The Development Study of Adisutjipto International Airport, Special Region of Yogyakarta

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ABSTRACT

Adisutjipto International Airport is one of the airports in Yogyakarta, besides the newest airport, Yogyakarta International Airport (YIA) Kulon Progo. The existence of passenger density of up to 8 million/year at Adisutjipto International Airport, and there will be flight diversions to YIA. Therefore, Adisutjipto International Airport needs to improve by developing the airport from the air side (runway, taxiway, and apron) to the land side (terminal). This development study used secondary data with linear regression of forecasting data for the next five years. Furthermore, this study reviews the runway's capacity at the time before the transfer of jet-type aircraft and after the transfer was carried out earlier in 2020 from the 2021 plan year to YIA. Furthermore, analysis and calculation of the runway, taxiway, and apron dimensions were carried out using the results of the existing forecast data on the planned aircraft, namely the Aircraft A320. Based on the analysis, it was found that 2500m x 60m (including shoulders) of runway dimension requirements. In addition, there was an additional runway length of 250m toward runway 09, and the dimensions of the taxiway width are 45m (including shoulders). The location of the exit taxiway was 1581m from the threshold. Meanwhile, the apron dimensions (1303.618m x 126.992m). On the land side, the total terminal area is 195623.1m2. After the development study was carried out, in the KKOP analysis, it can be concluded that it is still suitable for flight operations. Furthermore, the latest analysis regarding transferring from jet-type aircraft to YIA (29 March 2020) shows that Adisutjipto International Airport does not need airport development. It was because the runway capacity will be 14 operations/hour in 2025, while during peak hours, it will get 13 operations/hour.

INTRODUCTION

Adisutjipto International Airport is located in Sleman, Special Region of Yogyakarta. Adisutjipto International Airport serves flights to various regions, both domestically and internationally. It is planned that in 2021 the operations of Adisutjipto International Airport will be moved to Yogyakarta / YIA International Airport (Kulon Progo) after the inauguration. Before the inauguration of YIA, which is in line with the increasing development and economic development in Yogyakarta, Adisutjipto Airport begins to improve to deal with a passenger density of around 8 million passengers per year.

International flights of the Yogyakarta route are still landing at Adisutjipto International Airport. Even though YIA has started to carry out services to several domestic flights, international flights are still not possible since international flights such as international airlines Air Asia and Silk Air stated that they are not ready. Therefore, though YIA already exists, Adisutjipto International Airport will still improve its performance so that it can continue to serve both domestic and international flights.

In addition, Adisutjipto International Airport is also one of the airports used for military aviation activities. In 2018 there were an average of 176 flights per day and 90 military flights and flight school activities. Therefore, Adisutjipto International Airport is the most crowded airport with limited capacity compared to Juanda Airport.

Currently, Adisutjipto International Airport has a domestic terminal area of 8.184 m^2 with a passenger capacity of 800.000 people/year and an international terminal area of 1.018 m^2 with a passenger capacity of 100.000 people/year. The total area of the apron is 28.055 m^2, the runway dimension is (2.200x45) m^2, and the total area of the taxiways is 3.575 m^2 [1].

Developing the airport is a thing that an airport can do to continue to operate and provide flight services, which is accompanied by an increasing number of passengers and the development of airlines. In this case, Adisutjipto International Airport needs to be analyzed whether it can still be developed or not. This is important to be analyzed, considering that there are airlines with high tourism potential still operating at Adisutjipto Airport.

The development of airport facilities is significant for every airport serving passengers, which always increases yearly. Therefore, it is necessary to analyze the development of land-air facilities at Adisutjipto

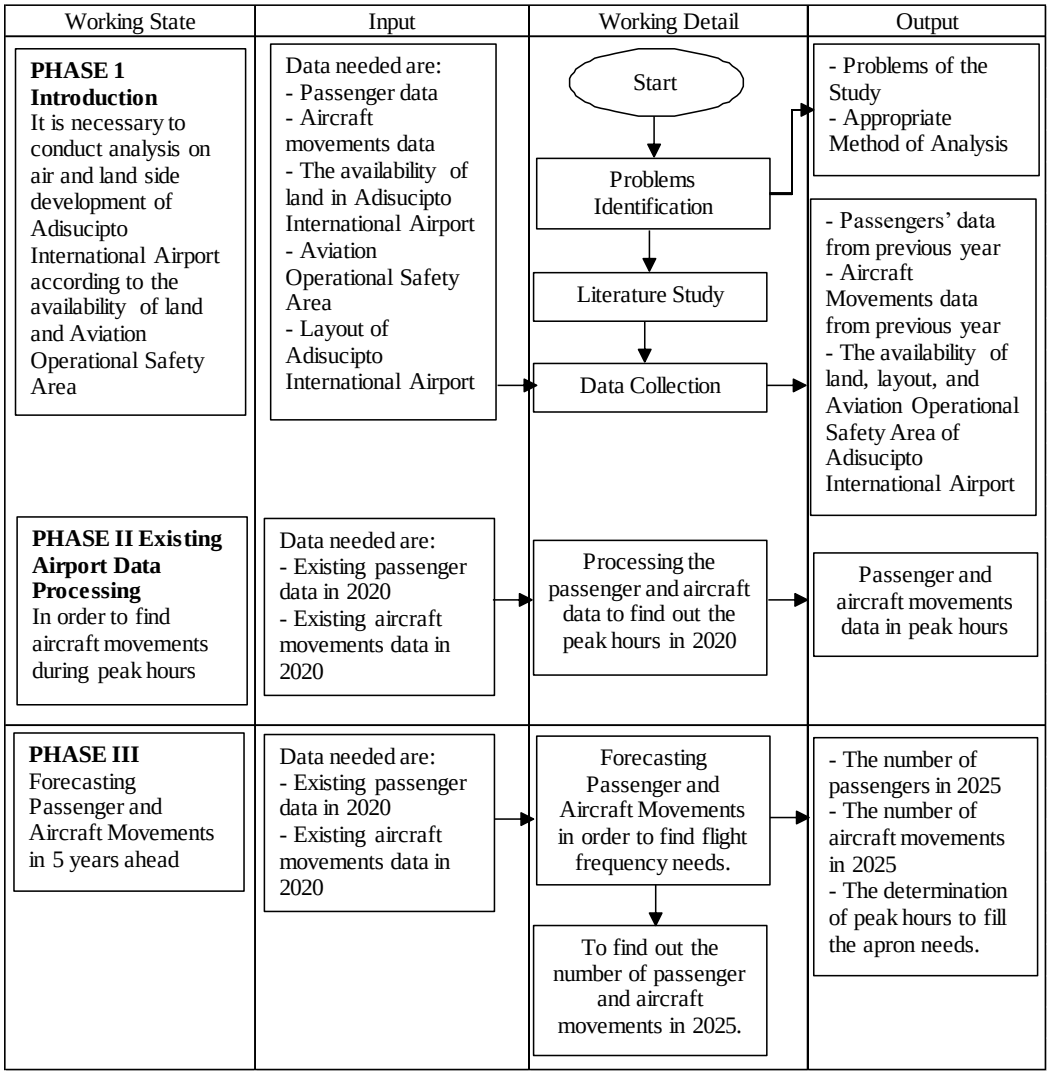

Figure 1. Study Completion Flowchart.

International Airport. Therefore, in the following years, it can accommodate the types of aircraft that can operate, which are adjusted to the conditions of land availability and KKOP. However, on March 29, 2020, PT. Angkasa Pura I moved all jet-type aircraft flight operations to YIA. Therefore, there will be two possibilities in the results of this study.

METHODOLOGY

The Data on aircraft and passenger movements at Adisutjipto International Airport from 2001–2017 was then processed using the linear regression method to predict the number of aircraft and passenger movements in 2025. Furthermore, the forecasting results were used to calculate the runway capacity for the plan year. Furthermore, it was used to calculate the required dimensions of the runway, taxiway, apron, and terminal area. The final step was an analysis of KKOP carried out in the airport area that had been developed. It can be seen in Figure 1.

RESULTS AND DISCUSSIONS

A. Aircraft and Passenger Movements

The data on the number of aircraft and passenger movements were used to predict the growth of aircraft and passenger movements in the plan year, which is 2025. The data was based on the secondary data obtained from the Annual Report of PT. Angkasa Pura I in 2001-2017.

B. The Linier Regression Forecasting Method

Forecasting of aircraft and passenger movements at Adisutjipto International Airport is calculated using historical data from 2001-2017. From the historical data above, forecasting was then carried out using the linear regression method with the help of Microsoft Excel software. Based on that, the forecasting results show that in 2025, the number of aircraft movements will be 135.937 aircraft/year, and the number of passenger movements will be 10.964.658 people/year with conditions before the transfer of jet aircraft to YIA. Meanwhile, the forecasting results regarding the conditions after transferring jet aircraft to YIA are: the number of aircraft movements is 39.422 aircraft/year, and the number of passenger movements is 1.754.345 people/year.

C. The Calculation of Peak Hour

The peak hour calculation was done by using the equation obtained based on Ashford, Mumayiz and Wright 2011[2]. The calculation of the peak hour was carried out twice with conditions before and after the transfer of the jet aircraft to YIA.

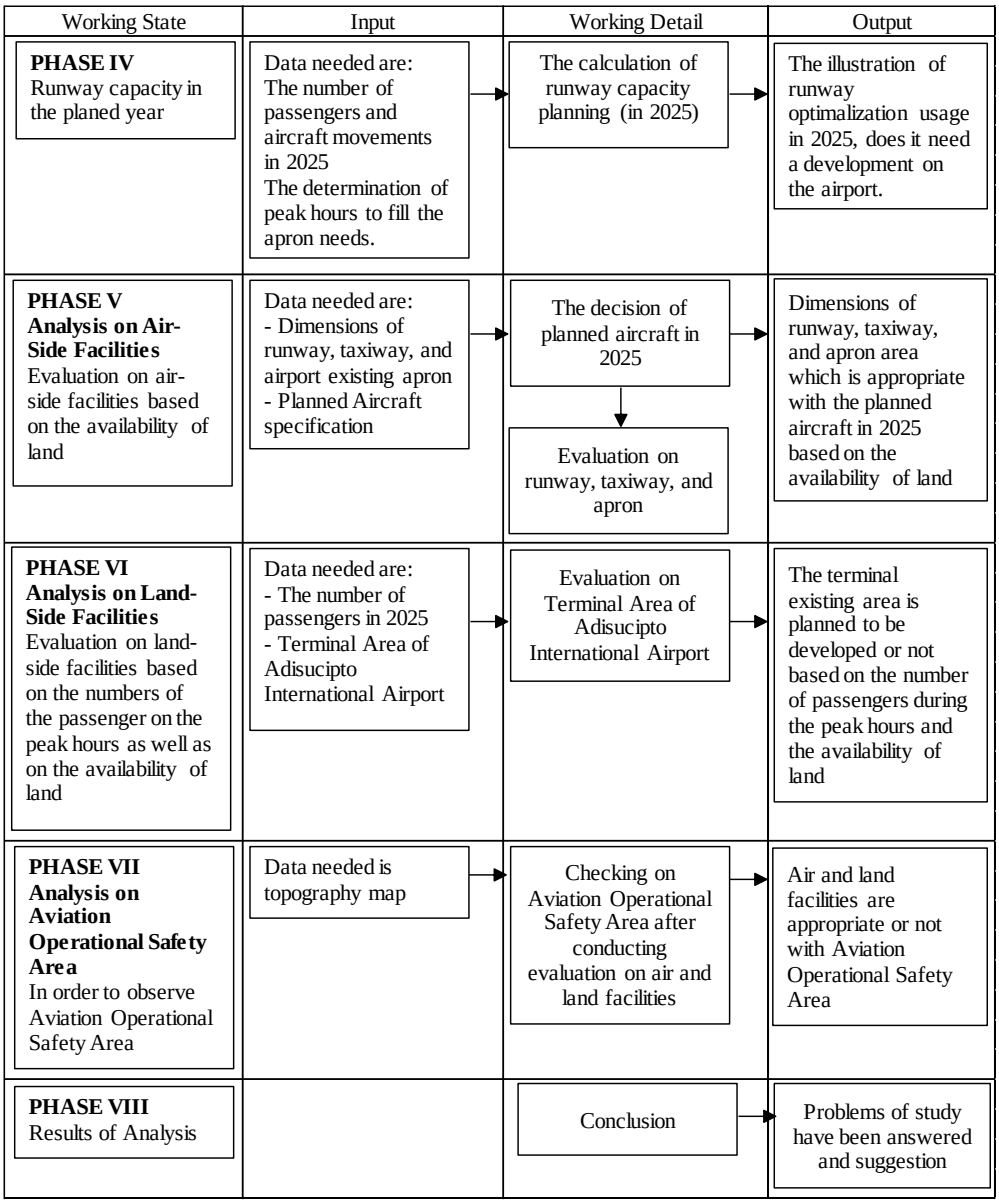

Figure 2. Continuation of Study Completion Flowchart.

1) Conditions before the transfer of jet aircraft to YIA.

a) Average Monthly Volume

Average Monthly = 0,08417 x *Annual Passenger*

Average Monthly = 0,08417 x 135.937

Average Monthly = 11.441,82 ≈ 11.442

b) Average Day Volume

Average Day = 0,03226 x *Monthly Maximum Volume*

Average Day = 0,03226 x 11.442

Average Day = 369,11 ≈ 370

c) Peak Day Movement

Peak Day Movement = 1,26 x *Average Day*

Peak Day Movement = 1,26 x 370

Peak Day Movement = 466,08 ≈ 467

d) Peak Hour Volume

Peak Hour = 0,0917 x *Peak Daily Flow*

Peak Hour = 0,0917 x 467

Peak Hour = 42,6 ≈ 43

From the calculation above, it was obtained that the peak hour of Adisutjipto International Airport in 2025 is 43 aircraft/hour.

2) Conditions after the transfer of jet aircraft to YIA.

a) Average Monthly Volume

Average Monthly = 0,08417 x *Annual Passenger*

Average Monthly = 0,08417 x 39.422

Average Monthly = 3.318,14974 ≈ 3.319

b) Average Day Volume

Average Day = 0,03226 x *Monthly Maximum Volume*

Average Day = 0,03226 x 3.319

Average Day = 107,07094 ≈ 108

c) Peak Day Movement

Peak Day Movement = 1,26 x *Average Day*

Peak Day Movement = 1,26 x 108

Peak Day Movement = 136,08 ≈ 137

d) Peak Hour Volume

Peak Hour = 0,0917 x *Peak Daily Flow*

Table 1. Aircraft Movements in 2001-2017.

Year	Aircraft Movements (Aircraft)
2001	11.505
2002	12.010
2003	17.052
2004	27.102
2005	25.961
2006	23.050
2007	22.559
2008	24.150
2009	37.894
2010	46.457
2011	51.516
2012	58.629
2013	64.719
2014	72.868
2015	83.773
2016	95.885
2017	103.944

Table 2. Passengers Movements in 2001-2017.

Year	Passengers Movements (People)
2001	806.744
2002	917.714
2003	1.481.022
2004	2.442.915
2005	2.558.262
2006	2.564.144
2007	2.598.549
2008	2.793.769
2009	3.368.228
2010	3.690.350
2011	4.292.156
2012	4.998.028
2013	5.775.947
2014	6.236.578
2015	6.380.336
2016	7.208.557
2017	8.634.369

Table 3. Aircraft Characteristics in Apron Planning

Prameter (m)	ATR 72-600 B Category	B735 C Category	A320 C Category
Wingspan	27,05	28,88	34,10
Wheel Base	10,77	11,07	12,64
Overall Length	27,166	31,01	37,57

Peak Hour = 0,0917 x 137

Peak Hour = 12,5629 ≈ 13

From the calculation above, it was obtained that the peak hour of Adisutjipto International Airport in 2025 is 13 aircraft/hour.

D. Calculation of Runway Capacity

1) Conditions before the transfer of jet type aircraft to YIA

1. Developing Arrival Only Model
a) *Error Free Case* of 25 operations/hour.
b) Considering of Position Error of 20 operations/hour.
2. Developing *Departure Only* Model of 57 operations/hour.
3. Developing *Mix Operation* Model of 15 operation/hour.

Due to the planning condition of Adisutjipto International Airport, the runway is experiencing arrival and departure operations. The conclusion that can be drawn is only in mix operation conditions. Therefore, based on the runway capacity calculation, it will not be able to handle the movements that occur in 2025. Because the number of the movement is 43 operations/hour during peak hours, and the calculating result shows that the maximum planned runway capacity is 15 operations/hour. Therefore, efforts are needed to increase the runway capacity by developing the airport's land-air side before the jet-type aircraft transfer to Yogyakarta International Airport.

2) Conditions after the transfer of jet type aircraft to YIA

1. Developing Arrival Only Model
a. *Error Free Case* of 20 operations/hour
b. Considering of Position Error of 17 operations/hour
2. Developing *Departure Only* Model of 53 operations/hour
3. Developing *Mix Operation* Model of 14 operation/hour

Due to the planning condition of Adisutjipto International Airport, the runway is experiencing arrival and departure operations, so that only in mix operation conditions are used. According to the calculation of propeller-type aircraft movements or conditions after the transfer of jet-type aircraft operation to YIA, it can be concluded that the runway's capacity in the planned year is still capable of handling the movements that may occur in 2025. Due to the movements in 2025, there will be 13 operations/hour in peak hours, and the maximum mathematical calculation of the design runway is 14 operations/hour. Thus, the runway is still capable of handling the maximum movements in 2025. Therefore, it

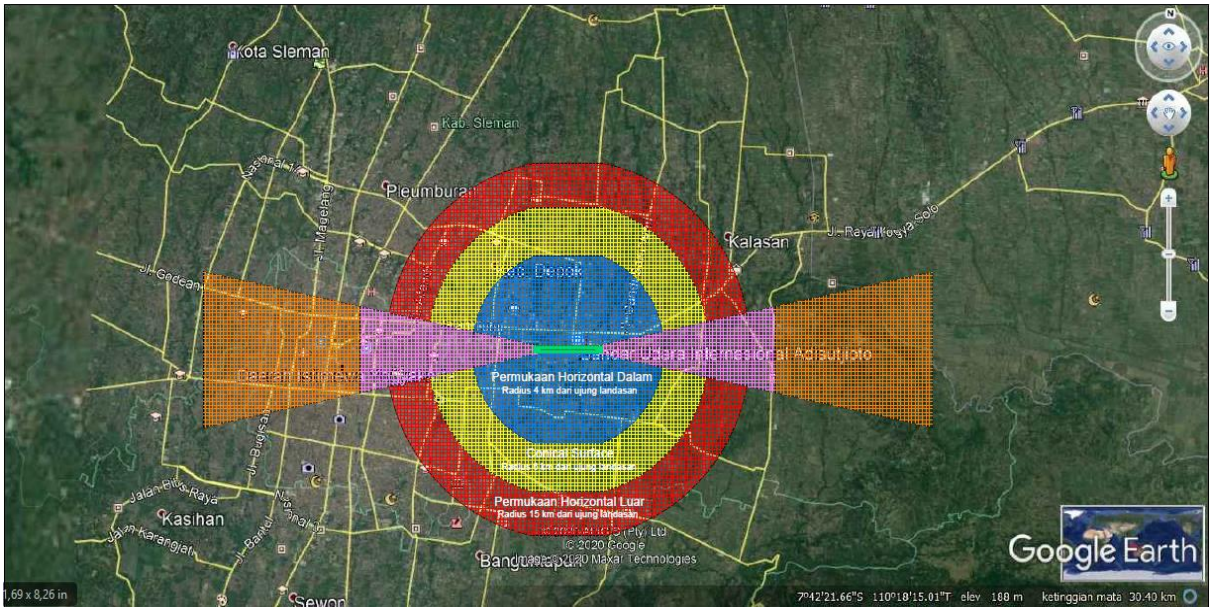

Figure 2. Aviation Operational Safety Area (KKOP) Adisutjipto International Airport, Special Region of Yogyakarta.

is not necessary to develop air and land side facilities to increase the capacity of the runway if faced with the condition of every jet-type aircraft operational flight in Adisutjipto International Airport moved to YIA.

E. The Calculations of Air-Side Development

1) Calculation of Runway Development

a) Runway Length

Based on the Regulation of the Minister of Transportation Number 69 of 2013 concerning National Airport Arrangements, it is stated that Adisutjipto International Airport in 2020 and 2025 will have the same runway classification, namely class 4D. It means that Adisutjipto International Airport can be landed for aircraft that have an ARFL (Aeroplane Reference Field). Length/Length of Runway based on aircraft reference) ≥ 1800 m, which has a wingspan between 36 m to 52 m. In addition to the development of this airport which uses A320 aircraft, class IV.

To determine the corrected runway length, a calculation of the aircraft with ARFL correction for elevation, temperature, and runway effective gradient is necessary to be done. The field conditions are as follows: the elevation above sea level is 107 m, the temperature is 27.25^{0}C , and the effective gradient of the runway is 0,444%.

a. Correction to elevation, Fe

The elevation correction factor (Fe), ARFL increases by 7% for every 300 m rise calculated from sea level. The following is the calculation of Fe :

$$Fe = 1+0.07 \times h/300$$

Fe = 1+ 0.07 x 107/300

Fe = 1.025

b. Correction to temperature, Ft

The temperature correction factor (Ft) to count the runway length to temperature are shown below:

$$Ft = 1+0.01 (T-(15-0.0065 \times h))$$

Ft = 1+0.01 (27.25-(15-0.0065 x 107))

Ft = 1.129

c. Correction to the runway effective gradient, Fs

The correction of *Effective Gradient* is the different ratio between the highest and lowest point of the runway to the its length.

$$Fs = 1+(0,1 \times s)$$

Fs = 1+(0.1 x 0.444%)

Fs = 1.0004

From the correction calculation above, therefore, the corrected runway length is as follow:

ARFL = (the corrected runway length)/(Fe x Ft x Fs)

2.090m = (the corrected runway length) / (1.025 x 1.129 x 1.0004)

The corrected runway length = 2.090m x 1.025 x 1.129 x 1.0004

The corrected runway length = 2.419,56769 m = 2.500 m

b) Runway Width

According to the Ministry Regulation of Transportation Number 69 of 2013 Adisutjipto International Airport uses 4D class runway and for the next planning will use 4D code. Therefore, the runway width will be 45 m.

c) Runway Shoulder

According to SKEP77/VI/2005 for Code Letter D, aircraft classification IV, the width of runway shoulder = 7.5 m, with the maximum effective gradient shoulder = 2.5%. It is due to the total width of shoulder = 7.5 m x 2 =15 m, and runway width = 45 m. Runway width + shoulder = 60 m.

d) Runway Cross Slope

For code letter D, aircraft classification IV, preferred slope is 1,5%, minimum slope is 1%, dan maximum slope is 2%. Therefore, the runway cross slope use is 1.5%.

e) Stopway

For code letter D, aircraft classification IV, the width of the stopway is the same as runway width, the length of stopway is 60 m with stopway slope is 0.3% per 30 m.

f) Area RESA (Runway End Safety Area)

For code letter D, aircraft classification IV, the minimum distance between the holding bay and the centerline of the runway, for instrument runways is 90 m,

and for non-instrument runways it remains 90 m. The minimum width of RESA = 45 m/2x runway width. For the maximum longitudinal and transverse slopes is 5%.

g) Holding Bay

For code letter D, aircraft classification IV, the free space between parked and moving aircraft on the taxiway is 7.5 m. The minimum distance between the holding bay and the runway centerline is 75 m.

2) The Calculation of Taxiway Development

a) Taxiway Dimension

For code letter D, aircraft classification IV, the width of the taxiway is 23 m because it will be used for aircraft with wheels of less than 9 m.

b) Taxiway Shoulder

For code letter D, aircraft classification IV, the minimum shoulder width of a taxiway on a straight section is 38 m, with a taxiway width of 23 m, and a shoulder width of 7.5 m.

c) Taxiway Transverse Slope

For code letter D, aircraft classification is IV, for the cross slope is 1.5%.

d) Exit Taxiway (Rapit Exit Taxiway and Exit Taxiway Location)

Referring to the existing condition of Adisutjipto International Airport which has 2 exit taxiways (N1 = 1581 m from runway 09 and 930 m from runway 27 and N2 = 2046 m from runway 09 and 465 m from runway 27).

e) Taxiway Curve

The design speed of the aircraft on the taxiway is 50 km/h, so the radius curve is 150 m.

f) Taxiway Minimum Separation Distance

For code letter D, aircraft classification IV, for instrument runways, the distance from the taxiway to the runway is 176 m. For the taxiway centerline is 66.5 m, for the taxiway centerline on a fixed object is 40.5 m, and for aircraft that are in the middle of a taxiway with a fixed object is 36 m.

g) Taxiway Strips

For code letter D, aircraft classification IV, the minimum distance to the center of the taxiway centerline strip (must be graded area is 19 m), the maximum leveled upward slope is 2.5%, and the maximum leveled downward slope is 5%.

3) The Calculation of Apron Development

a) Numbers of Aircraft Gate

The apron development of the Adisutjipto International Airport requires data such as aircraft movements during peak hours in 2025 which are obtained in the previous calculation, namely 43 movements /hour. The percentage of movements for each category of aircraft obtained from calculations, in which the results are Category B 12.85%, Category C 58.24%, and Category C 28.91%.

Therefore, the number of gates for each aircraft category is 3 for category B, 16 for category C, 8 for category C. The characteristics of the aircraft needed in the planning of the apron are wingspan, wheelbase, and length of the fuselage. The following are the characteristics of each aircraft with their own categories. It can be seen in table 4.

b) Gate Dimensions

The following formula can calculate the radius for each aircraft:

a. ATR 72-600

$$R = ((\text{Wingspan})/2)+(\text{Wheelbase}/\text{tg } 60^0)$$

$R = (27{,}05/2)+(10{,}77/\text{tg } 60^0)$
$R = 19{,}743$ m

b. B735

$$R = ((\text{Wingspan})/2)+(\text{Wheelbase}/\text{tg } 60^0)$$

$R = (28{,}88/2)+(11{,}07/\text{tg } 60^0)$
$R = 20{,}831$ m

c. A320

$$R = ((\text{Wingspan})/2)+(\text{Wheelbase}/\text{tg } 60^0)$$

$R = (34{,}10/2)+(12{,}64/\text{tg } 60^0)$
$R = 24{,}348$ m

Therefore, the dimension of apron is:

3 parking slots of ATR 72-600

$$\text{Apron length} = G \times 2R + (G+1) \times C$$

Apron length = 3 x (2 x 19,743) + (3+1) x 3
Apron length = 130,458 m

$$\text{Apron width} = L + C + W$$

Apron width = 27,05 + 3 + 48,768
Apron width = 78,818 m

For ATR 72-600 parking area is:

$$\text{Area} = \text{Apron Length} \times \text{Apron Width}$$

Area = 130,458 m x 78,818 m = 10282,439 m^2

1. 16 parking slots of B735

$$\text{Apron length} = G \times 2R + (G+1) \times C$$

Apron length = 16 x (2 x 20,831) + (16+1) x 4,5
Apron length = 743,092 m

$$\text{Apron width} = L + C + W$$

Apron width = 28,88 + 4,5 + 88,392
Apron width = 121,772 m

For B735 parking area is:

$$\text{Area} = \text{Apron Length} \times \text{Apron Width}$$

Area = 743,092 m x 121,772 m = 90487,799 m^2

2. 8 parking slots of A320

$$\text{Apron length} = G \times 2R + (G+1) \times C$$

Apron length = 8 x (2 x 24,348) + (8+1) x 4,5
Apron length = 430,068 m

$$\text{Apron width} = L + C + W$$

Apron width = 34,10 + 4,5 + 88,392 = 126,992 m

For A320 parking area is:

$$\text{Area} = \text{Apron Length} \times \text{Apron Width}$$

Area = 430,068 m x 126,992 m = 54615,195 m^2

Therefore, Apron Area = 10282,439 m^2 + 90487,799 m^2 + 54615,195 m^2

= 155.385,433 m^2

4) Marking Runway, Taxiway dan Apron

a) Marking Runway

Marking runway consists of some parts, namely runway designation marking, threshold marking, runway center line marking, aiming point marking, and touchdown zone marking.

b) Marking Taxiway

Marking taxiway consists of some parts, namely taxiway centerline marking, taxiway edge marking, taxiway shoulder marking, intermediate holding position marking, and exit guide line marking.

c) Marking Apron

Marking apron consists of some parts, namely apron safety line marking, apron lead-in and land-out marking, aircraft stop line marking, and aerobridge safety marking.

F. The Calculation of Development on Terminal Area

The area required for the passenger terminal at Adisutjipto International Airport in 2025 is calculated using the SKEP/77/VI/2005 standard. The calculations conducted shown a result that the number of passengers needed in 2025 is 10,964,658 passengers per year.

Furthermore, from the result of the calculation, it is obtained that the required area of the passenger terminal at Adisutjipto International Airport for a capacity of 10,964,958 passengers per year is 195.624 m^2.

G. Planning of Aviation Operational Safety Area (KKOP).

According to the KKOP shown in Figure 4.38, for the lateral surface (transitional surface, inner horizontal surface, conical surface, outer horizontal surface) and approach/landing surface, there are no tall buildings which is not in line with KKOP rules at Adisutjipto International Airport. Therefore, when the development of the airport is started, the requirements of Aviation Operational Safety Area still can be fulfilled.

CONCLUSIONS AND SUGGESTIONS

A. Conclusions

1. The forecasting calculation on Adisutjipto International Airport for aircraft movements in 2025 using linear regression shown that there are 135,937 aircraft/year, and it is formulated to obtain a peak hour composition of 43 aircraft/hour. Meanwhile forecasting the number of passengers in 2025 using linear regression shown that there are 10,964,658 passengers/year.
2. In calculating the planned runway capacity of Adisutjipto International Airport by applying the mathematical calculation of mixed operations shown 15 operations/hour as the results. In which in 2025, Adisutjipto International Airport will have 43 operations/hour in peak hour conditions, which means that in 2025 it is necessary to develop land-air airports, because runway capacity cannot accommodate flight needs and passenger movements in the plan year.
3. Based on the analysis of air facilities in 2025, there will be the largest aircraft operating at Adisutjipto International Airport A320 as the planned aircraft. The design geometry for the air side in 2025 has runway and shoulder dimensions (2500 meters x 60 meters), taxiway + shoulder width dimensions (38 meters) and apron dimensions (155,385.433 m^2). Furthermore, if it is related to the KKOP, it is still fulfilling the requirements for flight operations since there are no buildings with a height that exceeds the KKOP provisions around the area.
4. Based on forecasting calculations for passenger movements in 2025, the terminal area of Adisutjipto International Airport are as follows: the arrival terminal is 72.615,74 m^2 and departure terminal is 123.007,3 m^2.
5. Regarding to the condition of transferring flight operations for jet type aircraft from Adisutjipto International Airport to Yogyakarta International Airport (YIA) which is calculated according to the age of the development plan to be carried out in 2025, it is found that Adisutjipto International Airport does not need airport development. This is because in calculating the planned runway capacity of Adisutjipto International Airport, the results for the mixed operations mathematical calculation are 14 operations/hour. Adisutjipto International Airport will have 13 operations/hour in peak hour conditions in 2025, which means that in 2025 there will be no need for the development of the airport on the air side or the land side, because the runway capacity can still accommodate flight needs and passenger movements.

A. Suggestions

1. One method is still used in forecasting calculation, perhaps it can be linked to several other methods and sought for the most critical results.
2. In the development of Adisutjipto International Airport, an analysis on the dominant wind direction was not conducted, therefore, in the next study, an analysis can be carried out regarding wind direction before planning airside facilities.
3. It is necessary to re-calculate the analysis of Adisutjipto International Airport after the transfer of flights to Yogyakarta International Airport using the latest and more accurate data.

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