International Journal of
Science and Engineering Investigations
vol. 8, issue 90, July 2019
Received on July 31, 2019
ISSN: 2251-8843

Evaluation of Lux Level Adequacy: Case Study of School of Engineering, Federal University of Technology, Akure

M. O. Oyeleye[1], S. A. Akanni[2]
[1,2]Department of Electrical/Electronic Engineering Federal university of Technology, Akure, Nigeria
([1]mooyeleye@futa.edu.ng, [2]samsonagboibon@yahoo.com)

Abstract**-**Light in an academic environment is very important because study has shown that the poor lighting reduces the effectiveness of the brain's power to gather data performance of student, this affect ability to read which in turn harms academic performance. This paper focus on the evaluation of lux level adequacy using lux meter in the School of Engineering and Engineering Technology (SEET), Federal university of Technology Akure (FUTA). TES-1332A (procured meter) and EUROLAB 101A lux meters were used in this work including the work of Oyeleye (Oyeleye, 2019) for validation of the procured meter. On validation, the procured meter was used for data collection of illumination level of 79 out of 100 accessible spaces in the SEET building. The illumination standard used in this research was deduced from seven applicable standards for the accessible spaces. The measured lux level of the studied area using TES-1332A lux meter was compared with deduced applicable Standard (DAS) and the percentage variation was done. The result obtained furtherly shows that 2 out of 79 accessible spaces met the required standard. Only 2.5% of the sampled data are in conformity with the DAS. 97.5% of the illumination level of the accessible spaces in the studied area is below standard. The poor illumination being experienced by the staffs will in due time contribute to the damage of their eyes. To avoid the negative effects of poor illumination, burnt out lamp(s) in the affected area should be replaced with equivalent without any further delay or redesign if the burnt out lamp(s) in the affected yields no significant improvement in lux level.

Keywords- *Illumination, Lux Meter, Luminous efficiency, Lighting*

I. INTRODUCTION

Light is that part of the electromagnetic spectrum that is perceived by our eyes. Lighting which is also known as illumination of a space is the deliberate use of light to achieve a practical or aesthetic effect. Lighting includes the use of both artificial light sources, lamps and light fixtures as well as natural illumination by capturing daylight [1].

Electric lighting has brought about a significant improvement in the standard of living for millions of people all over the world. The availability of bright available illumination has made it possible for people to read, write, and do intricate work more effectively during the night-time hours without being subjected to fire hazards of open flames in fire places or from lamps fueled by environment unfriendly of burning coal, gas, whole oil, or kerosene [2].

Poor lighting reduces the effectiveness of the brain's power to gather data [3]. Full-spectrum lighting, natural light, works best to improve behavior, create less anxiety, stress, and improve overall health [3]. According to [2], overhead cool-white fluorescent lighting causes refection to eyes which results in unintended glare. This interferes with students' ability to read words on paper and chalkboard which in turn harms academic performance [2]. This work is actually motivated by some lecturers straining their eyes to read on their computers, even with the use of their eyes glasses. The aim of this research is to evaluate the lux level adequacy of 100 spaces. The 100 spaces were categorized into 8 spaces in SEET building for easy analysis and assessment. This is done in order to reduce eye straining of lecturers and other staffs in performing their responsibility.

II. LITERATURE REVIEW

A. Light

Light is the visible part of the electromagnetic spectrum [4]. Light radiates and can travel unlimited distances through space. Light rays can be reflected, transmitted or absorbed when they strike an object. The visible spectrum is only a small part of the full electromagnetic spectrum. The main source of our natural light is the sun which has a core temperature of approximately 10,000,000 K but a surface temperature which is a relatively cool 6,000 K. It is this surface temperature which determines the energy levels at the different frequencies of the electromagnetic spectrum [4].

Lighting has always been a fundamental human need [5]. Despite numerous improvements through new emerging technologies, lighting has always exercised and is still exerting a major drain on energy resources [5]. Any progress in chemical resources, physical phenomena has been put to good use throughout centuries to increase efficiency, improve light quality and reduce cost. Lighting methods have changed from olden way of burning wood in fireplaces or touches to lamps in illumination [5].

Lighting design and evaluation of lux level was approached from the aspect of factors that brings about the lack of illumination level in lecture theater and how it can be improved [6]. The artificial lighting was observed very poor during an examination and measured with lux meter which indicated that the average illumination at the lecture theatre did not meet the minimal standard of 400 lux [6].

B. Lighting Sources

Light Sources are sources of light production [6]. The sources of light can be divided into natural and artificial sources of light, however sources of light differ in how they provide energy to the charged particles such as electrons, whose motion creates the light. If the energy comes from heat, then the source is called incandescent, if the energy comes from another source, such as chemical or electric energy, the source is called luminescent [7].

Ambient lighting is natural lighting provided by windows supplemented by ceiling or wall mounted luminaires at various times [8]. However, it is supplied artificially by lamps and luminaires at night. The amount of ambient light required in a room depends on the activities that take place in that room and the color of its walls [8]. In this sense, it is advisable not to consider the contribution of day light in design for night usable activities. Dark walls absorb more light than white or off-white walls [8].

1) Luminescent Light and Incandescent Light Source

Luminescent light sources produce light without the use of heat [6]. Luminescent sources make light when their atoms become excited in a process that needs little or no heat to make it happen which in turn produces cooler light than that of incandescent sources [4]. The colour of a luminescent light source is not a function of its temperature. The moon is an example of luminescent light sources [4].

a) Incandescent Light Source

In an incandescent light source, hot atoms collide with one another, this collision results in a transfer of energy from one electron of an atom to another, this leads to a change in energy level from a lower state to a higher state. The energy of these superheated electrons is being discharged as photon generically known as light.

Sun produces light by a nuclear reaction called fusion. During nuclear fusion, nuclei of atoms interact and combine to release a great amount of energy which passes from one atom to the other until it gets to the surface of the sun. Different stars emit incandescent light of different frequencies which results in the tune of colours it radiates. [4].

C. Lighting Fixtures

Lighting Fixture is a holder for the light source to provide directed light and to avoid visual glare. Lighting fixtures come in a wide variety of styles for various functions. The necessary illuminance depends on the character of the task that is being performed. An important property of light fixture is its luminous efficacy. Luminous efficacy is the amount of luminous flux emanating from the fixture per used energy which is measured in lumen per watt. [6]

D. Lighting Blueprint

In the design process, there are lighting plans that are put in place to achieve good lighting. There are different types of lighting blueprints put in place base on the objective/purpose in which the lighting is meant to perform in the space in which it is been installed. It can be broadly divided into emergency lighting, exit lighting and decorative lighting [9].

Emergency light is usually off except in a case of emergency when it is turned on usually automatic. The lighting can be for fire emergency, low voltage emergency or any other form of emergencies. Emergency lighting in high-risk task areas such as laboratory should have an illumination of 10 lux [9]. However, manufacturers' data will give luminaire spacing at given heights to achieve these lighting levels. These lights work on low voltage DC. and are fed from a battery. A trickle charger permanently connected to the mains ensures that the battery is always fully charged. Emergency exit lights are designed to guide people to safety during an emergency. Emergency exit lights are a stand-alone system, which means they will stay lit during a power failure.

Decorative lighting is used basically for beautification and not as a means of contributing to the illuminance of the space in which it is being used.

E. Lamps

All light bulbs, generally called lamps, produce a thermal spectrum of light with a specific color temperature. This spectrum is a broad, featureless mixture of colors that peaks at a wavelength determined by the temperature or equivalent temperature of the light source. The spectrum of incandescent and tungsten-halogen lamps is determined by filament temperature, but that in fluorescent lamps and some high-intensity discharge lamps is the result of secondary emission from the phosphor coatings [6], [7].

Incandescent lamps are available in hundreds of different bulb shapes with a wide range of light output, energy consumption, and life ratings [6], [7]. The compact fluorescent light bulb or lamp is a type of fluorescent lamp generally designed as a replacement for incandescent or halogen lamps, which produce light in the same manner as linear fluorescent lamps [7], [8].

F. Useful Light Terms

Illuminance: The density of luminous flux incident on a surface, measured in foot-candles or lux. It is given by equation (1).

$$E = \frac{Luminous\ flux\ intensity\ (lm)}{area(m^2)}\ \text{lx} \quad (1)$$

Lamp life (lamp rated life): The median life span of a very large number of lamps or economic burning period of light sources [7], [10]. Half of the lamps in a sample are likely to fail before the rated lamp life, and half are likely to survive beyond the rated lamp life. Rated life is based on standard test conditions. For discharge light sources, such as fluorescent and HID lamps, lamp life depends on the number of starts and the duration of the operating cycle each time the lamp is started [7].

Lamp lumen depreciation (LLD): The reduction in lamp light output that progressive occurs during lamp life [7], [11].

Lumen (lm): The unit of luminous flux equal to the flux through a unit solid angle (steradian) from a point light source of 1 candela or to the flux on a square foot of surface, all points of which are 1 ft from a point source of 1 candela. A candle provides about 12 lm, and a 60-W white incandescent lamp provides about 860 lm [7].

Lumen maintenance: A measure of how a lamp maintains its light output over time. It can be plotted as a graph of light output versus time or numerically [7].

Luminaire: The preferred term for light fixture, it is the assembly of all elements of a lighting fixture, including lamp, socket, reflector or diffuser, and the necessary wiring to connect it to the power supply. Fluorescent and HID luminaires include ballasts [7], [11].

Luminaire efficiency: The ratio, expressed as a percentage, of the light output of a luminaire to the light output of the luminaire's lamps. Luminaire efficiency accounts for the optical and thermal effects that occur within the luminaire under standard test conditions [7], [10].

Luminance (L): The photometric quantity most closely associated with the perception of brightness. It is measured in units of luminance intensity (candelas) reflected in any direction per unit of projected area (ft^2 or m^2) [7], [11]

$$L = \frac{luminous\ intensity\ (I)}{Area(m^2)} \tag{2}$$

Lux (lx): The International System (SI) unit of illuminance on a surface 1 m^2 in area on which there is a uniformly distributed flux of 1 lm.

Luminous intensity Symbol: I. Unit: candela. The quantity which describes the power of a source or illuminated surface to emit light in a given direction.

Uniformity: Ratio of minimum to average illuminance, normally taken on the working plane [7].

Room Index: This takes account of room proportions and height of the luminaire above the

Working plane: It is used to determine the effect of the room geometry on the room utilization surface [7], [10].

It is given by equation (3).

$$Room\ Index = \frac{L \times W}{(L+W) \times H} \tag{3}$$

Where L is the length, W is the width, H is the height of luminaire above working plane.

Utilisation Factor (U_f): ratio of lamination flux striking the effective surface to the total normal luminous flux [10]. It depends on room index, room reflectance and type of luminaire used [7].

G. Methods for Light Calculation and Evaluations

In lighting design and analysis, there are a couple of ways in which our lighting design aim can be reached. The common methods of lighting design calculations include the lumen method, Watt per square meter and point-to-point or inverse square law method [7], [10]

1) Lumen or Light Flux Method

The lumen method is the most commonly used method of lighting calculation due to its simplicity. This method is most suitable for interior lighting design where a high proportion of light on the working plane is reflected by internal surfaces [7]. For external applications or where the reflectance of the surfaces is unknown or may not be relied upon (emergency lighting schemes), a utilisation factor for zero reflectance may be used. The lumen method, luminous flux method, of calculation, is normally used to calculate the number of luminaires required to provide a specified average illuminance in space [6], [7]. The following formula is use:

$$E = \frac{N \times L \times M_f \times U_f}{A} \tag{4}$$

$$N = \frac{E \times A}{M_f \times U_f \times L} \tag{5}$$

Where N is the number of luminaires required, E is the maintained illuminance (lux), L is the lumen output M_f is the maintenance factor, U_f is the Utilization factor and A is the area of room in (m^2)

2) Watts per Square Meter

This is principally a rule of thumb method, very handy for rough calculation or checking. It consists in making an allowance of watts per square meter of area to be illuminated according to the illumination desired on the assumption of an average figure of overall efficiency of the system [6], [7]

3) Point-To-Point Method

This method is applicable where the illumination at a point due to one or more sources of light is required, the candle powers of the sources in the particular direction under consideration being known, If a polar curve of lamp and its reflector giving candle powers of the lamp in different directions is known, the illumination at any point within the range of the lamp can be calculated from the inverse square law. If two and more than two lamps are illuminating the same working plane, the illumination due to each can be calculated and added. This method is not much used because of its complicated and cumbersome applications. It is employed only in some special problems, such as flood lighting and yard lighting.

H. Recommended Illumination Level

The Table 1 shows the recommended illumination level which were consulted and reviewed from existing literatures for appropriate application in this work.

TABLE I. RECOMMENDED ILLUMINATION LEVEL

S/N	Applicable Standard	Conference Room	Laboratory	Offices	Lobby/Corridor	Toilet	Lecture Room	Library	Stairs
1	IES	500	500	500	100	100	300	150	150
2	PHILIPS	300	500	500	50	100	500	300	150
3	IS	300-500	300	100	50-100	100	300-500	300-500	100
4	IESNA	300-500	500-750	300-500	50-100	100-300	300-500	300-500	50-100
5	MTS	300-400	300	400-400	50	100	300-500	300-500	100
6	PWO	500	750	500	250-500	300	N/A	300-500	100
7	Oyeleye	N/A	N/A	N/A	N/A	N/A	400	N/A	N/A

III. METHODOLOGY

A. Data collection

Lux level will be obtained using TES-1332A lux meter in Figure 1 for the School of Engineering and Engineering Technology (SEET), FUTA, the SEET building is present in Figure 2. In order to obtain the required data for the work, the lux level of the studied area will be classified into eight categories (laboratory, office, lecture room, lobby/corridor, conference room, library, toilet and staircase) and measure at task level. Secretary space is classified as office space since both spaces render similar operation. Spaces used for the purpose of offices will not be measured at night but day due to the fact that they were not accessible at night.

Figure 1. TES 1332A Lux Meter

Figure 2. School of Eng. and Eng. Technology

1) Meter Accuracy Verification

There is a paramount need to verify the accuracy of the acquired TES-1332A lux meter as to avoid working with wrong data. Two verification processes were employed.

i. According to Oyeleye (2019), the illumination level of the lecture theater was measured as 115 lux. The used lux meter, TES-1332A meter, will also be used to measure the lux at the center of the hall to verify its reliability.

ii. Another Lux meter will also be acquired from the department of physics electronic at the faculty of science, FUTA, to actualize the measured 115 lux obtained by Oyeleye.

B. Deduced Applicable Standard (DAS)

Deduced applicable standard lux value will be obtained from Table 1.The DAS will be a summary deduction from Table 1. The DAS is presented in Figure 3.

C. Evaluation of the Required Illumination Level

The result obtained from lux level measurement will be compared with DAS lux value of the accessible spaces and the percentage variation will be determined using Equation 6 & 7.

$$L_e = Lrs - Lm \quad (6)$$

Where L_e is the error in lux level, Lrs is the required standard lux level, Lm is the measured lux level.

$$\%L_{V} = \frac{L_e}{L_{rs}} x100\% \ [12] \quad (7)$$

where $\%L_v$ is the percentage variation in lux level.

IV. RESULTS AND ANALYSIS

A. Results

From Table 1, inference is made from reviewed literatures on applicable standards to obtained deduced applicable standard (DAS) used in this work. The result is presented in Figure 3.

B. Verification of Result

The result of the verification of test meters lux measurement is presented in Figure 4. The result of measured and deduced applicable standard is presented in Figure 5.

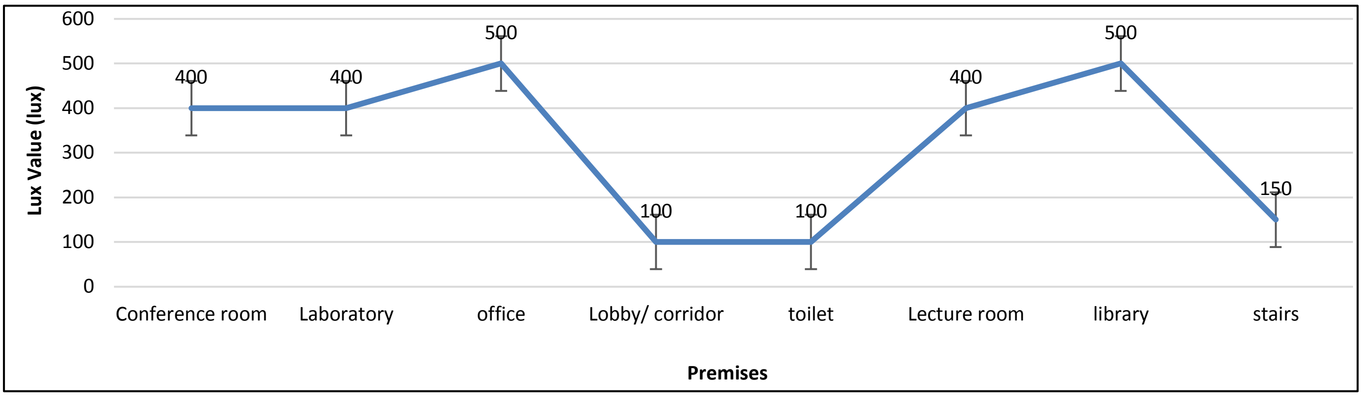
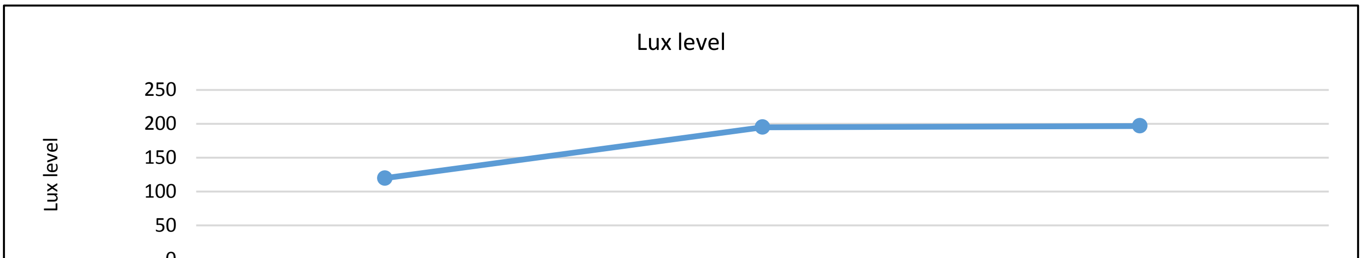


Figure 3. Deduced Applicable Standard Lux Value



	Tes-1332A Lux meter	Tes-1332A Lux meter	EUROLAB 101A
Lux level	120	195	197

Figure 4. Verification of Lux Meters Result

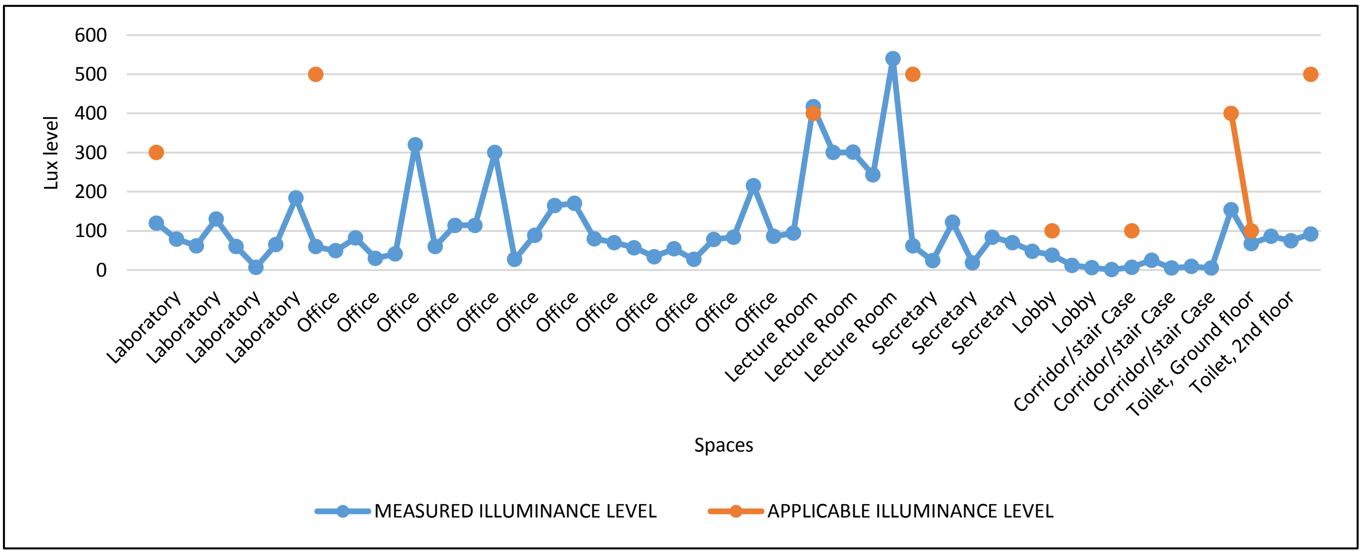


Figure 5. Graph of Measured and Deduced Applicable Standard

C. Analysis of Results

From Figure 3, the deduced applicable standard (DAS) is believed to be correct since they are obtained from reliable sources (Table 1) and adjudged by this research.

According to Oyeleye (2019) and Figure 4, the variation value of the measured lux level is 5lux.This implies 4.3% percentage error. From Figure 4, the variation value of the measured lux level for the two meters is 2lux. This implies 1% percentage error. These percentage variations are acceptable since percentage error is up to 5%. This validates the reliability of the meters used in the measured values.

From Figure 5, 2 (lecture rooms) out of 79 accessible spaces met the required standard. It follows that only 2.5% of the sampled data are in conformity with the standard.

V. Conclusions and Recommendations

A. Conclusions

i. The meters used for the lux level are reliable for lux measurement hence used in this work.

ii. 2.5% of the illumination level of the accessible spaces met the required standard.

iii. 97.5% of the illumination level of the accessible spaces in the studied area is below standard.

iv. The SEET building, FUTA, according to this research is grossly illumination poor.

v. The poor illumination being experienced by the staffs will in due time contribute to the damage of their eyes.

B. Recommendations

i. The burnt out lamp(s) in the affected area should be replaced with equivalent without any further delay.

ii. If the burnt out lamp(s) in the affected area is replaced without significant improvement in lux level, the affected space should be redesigned.

ACKNOWLEDGEMENT

We acknowledge Mr. I. Olugbemi, student of department of electrical and electronics engineering, FUTA for his contribution on the acquisition of data and Mr. T.D Makanju for typing of the manuscript.

References

[1] Zumtobel, (2011). The Lighting Handbook. Published by Zumtobel lighting GMBH 2011. INFO@ zumtobel.info. pg.1020.

[2] Pritchard, D. C (2014). Lighting 6th edition. CRC press, September 25, 2014 New York.

[3] Farnsworth. M. (2019). An adjusted error score calculation for the Farnsworth Musell 100 hue test. Journal of illuminating engineering society, volume 15, Volume 15, 2019 - Issue 2-3.

[4] Kevin K and Duff .J (2014). A new approach to interior lighting design. Journal of sustainable design and applied research Vol.2:Iss1, Article 3.

[5] Weisbuch, C. (2018). Historical perspective on the physics of artificial lighting. Comptes Rendus Physique, Califronia Elsevier Masson SAS 19 (3), pp.89-112.

[6] Oyeleye, M. (2019). illumination Evaluation of Lecture Theatre, Case Study of 1000 Seat Lecture Theatre, Federal University of Technology, Akure, Nigeria. European Journal of Engineering Research and Science, 4, 7(July. 2019), 31-36.

[7] Gupta J. B. (2006). A course in Electrical installation estimating and costing. Published by S.K Katari and Sons 2006, p. 468.

[8] Neil, S. and John, T. (2003). Electrical Design Details. Published by The McGraw-Hill professional p. 244.

[9] Wasilah J and Murni. R (2013). Artificial Lighting design at the Lecture Theatre of the Faculty of Engineering, Hasanuddin university International Journal of Engineering science and Innovation Technology (IJESIT), 1-8.

[10] Electrical Engineering handbook (2006). Published by Siemens AG Munchen and HYDEN & sons limited, London. p. 749.

[11] Philip Lighting Manual 3rd Edition, 1981, p. 306.

[12] Percentage error (July, 2019). https://socratic.org, Measurement › Accuracy, Precision, and Percent Error

How to Cite this Article:

Oyeleye, M. O. & Akanni, S. A. (2019) Evaluation of Lux Level Adequacy: Case Study of School of Engineering, Federal University of Technology, Akure. International Journal of Science and Engineering Investigations (IJSEI), 8(90), 74-79. http://www.ijsei.com/papers/ijsei-89019-11.pdf