Evaluation of lighting design on Working Space (Case Study: Indo Global Mandiri Faculty office)

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Abstract. These days when a well-lit working space yet with sustainable building are significant issues in building performance. A building that designed to be an office should have enough illumination and low energy consumption. The newest constructed and finished building designated for Faculty members of Indo Global Mandiri University (UIGM) is expected to provide the optimum well-lit working space that can give a good support for accomplishing work and task given. Therefore, an evaluation on illumination level obtained from lighting design on working space for this building should been done. Evaluation is carryout by simulation tools to find out the illumination level contour, and daylight factor. Several factors will be accounted for the evaluation such as opening, arrangement and type of luminaries, and material. The method used in this evaluation is simulation software that shows the value of illumination on working level plane and validate with field measurement. The result of this evaluation will show whether lighting design on working space in the case study meets the standard illumination for working space. Optimized daylight for minimum energy consumption in artificial lighting could be the proposed recommendation.

1. Introduction
A well-lit working space yet with sustainable building is significant issue in building performance. In working environment, productive and efficient energy-use is prioritized, and problem solving lighting design is expected to support it [1]. Illumination that gives comfort and convenience in working space must be considered in lighting design. Good lighting should provide for the needed level of visual performance, but it also determines spatial appearance, it provides for safety, and it contributes to wellbeing [2] - [4]. One of the factor that contribute to the good lighting is indicated by lighting design that meets standard of illumination required for completing certain levels of task difficulties.

Evaluation is needed to ensure that lighting design is well-design for building’s purposes. A good visual comfort determined by sufficiently high horizontal illuminances, properly distributed light on the workplane (appropriate illuminance uniformities) and avoided discomfort glare (from luminaries or from window) [5]. But a good visual comfort is not the only aspect to be considered while 30% of energy consumptions in an office building came from electricity used for artificial lighting [6]. Artificial lighting is responsible for a large part of an office building's electricity needs. In order to reduce this electricity consumption, important efforts have been made during the last decades and will still have to be made in the future [7].

Result from this evaluation will determined whether lighting design for the working space is need to be revised or not. And when a revised is needed, an efficiently energy consumption plan should be considered while revising lighting design. Thus revised lighting design should provide maximum visual comfort and efficient energy consumption.

2. Literature review
Daylight and artificial light are factors that contribute to the illumination level. Optimum daylight is gain from passive design from window opening and sky illumination. An artificial light is designed to
be flexible thus energy consumption should be considered. Daylight also as one of the key role in occupants’ visual comfort as well as developing a sustainable environment [8]. Artificial lighting design is defined by illumination method, type, pattern, and planning calculation. [9].

There are several standard for illumination level for working space. It depends what kind of working space that designated. Illumination level for office working space is range between 300-350 lux according to Indonesian Nasional Standard (SNI) [9]. To obtain a visual comfort, the minimum illumination level should be achieved. Illumination level depends on flux from daylight and artificial light. Daylight flux affect by several factors which are orientation, opening, and sky condition. While the artificial light obtain from electrical lighting luminaires and arrangement.

Working space in office building should well-lit as one of the requirement of visual comfort that support work performance. Working in a well-lit environment will increase the durability of worker especially that working with computer and diligent task.

3. Methods

3.1. Models

The latest asset addition to Indo Global Mandiri University campus on Palembang is a twelve stories building called Gedung C. the building was finished in the end of 2019 and start being used in early 2020. Facing northeast, this 12 stories building is dedicated to students, Faculty’s members, management of this university, and foundation management. The first until fifth floor was consisting of classrooms, computer laboratories, workshop rooms, and consultancy rooms. Faculty working spaces are on seventh to tenth floor. While eleventh is dedicated to university and foundation management.

Placed on tenth floor, the lecturer and staff members of engineering faculty were clustered based on departments. Varies for five to ten members, the working spaces of faculty members were divided into rooms. From figure 1, floor plan of tenth floor area divided into 13 rooms. Faculty members are in room 2-3, 5, 6, 8, and 9 that used for working space while room 1, 4, 7, 10, 11-13, are circulation and services area. Rooms that will be evaluated are rooms allocated for working space.

![Figure 1 layout of 10th floor Gedung C](image)

3.2. Measurement

Method used in this research was computer aided simulation on lighting. Calculating the daylight to determine the illumination level reached. The specific date and time is considered as baseline calculation. The date chosen is September 23rd, 2020 solstice of sun with the time is set on 8 am, 12 am, and 4 pm. The generated scenario was two condition, daylight only and daylight with artificial light. The computer software use is Dialux Evo 9.
Measurement of illumination level that is analyzed is the average illumination level for each room. And the arrangement of the artificial lighting is place as it is on the real room. The object of measurement is horizontal plane. Working plane is the standard 80cm raised from floor.

4. Finding and discussion
Evaluation of illumination level of daylight and artificial light is utilize a lighting software. For the purpose of this research, the condition that evaluation is 8 a.m. in the morning, 12 p.m., and 16 p.m. date of the evaluation is solstice time where sun is on the equator imaginary line. The figure 2 presents results of the simulation on daylight only while figure 3 present results of simulation of daylight factor combined with artificial light on.

![Figure 2. Iso-contour of illumination level from daylight on Sept 23rd 2020 (a) 8am, (b) 12am, (c) 4pm](image)

| Table 1. Illumination level from daylight |
|------------------------------------------|
| Room | Illumination level (lx) |
|      | 8 am | 12 am | 4 pm |
|      | Max LV | Min LV | Average LV | Max LV | Min LV | Average LV | Max LV | Min LV | Average LV |
| No   |      |      |      |      |      |      |      |      |      |
| 1.   | Room 2 | 403.0 | 11.2 | 47.7 | 757.0 | 21.1 | 89.7 | 365.0 | 10.2 | 43.0 |
| 2.   | Room 3 | 347.0 | 11.9 | 40.2 | 653.0 | 22.3 | 75.6 | 315.0 | 10.8 | 36.4 |
| 3.   | Room 5 | 356.0 | 15.4 | 60.2 | 669.0 | 28.9 | 113.0 | 323.0 | 14.0 | 54.6 |
| 4.   | Room 6 | 368.0 | 12.5 | 65.2 | 692.0 | 23.5 | 123.0 | 334.0 | 11.4 | 59.1 |
| 5.   | Room 8 | 776.0 | 34.3 | 187.0 | 1459.0 | 64.5 | 352.0 | 704.0 | 31.1 | 170.0 |
| 6.   | Room 9 | 421.0 | 27.8 | 90.4 | 792.0 | 52.4 | 170.0 | 382.0 | 25.3 | 82.0 |

The figure 2 and table 1 show that with only daylight, illumination for working space was not meeting the standard requirement. The average of illumination level on three different time are range between 36.4 to 352 lux. From the figure shown, at 8am, all rooms are underlit. In 12am 1 of the room (room 8) is well-lit (352 lux), and at the third simulation (4pm) all the room are underlit. this conditions happens because the illumination level depends on the sky condition. The brightest condition is at 12am. The room that illuminates well on 12 am has more opening that others room.

The second simulation is adding artificial lighting arrangements as designed. The luminaires are T8 16W with cool daylight color (6500K). Same time simulation, 8am, 12am, and 4pm. Results are shown in figure 3 and table 2. Range of average illumination level within rooms is varies between 154 to 575 lux. Significantly increased but not all rooms reach the standard illumination level that required. There are four of six room that have under-lit illumination level.
From the simulation is stated that the illumination generated in the working area is lower than standard value designated by SNI which was 350 lux as seen in figure 3 and table 1 within the hour designated. And the artificial light that design for the area is increasing the illumination but not enough to reach the standard illumination level. Significantly increase but not all room are well-lit.

### 5. Conclusion

Although the illumination gained for the working space was lower than standard value, the visual comfort for the user was enough. But for further use and health, the minimum standard should be provided. The effort to meet the minimum requirement can be achieved by changing the luminaries, arrangement of luminaries, or the arrangement working space.

Additionally, this research only focus on the measurement of illumination level from software simulation. The other aspect such as users’ satisfactory should be involved in the future study. Optimized daylight for minimum energy consumption in artificial lighting could be the proposed recommendation.

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