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Calculation of Load Metric Techniques of School Building and Green Innovations in INDIA

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Abstract— The continuous increase in the cost and demand for energy has led to more research and development to utilize available energy resources efficiently by minimizing waste energy. Air conditioning plays a very important role in HVAC and thus in this case study, school building is designed with minimum utilization of energy needed for the air conditioners to make the school more sustainable. The main objective of this case study is to provide a proper design for the school in terms of its energy usage by calculating the maximum possible accurate load which can be referred by reader for understanding and/or designing other building loads and to make building a green and sustainable one. Also reader will be able to know about impacts of building directions, material of constructions and related co-efficient on the calculation of load. First of all a site survey is provided which covers the entire school. Then after certain assumptions have been made in respect of number of students, load area etc. After that the actual load is being evaluated. And in the end what are the different new effective things that can be introduced in the school are also listed to make it green and sustainable.

Keywords: ***Dynamic latch, HVAC***

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I. INTRODUCTION

The continuous increase in the cost and demand for energy has led to more research and development to utilize available energy resources efficiently by minimizing waste energy. Air conditioning plays a very important role in HVAC and thus in this case study, school building is designed with minimum utilization of energy needed for the air conditioners to make the school more sustainable.

The main objective of this case study is to provide a proper design for the school in terms of its energy usage by calculating the maximum possible accurate load which can be referred by reader for understanding and/or designing other building loads and to make building a green and sustainable one.

Also reader will be able to know about impacts of building directions, material of constructions and related co-efficient on the calculation of load. First of all a site survey is provided which covers the entire school. Then after certain assumptions have been made in respect of number of students, load area etc.

After that the actual load is being evaluated. And in the end what are the different new effective things that can be introduced in the school are also listed to make it green and sustainable.

The case study done on HVAC Load Calculation of School Building and Green Innovations is being designed by considering the latest parameters available in the field of HVAC. This case study throws more light on the Air Conditioning section of HVAC that is required in a school under different load conditions. Use of ecofriendly coolant R32/125/134a is considered for the designing of air conditioning of the school.

The school selected for the project is present in a rural area and had been visited personally, to get the idea of the school. A lot of study has been done on it to make the selected school load calculation accurate in terms of energy. Direction of walls have been considered precisely.

Several materials of construction are considered for taking appropriate co-efficient into consideration. Internal heat gain as well as latent heat have been taken into consideration for arriving at more accurate load result. AutoCAD Drawings of First floor and Ground floor have been attached to get rough idea about the dimensions and load reference. Also as a part of suggestions in this study, it has been suggested to use solar energy for producing tandem power along with the power from thermal power plant so that the load on power plant can be minimized. S

ite survey and major assumptions made are also mentioned further sections. After going through this case

study, a much clearer idea of various loads and coefficients considered for building HVAC load calculation in practical way will be brought to notice and can be used as reference to calculate load of other buildings.

Various other suggestions to decrease the existing calculated load have been given at the end to make school greener in terms of energy savings. In this way, the case study is having the maximum possible accuracy along with solutions for the building using the latest trends in HVAC to make the school Green and Sustainable.

II. RELATED WORKS

The information collected during the site survey is listed below:

1) Total area to be air conditioned = 11933.78 square feet.

2) Total floors = 2 (Ground and First floor)

3) Contains only 1 major glass entry door.

4) Due to air conditioning, there is darkness which requires the light to be switched ON during peak hours.

5) Windows are lightly shaded.

6) Walls have 0.5" plaster.

7) As the conditioning system is to be used for comfort purpose accuracy is not much required as for the manufacturing purpose.

8) Load to be considered is of building and electrical.

9) Due to school site, air can be ventilated after school hours so no need to provide extra ventilation.

10) For various coefficients taken in load calculation, the time considered is 4 PM.

III. BACKGROUND OF STUDY

The circuit diagram of the single tail comparator shown in Fig 3. The single tail comparator circuit operation is given below. When CLK=0 the circuit works in reset phase so the Mtail NMOS transistor is in off position and the reset transistors M7 and M8 PMOS transistors are in on position now the output at OUTN and OUTP will be VDD.

When CLK= VDD , Mtail NMOS transistor is in ON position and M7 and M8 PMOS transistors are in OFF position now the OUTN and OUTP urrent to keep the differential amplifiers in weak condition so a large current required enabling fast regeneration in the circuit.

IV. METHODOLOGY

The school is located at Dist. Gandhinagar, Gujarat. – Size - Elevator area is not considered in load area. – Wall weight – 80 lbs/sq. feet. – Roof weight – 60 lbs/sq. feet. – Number of people – 400. Out of these 380 are students and 20 faculty members. – On each floor 200 people are considered. – Construction type – Primary school. – Temperature – Outside: 109® F. – Inside: 78® F.

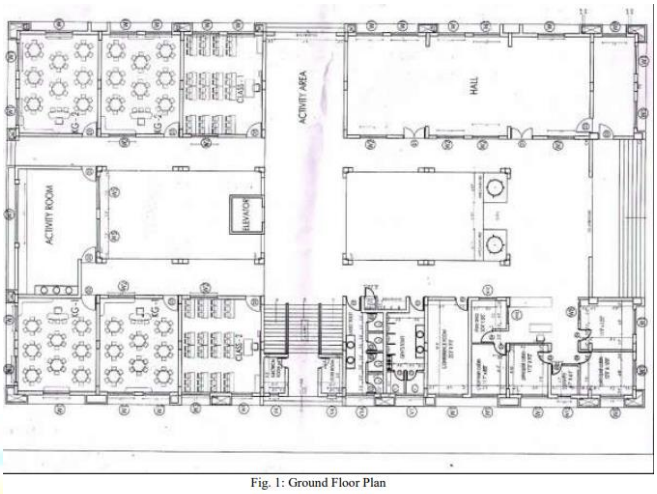

Fig. 1: Ground Floor Plan

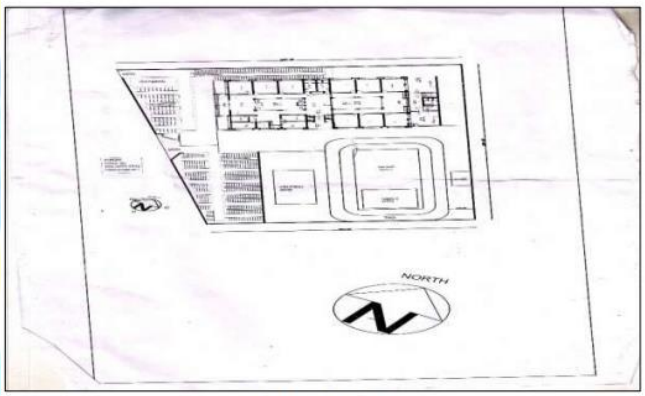

Fig. 2: Direction Indicator

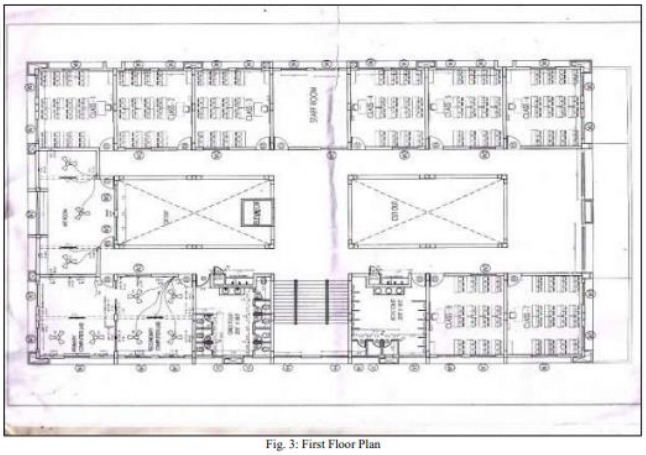

Fig. 3: First Floor Plan

Ground Floor Calculation of area NORTH WEST- Total length of the side=132.75' Total height of the side=12.5' Total area of the side=132.75'*12.5' = 1659.38 sq feet Total area of the glass = 315.16 sq feet Total area of the walls= Total area of the side- Total area of the glass = 1659.38-

315.16 = 1344.22 sq feet NORTH EAST- Total length of the side=79.83' Total height of the side=12.5' Total area of the side=79.83'*12.5' = 997.88 sq feet Total area of the glass= 187.1 sq feet Total area of the walls= Total area of the side- Total area of the glass = 997.88-187.1 = 810.78 sq feet SOUTH EAST- Total length of the side=132.75' Total height of the side=12.5' Total area of the side=132.75'*12.5' = 1659.38 sq feet Total area of the glass =327.11 sq feet Total area of the walls= Total area of the side- Total area of the glass = 1659.38-327.11 = 1332.27 sq feet SOUTH WEST- Total length of the side=79.83' Total height of the side=12.5' Total area of the side=79.83'*12.5' = 997.88 sq feet Total area of the glass= 121.68 sq feet Door area= 126 sq feet Total area of the walls= Total area of the side- (Total area of the glass+ Door area) = 997.88-(121.68+126) = 750.2 sq feet Load Calculation WALLS: Heat gain through walls (btu/hr) = Area of the wall * (Equivalent temperature Difference + Correction factor)*Transmission Co-efficient NORTH WEST: 1344.22*(9+17)*0.20 = 6989.9440 btu/hr NORTH EAST: 810.78*(11+17)*0.20 = 4540.3680 btu/hr SOUTH EAST: 1332.27*(18+17)*0.20 = 9325.8900 btu/hr SOUTH WEST: 750.2*(23+17)*0.20 = 6001.6000 btu/hr Total heat gain through walls = 6989.9440+4540.3680+9325.8900+6001.6000 = 26857.8020 btu/hr = (26857.8020 * 0.2930711) kilowatts = 7.8712 kW = 2.25 tons GLASS: Heat gain through glass = Area of glass * Solar gain * Transmission co-efficient NORTH WEST: 315.16 * 138 * 0.56 = 24355.56 btu/hr NORTH EAST: 187.10 * 12 *0.56 = 1257.31 btu/hr SOUTH EAST: 327.11 * 12 * 0.56 = 2198.18 btu/hr SOUTH WEST: 121.68 * 85 * 0.56 = 5791.97 btu/hr Total heat gain through glass = 24355.56 + 1257.31 + 2198.18 + 5791.97 = 33603.02 btu/hr = 9.85 kW = 2.81 tons

ROOF: The roof of the ground floor is shaded. Thus, Heat gain through the roof = Area of roof * Heat factor for shaded roof = (83.741 * 142.498) * 0.12 = 1431.95 btu/hr = 0.12 tons OUTSIDE AIR: Heat gain through outside air is = cfm/person * No. of persons * Bypass factor * Temperature difference * 1.08 = 15 * 200 *31 * 0.1 * 1.08 = 10044 btu/hr = 0.84 tons INFILTRATION Heat gain through infiltration = cfm/person * No. of persons * Temperature difference * 1.08 = 15 * 200 *31 * 1.08 = 100440 btu/hr = 8.40 tons INTERNAL HEAT GAIN a) People Sensible heat gain = No. of people * Sensible heat for people = 200 * 215 = 43000 btu/hr = 3.60 tons Latent heat gain = No. of people * Latent heat for people = 200 * 185 = 37000 btu/hr = 3.10 tons Total heat gain through people = Sensible heat gain + Latent heat gain = 3.60 + 3.10 = 6.70 tons b) Light: Heat gain through light = Area of space * Watts/ square feet * 3.41 = (83.741 * 142.498) * 2 *3.41 = 81382.55 btu/hr = 6.81 tons Total Internal heat gain = Total heat gain through people + Heat gain through light = 6.70 + 6.81 = 13.51 tons ROOM LATENT HEAT: a) People: Room latent heat for people = cfm/person * No. of persons * Bypass factor * Temperature difference * 0.68 = 15 * 200 * 0.1 * 31 * 0.68 = 6324 btu/hr = 0.53 tons Duct loss = 5% Effective room total heat = Room latent heat + Loss = 0.53 + (0.05 * 0.53) = 0.56 tons b) Outside Air Heat Sensible heat = cfm/person * No. of persons * Temperature difference * (1 – Bypass factor) * 1.08 = 15 * 200 * 31 * 0.9 * 1.08 = 90396 btu/hr = 7.58 tons Latent heat = cfm/person * No. of persons * Temperature difference * (1 – Bypass factor) * 0.68 = 15 * 200 * 31 * 0.9 * 0.68 =56916 btu/hr = 4.77 tons Sub Total heat = Sensible heat + Latent heat = 7.58 + 4.77 = 12.35 tons Return duct leakage loss = 2% Total outside air heat = Sub total heat + Return duct leakage loss = 12.35 + (0.02 * 12.35) = 12.59 tons – Total Heat gain through Ground Floor = Total heat gain through walls + Total heat gain through Glass + Total heat gain through roof + Heat gain through Outside air + Heat gain through infiltration + Total Internal Heat gain + Effective room total heat + Total Outside air heat = 2.25 + 2.81 + 0.12 + 0.84 + 8.41 + 13.51 + 0.56 + 12.59 = 41.09 T First floor Calculation of area NORTH WEST- Total length of the side=126.58'

Total height of the side=12.5' Total area of the side=126.58'*12.5' = 1582.26 sq feet Total area of the glass = 287.49 sq feet Total area of the walls= Total area of the side- Total area of the glass = 1582.26-287.49 = 1294.77 sq feet NORTH EAST- Total length of the side=79.24' Total height of the side=12.5' Total area of the side=79.24'*12.5' = 990.50 sq feet Total area of the glass= 187.10 sq feet Total area of the walls= Total area of the side- Total area of the glass = 990.50-187.10 = 803.40 sq. feet SOUTH EAST- Total length of the side=126.58' Total height of the side=12.5' Total area of the side=126.58'*12.5' = 1582.26 sq. feet Total area of the glass =365.04 sq feet Total area of the walls= Total area of the side- Total area of the glass = 1582.26-365.04 = 1217.22 sq feet SOUTH WEST- Total length of the side=79.24' Total height of the side=12.5' Total area of the side=79.24'*12.5' = 990.50 sq. feet Total area of the glass= 121.68 sq feet Total area of the walls= Total area of the side- Total area of the glass = 990.50-121.68 = 868.82 sq. feet LOAD CALCULATION WALLS: Heat gain through walls (btu/hr) = Area of the wall*(Equivalent temperature Difference + Correction factor)*Transmission Co-efficient NORTH WEST: 1294.77 * (9 + 17) * 0.20 = 6732.8040 btu/hr NORTH EAST: 803.40 * (11 + 17) * 0.20 = 4499.0400 btu/hr SOUTH EAST: 1217.22 * (18 + 17) * 0.20 = 8520.5400 btu/hr SOUTH WEST: 868.82 * (23 + 17) * 0.20 = 6950.5600 btu/hr Total heat gain through walls = 6732.8040 + 4499.0400 + 8520.5400 + 6950.5600 = 26702.9440 btu/hr = 7.8259 kW = 2.24 tons GLASS: Heat gain through glass = Area of glass * Solar gain * Transmission co-efficient NORTH WEST: 287.49 * 138 * 0.56 = 22217.23 btu/hr NORTH EAST: 187.10 * 12 *0.56 = 1257.31 btu/hr SOUTH EAST: 365.04 * 12 * 0.56 = 2453.07 btu/hr

SOUTH WEST: 121.68 * 85 * 0.56 = 5791.97 btu/hr Total heat gain through glass = 22217.23 + 1257.31 + 2453.07 + 5791.97 = 31719.58 btu/hr = 9.30 kW = 2.66 tons ROOF: The roof of the first floor is unshaded. Thus, Heat gain through the roof = Area of roof * Heat factor for unshaded roof = (83.741 * 142.498) * 0.16 = 1431.95 btu/hr = 0.16 tons OUTSIDE AIR: Heat gain through outside air is = cfm/person * No. of persons * Bypass factor * Temperature difference * 1.08 = 15 * 200 *31 * 0.1 * 1.08 = 10044 btu/hr = 0.84 tons

INFILTRATION Heat gain through infiltration = cfm/person * No. of persons * Temperature difference * 1.08 = 15 * 200 *31 * 1.08 = 100440 btu/hr = 8.40 tons INTERNAL HEAT GAIN – PEOPLE Sensible heat gain = No. of people * Sensible heat for people = 200 * 215 = 43000 btu/hr = 3.60 tons Latent heat gain = No. of people * Latent heat for people = 200 * 185 = 37000 btu/hr = 3.10 tons Total heat gain through people = Sensible heat gain + Latent heat gain = 3.60 + 3.10 = 6.70 tons – LIGHT: Heat gain through light = Area of space * Watts/ square feet * 3.41 = (83.741 * 142.498) * 2 *3.41 = 81382.55 btu/hr = 6.81 tons Total Internal heat gain = Total heat gain through people + Heat gain through light = 6.70 + 6.81 = 13.51 tons ROOM LATENT HEAT: – PEOPLE: Room latent heat for people = cfm/person * No. of persons * Bypass factor * Temperature difference * 0.68 = 15 * 200 * 0.1 * 31 * 0.68 = 6324 btu/hr = 0.53 tons Duct loss = 5% Effective room total heat = Room latent heat + Loss = 0.53 + (0.05 * 0.53) = 0.56 tons – OUTSIDE AIR HEAT Sensible heat = cfm/person * No. of persons * Temperature difference * (1 – Bypass factor) * 1.08 = 15 * 200 * 31 * 0.9 * 1.08 = 90396 btu/hr = 7.58 tons Latent heat = cfm/person * No. of persons * Temperature difference * (1 – Bypass factor) * 0.68 = 15 * 200 * 31 * 0.9 * 0.68 =56916 btu/hr = 4.77 tons Sub Total heat = Sensible heat + Latent heat = 7.58 + 4.77 = 12.35 tons Return duct leakage loss = 2% Total outside air heat = Sub total heat + Return duct leakage loss = 12.35 + (0.02 * 12.35) = 12.59 tons – Total Heat gain through First Floor = Total heat gain through walls + Total heat gain through Glass + Total heat gain through roof + Heat gain Through Outside air + Heat gain through infiltration + Total Internal Heat gain + Effective room total heat + Total outside air heat = 2.24 + 2.66 + 0.16 + 0.84 + 8.41 + 13.51 + 0.56 + 12.59 = 40.97 tons GRAND TOTAL LOAD = Total load on ground floor + total load on first floor = 41.10 + 40.97 ton = 82.07 tons

V. RESULTS AND DISCUSSIONS

All the circuits are designed by using Cadence Virtuoso tool and simulated in 90 nm CMOS technology with the supply voltage of 0.6V. The output waveform of comparator shown in Fig 8. Power waveform of the single tail comparator is shown in Fig 9.

VI. CONCLUSION

– All the time, the conventional source of energy should not be used for meeting the load requirements. Suitable low to medium size solar cells must be installed at the terrace to utilize the sun's energy. In this way, the total load will be shared by the sun's energy and usual conventional source of energy. – The windows and doors of most of the classes and computer room should be provided in the north and west direction. This will decrease the total amount of heat transferred through walls and glass. – The roof of the top floor can also be made shaded with the help of suitable coating material keeping in account the overall cost. – Absorption cooling can also be provided so that the heat released in various parts of the school can be utilized to provide an effective cooling. – A lot of trees implantation is always a natural way of making any school or any other building green. The shadows of the trees can be utilized to provide larger shaded area and thus reducing the total heat gain. • It shows that if the above stated solutions are adopted in the given school to make it green and sustainable, then its total load can be reduced from 82 tons to 70 tons

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