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The effect of building façade on natural lighting (Case study: Building of phinisi tower UNM)

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View Affiliations
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ABSTRACT

Utilization of natural lighting is one factor to lower the energy consumption of a building. Model building facade effect on natural light sources that can be absorbed into the building. UNM Phinisi Tower Building is a metaphor for the display of boats phinisi using Hyperbolic paraboloid facade which is futuristic sophistication of the application of science and technology, so that this object that is the focus of research on the effects on the building facade natural lighting. A quantitative research methods using Autodesk Echotech program to determine the value of the building into the natural lighting illuminance, either by using the facade and do not. The aim of research is to determine the percentage utilization of natural light into the building using a building facade. 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.

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The Effect of Building Façade on Natural Lighting (Case Study: Building of Phinisi Tower UNM)

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Abstract. Utilization of natural lighting is one factor to lower the energy consumption of a building. Model building facade effect on natural light sources that can be absorbed into the building. UNM Phinisi Tower Building is a metaphor for the display of boats phinisi using Hyperbolic paraboloid facade which is futuristic sophistication of the application of science and technology, so that this object that is the focus of research on the effects on the building facade natural lighting. A quantitative research methods using Autodesk Echotech program to determine the value of the building into the natural lighting illuminance, either by using the facade and do not. The aim of research is to determine the percentage utilization of natural light into the building using a building facade. 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.

INTRODUCTION

The architectural energy-saving concept is optimizing the lighting system taking into account the integration between natural light (sun) and artificial (lamp). The use of energy as a source of illumination will be reduced when natural lighting is used optimally by considering the negative effects such as glare, brightness and thermal. Utilization of natural lighting effect on the building envelope (façade), building orientation and wall wide openings.

Phinisi tower Makassar State University is a building for Academic Services Center (GPPA). This building is a manifestation of a series of meaning, function and application of technology that transformed into a figure of architecture. The building consists of three parts: the bottom of the form under / stage, the body in the form of podium consisting of three floors and part of the head in the form of a tower consisting of 12 floors which is a metaphor of the boat phinisi screen. Shape of the facade on the building, implemented a system which is a Paraboloid Hiperbolic as a facade futuristic sophistication of the application of science and technology.
LITERATURE STUDY

The energy consumption is the energy that functioned in both residential and office building in which the composition of energy consumption between these two functions are different. In order to improve the understanding of energy conservation in buildings, then compiled SNI Energy Conservation and Technical Guidelines for Energy Conservation in Lighting System is SNI 03-6197-2000. Energy is used as a source of lighting, air conditioning, and other equipment and energy use in office buildings is relatively large. Distribution of energy consumption in buildings is for air conditioning that is 50-70%, 10-25% for lighting and elevators only 2-10% (Sugijanto, 1998).

Facade of the building is a building element that surrounds the building which are the walls and the transparent or not transparent roof (Regulation of the Governor of the Province of Jakarta Capital Special Region No. 38 of 2012) . Illumination of buildings are generally obtained from the above (pit stop) or side (pit wall). Skylight from the roof operates as lighting lamps that emit light directly with the direction of light down the hole while the light from the side using vertical openings to take advantage of natural lighting (Karlen & James, 2008).

Pritchard (1986) stated that the lighting plan in general, aims to achieve strong illumination evenly on the entire field of work. Lighting was completely evenly is not possible in practice, but an acceptable standard minimum illumination is strong as low as 80% of the average of the average space powerful illumination. That is, suppose the average powerful illumination of 100 lux, the strong light of all the measuring point should be ≥ 80 lux. These requirements must be met, because if the required illumination levels are not met would interfere with visual tasks that result in decreased work productivity.

Sunlight as a source of natural lighting is expected to enter the building maximally, but keep in mind the negative effects that can be caused of which are the effects of brightness, glare and thermal. Brightness is a subjective response to the eye of the emitted light / reflected light of an object or object level refers to the human perception of the object observed. There is no specific meaning of brightness levels as in luminance, so that the value of the brightness of an object is not measurable (does not have unit), or subjective qualitative and general high luminance implicated in a high brightness anyway.

An object which during the day can easily be seen, could not be seen at night because our vision depends on a strong level of illumination. Strong level of illumination a large part determined by the strong light falling on a plane or surface area, and is expressed as the average illumination. The average illumination in lux is a stream of emitted light (0) in the lumen (lm) is divided with a field or area (A) in m². Illumination is a strong level of illumination mean average measured horizontally and vertically to a room or a field of work (Darmasetlawan, 1991).
Glare is a visual disorder that affects visual performance. Glare can be direct and indirect where direct glare occurs when the light source closer to the center of vision, while indirect glare caused by reflected light (Lechner, 2007). Source of glare caused by excessive brightness level which is of the armature or window, both seen directly or via reflections. There are two kinds of glare, disability glare which can reduce the ability to see, and discomfort glare that can cause visual discomfort. Both kinds of glare can occur simultaneously or individually.

In designing lighting, illumination standard recommendation is a reference in designing lighting space and is one of the parameters for creating visual comfort space. Particularly in Indonesia standards recommended by SNI 03-6575-2001 on procedures for the design of artificial lighting systems in buildings is referring to the National Electric Code (NEC), Illuminating Engineering Society (IES), the International Electrotechnical Commission (IEC) and the Australian Standard. The level of illumination on the recommendation of ISO 2001 based on the function space for example for office buildings namely the directorroom, work space, computer room recommended amount of 350 lux, conference room of 300 lux, the drawing room of 750 lux, warehouse archives of 150 lux and space active archive 300 lux.

**METHODOLOGY**

Quantitative research method was using Autodesk Ecotech Analysis program 2011. This program is used to determine the level of illuminance at the measuring point in the building. This study analyzes the building facade to the illuminance level of natural light into the building and comparing the value of illuminance when using and not using the building facade on the building of Tower Phinis Li UNM.

![Figure 2](image)

**FIGURE 2. Building design of Phinis Tower UNM on Ecotech Program**

Program Autodesk Ecotech Analysis simulate Tower Phinis Li UNM building by designing the bearing window material single-glazed aluminum frame and grid management auto - Fit grid to object - within- XY axis - number of cell x = 6 and y = 10 - calculated natural light level- sky condition , CIE overcast sky --- climate Makassar LGN -lat - 5.10 119.50 ( +8.0 ) in May to 12.00.

![Figure 3](image)

**FIGURE 3. Level Illuminance measurement of point A-B and 1-10**

Echotech program is to determine the value of the illuminance at some measuring point in the building. Measuring point arrangement based on a sketch of the building that is using notation 1-10 and A - F (Figure 3)
RESULT OF RESEARCH

Autodesk Ecotech Analysis calculated results of 2011 showed the level of illuminance in the Tower building Phinisi UNM. Placement window on the building envelope on the left, right, front and rear really varied so that the natural light coming into the building is different. Phinisi UNM building consists of 17 floors, but the placement, area and shape resemble the façade is on each floor, so the analysis is only done on the 16th floor. Image below shows the vast differences, location and position of the wall openings.

FIGURE 4. Design of Window Placement on the Building Envelope

This Research was analyzing the effect of building façade on the natural lighting comparing mode 1 and 2 as I figured below. Mode 1 is the Phinisi Tower with no building façade while the 2 has used the building façade.

FIGURE 5. Modeling analysis building of Phinisi Tower UNM

Analysis of level illuminance on Model 1

The simulation results show the value of illuminance (lux) and analysis in the form of a bar graph as shown below. Therefore placement influenced the measuring point plan shape, size and placement so that the window openings measuring point are grouped into zones 1 to 5 as shown 5 below.
Figure 5 shows a graph of the value of illuminance in Zone 1-4 as follows: (1) Zone 1 is the measuring point located on the front side of the building and the value of minimum illuminance of 1406 lux and 2206 lux maximum. This zone has a value of illuminance is relatively high compared with the others, because the measuring point is located close to both sides of buildings that have wall openings (windows) that is 50 cm from the building envelope; (2) Zone 2 is the measuring point located in areas that are not met by a wall openings so that the illuminance value cannot be analyzed is 258 lux minimum and a maximum of 1032 lux; (3) Zone 3 is a measuring point which is located on the side of the building were protected by massive walls so that the value of illuminance in this area, namely a low minimum of 247 lux and 296 lux maximum; (4) Zone 4 is the measuring point where located at the notation 4-10 where the overall building envelope is a wall openings (windows) so that the value of the illuminance is relatively high at between 297 lux to 3871 lux.

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Based on the graph analysis (figure 5) so that the fourth zone can be grouped based on different area of the openings in the building envelope. Measuring point in zone 1, 2 and 3 is Group A and Zone 4 is the group B, group A and B further analyzed in the form of a linear graph to determine the equation of the line, regression and percentage of impairment illuminance.
Figure 7 shows the equation of a line/ regression on the analysis of illuminance in group A that Zone 1-3 and the graphs formulating line equation (equation 1) and R-Square as follows:

1. Zone 1. The equation of the line \( y = 174.5x^2 - 1438.5x + 4358.5 \) and \( R^2 = 0.9724 \)
2. Zone 2 line equation \( y = 92.5x^2 - 708.24x + 1698.6 \) and \( R^2 = 0.8325 \)
3. Zone 3. The equation of the line \( y = 7.5x^2 - 60.9x + 366.4 \) and \( R^2 = 0.9365 \)

Further analyzes and regression line equation in Group B which measuring point 4-10 as shown in figure 7 below.

Figure 8 shows a graph of the value of illuminance in Zone 4 which measuring point 4-10. This graph shows that the value of the illuminance at the measuring point A and F are high, because the location of the measuring point to be near the building envelope so that natural light can be absorbed into the building. The next measuring point B-E showed low values and uneven illuminance, therefore located in the middle of the building. This graph shows the average value of the measuring point 4-9 that line equation \( y = 237.39x^2 - 1652.5x + 2843.6 \) and \( R^2 = 0.9206 \) between 2017 lux illuminance value of up to 197 lux, whereas the measuring point 10 is located near the building envelope so as to have a high illuminance values a value between 3871 lux illuminance up to 608 lux and line equation \( y = 465.82x^2 - 3131.3x + 5500.8 \) and \( R^2 = 0.85 \).
Based on the results of this analysis, it can be concluded that the level of luminance in the area of the building envelope is high, because it can absorb natural light as possible. Echotech program calculation process using intermediate sky weather is equal to 8500 lux luminance and the highest value in the area of building envelope 3871 lux so it can be concluded that the reflectance of natural light in the building envelope area that is equal to 45.5%. Value of luminance can be utilized optimally into the building, but this has a negative effect because the value of luminance is very high, causing negative effects, namely the occurrence of glare and brightness, so it needs to consider the use of facade building. Tower Building Phinisi UNM design buildings by using the facade of the building on the right and left side are straight (horizontal) while the front and rear diagonal shaped like a figure 8 below.

**Analysis of level illuminance on Model 2**

Further this research analyzes the value of the luminance of the building using the building facade (model 2) as in Figure 9 below.

![Level illuminance of building (Model 2)](image)

**FIGURE 9. Result simulation of echotech program on Model 2**

Figure 10 shows the value of the luminance at the measuring point A-F or zone 4. This graph shows the comparison of the absorption of natural light into the building between the two models. Value of luminance on the area of the building envelope is the point A and F of 1201 lux and 993 lux. Luminance value decreases when located away from the opening of the building envelope is the point C and D of 190 lux and 191 lux, whereas the mean value of the illumination at the measuring point A-F is between 1710–802 lux.
Analysis of comparison level illuminance on between model 1 and 2

Figure 11 shows the value of illumination in the area of the building envelope at points A and F are the building without the facade of 1897 lux and 2129 lux, while building using the facade of 1107 lux and 1040 lux. The decrease percentage in the value of the illuminance on the facade of the building uses 29.6% at a distance of 1 m from the building envelope is 328 lux, whereas in the building without a facade of 21%. Furthermore, to clarify the difference value of illuminance on both models, can be seen in Figure 12 below.

Figure 11 illustrates the average value of illuminance which formulate line equation and regression. That is:
- The design of the building without facades (Model 1) \[ Y = 136.99x^2 - 971.61x + 1920.1 \] and \[ R^2 = 0.9839 \]
- The building design using façade (Model 2) \[ Y = 270.05x^2 - 1872.7x + 3503.5 \] and \[ R^2 = 0.9426 \]

The analysis showed that the reduction percentage of in to use and not to use the building facade is of 49% - 74% and a mean value of 60.3%. Based on this analysis, it can be concluded that the design of the building envelope affect the value of the illuminance of the building.
CONCLUSION

The results showed that the area of the building envelope which are equipped with wall openings of the window very wide, can absorb natural light to the maximum so that the building has a relatively high value 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 facade as excessive sunlight.

The study concluded that the design of horizontal and diagonal facade as in the design of UNM Phinis Tower building, is one example of designing storey building so there is no glare and high brightness levels. In terms of aesthetics of architecture, building facade is a positive value, but to consider the visual comfort of the room users so that productivity can be increased.

The results showed that 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.

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