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A Comparative Study on Artificial lightning of Residential Hostel Building of a University Campus

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Abstract—*With increased demand of the energy due to population explosion and usage in versatile areas the energy crisis is becoming a great predicament in the society. This results in major setback and economic loss to the country. Therefore, there is a need to conserve and manage the energy resources in a responsible manner and is being increasingly felt by different sectors of the economy. In the present study an attempt has been made to evaluate the high energy consumption in the building sector and the imperative need to design the energy efficient buildings. Deenbandhu Chhotu Ram University of Science and Technology, Haryana students hostel building has been selected for the present study. The case studies of four hostels of Indian Institute of Technology, Mumbai, Indian Institute of Technology, Kanpur, MLA hostel of Nagpur and of Cross River University of Technology, Nigeria comprising of different climatic zones has also been considered and existing study has been compared with the same. The energy auditing has been conducted by collecting energy consumption data for the last five years. The air-to-air thermal transmittance of the wall and the roof for the hostel room has also been computed and compared with recommendations prescribed by the Energy Conservation Building Code and Bureau of Indian Standard Code number 3792- 1978. Various application pertaining to the use of renewable energy sources has also been explored in the present study. It has been found that the existing solar water heater for the kitchen is saving energy for cooking. From the present study it can be recommended that energy auditing and replacing the normal electrical appliances with energy efficient devices will save 7591.39 kWh of energy per year after replacing with179 FTLs by Electronic ballast. It is considered to be a best alternative and proves to be cost effective and energy efficient.*

1. INTRODUCTION

Light is that part of the electromagnetic radiation which is capable of exciting the retina of the eye to produce visual sensation. It is a vital and invaluable component of human life. Considerable care is therefore essential for creating effective visibility and providing visual satisfaction. The visible spectrum, to which the human eye is sensitive, is a narrow band of wavelengths between 380 and 780 nm. Buildings must have sufficient lighting in this band. Light has a major effect on the way one perceives spaces and their functions. Sufficient light is required to carry out everyday tasks in homes, offices and factories. The illumination requirements for the comfortable performance of various tasks need to be suitably considered in design. Daylighting strongly depends on external conditions and its control depends on the way a building is constructed. Very often, one finds numerous tube lights burning in offices, factories and homes during daytime even though there is plenty of sunlight outside. Because of its variability and subtlety, natural light has a more pleasing effect than monotonous artificial lighting. Building components such as windows and skylights, which admit light, enable a visual communication with the outside world. Since most buildings are largely used during the daytime, effective daylighting makes economic sense. Because a good daylighting system involves many elements, it is best to incorporate them in the building design at an early stage. The manner in which daylight enters and distributes itself in a room depends on the size and location of opening, type of glazing, configuration of the room and reflective properties of wall, ceiling and other surfaces. The intensity of daylight and the daylight factor also depend on the height and the location of the opening on a wall; the intensity reduces as the distance from the opening increases.

2. METHODS AND METHODOLOGY

The proposed study has been carried out in the student's hostel of Deenbandhu Chhotu Ram University of Science and Technology, Haryana for data analysis of day light factor and artificial light factors to neglect wastage of energy. Therefore, various parameters are considered to make the place energy efficient. In th present study calculation of day light factor is computed and artificial light factor is calculated by using lux meter.

2.1 Computation of Day light factor

The daylight received on the earth's surface is composed of direct light (light directly received from the sun) and diffuse light (light received from all parts of the sky due to atmospheric scattering and reflection). Light reaching a particular point inside a building may consist of (i) Direct sunlight, (ii) diffuse light or skylight (iii) externally reflected light (by the ground or other buildings) (iv) internally reflected light from walls, ceiling and other internal surfaces. In the present study day light factor can be calculated for hostel room refer to fig.2.1 expressed by eqn (1)

$D=E_i/Eo\times10$ ………(1)

where, Ei = indoor illumination at the point of consideration, Eo = outdoor illumination from unobstructed sky hemisphere.

The three components contributing to daylight factor are (i) Sky component (SC) (ii) Externally reflected component (ERC) and (iii) Internally reflected component (IRC) is given by eqn (2)

DF=SC+ERC+IRC ……..(2)

where, Sky component (SC) is the area of sky visible from the point considered and its average altitude angle (luminance (+e) of the sky at that angle) Externally reflected component (ERC) is the area of external surfaces visible from the point considered, and the reflectance of these surfaces. Internally reflected component (IRC) is the size of the room, the ratio of surfaces (wall, roof, etc.) in relation to the window area, and reflectance of indoor surfaces [1] & [2].

Table 2.1 Recommended daylight factors for different buildings and activities

BUILDING	AREA/ ACTIVITY	DAYLIGHT FACTOR
Dwellings	Kitchen	2.5
	Living room	0.625
	Study room	1.9
Schools	Class room	1.9 - 3.8
	Laboratory	2.5 - 3.8
Offices	General	1.9
	Drawing/ Typing	3.75
	Enquiry	0.625 - 1.9

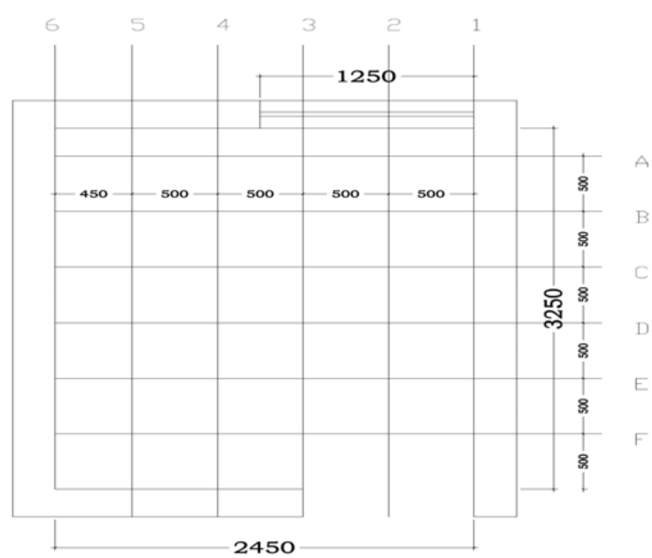

Figure 2.1 PLAN OF THE HOSTEL ROOM

2.2 Computation of Installed Load Efficacy Ratio (ILER)

The purpose of performance test is calculated by eight steps refer to Table 2.2 ILER value is calculated to know installed efficacy in terms of lux/watt/m² (existing or design) for general lighting installation After calculating ILER value in the present study these values can be compared with the norms for specific types of interior installations for assessing improvement options refer to Table 2.3.The installed load efficacy of an existing (or design) lighting installation can be assessed by using below steps and by using eqns (3) & (4).

Table 2.2 Calculation of Installed Load Efficacy Ratio

STEPS	PROCEDURE
1	**Measure the floor area of the interior**
2	Calculate the Room Index
3	Determine lamp wattages
4	Calculate Watts per square meter, **Value of step 3 ÷ value of step 1**
5	Ascertain the average maintained illuminance by using lux meter
6	Divide **5 by 4** to calculate lux per watt per square Meter
7	Obtain target Lux/W/m² lux for type of the type of Interior/application
8	**Calculate Installed Load Efficacy Ratio (6 ÷ 7)**

Installed power density (W/m^2/100 lux) = 100 / (Installed load efficacy(lux/Wm^2)) ……….(3)

Installed Load Efficacy Ratio (ILER) = ((Actual Lux) /Wm^2) / ((Target Lux)/Wm^2) …..…..(4)

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The procedure for assessment of lightning system can be computed by calculating the room index (RI) of the hostel room refer to fig.2.2 and eqn (5).

$$RI = L \times W / H (L + W) \text{ in m} \qquad \ldots\ldots\ldots\ldots(5)$$

where L = length of interior; W = width of interior; Hm = the mounting height, which is the height of the lighting fittings above the horizontal working plane. The minimum no. of measuring points for computing room index to calculate ILER values is given in Table 2.3. The working plane is usually assumed to be 0.75m above the floor in offices and at 0.85m above floor level in manufacturing areas [3] & [4].

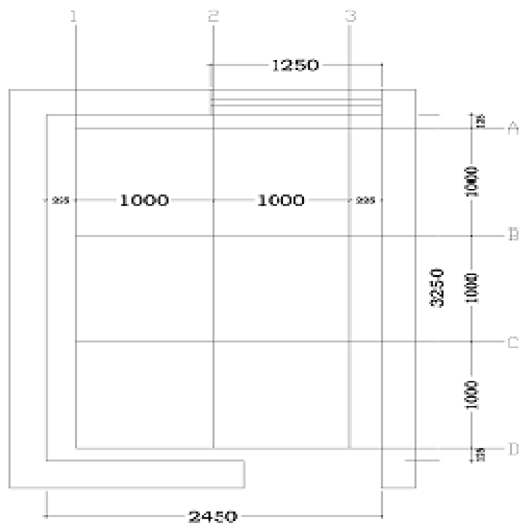

Figure 2.2 PLAN OF THE ROOM

Table 2.3 Room index

ROOM INDEX	BELOW 1	1 AND BELOW 2	2 AND BELOW 3	3 AND ABOVE
MIN. NO. OF MEASURING POINTS	9	16	25	36

3. RESULTS AND DISCUSSIONS

In the present study day light factor is calculated for various sections of a hostel room refer to Table 3.1

Table 3.1: Computed Day Light factor

	Sky Component (%)		Internal Reflected Component (%)	Day Light Factor (%)	Illuminance (LUX)	Illuminance (LUX after applying reduction factor 0.6)
A	1	21.29		23.35	1868.0	1120.8
	2	37.26		39.32	3145.6	1887.3
	3	33.30		35.36	2828.8	1697.2
	4	8.660	2.065	10.72	857.60	514.56
	5	1.450		03.51	280.80	168.48
	6	0.280		02.34	187.20	112.32

B	1	12.98		15.04	1203.2	721.92
	2	18.25		20.31	1624.8	974.88
	3	27.89		29.95	2396.0	1437.6
	4	09.36	2.065	11.42	913.6	548.16
	5	04.00		06.06	484.8	290.88
	6	02.04		04.10	328.0	196.8
C	1	7.824		9.889	791.12	474.67
	2	9.620		11.68	934.40	560.64
	3	7.548		9.613	769.04	461.42
	4	6.420	2.065	8.480	678.80	407.28
	5	4.360		6.425	514.00	308.4
	6	2.314		4.379	350.32	210.1
D	1	4.790		6.855	548.40	329.04
	2	5.096		7.161	572.88	343.72
	3	4.790		6.885	550.80	330.48
	4	4.232	2.065	6.297	503.76	302.25
	5	3.010		5.075	406.00	243.6
	6	1.340		3.405	272.40	163.4
E	1	3.083		5.148	411.84	247.10
	2	1.960		4.025	322.00	193.20
	3	3.275		5.335	426.80	256.08
	4	2.820	2.065	4.885	390.80	234.48
	5	2.920		4.985	398.80	239.28
	6	1.350		3.410	272.80	163.68
F	1	1.88		3.94	315.20	189.12
	2	3.09		5.15	412.00	247.20
	3	2.19		4.25	240.00	144.0
	4	1.65	2.065	3.71	296.80	178.08
	5	1.81		3.87	309.60	185.76
	6	1.03		3.09	247.20	148.32

Further it can be recommended that replacing incandescent bulbs in the bathrooms by CFL and replacing rheostatic speed regulators of 174 fans in the student rooms and mess with electronic speed regulators will save around 2596.08 kWh of energy per year. With electronic speed regulators not only, the fan rotates smoothly but also there is negligible heat dissipation. Normal fan speed regulators use resistance for controlling the speed whereas the electronic speed regulator uses the voltage regulator which changes the input voltage to the fan thereby changing the speed of the fan. Looking for natural lighting opportunities through windows a committee should be set by the University whose terms of reference will be solely on energy management. Purchasing energy at the most economical price through fuel selection and altering schedules to take advantage of our utility's rate structure and assess the scope for more energy efficient lamps and luminaries. Involvement of training staff and teaching all employees to identify ways to save energy through maintenance, optimum usage of day lighting should be adopted refer to Table 3.2 and various operational improvements throughout the university can be done. Energy auditing on regular basis should be done for university and proper reports should be made also, maintenance of solar water heater is very important and a maintenance secretary must be appointed. Energy saving accessories can be installed to replace the old high energy consuming ones.

Table 3.2 Reading By Lux Meter

		ARTIFICIAL LIGHT (LUX)	SUNLIGHT WITHOUT ARTIFICIAL LIGHT (LUX)
A	1	56	23
	2	105	85
	3	11	5

B	1 2 3	70 62 12	47 34 8
C	1 2 3	67 54 23	25 15 6
D	1 2 3	47 44 24	17 14 6

From the present study the value of ILER has been computed which gives the annual energy wastage of the energy in the hostel room refer to Table 3.3 & 3.4 and can be estimated by using the ILER value computed in the present study given by eqn (6) as

Annual Energy Waste = (1- ILER) × Watts × No. Of Operating Hours ……….(6)

= (1- 0.16) × 40 × 24 hrs / Day × 360 hrs = 290kW

The annual energy waste is 290kW per year which is a huge loss and can be minimized by using various solar power devices as the day light factor in the region is showing sunlight enrich environment.[5] & [6].

Table 3.3: INSTALLED LOAD EFFICACY RATIO CALCULATION

Steps	Values
1.Area	7.96 m^2
2.Room Index	7.96 / 14.25 = 0.55
3.Total circuit watts	40W
4.W/m^2	5.02
5. Average Illuminance	38.16
6. Lux/W/m^2	7.60
7.Target Lux/W/m^2	46
8.ILER	0.16

Table 3.4 Recommended ILER values

ILER	ASSESSMENT
0.75 or over	**Satisfactory to Good**
0.51 - 0.74	**Review suggested**
0.5 or less	**Urgent action required**

Ratios of 0.75 or more may be considered to be satisfactory. Existing installations with ratios of 0.51 - 0.74 certainly merit investigation to see if improvements are possible [7]. Of course, there can be good reasons for a low ratio, such as having to use lower efficacy lamps or less efficient luminaires in order to achieve the required lighting result -but it is essential to check whether there is a scope for a more efficient alternative. Existing installations with an ILER of 0.5 or less certainly justify close inspection to identify options for converting the installation to use more efficient lighting equipment.

4. CONCLUSIONS

From the present study, it can be concluded that this study is a mere mile marker towards the destination of achieving energy efficiency of the hostel. After carrying out an extensive study of the day lightning systems in the hostel it can be inferred that high amount of energy is wasting after calculating ILER factor. There are some recommendations for improving the energy efficiency of the hostel. (i) Energy auditing on regular basis should be done for university and proper reports should be made. (ii)

Maintenance of solar water heater is very important and a maintenance secretary must be appointed. (iii) Energy saving accessories can be installed to replace the old high energy consuming ones. A list of possible actions is compiled to conserve and efficiently utilize our scarce resources and identified their savings potential. The next step would be to prioritize their implementation. It is recommended that that the institute authorities, staff and students shall ensure the maximum execution of the implementation of energy saving and should optimize the utilization of energy resources in the campus.

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