Analysis of Public Street Lightingplacement in the Glugur Rimbun Area Medan

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Abstract

Public Street Lighting is an important infrastructure that plays a role in improving the safety, security, and comfort of road users at night. This study aims to analyze the needs and placement of Public Street Lighting light points in the Glugur Rimbun Medan area along 2,000 meters with a road width of 6 meters, as well as evaluate its conformity to the SNI 7391:2008 standard. The research method was carried out through a field survey to inventory the condition of road geometry and technical calculations using photometric parameters including illumination, light flux, and maintenance factors. The lamp used is a 150 Watt Hannochs LED with a light flux of 12,000 lumens, an IP65 protection standard, and a service life of 30,000 hours. The calculation results show that 58 light points are needed with a distance between the poles of 35 meters and an angle of inclination of the ornamental handlebar of 16.05°. The average luminance value obtained was 46.4 lux with an Emin value of 13.29 lux and a lighting uniformity (Uo) of 0.30. The total installed power of the Public Street Lighting system is 8.7 kW with an energy consumption of 104.4 kWh per day or 3,132 kWh per month. All parameters of the calculation have met the minimum requirements of SNI 7391:2008 for local and environmental road categories, even exceeding the standards of higher road categories. This research is expected to be a reference in planning an effective, efficient, and compliant Public Street Lighting system.

***Keywords**:* PublicStreet Lighting, Illumination, SNI 7391:2008, LED

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Introduction

Public Street Lighting is a lighting system installed on road sections to help road users' visibility at night. The existence of Public Street Lighting has a direct effect on the accident rate, community safety, and the quality of urban road services. Many studies show that good street lighting can improve driving safety and reduce crime-prone areas [1]. The city of Medan as a growth center in North Sumatra has high vehicle mobility. One of the areas that continues to grow is Glugur Rimbun Medan. Community activities in this area occur until night, so the existence of street lights is an important need. However, in practice, Public Street Lighting systems often experience problems in the form of uneven pole spacing, lack of light intensity, or maintenance problems [1].

In addition to the technical aspects of lighting, Public Street Lighting planning also needs to pay attention to the efficiency of the use of electrical energy and the sustainability of the lighting system used. The use of LED lights in Public Street Lighting systems is a solution that is widely applied because it has lower power consumption, longer service life, and better lighting levels than conventional lamps. Therefore, the selection of the type of lamp and its placement configuration is an important factor in producing an effective and economical street lighting system[1].

Proper lighting point planning should consider the length of the road, the width of the road, the height of the poles, the type of armatur, the flux of light, and the level of uniformity of the lighting. The use of LED lights is currently the top choice due to energy efficiency and longer lifespan[2]. The purpose of this study is to analyze the Public Street Lighting light point placement system on roads along the Glugur Rimbun Medan area, as well as evaluate whether the configuration is technically adequate.

The development of road infrastructure in residential areas needs to be balanced with the provision of adequate supporting facilities, one of which is the Public Street Lighting system. The existence of Public Street Lighting not only functions as a source of lighting at night, but also plays a role in increasing the social and economic activities of the community. Roads that have good lighting tend to be safer for motorists and pedestrians to use than roads with low lighting levels[3].

The Glugur Rimbun area is one of the areas that has experienced a fairly rapid growth in community activities. Population mobility at night is still ongoing for various purposes such as economic activities, education, and other social activities. This condition makes the need for an adequate street lighting system increasingly important to support the smooth running of community activities and reduce the potential for accidents and crime at night[4].

Based on these conditions, this study was conducted to analyze the needs and placement of Public Street Lighting light points in the Glugur Rimbun Medan area to be in accordance with street lighting standards based on SNI 7391:2008. The analysis was carried out through the calculation of illumination, lighting uniformity, distance between poles, and electrical power requirements[5]. The results of the research are expected to be a reference in the planning of a street lighting system that is able to improve the safety and comfort of road users, especially at night.

Literature Review

Public Street Lighting is a lighting system installed in the space of the road to provide sufficient visibility for road users. The main parameters in Public Street Lighting design include illumination (lux), luminance, light uniformity, and energy efficiency. LED lights are currently the main choice in Public Street Lighting system because they have high efficiency, long lifespan, and are able to produce more directed light distribution. In addition, the use of LEDs can significantly reduce energy consumption compared to previous lighting technologies[6].

According to SNI 7391:2008, the main purpose of street lighting is to provide an adequate level of visibility for road users so that objects around the road can be seen clearly. In addition, a good lighting system must be able to produce an even distribution of light to avoid the

occurrence of dark areas and glare that can interfere with the comfort and safety of road users[7].

In the planning of the Public Street Lighting system, the energy efficiency factor is one of the most important aspects. The use of LED lights is currently the main choice because it has high light efficiency, low power consumption, and a longer operational life than conventional lights. These characteristics make LED lights more economical in the long run because they are able to reduce operational costs and maintenance costs of street lighting systems[8].

In addition to the selection of the type of lamp, the aspect of the placement of the light points also affects the quality of the lighting produced. The distance between the poles, the height of the lamp installation, the angle of inclination of the armatur, and the width of the road must be precisely planned so that the distribution of light can reach the entire road surface evenly. Therefore, technical calculations that comply with the standards are required to obtain an effective, efficient, and meet the safety requirements of road users[9].

The distance between the light poles is greatly influenced by the height of the pole and the power of the lamp. In general, the ideal distance ranges from 3 to 5 times the height of the pole. Thus, for a 7-meter-tall pole, the ideal distance is in the range of 21 to 35 meters. The width of the road is also an important factor in determining the level of illumination. Roads with a width of 6 meters generally require lighting in the range of 5–15 lux to meet road user safety standards[10].

SNI 7391:2008 is a technical standard issued by the National Standardization Agency (BSN) that regulates the specifications of street lighting in urban areas. This standard sets the value of the minimum lighting parameters that must be met [11]. The following table summarizes the lighting requirements based on SNI 7391:2008:

Table 1. *Street Lighting Requirements Based on SNI 7391:2008*

Road Category	Eav (lux)	Emin (lux)	Uo = Emin/Eav	Ul
Primary Artery Pathway	≥ 20	≥ 6	≥ 0.30	≥ 0.50
Secondary Arterial Roads	≥ 15	≥ 4	≥ 0.27	≥ 0.50
Primary Collector Road	≥ 10	≥ 3	≥ 0.30	≥ 0.50
Secondary Collector's Street	≥ 8	≥ 2.4	≥ 0.30	≥ 0.50
Local Roads & Neighborhoods	≥ 5	≥ 1.5	≥ 0.30	≥ 0.50

In addition to the luminance value requirements, SNI 7391:2008 also regulates the geometric aspects of luminaire placement. The recommended pole height ranges from 8-12 meters for collector roads and 6-10 meters for local roads, with the overhang distance (the protrusion of the light arm to the middle of the road) not exceeding 1/4 of the width of the road. The spacing between the lamp poles (spacing) is determined based on a formula that considers the height of the pole, the angle of inclination of the luminaire, and the photometric distribution of the luminaire used [11].

The following is the flow of energy sources in the Public Street Lighting system starting from PLN's power supply to the street lighting process.

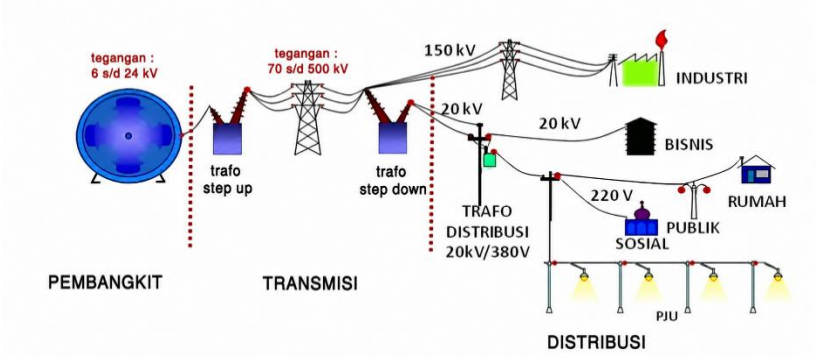

Figure 1. *Energy source flow in the Public Street Lighting system*

Some of the photometric parameters that are referenced in the analysis of the Public Street Lighting system include:

1) Luminous Flux is the total energy of light emitted by a light source in all directions per unit of time, expressed in Lumens (lm). Light flux is a measure of the total ability of light sources to produce light that can be seen by the human eye [12].
2) Illuminance is the amount of light flux that falls per unit area of the illuminated field, expressed in Lux (lx) or lumens per square meter (lm/m²). Illumination is the main parameter measured in the evaluation of street lighting quality [12].
3) Luminance is a measure of the intensity of light reflected by the road surface in the direction of the observer, expressed in cd/m². Luminance is strongly influenced by the reflective properties of the road surface (reflectance coefficient) and is a parameter that is more closely related to the visual comfort of the driver [12].

Based on this description, it can be concluded that light flux, luminance, and luminance are important parameters in the Public Street Lighting system. Light flux indicates the total light of the lamp, luminance indicates the level of illumination on the road surface, and luminance indicates the brightness of the road surface visible to road users. All three must be considered so that street lighting is effective, comfortable, and up to standard[12].

Research Methodology

Research data was collected through two main methods, namely field surveys and document studies. Field surveys were conducted to:

1. The inventory of light points includes the type of light, power, height of the pole, and the physical condition of the soil.
2. Road geometry measurements include lane width, median width, and distance between poles.

To clarify the stages of the research conducted, the research flowchart is shown in the following figure:

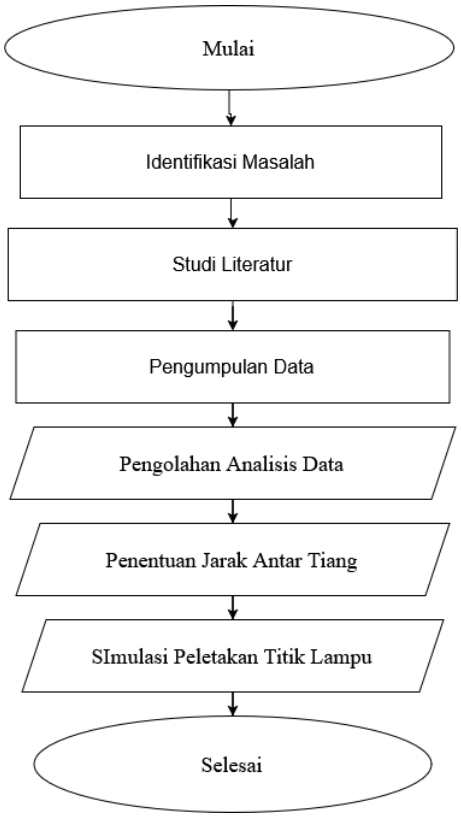

Figure 2. *Research Flowchart*

After the data is obtained, it is analyzed by the basic calculation method and the principal quantity in the lighting system. Data analysis includes:

1. Calculating the road area:

The formula used to calculate the road area is:

$$\mathbf{A = P \times L}$$

Where:
A = Road area
P = Length of the road
L = Width of the road

2. Determining the number of poles:
   According to [5] The formula used to measure the distance between the poles is:

$$\mathbf{T = +1\ \frac{L}{S}}$$

Where:
T = Pole
L = Road length (m)
S = Plan distance between poles (m)

3. Counting Immunizations:
   According to [13] The formula used to calculate Inter-Pole Immunization is:

$$\mathbf{E = \frac{\Phi \times Q \times MF}{A}}$$

Where:
E = Illumination (lux)
Q = Number of lights
Φ = Light flux in lumens (lm)
MF = Maintenance factor
A = field area (m2)

4. Counting ornamental handles
   According to [14] The formula used to calculate the ornamental handlebars is:

$$\mathbf{C = \frac{L}{2} - 1}$$

Where:
C = Ornament length
L = Width of the road

5. Calculating the power used
   According to [15] The formula used to calculate the power used is:

$$\mathbf{W = P \times t}$$

Where:
W = Electrical energy (Wh)
P = Power
t = Length of light on per day (hours)

Results

The measurement of the width of the road at the research location was carried out using a tensile meter by spreading the measuring instrument from one side to the other. This method aims to obtain direct and accurate road width data as a basis for planning the placement of street lighting points.

Figure 3. *Road Width Measurement*

Based on the results of the recalculation of the Public Street Lighting system in the Glugur Rimbun area of Medan with a road length of 2,000 meters and a road width of 6 meters, the area of lighting was obtained of 12,000 m².

The determination of the number of light points is carried out based on the planned distance between the poles of 35 meters according to the recommendations of the SNI 7391:2008 standard for poles with a height of about 7 meters. The number of light points is calculated using the equation:

1) Data of Glugur Rimbun Medan village:

Table 2. *Data of Glugur Rimbun village in Medan*

Village Name	Length of the Road	Road Width	Road Type
Glugur Rimbun Village Medan	2,000 meters	6 meters	Soil

2) Specification of the lamp to be used:

Table 3. *Lamp Specifications*

Lamp Name	Lumens	Power	Lamp Life	Protection Standards	Material
Hannochs LED	12000	150Watt	30,000 hours	IP65	AL + Glass

3) Calculating the road area:

$$A = P \times L$$
$$A = 2{,}000 \times 6$$
$$\mathbf{A = 12{,}000\ m2}$$

4) Determining the number of poles:

$$T = +1\ \frac{L}{S}$$
$$T = +1\ \frac{2000}{35}$$
$$\mathbf{T = 58\ pole}$$

5) Counting Immunizations:

$$E = \frac{12.000 \times 58 \times 0{,}8}{12.000}$$
$$E = \frac{556.800}{12.000}$$
$$\mathbf{E = 46.4\ lux}$$

So:

E = 46.4 lux

Uo = 0.30

6) Calculating the angle of inclination of an ornamental handlebar

$$C = \frac{L}{2} - 1$$
$$C = \frac{6}{2} - 1$$
$$\mathbf{C = 2\ meters}$$

$$T = \sqrt{h^2 + c^2}$$
$$T = \sqrt{7^2 + 2^2}$$
$$T = \sqrt{49 + 4}$$
T = 7.28 meters

So:

$$\text{Cos a} = \frac{h}{T}$$
$$\text{Cos a} = \frac{7}{7{,}28}$$
Cos a = 0.961

$$a = \cos^{-1} 0.961$$
a = 16.05°

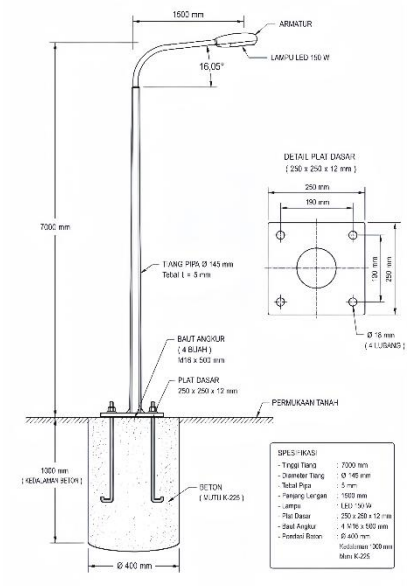

Figure 4. *Public Street Lighting Laying Simulation*

7) Calculating Uo:

$$U_o = \frac{E_{min}}{E_{avg}}$$

Because the minimum value does not exist yet, to meet the SNI standard, it can be calculated:

Emin = Uo×Eavg
Emin = 0.30 x 46.4
Emin = 13.29 lux

8) Calculating the power used:

a) Calculating the power of the whole lamp:

P. lamp = lamp power x number of lamps
P. lamp = 150 watts x 58
P. lamp = 8,700 Watts
P. lamp = 8.7 kW

b) Calculating power per day:

W = P x t
W = 8,700 x 12 hours per day
W = 104,400 Wh
W = 104.4 kWh/per day

c) Calculating monthly power:

W = 104.4 kWh x 30 days
W = 3,132 kWh/month

Based on the results of the calculations that have been carried out, the needs of the Public Street Lighting system in the Glugur Rimbun Medan area are as follows:

Table 4. *Recapitulation of Public Street Lighting Needs Calculation*

Parameters	Symbols/Formulas	Value	Units
Length of the road	P	2.000	meter
Width	L	6	meter
Road area	A = P × L	12.000	m²
Distance between poles	S	35	meter
Number of posts	T = (P/S) + 1	58	Pillar
Light flux	Φ	12.000	Lumens (LM)
Maintenance factors	MF	0,8	—
Average illumination	E = (Φ × Q × MF) / A	46.4 lux	(meet SNI)

Based on the results of the calculation of Public Street Lightingdata, a comparison was then made of the street lighting standards based on SNI 7391:2008.

Table 5. *Comparison of Results with SNI 7391:2008*

Road Category	Eav min (lux)	Eav Yield (lux)	Oo min	Status
Primary Artery	≥ 20	46,4	≥ 0.30	**Meet**
Secondary Arteries	≥ 15	46,4	≥ 0.27	**Meet**
Primer Collector	≥ 10	46,4	≥ 0.30	**Meet**
Secondary Collector	≥ 8	46,4	≥ 0.30	**Meet**
Local & Environment	≥ 5	46,4	≥ 0.30	**Meet**

Based on the results of the illumination calculation that has been carried out, a comparison is then made between the luminance value of the planned result with the street lighting standard according to SNI 7391:2008.

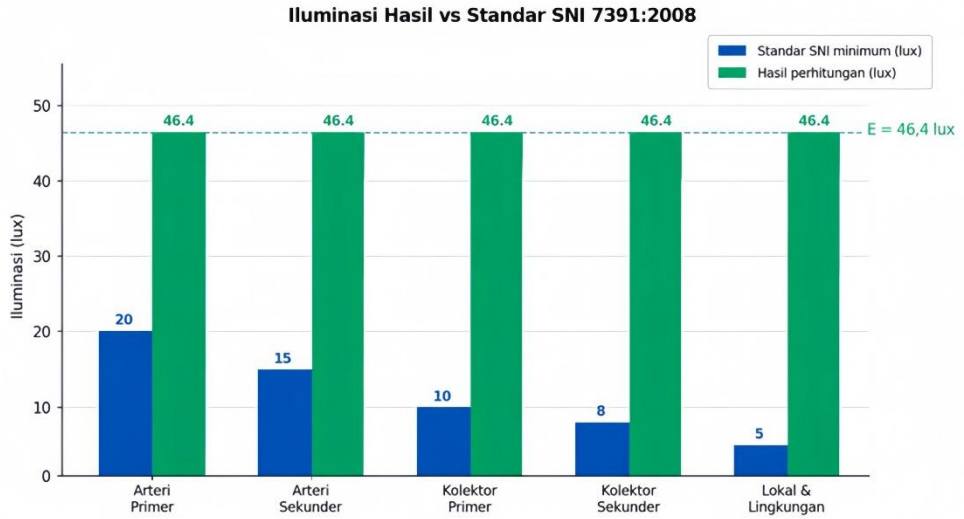

Figure 5. *Comparison of the illumination value of the calculation results (46.4 lux) to the minimum standard of SNI 7391:2008 in five road categories*

After calculating the lighting needs of public roads, the lighting points are then determined using software *AutoCAD.*

Figure 6. *Determining the light point using AutoCAD software*

The points of Public Street Lighting lights are marked with a yellow round symbol placed along the side of the road. The determination of the light point is done using software *Copyright © 201* Based on the results of the calculation of the distance between the poles and the classification of the road that has been determined beforehand.

Conclusion

Based on the results of research and calculations that have been carried out on the Public Street Lighting system in the Glugur Rimbun area of Medan, it was obtained that the planning of street lighting using Hannochs 150Watt LED lamps is able to meet street lighting standards based on SNI 7391:2008. On a 2,000-meter road with a width of 6 meters, there is a need for 58 light points with a distance between poles of 35 meters and a pole height of 7 meters. The calculation results showed an average illumination value of 46.4 lux and a lighting uniformity value (Uo) of 0.30 so that the distribution of light on the road surface was relatively even and according to the set standards.

In addition to meeting the technical aspects of lighting, the Public Street Lighting system designed also shows the efficiency of using electrical energy. The total power used is 8.7 kW with energy consumption reaching 104.4 kWh per day or 3,132 kWh per month. The use of LED lights provides advantages in the form of energy efficiency, longer service life. Thus, the results of this study show that the planning of the placement of Public Street Lighting light points in the Glugur Rimbun Medan area is able to improve the security, comfort, and safety of road users at night.

Suggestions

Based on the results of the study, the implementation of the Public Street Lighting system in the Glugur Rimbun area is recommended to be carried out in stages according to the priority needs and budget availability. The use of galvanized poles as well as automatic control systems such as timers or light sensors need to be considered to improve the reliability of the installation and the efficiency of electrical energy use. In addition, it is necessary to carry out regular maintenance regularly to maintain the quality of lighting and the performance of the Public Street Lighting system. After the installation is complete, illumination measurements using a lux meter are recommended to verify the suitability of the planning results with field conditions. Further research can develop an economic analysis of the Public Street Lighting system and examine the use of renewable energy, such as solar power, as a more sustainable alternative energy source.

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