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Evaluation of Room Comfort Characteristics in an Existing Educational Building to Consider Sustainability

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Abstract

Green house gases, energy extraction, production and consumption contribute to polluting the environment, which have lead to climate change and global warming. As per the present environmental conditions, building sector represents the third-largest domain of total energy consumption, after the industrial and transportation sectors.

In India, Karnataka States alone consists nearly one lakh learning centre, 10 lakh teachers and 8.5 million students spend at least eight hours a day in educational buildings. There is a growing demand to construct sustainable schools designed to provide more healthy, comfortable and productive learning environments as well as to reduce energy consumption and building costs.
The work presented here details the evaluation of an existing college building in the view of considering green (sustainable measures) that enables educational board to consider sustainable measures in order to overcome the teachers and student psychological behaviors' (Productivity and lack of concentration). The aim of the study was to investigate the perception of comfort as well as examine the prevailing room conditions in the classrooms. This work provides a method that can assist governments and decision makers in minimizing their overall expenditures on public buildings and to provide the best possible sustainable educational buildings.

Keywords: *Green, sustainable schools, Room comfort characteristics, psychological behaviours*

1. Introduction

Energy extraction, production and consumption contribute to polluting the environment, which have led to climate change and global warming. As per the present environmental conditions, building sector represents the third- largest domain of total energy consumption, after the industrial and transportation sectors. So, the term *energy efficiency* is playing a very vital role in present day scenario of construction sector. Like how there is a demand for construction of sustainable residential and commercial buildings, there's a huge increasing demand for the construction of sustainable schools wherein healthy, comfortable and productive learning environment is provided as well as to reduce energy consumption and building costs.

2. Objectives

The main objective of this work is to develop an energy efficient educational building. This focuses on measuring the sustainability level for educational buildings considering the energy consumption and recyclability which develops a correlation between sustainability, student psychology and their productivity.

3. Methodology

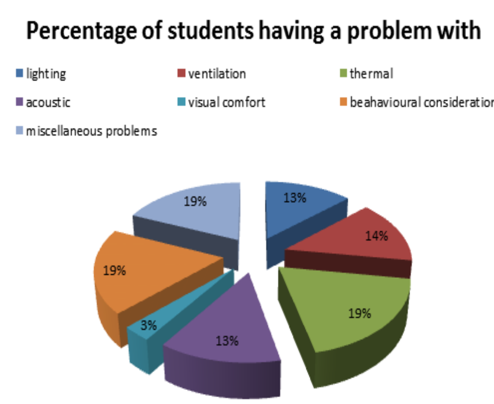
A systematic and multi-phase methodology is applied to develop a conventional and sustainable structure to achieve high performance sustainability in educational buildings.

The building was first investigated for the comfort conditions, energy efficiency, and was later dealt with the solutions and alternatives for every flaw we encountered to make the educational building more sustainable.

Selection framework is developed based on sustainability assessment by implementing green materials as certified by LEED (Leadership in Energy & Environment Design). Forecasting were done by using methodologies which was investigated and provided with several measurements for energy performance, room comfort, audible range and glare effect.

Finally, these readings were used to enhance the selection of the most attractive alternative for decision makers.

4. Experimental Work



Result of survey conducted in classroom showing problems related to lighting, ventilation, thermal comfort, acoustic, visual comfort and behavioural consideration.

4.1 Light Intensity Survey

Day lighting is a vital aspect for designing buildings to maximize the light availability. While day light is imperative for wellbeing, it is indeed effective in saving the consumption of electrical energy in buildings. For the Indian condition, out of the total consumption of electrical energy in buildings, energy consumed by lighting in residential buildings is 29% and in commercial buildings, it is 60%. Typically in normal Indian sky condition, 8000 lux of light is available in day light, whereas only 200 to 300 lux is normally required inside the spaces for doing normal work, which is 2% of the natural available light. Available day light can be effectively harnessed through an understanding with the principles of design for day lighting.

To measure the levels of light in a particular area, we need to use a device called a Light Meter, which measures the intensity of light in the vicinity of the sensor and displays the reading in lux. When measuring light intensity (or illuminance) in an office or classroom environment, we need to place the light meter on the working plane, which in this case is the level of the desks or worktops.
In order to get an accurate assessment of the lighting in a large area, such as a classroom, we need to take multiple readings on the working plane. Natural light levels constantly change, so accurate measuring of light intensity can be difficult, therefore in order to carry out the survey successfully, the readings from different points in the room at the same time are taken.
Light Luminosity in Classroom= 300lux - 500lux

(According to International Organization for Standardization)

The level of natural light is likely to change while taking the readings. Hence the survey was repeated and average was taken.

1. The dimensions of the working place were measured where survey was to be carried out.
2. The room was divided into 9 equal grids/parts.
3. In the grids, a rough floor plan of the room, including any windows, other sources of light were drawn and the readings are taken. Each block below typically represented 1m^2 of the room.
4. The light meter was placed at a distance of 1m from the main source of light (window), and readings were noted down. Then the light meter was moved to 2m from the window and another reading was taken. This process was repeated till the end of the wall was reached.

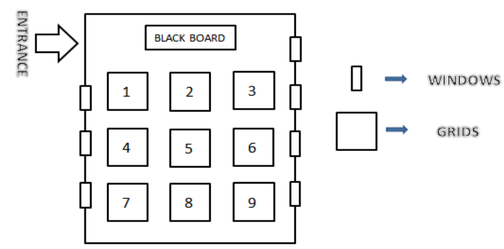


Figure1. *Representation of classroom.*

Table1. *Variation in light intensity in the classroom.*

GRIDS	FUNCTIONAL TIME IN HOURS				
	8:30am	10:30am	12:30pm	2:30pm	4:30pm
1	110	123.5	134.5	142.3	109.2
2	150	233.8	216.6	232.7	181.2
3	275	277	269.4	227.5	282
4	133	144.4	127	163	137
5	224	215.6	220	283	150.5
6	255	311.7	363.2	472	342.9
7	132	139	110.7	163	119.5
8	196	204.5	185.9	247	204
9	272	370.5	382.4	331	285

(All the values of light intensity are in lux)

4.2 Thermal Variation

Thermal comfort is achieved through an interactive relationship between air flow, ambient thermal and humidity conditions. While fresh air provides us the most important life sustaining oxygen, it is also the medium surrounding us as a fluid that effectively controls the balance between the body and its surroundings. Design of buildings to achieve effective ventilation is therefore critical to a climate responsive building.

Moderate Temperature in Summer = 23.5^{0}C-25.5^{0}C

Moderate Temperature in Winter = 21^{0}C- 23^{0}C

(According to ISO standards)

The following process is followed for the measurement of temperature in the considered working plane:

1. Consider a room in which the temperature is to be measured.
2. At various times of the day, starting from 8:30a.m, at an interval of every 2

hours, the temperature of the room is recorded.

3. Six readings till 6:30p.m is recorded.
4. Plot a graph showing the thermal variation from the recorded values.*(Fig 7, observation and discussion)*

Table2. *Thermal variation in the classroom*

TIME	READINGS (^{0}C)
8:30 AM	29.5
10:30 AM	30
12:30 PM	31.5
2:30 PM	32.5
4:30 PM	34
6:30 PM	32

4.3 Sound Intensity Survey

The audible frequency range is 20-20,000Hz for younger listeners with unimpaired hearing. For full sentence clearness in students, the signal to noise ratio i.e., the difference between the speech level and sound level of interfering noise; should be at least 15dB. According to ISO standardization, the recommended noise criterion level is 25-30dB according to the NC curve and the equivalent sound level in decibel is 35-40dB for lecture and classrooms and 45-50dB for open-plan classrooms. National Institute for Occupational Safety and Health recommended sound intensity in classrooms to range within 35dB. There should be complete or nearly no disturbance or back ground sounds which causes hindrance during lecturing.

Sound intensity = 35dB

(According to ISO standards)

Sound Intensity meter is used to record the readings of noise in decibel.

The following condition is considered and readings are noted.

- An empty classroom.
- A classroom with occupancy
- Instrument is placed 1m away from the lecturer.
- Instrument is placed at the end of the classroom.

5. Experimental work and discussion

5.1Light Intensity

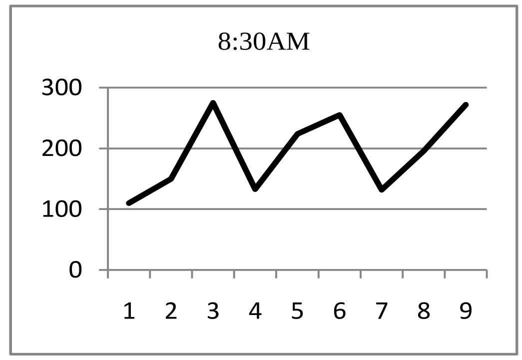


Figure1. *This graph represents the illuminance distribution in a horizontal plane at various places considered in the classroom at 8:30 am.*

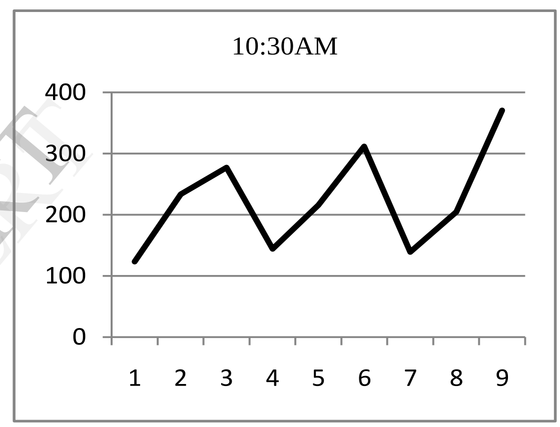


Figure2. *This graph represents the illuminance distribution in a horizontal plane at various places considered in the classroom at 10:30 am*

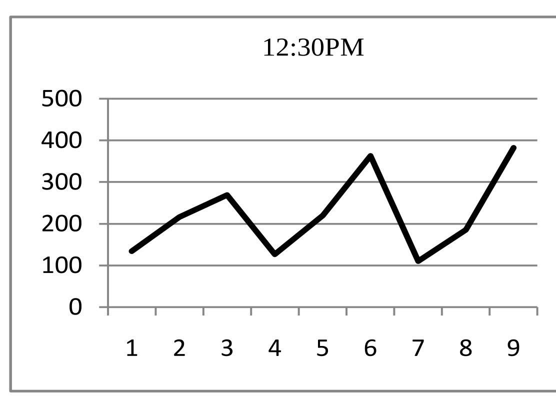


Figure3. *This graph represents the illuminance distribution in a horizontal plane at various places considered in the classroom at 12:30 pm.*

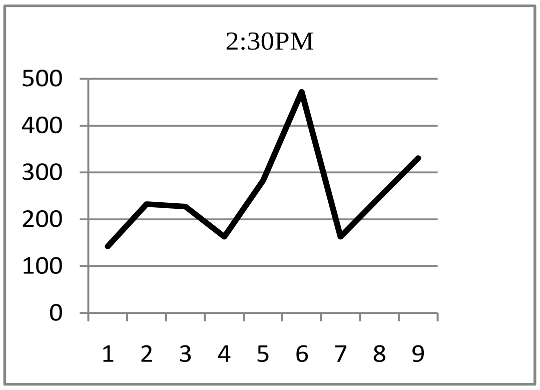


Figure4. *This graph represents the illuminance distribution in a horizontal plane at various places considered in the classroom at 2:30 am.*

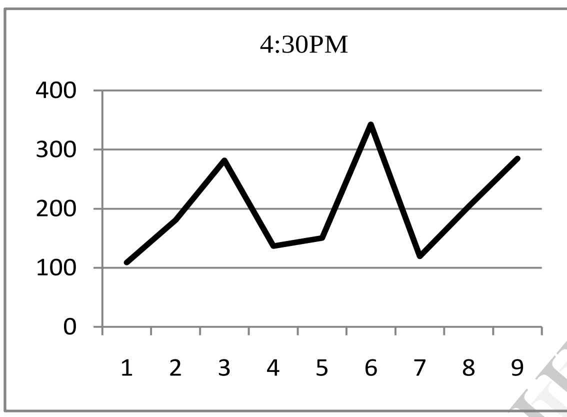


Figure5. *This graph represents the illuminance distribution in a horizontal plane at various places considered in the classroom at 4:30 pm*

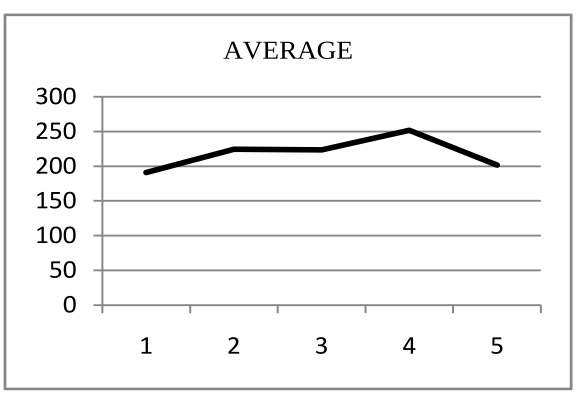


Figure6*. This graph represents the average illuminance distribution in a horizontal plane through the day.*

On the basis test conducted, it concluded that the light intensity required for the class rooms was not achieved (BS- 14) having recorded a minimum luminous intensity of 110lux and a maximum of 472lux, an average of 250lux throughout the class hours.
(from Table 1 considering Figure1 to Figure 6)

5.2 Thermal Variation

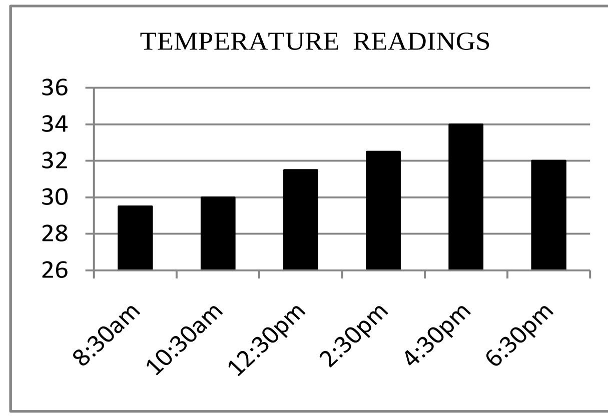


Figure7*. This graph represents the temperature variation in a class room during the class hours starting from 8:30am to 6:30 pm.*

On the basis of test conducted, we arrived at a conclusion that the temperature required for the class rooms were not achieved (BS- 14). Having recorded a minimum room temperature of 29.5^{0}C and a maximum of 34^{o}C, we have an average of 31^{o}C throughout the class hours from Table2 considering Figure7.

5.3 Sound Intensity

On the basis of test conducted, we arrived at a conclusion that the sound intensity required for the class rooms were not achieved. The following readings were recorded;

1. An empty classroom: 41.8dB
2. A classroom with occupancy
   a. Instrument is placed 1m away from the lecturer: 59.3dB
   b. Instrument is placed at the end of the classroom: 42.6dB.

6. Results and Discussions

After adopting a few sustainable and energy efficient methodologies, the following results were achieved.

Lighting: Usage of mirrors as reflectors and skylights to compensate the vast use of electric bulbs. The mirrors were placed at an angle of 20-30 degrees to the window sill allowing the sunlight falling to be reflected back on to the ceiling. Initial costs for fixations and mirrors were the only expense incurred. The power consumption was reduced immensely. The classrooms achieved the required luminosity of 350 lux to 450 lux throughout the class hours which fell well within the ISO standards. Skylights were useful and provided the required intensity of light ranging from 380 lux - 400 lux for the visibility of blackboards and desks as per ISO standards.

Thermal Variation: Fixation of light coloured half blinds for the windows.
The sun rays were not allowed to fall directly into the class rooms; instead the light partially seamed through the blinds and was reflected by the mirrors placed at the window sill.
The requirements for thermal comfort of a classroom were satisfied obtaining a result of temperature varying from 23^0C to 26^0C.

Sound Intensity: Acoustic wall panel or hanging baffles were mounted on the walls.
It was installed at a suitable height and was used as pin-boards. The wall absorbers were placed at the height of people's ears in both the sitting and standing positions. Corners are especially important for the acoustics - corners between walls and corners between the ceiling and the walls - sound absorbers perform optimally there.
Hence, maintaining the sound intensity in the class rooms within 37dB as per ISO standards.

7. Conclusion

This scope of study provides an overview of green and energy efficient educational buildings. An attempt has been made to describe each approach, followed by an explanation of each on its parameters with emphasis on the key energy efficient factors and cost, as applicable, in order to highlight the relevance of room comfort, student psychology and economy in educational buildings.
The mode of implementation, certification and legislation are described to support the adoption of green and energy rating systems for buildings.
This propaganda tailors a methodology to assist governments and the concerned authority to make cost effective educational buildings. Finally, by reducing the overall expenditure and fulfilling the energy efficient factor of the educational building by following alternative eco-friendly systems and remedies, the concept of "**GREEN**" is achieved.

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