cooled air from the air conditioning equipment must be properly distributed to rooms or spaces to be cold in order to provide comfort condition. When the cooled air cannot be supplied directly from the air conditioning equipment to the spaces to be cooled, then the ducts are installed. The duct systems convey the cold air from the air conditioning equipment to the proper air distribution point and also carry the return air from the room back to the air conditioning equipment for reconditioning and recirculation.

As the duct system for the proper distribution of cold air, costs nearly 20% to 30% of the total cost of the equipment required. Thus, it is necessary to design the air duct system in such a way that the capital cost of ducts and the cost of running the fans is lower.

VENTILATION

It is the process of exchanging or replacing of air in any space to provide high indoor air quality which involves temperature control, oxygen replenishment and removal of moisture content etc... Ventilation includes both exchange of air to the outside as well as circulation of air within the building.

CLASSIFICATION OF DUCTS

Supply air duct – The duct which supplies the conditioned air from the air conditioning equipment to the space to be cooled is called supply air duct.

Return air duct – The duct which carries the reciprocating air from the conditioned space back to the air conditioning equipment is called return air duct.

Fresh air duct – The duct which carries the outside air is called fresh air duct

Low pressure duct – When the static pressure in the duct is less than 50 mm of water gauge, the duct is said to be a low pressure duct.

Medium pressure duct - When the static pressure in the duct is up to 150 mm of water gauge, the duct is said to be a medium pressure duct

High pressure duct - When the static pressure in the duct is from 150-250 mm of water gauge, the duct is said to be a high pressure duct.

Low velocity duct – When the velocity of air in the duct is up to 600 m/min, the duct is said to be a low velocity duct.

High velocity duct - When the velocity of air in the duct is more than 600 m/min, the duct is said to be a high velocity duct.

DUCT MATERIAL

The ducts are usually made from galvanized iron sheet metal, aluminum sheet metal or black sheet. The most commonly used duct material in the air conditioning system is galvanized sheet metal, because the zinc coating of this metal prevents rusting avoids the cost of painting. The sheet thickness of galvanized iron duct varies from 0.55 mm to 1.6 mm. The aluminum is used because of its lighter weight and resistance to moisture. The black sheet metal is always painted unless they withstand high temperature.

Now a day, the use of non-metal ducts has increased. The resin bounded glasses are used because they are quite strong and easy to manufacture according to the desired shape and size. They are used in low velocity application less than 600 m/min and for a static pressure below 5 mm of water gauge. Sometimes cement asbestos duct also used for underground air distribution. The wooden duct may be used in places where moisture content in the air is not very large.

Duct System

APPLICATION

1. Air pollution control equipment's
2. HVAC ducting
3. Powder transportation industry
4. Cement plants
5. Wastewater Treatment Plants
6. Petrochemical Plants
7. Laboratory Exhaust Glass and Metal Foundries
8. Clean Rooms
9. Plating & Metal Finishing
10. Facilities Pulp and Paper Industry, Marine Exhaust Systems Food Processing Facilities
11. Marine Exhaust Systems
12. Food Processing Facilities etc..

DUCT SHAPE

Circular/round duct For a definite cross-sectional area and mean air velocity, a circular duct has less fluid resistance against air flow than other ducts. It also has better stiffness and strength. The longitude-seamed round ducts and spiral duct are used in commercial buildings. The main drawback of round ducts over the other duct is the more space required during installation

Circular Duct

Rectangular duct

Rectangular duct takes less space as compared to the round duct. It can be easily fitted where space is less. Rectangular ducts are less stiff than circular ducts, and also easily fabricated. the air leakage in joint of rectangular ducts has a greater percentage than other ducts joint. The rectangular ducts are generally used in low-pressure systems

Rectangular Duct

Flat oval duct

Flat oval ducts have a shape between round and rectangular cross-sectional shown in Fig. 1.1. Flat oval duct have the benefits of both the rectangular and the round duct with less large-scale air disorder and a lesser depth of space required. These ducts are easy to fit and also have lesser air leakage.

Flat Oval Duct

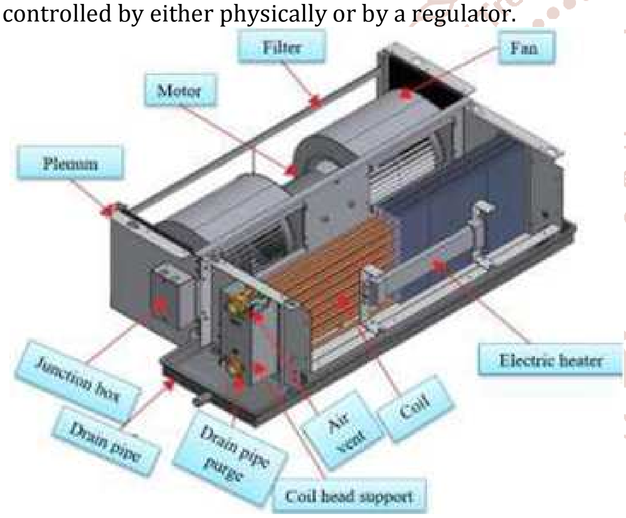
Flexible duct

Flexible ducts are used to connect the key duct to the incurable (terminal) box. Their plasticity and ease of elimination allow separation and rearrangement of the incurable (terminal) devices. These ducts are made of numerous-ply polyester film reinforced by a helical steel wire core. From an economical point of view, the circular ducts are preferable because the circular shape can carry more air in less space. This means that less duct material, less duct surface friction, and less insulation is required. Also, the circular ducts have less friction drop than the rectangular ducts.

Flexible Duct

FAN COIL UNIT (FCU)

A fan coil unit (FCU) is a device consisting of a cooling or heating coil and fan. It is a part of the heating ventilation and air conditioning system used to circulate the cold water into the room. In FCU no need to ductwork and it is used to govern the temperature in the region where it is fitted. It is controlled by either physically or by a regulator.



Fan Coil Unit

Fan coil units (FCU) are normally used in places where economic installations are desired such as storage rooms, loading docks and corridors. In high-rise buildings, fan coils may be arranged, situated one above the another from floor to floor and all interrelated by the same tubing loop. FCUs are an admirable delivery apparatus for hydraulic chiller boiler systems in large housing and light profitable applications. In these applications the FCUs are mounted in bathroom ceilings and can be used to provide infinite comfort zones - with the facility to turn off vacant areas of the building to save energy.

Advantages of FCU

There are some advantages with the FCU which are given below:

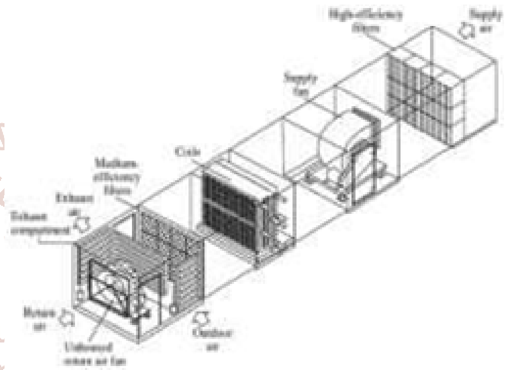
- The system requires only piping installation which takes up less space than all-air duct systems.
- FCU is available in many sizes, including with a self-finish galvanized steel chassis or a painted casing.
- Sound level in fan coil unit low and zones can be individually controlled.
- FCU is very efficient and energy consumption is less.
- Control and maintenance of FCU is also easy.

Disadvantages

- The FCU requires more maintenance than "all air" systems, and the maintenance work is performed in occupied areas.
- Interior zones may require separate ducts to deliver outside (ventilation) air.

AIR HANDLING UNIT (AHU)

Air handling unit (AHU), is a device used to circulate the air as part of a heating, ventilating, and air-conditioning (HVAC) system. An air handling unit is usually a big metal box having a blower, chambers, heating or cooling elements, dampers and sound attenuators. AHU generally connect to a ductwork ventilation system that allocates the cooled air through the house or rooms and takings it to the AHU.



Air Handling Unit

AIR HANDLING COMPONENTS

Filters

Air filter is used in the AHU in order to deliver clean dirt-free air to the house occupants. This air filter is generally placed leading in the air handling unit in order to retain all the other apparatuses clean. Depending upon the grade of filtration required, air filters will be organized in two or more successive banks with a coarse-grade section filter provided opposite of a fine-grade bag filter.

Heating or cooling elements

Air handlers need to deliver cooling, heating, or both to variation the supply air temperature, and humidity level contingent on the position and requirement. Such conditioning is delivered by a heat exchanger coil. Such coils may be direct or indirect in relation to the medium providing the cooling or heating effect.

Humidifier

Humidification is habitually essential in colder weathers where nonstop warming will make the air drier, resulting in uncomfortable air quality. Generally evaporative type humidifier is used.

Blower or fan

Air handlers generally employ a big blower, which is driven by an AC generation electric motor to transfer the air. The blower runs at a constant speed. Flow rate of air can be controlled by inlet blades or outlet dampers on the fan. Numerous blowers are used in big commercial AHU, normally placed at the end of the air handling unit and the opening of the source ductwork.

DESIGN
This project gives the fundamental principles of duct or air distribution system design for a multi-story building. There are mainly three types of duct sizing method namely

1. equal friction method
2. modified friction method (static regain method)
3. velocity reduction method.

Now a days, the use of manual duct calculator is normal and computer aided duct design is becoming more popular. Also understanding the friction chart is very important to use this manual duct calculator, because these are the foundations of the other methods. This will provide the necessary knowledge to the duct design error and overcome to the errors.

For designing a proper duct system, it is necessary to estimate cooling load which is used to select the zone and air flow rate that the duct system distributes. Once the air flow rate is determined, the duct system component can be placed. This includes the supply and returns diffusers and decides to air handling unit (AHU) or fan coil unit (FCU) is good for that space.

GENERAL RULES FOR DUCT DESIGN

1. Air should be conveyed as directly as possible to economize on power, material and shape.
2. Sudden change in direction should be avoided.
3. Air velocities in ducts should be within the permissible limits to minimize losses.
4. Rectangular ducts should be made as nearly square as possible. This will ensure minimum ducts surface. An aspect ratio of less than 4:1 should be maintained.
5. Damper should be provided in each branch outlet for balancing the system.

DUCT DESIGN CRITERIA
Many factors are considered when designing a duct system. They are as follows

1. Space availability
2. Installation cost
3. Air friction loss
4. Noise level
5. Duct heat transfer and airflow leakage.

Space Availability
The sizing of a duct depends on the space available in the building. Ceiling plenums, duct chases, obstruction like walls and beam dictate the size of duct to be used, irrespective of the size at a least cost. At the time of design, the duct coordination is required to avoid sprinkler piping, power and light fixtures. For this, header duct and runouts are easier to locate. Larger the trunk and branch ducts greater the coordination required with equally large piping.

Installation Cost
While designing, the duct installation cost is very important. This includes size of ducts, type of material used, number and complexity of the duct fitting and height of the site conditions impacting duct installation labor. Use least no of fitting as possible to lower the installation cost.

Air Friction Loss
Air friction loss is affected mainly by the duct size and shape, the material used, fittings used. According to ―Carrier Handbook‖ round galvanized sheet metal has the lowest friction loss per meter, while the flexible ductwork has the highest friction loss per meter. The quality of fitting has a direct effect on the overall pressure drop of a duct system, smooth and efficient fitting with a low turbulence reduce the duct system air pressure drop. A direct route using round duct with less fitting and size changes can have a less friction loss in comparison with the similar size rectangular system with a longer route and size changes at each branch duct.

Noise Level
The modern AC systems require control of noise level below a particular level in addition to the control of humidity, temperature and air velocity of excessive noise which causes uncomfortable feeling. The equipment as blowers, humidifiers, motors and many others contribute noise to the air conditioned space. The air passing through the ducts and grills also create noise.

Heat Transfer and Leakage
Ductwork that runs through very warm or cold areas can suffer heat gain or loss that effectively reduce the capacity of the cooling and heating equipment, result in occupant discomfort and higher operating cost. Leakage in duct also affects the capacity of cooling equipment and may create odors.

MODELLING

AUTODESK REVIT SOFTWARE
The original software was developed by Charles River Software, founded in 1997, renamed Rivet Technology Corporation in 2000, and acquired by Autodesk in 2002. The software allows users to design a building and structure and its components in 3D, annotate the model with 2D drafting elements, and access building information from the building model's database. Rivet is 4D BIM capable with tools to plan and track various stages in the building's lifecycle, from concept to construction and later maintenance and/or demolition.

There are many categories of objects ('families' in Rivet terminology), which divide into three groups:

- System Families, such as walls, floors, roofs and ceilings which are built inside a project
- Loadable Families / Components, which are built with primitives (extrusions, sweeps, etc.) separately from the project and loaded into a project for use
- In-Place Families, which are built in-situ within a project with the same toolset as loadable components.

SOME OF THE SHORTCUTS USED IN THE SOFTWARE
CL [COLUMN STRUCTURAL COLUMN]:- Adds a vertical load-bearing element to the building model.

CM [PLACE A COMPONENT]:- Place a component.

DR [DOOR]:- Adds a door to the Building model.

GR [GRID]:- Places column grid lines in the building design.

LL [LEVEL]:- Places a level in view.

RM [ROOM]:- Creates a room bounded by model elements and separation lines.

RP [REFERENCE PLANE]:- Creates a reference plane using drawing tools.

RT [TAG ROOM; ROOM TAG]:- Tags the selected room.

SB [FLOOR: FLOOR: STRUCTURAL] Adds structural floors to a building model.

WA [WALL; WALL: WALL: ARCHITECTURAL]:-Creates a non-bearing wall or a structural wall in the building model.

WN [WINDOW]:- Places a window in a wall or skylight in a roof.

CM PLACE A COMPONENT / Place a component.

DI ALIGNED DIMENSION / Creates an aligned dimension.

FR FIND/REPLACE / Find and replace.

GP MODEL GROUP:CREATE GROUP; DETAIL GROUP:CREATE GROUP / Creates a group of elements.

LI MODEL LINE; BOUNDARY LINE; REBAR LINE / Places a new line.

LL LEVEL / Places a level in view.

MD MODIFY / Enters selection mode to select elements to modify.

PP or CTRL-1 or VP PROPERTIES; TOGGLE PROPERTIES PALETTE / Toggles the Properties palette.

RP REFERENCE PLANE / Creates a reference plane using drawing tools.

TX TEXT / Adds text.

EXPERIMENTATION

STEPS FOR CALCULATING LOAD FACTORS

Step1

Finding the Location, Dry Bulb Temperature, Wet Bulb Temperature, Relative Humidity, Specific Humidity and Dew Point Temperature

Step 2

Glass

i. Radiation

Q= µxAxΔT ii. Transmission Q= UxAxΔT

u=coefficient of heat transfer and µ=transparency factor

Step 3

Walls Q= UxAxΔT

Step 4

Roof

Q= UxAxΔT

Step 5

Ceiling/Floor

Q= UxAxΔT

Step 6

Portions Q= UxAxΔT Step 7

Equipments Q=Wx4.16

Step 8

PEOPLE= BTU/hr person x no of people

Step 9

Infiltration

Q=CFMx1.08 (Sensible)xA

Q=CFMx0.68 (Latent)xA

Step 10

Ventilation

Q=CFMx1.08 (Sensible)

Q=CFMx0.68 (Latent)

Air Change Cfm= (VxNACPH)/60

where NACPH= no of air changes per hour

Step 11

Sum Of Sensible Heats=Glass+Wall+Roof+Floor/Ceiling+Portion+Equipment +People+Infiltration+Ventilation

Step 12

Effective Sensible Heat =Total Sensible Heat x10% of Total Sensible Heat

Step 13

Sum Of Latent Heat=people+ infiltration+ ventilation

Step 14

Effective Latent Heat= Total latent Heat x5% of Total latent Heat

Step 15

Ton Of Refrigeration= (Effective sensible heat+ Effective latent heat)/12000

Step 16

Sensible Heat AT Heat Engine= CFMx1.08xA

Latent Heat AT Heat Engine= CFMx0.68xA

Step 17

Effective Sensible Heat Factor=(Effective sensible heat+ Effective latent heat)/ Effective sensible heat

Step 18

Cfm= Effective sensible heat factor/Apparatus dew point x (BF)

Where Bf= By Pass Factor

CALCULATION FOR DUCT SIZE/DIMENSION

1. First find out the air flow rate i.e. dehumidified air and cooling load.
2. Based on cooling load select AHU or FCU which is to be installed. For FCU there is no need to duct system. If AHU then calculate the duct dimension.
3. Select initial velocity
4. Duct area =air flow rate / velocity
5. Select duct size/dimension also Equivalent duct diameter.
6. Then initial friction rate is determined by using friction chart, on the basis of air quantity and equivalent duct diameter or velocity of air.
7. Then initial friction rate is determined by using friction chart, on the basis of air quantity and equivalent duct diameter or velocity of air.

RESULTS

DUCT SIZE

To design the duct for Commercial building calculation of cooling load and air flow rate is done. By taking some suitable velocity (from Table 6.1), considering noise factor main duct area is calculated. Based on these duct area, the duct size is find out for the rectangular duct as well as round duct. The cooling load, dehumidified air flow, duct size for all room is given in below

S.N	ROOM NAME	Cooling Load (tons)	Dehumidified air Flow((m/min)	Type Of unit used (FCU/AHU)
1	120 seat lecture room1	12.39	113	AHU
2	Admin Office	3.03	32	FCU
3	Placement office	2.27	25	FCU
4	IPR Office	2.93	32	FCU
5	120 seat lecture room2	12.39	113	AHU
6	Office Room	6.96	69	AHU
7	Meeting Room	6.77	66	AHU
8	Interview Room	2.95	31	FCU
9	Auditorium	50.14	422	AHU

Calculation for the building

CONCLUSION

The following conclusion summarizes the design work presented in this thesis:-

1. The duct design for commercial building is done, by using equal friction method. All values are comparable with duct software called ductulator.
2. The calculated value of frictional is less or near as calculated by software. Due to less value of friction drop, duct diameter is increased but loss in total pressure (i.e. static pressure, velocity pressure) can be avoided.
3. Due to increased duct diameter the use of damper may be decreased.
4. Also the circular duct can carry more air in less space, because of that, less duct material, less duct surface friction and less insulation is required.
5. Pressure loss in duct fitting can be minimized by proper design the elbow shape.

REFERENCE

[1] G. S. Sharma and B. Sharma. ―Duct designing in air conditioning system and its impact on system performance‖ .VSRD International Journal of Mechanical, Automobile and Production Engineering.

[2] R. Whalley, A. A. Ameer. ―Heating, ventilation and air conditioning system modeling‖. Building and Environment.

[3] Tengfang T. Xu, Francois R. Carrie, Darryl J Dicker off, William J. Fisk. ―Performance of thermal distribution systems in large commercial building‖. Building and Environment.

[4] C. Aydin, B. Ozerdem. Air leakage measurement and analysis in duct systems. Energy and Buildings.