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ANALYSIS OF DAYLIGHT DISTRIBUTION ON BUILDING HEIGHT AND SPACE DEPTH.

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Abstract. Lighting design is one of the priorities in designing buildings. Natural lighting can reduce energy consumption in buildings. Aesthetic levels are the basis of the planning concept, but need to pay attention to the concept of using natural lighting, in order to realize the energy-efficient building design. The purpose of the study was to determine how the level of illuminance affects the opening area, depth of space and height of the building. Quantitative research method is to analyze statistical data from measurements of illuminance levels in space. The results of the study concluded that the level of illuminance in the meeting room of the Center of Technology building in Hasanuddin University exceeded the illuminance standard. The extent of openings in the building envelope affects the illuminance level in space. Natural light distribution affects the height of the building's floor and the depth of space. Based on this conclusion, it is expected that in designing a building it is necessary to pay attention to the building facade, so that the distribution of natural light is not too high into the building and to avoid negative effects such as glare, high brightness and contrast.

Keywords: illuminance level, daylight, light distribution

Introduction

Global Warming is a natural phenomenon which causes an increase in temperature at the earth's surface. Global warming will be followed by climate change, namely increasing rainfall in some parts of the world which sometimes causes floods and erosion hazards. But otherwise found in other hemispheres will experience a prolonged dry season due to rising temperatures

Other changes that occur are increasing sunlight, which causes the level of illuminance in the sky to increase as well. Sugianto (1970) The score of 10,000 lux and Rahim (2009) concludes the planning sky mean of 13.4 klux. Change the illuminance level on the outside of the building improved in the last few years. This is caused by global warming, so that the light from the Sun is higher. The condition of the sky affects the distribution of light into the building and Light distribution affects the level of illuminance in space. This study will analyze the level of illuminance in the meeting room of Center of Technology Hasanuddin University building on clear sky conditions.

Literatur Study

Indonesia is a tropical region that has abundant availability of light, so it is necessary to think of Architects using this light as one of the factors in designing buildings, especially in many-storey

buildings. Integration between natural lighting (sunlight) and artificial (lighting) needs to be considered to optimize the lighting system in designing buildings. The use of natural lighting will minimize the use of energy as an artificial lighting source, but it is necessary to consider the negative effects including: glare, brightness and bright. Satwiko (20 ..) stated that Indonesia is a humid tropical climate with high radiation characteristics (80% per year), high relative humidity (60% -80%) and unstable wind speed (velocity) (between 0-30 m / second).

Orbits (circular paths of the earth) are not circular, but ellipses so that the distance between the earth and the sun varies with the rotation of the earth around the sun. This distance varies around 3.3 percent and this is what results in small changes in the sun's intensity of solar radiation received annually. According to Jamala, N (2017) the result showed that the area of the building envelope which are equipped with wall openings of the very wide window, can be absorb natural light to the maximum so that the building has a relatively high level of illuminance, therefore occurs naturally light reflectance of 45.5%, but the negative effects occur namely glare and brightness so it is necessary to use a protective building façade as excessive sunlight.

SNI 03-2396-2001 explains that the daylight natural lighting factor is the ratio of the level of lighting at a point in the room to the level of flat lighting in an open field. This is a measure of the performance of the room's light hole. SNI-6575-2001 that is about the procedure for designing artificial lighting systems in buildings. This standard includes minimum requirements for artificial lighting systems in buildings. The preparation of this standard refers to the National Electrical Code (NEC), Illuminating Engineering Society (IES), International Electrotechnical Commission (IEC) and Australian Standard. Recommendation on illuminance level standard in meeting rooms is 300 lux, work space is 350 lux, archive warehouse is 150 lux and others.

Australian standard (1990) explained that the sun is the primary source of daylight. However its light diffused and scattered by the earth's atmosphere, so that the whole sky becomes a secondary source. Daylight therefore is the sum of light which is produced directly by the sun (sunlight) and indirectly by the scattering effect of the atmosphere (skylight). These two component of daylight are referred to separately although the term daylight is often use when referring to skylight being the main source of daylight in buildings. Both sunlight and skylight can be use to illuminate interiors directly through openings (windows, rooflights, etc) or indirectly by being reflected from external surfaces or devices (ground, building facades, shading control, etc).

Sunlight as a natural lighting source is expected to be able to enter the building to its full potential, but it should be noted that the negative effects. Brightness (brightness) is the subjective response of the eye to the light emitted / reflected by an object or the level of light of an object referring to human perception that observes the object. There is no special meaning of the brightness level as in lumination, so that the brightness level of an object cannot be measured (has no units), or is subjectively qualitative and generally high lumination has implications for high brightness as well

In designing space lighting, standard illuminance recommendation is a reference in designing space lighting and are one of the parameters for creating visual space comfort. Especially in Indonesia, standards recommended based on SNI 03-6575-2001 concerning the procedure for designing artificial lighting systems in buildings are referring to the National Electric Code (NEC), Illuminating Engineering Society (IES), International Electrotechnical Commission (IEC) and Australian Standard. The level of illuminance on SNI 2001 recommendations based on the function of the room for example for office buildings, namely the director's office, work space, recommended computer room of 350 lux, meeting room of 300 lux, image space of 750 lux, archive warehouse of 150 lux and active archive space of 300 lux. Tommy Goven and Lotta Bangens (2002) describe their research that respondents prefer ceiling of illuminance level is higher than the lumination level of the work field and luminaire / wall illuminance ratio higher than luminaire / ceiling illuminance ratio, this also shows higher wall illuminance from ceiling illuminance

Utilizing sunlight as the main light source by creating access to various spaces in the building is one simple step but requires careful design consideration. Absolute thorough consideration is made in each design process so that the resulting building is not only environmentally friendly, but also comfortable to use and has a strong character and identity (Manurung, 2012). Japanese authors

Nakamura et al. (1985) have classified into three groups sky condition i.e. overcast, clear and intermediate trying to define the luminance distribution of the intermediate sky.

Methodology

Quantitative descriptive research method was applied statistical data from the level of illuminance measurement at the measuring point inside the building. Data analysis using Excel program (bar and linear diagram) and Autodesk Ecotech program. The study was conducted at the meeting room of the building of the COT (Center of Technology) Faculty of Engineering Hasanuddin University. This building is the head office of the Faculty of Engineering, which consists of the Deans 'and deputy of Deans' workspace, meeting rooms, Quality Assurance rooms, administration rooms, and others. The meeting room at the COT building is located on floors 1,2 and 3.

This room is surrounded by a building glass opening in the form of massive glass. Orientation Building COT leads to the south while the envelope of meeting room buildings is oriented in two directions, namely Southeast and Southwest (figure 1). Measurements are made at the measuring point in the meeting room, which is designed using A-H notation and 1-8. The division of the measuring point zones is in the building veil 10 ft (Zone A) and right (Zone B), then the measuring point of the middle area of the space (Zone C) as shown in Figure 2 below.

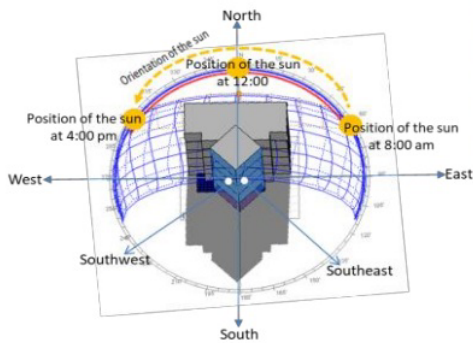


Figure 1. Position of the Sun

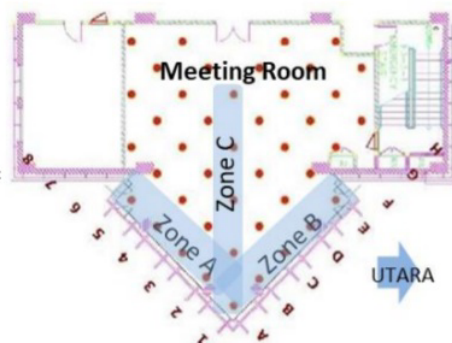


Figure 2. Measurement point on zona A, B dan C

Measurements are made in the morning (8:00 a.m. to 9:00 p.m.), noon (12:00 p.m. to 13:00 p.m.), and the afternoon (at 3 p.m. to 4 p.m.) Sky Intermediate and Sky Overcast. The rotation of the sun from east to west and the shadow of different buildings occur in the morning, afternoon and evening as shown in the following (figure 3).

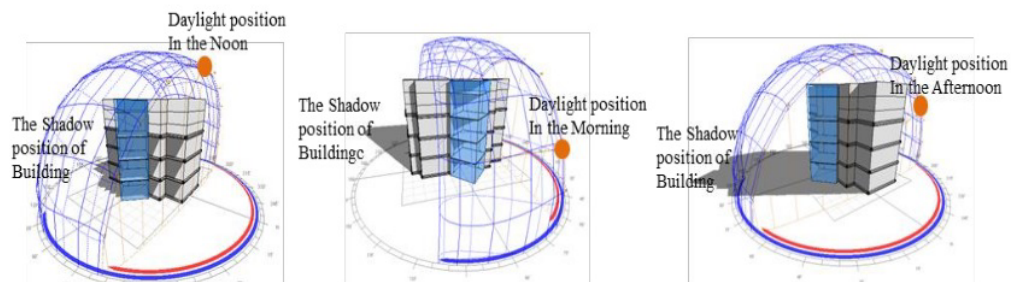


Figure 3. The shadow and daylight position of the building

Result and Discussion

3.1. Research object

The meeting room at the COT Building (Center of Technology) is located on floors 1, 2 and 3. This room, directly related to the building envelope in the form of massive glass, as shown figure 4 below.

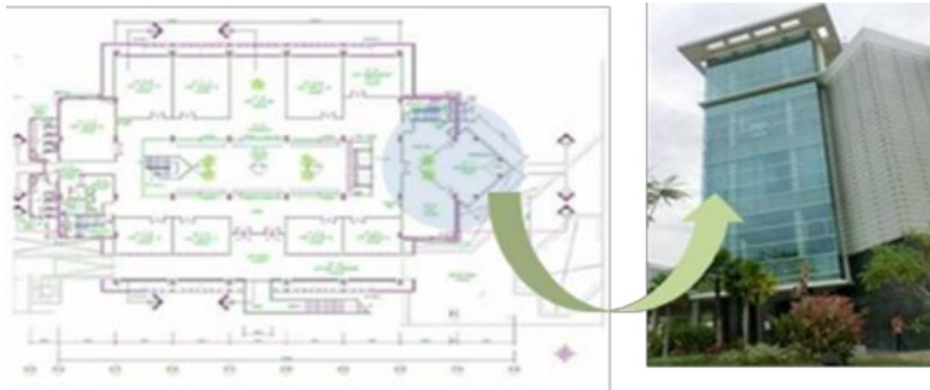


Figure 4. 1st Floor Plan and building view

Meeting room on the 1st floor, functioned as a meeting room during guest visits from other universities. In addition, it also functioned as an internal meeting room for lecturers of the Faculty of Engineering, Department of Industry. The front view of this room, surrounded by a building envelope in the form of massive glass. The building envelope is angular so that the light distribution comes from the left and right sides of the building envelope as shown in Figure 5 below.

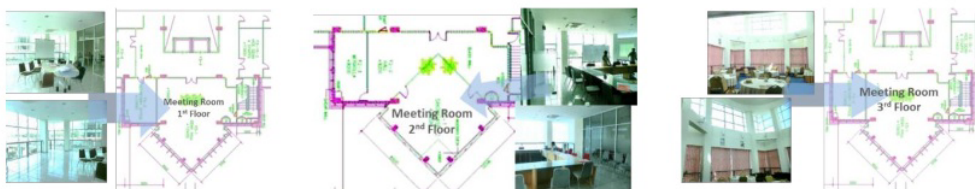


Figure 5. Meeting Room on 1st, 2nd and 3th Floor

On the 2nd floor there is a meeting room for the lecturer of the Engineering department of the Machine department. In addition, this space is also used as a final exam room for Mechanical Engineering students. Meeting rooms on the 3rd floor are multi-functional, because this space is used as a gathering place for lecturers who have positions in the Faculty of Engineering of Hasanuddin University. In addition, this space also functions as a meeting room for visitors to the Faculty of Engineering of Hasanuddin University. The 3rd floor is the highest floor in this building and the building envelope opening in this room is wider than the 1st and 2nd floors (figure 5).

3.2 Analisis data hasil pengukuran pada kondisi langit clear, intermediate dan overcast sky.

The condition of the sky on 14-22 June 2017 is not constant, namely clear, intermediate and overcast sky. Figure 8 shows a graph of the measurement results of illuminance on June 14-22 2017 in the morning, afternoon and evening. Measurements are made in clear sky conditions namely; (a) morning and afternoon on 14, 15, 16, 19 and 22 June 2017; (b) on the afternoon of the 15th and 19th of June 2017.

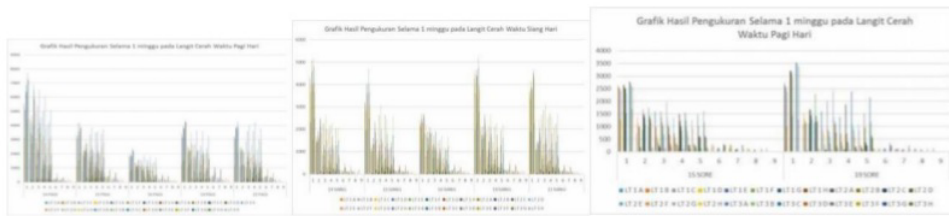


Figure 6. Result of measurement graph in the morning, noon and afternoon

3.3. Analisis titik ukur Zona A (area kanan se7bung bangunan)

Placement of the measuring point in Zone A is located on the left side area of the building envelope opening. This measurement is carried out to determine the percentage of sunlight distribution in the Zone A. area

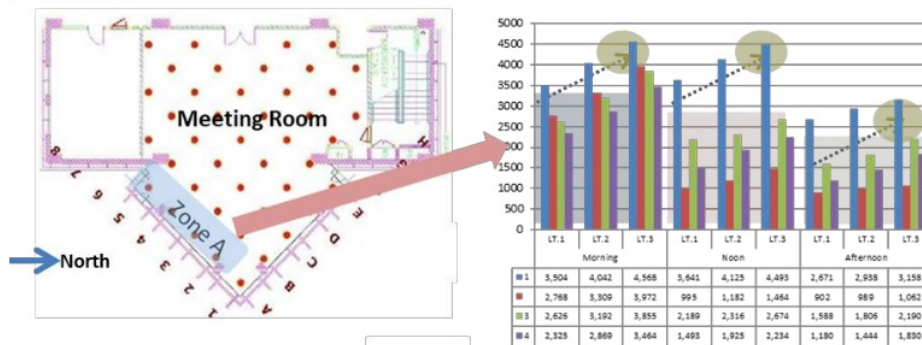


Figure 7. Grafik tingkat iluminasi pada Zona A

The measurement results in the Zone A meeting room show that in general, the level of illuminance during the day is higher than in the morning and evening, as shown in Figure 7.

3.3 Analysis of Zone B measuring points (left area of building envelope)

The area in Zone B shows that the highest illuminance level occurs during the day. Zone A (AH point) is located in the building envelope area facing northwest, so that in the morning, afternoon and evening the distribution of light enters the room decreases from the measuring point A to D. This can be seen on the 1st, 2nd and 3rd floors in the morning, day and evening that has a level of illuminance going down from the front towards the back of the building envelope.

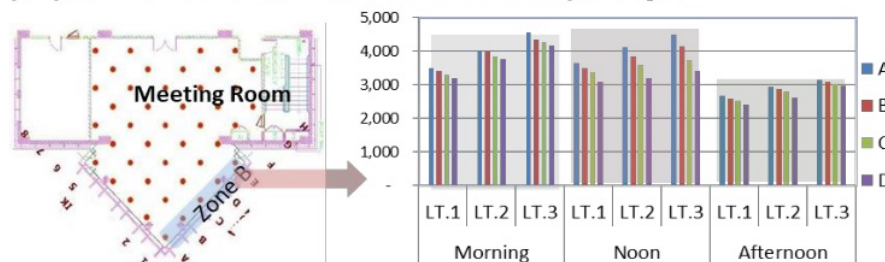


Figure 8. The level of illuminance on meeting room on 1st, 2st, and 3rd Floor

3.4 Analysis of Zone C measuring points (middle area of space)

The measuring point in the middle area of space (zone C) is to find out how the influence of the depth of space on the level of illuminance. In area C zone has a light distribution from the left and right sides

of the building envelope. Measurement results at measurement points 1A to 5D as shown in table 1 below.

Table 1. Result of measurement level of illuminance

Time	Floor	Measurement Point				
		1A	2B	3C	4D	5E
Level of illuminance (lux)						
Morning	1 st Floor	3,504	2,458	1,678	924	535
	2 nd Floor	4,042	2,688	1,743	999	583
	3 rd Floor	4,568	3,290	2,182	1,584	140
Noon	1 st Floor	3,641	1,985	983	544	244
	2 nd Floor	4,125	2,059	1,094	555	282
	3 rd Floor	4,493	2,461	1,573	1,035	68
Afternoon	1 st Floor	2,671	1,445	688	337	219
	2 nd Floor	2,938	1,645	980	604	181
	3 rd Floor	3,158	2,017	1,171	831	55

Table 1 shows that the farther away from the opening of the building envelope, the lower the illuminance level. For example: the illuminance level in the morning on the 1st floor is point 1A at 3504 lux and 5E at 535 lux. This level indicates that the farther away from the building envelope, the illuminance rate decreases. In the zone C area, the highest illuminance level is during the day and the lowest in the afternoon. The results of the analysis show that the maximum illuminance level is during the daylight, this happens on floors 1, 2 and 3.

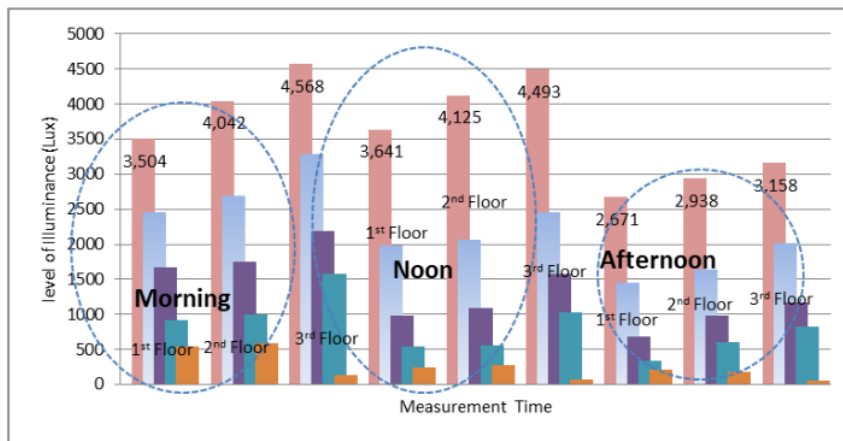


Figure 9. Illuminance level graph on Zone C

The average level of illuminance in Zone C, is made in graphical form to facilitate analysis of the decrease in illuminance level into space (figure 11). Measurement results in the middle area of the meeting room (Zone C) are the measurement points A1, B2, C3, D4 and E5 as follows:

- Morning: 3504 lux (1st floor), 4042 lux (2nd floor) and 4568 lux (3rd floor)
- Daytime: 3641 lux (1st floor), 4125 lux (2nd floor) and 4493 lux (3rd floor)
- In the afternoon: 2671 lux (1st floor), second floor 2938 lux and 3158 lux (3rd floor)

The mean level of measurement results in Zone C (points A1, B2 and C3) by the clear sky conditions as shown in Figure 12 below. The illuminance level on the 1st floor is 3504-2671 lux, the second floor is between 4042-2938 lux and the third floor is between 4568-3158 lux. This shows that the distribution of light in the morning, afternoon and evening will increase if the building gets higher.

Furthermore, analyzing the measurement data in the C zone area is by making the mean levels on floors 1, 2 and 3 in the morning, afternoon and evening, but by not entering the A1 measuring point, because the level fluctuates. This is done to confirm the occurrence of a decrease in illuminance level if the measuring point is further away from the building envelope opening.

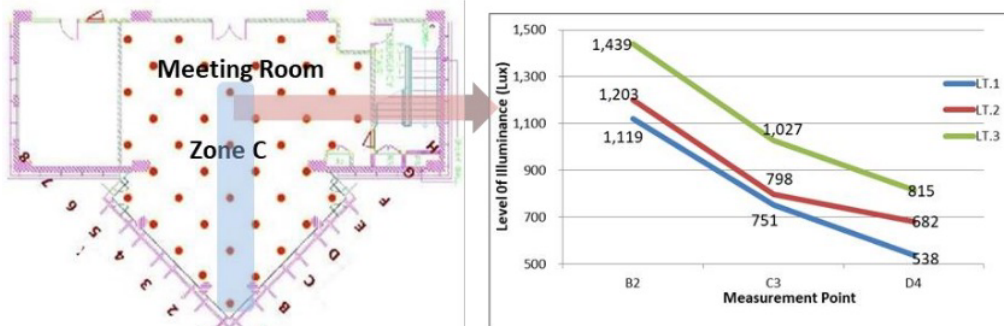


Figure 10. The mean level of illuminance in Zone C

Figure 10 is a graph of mean levels in Zone C (points B2, C3 and D4). This graph shows that the illuminance level from point B2 to D4 decreases. That is, the farther from the opening of the building envelope the illuminance level is lower

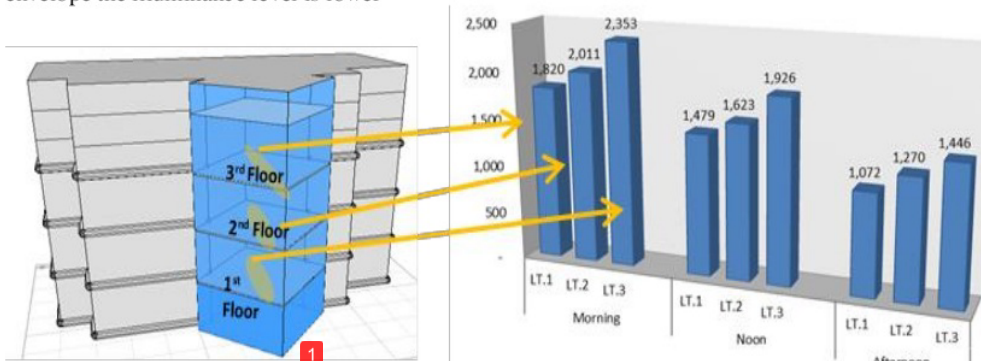


Figure 11. The mean value of illuminance level on 1st, 2nd, and 3rd Floor

Figure 11 shows that the highest illuminance level on the 3rd floor is 2353 lux (morning), 1926 (afternoon) and 1446 lux (afternoon). While the lowest illuminance level is on the 1st floor, namely 1820 lux (morning), 1479 lux (noon) and 1072 lux (afternoon). This shows that the higher the floor of the building, the level of illuminance increases.

3.5 Perbandingan tingkat rerata tingkat iluminasi pada Zona A dan B

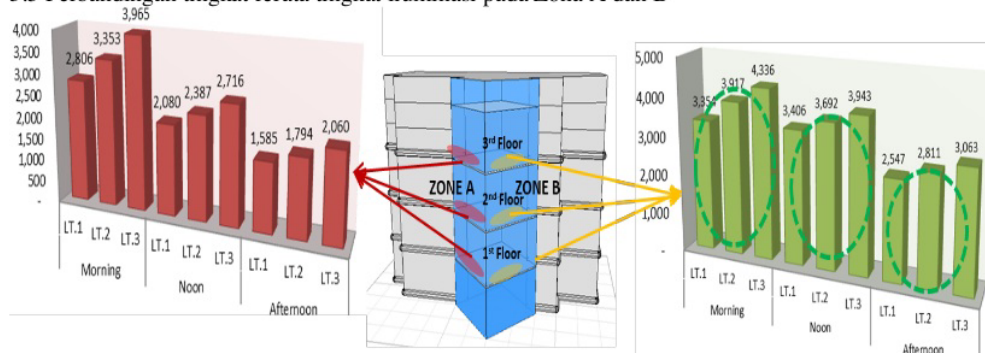


Figure 12. Illuminance levels of Building Envelope on Zona A and B

Figure 12 shows that the highest illuminance level in zones A and B is in the morning. The higher the floor of the building, the level of illuminance will increase. For example illuminance level in the morning on the first floor of 2806 lux, the second floor is 3353 lux while on the third floor is 3965 lux. This shows that the higher the building, the higher the level of illumination. Likewise, the conditions in Zone B were 3354 lux (1st floor), 3917 lux (2nd and 4336th floor (3rd floor). To facilitate comparison of illuminance levels in zones A and B, the graphs were made as shown in Figure 13 below.

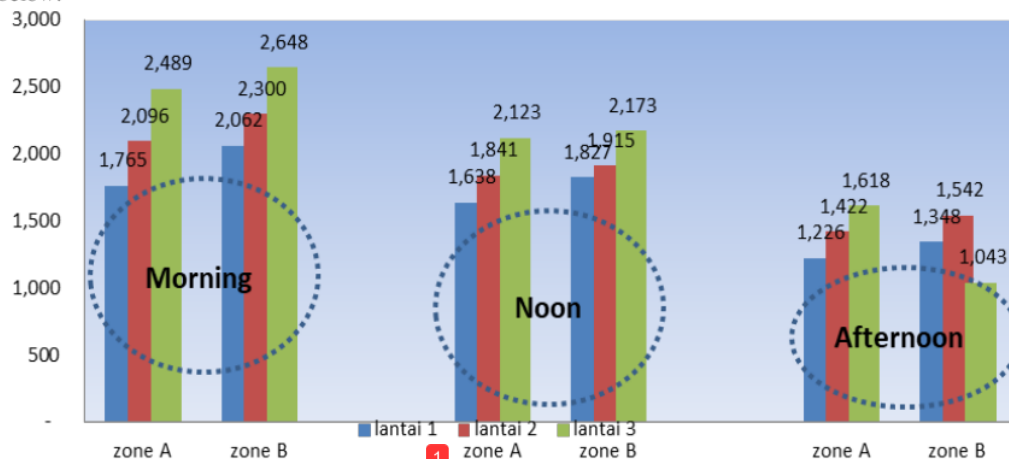


Figure 13. Comparison of illuminance level in Zone A and B

This picture shows the similarities in zones A and B, when the increase of illuminance level from 1st floor to the second floor to 3rd floor. For example in the morning in zone A of 1745 lux (1st floor), 2096 lux (2nd floor) and 2489 lux (3rd floor). Whereas in zone B is 2062 lux (1st floor), 2300 lux (2nd floor) and 2648 lux (3rd floor). This graph also shows that the illuminance level in zone B is higher than in zone A.

Acknowledgments

Appreciation is extended to Annajma Nurul Wika on her work to conducted measured on illuminance level in building.

Conclusion

Based on the measurement results, it can be seen that the illuminance level in the meeting room of the building COT exceeds the illuminance standard recommended by SNI 03-6575-2001. The average level of meeting rooms on floors 1-3 is 1459 lux (maximum) and 538 lux (minimum), while the standard illuminance recommendations are 300 lux. Based on this description, it can be seen that the illuminance level in the COT meeting room greatly exceeds the illuminance standard.

The results of the analysis show that the illuminance level on the 3rd floor is higher than on the 1st and 2nd floors. On the 3rd floor, the building envelope opening is wider than openings on floors 1 and 2 so it can be seen that the opening area in the building envelope affects the illuminance level in space. In the morning, afternoon and evening, the average level on the 2nd floor is higher than the 1st floor, so it can be seen that in the same condition of inside the building, there is an increase in illuminance level in the meeting room on the 2nd floor. So it can be concluded that the level of illuminance affects the height building floor.

The distribution of light enters the space higher in the area near the building envelope, the farther away from the opening of the building envelope, the lower the level of illuminance into the space. Based on this analysis, it can be seen that the depth of space affects the distribution of natural light

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