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LIGHT DISTRIBUTION ANALYSIS ON BUILDINGS LOCATED ON THE COASTAL

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Abstract. Issues of global warming are important and this affects the level of illuminance of natural light on the earth's surface. The use of natural light into buildings can minimize energy consumption as a source of artificial lighting, but it is important to attention to negative effects such as glare, brightness and thermal. The Aryaduta Hotel building located on the coastal area, is an object of research that needs to analyze the distribution of natural light come in to the building. The purpose of this study was to determine how the distribution of natural light in buildings on the coastal area. The results of research concluded that the farther away from the veil the building then the light distribution will decrease, orientation of the building affects the distribution of sunlight and distribution of natural light into the building affects the sun's radiation in the morning, afternoon and evening. This research can be the base for energy efficient building design.

Keywords: *light distribution, illuminance level, natural light*

1. Introduction

The concept of energy-efficient architecture is to optimize the lighting system by considering the integration between natural lighting (daylight) and artificial (lights). The use of energy in buildings, can be reduced if it can maximize the distribution of natural light, but by considering the negative effects include: thermal, glare and brightness.

Aryaduta hotel is located around the losari beach. Position of the rooms at this hotel are the view city and view losari beach. This building is one of the object in this study, the distribution of daylight is the different, because sunset and sunrise are different direction. Base on this, so the research need to analyze how the distribution daylight in to the rooms are oriented towards the Weast and East.



Figure 1. Aryaduta Hotel in Makassar

The building lighting design is designed according to the illumination ¹ standard recommended by SNI 03-6575-2001. level of Illuminance at work space of 500 lux, meeting room of 500 lux and hallway as connecting space of 150 lux. The sky conditions consist of clear sky, intermediate sky and overcast sky. Light distribution in buildings, can be influenced by sky conditions, position, wide and shape window (SNI 03-2396-2001).

Based on this recommendation, the designer can determine amount of armatures required on space, according to the activities in the space. According Nurul (2012) that although it does not meet these standards, can be running well, the activities of space. Based on this, it is necessary to study the distribution of natural light on selected objects.

2. Literatur Study ¹

Clasification of sky condition i.e. overcast, clear and intermediate sky, trying to define the luminance distribution of the intermediate sky Nakamura et al. (1985). Local Government Rules No. 38 (2012) suggested that the building envelope is a building element that surrounds the building. They are transparent or not transparent walls or the roof.

Satwiko (2009) suggested that Indonesia is a tropical humid region with high relative humidity characteristics (60% -80%), high radiation (80% per year), and unstable velocity (urbanized between 0- > 30 m / seconds). Tomy et al (2002) stated that the distribution of light lumination in open plan office by using general lighting and suitability of light lumination distribution. Newsham et al (2004) examined quantitative guidance of illuminance, luminance and ratio values in office buildings.

According to Soegijanto (1998), sky conditions based on the number and type of clouds can be grouped into: (a) Clear sky is the sky without clouds; (b) Overcast sky is a sky completely covered in white or gray white clouds or partial or complete partial clouds; (c) intermediate sky is a partially clouded sky with a variety of darker clouds and numbers; and (d) Uniform sky is the sky with the same luminance in all positions not dependent on the geographic latitude and the height of the sun.

The Phinisi tower building uses a diagonal and horizontal facade on the building's envelope, so there ² no glare and brightness in space. This building is one example of building in designing high building. In terms of aesthetics, building facade is a positive value but needs to be considered the visual comfort of space users so that work productivity can increased. The study concluded the decline percentage in the value of the illuminance after the building using the building facade is 49% -74% and a mean value of 60.3%, so it can be concluded that the building facade effects on the natural lighting (Jamala N, 2017).

3. Methodology

Quantitative research method is analyzing the data of measurement results of illuminance levels statistically descriptive. The research conducted was to analyze illuminance levels in a number of rooms with orientation of the building envelope opening to the east and west. Measurements were made at a measuring point with a distance of 50 cm (measuring point A1-A5) and 150 cm (measuring point B1-B5) from the building envelope opening. This research was conducted by analyzing the data objectively in assessing the results of the measurement of illuminance levels in a number of rooms.

4. Result of Research

In Aryaduta hotel there are various functions of space including: meeting room, fitness room, swimming pool area, administration room and hotel room. The orientation of some hotel rooms leads to the city (city view / east direction) and some point to Losari beach (view beach / west direction) as shown in Figure 2.



Figure 2. 6th Floor plan

Research activities were measuring the illuminance level in 8 Aryaduta hotel rooms located on floors 6, 8 and 9. Measurements were made on August 18-19 2018 in the morning, afternoon and evening. This study analyzed how the distribution of natural light in some hotel rooms that east and west oriented. The measuring point uses the A-B and 1-5 notation as shown in Figure 3.



Figure 3. Layout of measurement point

4.1 Analysis of illuminance level in the morning

4.1.1. Hotel rooms oriented to the west (beach view)

Room 909 is located on the 9th floor and this room consists of two rooms namely a bedroom (909-A) and a family room (909-B), where each room is directly related to the building envelope opening. The orientation of this hotel room leads to the west (beach view) (figure 4)

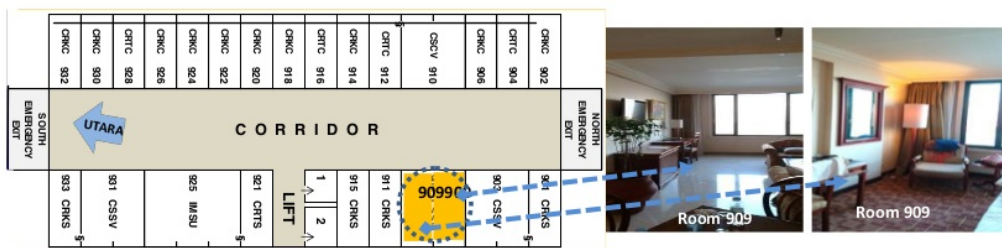


Figure 4. Room Hotel 909-A and 909-B to the west orientation building

Table 1 shows the average level of illuminance for 2 measurement days in the morning. The distribution of natural light in this space is 192-372 lux 9 measuring points A1-A5) and 157—213 lux (measuring point B1-B5). The results of the analysis show that the farther away from the building envelope the light distribution will decrease as shown in table 1 and figure 3 below.

Table 1. The Mean value of Illuminance Level on 909 A-B Room

Room Number	illuminance level (lux) 909-A					Room Number	illuminance level (lux) 909-B				
909A-1	226	338	428	265	187	909A-2	158	196	208	207	211
909A-1	221	337	372	282	190	909A-2	168	207	210	214	140
909B-1	202	420	360	215	198	909B-2	117	200	215	204	192
909B-1	211	380	326	256	194	909B-2	183	218	220	190	180
Average	215	369	372	255	192	Average	157	205	213	204	181

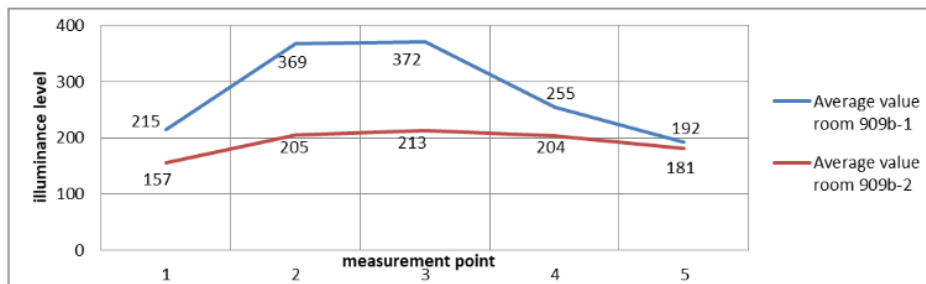


Figure 5. Graph of illuminance level at the rooms 909 A-B

4.1.2. Hotel rooms oriented to the east (city view)

Hotel rooms 616 and 624 are located on the 6th floor and are oriented towards buildings eastward (view city). This room is directly related to the building envelope opening with an area of 32 m² as shown in Figure 6.

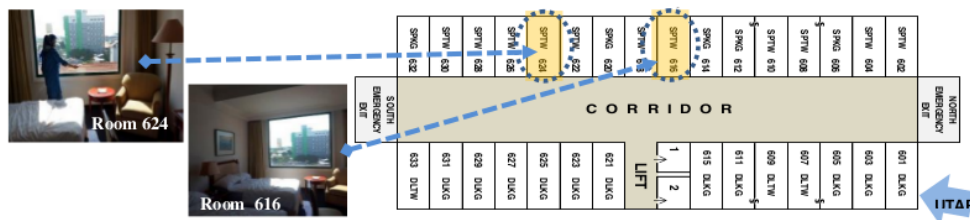


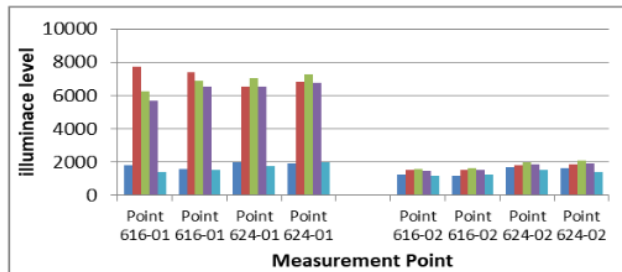
Figure 6. Position of Rooms hotel 612 and 624 on west orientation building

The light distribution in these two rooms is very high, with the highest illuminance level of 7757 lux (measuring point 616-A2) and the lowest is 1415 lux (measuring point 616-A5) in an area of 50 cm from the building envelope opening. While the light distribution in the 150 cm area of the building envelope opening has the highest value of 2109 lux (measuring point 624-B3) and the lowest is 1187 lux (measuring point 616-B1) as in table 2.

Table 2. The Mean value of Illuminance Level on Room 616 and 624

Room Number	Illuminance Level(lux) Room 616-624					Room Number	Illuminance Level(lux) Room 616-624				
	1	2	3	4	5		1	2	3	4	5
Point 616-A	1804	7757	6263	5700	1415	Point 616-B	1247	1532	1613	1461	1216
Point 616-A	1587	7402	6870	6520	1524	Point 616-B	1187	1530	1632	1516	1270
Point 624-A	1998	6553	7077	6545	1733	Point 624-B	1676	1789	1980	1877	1543
Point 624-A	1908	6800	7300	6788	1984	Point 624-B	1669	1898	2109	1932	1435

Table 2 shows that mean value of illuminance level on room 616 point A-B and 624 point A-B. The based on the measurement data, a graph is made to analyze the illuminance value in both rooms. (picture 4). The results of the analysis show that of illuminance level at point A is higher than point B, because point A is the closest area of the building envelope, so that the light distribution is higher.



Picture 4. Level of illuminance in the rooms 6th Floor

Table 3 shows that average value of illuminance level in the both rooms with point 01 and 02. This table show the higher of illuminance level on point 01 than 02.

Table 3. The Level of illuminance on room 616 and 624

Measurement Point	The Average rooms 616 and 624 point measurement 01 dan 02				
	1	2	3	4	5
Point 01	1824	7128	6878	6388	1664
Point 02	1445	1687	1834	1697	1366

The average of illuminance level on measurement point 1 and 2 show that illumination level at point 1 is higher than level 2 (figure 7). The highest of illuminance level at point 01 is 7128 lux and the lowest is 1664 lux, while at the highest point 02 is 1834 lux and the lowest is 1366 lux.

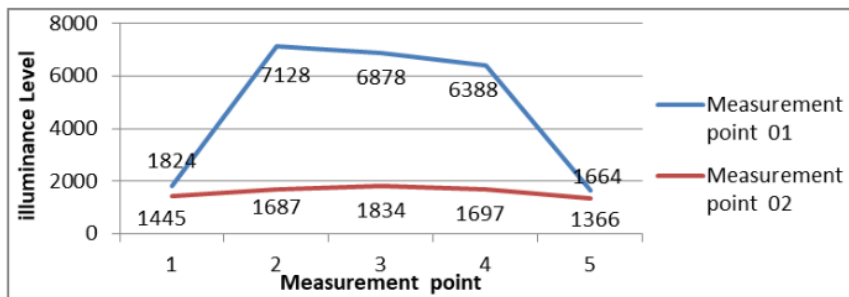


Figure 7. The average of illuminance level on measurement point 01 and 02

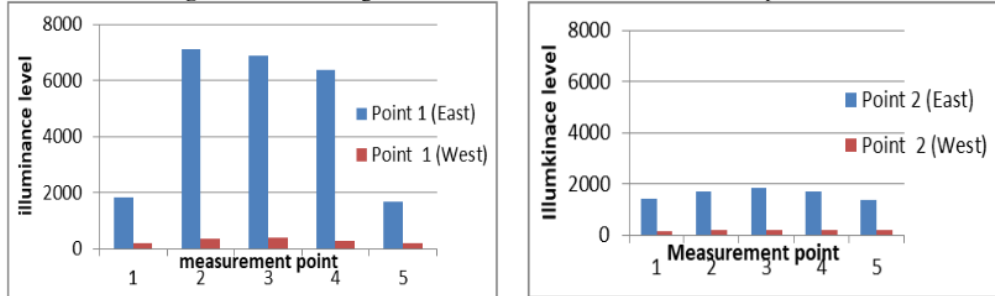


Figure 8. The Average of illuminance level on 6th Floor (room 616 and 624)

The average level of illumination ¹ shows that the distribution of light in the morning in east and west oriented rooms are very different. This can be seen in the graph of illuminance levels on West orientation (city view) of 1515 lux to 4408 lux, while in the west-oriented rooms (beach view) of 186 lux up to 293 lux. Comparison of illuminance levels between east and west orientation rooms is 200% (figure 9).

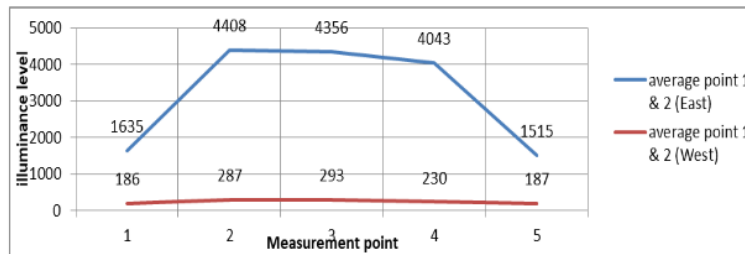


Figure 9. Comparison of illuminance level in room hotel in west and east oriented

4.2. Analysis of Differences in Illuminance level in Building Orientation West and East at noon

Comparison of light distribution in Aryaduta hotel East and West rooms oriented during the day is analyzing illuminance level in rooms 909-A and 909-B (west orientation) with rooms 808, 818, 830, 828, 630 and 604 (East orientation)

4.2.1. Hotel room oriented toward the west orientation (beach view) at noon

The average illuminance level for 2 measurement days is as follows:

- Room 909-A at the A1-A5 measuring point of 570-2821 lux and at the measuring point B1-B5 of 398-760 lux
- Room 909-B at the A1-A5 measuring point is 672-3308 lux and at the measuring point B1-B5 is 421-677 lux.
- The average value of rooms 909-A at A1-A5 was 1778 lux and B1-B5 was 593 lux
- The average value of rooms 909-B at A1-A5 was 1829 lux and B1-B5 was 531 lux.

The analysis shows ¹ that the farther away from the building envelope the illuminance level will decrease by 67% (room 909A) and 71% (room 909B). The average illuminance levels in the rooms are oriented towards the West (rooms 909 A and B) at the measuring points A1-A5 and B1-B5 can be seen in Figure 8.

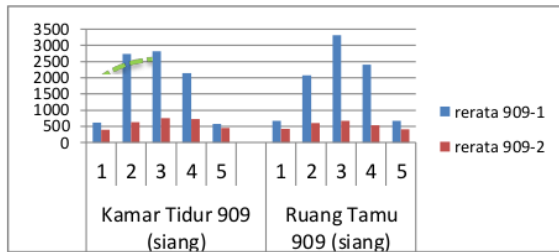


Figure 10. The average of illuminance level in west orientation rooms in the noon

The above graph shows the difference in illuminance level at a distance of 50 and 150 cm from the building envelope opening. Then analyze the average illuminance level in rooms 909-A and B for 2 days of measurement (figure 11).

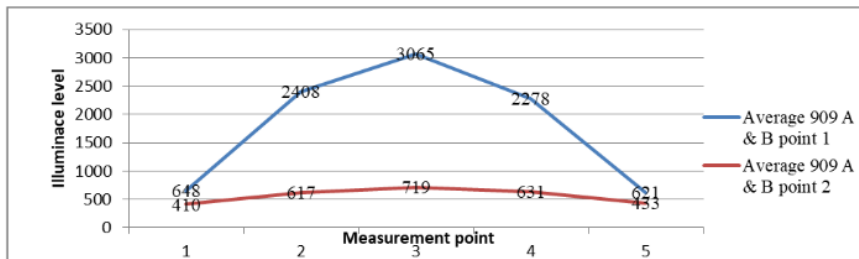


Figure 11. Comparison of illuminance level in west orientation rooms

4.2.2. Hotel room oriented toward the east (city view) at noon

Illumination measurements are carried out in six rooms, namely rooms 808, 818, 630, 604, 830 and 828 which are oriented towards the east, as in the table below. Illuminance level fluctuate, because the position of the room is different, on the 6th and 8th floors. The average value of the six rooms at the measuring points 1 and 2 is as in the following table.

Table.

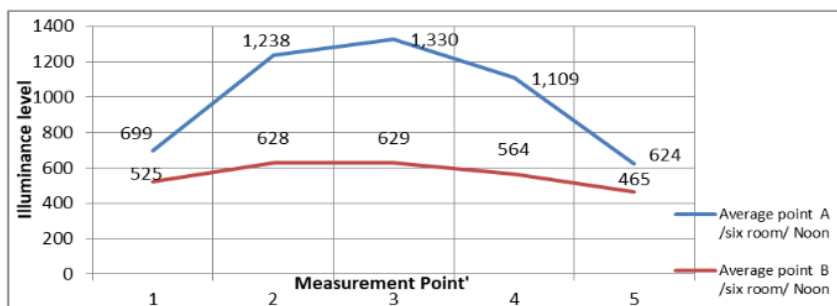


Figure 12. Average of illuminance level in east orientation rooms.

Furthermore, the comparison of illuminance level in east and west oriented rooms during the day. This graph shows that the distribution of light in the west-oriented rooms is higher at 621-3065 lux (A1-A5 measuring point) and 410-719 lux (B1-B5 measuring point). Rooms oriented towards the East are 525 lux-1330 lux (A1-A5 measuring points) and 624-629 lux (B1-B5 measuring points). This graph shows

that the light distribution in the west orientation room is higher than the east orientation, both at the A1-A5 measuring point and at the B1-B5 measuring point.

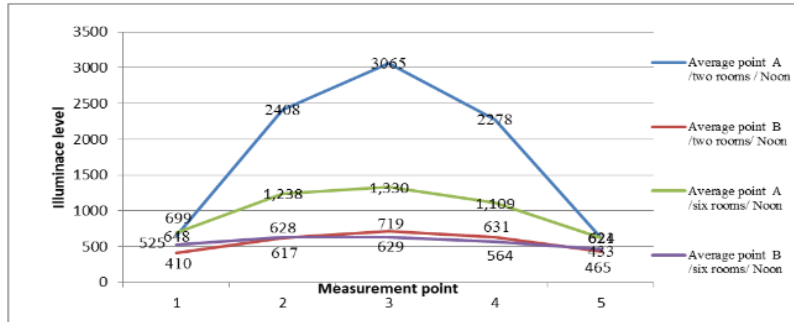


Figure 13. Average of illuminance level of measurement point A and B

Comparison of illuminance level in east and west oriented rooms during the day with mean values at the A1-A5 and B1-B5 measuring points. The graph shows that the distribution of light in the room is oriented westward (view beach) higher than east (view city). Light distribution has a west orientation of 3065 lux while the east orientation is 1330 lux as shown in the following figure 14.

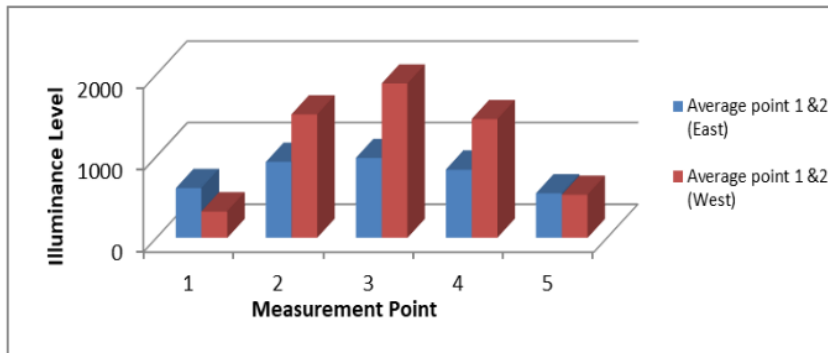


Figure 14. The average of measurement point on west and east orientation building

4.3. Analysis differences of building orientation of illuminance level toward west and east in the afternoon

Measurement of illuminance level in the afternoon is carried out in 8 rooms. Before analyzing the measurement data, an outlier was carried out to eliminate insignificant data, so that only 6 rooms would be analyzed. Furthermore, analyzing the comparison of rooms oriented to west and east. The mean value of measurement results is as in the following table 4 and picture 15

Tabel 4. The average of illuminance level in the rooms 909 A and B (west orientation)

Average point A (909 A)	2466	3718	4918	4421	1498
Average point B (909 A)	2046	3423	3419	1508	1186
Average point A (909 B)	213	554	775	522	280
Average point B (09 B)	274	358	512	323	300

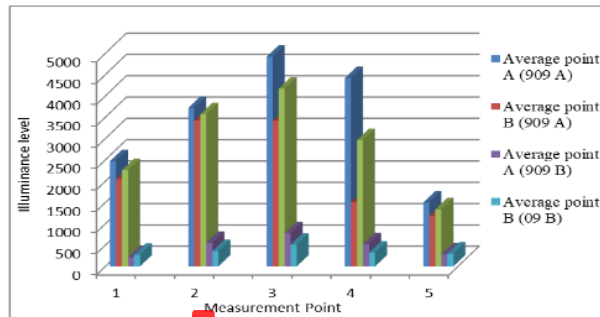


Figure 15. Average of illuminance level on room 909 A and B

The average illuminance level at the A1-A5 and B1-B5 measuring points were in the west oriented room of 3404 lux and 2316 lux, while in the east oriented rooms were 469 lux and 353 lux. The results of the analysis show the percentage decrease in light distribution at the A1-A5 measuring point to the B1-B5 measuring point of 32% (West orientation) and 25% (east orientation). The percentage difference between the two directions and the two measuring points is equal to A1-A5 and B1-B5 86% and 85%.

4.4. Comparison of illuminance level in the morning, afternoon and evening in the west and east orientated room

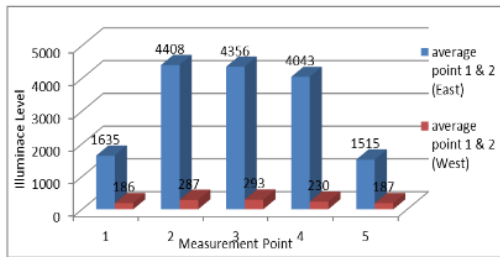


Figure 16. The average of illuminance level in west and east building orientation in the morning

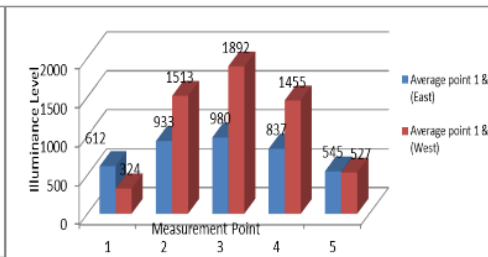


Figure 17. The average of illuminance level in west and east building orientation at noon

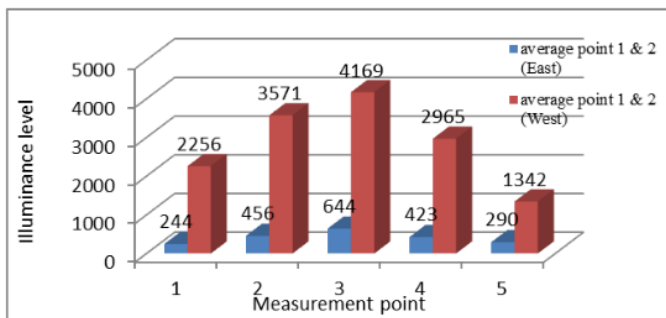


Figure 18. The average of illuminance level in west and east building orientation in the afternoon

5. Conclusion

The analysis result of research show the percentage decrease in light distribution at the distance of 50 cm to 150 cm on building envelope namely 32% (West orientation) and 25% (east orientation). Based on the results of the analysis it can be concluded that the farther away from the veil the building then the light distribution will decrease.

Distribution of natural light in the orientation of buildings westward; (1) morning: 293-186lux; (2) noon 1892-324 lux; and (3) afternoon 4169-1342 lux. Then the orientation of the building eastward: (1) morning: 4408-1515 lux; (2) noon: 980-545 lux; and (3) afternoon: 644-244 lux. The results of the analysis show that the orientation of the building in the West direction is higher from morning to evening, while in the east the lower. The conclusion is that the distribution of natural light into the building affects the sun's radiation in the morning, afternoon and evening.

The results showed the difference in the value of light distribution in the morning to evening, namely: (1) In the morning: the distribution of light was much higher in the orientation of the eastward building, which was 4408 lux compared to the westward orientation of 293 lux; (2) noon: a slightly higher west orientation of 1892 lux compared to the east orientation of 980 lux; and (3) afternoon: a much higher orientation towards the west at 4169 lux compared to the east at 644 lux. Based on the results of the analysis, it can be concluded that the orientation of the building affects the distribution of sunlight.

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