INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X
Impact factor: 4.295
(Volume3, Issue3)
Available online at www.ijariit.com

Energy Optimization and Variation of Cooling Load of Multistory Building at Same Latitude of Location with Different Degree of Rotation

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Abstract: ***Now a day energy is a fundamental need of everyone and saving of energy is the main aim of an engineer. So more practical emphasis work should be carried out on main two approaches, to save the energy and keep the environment clean and human comfort is also a fundamental need in the present scenario.***

In this research work, we are dealing with change in load due to the different orientation of a multistory building at same latitude of the location. For our analysis purpose, we are considering Mechanical Department building of MGITER (latitude- 20.9079ºN) which is situated at Navsari in Gujarat as a case study. From this research work, we have concluded that the building at 0º is the optimal condition as per the orientation which saves about 3-4% economically from the other orientation.

Keywords: Optimization, Orientation, HVAC.

INTRODUCTION

In present situation, world is facing the big problem towards the consumption of energy by different ways. And from many survey and research work, it is transpired that large amount of energy which is consumed by multistory building and a part of that energy is used for providing comforts in the building (cooling purpose). So we should take an effective step towards the saving of energy consumption. From various studies, it is found that the designs of the building as well as different parameters of the building affecting the cooling load of the building.

In this article, we are dealing with the orientation of the site. Here we are studying the effect of change of orientation of the complete building. We are trying to find the optimal orientation for the building at the particular location. Here we are considering L-shape multistory building (Mechanical department) of MGITER College which is situated at Navsari.

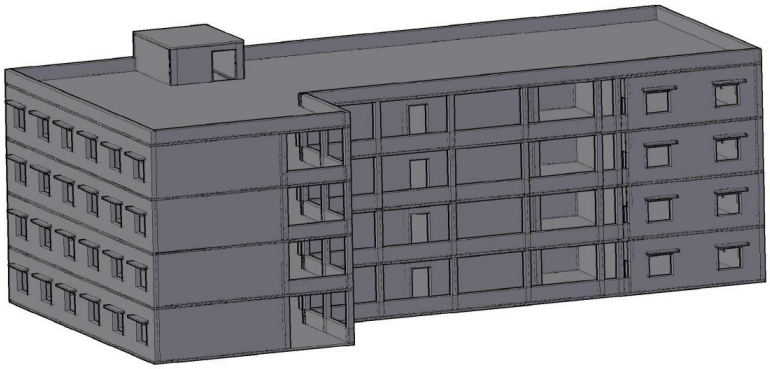

Figure1 Mechanical department of MGITER College (AutoCAD 3d drawing)

In this work we are calculating the actual cooling load of our site with original orientation, after that, we are finding the cooling load for the same site but now we are making changes with the orientation i.e. by rotating the complete model at different angle 0º(the actual position),45º, 90º. After the complete process of the cooling load calculation, we compare the result obtained at a different orientation and from that, we conclude that optimal situation for the site with respect to orientation and consumption of energy.

Nomenclature

Symbol	**Quantity**	**Unit**
U	Heat transfer Co-efficient	$W/m^2 K$
A	Area	m^2
Q	Heat Gain	W
Q_{glass}	Heat gain through a glass	W
SHGF	Solar Heat Gain Factor	W/m^2
ΔT	Temperature difference	°C
H	Height of the system	m
L	Length of the system	m
W	Width of the system	m
G	Number of air changes	hr^{-1}
TETD	Total Equivalent Temperature Difference	°C
CLTD	Cooling load temperature difference	°C
$(SHGF)_P$	Peak solar heat gain factor	W/m^2
$(SHGF)_A$	Average solar heat gain factor	W/m^2
F_C	Convective co-efficient Factor	-
F_R	Radioactive co-efficient Factor	-
S_C	Shading coefficient	-
TR	Ton of refrigeration	-

LITERATURE REVIEW

[1]. This paper consists discussion on the energy consumption of china (i.e.; Present Scenario 2013-15). Here they have studied the situation about the energy crises and they gave reasons for the high consumption as per the national policy, insufficient building design, energy monitoring platform and supervision system and the management are not perfect. The measures they obtained are technical measures, Air Conditioning system, Electrical equipment, Management Measure at a different level (Government, owner, user).

[2]. In this article they analyze different models in various condition of India by making a variable with different materials of wall and window (glass material), from this they came to the conclusion that building made from fly ash brick and with a gray glass window is a most energy efficient combination for reducing cooling load.

[3]. Here they made analysis for the energy demand, energy consumption and operative cost for a case study. For the analysis, they proposed two variant shading device (Active & Passive). The result obtained from the analysis that reduces total energy demand during the year wise range 17 to 19% , an energy saving of annual energy consumption was 4-11% and the financial saving of annual operation cost was 8-13% in compare with default state.

[4]. In this research, they have made analysis of window size, Position, and orientation. As windows play a significant role in energy load. This kind of simulation can't be directly applied to another site. For this analysis, they have divided the process into two stages. Here they concentrated over the window to wall ratio, Window position and the impact of window position & Orientation. From

the analysis they obtained that the biggest bad variation was 1% in the east facing window Scenario , it means that east side window position has the largest impact on the energy bad compared to its other side window shows on load variation.

METHODOLOGY

- For this work the first thing we have to perform the site survey and from that, we have obtained the physical plan and elevation as well as construction detail of the site. Also, we have obtained the site is located at 20.9079° N in India and the building is of L-shape multistory in construction which is made of 22.5cm brick wall + 1.25cm plaster on both the side. And the overall heat transfer co-efficient of this wall is 1.934 W/m^{2}K at the wind velocity 13.04 km/hr of the location.

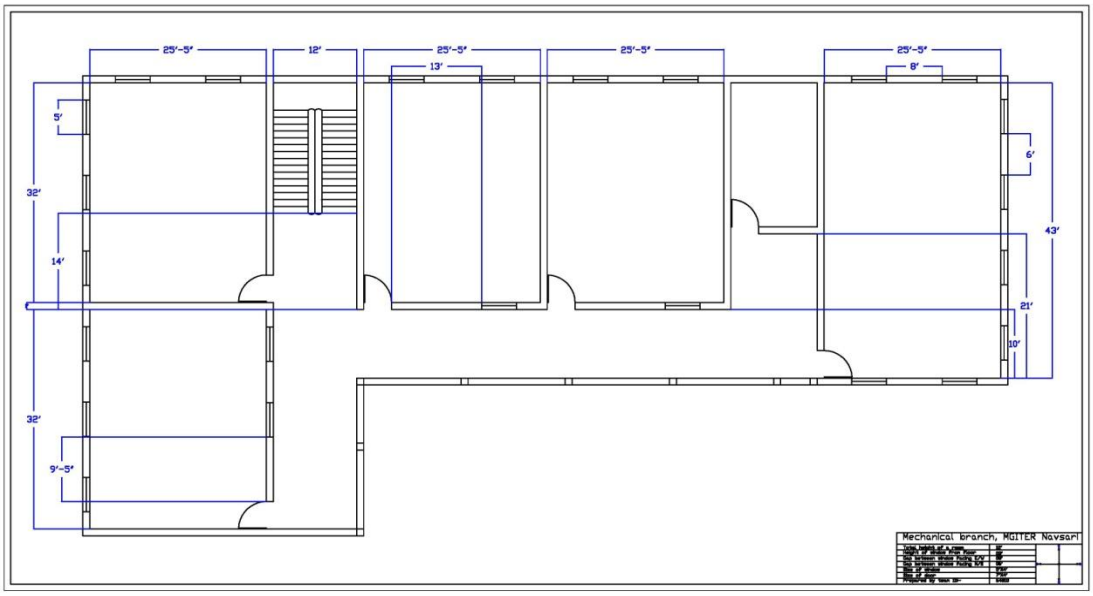

Figure 2 Plan layout of Mechanical department MGITER College

- For this site, the other parameters we have to obtain inside design condition 24-26°C with 40-50% relative humidity and outside design condition is 36-39°C, which is obtained from IMD (Indian metrological department). For this site, the building is of medium type construction and having time lag with 4-5 hour.
- Find the cooling load of the site and for this, we must have the idea of heat gain by the system in a different way such as heat gain through a glass window, wall, roof and heat rejected by the appliances.

  Heat gain of the system is depended on the following factor.

  1. Orientation of wall
  2. Time of the day
  3. Latitude of locality
  4. Month of the year

But in this research work we are focusing on the effect of orientation of the building on the cooling load and by this, we are trying to find the optimal situation of the site with respect to orientation. For this, we have to calculate the cooling load of the building at a different orientation which can be calculated from following way.

- Heat gain due to Fenestration: -

$$Q_{glass}=A\,[S_C\,\{F_C\,(SHGF)_P+F_R\,(SHGF)_A\}]+(UA\Delta T) \text{ watt}$$

For finding the cooling load we have obtained time of peak load, month, latitude of locality, orientation of wall and window, convective factor (F_C), Radiative factor (F_R) and shading coefficient (S_C) from the ASHRAE handbook which is recommended by ASHRAE (American society of heating, refrigeration and air conditioning engineers). For Peak solar heat gain factor $(SHGF)_P$ we are using the table of solar heat gain factor at given latitude, time and orientation of window. For finding Average solar heat gain factor (SHGF) we are using 4-5 hour ahead value of the solar heat gain factor at the peak time.

- The another way of heat gain is heat transmission thrown wall and ceiling this heat gain is find by TETD/CLTD method and transmission of heat gain throw wall and ceiling by using the following formula.

$$Q= UA\,[F_C\,(TETD)_P+ F_R\,(TETD)_A] \text{ watt}$$

- $(TETD)_P$ can be found from the table at given density and orientation of the wall and for shaded wall north wall considered at any orientation. F_C and F_R can be found by the table given by ASHRAE and correct value of TETD at given orientation and a daily range of locality.
- The next load is due to appliances: The Internal load is due to different appliances like lighting load, electrical motor and different machine load, and Infiltration heat gain. Infiltration load means when the door of the system open and closed to bring or for another purpose than outside air is entering which brings the heat with it and it can be calculated by the following formula.

Q= H x L x W x G/60 m^3/min

After calculating all heat gain load, take summation of all those values which results into the total load of the zone that is the total capacity of the site which is in TR.

RESULT

For this research work, we are considering same multistory building at a different orientation such as 0º, 45º, 90º of the site as shown in the figure.

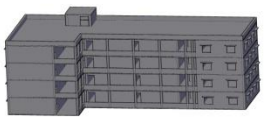

Figure 3 site at 0º

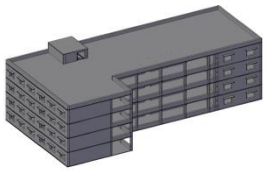

Figure 4 site at 45º

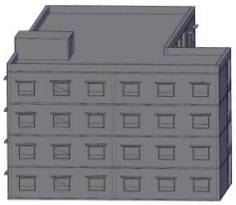

Figure 5 site at 90º

From the work, we can say that the cooling load can be affected due to the orientation as shown in the chart.

Table 1 total capacity of building

Orientation of building	Total capacity in TR
0º	85.52
45º	91.904
90º	88.70

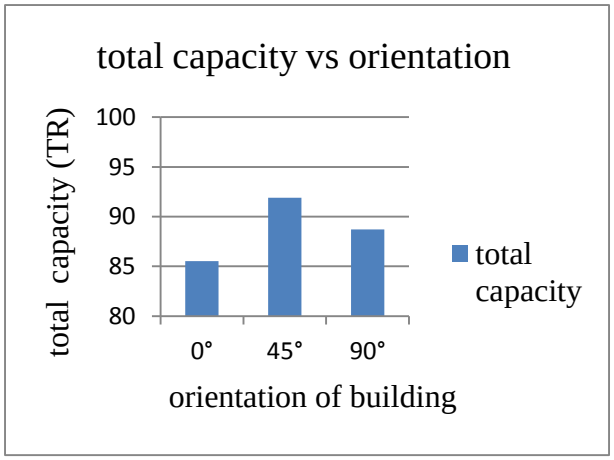

Figure 6 total capacity vs. orientation

From the analysis work we have made the result that is at 45º, 90º total cooling load capacity is more than the 0º that is 7.46% and 3.17% respectively.

CONCLUSION

For our research work, we have considered L-shape multistory building and find the cooling load at a different orientation such as 0º, 45º, 90º. From above research work, we have tried to find the optimal position of the building, optimize the load and cost compared to other position of the building. From that, we conclude that which position is optimal and the amount of cost saving as shown in the chart.

Table 2 cost analysis

Duration	Cost (Rs)

	0°	45°	90°
1 hour	906.94	974.65	940.66
1 day	7255.52	7797.20	7525.31
1 year	$174X10^4$	$187X10^4$	$180X10^4$

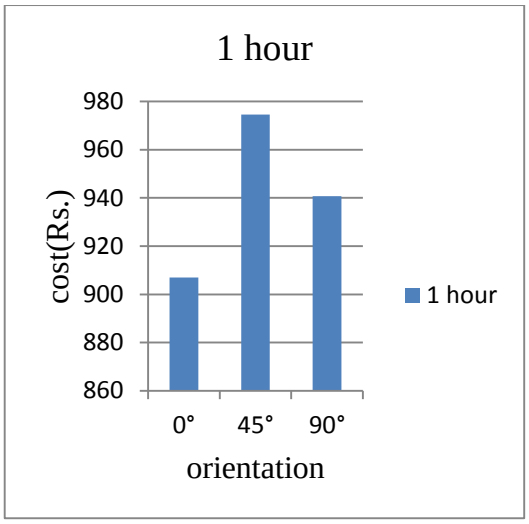

Figure 7 cost vs. orientation

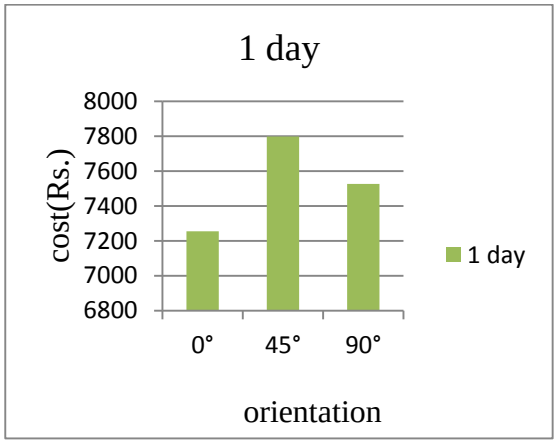

Figure 8 cost vs. orientation

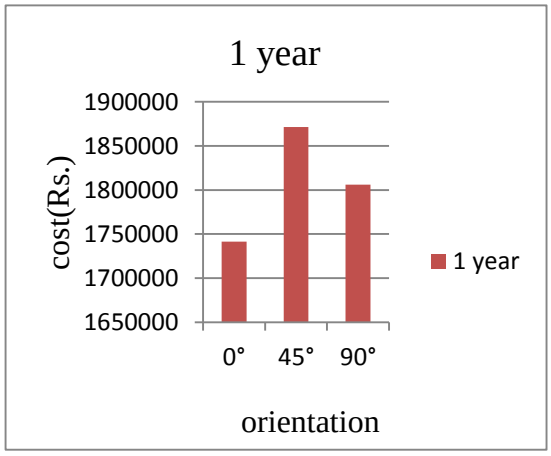

Figure 9 cost vs. orientation

As per Gujarat Government electricity charge, the cost of 1 unit is 5.05 rupees. The daily working time is 8 hour and 240 working days per year as per our consideration. Here we have considered an average load of the building 60% of the peak load as per research analysis.

ACKNOWLEDGEMENT

We are thank full to our guide Jignesh M. Barot (Asst. prof.) Mechanical department, and P.D. Ahir (H.O.D) Mechanical department, MGITER, Navsari.

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