

# Disaster mitigation in the aviation field through careful parking area planning

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**Abstract.** Aviation safety which is also related to security is closely dependent on the pavement at the airport, on the runway, taxiway and in the apron area. In 2017 some damage to the pavement of the runway at Halim Perdana Kusuma airport was a concern to national flight safety. To avoid similar incidents, care is needed in pavement designs in critical areas of the airport, including in the aircraft parking area. This study describes an analysis of the pavement layer used in an aircraft parking area. The pavement layer used was analysed for time of construction and in operation. The surface layer was rigid pavement. The parameters used in the analysis are taken from globally accepted requirements for airports. The study was conducted by analyzing the ability of the pavement system to withstand the aircraft load including while maneuvering and stopping. The results of the study will inform efforts to improve the safety of the aviation industry from the aspect of apron design.

## 1 Introduction

An airport is an essential supporting facility for air transportation that functions as a meeting place for aircraft, passengers, cargo or goods (Permenhub 69, 2013) [1]. An airport requires good planning for all necessary facilities both land-side and air-side. Air-side facilities include runways, connecting platforms, and aircraft parking spaces that must meet standards, both in terms of strength and dimensions. Likewise, the airport pavement structure is an important part of the infrastructure in the operation of an airport (Dwinanta Utama, 2013) [2].

Pavement spreads the load of the aircraft on to the subgrade. The lower the ability of the subgrade to bear the load, the thicker the required pavement layer because the overall pavement structure must be fully supported by the subgrade, hence the identification and evaluation of subgrade structure are very important for determining pavement thickness (Basuki, 1986) [3]

Increased traffic and frequency of flight affect the durability of the airside pavement layer. With the growth of passenger numbers and the regeneration of the aircraft fleet with heavier aircraft, the burden on the pavement becomes greater but is not offset by an increase in the carrying capacity of that pavement.

Pavement failure events can sometimes be related to increased aircraft weight and flight frequency. At Ahmad Yani Airport, Semarang, damage to the apron was caused by large body aircraft with higher loads which

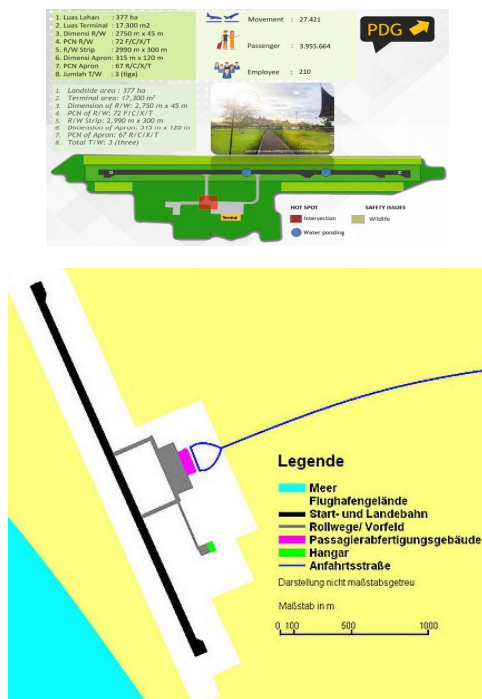
were not offset by an increase in the carrying capacity of the apron. Damage to a runway at Halim Perdana Kusuma Airport occurred after a large number of newly introduced Boeing 777 planes took off.

Minangkabau International Airport (BIM) which currently can accommodate 2.7 million passengers, aims to be ready to accommodate 5.7 million passengers per year by 2019. The expansion is being carried out by expanding the existing terminal building to a modern and integrated facility with a passenger capacity of 5.7 million people, construction and development of extensions to the runway and taxiways and expansion of the apron pavement to 80,520 m<sup>2</sup> to accommodate 16 large-bodied aircraft. Planning for this expansion requires both determinations of required dimensions and knowledge of the pavement strength requirements.

This present study analyzed the ability of a pavement system built on the subsoil present at Minangkabau International Airport to withstand the load of an aircraft while maneuvering and stopping. This was to provide knowledge about the required structure of the airside pavement which will be subject to direct and constant loads every day so helping to improve flight security. These results are then compared with the pavement being constructed at this site. The discussion is limited to this location and the parameters used in the analysis were taken from generally accepted requirements.

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## 2 Location



**Fig. 1.** Airport Specifications and facilities  
 Air side Facility : Runway (2750 M x 45 M/PCN 83 F/C/X/T),  
 Taxiway 3 Way ( A, B, dan C ) /PCN 83 F/C/X/T, Apron  
 (37.800 M2 / 7 Parking Stand (B737 Classic)

## 3 Literature review

A flat airside surface both protects an aircraft and increases passenger comfort, so each layer of the pavement must be hard and thick enough to withstand the load without experiencing distress which will distort the surface (Basuki (1986)[1].

In 2016 Brian et al. conducted a study analysing the planning of the runway, taxiway, and apron pavement structure of Sultan Syarif Kasim Airport II using the FAA method. This research showed there were differences between the existing structure and the theoretical analysis based on the FAA method. (1) For the runway; original underestimate of annual aircraft movements, aircraft growth rates and projected annual aircraft movement, differences in the CBR charts used to determine each pavement thickness and selection of the type of stabilized material. (2) For the taxiway; differences in the calculation results for the runway make a difference to the planning of the taxiway because the planned taxiway pavement thickness needed to be 0.9 of the to be aligned with the thickness determined for the runway. (3) For the parking apron; differences could be caused by different determinations of the subgrade modulus, the flexural strength of the concrete, forecast of the annual departure frequency of each aircraft type and the calculation of pavement thickness, dowel size, and width.

Tribowo et al (2015)[5] conducted a comparison of carrying capacity calculations using FAA, PCA and

LCN rigid pavement planning methods on the apron of Juanda Airport. The study showed that the design thicknesses for the rigid pavement were 44 cm for FAA, 33.5 cm for PCA and 32.5 cm for LCN. The thickness of the pavement produced by these three methods was different from the real conditions at Juanda Airport which is currently 45 cm. The results of these design methods along with data on aircraft movements in 2022 and 2026 indicate that the 45 cm thickness of the existing rigid pavement should still withstand aircraft traffic loads until 2026.

Huzeirien and Dahlan (2017)[6] conducted an analysis of rigid pavement planning at the Sultan Thaha Syaifuddin Airport's apron in Jambi. They compared the thickness of the apron pavement with that obtained using manual calculations the FAA method using curves. Pavement thickness obtained from manual calculation was 16.90 inches = 429.3 mm which was considered to be conservative because the calculated pavement carrying capacity => 400,000 lbs was greater than the carrying capacity of the heaviest aircraft using the area, Boeing 767-300 = 361,000 lbs.

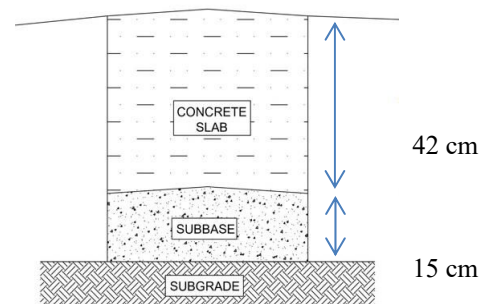
## 4 Method

The unit collecting data from various sources, starting from conducting direct reviews to Minangkabau International Airport, air transport data from local agencies, and official websites from the relevant institutions. The type of data needed in this thesis is as follows.

- a) The primary data was obtained from interviewing the contractor of the Minangkabau International Airport Apron Expansion and Turning Pad Development Project (PT. Nindya Karya). as the contractor of the Apron Expansion Development Project and Turning Pad of the Minangkabau International Airport. the data include :

**Table 1.** Project Data

Spesification	CBR
Subgrade	18%
Subbase	95%
Concret Slab	100%



**Fig. 2** Existing implementation project

- b) Secondary data included aircraft and passenger movements obtained from Minangkabau International Airport. Airplane movement data used were aircraft movements during 2017-2018 for scheduled flights.
- c) Pavement requirements for the apron were obtained from FAA (Federal Aviation Administration) Advisor Circular No. method. 150 / 5320-6D .

## 5 Result and Discussion

The pavement is a structure consisting of several layers with different hardness and carrying capacity. Pavement functions as the average foothold of the plane, a flat surface will produce a comfortable airplane path, so it must be guaranteed that each layer from top to bottom is hard enough and its thickness so that it does not experience distress (changes in layers because it is unable to withstand the load) According to Basuki (2008) [4]

The FAA method steps for rigid pavement planning were used:

### 1. Determine subgrade modulus

The AASHTO T222-86 method tests the foundation material that will support the pavement (Basuki, 2008) [4]. If the k value in the plan cannot be determined directly, then the k value can be estimated from the CBR value, but this estimate must be tested again in the field (Siswosubroto, 2006) [7]. In this present study, the k value was estimated from the CBR value. The value of the subgrade modulus was obtained from the CBR soil characteristics table. For Minangkabau International Airport apron the subgrade modulus (k) was found to be 100 pci.

**Tabel 2.** Soil classification based on CBR

CBR	General Rating	Uses	Unified	AASHTO
0 - 3	Very poor	Subgrade	OH, CH, MH, OL	A5, A6, A7
4 - 7	Poor to fair	Subgrade	OH, CH, MH, OL	A4, A5, A6, A7
7-20	Fair	Subbase	OL, CL, ML, SC, SM, SP	A2, A4, A6, A7
20-50	Good	Base, Subbase	GM, GC, SW, SM, SP, GL	A1b, A2-5, A3, A2-6
50	Excellent	Base, Subbase	GW, GM	A1a, A2-4, A3

Source: Braja M. Das, Mekanika Tanah Volume 1

### 2. Determine the flexural strength of concrete

Flexural strength values were obtained based on the relationship between flexural strength and compressive strength commonly used in pavement designs, in accordance with equation 1. The compressive strength of concrete was assumed to be 400 kg / cm<sup>2</sup> (K 400 ). This compressive strength value is for age 28 days while the FAA recommends

the value for 90 days be used. According to (Basuki, 2008) if 90-day flexural strength values are not available 110% x 28-day values should be used. concrete test results to determine the thickness of the rigid pavement plan.

$$MR = k\sqrt{f'c'} \quad (1)$$

$$= 0,7\sqrt{11 \times 33,2} \quad (2)$$

$$= 4,32 \text{ Mpa} \quad (3)$$

flexural strength is 4.23 Mpa = 613.54 psi.

### 3. Determine the MTOW of each type of aircraft served

The type of aircraft used Based on the aircraft operating the B 737-900ER aircraft is determined as a plan aircraft because it has the largest MTOW of 379,999.78 lbs.

**Tabel 3.** Recapitulation of Annual Departure Calculation of each type of aircraft served.

Tipe Pesawat	Kelas Pesawat	Konfigurasi Sumbu	MTOW (Kg)	Annual Departure
B737-900ER	4D	DWG	85139	14000
B737-800	4D	DWG	79016	18693
A320	4D	DWG	73500	1846
RENCANA				
B767-300	4D	Dual Tandem Wheel	172365	16146,86

### 4. Determine the annual departure forecast for each type of aircraft served

Next is the conversion of each aircraft landing gear type served to the aircraft plane wheel type (R2) with the following equation :

R2 is Annual Departure x Conversion factor

Conversion factor for conversion DWG wheel type to Dual Tandem Wheel is 0,6 :

Aircraft B737-900ER

$$R2 = 14,000 \times 0.6 = 8,400 \quad (4)$$

Aircraft B737-800

$$R2 = 18,693 \times 0.6 = 11,216 \quad (5)$$

Aircraft A320

$$R2 = 1,846 \times 0.6 = 1,108 \quad (6)$$

After converting the wheel type, the next step is to calculate the load of one wheel on the main gear assuming that the main gear is carrying 95% of the weight of the aircraft.

$$W2 = \text{MTOW} \times 0.95 \times 1/n \quad (7)$$

Therefore, W2 values for each type of aircraft served are as follows:

Aircraft B737-900ER

$$W2 = 85,139 \times 0.95 \times 1/4 = 20,200.51 \text{ n} \quad (8)$$

Aircraft B737-800

$$W2 = 79,016 \times 0.95 \times 1/4 = 18,766.30 \text{ n} \quad (9)$$

Aircraft A320

$$W2 = 73,500 \times 0.95 \times 1/4 = 17,456.25 \text{ n} \quad (10)$$

In addition to the three types of aircraft, the wheel load value (W1) of the planned aircraft must also be calculated B767-300: B767-300:

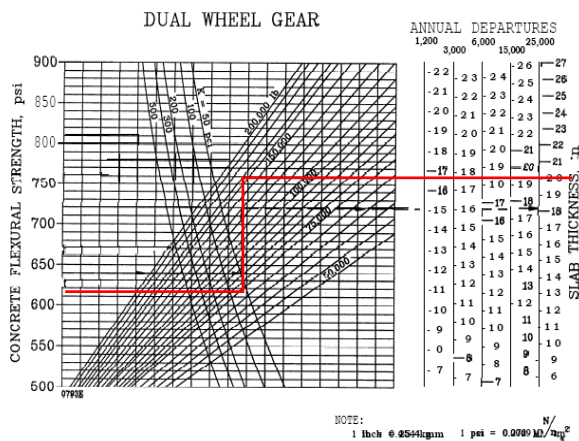
$$W1 = 172,365 \times 0.95 \times 1/8 = 20,468.34 \text{ n} \quad (11)$$

Then the Equivalent annual departure (R1) is calculated for the planes of the annual conversion of each aircraft type :

$$\Sigma R1 = 7,951.39 + 7,547.48 + 647.98 = 16,146.86$$

- Determine the thickness of the concrete slab

The thickness of the concrete layer was obtained by plotting the concrete flexural strength of 613.54 psi and a line drawn horizontally to meet the K value of 100 pci then a line is drawn vertically up to meet the MTOW value of the plane in question and then a line is drawn horizontally again to the annual departure rate of 16,146.86



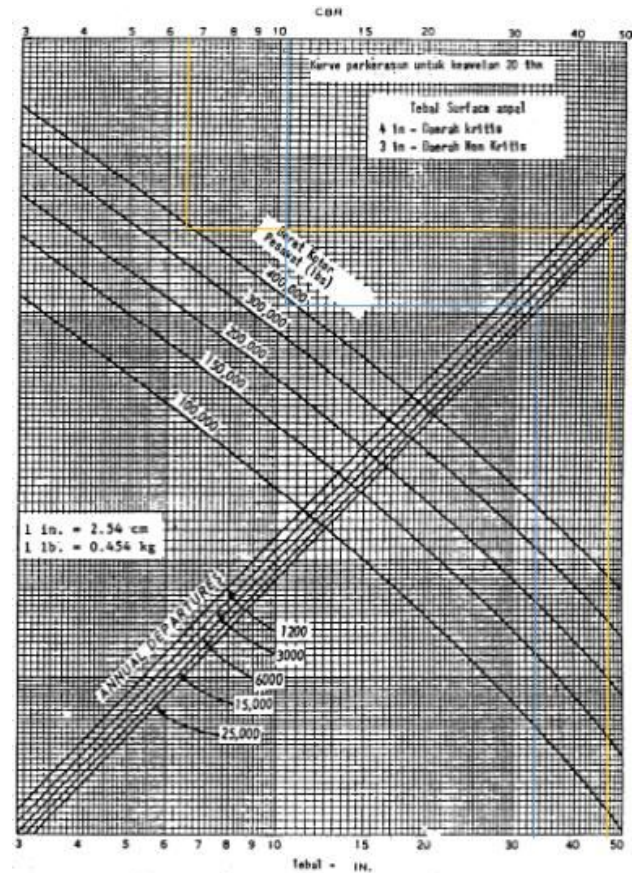
**Fig. 3** A rigid pavement graph of the FAA method for aircraft types

Source: FAA AC No.150/5320-6D,(1995)

Using this FAA rigid pavement method for the types of aircraft serving Minangkabau Airport resulted in a minimum thickness for the concrete slab of 20 inches ( 48cm) compared to the existing thickness of 42cm.

## 6 Conclusions

Based on the analysis and discussion using the graph below:



**Fig. 4** Pavement Thickness Planning Chart

We can conclude that :

No	Pavement	Hasil			
		Eksisting		Analisis	
		inch	cm	inch	cm
1	Concrete Slab	17	42	20	50,8
2	CTBC	5,91	15	5,91	15
3	Subgrade	7,87	20	20	50,8
4	Muru Beton	K400		K400	

Based on the calculation results described in the previous chapter, the following conclusions can be obtained:

- The results for pavement thickness using the FAA method were compared with the values used in the construction plan.
- The value obtained suggests the planned apron thickness is unsafe because the carrying capacity of the pavement will be greater than the predicted load of the aircraft
- As the carrying capacity of the pavement appears to be smaller than the load of the predicted aircraft traffic then the bearing capacity the rigid pavement will need to be increased.

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