Analysis and Calculation of Lighting Strength in the Annur Building Jalan Purnawirawan Bandar Lampung

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Abstract. The ideal lighting system is a lighting system that creates a comfortable feeling when felt in the room. The lighting strength recommended by SNI standards (Indonesian National Standards) consists of 150 lux (low), 200 lux (somewhat low), 250 lux (medium), 300 lux (somewhat high) and 350 lux (high). The method in this research is to compare the lighting (E) at each specific position in rooms R1, R2 and R3 with SNI lighting standards, so that the average ratio of lighting parameters in each room is obtained which is called the room comfort equation (RCE) and then adding them up for each space throughout the building which is called the building comfort equation (BCE). The parameter ratio is P1 = E1/ ESNI, for R1 and R2 both are meeting rooms with SNI ESNI standards = 300 lux and for R3 (parking space) it is P3 = E3/ESNI, with SNI I lighting standards = 150. The ideal prices for all three are at intervals $1 - 0.01 < P3 < 1 + 0.01$. The results of the calculations are the ratio of indoor lighting parameters of 0.260, 0.108 and 0.521, which is called the room comfort equation (RCE). in the building (BCE) with the Pt limit condition at interval $3 - 0.03 < Pt < 1 + 0.03$. Because the total lighting ratio Pt for the three rooms is not in the interval $2.97 < Pt < 3.03$, the Annur Center building authorities need to adjust the lighting strength to achieve ideal conditions.

Keywords: SNI standards, Strong lighting, equality, Room Comfort Equations and Building comfort equations

1 Introduction

1.1 Luminous flux (light current per second)

There are several variables related to the amount of light that we know in the world of physics. If light waves come from a certain light source or are emitted by a light source

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in a certain direction at a certain time [1], the behavior of the light applies to the equation. If a beam of light with a density of f (Lux) passes through a cross-section for a time t seconds [2], then the amount of light current per second or light flux (Lumen) is

$$F = \frac{f}{t} \tag{1}$$

Where

F = Light Flux (lux/second) or (lumen)
f = Light Current or Lighting Strength (lux)
t = Exposure Time (seconds)

1.2 Illuminant

If a light source emits a stream of light towards an object within a certain time and within a certain area, the area is the area of a sphere [2]. The behavior of light in this way applies the equation.

$$E = \frac{F}{A} \tag{2}$$

Where

E = light illumination intensity (lumen/second)
F = Luminous flux (lumen)
A = area of the flat area (m2)

1.3 Light intensity (luminous intensity)

It is the strength of light emitted by a light source in units of candela, where one candela of light intensity is defined by the standard intensity of a candle (candle) in illuminating a spherical area where the monochromatic light source emits radiation at a frequency of 540 x 10^12 Hz.[2] . With a radiation intensity of 1/683 Watt/setradian, this law can be explained below. There are physical laws that apply to light variables.

$$I = \frac{F}{A} \tag{3}$$

Where

I = Intensity of light incident on the sphere (candela/m2)
F = light flux that hits the sphere (candela)
A = Area of the sphere (m2)

1.4 Lighting System in the Building

Lighting is part of the release of energy in a building [3], for certain buildings that are only used as meeting places, lighting absorbs the greatest amount of energy [4], because lights play the most important role in the building when they are used. The value of lighting in a room is very dependent on the colors that decorate the room [5], the lighter the color of a room, the greater the light reflected and the more economical

it is [5]. Based on the lighting level, the SNI 03-6197-2011 standard provides recommendations in Table 1 below [6]:

Table 1. Average indoor lighting for offices (SNI 6197-2011)

Room	Level of Strong Lighting (Lux)
Chairman's Room	350
Workspace Room	350
Admin Room	350
Meeting Room	300
Archive Room	150
Archives Reading Room	300
Reception Room	300
Reading Room	350
Library Room	150
Toilet	150
Sitting Room	150
Waiting Room	150
Tuesdayr	150

1.5 Lighting Management

A lighting system audit aims to determine the level of lighting intensity in an area room [7]. Saving electricity consumption through lighting systems as followsreferred to in the regulation of the Minister of Energy and Mineral Resources of the Republic of Indonesia numr 13 of 2012 concerning saving electrical energy in article 4 paragraph 1 letter b, this is done by selecting alternatives where the aim is to achieve comfort [8] without ignoring energy savings. The selection and use of lamps can be seen below.

1. Use *energy*- saving lamps according to their intended purpose Energy efficient lamps are lamps that have low heat radiation and have a high level of lighting.
2. Reduce the use of decorative lights *(accessories*
3. Using electronic ballast on TL (neon) lamps.
4. Set the maximum electrical power for lighting (including ballast losses) according to Indonesian National Standards (SNI) for:
   a. The reception room is 13 watts/m² with a minimum lighting level of 300lux.
   b. 12 watt/m² workspace with the lowest lighting level 350 lux.
   c. Meeting room, active archive room 12 watt/m² with maximum lighting level low 300 lux. Archive warehouse 6 watts/m² with the lowest lighting level 150 lux.
   e. 4 watt/m² emergency stair room with the lowest lighting level150 lux.
   f. Parking area 4 watts/m², lowest lighting level 100 lux.
5. Use a lamp housing *(armature)* reflector that has reflections high light

6. Arrange switches based on area groups, so that they suit room utilization
7. Using an automatic switch using a timer and sensor light *(photocell)* for garden, corridor and terrace lights
8.Turn off room lights in buildings when not in use
9. Make use of natural light (sun) during the day by opening the window curtains sufficiently so that the light level is adequate for carrying out work activities
10. Clean the lights and the lamp housing *(armature)* if it is dirty and dusty so that it does not block the light from the lamp real. In contrast to light bulbs which emit yellow light, and lamps fluorescent which emit light that tends to be blue or green.

1.6. Room comfort and building comfort are based on the room comfort equation.

(RCE) and building comfort equation (BCE).
1. The original data in the room dr is compared with standard data ds from SNI, namely reference data from SNI standards to obtain equations in the form indoor parameter ratio (RCE) below

$$P = dr/ds \quad (4)$$
$$P1 = dr1/ds1 \quad (5)$$
$$P2 = dr2/ds2 \quad (6)$$
$$Pn = drn/dsn \quad (7)$$

P = Room Comfort Equation
P = Indoor parameter ratio equation
dr = indoor parameter data
ds = reference parameter data (SNI standard)
The size of the ds depends on the type of room (Table 1) so you can find out. comfort level as green building data.
2. If the comparison ratio in each room produces a comfort equation added up the indoor space (RCE), we will produce the comfort equation. building (BCE) or Pt which can be seen as in the equation below.

$$Pt = P1 + P2 + \ldots + Pn \quad (8)$$

Based on the ratio of room data parameters with SNI standard data for comfort sprices the ideal Pt = 1, for widening tolerances the comfort level can be added 1% to 10% . The comfort level of the P_t Building widened 1% until 5% is below.

$$1 - 0.01 < Pt < 1 + 0.01 \text{ (SI)} \quad (9)$$
$$1 - 0.05 < Pt < 1 + 0.05 \quad (10)$$

2 Research Methods

2.1 Time and Place of Research

The research location is in the Annur Center building which is located on Jalan Purnawirawan Raya in Gunung Terang Langkapura village, Bandar Lampung. The background for choosing this building as a research site is because this building is the largest building in the Gunung Terang area has a strong lighting system with a fairly

large electrical installation system, has a lot The lighting source and the lighting system need to be repaired. This research was carried out in August 2023. At 19.00 WIB and continued the following evening until finished.

2.2 Survey data on research objects.
Before the research is carried out, data that is the supporting capacity of the research is first collected so that the research can actually be carried out.

2.3 Research Work Stages
2.3.1 Controlling the Building Electrical Installation system.

When we started carrying out extensive research into the strong lighting in the Annur Center building, the first thing we did was control the building's electrical installation system, to ensure that the building's electrical installation system had no problems. The parameters we check are the voltage and current as well as the power used by the transformer in the building. The equipment used in this stage is a clamp meter which can be seen in Fig 1 below.

Fig. 1. Clamp meters.

2.3.2 Survey Data in the field.

When you want to carry out the process of measuring the strong lighting of the building, we check the height of the lamp relative to the floor so that we can find out the position of the lighting distance of the lamp for reading and writing media that still meet SNI standards. The equipment we use in Knowing the position of this light source is a digital laser meter which can be seen in Fig. 2 below.

Fig. 2. Digital Laser meters.

2.4 Determining the Position of the Lighting Data Collection Point

At this stage we take the position of data collection points almost throughout the room because almost all point positions in the room are used for activities by the occupants. Building Annur Center. The equipment we use in this activity is a digital laser meter which can be seen in Fig. 3. below.

Fig. 3. Manual meter.

2.5 Strong Lighting Data Retrieval

The lighting parameter is the parameter that we will examine, how strong the lighting is in the main room in the Annur center building because it is strong the lighting looks less than up to standard. Equipment used in this strong lighting measurement is an Envirometer which can be seen in Fig. 4. below

Fig. 4. Environmental meters.

2.6 Collecting research data.

Data from research on strong lighting is collected to be immediately processed in data processing, so that we can immediately get conclusions.

2.7 Research Data Processing

Data from research results in the field are then immediately processed and completed in operations that follow the laws of physics and engineering laws in the electrical field. Data processing involves Microsoft Office applications (Ms. Word and Ms. Excel), with SNI standards. If room R1 has E1 lighting strength and SNI standard lighting strength is E2, then the ratio of strong lighting between room R1 to SNI standard strong lighting is P, where the price is comparable. P is formulated as P = E1/E2. The E2 value for room strong lighting is based on the function of the room and the lighting level recommended by SNI. The conclusion from the three rooms is Pt = P1 + P2 + P3, if the P value for each room is ideal P1 = 1, P2 = 1 and P3 = 1 means the Pt is Pt = 1 + 1+ 1, Pt = 3 means the building's strong lighting is ideal. But where is the Pt price for the three rooms Pt < 3 then the strong lighting in the building is not ideal or less than ideal.

3. Results and Discussion

3.1 Data Processing Results of E1 Strong Lighting in R1 with E2 = 300 lux

Table 2. Room R1 (Meeting Room 1) with E sni = 300 lux.

No	LR-1	LR-2	LR-3	LR-4	LR-5	LR-6	LR-7	LR-8	LR-9	LR-10	A LR
1	0.2	0.22	0.19	0.2	0.2	0.2	0.18	0.2	0.1	0.2	0.18
2	0.2	0.21	0.21	0.2	0.2	0.2	0.21	0.2	0.2	0.2	0.21
3	0.2	0.24	0.25	0.2	0.2	0.2	0.21	0.2	0.2	0.2	0.22
4	0.2	0.22	0.22	0.2	0.2	0.2	0.26	0.3	0.3	0.2	0.23
5	0.2	0.25	0.29	0.3	0.2	0.2	0.2	0.2	0.3	0.3	0.25
6	0.3	0.3	0.31	0.3	0.3	0.2	0.23	0.3	0.2	0.3	0.27
7	0.2	0.19	0.28	0.3	0.3	0.3	0.32	0.3	0.3	0.3	0.28
8	0.3	0.35	0.29	0.3	0.3	0.3	0.23	0.3	0.3	0.2	0.28
9	0.3	0.29	0.28	0.3	0.3	0.3	0.32	0.4	0.4	0.3	0.31
10	0.3	0.32	0.29	0.3	0.3	0.4	0.36	0.4	0.3	0.3	0.33
11	0.3	0.32	0.28	0.2	0.3	0.4	0.31	0.3	0.3	0.3	0.31
12	0.2	0.28	0.24	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.27
											0.26

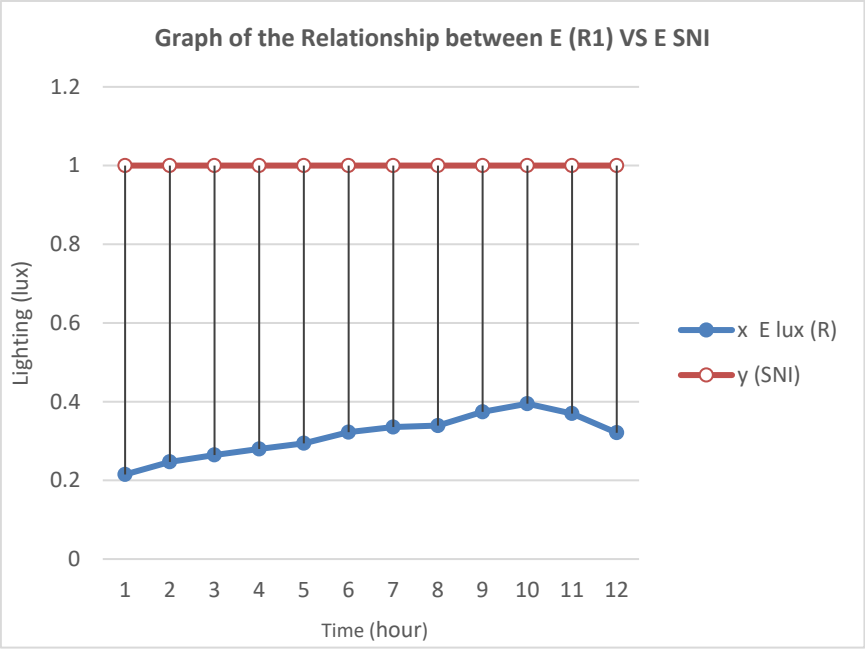

Fig. 5. Correlation between Lighting in R1 and E sni with Time.

3.3 Discussion

Based on the results of the data processing above, the ratio of lighting parameters in the room to SNI lighting standards for one parameter (lighting), the room comfort price P1 is obtained below.

P1 = 0.313

Because there is only one parameter measured in the room, the comfort of the room is only represented by parameter P1. In other words Pt = P1 where Pt is BCE and P1 is RCE. Based on the ideal limits of room comfort and building comfort, room R1 is not classified as a room with uncomfortable lighting because it is located outside the ideal comfort limits, based on the comfort limits which can be seen below

$$Pt = P1 = 0.313$$
$$1 - 0.05 < Pt < 1 + 0.05$$
$$0.95 < Pt < 1.05$$

Because the price Pt = 0.313 is outside the ideal price

In Fig. 5., the graph shows that the main room R1 has very different conditions from the other rooms. The main room in R1 is a room that is widely used for activities, especially worship activities, meetings and other activities such as reference reading activities, reading the Koran, meeting activities and other socialization activities between the congregation. This room is the center of activity, so it could be said that this room is a room that consumes a lot of electrical energy, being the center of activity. Based on primary data it turns out that the atmosphere

lighting that does not meet the requirements of SNI standards, namely below the curve at a price of 0.4, which is the best lighting strength in a building, this price is still below standard, however, this happens not simply because they do not understand the rules for lighting strength systems, but because it is done deliberately for the sake of saving costs. electricity bill payment. Based on the graph in Fig. 1., it is clear that the lighting strength is still very far below the SNI lighting strength standard line, so the lighting strength still needs to be increased for comfort in activities.

3.4. E1 Strong Lighting in R2 with E2 = 300 lux

Table 3. Room R2 (Meeting Room 2) with E sni = 300 lux.

No	LR-1	LR-2	LR-3	LR-4	A LR
1	0.1	0.1	0.07	0.1	0.07
2	0.1	0.1	0.1	0.1	0.09
3	0.1	0.1	0.1	0.1	0.1
4	0.2	0.1	0.1	0.1	0.11
5	0.1	0.1	0.08	0.1	0.08
6	0.1	0.1	0.06	0.1	0.07
7	0.1	0.1	0.09	0.1	0.09
8	0.1	0.1	0.09	0.1	0.09
9	0.1	0.1	0.09	0.1	0.09
10	0.1	0.1	0.1	0.1	0.09
11	0.1	0.1	0.1	0.1	0.1
12	0.1	0.1	0.11	0.1	0.1
13	0.1	0.1	0.12	0.1	0.1
14	0.1	0.1	0.08	0.1	0.1
15	0.1	0.1	0.05	0.1	0.07
16	0.1	0.1	0.1	0.1	0.09
17	0	0.1	0.08	0.1	0.07
18	0	0.1	0.08	0.1	0.07
					0.09

3.5. Relationship between E1 Strong Lighting in R2 VS SNI with E2 = 300 lux

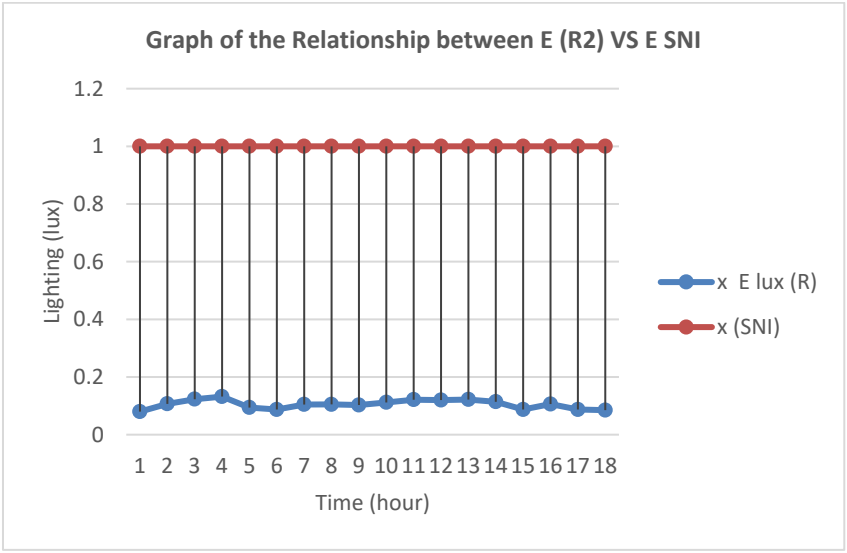

Fig. 6. Correlation between Lighting in R2 and E sni with Time.

3.6 Discussion

Based on the results of the data processing above, the ratio of lighting parameters in the room to SNI lighting standards for one parameter (lighting), the room comfort price P_2 is obtained below.

$P_2 = 0.104$

Because there is only one parameter measured in the room, the comfort of the room is only represented by parameter P2. In other words Pt = P2 where Pt is BCE and P2 is RCE. Based on the ideal limits of room comfort and building comfort, room R_2 is not classified as a room with uncomfortable lighting because it is located outside the ideal comfort limits, based on the comfort limits which can be seen below

$$Pt = P2 = 0.104$$
$$1 - 0.05 < Pt < 1 + 0.05$$
$$0.95 < Pt < 1.05$$

Because the price Pt= 0.104 is outside the ideal price

In Fig. 6., the graph shows that the second room has slightly different conditions from the other rooms. The main room for R2 is a room that is widely used for carrying out activities, especially activities, meetings and other activities such as reference reading activities, reading the Koran, meeting activities and other socialization activities between members. This room is the center of activity, so it could be said that this room is a room that uses a lot of electrical energy, being the center of activity. Based on primary data, it turns out that the strong lighting atmosphere does not meet the requirements of SNI standards not because it was done accidentally but was done to save electricity costs. Based on the graph in Fig. 2, it is clear that the lighting strength is still far below the SNI lighting standard line, namely at a price below 0.2, so the lighting strength still needs to be increased for comfort in activities.

3.7. E1 Strong Lighting in R3 with E2 = 150 lux

Table 3. Room R3 (Parking Room 3) with E sni = 150 lux.

No	LR-1	LR- 2	LR-3	LR-4	LR-5	LR-6	LR-7	LR-8	A LR
1	0.02	0.03	0.06	0.03	0.04	0.04	0.04	0.04	0.04
2	0.04	0.04	0.08	0.08	0.07	0.08	0.11	0.07	0.07
3	0.04	0.03	0.07	0.09	0.07	0.09	0.1	0.06	0.07
4	0.08	0.07	0.06	0.07	0.06	0.06	0.08	0.08	0.07
5	0.12	0.16	0.08	0.06	0.07	0.12	0.11	0.07	0.1
6	0.07	0.07	0.06	0.06	0.07	0.05	0.08	0.08	0.07
7	0.04	0.08	0.07	0.1	0.1	0.09	0.1	0.1	0.08
8	0.04	0.05	0.06	0.07	0.1	0.1	0.12	0.12	0.08
9	0.03	0.04	0.04	0.08	0.13	0.13	0.13	0.13	0.09
									0.07

LR = Lighting Ratio ALR = Average Lighting Ratio

3.8. E1 Lighting in Parking Spaces VS SNI Standard with E2 = 150 lux

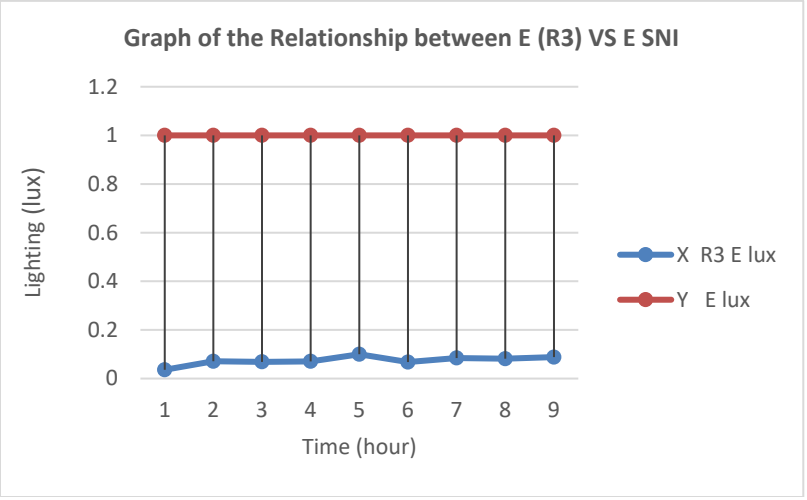

Fig. 7. Correlation between Lighting in R3 and E sni with Time.

3.9 Discussion

Based on the results of the data processing above, the ratio of lighting parameters in the room to SNI lighting standards for one parameter (lighting), the room comfort price P3 is obtained below.

P3 = 0.0743

Because there is only one parameter measured in the room, the comfort of the room is only represented by parameter P2. In other words Pt = P3 where Pt is BCE and P2 is RCE. Based on the ideal limits of room comfort and building comfort, room R_3 is not classified as a room with uncomfortable lighting because it is located outside the ideal comfort limits, based on the comfort limits which can be seen below

$$Pt = P3 = 0.0743$$
$$1 - 0.05 < Pt < 1 + 0.05$$
$$0.95 < Pt < 1.05$$

Because the price Pt= 0.0743 is outside the ideal price

In Fig. 7., the graph obtained from observations of the lighting strength in the parking room (room R3), this room has a quiet condition and almost all the activity is just for placing vehicles. Based on primary data, it turns out that the strong lighting atmosphere that does not meet the requirements of SNI standards is not merely a lack of understanding but because it is done deliberately to save costs on paying electricity bills. Based on the graph in Fig. 3., it is clear that the lighting is still far below the SNI lighting strength standard line, namely below 0.2, even though the ideal lighting strength is 1, so the lighting strength still needs to be increased for comfort in activities in the parking area.

4. Conclusion

1. Equal lighting strength in the main room. R1 has equal lighting strength which is still far from the standard (SNI = 1), namely 0.313
2. Equal lighting strength in the main room. R2 has equal lighting strength which is still far from the standard (SNI = 1), namely 0.1049
3. Equal lighting strength in the main room. R3 has equal lighting strength which is still far from the standard (SNI = 1), namely 0.0743

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