DESIGN LAMP LIGHTING STREET BASED COMFORT, EYE FATIGUE, AND SECURITY

I Ketut Wijaya

Faculty of Electrical Engineering University of Udayana, Badung, Bali, Indonesia

Home address : Jln. Gunung Batukaru 42 A Denpasar, Bali, Indonesia, Post Code: 80119

ABSTRACT

Public street lighting is very helpful in the creative endeavors of the community though only small but sustainable. Street lights are required for all walks of life. Street lighting is required for activities and other activities.

The community desperately needs street lighting in relation to relaxing on the field with the family. Street lighting can work as well as to provide comfort, reduce eyestrain, and make to sense of security. The data is taken from calculation on the street lighting and gives the questionnaire on the subject. The method used is the method of analysis by analyzing the results of the calculation and the results of the questionnaire.

The calculation results of 120 Watt LED lamps with 121 lumens / Watt mounted as high as 6 meters produces light intensity of 23.06, 19.63, 14.56, 10.68, 8.85, 6.95, and 5.49 Lux on as far as 3, 4, 5, 6, 7, 8, and 9 meters up to the edge of the road. There was a 53% increase in comfort, reduction in eyestrain amount 75 %, and adds a sense of security amount 57%. The results obtained from this research deserve to be followed up to be able to be installed the lamp street lighting.

Keywords: Street lighting, Comfort, Eye Fatigue, Security.

A.BACKGROUND

Street lighting is required for road lighting in terms of comfort, eyestrain, and people's safety on the road. The street lighting is needed to be able to indulge in any activity without any hesitation. Street lighting is necessary to accelerate the economy from a small economy to the largest economy. The street lighting can spur economic growth with higher levels of security.

Street lights should be designed based on the needs and characteristics of the road users' activities. The community of road users should feel safe and comfortable in the activity after installed lamp the street lighting. In the City people have started beraftifitas at night according to the needs of the market. Street lights should be bright enough so that the community are not afraid of the conditions night. Street lighting can funcion as well as reducing people to evil and discouraging to do evil. Evil intentions can arise because there is an opportunity and let alone no street lighting. The needs of street lighting can stimulate the community to conduct activities related to the addition of family income. People in Bali have started with night activities going to the market to selling something. People in Bali have started with the activities of the night went to market to selling. Seen people who to the selling are ready to go to the market at night at 12:00 in the morning.am until 7:00 am. The existence of street lights buffers help people to the trade

because people in selling do not use lighting at all. Street lighting is indispensable for night activities with designs that meet comfort, eye health, and safety requirements.

Will be conducted research to get comfortable condition, eye health and safety in activity with existence of street lighting. Street lights will be ergonomically designed to get a sense of comfort, eye health, and a sense of security in the activity.

a. Problem Formulation

From the above uaraian can be made problem formulation as follows:

1. What is the operational cost per year?
2. Does the street lighting can add to the comfort of outdoor activities?
3. Does the street lighting reduce eyestrain?
4. Does the street lighting can increase the security of activities outside the home?

b. Research Benefits

The benefits of this research are:

1. The benefit of this research is to provide understanding that street lighting can serve to keep society from unfavorable condition.
2. Research may also reveal unfavorable conditions due to no street lighting.

c. Way Conduct Research

1. Doing calculations on street lighting.
2. Measuring the intensity of light on street lighting.
3. To giving questionnaires to the community around street lighting.
4. Conducted analysis to be able to generate conclusions.

B. THE MATERIAL AND METHODS

The material in this research is LPJ lamp in Badung regency in one place where activity is often done by society.

The method used is to calculate the intensity of street lighting, to provide comfort questionnaires, eyestrain, and safety with samples in the that place.

C. RESULTS AND DISCUSSION

a. Results

b.

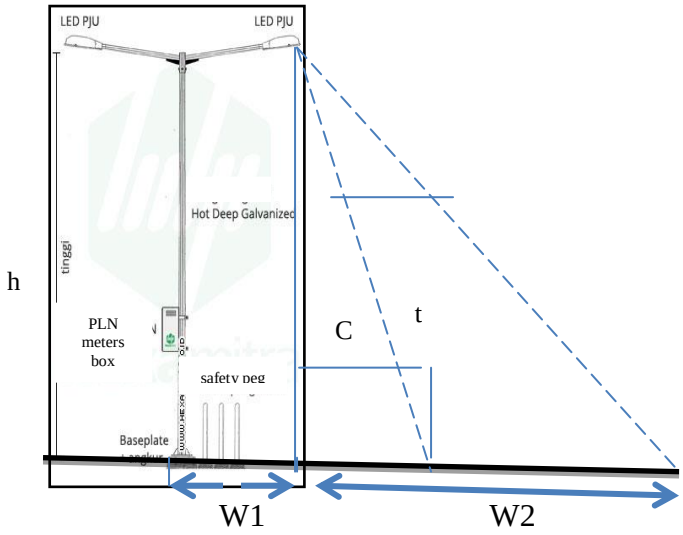
a) Lamp Completeness

Very necessary to do calculate street lighting for easy installation preparation. Street lighting has the criteria:

1. Artery
2. Collector road

3. Local road

b) Image from lamppost



Where :

h: height of pole

c: : the horizontal distance of the lamp in the middle of the night

t: The lamp distance to the middle of the road

W1:distance the pole to the end of the lamp

W2: the horizontal distance of the lamp to the end of the road.

To find the slope angle from lamp so point of illumination towards the middle of the road.

$T = \sqrt{t^2 + C^2}$ (1)

So $\cos \emptyset = h / t$ (2)

c). Part of the streetlight house

1. Reflector of lamp
2. Armature of lamp

d). *Cable*

The cable used is a cable that can be planted in the ground.

1. Cable NYA (single core cable with insulate of PVC) with a maximum temperature of 700^0 C
2. NYM cable (multicore PVC with insulated of the white)
3. NYY cable (multinode cable PVC insulated black) has a maximum ability of 1 KV.

e). Protection used

1. Type of protection (MCB) which if there is more current then this protection will be open in accordance PUIL 2011.
2. This type of protection is required to withstand the shock current (lightning strike) or due to the infestation (RCCB protection).

f***). Lamp***

Lamp that is used is a type of LED lamp with the provision of a large 120 Watt lamp with a 6 meter pole height, both for one handlebar or two handlebar.

1. Lamp type: LED
2. Power: 120 Watt
3. Light efficiency: 14,520 lumens
4. Luminous efficiency:> 121 lm / W
5. Color: yellow

g). ***Calculation result***

(a) Determined the angle of inclination with a width of 4 meters:

r = $\sqrt{h^2 + c^2}$

r = $\sqrt{6^2 + 4^2}$ = 7,21 meters

So that Cos Ø = $\frac{h}{t}$ = $\frac{6}{7.21}$ = 0,83

Ø= Cos^{-1}0,83 = 37,55^0

(b) The magnitude of index K (light efficiency of the lamp) and the angle of slope ω = 4π

Then $i = \frac{KP}{\omega}$ = $\frac{120x121}{4\ x\ 3.14\omega}$ = 1156,05 Cd

(c). Calculates illumination at the lamp point to the end of the road

(a) Calculating the illumination with a 3 meter road width:

r = $\sqrt{6^2 + 3^2}$ = 6,71

So that Cos Ø = $\frac{h}{t}$ = $\frac{6}{6,71}$ = 0,89

Ø = Cos^{-1}0,89 = 30,14^0

Er = $\frac{i}{r^2}$ $Cos\ \beta$ = $\frac{1156,05}{6,71^2}$ x $\frac{6}{6,71}$ = $\frac{1156,05}{45,02}$ x 0,89 = 22,85 Lux

(d) Calculating illumination at the point of lamp to end of ramp (r)

$r = \sqrt{6^2 + 4^2} = 7{,}21$ meters

$$Er = \frac{i}{r^2} Cos\ \beta = \frac{1156.06}{(7.21^2)} \times \frac{6}{7.21} = \frac{1156.06}{51.98} \times 0{,}83 = 18.46 \text{ Lux}$$

(c) Illumination at a distance of 5 meters (r)

$r = \sqrt{6^2 + 5^2} = 7{,}81$ meters

$$Er = \frac{i}{r^2} Cos\ \beta = \frac{1156.06}{(7.81^2)} \times \frac{6}{7.81} = \frac{1156.06}{60.99} \times 0.77 = 14.59 \text{ Lux}$$

Table 1. Angle of Tilt

No.	*High of Pillar*	*Length Stang 2.1 meters*	*Length Stang 3 meters*
		Angle of Slope (^{0})	*Angle of Slope (^{0})*
1	6	36.63	29.55
2	7	32.31	25.66
3	8	28.87	22.76
4	9	19.29	20.34
5	10	10.73	10.44
6	11	11.67	11.40
7	12	19.88	15.40

Table 2. Light Intensity Calculation Result

No.	Distance of Illumination Up to the Edge of the Road	Light Intensity of LED Lights			
		120 Watt LED Lamp (121 Lumen / Watt with Height of Pole 6 meters	200 Watt LED Lamp (23000 Lumen) with 7 meter pole height	200 Watt LED (100 Lumen / Watt) lamp with 7 meter pole	LED 240 Watt (26000 Lumen / Watt) with 8 meter pole height
1	3	22,85	25.03	21.68	19.54
2	4	18.46	21,14	18.38	17.38
3	5	14.59	17.27	15.02	14.81
4	6	10.68	14.02	12.19	12.00
5	7	8.85	11.36	5.35	10.34
6	8	6.95	9.15	7.95	8.59
7	9	5.49	7.42	6.45	7.12

h) Number of Lamp Point Required at 40 Meters Place Distance Between Pile

$$B = \frac{l}{s} + 1 = \frac{500}{40} + 1 = 13{,}5$$

So the number of lamp points needed is 14 point lights.

For public roads with a length of 500 meters can be installed lights with a distance of 25 meters or with a distance of 30 meters between the lamp.

i) Calculation of protection used

The large calculation of the safety current used for the bulb is Power that used 14 pieces of lamp = 14 x 120 x Cos θ = 1480 Watt.

$$I_n = \frac{P}{V\ Cos\ \emptyset} = \frac{14x120}{220x0.85} = 8.98A$$

I_{rating} = K x I_n = 125% x I_n = 125% x 8.98 = 11.23 A

APP rating flows are:

$$I_n = \frac{P_{total}}{\sqrt{3}\ V\ Cos\emptyset} = \frac{120x14}{\sqrt{3}VCos\theta} = \frac{1680}{3.14x380x0.85} = 1.66\ A$$

j) Flows of rating on the APP ie

Calculation of protection used

The large calculation of the safety current used for the bulb is

Flows of the rating = K x In = 125% x 1.66 A = 2.075 A

Based on field observation, there is no the protection 3 A, therefore protection is used with large current of 4 A. The size of 4 A protection can be used for 8 lamps.

k) Calculation of electrical power required is

At six o'clock the lights came on and stopped burning at 6:00 am. Lights operate for 12 hours. Energy required for 12 hours of operation is P = 120 watt x 40 (The distance between the pole) x Cos ∅ = 4800 x 0.85 = 4080 Watt.

Then the power is connected to 14 lights = 4.8 kVA.

l) The fact the lights turn on in 12 hours for 14 pieces of light per day is

W = (P x t) / Cos∅

= (120 x 14 x 12) / 0.85

= 23.72 kWh per day

In one month the energy needed for 14 lamps:

W / month = 23.72 x 30 days = 711.6 kWH. Based on the Regulation of the Minister of Energy and Mineral Resources of the Republic of Indonesia (ESDM) no. 28 year 2016, regarding the electricity tariff provided by PT Perusahaan Listrik Negara (PERSERO), that the electricity tariff for street lighting in the January-March 2018 tariff adjustment from 1300 VA - 200 kVA = Rp. 1,049, - / kWH. Electricity used in one month for 14 lamps are:

Table 3. Tariff of Electricity Usage

N0.	***Number of Pole***	***Number of Zones***	***Power of Electricity (kWH / month)***	***Basic Electricity Tariff (TDL) (Rp./kWH)***	***Total Electricity Tariff (Rp.)***
1	T7	1	355.8	1,049.00	373.23
2	T7	1	355.8	1,049.00	373.23
			Total Cost		746.47

To find the total cost of the load used by 14 lamps per month is the calculation of the Tariff of load of PJU = (40 (flash time) x connected power x usage cost per kWH).

Table 4. Total Cost of Expenses

N0.	***Number of Pole***	***Number of Zones***	***Load (S) / kWh***	***Basic Electricity Tariff (TDL) (Rp./kWH)***	***Total Cost of Expenses (Rp.) = (40xZxSxTDL)***
1	T7	1	2.95	1,049.00	123.78
2	T7	1	2.95	1,049.00	123.78
			Total cost		247.56

The operational cost of conventional PJU is monthly electricity bill (load charge + electricity usage rate) to be paid. So the monthly electricity bill costs around:
Total operational cost / month = 746.47 + 247.56 = Rp. 994.03, -
Total operational cost / year = Rp. 994.03 x 12 = Rp. 11,928.36, -

m) Comfort Analysis Results

Table 5. Results of Comfort Analysis Before and After Repair

Data	***N***	***Mean***	***SD***	***Different***	***SD***	***P***
Before Repair	10	24.03	2.68	12.67	1.69	0.00
After Repair	10	36.70	1.84			

n) Eye Fatigue Analysis Result

Table 6. Eye Fatigue Analysis Result

Data	*N*	*Mean*	*SD*	*Different*	*SD*	*P*
Before Repair	30	15.10	2.82	11.27	1.74	0.00
After Repair	30	26.37	3.76			

o) Results of Security Analysis

Table 7. Security Analysis Results

Data	*N*	*Mean*	*SD*	*Different*	*SD*	*P*
Before Repair	30	18.33	2.25	10.40	1.16	0.00
After Repair	30	28.73	2.70			

b. Discussion

a). ***Large of intensity of light at the street point from of the lamp***

(a) ***Results of analysis of 120 Watt LED lamp***

The calculation results show 120 Watt LED lamp with 121 Lumen / Watt is able to give light intensity equal to 23.06; 19.63; 14.56; 10.68; 8.85, 6.95. and 5.49 Lux at the farthest point of the lamp that is as far as 3, 4, 5, 6, 7, 8, and 9 meters. At a distance of 3 meters can provide a light intensity of 23.03 Lux. Intensity of lighting has been qualified to be used as street lighting (Badung Government, 2016). Street lights are installed with a 6 meter pole height with a width of 9 meters. Installation of street lighting with one another will strengthen the intensity of each other. Installation of street lighting should be installed closer than 40 meters (20, 25, 30, and or 35 meters) with 120 Watt street lamps or enlarged street lighting with larger Watt (Table 2.).

(b) ***Electricity operational cost per month***

The electricity cost per month is derived from the electricity usage rate and total monthly load cost. PJU lamp with 14 lamps will pay Rp. 746.47 + Rp. 247.56 = Rp. 994.03, - per month.

Total operational cost per year is Rp. 11,928.36, -

From this operational cost value can be selected mounting on the distance between lampposts as far as 20, 25, 30, 35, 40 meters or more. This selection depends on the financial condition of the region.

b). Street lights can provide comfort activities

From the results of questionnaires conducted on 30 correspondents can produce the following analysis.

Results of the questionnaires conducted at the research site found all respondents feel comfortable after the lights provide street lighting. Respondents also made longer visits than previous ones because they languish comfortably with families in them having street lighting. The results of from respondents obtained before and after installed lamps that

produce a comfort difference of 12.67 ± 1.69. This means Convenience gained in that place is very significant because of the difference before and after being installed with a good enough improvement (significant).

c) The street lighting lights can reduce the Eye Fatigue

Basically the lights in general can ease in the eyesight. Lights also provide a sense of comfort according to the results of the research above. The results of research conducted at the place of research showed a significant change to the one's sight who was around the research. This change leads to a the less mistakes that occur effect the eye can not see well. Changes in eye fatigue caused by street lighting are 11.27 ± 1.74. This result is indeed a significant result because it resulted in longer visiting hours.

d) Street lighting can enhance security

Based on the results of the above research that lighting lamps can increase safety in one's condition. Street lights are able to provide a sense of security to a person as big as 10.40 ± 1.16 of the respondents 30 people. A person's sense of security will cause people to stay longer in that place. It is expected that all places to gather should be installed street lights. Instalation of street lamps must comply with predetermined standards.

RESEARCH CAN BE DEVELOPED

New finding in this study is that this calculation can be changed according to the willingness of the researcher. The brighter the lights are installed will cause comfort, reduce the eyes berakomodasi, and more security.

ACKNOWLEDGMENT

My thanks to friends in UNUD electro technique that has helped in this research.

CONCLUSIONS

From the above Description it can be concluded:

1. The calculation results may change as desired by the researcher.
2. Can be used in planning the street lamp to obtain the desired light intensity.
3. Installation of street lights can add comfort, eyestrain, and security in place.

REFERENCE

[1] Andreas, Ricky. 2015. Analysis of Lighting Quality And Operational Costs Lighting Street Light Type And Led On Toll Road Srondol-Krapyak

[2] National Standardization Agency, 2000. SNI 6197 Energy Conservation Lighting System in Building Buildings, Jakarta: BSN.

[3] National Standardization Body, 2003. SNI 6967 General Requirements of Network and Geometric System of Housing Road, Bandung: BSN

[4] National Standardization Body, 2008. SNI 7391 Lighting Information on Urban Roads, Jakarta: BSN.

[5] Direktorat Jenderal Bina Marga, 1991. Specification Lamp Street Lighting in the Urban, (Jakarta).

[6] Harten P.Van,1981. Strong Flow Installation 2, Bandung: Bina Cipta

[7] I Ketut Wijaya, 2011. Ergonomic Redesign Of Computer Laboratory To Improve Performance And Efficiency Power Electrics In Electrical Engineering Computer Laboratory At Udayana University

[8] I Ketut Wiajaya, 2012. Word Effects of Temperature, the Lighting, Workload, Noise Against Eye Fatigue, General Fatigue and Stress Affect Learning Outcomes the Student Computer Users, Journal.

[9] Kadir, Abdul 2000. Distribution and Utilization of Electric Power. Jakarta: University of Indonesia (UI-Press).

[10] Mayretta, Santa. 2014. Evaluation of Street Lighting (Road Case Study W.R Supratman Bandung, West Java). Essay. Yogyakarta: Civil Engineering, Atma Jaya University Yogyakarta.

[11] Badung District Government, 2018. Road Lighting Planning.

[12] SNI 7391. 2008. Specification Information on Road in Urban Area. Jakarta: National Standardization Agency.

[13] Syarifudin, Ilyas Achmad. Design of Lighting of General Street Lighting Lighting in Sintang City, Thesis. Pontianak: Electrical Engineering, Tanjungpura University.

[14] PUIL 2011 SNI 040225-2011

[15] SNI 7391: 2008 Specification of street lighting Electricity utilization technique, volume 1 Prih sumardjati Lighting Engineering, Ir. S Gunawan, MSc Jakarta 2008

[16] Wibawa, Unggul, 2004. Management of Industry-II, Malang: Department of Electrical Engineering Universitas Brawijaya.

AUTHOR PROFILE

First author : I Ketut Wijaya.

I was born : in Padangbai, Karangasem, Bali, Indonesia

Date: October 12, 1959

Education :

1. Education Strata 1: Institute of Technology Surabaya in Surabaya, Indonesia and Acquired degree which is Ir, 1986
2. Education Strata 2: Ergonomics of Work Physiology Udayana University in Denpasar, Bali, Indonesia, and degree which obtained is M.Erg (Master Ergonomics), 2007
3. Education Strata 3: Ergonomics of Work Physiology Udayana University in Denpasar, Bali, Indonesia, and degree which obtained is Dr (Doctor), in 2011

Often participated in the training, the writing and research national nor international.

Worked as a lecturer at the Faculty of Electrical Engineering University of Udayana Badung, Indonesia from 1987 to the present.