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Comparison of Building Envelope Models to Illuminance Level in Phinisi Tower Building

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Abstract. The hyperbolic parabolic facade is the appearance of a Phinisi Tower Building. The building facade characterizes this building and is also the aesthetic value of this building. Building facade models are increasingly developing, but need to pay attention to their association with visual for space users. Visual comfort is related to the standardization of the level of illuminance, which has been recommended by Indonesia National Standards. Quantitative research methods that used describe data measurement results in the workspace, which are directly related to the opening of the building envelope. The level of illuminance measurements are carried out in the workspace and in open areas in medium sky conditions. The results of the study are that the level of illuminance in the workspace is very different, because of the different facade models. vertical and horizontal strip facade models have a higher level of illuminance than the hyperbolic parabolic facade, whereas in spaces that do not use a facade but shaded by sunscreen are the highest. The results of the study concluded the building facade model influence of the level of illuminance in the workspace. The contribution of this research can be a guide in designing the facade shape of buildings, by paying attention to the distribution of lighting into the space, so that it can reduce the use of energy in terms of lighting and can create energy efficient building designs.

1. Introduction

The building facade needs to be considered in planning a building, because this is the aesthetic value of the building. The facade model is the appearance of a building, but it should be noted its relationship with the distribution of natural lighting entering into the building. Building facade models need to be adapted to the climatic conditions in which the building will be planned.

The city of Jakarta has issued governor regulation No. 38 of 2012 concerning green buildings [1], where the current development has implemented a reduction in energy use to achieve sustainable development goals in the future. Building facade model as building envelope design has an important role to protect the building in terms of visual and thermal convenience. Solar thermal (thermal), glare and brightness can be avoided by using building facades.

This research analyzed the Phinisi building that functions as the administration of Makassar State University. This research is related to the level of illuminance in the building workspace. The front view of the building uses a form of hyperbolic paraboloid facade which is a futuristic expression and application of sophisticated science and technology. In addition, this building also uses a horizontal and vertical strip facade. Shape of façade building have effect to level illuminance in the room with direct area to building envelope were develop [2]. According to Soegijanto [3] 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 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 [4].

This study analyzed the level of illuminance in the space located in the area of the building envelope opening using the building facade. This is related to the design of energy-efficient buildings that is by maximizing the use of natural lighting, while still considering visual comfort and thermal comfort. This study only focused on visual comfort in accordance with recommendation on natural and artificial light namely SNI 03-6575-2001 [5] and SNI 03-2396-2001 [6]. The United Nations Environment Program [7] states that the level illuminance standard recommendation for the office room, based on values recommended by IES (Illuminating Engineers Society) [8] and CIE (Commision International De I'Eclaire) [9]. The Illuminance level of daylight depends on the sky condition and it have affect the light distribution into the building. The increased light distribution at the height of the floor. As well as of window opening on the building envelope (top lighting and side lighting) have effect on the level of illuminance in the building [10]. The height and depth of the space affect the distribution of natural light come into the room [11]. The building orientation have the effect of iluminance level come into the room. The Level of illuminance in the oriented space to the north are higher than south orientation. the other than, level illuminance has an influence the distance of the measurement point from the window opening on building envelope, the further away from the building envelope the light distribution decreases [12]. The distribution light will decrease, if the point measurement farther away from the building envelope and natural light come into the building affects the sun's radiation in the morning, afternoon and evening [13]. Rahim stated that CIE (International Illumination Commission) reference sky conditions namely clear sky and overcast sky [14]. In addition these, Nakamura proposed the sky condition third called i.e. overcast, clear and intermediate sky. Trying to define the luminance distribution of the intermediate sky [15].

2. Methodology

This study uses quantitative methods that describe the measurement data and analyze data in the form of tables, bar charts and graphs. The level of illuminance measurements carried out are outside and inside the building, at the planned placement of measurement points. The number of measuring points in space is adjusted to the area of the selected object. Measurements were made on 17-18 July 2019 at 10:00 to 12:00 o'clock with intermediate sky condition. The level of illuminance outside the building at the time of measurement $\pm$100,000 lux. Building orientation to the west-south-west (WSW) and east-north-east (ENE)

3. Result and Discussion

The Phinisi Tower Building consists of 19 floors, but in this study only analyzed the workspace located on the second floor. On the 2nd floor there is a workspace with different spatial orientations. The workspace is directly related to openings in the building envelope, with different facade forms, namely hyperbolic paraboloid facades, horizontal and vertical strips.

The work space on the 2nd floor has different functions, namely (1) zone-1: administration room, the interests and reasoning section room, student and welfare room and Public Relations Room; (2) Zone-2: Education room; and (3) Zone-3: Asset management room and internship room. These three zones were selected as objects in this research, with consideration of using different forms of façade (Figure 1).

Figure 1. Orientation of the Phinisi Tower building

The shapes of façade in room on zone-1, zone-2 and zone-3 have building façade shape is the different. The three zone, have facade diagonal, horizontal strip and fertikal as show in Figure 2 below.

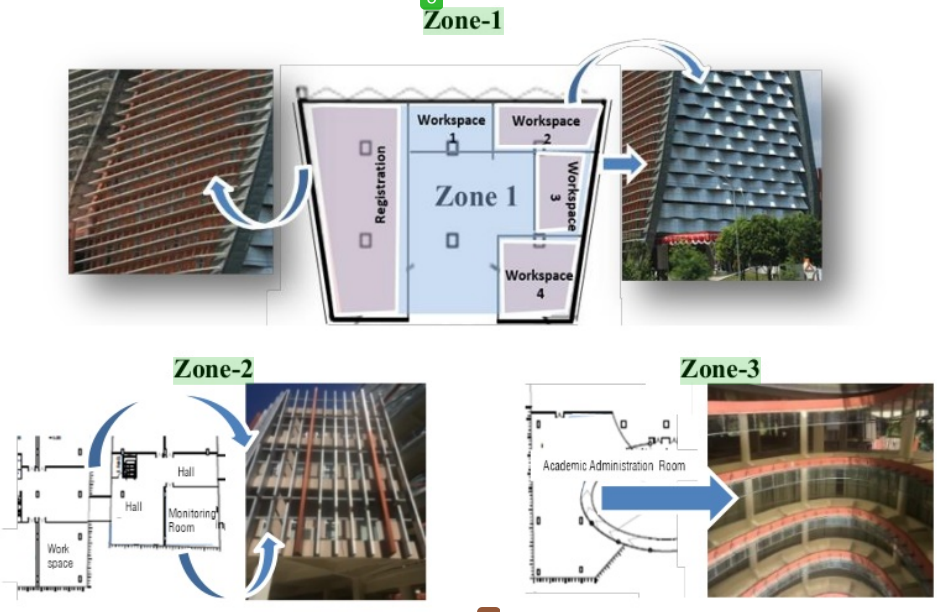

Figure 2. Shape of facade on zone-1, zone-2 and zone-3

In zone-1 the form of the building envelope uses a diagonal and horizontal facade, zone-2 forms the vertical facade and zone-3 of the building envelope using glass windows that are directly related to the open void. These third facades are able to distribute natural lighting that is different, so it is necessary to analyze this.

3.1. Analysis of Zone-1 (The façade Model of Strip Horizontal and Diagonal)

Figure 3. Administration room in second floor

In zone-1 it consists of several workspaces that are directly related to the openings of the diagonal shaped building and horizontal strips. This study analyzes the level of illuminance in the office room, as shown in Figure 4 below.

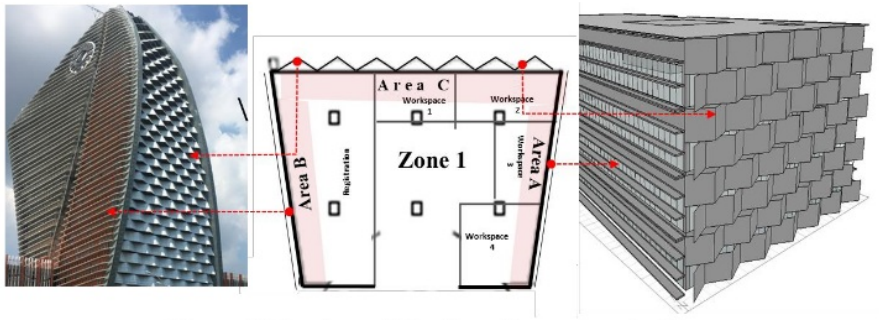

Figure 4. The shape of façade on the envelope building

In zone-1 it is divided into 3 areas, namely (1) Area-A: workspace oriented towards north-north-west; (2) Area-B: orientation towards south-south-east; and (3) Area-C: work space towards west-south-west. Area A and B have horizontal strip facade while Area C is hyperbolic paraboloid. Area-A and area-B have the same facade shape but different building orientations (Figure 4). The above area measured and analyzed by the measurement point in that space.

The second floor workspace has openings in the building envelope in the form of glass windows (Figure 5). Window openings are not entirely the envelope in the building, but there is a distance between the windows as shown in Figure 5 below. Measurements were made with intermediate sky weather conditions and artificial lighting (lamps) were turned on in each measured space.

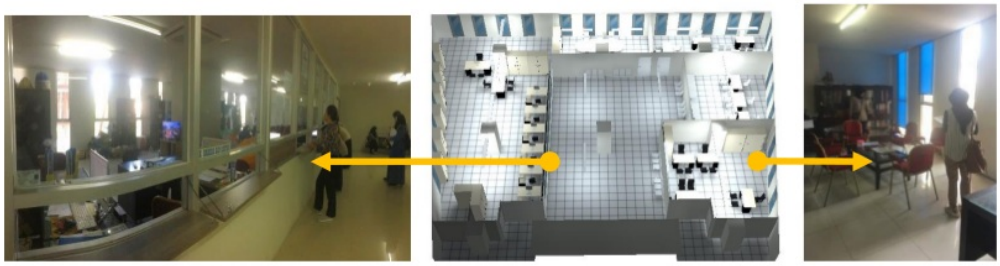

Figure 5. Layout design of windows on building envelope (Zone-1/area-A, area-B and area-C)

In Zone-1 there are several workspaces and when the was measured the condition of lights. Placement of the measuring points as shown in Figure 6 below and the measuring point notation is A-I and 1-9, as shown in Figure 6. Analysis carried out in zone-1 is divided into 3 areas, namely area-1 (horizontal facade model oriented towards the north-north-west), area-B (horizontal facade model oriented towards the south-south-east) and area-C (paraboloid hyperbolic facade model oriented towards the west-south-west). Measurement of the mean value is based on the placement of measuring points in the area of the building envelope, namely in area-1 (measuring points I1-I9), area-2 (measuring points A1-A9) and area-3 (measuring points A1-I1), as shown in Figure 6.

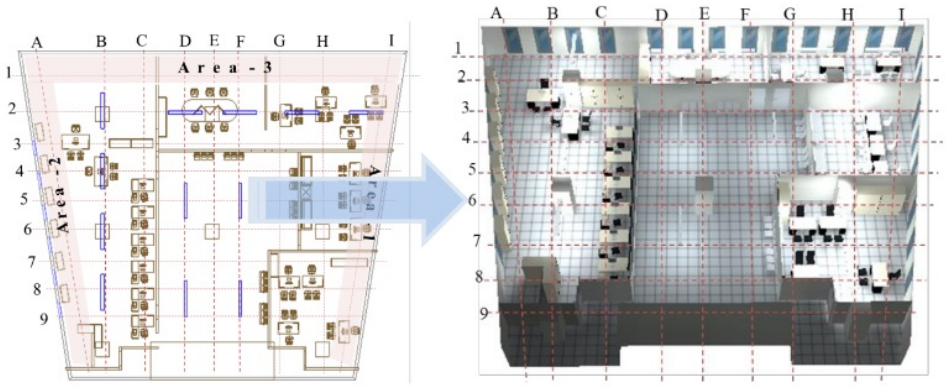

Figure 6. Placement of the measurement point in Zone 1 (A-I and 1-9)

Before analyzing the mean values in the area of the building envelope, namely area-1, area-2 and area-3, the distribution of measurement results data is carried out across all spaces in zone-1, as shown in Figure 7 below. The light source comes from natural and artificial lighting, but the level of illuminance is only high in the area near the openings of the building envelope, even though it has turned on the lights. The mean values in zone-1 area differ in each workspace, because the distribution of natural light is not the same as the percentage that enters the space.

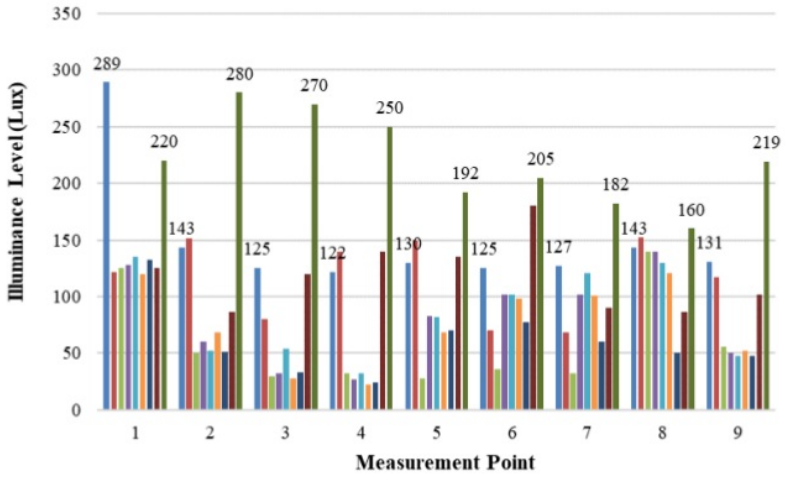

Figure 7. Level of illuminance on Zone-1

The level of illuminance at the measuring points I-1 to I-9 (area-1) is a room with a horizontal grid-shaped building façade 280-160 lux. The illumination value in area-1 has the highest illumination value compared to area-2 (A-1 to A-9) amount 289-70 lux and area-3 (B-2 to H-1) amount 135-120 lux, as shows in Figure 8.

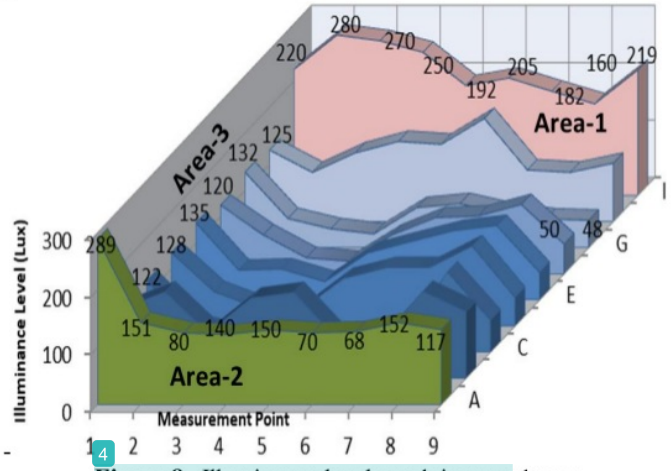

Figure 8. Illuminance level graph in zone-1 area

Figure 8 shows a graph of illuminance level in zone 1 area. This graph shows that the level of illuminance in the area near the building envelope openings is a maximum of 280 lux and a minimum of 70 lux. The level of illuminance in this area varies greatly, so it is necessary to analyze the level of illuminance at the measuring point located along the building envelope.

3.2. Analysis of the Illuminance Level in the Horizontal Facade Model

In the area-1 there are several spaces that are directly related to the openings of the building envelope with a horizontal facade model as shown in Figure 9 below. Workspace orientation in areas-1 and 2 with different orientations but the same facade model is horizontal facade as shown in the following.

Figure 9. Administration room with horizontal facade on the 2nd floor

In the area-2 there are several spaces that are directly related to the openings of the building envelope with a horizontal facade model as shown in Figure 10 below. Workspace orientation in areas 1 and 2 with different orientations but the same facade model is horizontal facade as shown in the Figure 10.

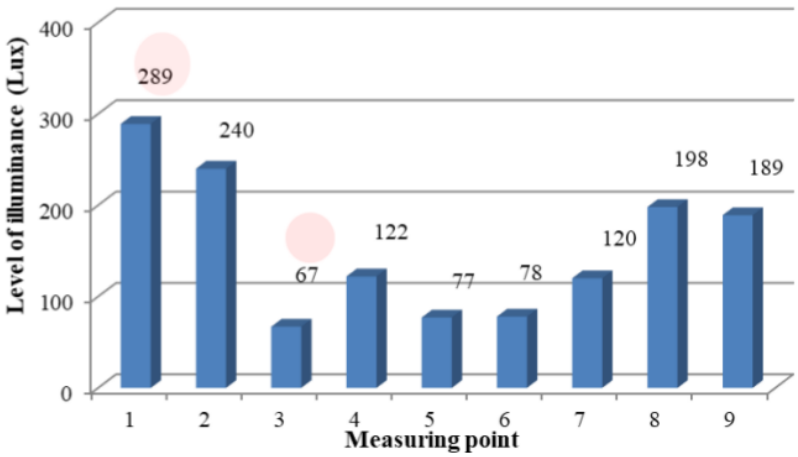

Figure 10. Level Illuminance chart on envelope building area of horizontal model (Area-1)

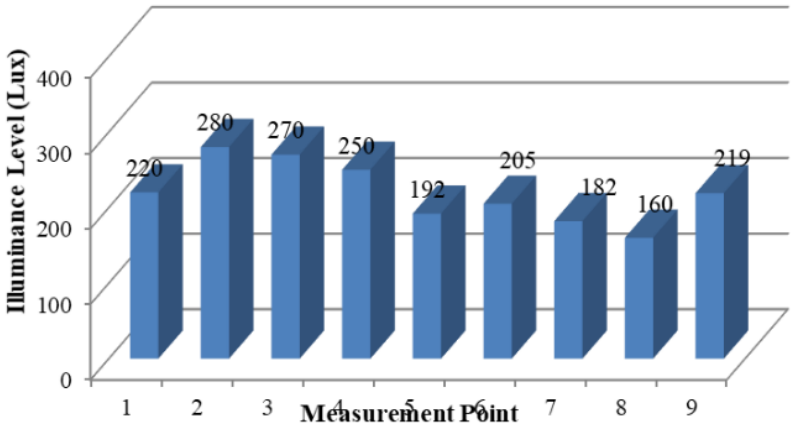

Figure 11. Level Illuminance chart on envelope building area of horizontal model (Area-2)

The level of illuminance in this workspace, is not uniformity because there are cabinets in the area of the building envelope so that the light distribution decreases. The average value in this area is 219 lux. Whereas in area 2 it has an average value of 222 lux. These two areas have the same facade shape but different orientations. The average level of illuminance in these two areas is 224 lux. Based on this analysis, it can be seen that the percentage of light distribution in the Phinisi building in the form of a horizontal facade that is in the intermediate sky conditions (18.000 lux) is 1.25 percent.

3.3. Analysis of Illuminance Level in the Diagonal Façade Model

Area-3 has a diagonal oriented facade west-south-west. The room is directly related to the building envelope as shown in the following Figure 12.

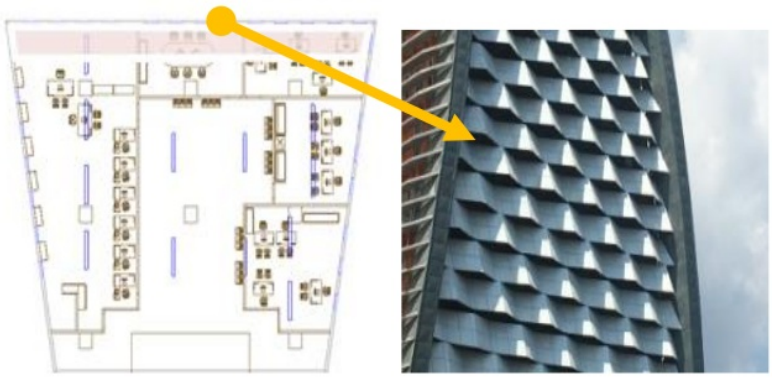

Figure 12. Administration room with hyperbolic paraboloid facade

Illuminance level on Area-3 has a diagonal façade, maximal 289 lux and minimal 101 lux. Average value of level illuminance amount 157 lux in Area-3. Measurement point A (289 lux) and point I (268 lux) have the highthes of illuminance level compare to others, because it is located in the corner of the room which has windows on two sides. While the other (point B-H) has a low illuminance value, because it has a smaller window area, namely between 101 lux to135 lux (Fig. 13).

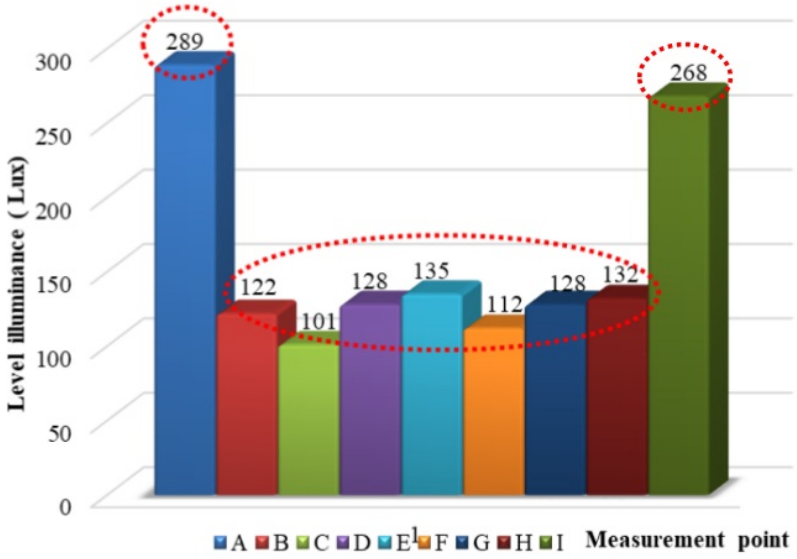

Figure 13. Level illuminance in Area-3 has a hyperbolic paraboloid facade

3.4. Analysis of Area-2 (Without Building Facade)

Area-2 functions as a student and educational room. In area-2, the administration room is directly related to the natural light source. the building envelope are glass and bordered by voids outside the building as shown in Figure 14 below. The building envelope does not use a facade, but the light source is protected by a sunscreen that functions as a corridor in the outdoor building.

Figure 14. Zone-2 on administration and education room

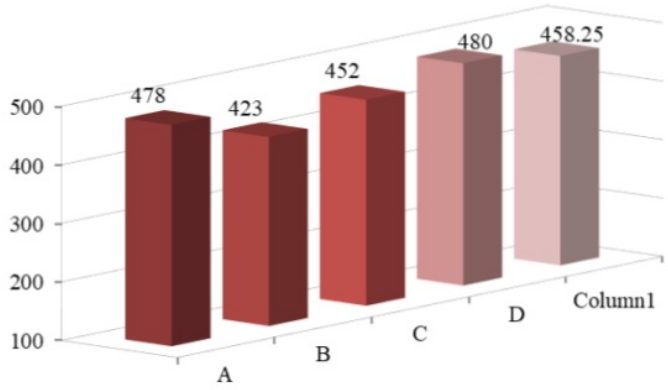

Figure 15. Illuminance level chart on envelope building without façade

The average value in the area of the building envelope is very high, because the building envelope is glass material that is directly related to the void, so that the light distribution can be maximized. Based on the measurement results, the average value of the five measurement points along the building envelope is equal to 458 lux.

3.5. Zone-3 Analysis (Strip Vertical Façade)

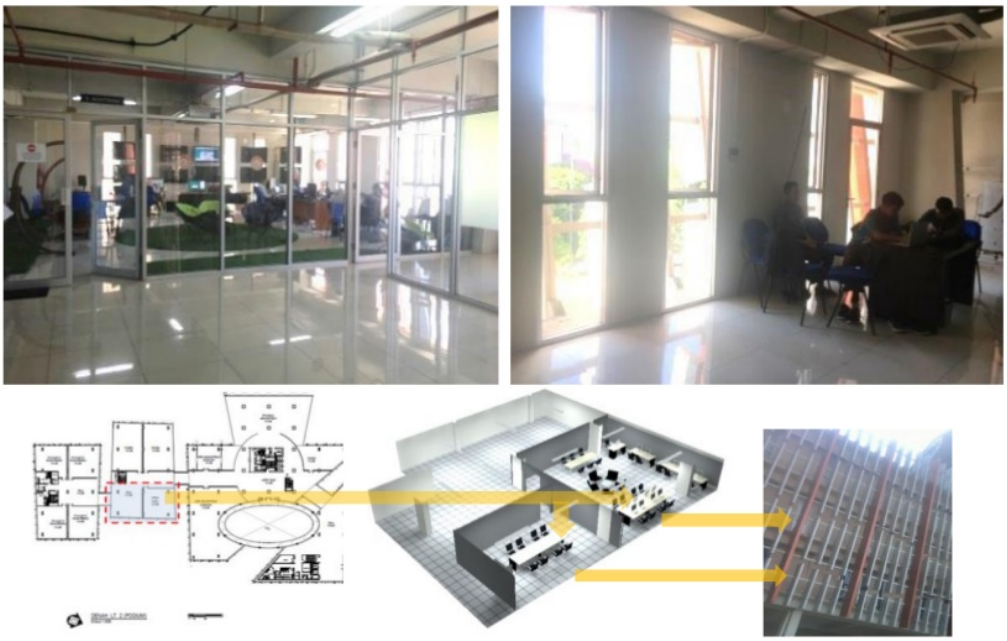

Figure 16. The shape of the vertical grid façade (zone 3th)

On the second floor there is an asset management room and an internship room. The space is directly related to the building envelope by using the vertical facade (figure 16). The average value of a number of points which have a distance of 50 cm from the building envelope is 723 lux while 150 meters from the building envelope is 230 lux. This space uses massive glass throughout the building envelope, but also uses a vertical façade.

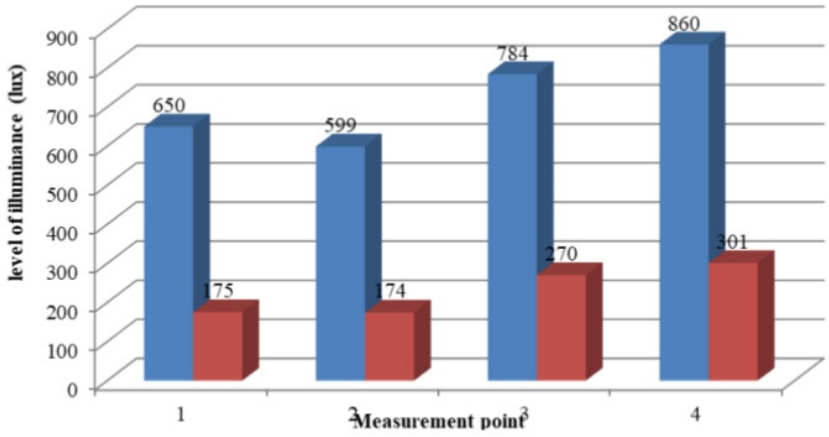

Figure 17. Illuminance level chart on workspace zone 3th

3.6. Analysis of Light Distribution in Horizontal, Vertical and Hyperbolic Paraboloid Facade Spaces

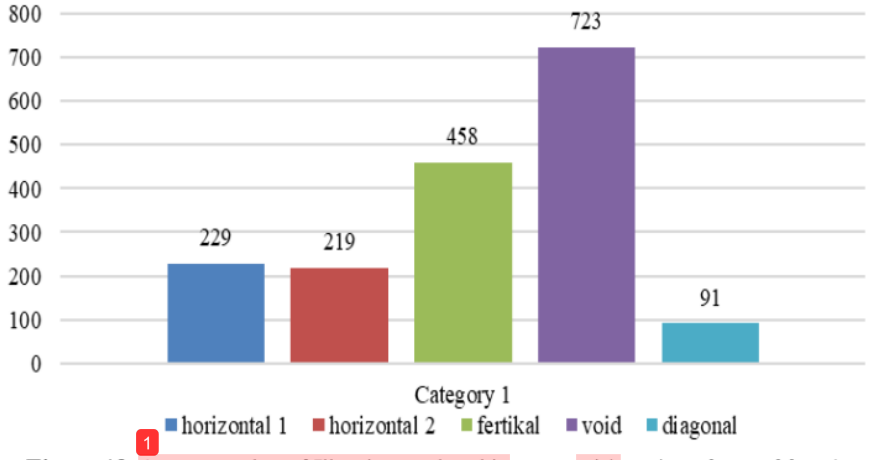

Figure 18. Average value of Illuminance level in space with various form of facade

The picture above shows a graph of mean values in spaces using horizontal, vertical, hyperbolic paraboloid facades and no façade. The level illuminance in spaces that do not use the façade has the highest value compare to the others. The level illuminance in spaces using horizontal 1 and 2 is the same.

Conclusion

This study analyzes the effect of building facade models on the level of illuminance in buildings that is directly related to openings in the building envelope. In the phinisi tower building there are three building facade models, namely horizontal, fertile and hyperbolic paraboloid strips, as well as comparing the level of illuminance in a room that does not use a facade but in the area of the building envelope covered by sunscreen. The results showed that the average level of illuminance rate in the space that uses a horizontal facade that is oriented towards the north is 299 lux and the space that leads to the south is 219 lux. Whereas the space using diagonal facade is 91 lux and the fertile facade model is 723 lux and the room without facade uses sunscreen of 458 lux.

Based on this description, it can be concluded that the building facade model influences the level of illuminance in space. The level of illuminance in space with horizontal stripes facades. lower than the vertical strip and hyperbolic paraboloid forms lower than both models. The level of illuminance in a room without a facade, but there are sunscreens on all sides of the building envelope, this space has a higher level of illuminance than the three forms mentioned above, this is because the distance between the sunscreen is greater than the distance between the vertical and horizontal shaped facades. And has wider openings between the three models. So on the second floor, this workspace has the highest level of illuminance. However, it is necessary to consider the negative effects of glare, thermal and brightness. This study analyzes based on the facade model on the Phinisi Tower building. Furthermore, this research can analyze the shape of building facade models by using echotech software to develop knowledge about the distribution of natural light to the facade models.

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