

DESIGN OF APRON FLOODLIGHT LIGHTING SYSTEM AT HUSEIN SASTRANEGARA AIRPORT

Andika Hakim Putra⁽¹⁾, Riyanto Saputro⁽²⁾, Taryana⁽³⁾

^{1,3}Politeknik Penerbangan Indonesia Curug

²Badan Kebijakan Transportasi, Kementerian Perhubungan

e-mail: ¹andikahakimputra@gmail.com, ²riyantosaputro@gmail.com, ³taryana@ppicurug.ac.id

corresponding: ³andikahakimputra@gmail.com

Received :
06 May 2026

Revised :
12 September 2026

Accepted :
01 October 2026

Abstract: One of the important aspects of ensuring smooth operation, safety, and security in the terminal apron area is a lighting system that complies with applicable standards. However, substandard lighting conditions are still found at Husein Sastranegara Airport, as indicated by apron user complaints validated by the Assistant Electrical Manager, showing inadequate illumination levels that may affect safety and visual performance. Measurements showed that the average illumination level of the existing apron lighting system was 12.38 lux, which did not meet the standards specified in ICAO Annex 14 Volume 1 requiring 20 lux. This study aims to redesign the apron floodlight system to meet the applicable standards using the Research & Development method. The design was evaluated using DIALux evo software considering luminous flux, beam angle, mounting height, pole spacing, and lighting distribution. The simulation results showed that the proposed design successfully achieved the required illumination standard.

Keywords: Lighting, Floodlight Apron, DIALux

Introduction

In the world of aviation, lighting is one of the guidelines for pilots when carrying out flight activities such as takeoff, landing, and taxiing, so that they can move efficiently and safely. The lighting system also helps the process of aircraft movement to the intended area to carry out flight activities in each area at the airport, one of which is the apron area. Aprons are provided to enable aircraft to perform optimal services such as boarding and disembarking passengers, loading and unloading cargo and mail delivery, without disrupting airport traffic. Lighting is an important aspect to optimize the process of activities that take place in the apron area. The installation of an apron floodlight helps in providing lighting for service activities on the apron including helping the aircraft service process at night or during the day when the weather is bad. Good lighting allows workers to be safer and more comfortable. This allows workers to be able to see and work on an object clearly, quickly and without obstacles (Yusuf, 2015).

Adequate lighting is a critical requirement for ensuring safe and efficient airport operations, particularly in apron areas where aircraft and ground handling activities are conducted simultaneously. Quality, quantity, and lighting rules are the three main criteria that must be met in designing a quality lighting system (Wiyanto, 2021). Based on previous research, Insufficient lighting quality may negatively impact the efficiency, safety, and continuity of apron operations. Therefore, to improve operational service quality in the apron area, it is essential to provide apron floodlighting systems with illumination levels that meet the prescribed illuminance standards and regulatory requirements (Suprihartini Yayuk, 2019).

The significance of complying with apron lighting standards is reflected in several aviation incidents, where inadequate visibility and lighting conditions were identified as

contributing factors to operational accidents and safety risks during night operations. Several real-world aviation incidents have demonstrated the importance of adequate apron lighting during night operations. In 2010, an Antonov An-124 aircraft collided with apron lighting towers at Zaragoza Airport during night taxi operations due to insufficient visual guidance (Comisión de Investigación de Accidentes e Incidentes de Aviación Civil, 2012). Similarly, a ground collision involving Batik Air and an ATR aircraft at Halim Perdanakusuma Airport in 2016 highlighted the risk of limited visibility during night operations (Komite Nasional Keselamatan Transportasi Republic of Indonesia, 2017). Another investigation at Yangon International Airport reported that dim apron floodlights contributed to pilots' inability to detect nearby aircraft during taxi operations (Flight Safety Foundation, 2015). These incidents indicate that inadequate apron lighting may increase the risk of human error, aircraft collision, and operational accidents, thereby emphasizing the importance of designing an apron floodlight system that complies with ICAO lighting standards.

Based on the current conditions, there are verbal reports from the VIP guests of the Indonesian Air Force that have been confirmed by the Assistant Manager of Electrical, Mechanical & Facilities (EMF) regarding the lack of lighting in the apron area. In response to the report, field observations were carried out, including measuring the average value of illumination. Observation and measurement activities were carried out twice, first at night at 20.00 WIB producing an average illumination value of 12.38 lux and in the morning at 04.00 WIB producing an average illumination value of 12.03 lux. Based on the results of observation and measurement, it can be concluded that the illumination value in the apron area is still lacking and has not reached the predetermined standard. Based on International Civil Aviation Organization (2004) the lighting of the apron on the aircraft parking stand is a minimum of 20 lux. Lighting that does not meet standards such as dim or very bright lighting can interfere with vision for every user of the space (Pahlevi & Muliadi, 2022). In order to realize a smooth, safe, and comfortable situation for the users of a space, one of the important aspects that must be met is the lighting installation that meets the standards (Syukri et al., 2021).

Several studies related to apron floodlight systems have been conducted. Research conducted by I Wayan Sugara Yasa & I Wayan Suriana (2021) proved that adjusting floodlight beam angles affects the average illumination level in apron areas. Furthermore, Pratama Aditya et al. (2020) focused on calculating illumination intensity to comply with applicable standards and evaluating electrical efficiency following the replacement of conventional lamps with LED technology. This limitation is particularly relevant to the conditions at Husein Sastranegara Airport. Therefore, this study proposes a redesign of the apron floodlight system using DIALux evo software by optimizing floodlight specifications, beam angles, mounting configurations, and lighting distribution. Through a three-dimensional simulation approach, the proposed design aims to achieve the required illumination standard while improving lighting effectiveness and supporting safer apron operations during night-time activities.

Metode

The design method used in this study is the research and development (R&D) method. The purpose of this method is to test the effectiveness of a product and involves the stages of planning, drawing, and manufacturing an object, system, component, or structure. The goal is to produce renewable theories, solve problems, develop and create innovations in a product so as to provide future benefits (Sugiyono, 2019).

Discussion

Referring to the current condition of the lighting system, direct observation and measurement were carried out. The process of determining lighting intensity measurement points is based on the rules of SNI 7062:2019 concerning Lighting Intensity Measurement in the Workplace, 2019). The Lighting System Area of the Apron Terminal of Husein Sastranegara Airport has an area of 25,243 m² and there are six poles to meet the lighting on seven parking stands. If the lighting measurement point is determined according to the Indonesian National Standard (SNI), it is included in the category of calculating the area of space of more than 100 m² with the number of lighting measurement points at least 36 points. Each one point represents an area of 700 m² and the measurement point is made with a distance between the points of 25x28 meters.

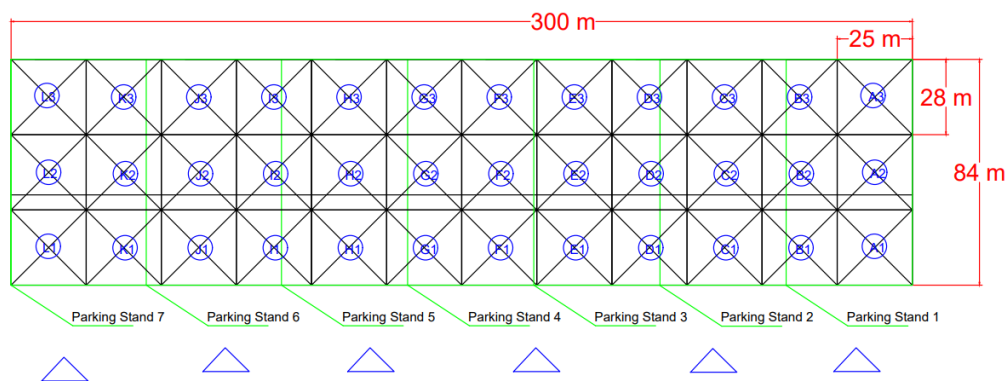


Figure 1. Lighting measurement point plan layout

Based on the measurement data, the average total illumination value obtained through measurement with a lux meter is 12.38 lux for measurement at 20.00 WIB (Western Indonesian Time) and 12.01 lux for measurement at 04.00 WIB (Western Indonesian Time). The overall measurement results of both the total average value and the lighting value of each apron area have not met the set standards, namely an average of at least 20 lux for the aircraft stand area and 10 lux for the apron area between the outer boundary of the aircraft stand and the boundary of the apron (service equipment, parking area, service road).

Efforts were made in designing lighting systems to meet applicable standards. Observation activities related to conditions and factors that affect the lighting illumination value on the floodlight apron aim as information and supporting data in making the design. Observation of conditions at the Apron Terminal of Husein Sastranegara Airport includes measuring the dimensions of the apron, the type of surface of the apron, and the height of the floodlight pole used. Based on the results of observation and measurement, there are:

The area of the terminal apron = 25.243 m²

Average illumination = 12,38 Lux
(normal weather conditions)

Air Pollutant Content = 20,9 µg/m³.

(Source: IQAir.com, 2024)

Design of Apron Floodlight Lighting System at Husein Sastranegara Airport

Floodlight MASTER HPI-T Plus 400W/645 E40 1SL/12 = 19 x 33.200 lm
(19 units) = 630.800 lm

Operational lighting time (Burning Hours) = 12 hours x 360 days x 3 years
= 12.960 hours

Floodlight LED Zetalux 200 Watt (6 units) = 6 x 39.000 lm
= 234.000 lm

Operational lighting time (Burning Hours) = 12 hours x 360 days x 4 years
= 17.280 hours.

There is a formula used to calculate the strong value of lighting which is:

$$E = \frac{\Phi \times Kp \times LLF}{A} \quad (1)$$

Description:

Φ : Fluks luminous (lm)

Kp : Usage coefficient (utility)

LLF : Light Loss Factor

A : Measurement area (m²)

$$LLF = LLD \times LDD \times BF \quad (2)$$

Description:

LLD : Lamp Lumen Depreciation

LDD : Luminaire Dirt Depreciation

BF : Ballast Factor

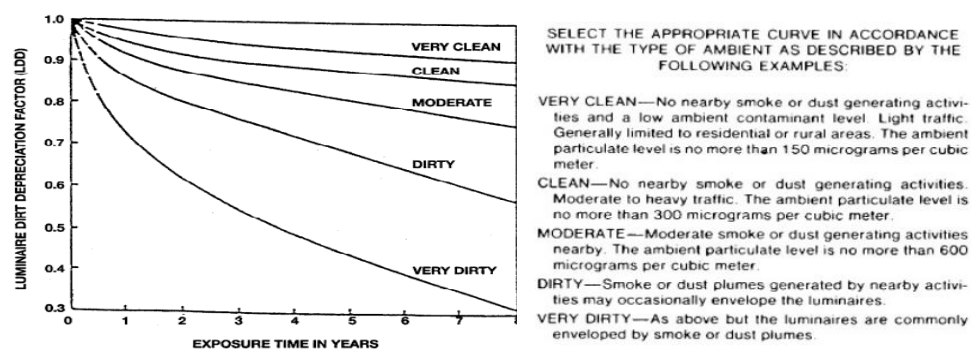
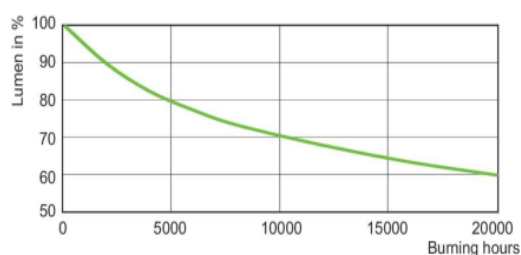


Figure 2. Dirt Depreciation Luminaire Graphics

Metal Halide lamp chart



LED lamp chart

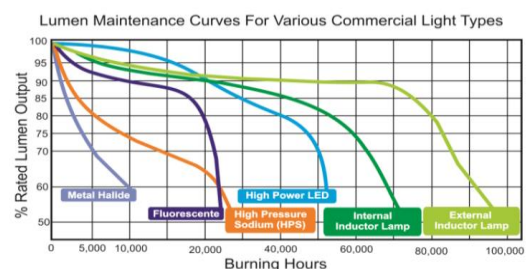


Figure 3. Comparison of burning hours and lumen output of different types of lamps (LLD)

Light loss factor = $LLD \times LDD \times BF$
(LLF) metal = $0,67 \times 0,96 \times 1$
halide type lamp = 0,64

Light loss factor = $LLD \times LDD \times BF$
(LLF) type of lamp = $0,93 \times 0,95 \times 1$
LED = 0,88

After getting the value of the Light loss factor (LLF) of each type of lamp, then look for the value of the Usage Coefficient (Kp):

$$E = \frac{\Phi \times Kp \times LLF}{A}$$

$$Kp = \frac{E \times A}{\Phi \times LLF}$$

$$Kp = \frac{12,38 \times 25.243}{((630.800 \times 0,64) + (234.000 \times 0,88))}$$

$$Kp = \frac{312.508}{(403.712) + (205.920)}$$

$$Kp = \frac{312.508}{609.632}$$

$$Kp = 0,51$$

It further determines the number of lumens that required for lighting to be up to standard:

$$E = \frac{\Phi \times Kp \times LLF}{A}$$

$$\Phi = \frac{E \times A}{Kp \times LLF}$$

$$\Phi = \frac{35 \times 25.243}{0,51 \times 1}$$

$$\Phi = 1.732.362 \text{ lm}$$

Then a search is carried out in determining the type of floodlight to be used, there are two types that have different specifications.

Table 1. The name and value of the floodlight lumen to be used

Name of Floodlight	Lumen Value	Life time of 100,000 hours	Color of Temperature
BVP651 T25 1 xLED500-4S/740 S	43.000 lm	L96	4000 K
BVP651 T25 1 xLED800-4S/740 S	65.992 lm	L96	4000 K

$$43.000 \times 25 \text{ unit} = 1.075.000 \text{ lm}$$

$$65.992 \times 10 \text{ unit} = 659.920 \text{ lm}$$

$$\text{Total 35 unit} = 1.734.920 \text{ lm (fulfill)}$$

After finding the required lumens value on the apron, then a calculation is made to adjust the angle of placement of the floodlight according to the object or area to be illuminated by maintaining the current placement point of the floodlight pole. In calculating the angle of the floodlight, it is adjusted to existing rules and theories.

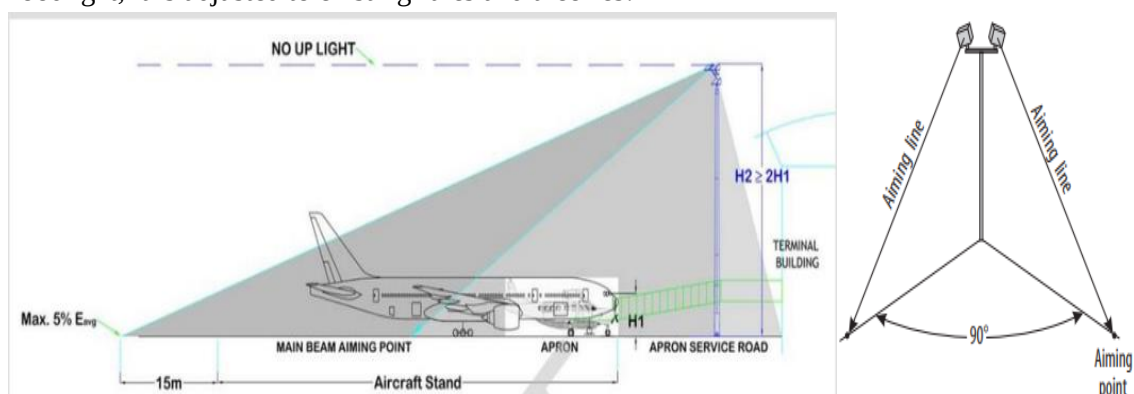


Figure 4. Floodlight lighting angle requirements

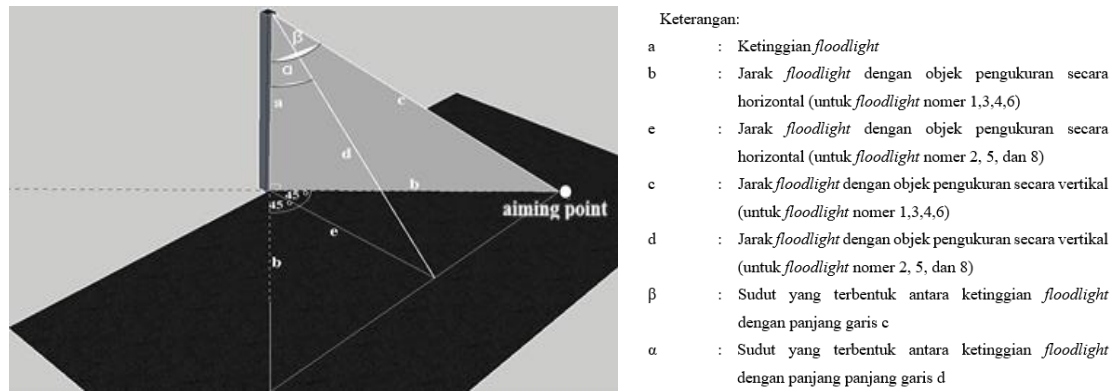


Figure 5. Calculation of floodlight lighting angle

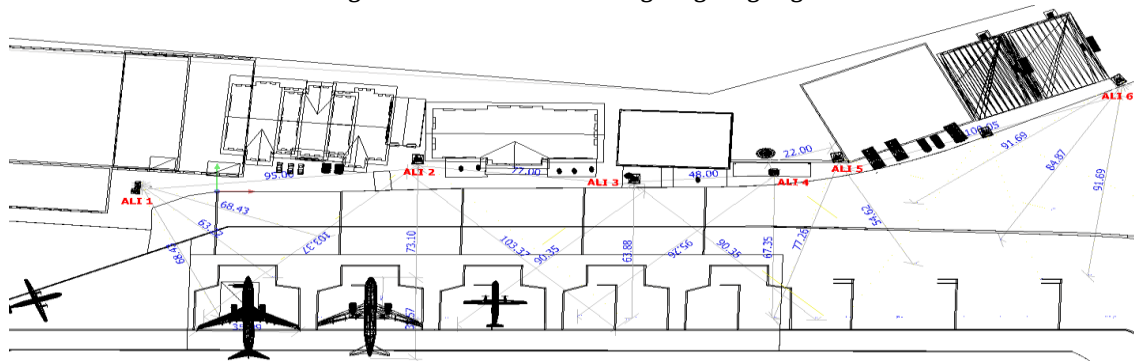


Figure 6. Floodlight Apron Pole Distribution Plan

The following is one of the calculations of the floodlight angle, namely in ALI 2:

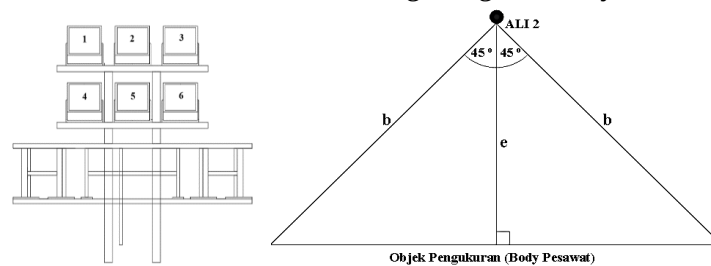


Figure 7. Horizontal illumination of floodlight numbers 2 and 5

Calculation of the length of line b, where e: 73.10 m. As for floodlights number 2 and 5, angles produced horizontally by 0° .

$$\begin{aligned}\sin 45^\circ &= \frac{e}{b} \\ b &= \frac{73,10}{0,707} \\ b &= 103,37 \text{ m}\end{aligned}$$

Calculation of the installation angle of floodlights number 2 and 5 vertically:

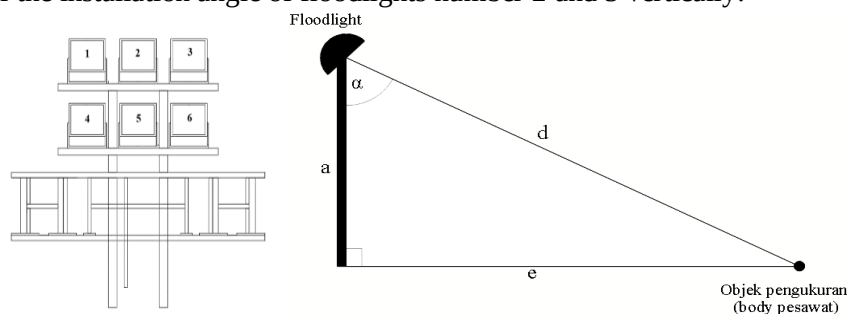


Figure 8. Calculation of floodlight angle numbers 2 and 5 vertically

a_2 : 14,5 m (high floodlight number 2)
 a_5 : 13,4 m (high floodlight number 5)
 e : 73,10 m

So to find d_2 and d_5 using the trigonometric formula equation:

$$d_2 = \sqrt{(a_2)^2 + e^2} \quad d_5 = \sqrt{(a_5)^2 + e^2}$$

$$d_2 = \sqrt{14,5^2 + 73,10^2} \quad d_5 = \sqrt{13,4^2 + 73,10^2}$$

$$d_2 = 74,52 \text{ m} \quad d_5 = 74,34 \text{ m}$$

After that, look for the α angles, namely the angle of placement of floodlights 2 and 5 vertically:

$$\cos \alpha_2 = \frac{a_2}{d_2} \quad \cos \alpha_5 = \frac{a_5}{d_5}$$

$$\cos \alpha_2 = \frac{14,5}{74,52} \quad \cos \alpha_5 = \frac{13,4}{74,34}$$

$$\cos \alpha_2 = 0,194 \quad \cos \alpha_5 = 0,180$$

$$\alpha_2 = \cos^{-1}(0,19) \quad \alpha_5 = \cos^{-1}(0,18)$$

$$\alpha_2 = 78,81^\circ \quad \alpha_5 = 79,63^\circ$$

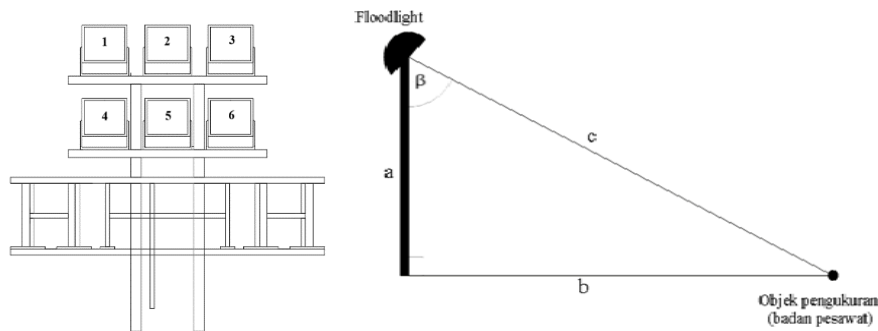


Figure 9. Calculation of floodlight angles 1,3,4, and 6 vertically

So to find $c(1,3)$ and $c(4,6)$ use the equation of the trigonometric formula:

$$c_{1,3} = \sqrt{(a_3)^2 + b^2} \quad c_{4,6} = \sqrt{(a_6)^2 + b^2}$$

$$c_{1,3} = \sqrt{14,5^2 + 103,37^2} \quad c_{4,6} = \sqrt{13,4^2 + 103,37^2}$$

$$c_{1,3} = 104,23 \text{ m} \quad c_{4,6} = 104,38 \text{ m}$$

After that, look for the β angles, which is the angle of placement of floodlights number 3 and 6 vertically:

$$\cos \beta_{1,3} = \frac{a_3}{b_3} \quad \cos \beta_{4,6} = \frac{a_6}{b_6}$$

$$\cos \beta_{1,3} = \frac{14,5}{104,38} \quad \cos \beta_{4,6} = \frac{13,4}{104,23}$$

$$\cos \beta_{1,3} = 0,138 \quad \cos \beta_{4,6} = 0,128$$

$$\beta_{1,3} = \cos^{-1}(0,138) \quad \beta_{4,6} = \cos^{-1}(0,128)$$

Design of Apron Floodlight Lighting System at Husein Sastranegara Airport

$$\beta_{1,3} = 82,06^\circ$$

$$\beta_{4,6} = 82,64^\circ$$

The configuration of each installed lamp is according to the results of the simulation as follows:

Nama Tiang	Konfigurasi Floodlight				Nama Tiang	Konfigurasi Floodlight			
	Nomer	Jenis	Sudut vertikal	Sudut Horizontal		Nomer	Jenis	Sudut vertikal	Sudut Horizontal
ALI 1	1	530 W	78,28°	337,5°	ALI 4	1	310 W	80°	315°
	2	310 W	77,34°	0°		2	310 W	76,11°	0°
	3	310 W	78,28°	22,5°		3	310 W	80°	45°
	4	530 W	79,16°	337,5°		4 dan 6 kosong			
	5	310 W	78,28°	0°		5	310 W	76,99°	0°
	6	310 W	79,16°	22,5°		7	310 W	81,37°	315°
ALI 2	1	310 W	82,06°	315°		8	530 W	77,87°	0°
	2	530 W	78,81°	0°		9	310 W	81,37°	45°
	3	310 W	82,06°	45°	ALI 5	1	310 W	79,39°	315°
	4	310 W	82,64°	315°		2	530 W	75,52°	0°
	5	530 W	79,63°	0°		3	310 W	79,39°	45°
	6	530 W	82,64°	45°		4	310 W	80,21°	315°
ALI 3	1	310 W	80,9°	315°		5	310 W	76,23°	0°
	2	310 W	77,23°	0°		6	530 W	80,21°	45°
	3	310 W	80,9°	45°	ALI 6	1	310 W	81,02°	337,5°
	4	310 W	81,6°	315°		2	530 W	81,02°	22,5°
	5	310 W	78,17°	0°		3	310 W	81,72°	337,5°
	6	310 W	81,6°	45°		4	530 W	81,72°	22,5°

Figure 10. Floodlight configuration attached to each pole

- Simulation with DIALux software:

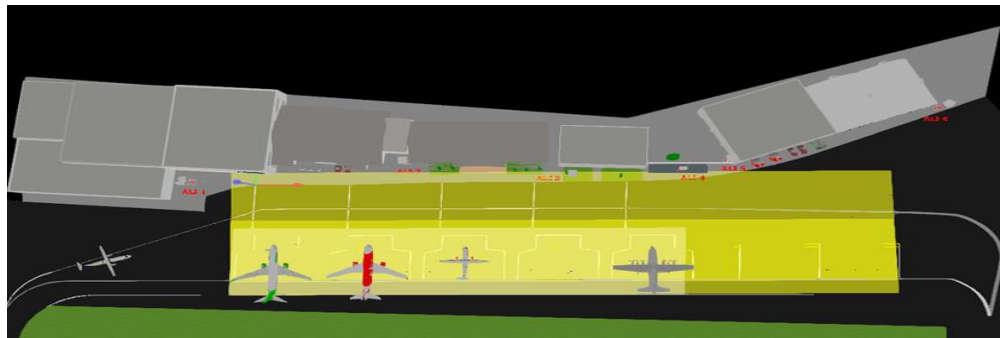


Figure 11. Exposure calculation area in simulation

Apron Terminal Bandar Udara Husein Sastranegara

Luminaire list

Φ_{total}		P_{total}		Luminous efficacy		
1734920 lm		13050.0 W		132.9 lm/W		
pcs.	Manufacturer	Article No.	Article name	P	Φ	Luminous efficacy
25	Philips	BVP651 T25 1	xLED500-4S/740 S	310.0 W	43000 lm	138.7 lm/W
10	Philips	BVP651 T35 1	xLED800-4S/740 S	530.0 W	65992 lm	124.5 lm/W

Figure 12. Number of floodlights and lumens required

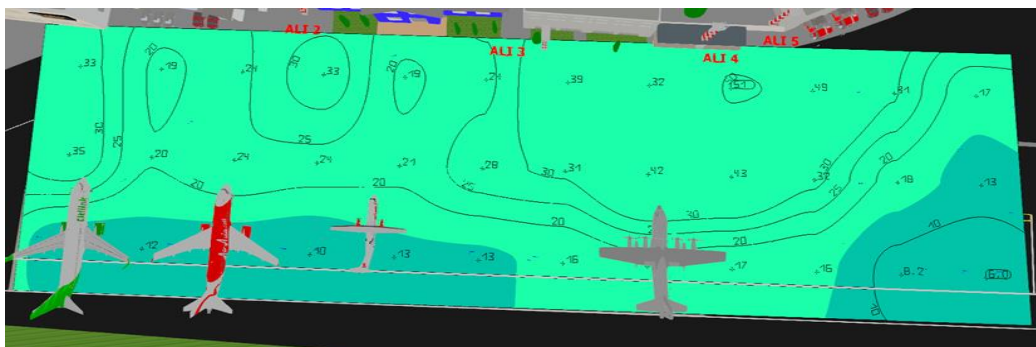


Figure 13. Horizontal distribution of illumination isolux

Apron Terminal Bandar Udara Husein Sastranegara (Rancangan Sistem Pencahayaan Pada Apron Terminal)

Calculation objects

Calculation surfaces

Properties	E	E _{min}	E _{max}	U _o (g ₁)	g ₂	Index
Rata-rata pencahayaan apron terminal Horizontal illuminance Height: -0.000 m	23.7 lx	6.04 lx	50.6 lx	0.25	0.12	CG1
Rata-rata pencahayaan apron terminal Vertical illuminance Rotation: 270.0°, Height: 2.000 m	71.3 lx	22.8 lx	151 lx	0.32	0.15	CG1
Rata-rata pengukuran pencahayaan aircraft stand Horizontal illuminance Height: -0.000 m	20.0 lx	6.00 lx	42.5 lx	0.30	0.14	CG2
Rata-rata pengukuran pencahayaan aircraft stand Vertical illuminance Rotation: 270.0°, Height: 2.000 m	81.3 lx	36.2 lx	150 lx	0.45	0.24	CG2

Utilisation profile: Airports (5.2.2 Terminal apron)

Notes on planning:

The results were calculated without consideration of objects and furniture. No results were determined on their surfaces. Daylight proportion for Overcast Sky on 4/16/2024 at 8:00 PM (UTC+07:00) Bangkok, Hanoi, Jakarta).
Adapun dalam menentukan luas daerah perhitungan pencahayaan yang nantinya akan disimulasikan diatur sesuai dengan metode pengukuran titik ukur yang mengacu pada aturan SNI 7062:2019 tentang pengukuran intensitas pencahayaan di tempat kerja.

Figure 14. Lighting simulation results with DIALux

The proposed apron floodlight design achieved an average illumination level, meeting the requirements of ICAO Annex 14 and improving visibility within the aircraft stand area. Enhanced lighting distribution supports critical night-time operations, including aircraft parking, marshalling, refueling, baggage handling, and other ground handling activities, thereby improving situational awareness and reducing the potential for operational errors caused by insufficient illumination. The design was developed through adjustments to lamp specifications, beam angles, lighting direction, and switching to luminaires LED to optimize lighting performance. Although glare was not specifically evaluated, the simulation identified several localized areas with relatively high illumination levels that may potentially affect pilot visibility and visual comfort. Furthermore, the recommendation for aircraft stand relocation is intended as an operational consideration based on simulation results indicating that areas closer to the lighting coverage achieved more favorable illumination distribution.

The recommendation to relocate the aircraft stand closer to the floodlight coverage is consistent with the findings of Saputri & Triana, 2016, who evaluated the apron layout at Husein Sastranegara Airport and recommended reconfiguring the aircraft stand because the existing layout did not comply with KP No. 39 of 2015. Integrating this recommendation with the lighting simulation results may provide a more balanced illumination distribution while reducing localized over-illumination.

After the testing process regarding the lighting simulation, then wiring the electrical diagram for the floodlight power supply to be used.

Design of Apron Floodlight Lighting System at Husein Sastranegara Airport

Determining the type of cable from the pole panel to the floodlight.

Known:

P = 840 Watt

V = 220 Volt

$$I = \frac{P}{V \times \cos \phi}$$

$$I = \frac{840 \text{ Watt}}{220 \text{ Volt} \times 0,8}$$

$$I = 4,77 \text{ A}$$

$$\text{KHA Results} = I \times 125\%$$

$$\text{KHA} = 5,96 \text{ A}$$

Based on the calculation results for cables used with a current carrying capacity of 5.96 A using the NYY 3 x 1.5 mm² cable type.

Determine the value of the circuit breaker used on each pole.

Known:

P = 840 Watt

V = 220 Volt

$$I = \frac{840 \text{ Watt}}{220 \text{ Volt} \times 0,8}$$

$$I = 4,77 \text{ A} \times 115\%$$

$$\text{Circuit breaker} = 5,4 \text{ A}$$

Based on the results of calculations in determining the safety (circuit breaker) using a safety with a maximum current of 5.4 A in accordance with the specifications produced, namely the Miniature Circuit Breaker (MCB) 1P 6 A.

Nama Tiang	Nomer Lampu	Total Daya Lampu (W)	Kelompok	Pemutus Arus 1P (A)	Pemutus Arus 3P (A)	Nama Tiang	Nomer Lampu	Total Daya Lampu (W)	Kelompok	Pemutus Arus 1P (A)	Pemutus Arus 3P (A)
ALI 1	1 dan 2	840	1	6	10	ALI 4	1, 2, dan 3	930	1	6	10
	3 dan 4	840	2	6			5 dan 7	620	2	6	
	5 dan 6	620	3	6			8 dan 9	840	3	6	
ALI 2	1 dan 2	840	1	6	10	ALI 5	1 dan 2	840	1	6	10
	3 dan 5	840	2	6			3 dan 4	620	2	6	
	4 dan 6	840	3	6			5 dan 6	840	3	6	
ALI 3	1 dan 2	620	1	6	10	ALI 6	1 dan 2	840	1	6	10
	3 dan 4	620	2	6			3 dan 4	840	2	6	
	5 dan 6	620	3	6							

Figure 15. Power grouping on floodlight aprons

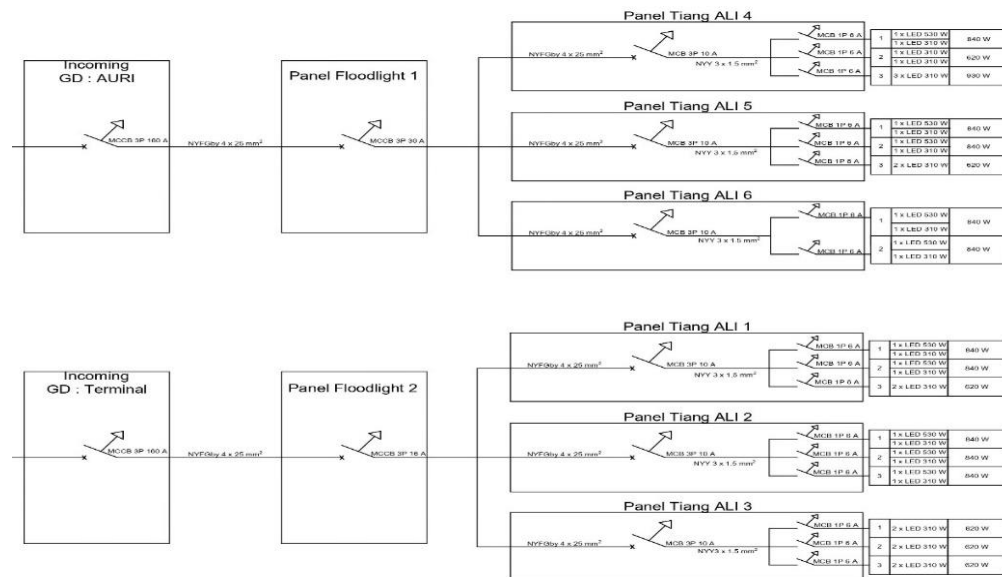


Figure 16. Wiring diagram apron floodlight

Conclusion

This study successfully redesigned the apron floodlighting system at Husein Sastranegara Airport by optimizing LED luminaire specifications, beam angles, lighting direction, and the configuration of floodlights without changing the existing pole layout. The proposed design, evaluated using DIALux evo, achieved the illumination requirements specified in ICAO Annex 14 and PR No. 8 of 2022, with an average horizontal lighting measurements obtained an overall average value of 20 lux and a minimum value of 6 lux and a uniformity ratio between the average illumination value to the minimum value of 0.30 with a ratio of no more than 4:1. Vertical lighting measurements at a height of 2 m obtained an average result of 81.3 lux and a minimum value of 36.2 lux and a uniformity ratio between the average illumination value to the minimum value of 0.45 with a ratio of no more than 4:1. The selection of LED floodlights also provides longer service life and improved lighting performance compared with the existing metal halide system. As a scientific contribution, this study demonstrates that three-dimensional lighting simulation is an effective approach for evaluating and redesigning airport apron lighting systems while identifying both under-lighted and localized over-lighted areas. From an operational perspective, the improved lighting distribution enhances visibility for aircraft parking, marshalling, refueling, baggage handling, and other ground handling activities, thereby supporting aviation safety through improved situational awareness and reduced potential for operational errors caused by inadequate illumination.

Bibliography

- Comisión de Investigación de Accidentes e Incidentes de Aviación Civil. (2012). *Antonov An-124 Aircraft Collided with Apron Lighting Towers at Zaragoza Airport*.
- Flight Safety Foundation. (2015). *Final Report of Ground Collision Occurrence (GCOL) Korean Air, Airbus, A- 330- 200 (HL- 7538) & Bangkok Airways, ATR 72- 212A (HS- PGA) at Yangon International Airport*.
- I Wayan Sugara Yasa, & I Wayan Suriana. (2021). Analisis Konsumsi Energi Untuk Efisiensi Kelistrikan Pada Penggunaan Sistem Tata Cahaya Apron Flood Light Bandar Udara. *Jurnal Kajian Teknik Elektro*, 6(2), 54–61. <https://doi.org/10.52447/jkte.v6i2.5863>

- International Civil Aviation Organization (ICAO). (2004). *Annex 14 to the Convention on International Civil Aviation: Aerodromes: I* (4th ed). <http://www.icao.int>
- Komite Nasional Keselamatan Transportasi Republic of Indonesia. (2017). *Aircraft Accident Investigation Report Batik Air Indonesia and TransNusa Aviation Mandiri Boeing 737-800 (PK-LBS) and ATR 42-600 (PK-TNJ) Halim Perdanakusuma International Airport*.
- Pahlevi, R., & Muliadi. (2022). Analisis dan Desain Tingkat Pencahayaan Pada Ruang Perpustakaan Universitas Iskandar Muda. *Jambura Journal of Electrical and Electronics Engineering*, 4(2), 196–201.
- Pratama Aditya, Taryana, & Rubby Soebiantoro. (2020). Analisa Apron Floodlight Menggunakan Lampu LED Di Bandar Udara Adi Soemarmo – Solo. *Journal Ilmiah Aviasi Langit Biru*, 13, 69–78. <https://doi.org/10.54147/langitbiru.v13i2.549>
- Saputri, D. M., & Triana, S. (2016). Evaluasi dan Perencanaan Posisi Parkir Pesawat pada Apron Bandara Husein Sastranegara Bandung. *Jurusan Teknik Sipil Itenas*, 2, 126–134.
- SNI 7062:2019 Tentang Pengukuran Intensitas Pencahayaan Di Tempat Kerja, 1 (2019).
- Sugiyono. (2019). *Metode Penelitian Kuantitatif, Kualitatif, dan R&D* (Sutopo, Ed.; 2nd ed.). Alfabeta.
- Suprihartini Yayuk. (2019). Kajian Pencahayaan Flood Light Di Apron Selatan Bandar Udara Internasional I Gusti Ngurah Rai Bali. *Langit Biru: Journal Ilmiah Aviasi*, 12(2), 141–148. <https://doi.org/https://journal.ppicurug.ac.id/index.php/jurnal-ilmiah-aviasi/article/view/172>
- Syukri, M., Multazam, T., & Malek, A. (2021). Perencanaan Sistem Penerangan Jalan Umum di Kampus UNIDA. *Serambi Engineering*, VI(4), 2493–2498. <https://doi.org/10.32672/jse.v6i4.3526>
- Wiyanto, Agrippina. F. E. (2021). Analisis Pencahayaan Alami Dan Buatan Pada Ruang Kantor Terhadap Kenyamanan Visual Pengguna. *Jurnal PATRA*, 3(1), 33–42. <https://doi.org/https://doi.org/10.35886/patra.v3i1.182>
- Yusuf, M. (2015). Efek Pencahayaan Terhadap Prestasi dan Kelelahan Kerja Operator. *Seminar Nasional IENACO*, 24–29.