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COMPARATIVE EVALUATION OF LIGHTING DESIGN SOFTWARES AND EXCEL LUMEN COMPUTATIONAL (ELC) METHOD

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ABSTRACT

This research focus on multipurpose-hall interior lighting design, using two lighting design softwares and Excel Lumen Computational (ELC) method of lighting design without considering day-light. This is to ascertain the overall benefits of lighting design software as compared to ELC method. AutoCAD architectural drawings of the building was obtained for floor plan dimensions. The building was categorized into seven different spaces and the lux level of the spaces considered varies. The used softwares were downloaded. Utilization factor is not visible for the user and maintenance factor is fixed (0.85) in Dialux while it is 0.6 and 0.8 respectively in Relux which is variable. The utilization and maintenance factor used in the ELC method is 0.7 and 0.8 respectively. AutoCAD was used to measure irregular shapes. 2018/2019 catalogue of a reputable manufacturer was used for lamp selection. None of the selected lamp was accessible in the softwares. All the selected lamps were accessible in ELC method. The former is characterized with difficulty to access selected lamp specifications, a lot of time and energy were devoted for searching and downloading the softwares without any useful result. These softwares are monetary. ELC method overrides these shortcomings thus recommends in this work.

KEYWORDS: Light, Lighting-design, Lumen, Lighting-software, Simulation and Lux-level.

1. INTRODUCTION

Lighting has always been a fundamental human need [1]. Despite numerous improvements through new emerging technologies, lighting has always exercised and is still exerting as a major drain on energy resources. 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 have changed from olden way of burning wood or touches to lamp for illumination [1]. Good lighting of a place can improve task work output or have optimistic psychological effects on occupants [2]. Architects and lighting designers are increasingly using simulation software tools to assess and optimize their design solutions. However, a large portion of their design decisions are still based on perception rather than on the specificities and dynamics of the project at hand [3]. Strategies for more daylight inclusion is needed for interiors lighting in the context of any nation which has a growing demand on electricity in excess of its electricity generation [4]. Combination of artificial and day light schemes with energy efficient luminaries and lighting controls can help reduce the electrical energy cost and improve vision efficiency of the building occupants [5, 6]. For lighting simulation tools in existence today, Radiance software continues to be the most influential of them. It has received an extensive number of literature citations and was among the first to employ integrative techniques. It lacks many user-friendly features such as an interface [7]. As a general purpose tool, it solves a large number of lighting simulation problems. It has been validated extensively and incorporated into other tools. It is not difficult to understand that day light controls can result in significant energy savings [4]. However comparisons are often made between real life and computer models to verify their accuracy or features, but these evaluations become outdated as computer programs are modified or fall into disuse [8]. This research will compare the use of two lighting design software namely DiaLUX Evo and RELUX Desktop versus the Excel Lumen Computation (ELC) method. The objective is to ascertain the overall benefits of lighting design software as compared to ELC method of lighting design. This is necessary to promote good design void of wrong assumptions by detecting possible flaws before projects are embarked upon. This research covers the Interior Lighting Design of Multipurpose Hall building. This work do not consider lighting simulation software but artificial lighting software and ELC methods. This research comes

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out with simple, costless and time saving lighting design method with the use of ELC method. This will enable our young electrical lighting design engineer in their work.

1.1 Light

Light is a form of radiant energy which simulates human sense of vision. The light incident on a non-luminous object scatters it partly. This scattered ray of light from the object enters the human eyes and enables us to identify the objects [9]. Despite numerous improvements through new emerging technologies, lighting has always exercised and is still exerting a major drain on energy resources. 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 [1].

1.2 Light source

Light sources are sources of light production. The sources of light can be divided mainly 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 [10].

Incandescent light source

Incandescent light source, uses heat luminescent hot atoms collide with one another, these collisions result 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 this superheated electrons is being discharged as photon generically known as light.

Luminescent light source

As oppose incandescent light source, luminescent light sources produce light without the use of heat 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, the colours of a luminescent light source is not a function of its temperature. The moon is an example of luminescent light sources [11].

1.3 Definition of Terms

There is need to define the terms frequently used in order to understand illumination design in engineering

Light and Lighting

Light may be defined as that radiant energy which produces a sensation of vision upon the human eye.
Lighting is the deliberate use of light to achieve a practical or aesthetic design.

Luminaire and illuminance (L)

A luminaire is a complete light unit consisting of lamps, reflectors and other parts that hold the lamp in place and protect it. Choosing luminaires with the right type of lamp and reflector type, which efficiently provides the appropriate lighting patterns, is also an important part of energy efficient lighting design [12, 13].

Illuminance is the term used for expressing the intensity of the light emitted in a given direction per unit area of a luminous or reflection surface. The unit of Luminance, Equation (1), is Lumen per square meter or Candela per square meter (lumen/m^2) or (Cd/m^2) [12, 14].

$$L = \frac{I}{A} \qquad (1)$$

Where I is the luminous intensity and A is the area of the space in meters square.

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Illuminance (E) and Room index (RI)

Illuminance is the measure of the concentration of light falling on a surface, that is the flux density on the surface it is also the Luminous flux incident per unit area. The unit of Illuminance is Lux (lx). This is expressed by Equation (2)

$$E = \frac{F}{A} \qquad (2)$$

Where F is the luminous and A is the area.

Room Indexis an index related to the dimensions of a room, and used when calculating the utilization factor and the characteristics of the lighting installation. It is given by:

$$\boldsymbol{RI} = \frac{\boldsymbol{L \times W}}{\boldsymbol{(LXW)H_m}} \qquad (3)$$

Where L is the length, W is the width and $H_m$is the height.

Luminous flux, Maintenance and Utilization factors

Luminous Flux is a term used to describe the amount of light that is emitted by a light source or the amount of light that is received by a surface. The unit of luminous flux is Lumens (lm).

Maintenance factor (M_f) is the loss of light due to collection of dirt and ageing. It is usually 0.8 or 0.85 [13, 15].

Coefficient of utilization (CU) or Utillization factor (U_f) is the amount of useful light reaching a working plane which depends on the lamp output, reflectors and or diffuser used, position of lamp, color of walls and ceiling. The utilization factor can be between 0.5 to 0.8 [16] or 0.7 [13],[17], [18].

Room surface reflectance

The room surface reflectance is another factor that has to be taken into account in lighting design. The reflections off the wall, the ceiling and the floor contribute to the overall illuminance of the spaces.

1.4 Method of Lighting Calculation

There are different methods for lighting calculations which namely Watts per square meter, Point to point or inverse square law method and lumen or light flux method. However this research make used of lumen method for the excel computational method [12,3]

$$N = \frac{E \times A}{M_f \times U_f \times L} \qquad (4)$$

$$E = \frac{N \times L \times M_f \times U_f}{A} \qquad (5)$$

Equation (4) can be re-written as in Equation (5) when E is to be computed.

Where N is the number of luminaires required, E is the maintained illuminance (lux), Lis the lumen output M_f is the maintenance factor, U_f is the Utilization factor and A is the area of spaces.

1.5 Lighting Design Softwares

Lighting design software can be day lighting design which combine daylight and artificial lighting or artificial design software which consider only artificial lighting.

Lighting simulation falls into two main areas namely photorealistic rendering and physically based visualization. Photorealistic rendering which deals primarily with artistic production of images. The second field is physically-based visualization also called predictive rendering. Which deals with accurate representation and prediction of reality under given conditions and following physical laws [7]. According to [19], modern physical models explaining light transport in all types of media are too complex for computer calculations and image generation. There are many lighting simulation tools, however radiance softwares is the most influential of them [8]. Widely used electric lighting design programs are AGI 32 [20], Dialux [21] and Relux [22]. This programs combinedraytracing and radiosity in diverse ways and for different purposes. Common features include defining geometry through their own CAD systems. Users can select luminaries from manufacturers maintained [8].

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Also Architectural lighting analysis tools include Inspirer [23], which apply bidirectional raytracing, mental ray modelling engine [24]. The softwares used in this work allows either day lighting simulation or artificial lighting design only or combination of the two.

1.6 Excel design Computation (EDC)

This is using of excel software to program lumen formula in order to obtain number of lamps to be designed. Usually all consulting firm and electrical lighting designer use lumen method for their lighting design. Lumen calculation is used for space design. The utilization factor of 0.6 to 0.7 is used. Some of them use room index calculation for their utilization factor while majority use 0.7. For the maintenance factor, 0.8 or 0.85 is used based on their past projects experience.

2. MATERIALS AND METHOD

2.1 Materials

AutoCAD architectural drawing (AAD) of the building under consideration will be obtained from the client. The lighting electrical luminaire data will be source for through the manufacturer catalogue. The utilization factor and the maintenance factor will also be source for from a reliable literature. The applicable illumination level codes will be source for from international and reputable sources. Also DiaLuxEvo and Relux softwares will be consulted for usable data in this work.

2.2 Methods

The following method are used in the research

2.2.1 AutoCAD architectural drawing (AAD)

Architectural drawing will be converted to Electrical Colour 8.This will enable the measurement to be measured and compared with the architectural AutoCAD dimension. The reason for this is that atimes, there is variation in architectural dimension and electrical engineer dimension. Where the space is irregular, AutoCAD software will be used.

2.2.2 Applicable Illumination level code

In order to determine the applicable illumination level code, the spaces involve must be known and classified.

2.2.2.1 Classification of the Spaces

The space task is used to select the lux level. The building ground floor spaces were counted as eleven and the basement as twelve as shown in Table 1.
Both spaces in ground floor and basement are classified into seven Figure 1, according to Oyeleye mode of classification [14].

2.2.2.2 Determination of Lux Level

In order to determine the lux level standards code will be considered for the spaces under consideration and a general acceptable lux will be obtained from the standards reviewed in our literature.

2.2.3 Softwares

Two lighting design software (LDS) will be downloaded which are Dialux Evo and Relux. Also ELC method will be used for number of lighting required.

2.2.4 Utilization factor and the maintenance factor

The DiaLux and Relux softwares utilization factor and maintenance factor will be used. These factors may be fixed or varied. For excel computational method 0.7 and 0.8 for utilization factor and maintenance factor respectively according to [13].

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2.2.5 Excel Lumen Computational (ELC) method

This is using of excel software to program lumen formula in order to obtain the number of lamps to be designed. Lumen method of calculation is used in the microsoft excel software for computation of number of luminaries need as present in Equation (5).

2.3 Comparism Between the Excel Lumen Computational Method and the Two Software Used

The result of Lumen lighting computational method using Microsoft excel will be compared with the result obtained from the two softwares that will be used in this research.

3. RESULTS AND DISCUSSIONS

The results are presented in Table 1, 2 and Figure 1.

Table 1: The Dimensional Measurement of the Multipurpose Hall Building

S/N	SPACE	LENGTH	BREADTH	AREA
GROUND FLOOR				
1	STAIR 1	N/A	N/A	29
2	STAIR 2	N/A	N/A	29
3	CORRIDOR 1	29.9	2	60
4	CORRIDOR 2	29.9	2	60
5	MAIN HALL	N/A	N/A	543
6	ENTRANCE	N/A	N/A	33
7	OFFICE	4.7	3.5	16
8	TOILET	1.8	1.1	2
9	VIP LOUNGE	4.8	3.5	17
10	GALLERY			146
BASEMENT				
1	HALL	15.2	10	152
2	TOILET 1 L	1.2	0.8	1
3	TOILET 2 L	1.2	0.8	1
4	TOILET 3 L	1.2	0.8	1
5	TOILET LOBBY 1	2.8	2.3	6
6	TOILET 1 R	1.2	0.8	1
7	TOILET 2 R	1.2	0.8	1
8	TOILET 3 R	1.2	0.8	1
9	TOILET LOBBY 2	2.8	2.3	6
10	CORRIDOR FRONT	19.5	1.6	31
11	CORRIDOR L EFT	15.5	2	31
12	CORRIDOR RIGHT	15.5	2	31

It is easier to use calculation to determine the regular shape dimension than using AutoCAD for irregular shape. However, AutoCAD helps to solve the problem of irregular shape area measurement.

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3.1. Space Categorizations and Code summary

Code summary in this work is a review of accessible and applicable international including local standards. The code summary take into consideration of [14],[15], [25],[26], [27] . The result of space and code summary is presented in Figure 1

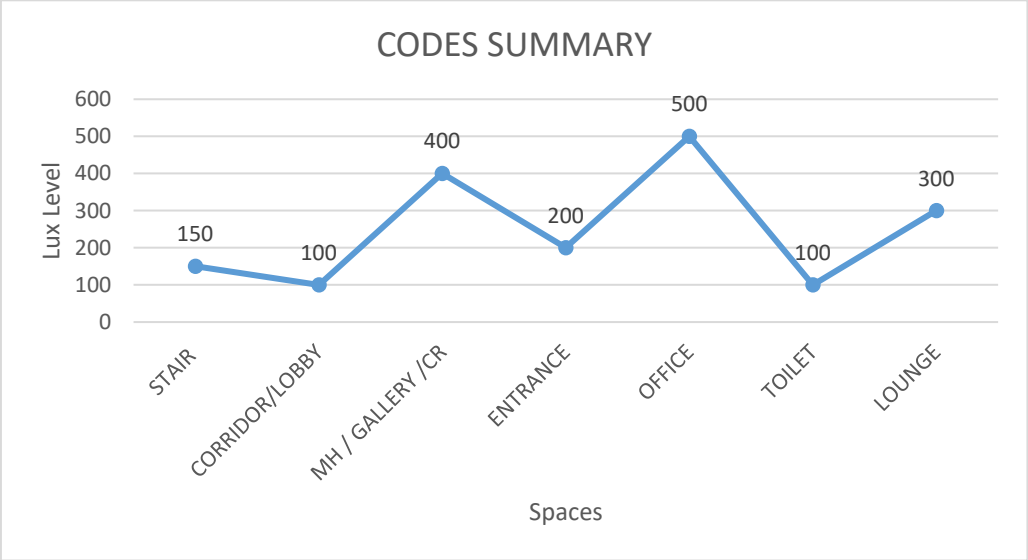

Figure 1: Space Categorization and Code Summary

The building was categorized into seven and the lux level of the space considered varies from 100 to 500. Each space has its lux level specified. However, individual lux level per space is reliable having been tested on past projects [13, 14].

3.1.2 Softwares Results

The selected lighting fittings were not compactable with the softwares, in term of accessing specific electrical designer lighting specification. A lot of time and energy were devoted for searching and downloading the softwores. These softwares are not free they are monetary. However, Relux is user Friendly compare to DiaLuxEvo.

3.1.3 Excel Lighting Computational (ELC) Method

The result obtained from the (ELC) method is presented as shown in Table 2.

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Table 2: Excel Lighting Computational Method

S/N	Space	Length L(m)	Breadth B(m)	Area A(L*B)(m^2)	Lux Level E	U_f	M_f	Watt	Lumen per output (L)	Designed No of Lamps [EA/(U_f*M_f* L)]	Rec. No of Lamps
GROUND FLOOR											
1	STAIR 1			29	150	0.7	0.8	26	1800	4.3	5
2	STAIR 2			29	150	0.7	0.8	26	1800	4.3	5
3	CORRIDOR 1	29.9	2	60	100	0.7	0.8	36	3300	3.2	3
4	CORRIDOR 2	29.9	2	60	100	0.7	0.8	36	3300	3.2	3
5	MAIN HALL			543	400	0.7	0.8	200	28000	13.9	14
6	ENTRANCE			33	150	0.7	0.8	16	1200	7.4	8
7	OFFICE	4.7	3.5	16	500	0.7	0.8	38	4000	3.7	4
8	TOILET	1.8	1.1	2	100	0.7	0.8	4.5	500	0.7	1
9	VIP LOUNGE	4.8	3.5	17	300	0.7	0.8	125	1550	5.8	6
10	GALLERY			146	400	0.7	0.8	90	3400	30.6	31
BASEMENT											
1	HALL	15.2	10	152	400	0.7	0.8	150	21000	5.2	6
2	TOILET 1 L	1.2	0.8	1	100	0.7	0.8	15.5	1000	0.2	1
3	TOILET 2 L	1.2	0.8	1	100	0.7	0.8	15.5	1000	0.2	1
4	TOILET 3 L	1.2	0.8	1	100	0.7	0.8	15.5	1000	0.2	1
5	TOILET LOBBY 1	2.8	2.3	6	100	0.7	0.8	15.5	1000	1.2	1
6	TOILET 1 R	1.2	0.8	1	100	0.7	0.8	15.5	1000	0.2	1
7	TOILET 2 R	1.2	0.8	1	100	0.7	0.8	15.5	1000	0.2	1
8	TOILET 3 R	1.2	0.8	1	100	0.7	0.8	15.5	1000	0.2	1
9	TOILET LOBBY 2	2.8	2.3	6	100	0.7	0.8	15.5	1000	1.2	1
10	CORRIDOR FRONT	19.5	1.6	31	100	0.7	0.8	15.5	1000	5.6	7
11	CORRIDOR LEFT	15.5	2	31	100	0.7	0.8	15.5	1000	5.5	7
12	CORRIDOR RIGHT	15.5	2	31	100	0.7	0.8	15.5	1000	5.5	7

ELC method makes use of laptop computer with Microsoft excel facility. Besides the procurement of the laptop which is analogical to the two lighting softwares use in this work nothing is bought again. Required lighting specification were downloaded on internet freely. Less time was spend in downloading and selecting required lighting lamps. The U_f, M_f and lux level followed a reliable literature, codes and past project experience. ELC method is simple, accessible for use and costless and easy to use. The manufacturers of the used fittings were deliberately deleted to avoid infringing on their rights.

3.2 Comparism between the ELC Method and the Softwares

It was found out that none of the selected lamp was accessible in the softwares. All the selected lamps were accessible in ELC method. The former is characterized with difficulty to access selected lamps, a lot of time and energy were devoted for searching and downloading the softwares, and these softwares are not free. ELC method override all these shortcomings.

4. CONCLUSIONS AND RECOMMENDATION

4.1 Conclusions

The following conclusions are made based on this research**:**

i. ELC method requires no money compare to softwares used in this work.
ii. there is simplicity in lighting design and less time spent using ELC method compared to the softwares used.
iii. using software is complex and it is time consuming for electrical lighting designer.
iv. Dialux Evo is not user friendly and flexible compared to Relux.

4.2 Recommendation

It is recommended that ELC method should be encouraged for lighting design because of the aforementioned benefits.

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