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# Lighting Installation Calculation and Cost Budget on Road Protocol

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**ABSTRACT**

Based on the results of the discussion in data processing according to field data, there are the results of the discussion, as follows: The number of street light poles is 100 traveling rods and one hundred lighting lamps. The distance between the poles is 50 meters and the height of the poles is 7 meters and the LED lights are 90 watts so that they do not meet the lighting standards of general street lights. Installation must follow the provisions for installing aerial cables in PUIL 2000 TC (Twistet cabel) as aerial cables are already familiar in the field. (In PUIL, there are various types of aerial cables NFY, NFAY, NF2X, NFA2X, etc.) On the TC cable for identification: On the TC cable there is a line / strip one is used to mark the phase = N, On the TC cable there is no line / strip is used to mark the neutral = N The nominal current in each panel is 12.37 amperes and the total use of lighting on the Sutomo-Merdeka road is 18,000 watts . The total cost budget is; total material price + tax + profit = IDR 1,515,164,000.- + IDR 174, 243,860.- + IDR 303,032,000.- , = IDR 1,992,440,660 -.



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## 1. INTRODUCTION

In lighting, it is very necessary to have skilled personnel who also understand the types of lamps so that the condition of the lamps we use on the highway. For this reason, an explanation calculation is needed. On the highway, good lighting can reduce the risk of motor vehicle accidents that occur, in addition to getting a more comfortable atmosphere, and better road user safety, and the risk of crime can be reduced.

Budget is a tool for management in planning and controlling the company. Budget is an organization's work plan in the future which is realized in quantitative, formal and systematic form. In general, all functions within an organization can be grouped into four main functions, namely *planning* (planning), *organizing* (organizing), *actuating* (moving), *controlling* (controlling). Budgeting is usually done at the planning stage. At the activity stage, they are grouped into several types, namely the basis of preparation, method of preparation, time period, field, ability to compose, function and method of determining product cost ( Rudianto , 2009 ).

### 1.1 Definition of Unit in Lighting

The term lighting technique is understood and deepened into one technique

which includes everything related to the production and illumination of light

According to Cristian Huigen in (1678) put forward an opinion that light is a wave event. Where based on this theory light consists of free movements carried out by electromagnetic waves

In free space electromagnetic waves have a late velocity V = 3. $10^5$km/second with frequency F ( $H_Z$) according to this condition, then the wavelength is.

**1.2. Lighting Basics**

Light current/ luminous flux () According to Abdul Kadir (1995) luminous flux is the total light emitted every second by a light source. Where, = luminous flux (lm) Q = light energy (lm.s) t = time (s)

**1.3. Terms of Good Lighting**

Good lighting is closely related to success because it can increase work effectiveness. To get good lighting, there are several conditions that must be met, including:

1. Strong lighting.
2. Strong uniformity of illumination.
3. Room index.

**1.4 Glare Effect**

Glare is false light within the reach of the eye that causes discomfort, fatigue or irritation to the eye. Glare occurs when a person receives direct light from a very bright light source. This glare is called direct glare.

Glare that occurs due to the difference in contrast between the light source and its surroundings is called contrast glare. We can feel the glare itself if we look at the light of the car's headlights at night. Due to the difference in the contrast of the light with the dark surroundings. But during the day the same light does not cause glare because the surroundings are also daytime.

**1.5 General**

The equipment used in electrical installations varies depending on the nature of the room or location and the environmental conditions in which the installation is used where the installation will be installed.

**1.6. PJU Installation By Air Cable Way**

Usable Conveyor

1. Installation must comply with the provisions of aerial cabling in PUIL 2000
2. TC (Twistet cabel) is the name of the aerial cable that is already familiar in the field. (in PUIL, all kinds of aerial cables are NFY, NFAY, NF2X, NFA2X, etc.)
3. On the TC cable for identification.
4. On the TC cable there is a single line / strip used to mark the phase = R
5. On the TC cable no lines/strips are used to mark neutral = N

**1.7. Insulator**

Insulation or insulators are used to support electrical conductivity where an insulator is needed. Insulators must be made of porcelain or other materials and must have smooth and not sharp corners and curves. To avoid damage to the conductor during installation .

The installation of the insulator must be strong and such that there is no excess mechanical force on the supported conductor. For installation in street lights, roller insulators are often used. above above the street light cable the installation of the roller isolator shall be such that the clearance between conductors of different phases or of different polarity is not less than 3 cm. For street light cables of type (NYM) 1.5mm and 2.5mm the distance between the fulcrums should not exceed 1 m (Puil 1987 paragraph 742A5).

**1.8. Understanding Budget**

Budget is a tool for management in planning and controlling the company. Budget according to Rudianto (2009). is an organizational work plan in the future which is realized in quantitative, formal and systematic form.

According to Rudianto in (2009), in general, all functions within an organization can be grouped into four main functions, namely: *Planning* (Planning), *Organizing* (Organizing), *Actuating* and (Moving), *Controlling* (Controlling).

**1.9. Operating Cost Budget**

The operational cost budget is all expenditure plans related to the distribution and sale of the company's products as well as expenses to run the organization's wheels. Rudianto (2009)., According to Munandar (2007). the preparation of an operational cost budget that commonly occurs in a company includes the following budgets; Fixed Cost Budgeting ( *Fixed Cost Budgeting* ), Variable Cost Budgeting ( *Variable Cost Budgeting* ), Semi-Variable Cost Budgeting.

## 2. RESEARCH METHOD

### 2.1 Research Time and Location

It was carried out on Jalan Merdeka-Sutomo in the Siantar Simalungun area, namely surveying the existing street lights and checking for deficiencies that occurred in the lighting of Jalan Merdeka - Sutomo. Climatology data collection at the research site. The data was obtained from the Tarukim Office of Public Street Light Lighting in the South Pematang Siantar area.

### 2.2 Research Method

To obtain the results of the calculation of lighting installations and budget costs on the Sutomo-Merdeka road, the author must collect data from KPR . In the process of collecting data, the author also conducted interviews in order to obtain complete data.

### 2.3 Data Processing

After the data is collected, the data is processed based on theories and information obtained from existing sources.

### 2.4 Data Analysis Theories

Technical analysis is carried out to obtain a lighting system that is good, safe, reliable, durable, and in accordance with the manufacturer's specifications and especially according to SNI. The technical analysis is carried out on the components which include lighting, poles, and others.

In analyzing lighting installations, there are several things that need to be considered to get good lighting, which fulfills its function so that the eyes can see clearly and comfortably. Therefore, several lighting calculations are needed, including: Light Intensity , Luminance , Illumination Intensity ( Illumination ) , Illumination Efficiency.

### 2.5 VAT Rate

For the calculation of the budget for the installation of public street lights must be subject to VAT. The determination of the VAT rate is regulated in Law Number 42 of 2009 concerning Value Added Tax of Goods and Services and Sales Tax on Luxury Goods.

The VAT rate charged to the buyer will be clearly written on each proof of the sale and purchase transaction. This means that the price paid will be added to the amount of VAT. However, if we do not find a VAT statement on the receipt, it means that the total price listed includes VAT.

## 3. RESULTS AND DISCUSSIONS

### 3.1 Light Intensity Polar Diagram

Figure 1. shows a polar diagram of the luminous intensity of a lamp armature. The light intensity of an incandescent lamp has space symmetry with respect to the vertical line through the center of the lamp. Therefore the division of light intensity is given in a plane through the axis of symmetry. The diagram doesn't need to be drawn entirely, only half is enough.

Measurements are carried out at a relatively far distance. Therefore the light source can be considered as a point-shaped light source. In Figure 4.1 the length of the radius from 0 to a point on the graph represents

the intensity of light in that direction in a candela. Generally these diagrams are given for lamps giving 1000 lumens. The luminous intensity of a lamp is proportional to the flux of other light, the values given in the diagram must still be multiplied by the number of thousands of lumens of the lamp.

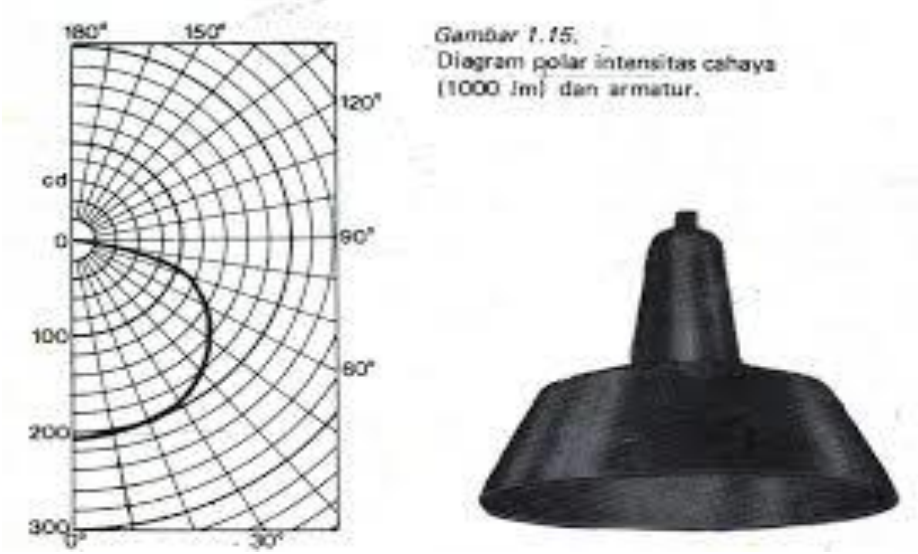


**Figure 1 Illumination Intensity Graph**

With polar light intensity used to calculate the intensity With 1=400 cd, and the distance between L and P equal to r = 2m, then the illumination intensity of point P is equal to:

$$Ep = \frac{I}{r^2} = \frac{400}{2^2} 100$$

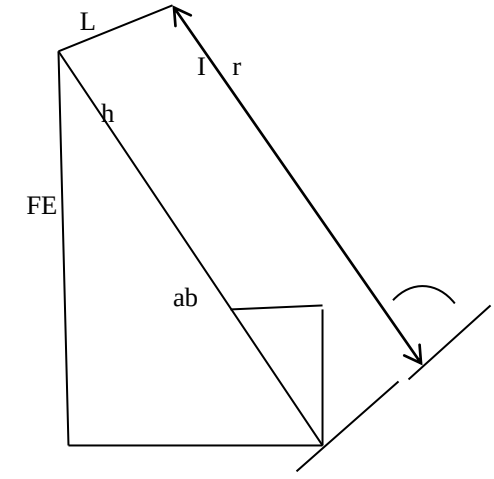


**Figure 2 Lighting Intensity**

In Figure 4.2, the intensity of illumination $E^1$in $a^1$the $b^1$perpendicular plane in the direction 1 according to the square law will be equal to:

$$E^1 = \frac{I}{r^2} \text{.....}$$

The intensity of illumination E in the horizontal plane ab is the projection of $E^1$the perpendicular to the plane ab at point P, so

E = $E^1$cos a.....

Where:

a = angle between the ray of light and the perpendicular on the plane ab at the point P

E =$\frac{I}{r^2}$

**3.1.1 Calculation of Illumination Intensity**

Illumination intensity at point a

Pa= r =$\sqrt{ab^2 + Pb^2}$

=$\sqrt{2^2 + 7{,}99^2}$

=$\sqrt{4 + 63{,}84}$

=$\sqrt{67{,}84}$

= 8,236 m

$r^2$ = 67.84$m^2$

To find the light intensity, we use the interpolation method (see table for street light intensity).

If $r^2$= 67.84 $m^2$ then the table shows

$r_1$= 98 : $I_1$ = 200

$r_2$= 113 : $I_2$ = 0

So:

I=$\frac{(r_2 - r^2)}{(r_2 - r_1)} I_1 + \frac{(r^2 - r_1)}{(r_2 - r_1)} I_2$

=$\frac{(113-67{,}84)}{(113-98)}.200 + \frac{(67{,}84-113)}{(113-98)}.0$

=$\frac{(45{,}16)}{(15)}.200$

= 602.13 cd

Cos $\theta$ =$\frac{pb}{pa}$

=$\frac{7{,}99m}{8{,}236m}$

= 0.97

$E^1$ =$\frac{I}{r^2}$

=$\frac{602{,}13}{67{,}84}$

= 8.87 lux

E= E' x cos $\theta$

= 8.87 x 0.97

= 8.60 lux

Illumination intensity at point b

The light is perpendicular to the plane, then it can be seen that the intensity of the lighting on the street lamp is:

Distance = 0 and $r^2$ = 67.84

I = 800 cds; E' = 16.3 lux and E = 16.3 lux

Illumination intensity at point c

Pc = r =$\sqrt{bc^2 + pb^2}$

=$\sqrt{0{,}5^2 + 7{,}99^2}$

=$\sqrt{63{,}84 + 0{,}25}$

= $\sqrt{64{,}09}$

= 8.005 m

$r^2$ = 64.09 $m^2$

To find the light intensity we use the interpolation method (see table of street lamp light intensity)

If $r^2$ = 64.09$m^2$ then the table looks

$r_1$ = 98 : $I_1$ = 200

$r_2$ = 113: $I_2$ = 0

I $= \frac{(r_2 - r^2)}{(r_2 - r_1)} . I_1 + \frac{(r^2 - r_1)}{(r_2 - r_1)} . I_2$

$= \frac{(113-64,09)}{(113-98)} . 200 + \frac{(113-98)}{(113-98)} . 0$

$= \frac{(48,91)}{(15)}$

= 640 cd

Cos $\varphi$ $= \frac{pb}{pc}$

$= \frac{7,99}{8,005}$

= 0.99

E' $= \frac{I}{r^2}$

$= \frac{640}{64,09}$

= 9.95 lux

E = E' x cos$\varphi$

= 9.95 x 0.99

= 9.85

Illumination intensity at point d

Pd = r $= \sqrt{bd^2 + pb^2}$

$= \sqrt{1^2 + 7,99^2}$

$= \sqrt{1 + 63,84}$

$= \sqrt{64,84}$

= 8.05 m

$r^2$ = 64.84$m^2$

To find the light intensity we use the interpolation method (see table light intensity of street lamps)

If $r^2$ = 64.84 $m^2$then the table shows

$r_1$ = 98: $I_1$ = 200

$r_2$ = 113: $I_2$ = 0

So

I= $\frac{(r_2 - r^2)}{(r_2 - r_1)} . I_1 + \frac{(r^2 - r_1)}{(r_2 - r_1)} . I_2$

$= \frac{(113-64,84)}{(113-98)} . 200 \frac{(64,84-98)}{(113-98)} . 0$

$= \frac{(48,52)}{(15)}$

= 646 cd

cos $\varphi$ $= \frac{pb}{bd}$

$= \frac{7,99}{8,05}$

= 0.99

E'= $\frac{I}{r^2}$

$= \frac{646}{64,84}$

= 9.96 lux

E= E' x Cos $\varphi$

= 9.96 x 099

= 9.86 lux

Explanation at point e

Pe = r = $\sqrt{be^2 + pb^2}$

$= \sqrt{1,5^2 + 7,99^2}$

$= \sqrt{2,25 + 63,84}$

$= \sqrt{66,09}$

= 8.12m

$r^2$ = 66.09$m^2$

To find the light intensity we use the interpolation method (see table of street lamp light intensity)

If $r^2$ = then the table looks

$r_1$ = 98: $I_1$ = 200

$r_2$ = 113: $I_2$ = 0

So :

$$I = \frac{(r_2 - r^2)}{(r_2 - r_1)} . I_1 + \frac{(r^2 - r_1)}{(r_2 - r_1)} . I_2$$

$$= \frac{(113-66,09)}{(113-98)} . 200 \frac{(66,09-98}{(113-98)} . 0$$

$$= \frac{(64,91)}{(15)} .200$$

= 864cd

Cos $\varphi$ $= \frac{pb}{pe}$

$= \frac{7,99}{8,12}$

= 0.98

$E' = \frac{I}{r^2}$

$= \frac{864}{66,09}$

= 13.07 lux

E= E' x Cos $\varphi$

= 13.07 x 0.98

= 12.80 lux

Illumination intensity at point f

Pf = r = $\sqrt{bf^2 + pb^2}$

$= \sqrt{2^2 + 7,99^2}$

$= \sqrt{4 + 63,84}$

$= \sqrt{67,84}$

= 8.23 m

$r^2$ =67,84 $m^2$

To find the light intensity we use the interpolation method (see table of street lamp light intensity)

If $r^2$ =67,84 $m^2$then in the table see

$r_1$ = 98 ; $I_2$= 200

$r_2$ = 113 ; $I_1$= 0

So :

$$I = \frac{(r_2 - r^2)}{(r_2 - r_1)} . I_1 \frac{(r^2 - r_1)}{(r_2 - r_1)} . I_2$$

$$= \frac{(113-67,84)}{(113-98)} . 200 \frac{(67,84-113)}{(113-98)} . 0$$

$$= \frac{(45,16)}{(15)} .200$$

= 602 cd

Cos $\varphi$ $= \frac{pb}{pf}$

$= \frac{7,99}{8,23}$

= 0.97

$E' = \frac{I}{r^2}$

$= \frac{602}{67,84}$

= 8.87 lux

E= E'x Cos$\varphi$

= 8.60 lux

Intensity of illumination at point g

Pg = r=$\sqrt{bg^2 + pb^2}$

=$\sqrt{2,5^2 + 7,99^2}$

=$\sqrt{6,25 + 63,84}$

=$\sqrt{70,09m^2}$

= 8.37 m

$r_2$ =$70,09m^2$

To find the light intensity we use the interpolation method (see table of street lamp light intensity)

If $r^2$ = $68,09m^2$then in the table it can be seen

$r_1$ = 98; $I_1$ =200

$r_2$ = 113; $I_2$= 0

So :

I=$\frac{(r_2-r^2)}{(r_2-r_1)}.I_1\frac{(r^2-r_1)}{(r_2-r_1)}.I_2$

=$\frac{(113-70,09)}{(113,98)}$ .200$\frac{(68,09-113)}{(113-98)}$ .0

=$\frac{(44,91)}{(15)}.200$

= 572 cd

Cos $\varphi$ =$\frac{pb}{pg}$

=$\frac{7,99}{70,09}$

= 0.95

E'=$\frac{I}{r^2}$

=$\frac{572}{70,09}$

= 8.16 lux

E= E' x Cos $\varphi$

= 8.16 x 0.95

= 7.75 lux

Illumination intensity at point b

Ph = r=$\sqrt{bh^2 + pb^2}$

=$\sqrt{3^2 + 7,99^2}$

=$\sqrt{9 + 63,84}$

= $\sqrt{73,84}$

= 8.59 m

$r^2$ = $72.84m^2$

To find the light intensity we use the interpolation method (see table of street lamp light intensity)

If $r^2$ = $72.84m^2$

$r_1$ = 98 ; $I_1$ = 200

$r_2$ = 113; $I_2$= 0

So :

I= $\frac{(r_2-r^2)}{(r_2-r_1)}.I_1\frac{(r^2-r_1)}{(r_2-r_1)}.I_2$

=$\frac{(113-72,84)}{(113-98)}.200\frac{(72,84-113)}{(113-98}.0$

=$\frac{(40,16)}{(15)}$

= 534 cd

Cos $\varphi$ =$\frac{pb}{ph}$

$= \frac{7,99}{8,59}$
= 0.93

E'=$\frac{I}{r^2}$
$= \frac{534}{72,84}$
= 7.33 lux

E= E' x Cos $\varphi$
= 7.33 x 0.93
= 6.81 lux

**3.1.2 Nominal Current (I) Calculation**

The entire installation consists of eight panels, namely panels I to VIII
The nominal for each phase is

panel I

1. R phase

I $= \frac{p}{V.cos\emptyset}$
$= \frac{90 .25=2250}{220.0,8=178}$
= 12 amperes

Panel II

1.phase R

I $= \frac{p}{V.cos\emptyset}$
$= \frac{90 .25=2250}{220.0,8=178}$
= 12 amperes

Panel I II

1.phase R

I=$\frac{p}{V.cos\emptyset}$
$= \frac{90 .25=2250}{220.0,8=178}$
= 12 ampere

Panel IV

1.phase R

I=$\frac{p}{V.cos\emptyset}$
$= \frac{90 .25=2250}{220.0,8 .=187}$
= 12 ampere

Panel V

1.phase R

I=$\frac{p}{V.cos\emptyset}$
$= \frac{90 .25=2250}{220.0,8=187}$
= 12 ampere

Panel VI

1.phase R

I=$\frac{p}{V.cos\emptyset}$
$= \frac{90 .25=2250}{220.0,8=187}$
= 12 ampere

Panel VII

1.phase R

I=$\frac{p}{V.cos\emptyset}$

$= \frac{90 .25=2250}{220.0,8=187}$ = 12 amperes

Panel VIII

1.phase R

I $= \frac{p}{V.cos\emptyset}$

$= \frac{90 .25=2250}{220.0,8=187}$

= 12 amperes

**3.2 Total Number of Lamp Usage**

The total number of lamps used for lighting on Jalan Merdeka-Sutomo Pematang Siantar is:

a.Load on panel I

1.phase R= Number of lamps x Lamp load

= 25 x 90

= 2250 watts

b.Load on panel II

1.phase R= Number of lamps x Lamp load

= 25 x 90

= 2250 watts

Panel load III

1.phase R= Number of lamps x Lamp load

= 25 x 90

= 2250 watts

IV panel load

= 25 x90

= 2250 watts

Panel load V

1.phase R = Number of lamps x Lamp load

= 25 x 90 watts

VI panel load

1.phase R = Number of lamps x Lamp load

= 25 x 90

= 2250 watts

VII . panel load

1.phase R = Number of lamps x Lamp load

= 25 x 90

= 2250 watts

VIII panel load

1.phase R = Number of lamps x Lamp load

= 25 x 90

= 2250 watts

So the total load usage of all lamps is:

P = Panel I load + II panel load + III panel load + IV panel load + V panel load + VI panel load + VII panel load

VIII panel load

= 2250 + 2250 + 2250 + 2250 + 2250 +2250 + 2250 + 2250

Total power used on free road – sutomo

= 18,000 watts

**3.3 Cost Calculation**

**3.3.1 Calculation of Foundations and Piles**

a. Calculation of the cost of making pillars

1. Reinforced concrete ; 1 $m^3$ = Rp. 800,000.-
2. Armature bolts with a diameter of 3/4" 4 pieces = Rp. 92,000.-

@ IDR 23,000.-
So the total cost of the pile foundation = RP 892,000.-
b. Calculation of the cost of making each pole
1. 1 rod round pole = IDR 2,700,000.-
2. led lights (1 complete set) = Rp. 4,500,000.-
So the total cost for each pole. = IDR 7,200,000.-
(The calculation above is based on information from the PRKP Pematang Siantar office).
So it can be seen that the cost of making the entire foundation and making the pile is:
= (foundation cost + pile cost) x total pile
= (Rp 892,000.- + Rp 7,200,000.-) x 200 poles
= Rp 8. 092,000.- x pole
= IDR 1,618,400,000.-

**4.6.2 Overall Budget Calculation**

Tax (PPh and VAT) = 11.5%x total material price
= 11.5% x IDR 1,515,164,000
= IDR 174,243,860

Profit = 20% x (total material price + tax)
= 20% x IDR 1,515,164,000.-
= IDR 303,032,800.-

Then the total budget of the whole, is
= total material price + tax + profit
= IDR 1,515,164,000.- + IDR 174,243,860,- + IDR 303,032,800.-
= Rp. 1,992,440,660.-

## 4. CONCLUSION

Based on the results of the discussion in data processing according to field data, there are several conclusions, as follows:

1. The number of street light poles is 100 walking sticks and one hundred lighting lamps. The distance between the poles is 50 meters and the height of the poles is 7 meters and the LED lights are 90 watts so that they do not meet the lighting standards of general street lights.
2. The nominal current on each panel is 12.37 amperes and the total use of lighting lamps on the Sutomo-Merdeka road is 18,000 watts.
3. The total cost budget is; total material price + tax + profit = IDR 1,515,164,000.- + IDR 174, 243,860.- + IDR 303,032,000.- = Rp. 1,992,440,660.-

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