PLANNING FOR THE EXPANSION OF THE APRON AT LEDE KALUMBANG AIRPORT TAMBOLAKA EAST NUSA TENGGARA

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ABSTRACT
This research examines the apron expansion planning at Lede Kalumbang Tambolaka Airport, East Nusa Tenggara, which is crucial given the current limited airport facilities, particularly the apron and runway capacity, leading to operational constraints and flight delays, and an inability to accommodate larger aircraft like the Airbus 320. Therefore, the apron expansion from 268 x 95 m² to 268 x 108 m² and the addition of one parking stand are urgently needed to increase capacity, meet safety standards, and support regional and tourism development. The main objectives of this study are to design the flexible pavement structure thickness for the apron for the critical A320 aircraft using FAARFIELD software, calculate the Pavement Classification Number (PCN) using the COMFAA application, and determine the estimated budget (RAB) required. The methodology involves problem identification, data collection, subgrade strength analysis, apron dimension calculation, pavement thickness calculation, and PCN determination with the aid of advanced software such as FAARFIELD and COMFAA. The results of this research are expected to provide an optimal apron pavement thickness design, an accurate PCN value, and a comprehensive cost estimation. The contributions of this final project include increased knowledge in using FAARFIELD and COMFAA applications, the final result of the RAB is based on the HSPK Analysis of Southwest Sumba, East Nusa Tenggara and PM 78 of 2014. The total RAB for the expansion was Rp1.654.100.000,00 *(One Billion Six Hundred Fifty Four Million One Hundred Thousand Rupiah).*

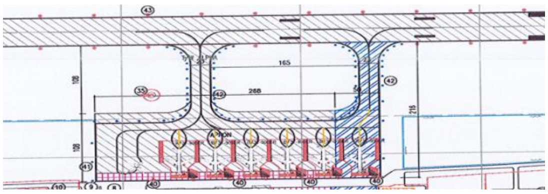
Keywords: *Apron Planning, Flexible Pavement, FAARFIELD, COMFAA, PCN, RAB, Lede Kalumbang Tambolaka Airport*

1. PENDAHULUAN

Aviation infrastructure plays a strategic role in the regional connectivity of Southwest Sumba Regency, East Nusa Tenggara. Lede Kalumbang Tambolaka Airport serves as the main gateway connecting this area with the national economic center, facilitating the mobility of the population as well as the distribution of goods and services for tourism and regional economic development in Sumba Island.

The existing condition of the infrastructure faces significant capacity challenges at the apron facilities. Flight operations involve NAM Air with Boeing 737-500 and WINGS Air using ATR72-600. The limited parking space for aircraft results in operational bottlenecks during peak hours, leading to delays and inefficiencies in the airport system.

The airport development master plan (KM 156 TH 2022_RIB BU TAMBOLAKA.Pdf, n.d.) identifies the need to expand the apron from the existing dimensions of 268 x 95 m² to 268 x 108 m² with the addition of one parking stand. The existing layout and the expansion plan are shown in Figure 1.1, with the expansion area shaded in blue, while the projections for increased traffic movement are recorded in Table 1.1.



Gambar 1.1 Masterplan Bandara Lede Kalumbang Tambolaka (Sumber: Bandara Lede Kalumbang Tambolaka)

NO	ITEM	EKSISTING (2019)	TAHAPAN			KETERANGAN
			TAHAP I	TAHAP II	TAHAP III	
1	**PENUMPANG (Per Tahun)**					
	- Internasional	-	-	-	-	Penumpang
	- Domestik	227.493	302.469	364.097	487.354	Penumpang
	-Total	**227.493**	**302.469**	**364.097**	**487.354**	Penumpang
2	**PERGERAKAN PESAWAT (Per Tahun)**					
	- Internasional	-	-	-	-	Pergerakan
	- Domestik	3.674	4.364	4.939	6.089	Pergerakan
	-Total	**3.674**	**4.364**	**4.939**	**6.089**	Pergerakan
3	**PENUMPANG (Harian)**					
	- Internasional	-	-	-	-	Penumpang
	- Domestik	870	1.157	1.392	1.864	Penumpang
	-Total	**870**	**1.157**	**1.392**	**1.864**	Penumpang
4	**PERGERAKAN PESAWAT (Harian)**					
	- Internasional	-	-	-	-	Pergerakan
	- Domestik	12	16	18	20	Pergerakan
	-Total	**12**	**16**	**18**	**20**	Pergerakan

Tabel 1.1 Jumlah Pergerakan Pesawat Bandara Lede Kalumbang Tambolaka (Sumber: Bandara Lede Kalumbang Tambolaka)

The expansion is designed to accommodate larger capacity aircraft such as the Airbus A320 with the implementation of national and international aviation safety standards. Based on this urgency, the research is formulated under the title 'PLANNING OF APRON EXPANSION AT LEDE KALUMBANG TAMBOLAKA AIRPORT, EAST NUSA TENGGARA'.

The research focuses on the planning of the thickness of the apron pavement structure using FAARFIELD software with flexible pavement for the critical aircraft A320, the calculation of the PCN value through COMFAA software, as well as the budget estimation for the implementation of apron expansion.

The scope of the research is limited to the planning of apron expansion without discussing airside markings and the methodology for construction implementation.

The research aims to plan the thickness of the flexible pavement structure for the critical aircraft A320, calculate the Pavement Classification Number (PCN) using COMFAA, and determine the comprehensive budget estimation for the expansion.

The research contributes to the enhancement of software pavement design application competencies for researchers, strategic technical input for airport operators, enrichment of the knowledge base for educational institutions, and serves as a foundational reference for further researchers in the development of aviation infrastructure.

2. LANDASAN TEORI

2.1 Pengertian Bandar Udara

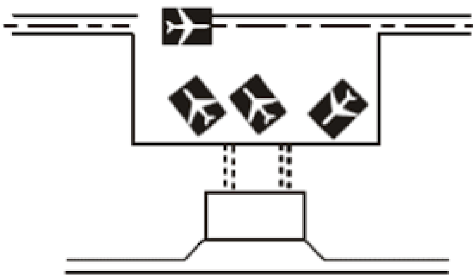
Airports are complex flight infrastructures that integrate various operational systems. According to [2] in Volume 1 Aerodrome Design and Operation, an airport is defined as a specific area on land or water that includes buildings, installations, and equipment to serve the arrival, departure, and movement of aircraft. This definition is adopted in national regulations through the Directorate General of Air Transportation in CASR Part 139, which emphasizes airports as areas with facilities supporting the operational processes of aircraft.

2.2 Apron

The apron is a critical component that connects the terminal and the aircraft movement area. [2] defines the apron as an area to facilitate the boarding and disembarking of passengers, cargo, refueling, parking, and maintenance of aircraft. [3] reinforces this concept by emphasizing the apron's function in supporting activities without disrupting airport traffic.

2.2.1 Konsep Apron

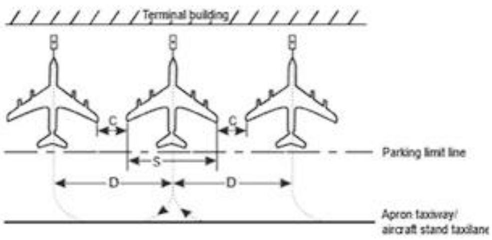
[4] identifies six apron concepts: Simple Concept for low traffic with angled configuration, Linear Concept with efficient nose-in layout, Pier/Finger Concept with Y and T pier variants, Satellite Concept with units separated from the terminal, Transporter Concept that is flexible but requires special vehicles, and Hybrid Concept that combines various concepts.



Gambar 2.1 Simple Concept (Sumber: Aerodrome Design Manual Part 2 Taxiway, Apron and Holding bay)

2.2.2 Konfigurasi Pesawat Udara

The International Civil Aviation Organization (1987) identified four standard configurations: Angle Nose-in (45° to the terminal, self-maneuvering), Nose-in (perpendicular to the terminal, efficient but requires towing), Angle Nose-out (facing away from the terminal at 45°), and Parallel (parallel to the terminal, reducing noise). Each configuration has different implications for operational efficiency and space requirements.



Gambar 2.2 Nose-in (Sumber: ICAO)

2.2.3 Dimensi dan Wing Tip Clearance

According to SKEP 77 of 2005, the dimensions of the apron vary according to the aircraft category. The wing tip clearance, according to [4], varies from 3.0 meters for code letters A-B to 7.5 meters for code letters D-F, ensuring safe operations between aircraft.

Tabel 2.1 Dimensi Apron

Uraian	**Penggolongan Pesawat**				
	I	II	III	IV	V
Self taxing (45°)					
Panjang (m)	40	40	70	70-80	70-80
Lebar (m)	25	25	55	55-80	55-80
Nose in					
Panjang (m)	-	-	95	190	190
Lebar (m)	-	-	45	70	70

2.3 Software FAARFIELD

FAARFIELD is software for airport pavement design following the standards [4] FAA AC 150/5320-6F. This software calculates the thickness of multi-layer pavements based on the CBR value of the subgrade, where a higher CBR results in thinner pavement.

Gambar 2.3 Software FAARFIELD (Sumber: FAA-AC No: 150/5320-6F)

2.4 Aircraft Classification Number (ACN) dan Pavement Classification Number (PCN)

ACN indicates the relative impact of the aircraft on the pavement based on standard subgrade, while PCN indicates the load-bearing capacity of the pavement with the principle that ACN ≤ PCN. ICAO (2022) classifies pavements into Rigid (R) and Flexible (F), with subgrade load-bearing capacity ranging from High (>13% CBR) to Very Low (<4% CBR).

2.5 Penelitian Terdahulu

Relevant research provides methodological references for the development of this research, including planning and evaluation of airport infrastructure.

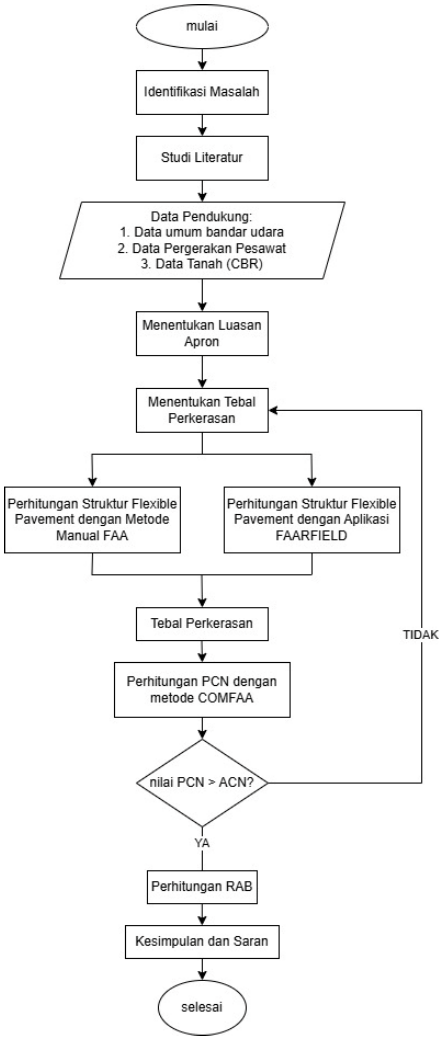
Tabel 2.2 Penelitian Yang Relevan

No	**Judul**	**Metodologi**	**Hasil**
1.	Perencanaan Apron Bandar Udara Depati Parbo Kerinci (Maulan, 2020) [5] Perencanaan Apron di Bandar Udara Depati Parbo Kerinci	Peramalan regresi linier, dimensi apron, perkerasan rigid FAA, PCN dengan COMFAA	PCN 16,30 untuk ATR 72-600, ACN 13,10. PCN > ACN memenuhi persyaratan
2.	Evaluasi Kebutuhan Luas Apron Ahmad Yani (Nursalim, 2017) [6]	Peramalan lalu lintas, dimensi apron, perkerasan FAARFIELD	Peramalan hingga 2025, rencana dimensi apron

3.	Analisa Perkerasan Kaku Apron Halueleo Kendari (Wunantari et al., 2019) [6]	Peramala n lalu lintas, perkerasan PCA dan FAA	Peramala n hingga 2035, rencana tebal perkerasan
4.	Perluasan Apron Tebelian Sintang (Akhir et al., 2022) [2]	Data bandar udara, pergerakan pesawat, tipe pesawat	PCN 16,30 untuk ATR 72-600, memenuhi persyaratan kekuatan
5.	Kapasitas Fasilitas Apron Yogyakarta (Setiawan, 2019) [1]	Perluasa n apron FAA, optimalisasi Gate Occupancy	Rencana dimensi apron, optimalisasi waktu

3. METODE PENELITIAN

This research method is systematically designed to analyze the need for apron expansion at Lede Kalumbang Airport. The research stages begin with problem identification, namely the limitation of the existing apron area of 268 x 95 m², which can only accommodate the ATR 72-600 aircraft and several smaller aircraft. This condition is inadequate to accommodate main aircraft types such as the A320-200 and B737-500, which are the operational targets of the airport in the future. Therefore, the planning for apron expansion is carried out by considering applicable technical standards and regulations. The research planning flow is shown in Figure 3.1.



Gambar 3.1 Alur Perencanaan

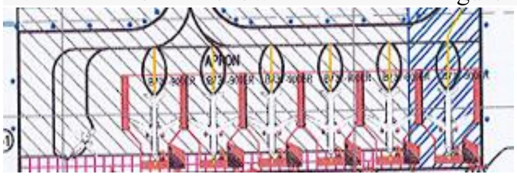
Data collection is carried out through three main approaches, namely data from the UPBU Lede Kalumbang, field observations, and literature studies. Technical data includes the strength of the subsoil, aircraft movement traffic, number of passengers, and aircraft operational plans. Observations were obtained while the author conducted fieldwork practice from October 2, 2024, to February 28, 2025. Meanwhile, literature is used to strengthen the theoretical basis by referring to relevant scientific sources and regulations [6].

The next stage is technical analysis, which includes calculating the dimensions of the apron based on the Manual of Standard CASR Part 139 (PM 21 of 2023) while considering the characteristics of the heaviest and most critical aircraft. Data related to the reference aircraft can be found in Table 3.2 [7].

Tabel 3.2 Data Pesawat Terkritis dan Pesawat Rencana

No	Aircraft Type	Wingspan (m)	Length (m)	MTOW (kg)
1	Airbus A320	34,1	37,6	72.000
2	Boeing 737-500	28,9	31	60.560

Next, the calculation of pavement thickness was carried out using two methods, namely manual FAA and FAARFIELD application, the results of which were analyzed through the COMFAA program to obtain the Pavement Classification Number (PCN). If the PCN results meet the requirements, then the design can be implemented. From the design results, the apron is expected to accommodate five ATR 72-600s and one A320 as shown in Figure 3.2.



Gambar 3.2 Apron yang diinginkan (Sumber: Masterplan Bandara Lede Kalumbang Tambolaka)

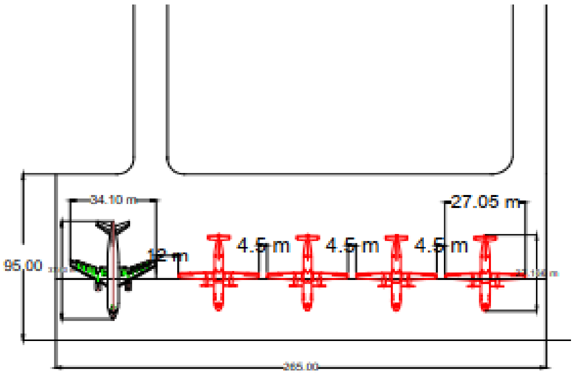
After that, the preparation of the Cost Budget Plan (RAB) was carried out based on the HSPK of Southwest Sumba Regency for the year 2024 and the cost standards of the Ministry of Transportation (PM 78 of 2014). All stages of the research were conducted at Lede Kalumbang Airport according to the schedule listed in Table 3.3.

Tabel 3.3 Waktu Penelitian (Sumber: Olahan Penulis, 2025)

No	Tahap Kegiatan	Periode (2024-2025)
1	Pengamatan Lapangan	Okt 2024 - Feb 2025
2	Studi Literatur	Okt 2024 - Des 2024
3	Pengumpulan Data	Nov 2024 - Jan 2025
4	Perhitungan Luasan Apron & Tebal Perkerasan	Jan 2025 - Mar 2025
5	Perhitungan PCN & RAB	Mar 2025 - Mei 2025
6	Penyusunan Laporan TA	Jun 2025 - Jul 2025

4. HASIL DAN PEMBAHASAN

4.1 Perhitungan Dimensi Apron



Gambar 4.1 Perhitungan Perluasan Apron (Sumber: Olahan Penulis, 2025)

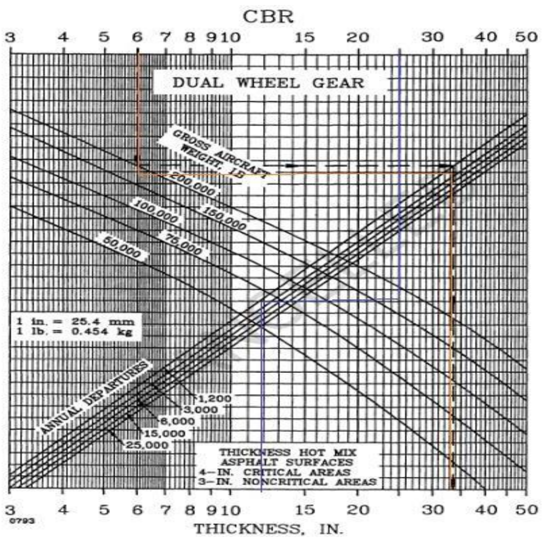
Based on the projected needs until 2035, the apron is planned to accommodate five parking stands with the critical aircraft Airbus A320-200 as a reference. The technical data of the aircraft displayed in Table 4.1 [8] shows that the Airbus A320-200 has a wingspan of 34.10 m and a fuselage length of 37.60 m. Referring to the aircraft parking configuration both in self-taxiing and nose-in conditions, the calculated dimensions of the apron are 95 m in length and 265 m in width, with a total area of 25,175 m². This area ensures that the apron can accommodate aircraft movements according to the peak traffic capacity during the planning period.

Tabel 4. 1 Karakteristik Pesawat Airbus A320-200 (Sumber : KP 39 Tahun 2015)

Penjelasan	Kategori Pesawat udara					
	A	B	C	D	E	F
Dimensi Apron (untuk 1 pesawat)						
a. *Self taxiing* (45° taxiing)						
Panjang (m)	40	40	70	70-85	70	85
Lebar (m)	25	25	55	55-80	55-80	55-80
b. *Nose in*						
Panjang (m)	-	-	95	190	190	190
Lebar (m)	-	-	45	70	70	70

Gambar 4.2 Perhitungan Perluasan Apron (Sumber: Olahan Penulis, 2025)

4.2 Ketebalan Perkerasan dengan FAA Manual



Gambar 4.3 Plotting Grafik Tebal Perkerasan Lentur untuk Dual Wheel (Sumber: KP 94 Tahun 2015)

Thickness analysis of the pavement is crucial because it directly relates to operational safety. Technical data of two main aircraft, the Airbus A320-200 and Boeing 737-500, is presented in Table 4.2. From the wheel load calculations, the Airbus A320-200 has the largest wheel load of 18,287.5 kg, thus it is designated as the critical aircraft. Furthermore, through the calculation of equivalent annual departures (Table 4.3), a total of 1,488.8 equivalent departures is obtained. This value is used to plot the pavement thickness graph according to FAA standards (Figure 4.3).

Tabel 4.2 Data Pesawat Rencana

Tipe Pesawat	Annual Departure	MTOW (Kg)	Landing Gear
Airbus A320-200	4.364	77.000	Dual Wheel
Boeing 737-500	3.674	60.560	Dual Wheel

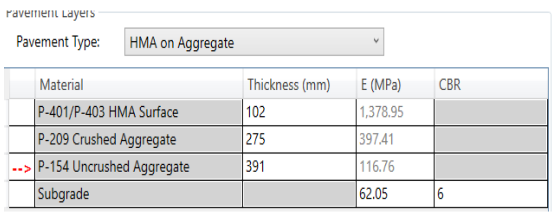
Tabel 4.3 Perhitungan Equivalent Annual Departure R1

Jenis Pesawat	MTOW (kg)	Annual Departure	Wheel Load (kg)	Equivalent Annual Departure
Airbus A320-200	73.500	1.374	17.456,25	1.374
ATR 72-600	22.800	5.000	5.415	114,8

Tabel 4.4 Hasil Tebal Perkerasan dengan Metode FAA Manual

Lapisan Perkerasan	Tebal Rencana (cm)
Surface Course	10,16
Base Course	20,32
Subbase Course	53,32
Total.	83.8

4.3 Perhitungan Tebal Perkerasan FAARFIELD



Gambar 4.4 Hasil Run Evaluasi Tebal Perkerasan FAARFIELD (Sumber: Olahan Penulis, 2025)

To validate the manual results, an analysis was conducted using the FAARFIELD software in accordance with FAA AC 150/5320-6F guidelines. The inputs used include aircraft design data (Airbus A320-200 and ATR 72-600), a subgrade CBR value of 6%, as well as annual departure data. The evaluation results indicate a total pavement thickness of 76.8 cm, consisting of a surface layer of 10.2 cm, base course of 27.5 cm, and subbase course of 39.1 cm (Table 4.6). When compared to the manual method, there is a slight difference in layer thickness, where FAARFIELD produces a thinner total thickness (Table 4.7). This indicates that software-based calculations can optimize material needs without compromising safety aspects.

Tabel 4.5 Hasil Tebal Perkerasan Flexible Dengan Program FAARFIELD

Layer	Tebal (mm)	Tebal (cm)
Surface Course (P-401/P-403 HMA)	102	10,2
Base Course (P-209 Crushed Aggregate)	275	27,5
Subbase Course (P-154 Uncrushed Aggregate)	391	39,1
Subgrade	CBR (6%)	CBR (6%)

Tabel 4.6 Perbandingan Hasil FAA Manual dan FAARFIELD

Data Perkerasan	FAA Manual	FAARFIELD
Surface	10,16	10,2
Base Course	20,32	27,5
CBRSubgrade	6%	6%
Subbase	53,32	39,1
Tebal Total	83,8	76,8

4.4 Penentuan Nilai PCN dengan COMFAA

The next step is to determine the Pavement Classification Number (PCN) using the COMFAA program. This analysis takes into account the Cumulative Damage Factor (CDF) to assess the pavement's ability to withstand mixed aircraft traffic. Input data includes MTOW, annual departure numbers, and a CBR value of 6%. The calculation results show that the apron PCN is 56.3 (Figure 4.14). This value is greater than the Aircraft Classification Number (ACN) of the planned aircraft which is 44.4, thus it can be concluded that the apron is capable of supporting Airbus A320-200 operations without load restrictions.

4.5 Rencana Anggaran Biaya (RAB)

REKAPITULASI RAB PERLUASAN APRON						
NO	**URAIAN PEKERJAAN**	**SATUAN**	**VOLUME**	**HARGA SATUAN**		**JUMLAH HARGA**
A. PEKERJAAN PERSIAPAN						
1	Pekerjaan Pengukuran (m2)	M2	3484	Rp 5.267,98	Rp	18.353.642,32
2	Pekerjaan Pembersihan (m2)	M2	3484	Rp 715,00	Rp	2.491.060,00
B. PEKERJAAN PERLUASAN APRON						
1	Pekerjaan Subbase Tebal 39,1 cm	M3	1362,244	Rp 357.457,06	Rp	486.943.739,33
2	Pekerjaan Base Course Tebal 27,5 cm	M3	958,1	Rp 458.663,75	Rp	439.445.743,47
3	Pekerjaan Prime Coat AC 60/70 2.5 kg/m2	M2	3484	Rp 39.764,46	Rp	138.539.378,64
4	Pekerjaan Asphalt Treated Base (ATB) Tebal 7,5 cm	M2	261,3	Rp 228.363,02	Rp	59.671.257,54
5	Pekerjaan Tack Coat AC 60/70 1,5 Kg/m2	M2	3484	Rp 24.883,96	Rp	86.695.716,64
6	Pekerjaan Asphalt Treated Base (ATB) Tebal 5 cm	M2	174,2	Rp 152.387,88	Rp	26.545.968,85
7	Pekerjaan Tack Coat AC 60/70 1,5 Kg/m2	M2	3484	Rp 24.883,96	Rp	86.695.716,64
8	Pekerjaan Asphalt Concrete (AC) Tebal 5 cm	M2	174,2	Rp 166.554,09	Rp	29.013.722,70
9	Pekerjaan Tack Coat AC 60/70 1,5 Kg/m2	M2	3484	Rp 24.883,96	Rp	86.695.716,64
10	Pekerjaan Asphalt Concrete (AC) Tebal 5 cm	M2	174,2	Rp 166.554,09	Rp	29.013.722,70
				JUMLAH	Rp	1.490.105.385,49
				PPN 11%	Rp	163.911.592,40
				TOTAL	Rp	1.654.016.977,89
				DIBULATKAN	Rp	1.654.100.000,00
Terbilang : *Satu Milyar Enam Ratus Lima Puluh Empat Juta Seratus Ribu Rupiah*						

Gambar 4.5 Rencana Anggaran Biaya (Sumber: Olahan Penulis)

The final stage of the analysis is the preparation of the Detailed Cost Estimates (RAB) based on the pavement volume calculated through FAARFIELD. Referring to the Unit Price Analysis of Southwest Sumba Regency in 2024 and the PM 78 Year 2014 standards, an estimated cost of Rp 1,654,100,000.00 (Figure 4.17) is obtained. This value includes the apron expansion work with structural specifications according to the design results. This estimate is important to provide a realistic and measurable overview of investment needs in airport development planning.

In addition to the calculation results that have been presented, there are several important aspects that need to be discussed in more depth. The selection of the Airbus A320-200 as a critical aircraft is based not only on its higher MTOW value compared to the B737-500 but also on the development of domestic air traffic trends in Indonesia. The Airbus A320 is one of the aircraft types that are widely operated by national airlines, so its presence has long-term implications for airport infrastructure planning. By using the A320 as a reference, the resulting apron design is more adaptive to future air traffic growth.

The comparison of results between the FAA manual method and the FAARFIELD software also provides interesting insights. The FAA Manual yields a total pavement thickness of 83.8 cm, while FAARFIELD produces 76.8 cm. This difference of about 7 cm essentially reflects FAARFIELD's advantage in optimizing construction material needs. However, the slightly thinner thickness must still be reviewed carefully to avoid the risk of reducing the pavement's lifespan.

Therefore, the final decision often takes into account operational safety factors, budget availability, and material usage efficiency.

The PCN value of 56.3 obtained from COMFAA analysis indicates that the apron has adequate capacity to support the operation of aircraft with lower ACN, including the Airbus A320 with an ACN value of 44.4. This difference indicates a significant safety margin. The implication is that the apron pavement is not only able to withstand the current load but can also accommodate traffic growth over the planned period. Furthermore, the higher PCN value compared to ACN reduces the risk of operational restrictions such as takeoff weight reduction which could be detrimental to airlines.

From an economic standpoint, the estimated cost of building the apron at Rp 1.65 billion has significant importance in the planning of regional airports. This cost is not just a nominal figure, but reflects the investment needs that must be allocated by both local and central governments to support connectivity between regions. This investment is expected to have a positive economic impact, such as an increase in tourist flows and smooth logistics distribution. Thus, the results of the technical analysis combined with the cost estimation provide a strong foundation for policymakers to realize this project.

From the results of this research discussion, it is evident that the choice of the Airbus A320-200 as a critical aircraft yields apron designs with an area of 25,175 m². The comparison of manual methods and FAARFIELD shows consistent results, although there are variations in layer thickness. The higher PCN values compared to ACN affirm that this apron design is safe for long-term operations. With a cost estimate of IDR 1.65 billion, the apron expansion plans not only meet technical standards but are also economically feasible.

KESIMPULAN

Based on the comprehensive evaluation conducted in this research, significant findings were obtained regarding the planning of apron pavement structure. The implementation of the FAA Manual methodology for critical aircraft Airbus A320-200 resulted in a total pavement thickness of 83.8 centimeters with a surface layer composition of 10.16 centimeters, a base upper layer of 20.32 centimeters, and a bottom foundation of 53.32 centimeters. In contrast, the application of the FAARFIELD methodology provided a more efficient dimension with a total thickness of 76.8 centimeters, consisting of a surface layer of 10.2 centimeters, an upper base of 27.5 centimeters, and a lower foundation of 39.1 centimeters.

The evaluation of structural suitability resulted in a Pavement Classification Number of 56.3 and an Aircraft Classification Number of 44.4. The comparison shows that the PCN is greater than the ACN, indicating that the design meets technical criteria and is capable of withstanding the operational loads of aircraft. The budget estimate based on the Unit Price Analysis of Southwest Sumba Regency refers to PM 78 of 2014, showing a total funding requirement of Rp1,654,100,000.00.

Referring to the research findings, comprehensive planning of the airside operational area marking system is necessary to ensure optimal safety. The implementation of proper markings provides visual guidance for pilots and ground handling personnel. Researchers are then advised to evaluate the apron drainage system at Lede Kalumbang Tambolaka Airport after expansion, referring to aviation industry regulations to ensure the effectiveness of rainwater management and maintain optimal operational conditions.

REFERENCES

[1] M. H. Rassya, “Optimalisasi Penggunaan Gate Terminal 3 Domestik Bandar Udara Internasional Soekarno-Hatta Di Masa Pandemi Covid-19,” *Matriks Tek. Sipil*, vol. 9, no. 4, p. 251, 2021, doi: 10.20961/mateksi.v9i4.54830.

[2] D. R. Panduwinata, Sukamto, and I. Endrawijaya, “Perencanaan Perluas Apron Menggunakan Konstruksi Rigid Di Terminal Baru Bandar Udara Internasional Ahmad Yani Semarang,” vol. 1, no. 1, 2020.

[3] E. Boeriswati and F. Arung, “Ruang Lingkup Filsafat,” *Idik4006/Modul 1*, no. 1, pp. 1–54, 2018.

[4] V. M. Hadinata and D. Fadillah, “Phenomenology of toxic behavior in language use by children in Wanasalam village, Banten,” *J. Soc. Stud.*, vol. 20, no. 1, pp. 1–8, 2024, doi: 10.21831/jss.v20i1.75589.

[5] N. Maulana, “Perencanaan Apron di Bandar Udara Depati Parbo Kerinci,” *Pros. SNITP (Seminar Nas. …*, 2020.

[6] W. O. A. Wunantari, E. Ngii, and L. B. Suparma, “Analisis Desain Tebal Perkerasan Kaku Apron Bandara Haluoleo Kendari Dengan Metode Faa & Pca,” *STABILITA|| J. Ilm. …*, vol. 7, pp. 161–166, 2019.

[7] M. F. Suryana, D. Rintawati, and C. Sari, “Analisis Pengembangan Geometrik Fasilitas Airside (Studi Kasus : Bandar Udara Internasional Sultan Hasanuddin) Geometric Development Analysis of Airside Facilities (Case Study : Sultan Hasanuddin International Airport),” *J. Rekayasa Lingkung. Terbangun Berkelanjutan*, vol. 01, no. 02, pp. 263–269, 2023.

[8] CAAS, “Manual of Aerodrome Standards,” no.

June, 2021.

[9] M. I. Setiawan *et al.*, “Jurnal Desentralisasi Fiskal, Ekonomi, dan Keuangan Daerah,” *J. Defis*, vol. I, p. 111, 2017.

[10] R. F. Adefertana, S. Lamtiar, and T. Nugrahayani, “Analisis Tebal Lapis Tambah (Overlay) Pada Runway Eksisting Di Bandar Udara Juwata Tarakan,” vol. 01, no. 02, pp. 82–89, 2025.