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Study Of Flight Operations Safety Area (KKOP) At Yogyakarta International Airport – Kulonprogo

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Abstract. Yogyakarta-Kulon Progo International Airport is a replacement airport for Adisutjipto-Yogyakarta Airport which can no longer be expanded due to land limitations. Where the airport has an aerodrome reference code 4E instrumnet precision category I this is reviewed from the ultimate runway which has a size of 3,600 metres x 45 metres. Basically to determine the main boundaries of the Flight Operation Safety Area (KKOP) by looking at the difference in terrain height for the method used is qualitative with descriptive analysis. The location of the measurement in the Flight Operation Safety Area (KKOP) of Yogyakarta International Airport, the secondary data carried out is to analyse and determine the height of the obstacle. In determining the boundaries of the flight operation safety area (KKOP) around Yogyakarta-Kulon Progo International Airport using coordinate points applied in geographic coordinates there are obstacles, namely: three (3) hotel buildings located in the area below the horizontal surface in. The need for control and guidance by the Ministry of Transportation in order to maintain flight safety for buildings and objects growing in the Flight Operation Safety Area (KKOP) of Yogyakarta-Kulon Progo International Airport to ensure flight safety so as not to endanger flight operations.

Keywords : YIA Airport, KKOP, Obstacle Height Limit, Air transport safety

Abstrak. Bandara Internasional Yogyakarta-Kulon Progo merupakan bandara pengganti Bandara Adisutjipto-Yogyakarta yang sudah tidak dapat diperluas lagi karena keterbatasan lahan. Dimana bandara ini memiliki kode referensi aerodrome 4E instrumnet kategori ketelitian I hal ini ditinjau dari landas pacu utama yang memiliki ukuran 3.600 meter x 45 meter. Pada dasarnya untuk menentukan batas-batas utama Kawasan Keselamatan Operasi Penerbangan (KKOP) dengan melihat perbedaan ketinggian medan untuk metode yang digunakan adalah kualitatif dengan analisis deskriptif. Lokasi pengukuran di Kawasan Keselamatan Operasi Penerbangan (KKOP) Bandara Internasional Yogyakarta, data sekunder yang dilakukan adalah dengan menganalisa dan menentukan ketinggian halangan. Dalam penentuan batas Kawasan Keselamatan Operasi Penerbangan (KKOP) di sekitar Bandar Udara Internasional Yogyakarta-Kulon Progo dengan menggunakan titik-titik koordinat yang diaplikasikan dalam koordinat geografis terdapat halangan, yaitu: 3 (tiga) bangunan hotel yang berada di area bawah permukaan horizontal dalam. Perlunya pengendalian dan pembinaan oleh Kementerian Perhubungan dalam rangka menjaga keselamatan penerbangan terhadap bangunan dan benda-benda yang tumbuh di Kawasan Keselamatan Operasi Penerbangan (KKOP) Bandar Udara Internasional Yogyakarta-Kulon Progo untuk menjamin keselamatan penerbangan agar tidak membahayakan operasional penerbangan.

Abstrak : Bandara YIA, KKOP, Batas Ketinggian Rintangan, Keselamatan transportasi udara

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1. Introduction

Airports act as a gateway for regional economic growth by creating many new business opportunities such as hotels, culinary, and transportation services. Growth in the number of passengers will encourage the development of regional infrastructure, including the construction of tall buildings such as hotels, restaurants, and towers. Along with the increasing construction of these tall buildings, attention to the Flight Operation Safety Area (KKOP) is becoming increasingly important to ensure the smooth flow of aircraft traffic.(Calisir et al., 2016; McCarthy et al., 2015)

KKOP is an area of air, water and land around the airport that is used for flight safety. In determining the main boundaries of the Flight Operations Safety Area, the difference in the height of the earth's surface is an important factor. The obstacle height limit zone map that describes the contours of the land and the maximum height limit in each area can be used as a reference to facilitate the process of determining the boundary. The height threshold of objects (buildings, structures, towers, trees, etc.) in each area is determined according to the category of the airport concerned, in line with the Minister of Transportation Regulation No. KM 44 Year 2005 related to Airport Operations. Indonesian National Standard (SNI) 03-7112-2005 treats KKOP as a mandatory standard.

In this study, researchers analyzed the regulation of development and growing objects in the Flight Operation Safety Area (KKOP) at Yogyakarta International Airport. The regulation of development is carried out by reviewing the safety standards related to flight operations, ensuring that all structures and obstacles in the KKOP area comply with the requirements. Additionally, the determination of the KKOP boundaries is conducted by assessing the surrounding terrain to ensure compliance with aviation safety standards as set by the relevant authorities.(Karatepe & Talebzadeh, 2016)

An airport is a specially demarcated area, either at sea or on land, used for aircraft to conduct activities such as landing, takeoff, loading and unloading of goods, and boarding and disembarking of passengers. Airports also serve as a meeting place for various types of transportation and provide various facilities needed to support flight operations, such as security systems and other supporting facilities(*UU NO. 1*, 2009). (Kim, 2016)

KKOP is the area around the airport, whether on land, sea, or in the air, which is very important to ensure flight safety. The most common thing to consider in KKOP is the height of buildings, hills, mountains, trees, or other objects in the vicinity. To regulate safety, KKOP is divided into several zones(*PERMENHUB NOMOR: KM 44*, 2005), including:(Rachman et al., 2021)

Transitional Surface: The boundary of the area in question is determined by starting the measurement from one side of the long surface at the same height as the surface. It then follows the approach surface with a consistent slope until it reaches the inner horizontal plane. The height above the lowest runway threshold at this intersection point should be at least (45 + H) meters, where the value of H will be adjusted according to the runway classification. (Kementerian Perhubungan, 2020)The slope of this approach surface can be 14.3% or 20%, depending on the type of runway.

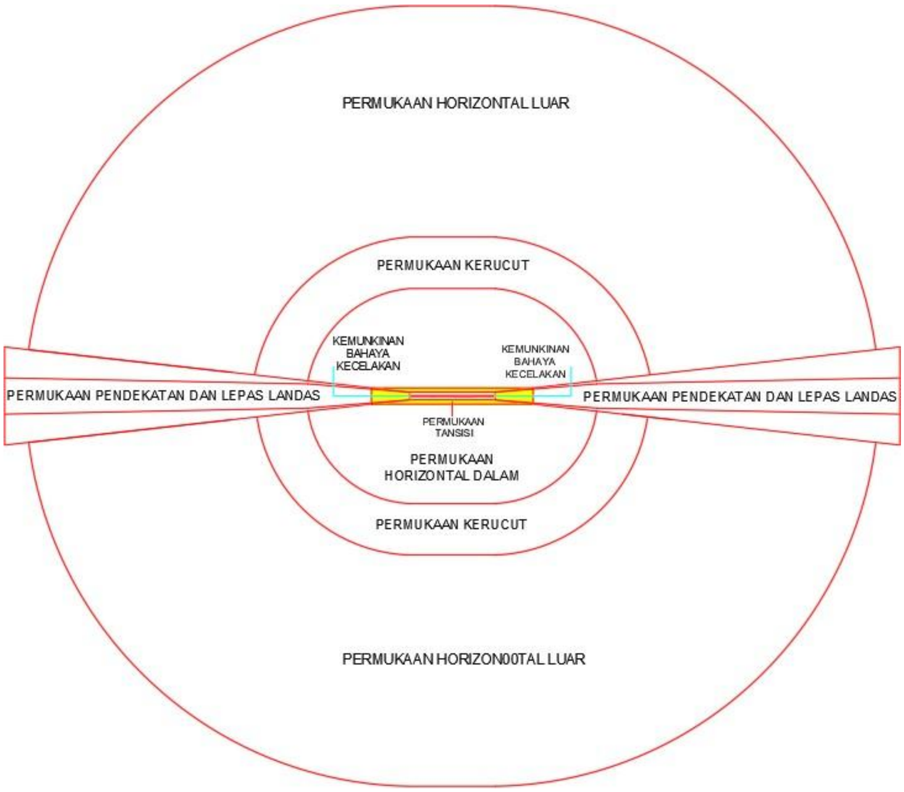

Fig. 1. Transitional Surface

Source: Researcher Result, 2024

Conical Surface: The boundary start point is the outer edge of an area located below the flat top. The height of this starting point can be (145+H), (120+H), (105+H), (100+H), or (80+H) meters, depending on the runway classification. From this starting point, the boundary has a 5% slope upwards.(Yarlina, 2018)

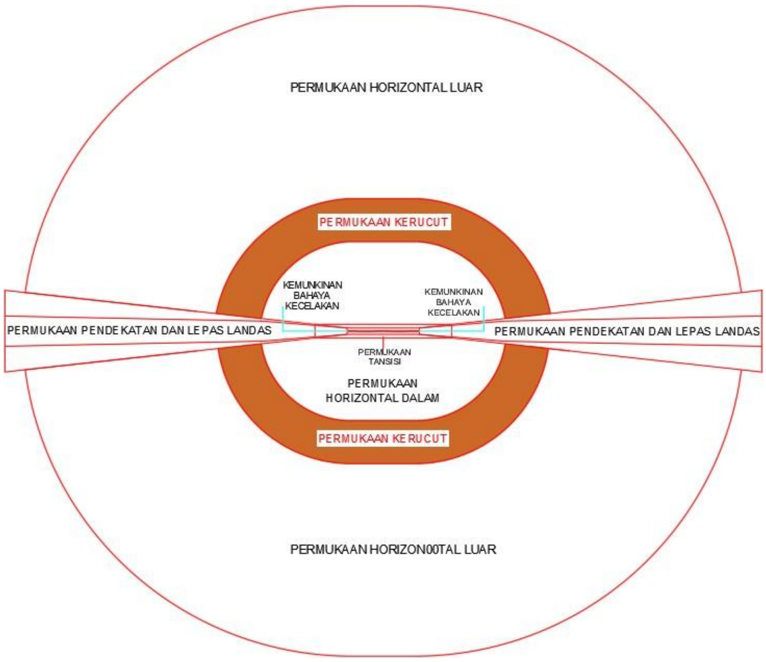

Fig. 2. Conical Surface

Source: Researcher Result, 2024

Outer Horizontal Surface: The starting point of the boundary is at a height of (150+H) meters above the lowest runway threshold elevation.

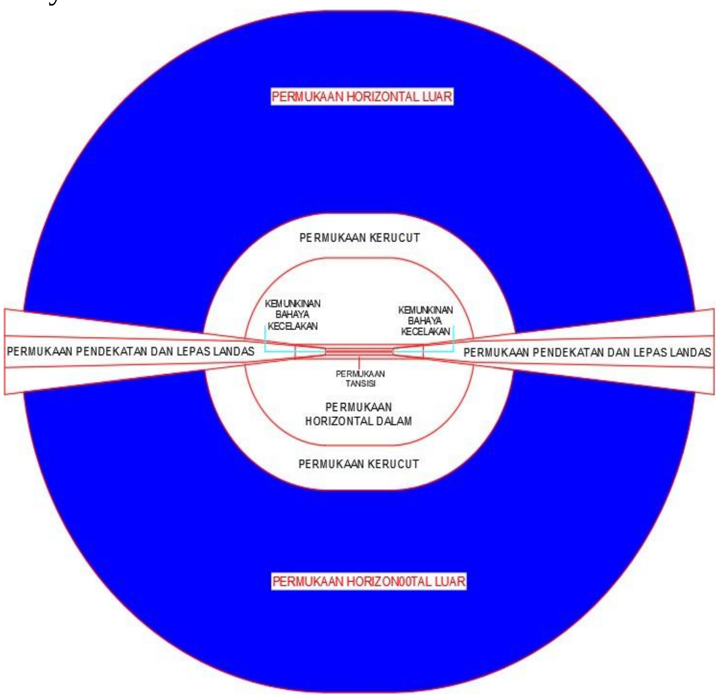

Fig. 3. Outer Horizontal Surface

Source: Researcher Result, 2024

Inner Horizontal Surface: The boundary start point is at an elevation of (45+H) meters above the lowest runway threshold elevation.

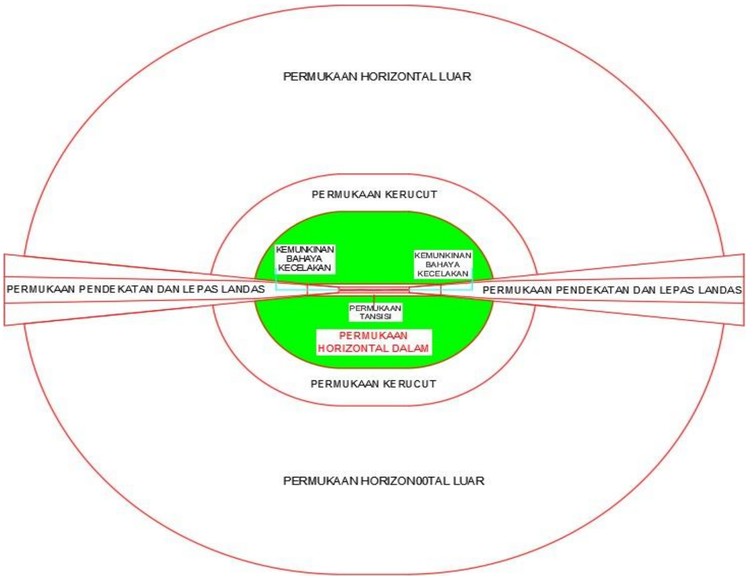

Fig. 4. Inner Horizontal Surface

Source: Researcher Result, 2024

Zone of Possible Accident Hazard: This boundary starts at the end of the runway on each side and extends upwards to a height of (45 + H) meters above the lowest point of the runway. It continues horizontally for 3,000 meters from the center of the runway. The slope of this boundary can be 2%, 2.5%, 3.33%, 4%, or 5%, depending on the type of runway, and the direction is upward and away from the center of the runway.(Humang, 2018; Purwanto et al., 2017)

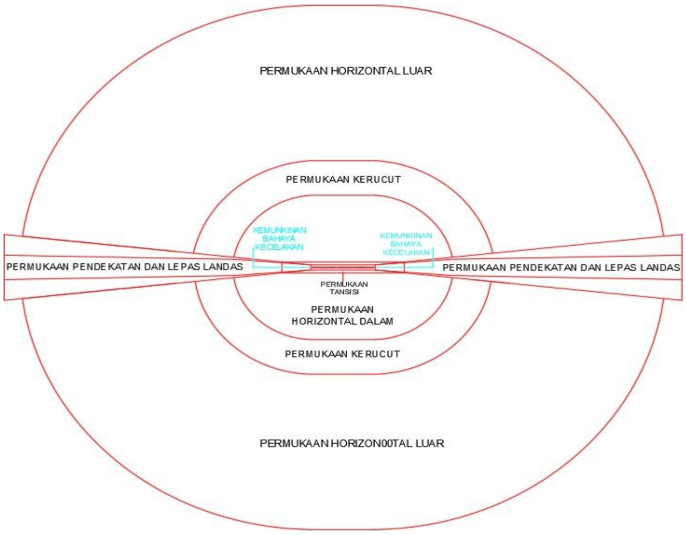

Fig. 5. Zone of Possible Accident Hazard

Source: Researcher Result, 2024

Landing and Take-Off Approach Zones: This limit is determined based on the height of the lowest point of the takeoff surface, approach path, conical surface, and horizontal planes inside and outside the KKOP.

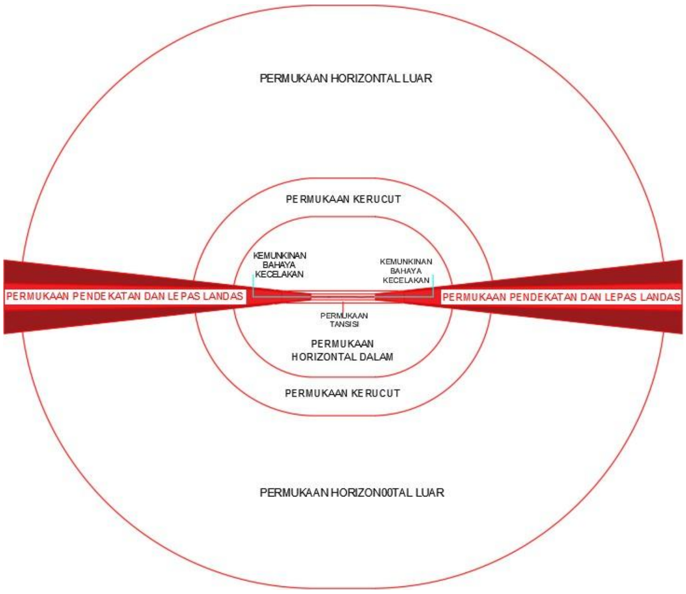

Fig. 6. Landing and Take-off Approach Zone

Source: Researcher Result, 2024

Information on the vertical and horizontal dimensions of the Flight Operations Safety Area (KKOP) can be found in detail in the following table based on (ANNEX 14, 2018)

Table 1 Dimensions and slope of obstacle surface boundaries

	RUNWAY CLASSIFICATION									
								Precision approach category		
	Non-instrument Code number				Non-precision approach Code number			I Code number		II or III Code number
Surface and dimensions[a] (1)	1 (2)	2 (3)	3 (4)	4 (5)	1,2 (6)	3 (7)	4 (8)	1,2 (9)	3,4 (10)	3,4 (10)
CONICAL										
Slope	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Height	35m	55m	75m	100m	60 m	75 m	100 m	60m	100m	100m
INEER HORIZONTAL										
Height	45m	45m	45m	45m	45m	45m	45m	45m	45m	45m
Radius	2000m	2500m	4000m	4000m	3500m	4000m	4000m	3500m	4000m	4000m
INEER APPROACH										
Width	-	-	-	-	-	-	-	90m	120m[e]	120 m[e]
Distance from threshold	-	-	-	-	-	-	-	60m	60m	60m
Length	-	-	-	-	-	-	-	900m	900m	900m
Slope								2,5%	2%	2%
APPROACH										
Length of inner edge	60m	80m	150m	150m	140m	280m	280m	140m	280m	280m
Distance from threshold	30m	60m	60m	60m	60m	60m	60m	60m	60m	60m
Divergence (each side)	10%	10%	10%	10%	15%	15%	15%	15%	15%	15%

First section										
Length	1600m	2500m	3000m	3000m	2500m	3000m	3000m	3000m	3000m	3000m
Slope	5%	4%	3.33%	2.5%	3.33%	2%	2%	2.5%	2.5%	2%
Second section										
Length	-	-	-	-	-	3600 m[b]	3600 m[b]	12000m	3600 m[b]	3600 m[b]
Slope	-	-	-	-	-	2.5%	2.5%	3%	2.5%	2.5%
Horizontal section										
Length	-	-	-	-	-	8400 m[b]	8400 m[b]	-	8400 m[b]	8400 m[b]
Total length	-	-	-	-	-	15000m	15000m	15000m	15000m	15000m
TRANSITIONAL										
Slope	20%	20%	14.3%	14.3%	20%	14.3%	14.3%	14.3%	14.3%	14.3%
INNER TRANSITIONAL										
Slope	-	-	-	-	-	-	-	40%	33.3%	33.3%
BALKED LANDING SURFACE										
Length of inner edge	-	-	-	-	-	-	-	90m	120 m[e]	120 m[e]
Distence from threshold	-	-	-	-	-	-	-	[c]	1800 m[d]	1800 m[d]
Divergence (each side)	-	-	-	-	-	-	-	10%	10%	10%
Slope	-	-	-	-	-	-	-	4%	3.33%	3.33%

All dimensions are measured horizontally unless specified otherwise.
Variable length (see 4.2.9 or 4.2.17).
Distance to the end of strip.
Or end of runway whichever is less.
Where the code letter is F (Table 1-1), the width is increased to 140 m except for those aerodromes that accommodate a code letter F aeroplane equipped with digital avionics the provide steering commands to maintain an established track during the go-around manoeuvre.

Source: Annex 14

Based on the Regulation of the Minister of Transportation Number KM 23 Year 2005 which adopts the Indonesian National Standard (SNI) Number 03-7051-2004, the implementation of marking and lighting systems around airports aims to minimize the risk of aircraft accidents due to physical obstacles(*PERMENHUB NOMOR: KM 23,* 2005). (Kebijakan & Regulasi, 2015)This research focuses on analyzing the types of objects that require special markings, namely:

1. Tall Structures: Buildings or objects with prominent vertical surfaces, especially those that exceed the height limit set for the Flight Operation Safety Area (KKOP).
2. Moving Objects: Heavy vehicles or equipment that operate in the vicinity of the airport and have the potential to interfere with air traffic.
3. Utilities: Infrastructure such as High Voltage Aerial Lines (SUTT) and Extra High Voltage Aerial Lines (SUTET) that cross the aerodrome area and could jeopardize flight operations.

Colors used during the day should be striking and have an alternating city pattern of the same size. (La Manguntara & Hasniah, 2023)The color chosen can be Orange-white, Red-white or any other color that does not blend in with the surrounding buildings. Important points to be noted are as follows:

1. Buildings with uninterrupted horizontal and vertical planes of at least 4.5 meters, should have an alternating grid pattern with sides of maximum 3 meters and minimum 1.5 meters.
2. If the vertical plane is less than 4.5 meters or the horizontal is more than 1.5 meters, the color is used with an alternating rectangular pattern, the width of the box is 1/7 of the longest plane, maximum 30 meters.
3. For buildings with a plane of less than 1.5 meters, only one color is used, red or orange, unless the color blends in with its surroundings.
4. Mobile buildings should use red for emergency and yellow for operation.
5. The patterns and colors can be seen in the following figure.

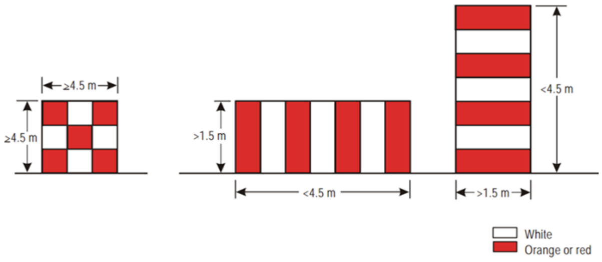

Fig.7. Basic Marking Patterns

Source: SNI 03-7051-2004

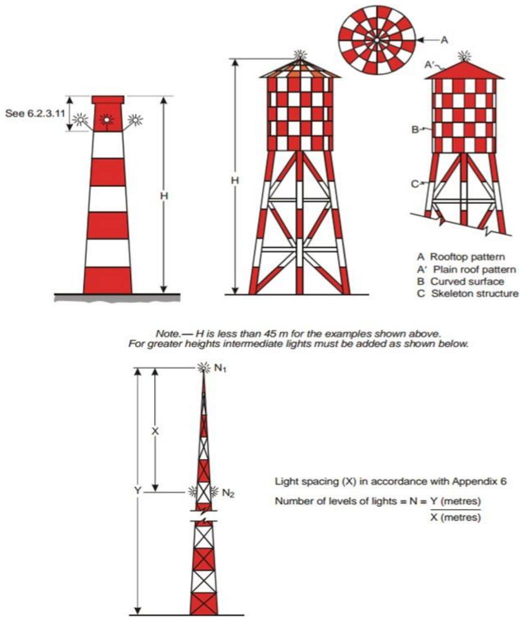

Fig.8. Marking and Lighting of Tall Structures

Source: SNI 03-7051-2004

For lighting, the lamps used should stand out at night with the criteria that the white or red-light flashes and the white or red light stays on with the type of lamp used:

1. Type I light, lights with low light intensity used for:
    a. Permanent buildings less than 45 m above ground level, with a fixed red light with a minimum intensity of 10 cd.
    b. Fixed red light with a minimum intensity of 10 cd for buildings with movement restrictions.
    c. Mobile buildings such as emergency or security vehicles use blue and yellow flashes of 60 - 90 flashes per minute with higher light intensity.
2. Type II lights, lights with medium light intensity used for:
    a. Buildings more than 45 m above ground level.
    b. Large and wide objects with a height of less than 45 m.
3. Type III light, lights with high light intensity used for:
    a. Buildings with a height of more than 150 m above ground level.
    b. SUTT poles must have lights at the top, the lowest point of the wire stretch, and the midpoint between the two.
    c. Other buildings whose marquees are not easily visible must have lights at the top, lowest point, and midpoint.
4. Combination of Type I, II, and III.

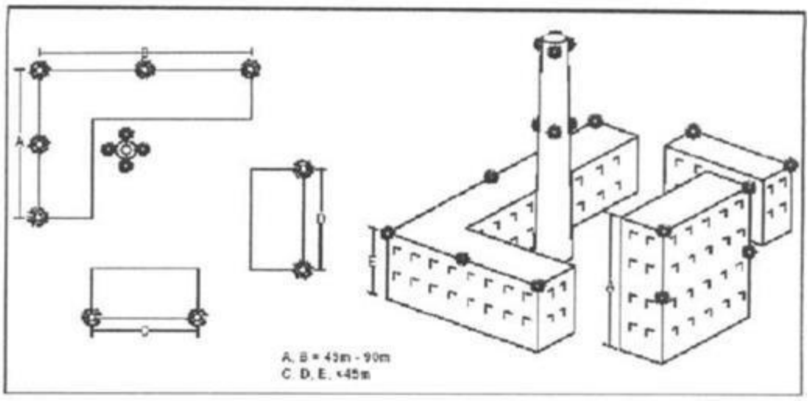

Fig.9. Installation of Lights In Buildings

Source: SNI 03-7051-2004

In marking, an orange marker ball should be attached to the SUTT cable at a maximum distance of 40 meters. This ball should be clearly visible in clear weather from a distance of 1,000 meters in the air and 300 meters from ground level, distinct from the surrounding colors.

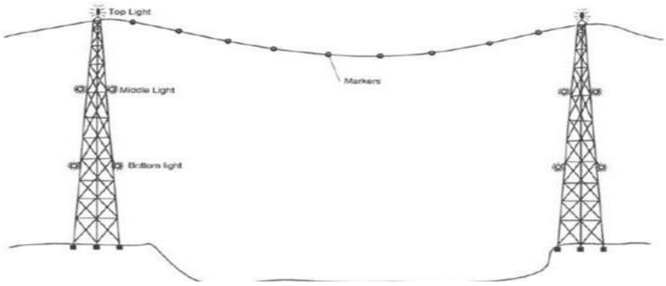

Fig.10. Marking and Location of High-light Intensity Obstacle Signs On High-rise Overhead Line Support Towers

Source: SNI 03-7051-2004

2. Research method

This research adopted a descriptive qualitative approach to analyze the condition of the Flight Operation Safety Area (AOSA) at Yogyakarta-Kulon Progo International Airport. (Sugiyono, 2015a, 2015b)The research method involved primary data collection through field surveys conducted using GPS, altimeter, and camera. Secondary data such as topographic maps, airport technical data, and related laws and regulations were also collected to complete the analysis. The data obtained were then analyzed descriptively by comparing the results of field measurements with the provisions listed in the Minister of Transportation Regulation Number KM 44 of 2005 and SNI 03-7112-2005.(Kebijakan & Regulasi, 2015)

3. Results and discussion

The ultimate condition of Yogyakarta-Kulon Progo International Airport has an instrument precision category I runway with code number 4E. Based on technical data, the height of important points around the runway is determined using two height measurement systems, namely the Aerodrome Elevation System (AES) and Mean Sea Level (MSL). This height calculation is done by applying the following formula:

a. Data:

$$\mathrm{X_0} = 0.00\ (\mathrm{AES})$$
$$\mathrm{Y_1} = 7.315\ (\mathrm{MSL})$$
$$\mathrm{X_1} = 7.315\ (\mathrm{AES})$$

b. Formula:

$$\mathrm{A_1} = (\mathrm{X_0})\mathrm{AES} + (\mathrm{Y_1})\mathrm{MSL} = (\mathrm{m})\mathrm{Meter}$$
$$\mathrm{A_2} = (\mathrm{m}) + (\mathrm{X_1}) = \mathrm{MSL}$$

Calcilation:

$A_{11} = 0.00 + 7.315 = +7.315 \text{ m (MSL)}$

$A_{29} = +7.315 + 7.315 = +14.63 \text{ m (MSL)}$

Then obtained the height of the runway threshold 11 () at Yogyakarta-Kulon Progo International Airport is used as a reference point for the altitude system with a value of 0.00 m (AES) or +7.315 m above MSL. While the runway 29 () threshold has an altitude of +7.315 m (AES) or +14.63 m above MSL.

The calculation of obstacle height limits in the landing and take-off approach areas on runway 11 (sections I, II, III, IV, and V) starts from section I, where the area is trapezoidal in shape:

Maximum Obstacle Height:

$= (\text{Slope}) \times (\text{Distance}) = (\text{AES})$

$= (\text{AES}) + (\text{Elevation}) = (\text{MSL})$

With a 2% slope, the maximum height of the obstacle is calculated as follows:

$= 2\% \times 2.250 = 45 \text{ m (AES)}$

Then, add the MSL elevation:

$= 45 \text{ m} + 7.315 \text{ m} = 52.315 \text{ m (MSL)}$

So, the maximum height of the barrier is 45 meters (AES), and after adding elevation, it becomes 52.315 meters (MSL). Thus, buildings permitted in section I along 2,250 meters from the end of the runway are between 0 to 45 meters high (AES) with a 2% slope. While the height based on MSL ranges from +7.315 to +52.315 meters with the same slope. The calculation results for sections II, III, IV and V, which are also trapezoidal in shape, can be seen in the following table.

Table 2 Obstruction height limit in the approach and takeoff area in the runway direction

Area	Slope %	Distance (m)	Height Above RW Threshold	
			AES (m)	MSL (m)
Section I	2	2,250	45	52.315
Section II	0	1,750	45	52.315
Section III	5	1,167	103.35	110.665
Section IV				
Center	2	2,333	150.01	157.325
Edge I	5	433	125	132.325
Edge II	2.5	1,000	128.35	135.665
Edge III	0	900	128.35	135.665
Section V	0	7,500	128.35	135.665

Source: Researcher Result, 2024

The height limits in the Flight Operation Safety Area (KKOP) at Yogyakarta-Kulonprogo International Airport are described as follows:

a. Approach and Takeoff Area Height Limits

The area boundary starts 60 meters from the end of the runway with an initial width of 300 meters, widening gradually outward at an angle of 15%. The centerline is an extension of the runway axis, with a horizontal distance of 15,000 meters and a final width of 1,200 meters.

b. Elevation Limit of Possible Accident Hazard Area

2% upward and outward slope starting from the end of the main surface. The final elevation is +60.00 meters (AES) or +103.35 meters (MSL), with a horizontal distance of 3,000 meters.

c. Elevation Limit of Transition Subsurface Area

A 14.3% slope upward and outward, starting from the long side of the main surface to intersect the deep horizontal surface at +45.00 meters AES (+52.315 meters MSL).

d. Height Limit of the Area Below the Inner Horizontal Surface

Set at +45.00 meters above the runway threshold.

e. Height Limit of Area under Conical Surface

Slope 5% upward and outward from the edge of the inner horizontal surface at elevation +45.00 meters AES (+52.315 meters MSL) to the outer horizontal surface at elevation +150.00 meters AES (+157.315 meters MSL).

f. Altitude Limit of the Area Below the Outer Sureface

Defined by a circle with a radius of 15,000 meters from the tip of the main surface, and not included in conical surface, transition, or approach and takeoff areas.

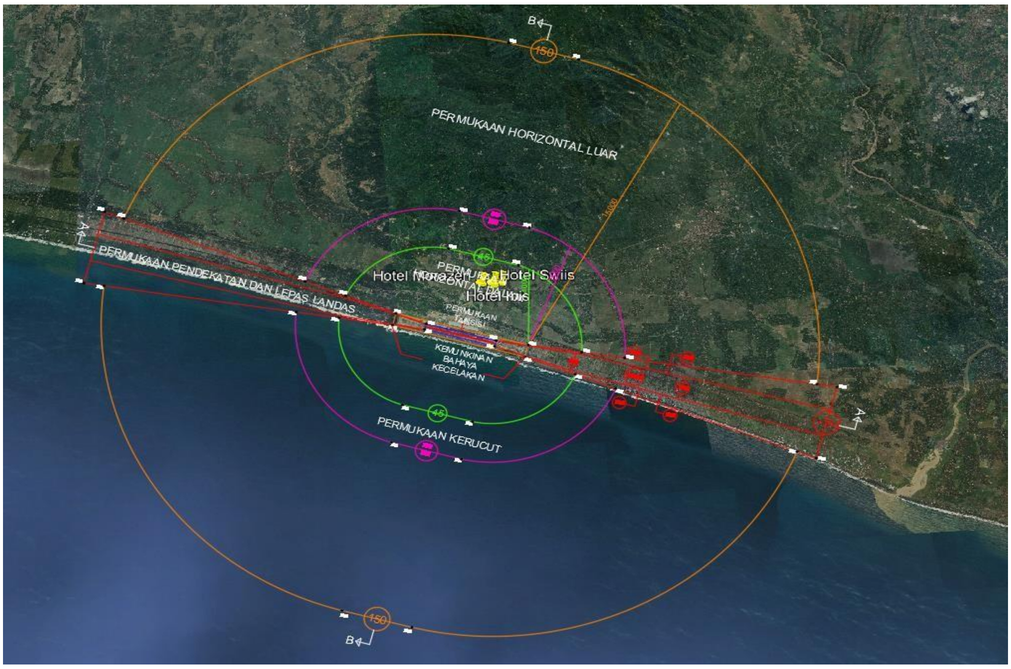

Fig. 11. Height Limit of KKOP

Source: Researcher Result, 2024

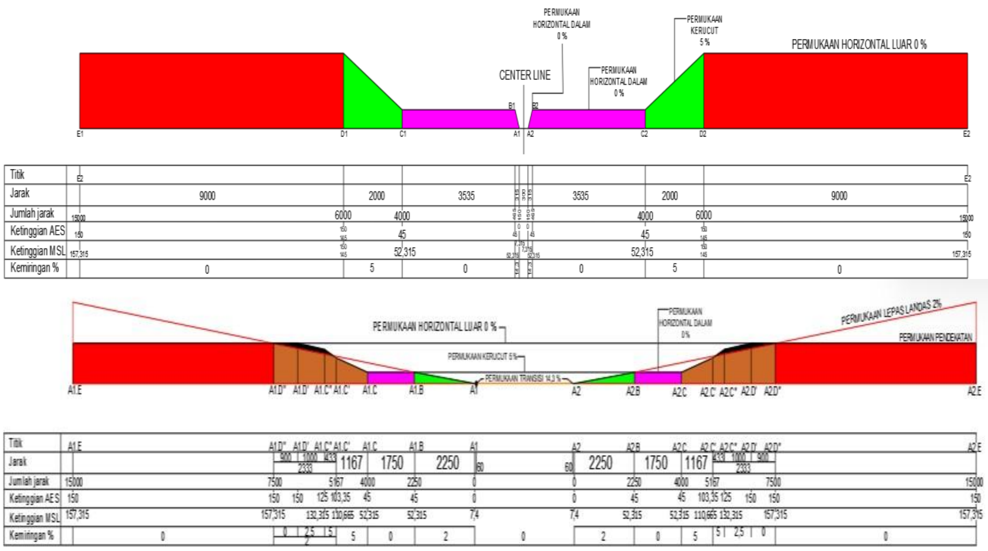

Fig. 12. KKOP Longitudinal Cut

Source: Researcher Result, 2024

Calculation of the height of tall buildings in the Flight Operation Safety Area (KKOP) around Yogyakarta-Kulon Progo International Airport:

Table 3 Obstacle point technician data

Point	Coordinates WGS'84		Distance (m)	Elevation (m)
ARP	X	7°54'1.05"S	0.0	7.315
	Y	110° 2'36.06"E		
HOTEL IBIS	X	7°53'13.43"S	2,900	8.2
	Y	110° 4'11.64"E		
HOTEL SWIIS	X	7°53'12.55"S	3,250	4.2
	Y	110° 4'21.82"E		
HOTEL MORAZEN	X	7°53'10.31"S	3,555	5.9
	Y	110° 3'56.09"E		

Source: Researcher Result, 2024

a. Calculation of height at Hotel Ibis

Data:

ARP elevation = 7.315 m

Obstacle elevation = 8.2 m

Obstacle height = 46 m

Inner Horizontal surface = 45+H

Obstacle distance from ARP point = 2,900 m

Runway strip = 150 m

Calculation of the height of the obstacle entering the KKOP area in the area zone below the inner horizontal surface:

1. Distance from Object - Runway Strip

   2,900 m - 150 m = 2,750 m

2. Object height from sea level (MSL)

   46 m + 8.2 m (MSL) = 54.2 msl

3. Object Height in line with KKOP from sea level (MSL)

   45+H = 45+7.315 = 52.315 MSL

4. Object that must be cut off

   54.2 m – 53.315 m = 1.885 MSL

b. Calculation of height at Hotel Swiis

ARP elevation = 7.315 m

Obstacle elevation = 4.2 m

Obstacle height = 48 m

Inner horizontal surface = 45+H

Obstacle distance from ARP point = 3,250 m

Runway strip = 150 m

Calculation of the height of the obstacle entering the KKOP area in the area zone below the inner horizontal surface:

1. Distance from Object - Runway Strip

   3,250 m - 150 m = 3,150 m
2. Object height from sea level (MSL)

   48 m + 4.2 m (MSL) = 52.2 msl
3. Object Height in line with KKOP from sea level (MSL)

   45+H = 45+7.315 = 52.315 MSL
4. Object that must be cut off

   52.2 m – 53.315 m = -0.115 MSL (not obstacle)

c. Calculation of height at Hotel Morazen

ARP elevation = 7.315 m

Obstacle elevation = 5.9 m

Obstacle height = 46 m

Inner horizontal surface = 45+H

Obstacle distance from ARP point = 3,555 m

Runway strip = 150 m

Calculation of the height of the obstacle entering the KKOP area in the area zone below the inner horizontal surface:

1. Distance from Object - Runway Strip

   3,555 m - 150 m = 3,405 m
2. Object height from sea level (MSL)

   46 m + 5.9 m (MSL) = 51.9 msl
3. Object Height in line with KKOP from sea level (MSL)

   45+H = 45+7.315 = 52.315 MSL

4. Object that must be cut off

51.9 m – 53.315 m = -0.415 MSL (not obstacle)

Table 4 List of Obstacle Calculation Results

No	Area (KKOP)	Elevation (MSL)	Excess (MSL)	Obstacle
1	Hotel Ibis	54.2	1.885	Obstacle
2	Hotel Swiis	52.2	-0.115	No Obstacle
3	Hotel Morazen	51.9	-0.415	No Obstacle

Source: Researcher Result, 2024

After knowing the calculation results of the three hotels identified as obstacles in the Flight Operation Safety Area (KKOP) below the deep horizontal surface, it is necessary to monitor by installing obstacle signaling lights above the hotel buildings.

4. Conclusion

Based on the results of the Yogyakarta-Kulon Progo International Airport Aviation Operation Safety Area (KKOP) study, it was found that a number of tall buildings, such as three hotels located below the deep horizontal surface, exceeded the predetermined height limit. This condition has the potential to interfere with flight safety. Therefore, it is recommended to conduct supervision and implement corrective actions in the form of installing barrier sign lights on these buildings, in accordance with the provisions of the Minister of Transportation Regulation Number KM 23 of 2005 and SNI 03-7051-2004.

The results of this study indicate the need for attention from local governments, especially the Kulon Progo Regency Government, in managing spatial planning and development licensing around Yogyakarta-Kulonprogo International Airport. The existence of tall buildings that do not comply with aviation safety regulations can endanger flight operations. Therefore, it is recommended that the local government tighten supervision of the construction of BTS towers, electricity towers, and other tall buildings in the area. In addition, the installation of obstruction lights on buildings that have violated the provisions is an urgent step to improve visibility for pilots. Regular socialization to the public about the importance of flight safety also needs to be carried out intensively.(Bartels et al., 2018; Brown, 2016)

This research has several limitations that must be considered. First, the control of tall buildings in the horizontal subsurface area within the Flight Operation Safety Area (KKOP) of Yogyakarta-Kulon Progo International Airport is only limited to the calculation of building heights that exceed the limit, without further study of the long-term impact on flight operations. (Reynolds-Feighan, 2001; Shali et al., 2021)Second, although the recommendation for the installation of obstacle signaling lights on tall buildings is in accordance with applicable regulations (KM 23 of 2005 and SNI 03-7051-2004), its implementation in the field still requires more structured monitoring, especially in maintaining the continuity of supervision by airport authorities and local governments. Third, this study has not explored in detail the potential development of the area around the airport that could affect spatial planning and flight safety in the future. Finally, the proposed socialization to the community around the airport related to aviation safety has not been discussed in depth regarding the effectiveness of socialization methods and the role of the community in maintaining this safety.

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