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Cooling Load Calculation of a Room with Different Design Temperature by Analytical Method and Analysed by ANSYS (Fluent)

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Abstract - Load calculations are used to determine the accurate size of the heat pump and air conditioner required to heat and cool a building. A right-sized unit is energy-efficient, operates quietly, and regulates both temperature and humidity. The more exact the information (Data Collection) the more accurate will be the load calculated. The amount of heat generated in a specific room depends on many factors such as the position of the room, electric Equipment, wall materials, and number of people occupied in the room. The method of cooling load calculation by using analytical method. The case study of the present work is only focused on one room specifically One room in Bilaspur CG located at 82.1409° E longitude and 22.0797° N latitude. From the calculation, we can say that for high design temperature, we need low cooling capacity and for low design temperature we need high cooling load capacity. After calculating the analytical, it was analysed using ANSYS (Fluent) software.

***Key Words*:** Cooling load, Air conditioning, Energy efficient, ANSYS (Fluent)

1. INTRODUCTION

Nowadays, the use of Air conditioners is increasing a lot due to which electricity consumption and global warming are increasing. As we know humans feel comfortable between 21°C to 25°C. We also know that for high design temperature, we need low cooling capacity, and for low design temperature we need high cooling load capacity. So, to check this, the load was calculated at two different design temperatures. After that, with the help of Ansys, the average temperature of the room was checked in two different conditions.

2. DATA COLLECTION AND METHODOLOGY

a) methodology which is in two parts

1. Analytical method ,
2. Practical method which is done by Ansys software

The total cooling load of a room consists of heat transferred through the building envelope (walls, roof, floor, windows, doors, etc.) and heat generated by occupants, equipment, and lights. The load due to heat transfer through the envelope is called an external load, while all other loads are called internal loads. The more exact the information the more accurate will be the load calculated.

b) Room Structures:-

The dimension of the room which is to be air conditioned is, 2.68m×4.48m×3.39m in size. The wall of the room consists of 330mm common brick + 60mm (30mm on both sides) sand cement plaster. The roofs consist of 160 mm concrete poured into a metal sheet with 25 mm plaster. The windows consist of single glass materials of 10mm thick with a frame panel.

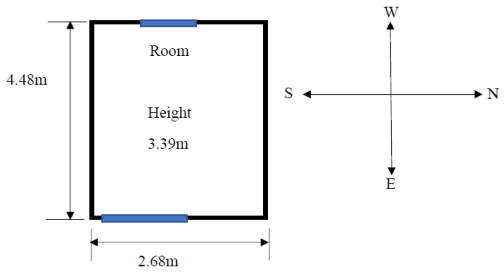


Fig -1: Room Dimension

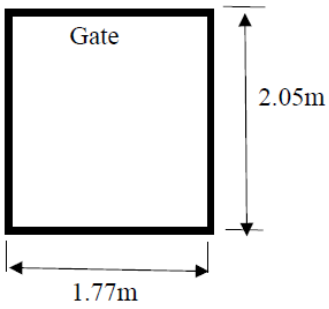


Fig -2: Gate Dimension

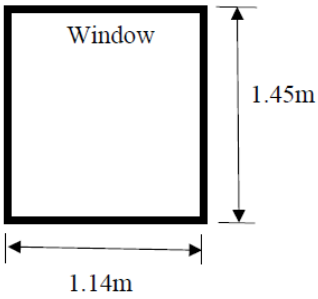


Fig -3: Window Dimension

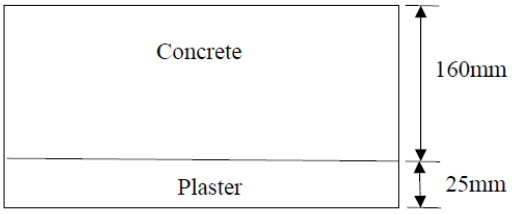


Fig -4: Roof Dimension

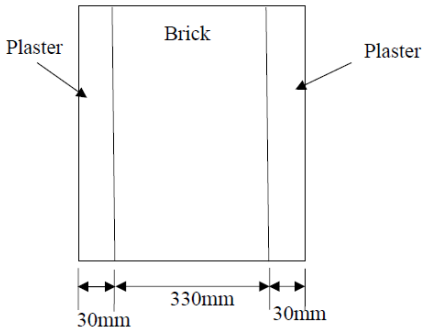


Fig -5: Wall Dimension

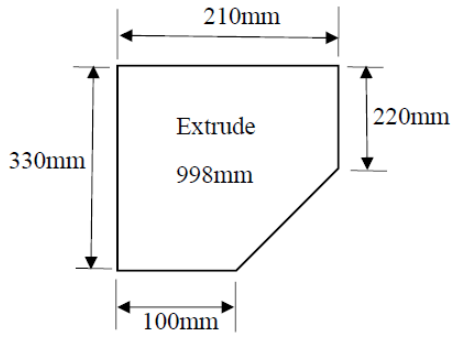


Fig -6: AC Dimension

3. CALCULATION

a) General calculation :-

Thermal conductivity & Film coefficient (Source CP Arora Book)

K_{glass} = 0.78 W/mK

$K_{concrete}$ = 1.73 W/mK

K_{brick} = 1.32 W/mK

$K_{plaster}$ = 8.65 W/mK

K_{wood} = 0.158 W/mK

h_o = 23.3 W/m2K

h_i = 8.5 W/m2K

Table -1: General calculation

A_{window}	1.653m^2
A_{Gate}	3.6285m^2
A_{ww}	7.4322 m^2
A_{nw}	15.1872 m^2
A_{ew}	5.4567 m^2
A_{sw}	15.1872 m^2
A_{Roof}	12.0064 m^2
V_{Room}	40.7017 m^3
U_{ow}	2.395 W/m^2K
U_{pw}	2.0315 W/m^2K
U_R	3.9071 W/m^2K
U_G	5.7675 W/m^2K
U_w	2.8535 W/m^2K

b) Load Calculation :-

the load was calculated at two different inside condition of 22°C & 24°C , outside condition is constant at 42°C

Table -2: Load Calculation by Analytical method

Heat Gain	Condition 1	Condition 2
Q_{ow}	1344.8452 W	1210.36 W
Q_{pw}	154.2639 W	92.5583 W
Q_R	938.2042 W	844.3837 W
Q_G	190.6736 W	171.6062 W
$(Q_s)_{occupancy}$	450W	400W
$(Q_L)_{occupancy}$	250W	300W
Q_{light}	87.5 W	87.5 W
$Q_{Electric}$	270W	270W
$(Q_s)_{inf}$	554.62 W	499.1570 W
$(Q_L)_{inf}$	373.0925 W	284.907W
$(Q_s)_{vent.}$	306W	275.94W
$(Q_L)_{vent.}$	206.25W	157.5W
RSHG	4296.1069W	3851.5053W
RLHG	829.3425W	742.407W
RTH	5125.4494W	4593.9123W
RSHF	0.8382	0.8384
Total load in Ton	1.464 TR	1.312

4. MODELLING AND IMPLEMENTATION

The framework is to optimize the Air conditioning analysis by using Computational Fluid Dynamics using ANSYS fluid flow. This chapters also include several stages taken for our simulation analysis on room air conditioning. ANSYS steps for execution Air conditioning room thermal testing are taken for our analysis is described here.

a) **Create Geometry: -** Create geometry in Design Modeler. The dimension of the room which is to be air conditioned is, 2.68m×4.48m×3.39m in size. With one Gate (2.05m×1.77m) and one window (1.45m×1.14m) which is 1.24m above the floor, AC is located at 2.86m above from base floor.

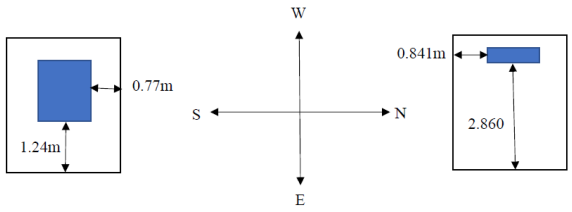


Fig -7: AC & Window position

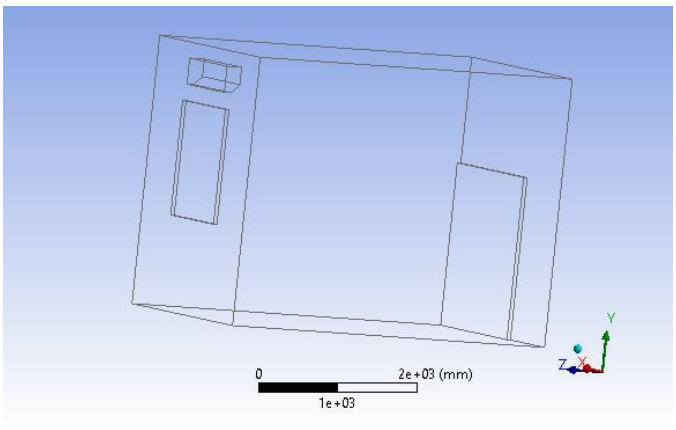


Fig -8: Geometry of room

b) Mesh Generation:-In Fluid Flow (Fluent) simulation, meshing is one of the most time taking events. Fluid Flow (Fluent) simulation is the discretization of the computational domain. The result quality is strongly dependent on the mesh quality.

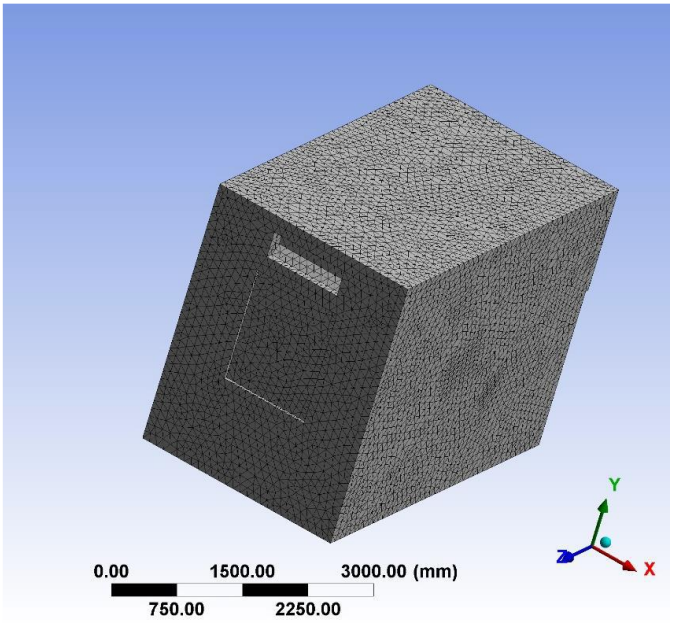


Fig -9: Meshed AC room

In Ansys for calculate Room average temperature with two conditions

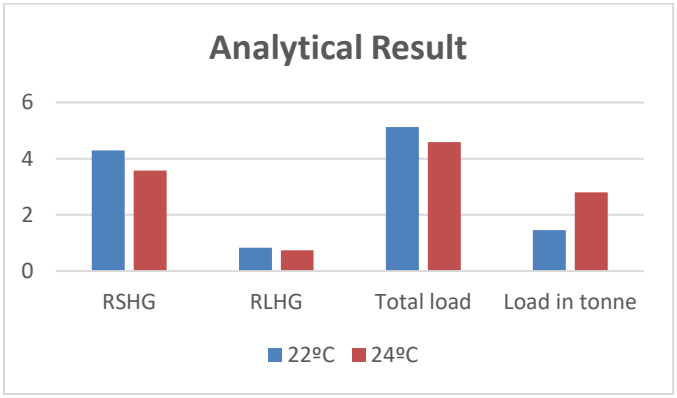
a) Condition 1 = Air velocity of 0.39m/s with 16°C temperature

b) Condition 2 = Air velocity of 0.54m/s with 17 °C temperature

5. MODELLING AND IMPLEMENTATION

a) In analytical method :- We are calculated cooling load for room design temperature at 22 °C and 24 °C and outside temperature 42 °C.

Chart 1 :- Variation of result (Analytical)



b) In Ansys Fluent (CFD) :- In Ansys for calculate Room average temperature with two conditions Air velocity of 0.39m/s with 16°C temperature & Air velocity of 0.54m/s with 17 °C temperature .

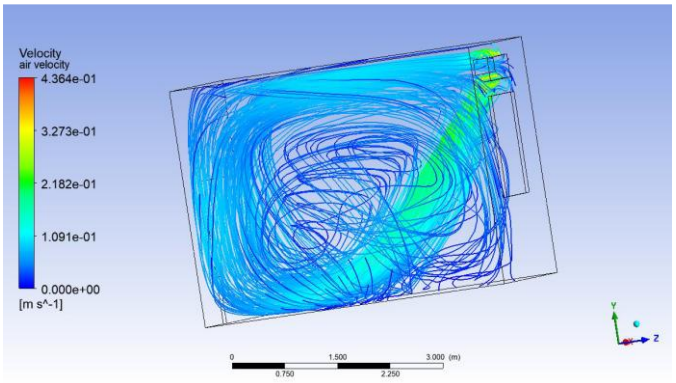


Fig -10:Streamline of air flow in room for condition 1

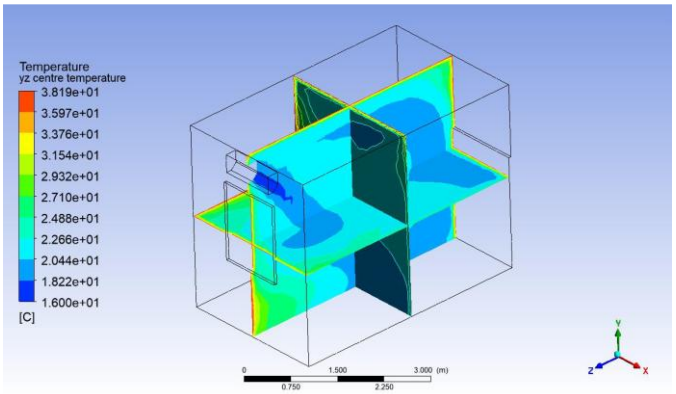


Fig -11: Temperature variation in XYZ plane for condition 1

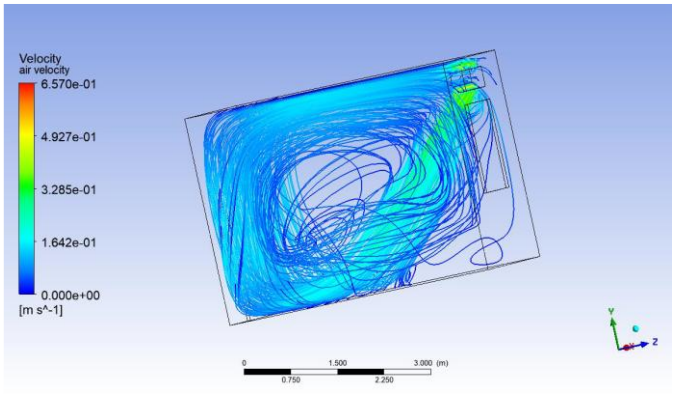


Fig -12:Streamline of air flow in room for condition 2

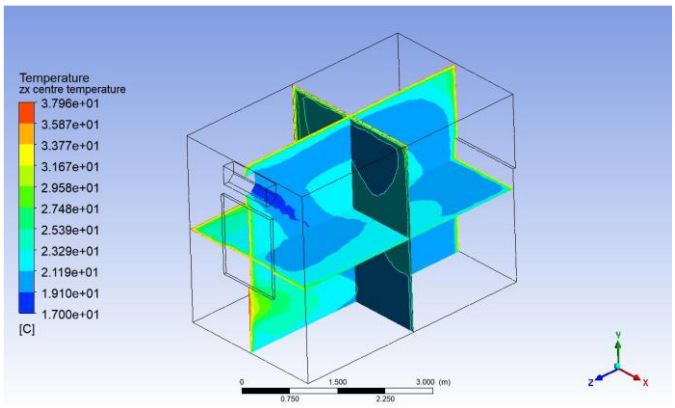


Fig -13: Temperature variation in XYZ plane for condition 2

Above figures (10,11,12,13) shows the variation of AC room temperature and air velocity. Average temperature of room for condition 1 is 22.123 °C and for condition 2 is 22.347 °C .

6. CONCLUSION

The cooling load calculation analysis has been conducted for a room present in Bilaspur (C.G.). According to cooling load calculation, suitable air conditioning system will be selected for the room. The cooling capacity for 22 ℃ and 24 ℃ are 1.464TR and 1.312TR respectively.

From the calculation we can say that for high design temperature we need low cooling capacity and low design temperature we need high cooling load capacity.

In Ansys calculated Room average temperature with conditions of Air velocity of 0.39m/s with 16 ℃

temperature and Air velocity of 0.54m/s with 17 ℃ temperature are 22.123 ℃ and 22.347 ℃ respectively.

Ansys Fluid Flow (Fluent), show that to increase condition space temperature by 1 ℃ with increasing air velocity by 0.15m/s. The average temperature of the room remains almost the same.

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