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Experimental Investigation On Effect Of Supply Air Diffuser Placement In Indoor Thermal Environment

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Abstract:

In the air conditioning systems the variations in temperature is most important part for load calculations, India is a tropical country where variations in environmental temperature is between 0°c to 45°c . In corporate sector the load calculations for air conditioner inside glass chamber & variation in temperature at different duct altitude of chamber is very essential. It is also very much required to calculate the heat effect of occupants and accessories for proper load calculations. In this dissertation work, I have been investigated the effect of on the thermal comfort conditioning inside the glass chamber assuming moderated office work condition. The variation in temperatures with respect to horizontal distance & vertical distance at particular test point location inside the glass chamber at particular heights of duct has been investigated for properly sealed glass chamber.

The experiment has been investigated inside 2.66m x 3.4m x 2.72m glass chamber using thermocol insulated roof & according to that temperature have been calculated the essential load for conditioner neglecting humidity effects inside the glass chamber at varying altitude of air conditioning duct.

Keywords: *Air distribution, temperature distribution, thermal comfort*

Introduction

Air Condition System

An air conditioner is an appliance, system, or machine developed to change the air temperature and humidity within an area used for cooling as well as heating depending on the air properties at a given time by using a refrigeration cycle but many times using evaporation, most commonly for comfort cooling in buildings and other purpose.

History Of Air Conditioning

The concept of air conditioning is known to have been applied in ancient Egypt where reeds hung in the windows had water trickling down; evaporation cooled the air though made it more humid. In Ancient Rome aqueducts water was circulated through the walls of certain houses to cool them down. The first electrical air conditioning was invented and used in 1911 by Willis Haviland Carrier.

Air Distribution System

Air distribution systems include air handlers, ductwork, and associated components for heating, ventilation, and air conditioning building. They provide fresh air to maintain adequate indoor air quantity while providing conditioned air to offset heating and cooling.

Object Of Air Distribution System

The objective of an air distribution system is to create a proper combination of temperature, humidity; air motion in the occupied zone of the conditioned room the comfort conditions for the occupants must be met.

Supply Duct Systems

Supply ducts deliver air to the spaces that are to be conditioned. The two most common supply duct systems for residences are the trunk and branch system and the radial system because of their versatility, performance, and economy. The spider and perimeter loop systems are other options.

Comfort Condition

Air conditioning system which deals with the comforts of human beings in an enclosed conditioned space is known as Comfort Air Conditioning.

Thermal comfort is defined as 'That condition of mind which expresses satisfaction with the thermal environment.'

So the term 'thermal comfort' describes a person's psychological state of mind and is usually referred to in terms of whether someone is feeling too hot or too cold.

The Six Basic Factors Determining Thermal Comfort

The six factors affecting thermal comfort are both environmental and personal. These factors may be independent of each other, but together contribute to a worker's thermal comfort.

Environmental Factors

- **Air temperature.**
- **Radiant temperature.**
- **Air speed.**
- **Humidity.**

Personal Factors

- **Metabolic rate.**
- **Clothing insulation**

Thermal Environment

The design criteria for the thermal environment in CEN CR1752 are based on ISO 7730. The PMV index describes the predicted mean vote for the human response to the thermal environment. The PPD index expresses the predicted percentage dissatisfied with thermal environment and can be calculated from the Predicted mean vote index. The Predicted mean vote index combines several measurable parameters which are related to the thermal environment with parameters describing the occupant. The parameters are:

- **The occupants physical activity (metabolic rate)**
- **The thermal resistance of the occupants clothing**
- **The air temperature**

- The mean radiant temperature
- The air velocity
- The relative humidity

Concepts And Fundamentals Of Air Conditioner Sizing

Air conditioner sizing is a very important aspect of maintaining a desirable environment in buildings. Get the sizing wrong, and you'll be facing problems such as insufficient cooling, insufficient moisture removal, and unnecessarily high electricity bills. Use of psychometric and psychometric chart is very important to determine the volume flow rates of air to be pushed into the ducting system and the sizing of the major system components. The goal of air conditioning processes is to provide a sufficient amount of fresh air at desirable temperature and humidity.

Cooling Capacity

Cooling capacity for a room is defined as the heat load in a room that has to be removed in order to achieve a certain room temperature and humidity. The typical design is set to 24°C temperature and 55% Relative Humidity. Study shows that this combination of temperature and RH is the most conducive for the human body. The unit used to measure heat load is BTU/hr. 1 BTU/hr is the heat energy needed to increase 1 pound of water by 1°F.

The most common rule of thumb is to use "1 ton for every 500 square feet of floor area".

Cooling Load Calculations

The term load from point of view of air conditioning systems means the heat removed or heat added to any space. If heat is removed it is termed as cooling load and if heat is added it is termed as heating load. Load calculation is the determination of the cooling load. This is important as it decides the size of equipment and power consumption of the unit. The cooling load is affected by design condition both indoor and outdoor. Cooling load itself is of two main types

- Sensible heat load
- Latent heat load

Sensible Heat Loads

These loads are due to the heat gained by the space with sensible temperature rise. The heat gained by the space is removed by the air conditioner as the cooling load. Sensible heat gain by a space occurs due to the following reasons.

- Heat load of occupants.
- Heat gain from infiltration of air
- Heat gain from lights
- Heat gain from appliances
- Heat gain by conduction of heat through walls, floors, ceiling, doors, windows.

Experimental Investigation

Glass Chamber

The test facility is located at the cad lab on the first floor of CME building. The test chamber has the inner dimension (length x width x height): 2.66 x 3.40 x 2.72 m, which is equivalent to a typical two-person office. The walls of test chamber are insulated and the whole room is guarded in a box, which separates the room and thermo active components from the hall. The thermocol ceiling is located at the height of 2.72 m. The inlet air comes from the adjacent room around 3 m away from the glass chamber. Outer room acts like a cooling unit providing the cooled air to the glass chamber. The exhaust air is directly exhausted to the hall.

Air Temperature Measurement

Thermocouple Type k is used to measure the air temperature at inlet, exhaust and along a measuring stand. The temperature is calculated internally in the instrument by using temperature indicator. 13 thermocouples at different heights (0.2m, 0.4m, 0.6m, 0.8m, 1m, 1.2m, 1.4m, 1.6m, 1.8m, 2.0m 2.2m 2.4m 2.6m), are mounted on a stand to measure the air temperatures.

Experimental Assumptions

The following assumptions are applied in the investigation of experimental analysis.

- Metabolic rate and preference of closing in the office varies from the people to people. The standard values for metabolic rate and closing factor are to be considered. The activity of a sedentary occupant is estimated to be 1.2 met and the clothing insulation is 1.0 clo in winter and 0.5 clo in summer.

- The building is situated in a clean area with excellent air quality.
- Thermocol ceiling are used for the suitable height for the room so from the ceiling heat transfer rate could be zero.
- The position of the room respect to sun direction and altitude may be assumed identical for heat load calculation. So no effect has been considered.
- Only sensible heats are calculated for the calculation neglecting latent heat.

Experimental Setup

In the experimental investigation experimental setup has been made thermocol ceiling with ventilation has been provided for the suitable room height and also providing insulation from the top of the roof. Measuring stand with thermocouple and temperature indicator are placed at different test point for the recording the inside temperature of the room. There are five test locations A, B, C, D, are the all four corner of the room and E is the centre of the room. Air conditioner systems are used to supply air at different height of the duct inside the room. After all the arrangement all the suitable data has been recorded by varying the height of the supply air duct.

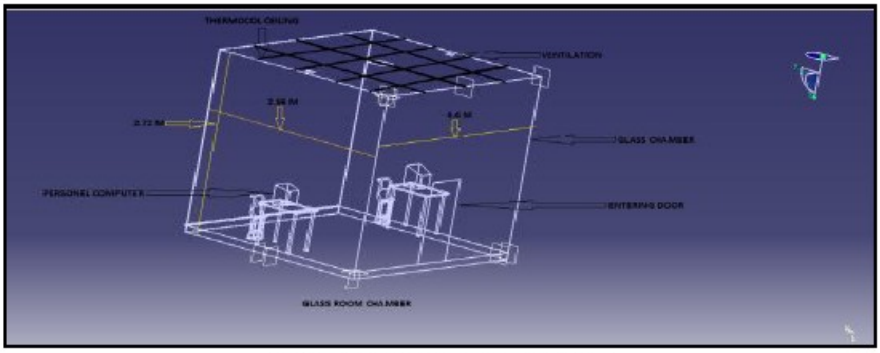

Figure1.1: Glass room model

Figure1.2: Front view of the glass chamber

Figure1.3: Duct position set up

Experiment Result

The main results of experiments are presented as thermal comfort environment according to the temperature variation inside the room at varying duct height. At various duct height the circulation of the air inside the room has been changed. Due to circulation of the air the temperature distribution through out the room varies which we have recorded by the dividing the room in to 5 test locations. The temperature shows the variation respects to height are tabulated and find the variation between the temperature and height according the position of the duct. The study shows the temperature variation inside the room at which position of the duct height at which suitable uniform temperature can be achieved of at which vertical height temperature ranges varies. In the study at 2.50meter height suitable uniform temperature recorded has shown in graph and all the duct position the vertical height inside the room say 1.2meter uniformity achieved between all temperature range and at the centres find the uniformity zone at all the duct position.

Various data has been recorded at different duct height and tabulated as shown in the tables. Table 1.1 and Table 1.4 shows the temperature data recorded inside the room at duct height 0.50m, as well as Table 1.2 and 1.5 for duct height 1.50m and Table 1.3and Table 1.6 for duct height 2.50m

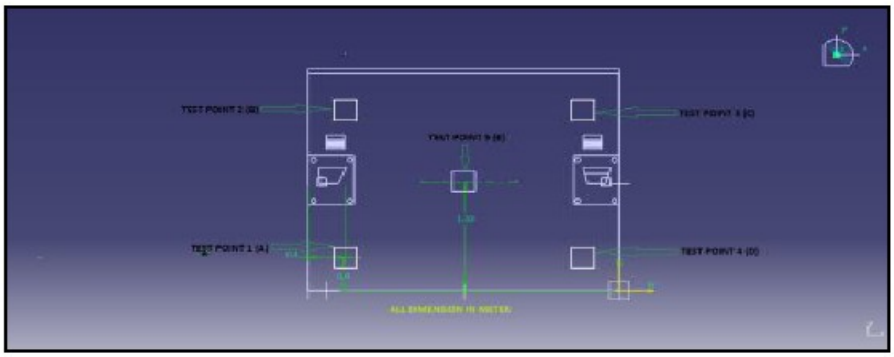

Figure1.4: Test points location inside the room

Condition temperature	Initial temperature
Window glass temp: - 36°c	Supply air temp: -
Glass temp (G-1):- 31°c	Before entry: - 17°c
Glass temp (G-2):- 31°c	After entry: - 19°c
Glass temp (G-3):- 31°c	Room temp: -
Glass temp (G-4):- 31°c	Inside temp: - 31°c
Exit temp (EX-1):- 33°c	Outside temp: - 31°c
Exit temp (EX-2):- 33°c	

Table.1.1: Temperature data at duct position 0.50meter

Condition temperature	Initial temperature
Window glass temp: - 35°c	Supply air temp: -
Glass temp (G-1):- 30°c	Before entry: - 15°c
Glass temp (G-2):- 30°c	After entry: - 19°c
Glass temp (G-3):- 30°c	Room temp: -
Glass temp (G-4):- 30°c	Inside temp: - 30°c
Exit temp (EX-1):- 31°c	Outside temp: - 31°c
Exit temp (EX-2):- 31°c	

Table.1.2: Temperature data at duct position 1.50 meter

Condition temperature	Initial temperature
Window glass temp: - 33°c	Supply air temp: -
Glass temp (G-1):- 30°c	Before entry: - 18°c
Glass temp (G-2):- 30°c	After entry: - 20°c
Glass temp (G-3):- 30°c	Room temp: -
Glass temp (G-4):- 30°c	Inside temp: - 31°c
Exit temp (EX-1):- 29°c	Outside temp: - 33°c
Exit temp (EX-2):- 29°c	

Table.1.3: Temperature data at duct position 2.5 meter

S.NO.	HEIGHT	TP-1(A)	TP-2(B)	TP-3(C)	TP-4(D)	TP-5(E)
Unit:-	Meter	°c	°c	°c	°c	°c
1	0.2	26	27	27	28	24
2	0.4	27	28	28	28	22
3	0.6	28	28	27	28	22
4	0.8	29	29	27	28	23
5	1.0	29	29	29	29	27
6	1.2	30	30	29	28	28
7	1.4	30	30	30	28	29
8	1.6	31	30	30	29	31
9	1.8	31	30	31	30	31
10	2.0	31	31	32	31	32
11	2.2	32	31	32	31	32
12	2.4	32	31	32	32	32
13	2.6	32	31	33	33	33

Table 1.4: Temperature data at duct Position 0.50 meters

S.NO.	HEIGHT	TP-1(A)	TP-2(B)	TP-3(C)	TP-4(D)	TP-5(E)
Unit:-	Meter	°c	°c	°c	°c	°c
1	0.2	27	27	26	26	25
2	0.4	28	28	25	27	25
3	0.6	28	28	26	27	25
4	0.8	28	26	26	27	25
5	1.0	27	28	27	28	23
6	1.2	27	27	26	28	22
7	1.4	27	26	27	27	21
8	1.6	28	26	27	28	22
9	1.8	28	27	27	28	24
10	2.0	28	28	28	28	27
11	2.2	28	27	29	29	28
12	2.4	28	27	29	29	29
13	2.6	29	28	29	29	30

Table.1.5: Temperature data at duct position 1.50meter

S.NO.	HEIGHT	TP-1(A)	TP-2(B)	TP-3(C)	TP-4(D)	TP-5(E)
Unit:-	Meter	°c	°c	°c	°c	°c
1	0.2	29	29	29	28	28
2	0.4	30	28	28	28	28
3	0.6	30	28	29	29	28
4	0.8	29	28	29	29	29
5	1.0	29	28	29	29	29
6	1.2	29	28	28	29	29
7	1.4	29	28	28	29	29
8	1.6	29	27	28	29	29
9	1.8	29	27	28	29	28
10	2.0	29	27	28	29	27
11	2.2	28	28	29	29	26
12	2.4	29	28	29	29	25
13	2.6	29	28	29	29	26

Table.1.6: Temperature data at duct position 2.50meter

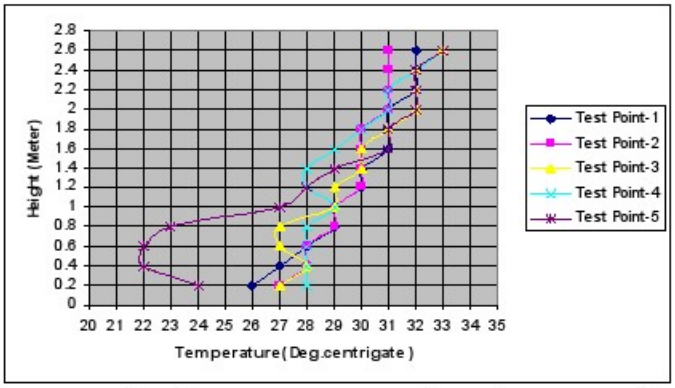

Figure 1.5: Variation of height vs. temperature all test location at duct height 0.50m

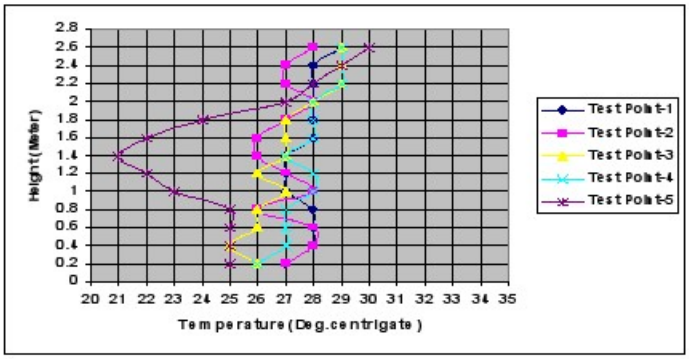

Figure 1.6: Variation of height vs. temperature all test location at duct height 1.50m

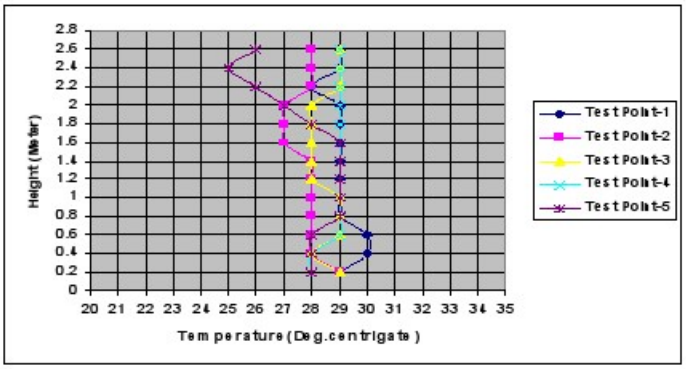

Figure 1.7 : Variation of height vs. temperature all test location at duct height 2.50m

Conclustion

In the above Investigation work it has been found that in proper sealed glass chamber having moderate office work condition with two computers and other accessories. The maximum comfort obtained at the centre of the room. The variation obtained at the horizontal distance towards corner of the room.

The maximum variation obtained at a horizontal distance of 1.2 m from the centre towards corner, when

investigated 0.50meters and 1.5meters are the suitable ducts height which gives the transits air distribution in the glass chamber.

In the investigation we found that the air moves downward and moves upward in 0.50meter height of the duct which gives more comfortable temperature variation at the suitable vertical height inside the room say, 1.2m in case of 1.50meter duct level less variation as compare to 0.50m found. In case of 2.50m height of duct the air movement fall from the duct at downward direction so the variation of temperature comes downward which gives less ground level comfort.

So investigation shows all the possible temperature variation due to its various heights of the duct.

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