Adjustment Of Light Distribution In Auditorium Of Universitas Negeri Manado

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Abstract. This paper provides an overview about the visibility condition in an auditorium of Universitas Negeri Manado. As a place used for holding official meetings and numerous formal activities, it requires proportional light distribution. An experimental simulation about lighting system in auditorium is carried out based on data analysis using AutoCAD and Dialux. The simulation resulted paucity of light intensity and bleak radiance distribution which, based on Indonesian national standards, is noncompliance. Several methods of lighting adjustment are proposed: enlargement of exposure by replacing and setting glass material proportional to the incoming sunlight, adjustment of reflectance equipment in the vicinity, applying lightselves and setting light spots. Enlarging exposure and adjusting reflectance equipment permits 15% larger comfort area for user, based on DIALux simulation. Adjusting the use of solar control glass and lightselves at the aperture will reduce ablaze of light by up to 20%. Using LED reliably light offers magnificent brightness and providential low voltage.

1. Introduction

An auditorium, as a capacious place for large number of human assembly, needs to be designed properly considering the quality and quantity of building materials, geological and climatic factors, and convenience, such as thermal and lighting. In most cases, thermal and lighting are considered after the building has been built. Therefore, adjustment is almost always necessary in a construction.

This study aims to provide suggestible adjustment of lighting intensity optimisation of auditorium in Manado State University which is large and located on the hill of Tonsaru Minahasa the auditorium is mostly used to hold academic meetings such as graduations, university celebrations, and workshops and seminar. Further information regarding various layouts and functions of academic buildings at Manado State University such as the Auditorium presented by Sondakh et al. (8).

Fig (1). Auditorium

The study location is in the city of Tondano which is also the capital of Minahasa Regency, located on the island of Sulawesi at the position of 1.18 ° N and 124.45 -125.02 ° E, which is geographically located in the tropics and is quite humid. The climate characteristics of Tondano, which are in the...
mountains, have an impact on cool temperatures, generally causing a feeling of comfort throughout the day. The aim of the study is elaborated as to identify the distribution of lighting in the room and adjustments to lighting levels, both theoretically and through direct measurements and simulations. The auditorium as a case object is a meeting building which according to the building classification is included in the type of classification based on its activities for meetings. As a note, by Leslie L. Doelle (9), it can be classified as a rectangle. Doelle's writing (9) classifies rectangles by having a high level of sound uniformity so that there is a balance between the initial sound and the final sound. However, the weakness of this form is the long side because it makes the distance between the audience and the stage too far. The Manado State University auditorium with a stage concept in the speaker area has a great distance from the audience so it requires an approach in terms of lighting arrangements. guidelines, written in the style of a submission to J. Phys.: Conf. Ser., show the best layout for your paper using Microsoft Word. If you don’t wish to use the Word template provided, please use the following page setup measurements.

2. Content
During the day, the lighting distribution in public buildings is still not optimal in several areas and at certain times (Azizah, (2), Novianty (3), Setiawan (4), Yuniar (16)). Factors such as building design and layout are important to increase the lighting distribution. building materials plays important role in light distribution (Novianty (3)). Nevertheless, optimizing light intensity could be artificially adjusted. Several studies by Ardiyanto (5), Setiawan (4), Russel (7), Benya et al (6) and Bean (1) mentioned natural lighting (such as sunlight) is available as strategy to adjust light distribution. Placement of light points is also crucial to absorb natural lighting and distribute it (Benya (6)). The placement of the light points includes: adjustment of the lamp armature place, adjustment based on activity, adjustment of the light layout based on the room design, and adjustment of appropriate reflectance material. In addition, it is also necessary to understand the building orientation to improve lighting system through cross ventilation.

Sunlight orientation also provides lighting adjustment of building facades in tropical areas. Given the framework of the building, which mostly rectangular prism, the building will have four facades and each facade is triangular or square. However, the influence of the facade does not necessarily have an effect on the intensity of sunlight get through the room either directly facing East or to West. Nevertheless, the wider the surface area of the facade facing West or facing East, the higher the light intensity that can enter the room. Thus, the determination of orientation becomes a factor that can influence the facade as much as possible. In addition, the direction of the building axis also determines the heat intensity of the room. According to Lippsmeier (10), the axis length of a building is at least parallel to the east-west axis. The parallel- to-the- East-West-direction axis will maximize sunlight exposure to the building facade.

Additional wide shade also reduces sunlight to the room, thus the placement of the shade is necessary to suppress heat radiation but not blocking incoming sunlight. Visual comfort is quantified by empirical result on climatic variables (sunlight), artificial light, and human parameters (eye-vision). Then, empirical modeling is carried out to obtain a formula that shows a lighting scale related to the sense or physical perception of humans to their surroundings.

2.1 Method
Location and sampling is carried out auditorium, in consideration of capacious room with supposedly strategical lighting system depended on activities inside the room. Sample points are determined by the level of use of the workplace. Six (6) points is used as measuring points in the room sized 54 x 40 m, without changing furniture arrangement of the room. Six (6) volunteers (A, B, C, D, E, F) are placed at the measuring points. Nevertheless, adjustment to optimize lighting distribution is carried out during simulation to align the national lighting standard (SNI 03-6575-2001). SNI 03-6575-2001 is Indonesia National Standard on lighting based on the framework of building. It also provides technical guidelines contains how to calculate of lighting strength, either centrally or dispersely.
Distribution of lighting is calculated by ceiling cavity ratio (CCR), room cavity ratio (RCR), and floor cavity ratio (FCR). Utilization factor (UF) is defined by the lamp armature available in the auditorium area (Table 1).

### Table 1. Data Comparison Existing and Adjustment

| Measurement          | Existing (Max) | Simulation (Max) | Adjustment (Max) |
|----------------------|----------------|------------------|------------------|
| 09.00 am             | 70             | 90               | 200              |
| 12.00 am             | 90             | 120              | 200              |
| 03.00 pm             | 80             | 100              | 200              |
| Wall I               | 70             | 80               |                  |
| Wall II              | 70             | 80               |                  |
| Wall III             | 70             | 80               |                  |
| Wall IV              | 70             | 80               |                  |
| Floor                | 50             | 60               |                  |
| Ceiling              | 70             | 80               |                  |
| RCR                  | 1.65           | 2.36             |                  |
| CCR                  | 0.004          | 0.01             |                  |
| FCR                  | 0.177          | 0.177            |                  |
| Spot of Light        | 8              | 33               |                  |
| UF                   | 0.43           | 0.48             |                  |
| MF                   | 0.8            | 0.8              |                  |

The measurement of light intensity is carried out on October 1 at period 09.00, 12.00, and 15.00 by luxmeter and validation by simulation of DIALux. The software used includes DIALux version 8, and the AutoCAD. DIALux requires input data from AutoCAD. The output is design of the indoor lighting optimization adjustment aligned to national lighting standard.

#### 2.2 Discussion
Measurement of brightspot at 09.00, 12.00, and 15.00 respectively is shown in Table 2. The value of the measurement is more than a half as low as the value of lighting standard based on Indonesian National Standard. The beam of light passed through the window gradually evades as it away from the window,
means relatively less sizeable windows are not sufficient to enlight the entire spacious room. Conversely, activities mainly occur in the middle part of the room. Although based on the questionnaire results, the litless room is visibly acceptable (Tables 3, 4, 5), the improvement of substandard lighting is suggestible.

Table 2. Result of the Measurement on 1st October 2020

| Time | Unified Facilities | SNI | Result (Max) |
|------|-------------------|-----|--------------|
|      | Ambient           | Task/Workplace |              |
| 09.00| 200-250 lux       | 200-300 lux   | 70 lux       |
| 12.00| 200-250 lux       | 200-300 lux   | 90 lux       |
| 15.00|                   |               | 80 lux       |

Table 3. Result of the Measurement and Questioner Response at 09.00 am

| No  | Point of Sample | Range of Age | Period of Activity (hour) | Wearing Glasses | Lighting Response | Measurement |
|-----|----------------|--------------|---------------------------|-----------------|-------------------|-------------|
|     |                | 20-30        | 31-40                     | 41-50           | 1/5               | 6/10        | 11/15      | Good | Average | Poor | Lux meter | Dialux |
| 1   | A              | -            | -                         | -               | -                 | x           | x          | x    | -       | -   | 68         | 88     |
| 2   | B              | x            | -                         | -               | -                 | -           | x          | x    | -       | -   | 68         | 90     |
| 3   | C              | -            | x                         | -               | x                 | -           | -          | x    | -       | -   | 67         | 89     |
| 4   | D              | x            | -                         | -               | -                 | x           | x          | x    | -       | -   | 67         | 88     |
| 5   | E              | -            | x                         | -               | -                 | x           | x          | x    | -       | -   | 70         | 89     |
| 6   | F              | x            | -                         | -               | -                 | x           | x          | x    | -       | -   | 70         | 88     |

Table 4. Result of the Measurement and Questioner Response at 12.00 am

| No  | Point of Sample | Range of Age | Period of Activity (hour) | Wearing Glasses | Lighting Response | Measurement |
|-----|----------------|--------------|---------------------------|-----------------|-------------------|-------------|
|     |                | 20-30        | 31-40                     | 41-50           | 1/5               | 6/10        | 11/15      | Good | Average | Poor | Lux meter | Dialux |
| 1   | A              | -            | x                         | -               | -                 | -           | x          | x    | -       | -   | 88         | 108    |
| 2   | B              | x            | -                         | -               | -                 | -           | x          | x    | -       | -   | 88         | 112    |
| 3   | C              | -            | x                         | -               | -                 | -           | x          | x    | -       | -   | 87         | 114    |
| 4   | D              | x            | -                         | -               | -                 | -           | x          | x    | -       | -   | 87         | 114    |
| 5   | E              | -            | x                         | -               | -                 | x           | x          | x    | -       | -   | 90         | 120    |
| 6   | F              | x            | -                         | -               | -                 | x           | x          | x    | -       | -   | 90         | 118    |

Table 5. Result of the Measurement and Questioner Response at 03.00 pm

| No  | Point of Sample | Range of Age | Period of Activity (hour) | Wearing Glasses | Lighting Response | Measurement |
|-----|----------------|--------------|---------------------------|-----------------|-------------------|-------------|
|     |                | 20-30        | 31-40                     | 41-50           | 1/5               | 6/10        | 11/15      | Good | Average | Poor | Lux meter | Dialux |
| 1   | A              | -            | x                         | -               | -                 | x           | -          | x    | -       | -   | 78         | 90     |
| 2   | B              | x            | -                         | -               | -                 | -           | x          | x    | -       | -   | 78         | 92     |
| 3   | C              | -            | x                         | -               | -                 | -           | x          | -    | -       | -   | 77         | 94     |
| 4   | D              | x            | -                         | -               | -                 | -           | x          | x    | -       | -   | 77         | 94     |
| 5   | E              | -            | x                         | -               | -                 | x           | x          | x    | -       | -   | 80         | 100    |
| 6   | F              | x            | -                         | -               | -                 | x           | x          | x    | -       | -   | 80         | 98     |
Based on the measurement, the lighting level is calculated on a workplace to obtain appropriate standard of lighting. Distribution of lighting existing is calculated by ceiling cavity ratio (CCR), room cavity ratio (RCR), and floor cavity ratio (FCR). Utilization factor (UF) is defined by 70% CCR, 70% RCR, 50% FCR, as the material of floor is less reflective. Given the value of CCR = 0.04 and FCR = 0.17 according to Sangkertadi table (11), ceiling coefficient \( C_{\text{ceiling}} = 71\% \) or 0.71. the UF table which is obtained from the results of CCR = 0.7 x 0.7 (ceiling coefficient) = 0.49; FCR = 0.7 x 0.5 (floor coefficient) = 0.35. the value in the Utilization Factor (UF) table is corrected, where the ceiling coefficient = 0.49 is rounded to 0.5; floor coefficient = 0.35 rounded to 0.3 and RCR 1.65. then the value in table Utilization Factor (UF) is 0.43. The light intensity of the room is 200-250 lux.

Calculate the light intensity with formula (Sangkertadi, (11)).

\[
\phi_r = E \times A \\
\phi_r = 180000 \text{ lux} \\
\phi_r = \phi_D \times MF \times UF \\
\phi_D = \frac{\phi_r}{MF \times UF} \times \frac{1}{90000} \\
\phi_D = 0.8 \times 0.43 \\
\phi_D = 523.255 \text{ lumen (200 lux), assumption if using day lighting. So if we adjust the light distribution, we can using formula without day lighting max 100 lux, (200-100) = 100 lux} \\
\phi_r = E \times A \\
\phi_r = 90000 \text{ lux} \\
\phi_r = \phi_D \times MF \times UF \\
\phi_D = \frac{\phi_r}{MF \times UF} \times \frac{1}{90000} \\
\phi_D = 0.8 \times 0.43 \\
\phi_D = 261.627 \text{ lumen} \\
\phi_L = (\text{lumen output} \times 2) \ldots \text{ using 2 lamps} \\
\phi_L = 4025 \times 2 = 8050 \\
N = \frac{\phi_D}{\phi_L}, \quad N = \frac{261627}{8050}, \quad N = 32.5 \text{ become 33 point of lamps} \\
\text{The adjustment of lamp is 33 point of lamps.}
\]

![Lamp LED](image)

**Fig 3.** Type of Lamp LED
Based on simulation, lighting adjustment for the room is up to 180,000 lux include daylighting. Therefore, additional lamps in twelve 33 points is can be done. Layout points are adjusted in simulation based on the distance between lamp points of 4-6m y range is 4-6 m, and from the wall axis 0.87 m. the value of E = 200 lux and E_max = 300 lux, which exceeds the SNI 03-6575-2001 standard. DIALux simulation approach provides an overview of the model in several light intensity experiments. Further research is needed with certain building characteristics to produce lighting levels that comply SNI standards. The development of lighting models will be increasingly complex with simulations with approaches based on existing geometric characteristics and location data.

3. Conclusion

The result shows different lighting intensity at each measurement point. Based on the measurement results, it was found that it was still below the standard results set by SNI, namely 60-100 lux. With the approach of the reflectance coefficient of the material, there has been a significant difference in the strength of the light. Based on this, a simulation was carried out using a building geometry data approach and lighting. The results based on simulation modeling obtained an average light strength that is close to the standard.

Recommendations for adjustments based on findings and building characteristics include the adjustment of proportional glass material selection in an effort to include natural lighting where the ratio is 20-30% compared to the surface area of the wall. In addition, the use of glass material to control the incoming light so that it can maximize light evenly. The use of energy efficient lighting can control the energy consumption of buildings.

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