International Journal of Engineering Research and Advanced Technology (IJERAT)

DOI: 10.31695/IJERAT.2024.2.1

E-ISSN : 2454-6135

Volume. 10, No.2
April - 2024

Analysis of Implementation Plans for the ACR - PCR System on Flexible Pavement Runways at Utilization Cooperation Airport

Edy Arif Nugroho[1], Nunung Widyaningsih[2], Hermanto Dwiatmoko[3]

[1]Master Civil Engineering, [2]Doctor, [3]Doctor

Mercubuana University, Jakarta, Indonesia

Jl. Meruya Selatan, Kecamatan Kembangan

Jakarta Barat, Indonesia 11650

ABSTRACT

ICAO determined that the ACR–PCR system will take effect in July 2020 and be effective in November 2024. It is very important for airports in Indonesia to make adjustments to optimize the use of pavement assets. The research aims to calculate ACR-PCR, compare it with ACN-PCN, evaluating the airside pavement structure of airport through the application of the ACR-PCR system. Case study analysis of calculations with ICAO–ACR1.32 and FAARFIELD2.0. ACN/PCN and ACR/PCR ratios are classified against pavement strength limitation criteria. Evaluation based on the criteria for permanent deformation of the subgrade layer and fatigue cracking of the asphalt layer. Tjilik Riwut airport runway PCR value 542FBXT, Radin Inten II 850FCXT, Fatmawati Soekarno 712FCXT and H. AS. Hanandjoeddin 643FCXT. Comparison of the ACR/PCR and ACN/PCN ratios shows an increase in pavement capacity of 1.4746. Based on the criteria for fatigue cracking of the asphalt layer and permanent deformation of the PCR subgrade layer at Tjilik Riwut airport 668 and 575 FBXT, Radin Inten II 1027 and 629FCXT, Fatmawati Soekarno 862 and 629 FCXT, H. AS. Hanandjoeddin 675 and 560 FCXT. The structural pavement capacity of PT Angkasa Pura Indonesia airport has the opportunity to be increased in terms of flight frequency.

Key Words: ACR – PCR Implementation, Ratio Comparation, Structural Capacity.

1. INTRODUCTION

One of the basic elements of a runway is a pavement structure to support the weight of aircraft. ICAO as an international civil aviation organization introduced an airport pavement strength rating system in 1981 known as ACN – PCN and is used by 200 ICAO member countries. The airport pavement expert group within the ICAO organization has developed a new system to replace the ACN – PCN system. The ACR calculation procedure is completely determined directly and is closely related to the more complex PCR determination process, as it relies on many skills related to geotechnical engineering, pavement materials, pavement damage modeling, as well as good knowledge of the impact of aircraft operations on pavement (ICAO, 2019)

Utilizing the ACR – PCR system, airports must determine the PCR as accurately as possible, which requires careful analysis of the required aircraft traffic and pavement structure data. PCR calculations depend on a pavement damage model whose selection can greatly influence the results. Since there is no universal damage model, it is important to understand the assumptions and check their adequacy in the context of PCR calculations. In particular, airports should ensure that the damage model implemented in the PCR calculation software is consistent with the design input parameters before using it. If it fails, the PCR will be assessed incorrectly, leading to operational problems. PCR that is underestimated or calculated too low will result in aircraft operational weight restrictions or in the worst case the aircraft

refusing to operate, resulting in loss of airport revenue and the pavement not being used optimally for the structural
capacity of the existing pavement. On the other hand, a PCR that is calculated too high will cause an excessive increase in aircraft load operations, resulting in a reduction in the design life of the pavement.

Current conditions based on AIM Indonesia data from the Ministry of Transportation of the Republic of Indonesia, all airports in Indonesia still use the old airside facility pavement strength rating system, namely the ACN – PCN system, whereas internationally ICAO has established the ACR – PCR as airside facility pavement strength rating system. The PCR took effect in July 2020 and will be declared effective in November 2024, so that during the transition period adjustments are needed in the two airside facility strength rating systems, especially by each airport operators in Indonesia, both government and private. These adjustments really need to be made by airport operators in Indonesia to determine the impact both from technical, cost and flight safety aspects.

There is a great need for research regarding the analysis of implementation plans for the Aircraft Classification Rating (ACR) - Pavement Classification Rating (PCR) system on flexible pavement runways at utilization cooperation airport, especially for airport companies in providing services to stakeholders so that they can maintain and improve safety flight operations in Indonesia.

2. LITERATURE REVIEW

2.1. Theoritical review

Airports have two different areas, namely the land side and the air side. On the air side there are several facilities, namely the runway, taxiway, parking runway (apron), ATC (air traffic control), accident response unit (air rescue service), fuel facilities (aircraft fuel facilities), and navigational aids. Meanwhile, facilities on the land side include the airport terminal (concourse), curb, vehicle parking, ticket sales, immigration officers, shops and public parking (Suryani, 2020). Airports are included as airfields with all buildings and equipment as minimum equipment to ensure the availability of facilities for air transportation for the public. Management and maintenance of airport infrastructure is of course something that is absolute and must be done by airport operators so that activities that take place at the airport run smoothly (Baiq Setiani, 2015).

2.2. Flexible Pavement

Flexible pavement is a type of pavement that uses asphalt as a binding material for the pavement layer. Flexible pavement construction consists of layers placed on compacted subgrade. This layer functions as a receiver of traffic loads and spreads them to the layers below. Hot asphalt mixture is a mixture of solid aggregates containing coarse, fine and filler aggregates as the main composition, then asphalt is added as a binder (Widyaningsih et al., 2018).

Flexible pavement consists of aggregate as a material and asphalt as a binder, either with or without additional materials. Asphalt forming materials are mixed at a temperature that has been adjusted to the type of asphalt used. The components that make up a pavement consist of a surface layer (surface course), top foundation layer (base course), and bottom foundation layer (sub-base course) which have a function in each layer. The surface layer functions as a pavement material to support the weight of the aircraft wheels and as a wear layer. The upper foundation layer functions as a part of the pavement that supports the surface layer and spreads the stress that occurs to the lower foundation layer to be distributed to the subgrade. Meanwhile, the lower foundation layer functions as a pavement support in

International Journal of Engineering Research and Advanced Technology (IJERAT)

DOI: 10.31695/IJERAT.2024.2.1

E-ISSN : 2454-6135

Volume. 10, No.2
April - 2024

spreading the wheel load and preventing the subgrade from entering the foundation layer (Setiawan M et al., 2018).

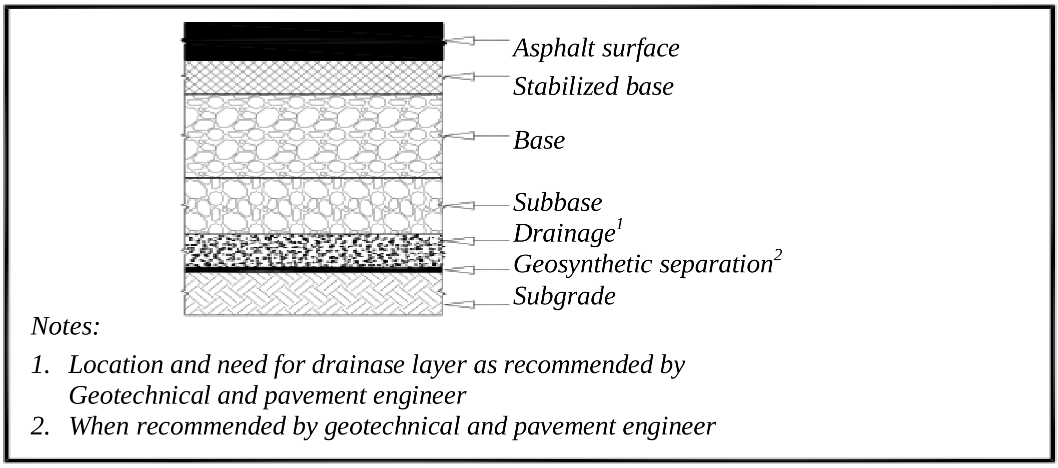


Figure 1 Flexible Pavement Structure on Runways, Source: FAA AC 150/5320-6G, 2021

Damages to flexible pavement, such as cracks, deformation, surface defects, etc. can disrupt the comfort of traffic at airports which can result in aviation accidents (Bolla et al., 2012).

2.3. Aircraft Classification Number (ACN) – Pavement Classification Number (PCN) System

The use of the ACN/PCN method only applies to aircraft with an All-up Mass of more than 12,500 lbs or 5,700 kg. Meanwhile, for pavement surfaces that can only be used by aircraft weighting less than 12,500 lbs/5,700 kg, the form is only: Maximum allowable aircraft mass and Maximum allowable tire pressure (Pradana et al., 2020).

The PCN code consists of 5 codes;

1. The first code is a value set to determine the strength of the pavement
2. The second code is the pavement type
   R – *Rigid* F – *Flexible*
3. The third code is the strength of the layer under the pavement (*subgrade*)
   A – *High Strength*, CBR 15 C – *Low Strength*, CBR 6
   B – *Medium Strength*, CBR 10 D – *Ultra Low Strength*, CBR 3
4. The fourth code is the maximum aircraft tire pressure that can be accepted by *pavement*
   W – *No preassure limit* Y – *Medium, limited* to 1,25Mpa (181psi)
   X – *High, limited* to 1,75Mpa (254psi) Z – *Low, limited* to 0,50Mpa (73psi)
5. The fifth code is the method for calculating the PCN value
   T – *Technical Evaluation* U – *Using Aircraft Experience*

To facilitate use of the ACN/PCN system, the FAA (Federal Aviation Administration), U.S. Department of Transportation, developed a software application that calculates ACN values using procedures and conditions specified by ICAO. This software is called COMFAA. This program is useful for determining ACN values in various conditions.

2.4. Aircraft Classification Rating (ACR) – Pavement Classification Rating (PCR) System

The ACR-PCR system was developed based on the same principles and mechanisms as the ACN-PCN system. Despite the apparent similarities in both systems, the ACR-PCR system includes significant changes:

International Journal of Engineering Research and Advanced Technology (IJERAT)
DOI: 10.31695/IJERAT.2024.2.1
E-ISSN : 2454-6135
Volume. 10, No.2
April - 2024

a. Strain is used as an indicator of relative damage, not deflection bowl.
b. All wheels are considered explicitly, rather than being converted into a single equivalent wheel.
c. Actual pavement materials and compositions are considered explicitly, rather than converted to standard compositions that are rarely used in many countries.
d. The load repetitions, tire pressures, and pavement structure were selected to be more comparable to typical modern airport pavement structures.
e. Rigid and flexible pavement subgrade categories use the same modulus of elasticity (or CBR) range and elimination of the largely discontinued k-value (modulus of subgrade reaction) for rigid pavement subgrades.

The term ACR-PCR was adopted to avoid confusion with ACN or PCN values. Furthermore, ACR is defined as twice the equivalent wheel load in hundreds of kilograms, rather than in tonnes. This means that the ACR value generally ranges from 50 to 1000, compared to the ACN value which generally ranges from 5 to 100. This change is also designed to avoid confusion between the two systems. Aircraft internal library is based on information provided by ACAP (Airplane Characteristics for Airport Planning). The default aircraft characteristics in the internal library represent the ICAO standard conditions for ACR calculations (White, 2021).

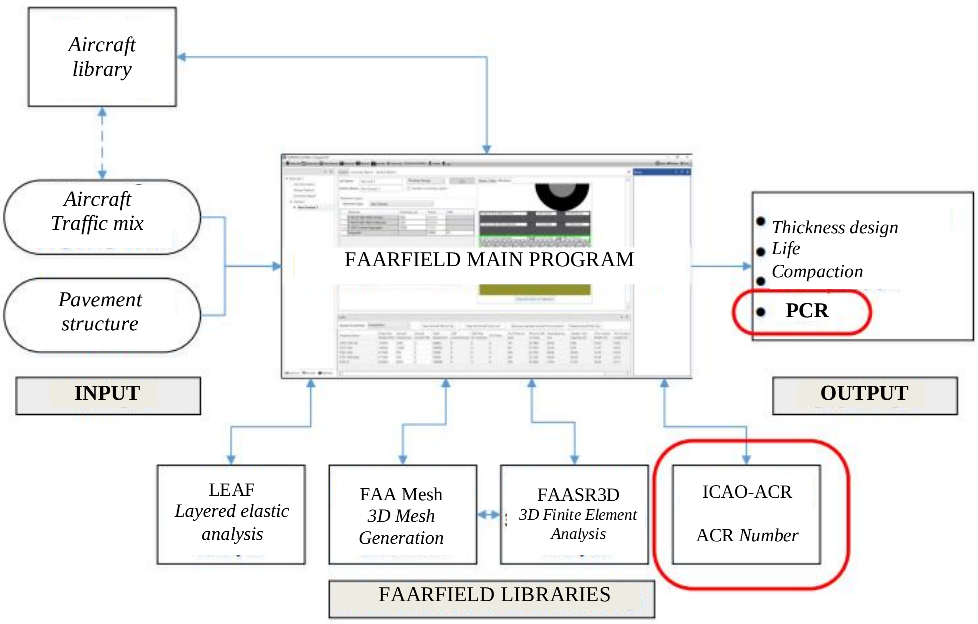


Figure 2 FAARFIELD 2.0 PCR Integration, Source: FAA AC 150/5335-5D, 2022

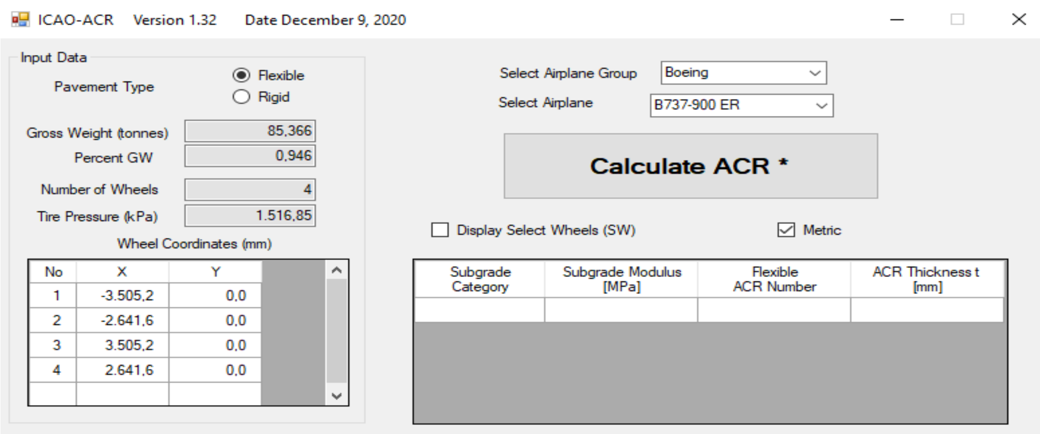
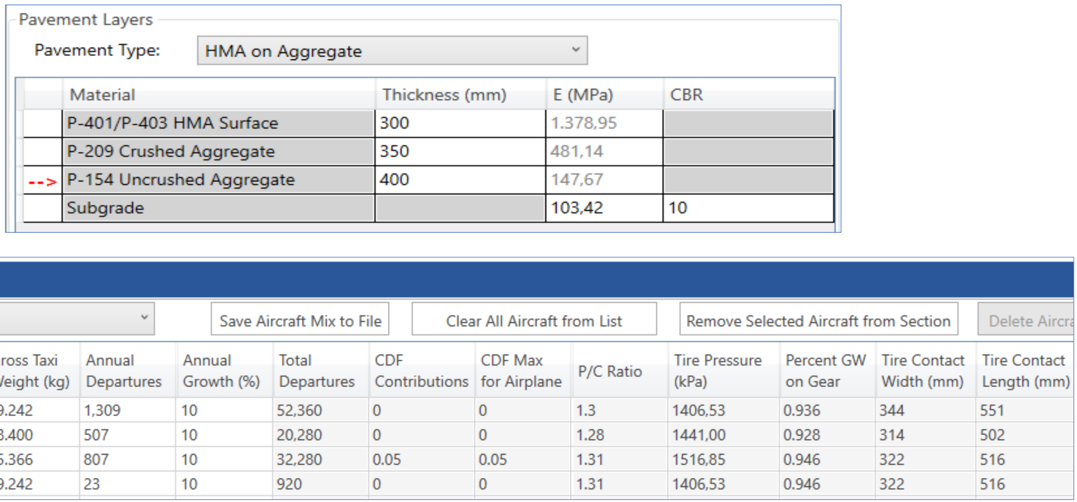


Figure 3 ICAO-ACR Program, Source: FAA AC 150/5335-5D, 2022

3. METHODOLOGY RESEARCH

3.1. Research Design

This research design uses qualitative research methods. Qualitative approach to information or data presented in the form of statements. Collecting data from surveys and testing field conditions of airside pavement facilities in the form of test pit testing is analyzed to obtain runway pavement layering according to segmentation, arrangement and thickness of runway pavement layers, DCP testing is analyzed to obtain the bearing capacity of the subgrade or the density value of the subgrade in the form of the CBR value. The primary data obtained from this analysis is validated with secondary data in the form of the Airport Pavement Management System document which contains pavement system layering data according to runway segmentation, the Aeronautical Information Publication document contains publications of runway PCN values and subgrade CBR values. The results of this analysis are to obtain data on the structure and condition of the airside pavement which will then be input into the ICAO ACR program and the FAARFIELD 2.0 program. for a case study of calculating ACR – PCR values.



Pavement Layers

Pavement Type: HMA on Aggregate

	Material	Thickness (mm)	E (MPa)	CBR
	P-401/P-403 HMA Surface	300	1.378,95	
	P-209 Crushed Aggregate	350	481,14	
-->	P-154 Uncrushed Aggregate	400	147,67	
	Subgrade		103,42	10

Traffic

Stored Aircraft Mix | Save Aircraft Mix to File | Clear All Aircraft from List | Remove Selected Aircraft from Section | Delete Aircra

Airplane Name	Gross Taxi Weight (kg)	Annual Departures	Annual Growth (%)	Total Departures	CDF Contributions	CDF Max for Airplane	P/C Ratio	Tire Pressure (kPa)	Percent GW on Gear	Tire Contact Width (mm)	Tire Contact Length (mm)
B737-800	79.242	1,309	10	52,360	0	0	1.3	1406,53	0.936	344	551
A320-200 opt	78.400	507	10	20,280	0	0	1.28	1441,00	0.928	314	502
B737-900 ER	85.366	807	10	32,280	0.05	0.05	1.31	1516,85	0.946	322	516
B737-900	79.242	23	10	920	0	0	1.31	1406,53	0.946	322	516

Figure 4 Screenshot of FAARFIELD 2.0 Pavement Structure and Traffic List
Source: FAA AC 150/5335-5D, 2022

The data sources used for this research consist of:

1. Secondary Data
   a. Literature and regulation reviews come from books, regulations and national and international journals. Other data that supports research so that the research obtains results that can be applied.
   b. Data obtained from PT Angkasa Pura Indonesia includes: AIP (Aeronautical Information Publication) data, Annual Report, Airport Pavement Management System (APMS), Detail Engineering Design (DED) data for airside pavement.
2. Primary Data
   Data obtained from the results of surveys and tests in the study area on the condition of the airside pavement structure of branch office airports managed by PT Angkasa Pura Indonesia.

4. RESULTS AND DISCUSSION

4.1. Aircraft Characteristic

One of the research objectives is to evaluate the structure of airport runway pavement facilities managed by PT Angkasa Pura Indonesia, namely Tjilik Riwut airport, H. AS Hanandjoeddin airport, Fatmawati Soekarno airport and Radin Inten II airport by considering predictions of accumulated damage to the asphalt layer and subgrade layer. The evaluation stage consists of analysis of the response of the airside pavement structure to the loading of each aircraft, analysis of the CDF value, analysis of

DOI : 10.31695/IJERAT.2024.2.1

International Journal of Engineering Research and Advanced Technology (IJERAT)
DOI: 10.31695/IJERAT.2024.2.1
E-ISSN : 2454-6135
Volume. 10, No.2
April - 2024

the contribution of the CDF value of each aircraft to the number of annual departure movements, comparative
analysis of operational weight and maximum permitted weight and analysis of the calculation of the ACR – PCR value for each aircraft at Maximum Allowable Gross Weight condition.

Aircraft annual departure data at Tjilik Riwut airport and H. AS Hanandjoeddin airport used in this research is 2019 data which is available through a 2021 study. Meanwhile for Fatmawati Soekarno airport and Radin Inten II airport is 2022 data which is available through a 2023 study. Aircraft characteristics can be seen in Figures 5 and 6. Based on the data obtained shows that the types of aircraft operating at the four airports are dominated by narrow body aircraft in the class of the Boeing 737 and Airbus A320 series. The operational weight of each aircraft (aircraft gross weight) is assumed to be the same as the MTOW (maximum take-off weight).

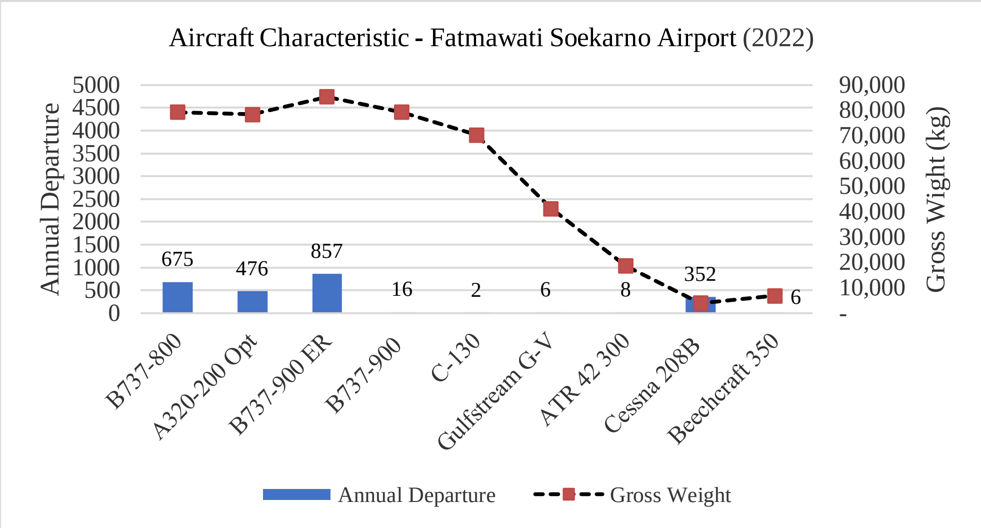


Figure 5 Aircraft Characteristics at Fatmawati Soekarno Airport

Source: Researcher Processed Data (2024)

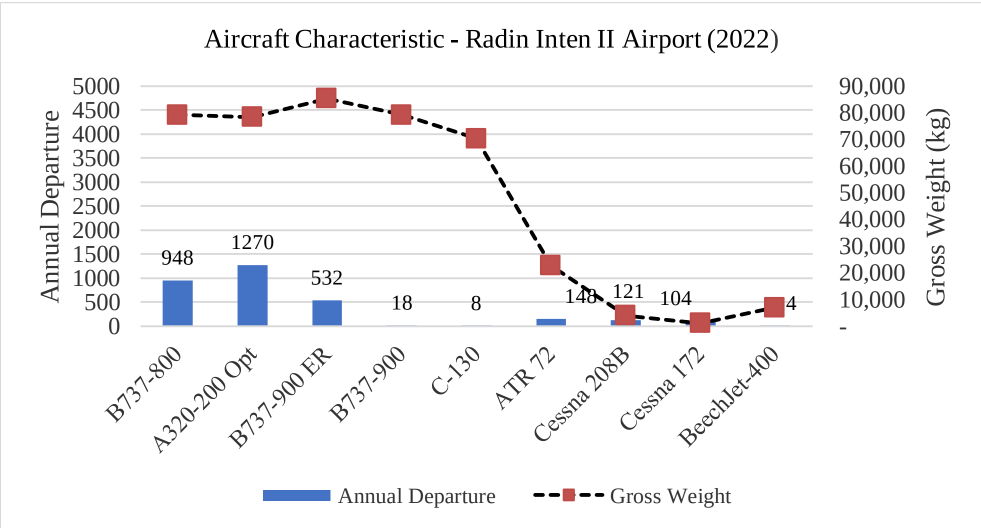


Figure 6 Aircraft Characteristics at Radin Inten II Airport

Source: Researcher Processed Data (2024)

The pavement construction reviewed is only runway construction. Based on the data obtained, the four airports have different runway pavement structures and each runway at each airport has several different pavement layer segments. Ideally, the modulus characteristics of each layer are obtained through laboratory tests or estimated through backcalculation analysis of deflection data. However, due to limitations, this research uses default values from the FAARFIELD 2.0 program. To estimate the number of permit passes based on asphalt layer fatigue crack criteria, this study uses the formula $PV = 44{,}422\ \mathcal{E}h^{5,14} S^{2993} VP^{1,85} GP^{-0,4061}$ or the formula $\mu\mathcal{E}h = 9{,}94 VP^{-0,356} GP^{0,079} MNf^{-0,216} (\frac{S}{500})^{-0,5823}$. The gradation and volumetric parameters used are the default values used in the FAARFIELD program.

4.2. List of Airport Operator

Based on data from the Director General of Civil Aviation, Ministry of Transportation, there are 340 airports in Indonesia with management carried out by Technical Implementation Unit of Directorate General of Transportation, Technical Implementation Unit of Regional Government, Indonesian Air force, PT Angkasa Pura Indonesia and Private with details of the number of management as in table 1.

Table 1 List of Airport Operators

No	Airport Operators	Number of Airport
1	Tech Implementation Unit of Directorate of General of Transportation	194
2	Tech Implementation Unit of Regional Government	68
3	Indonesian Air Force	39
4	PT Angkasa Pura Indonesia (PT AP I)	15
5	PT Angkasa Pura Indonesia (PT AP II)	20
6	Private	4

Source: (Directorate General of Civil Aviation, 2019)

PT Angkasa Pura Indonesia is a State-Owned Enterprise which is engaged in the business of airport services and airport-related services in several regions of Indonesia. PT Angkasa Pura Indonesia has demonstrated rapid progress and business improvement in the airport services business through the addition of various infrastructure and improving the quality of service at the airports it manages. To date, PT Angkasa Pura Indonesia has managed 35 airports in Indonesia (Annual Report PT AP I and PT AP II, 2021).

4.3. Aircraft Traffic Data

Fatmawati Soekarno airport aircraft traffic data that will be used as input is aircraft traffic data in 2022. The aircraft growth rate value is taken based on the average GDP of Bengkulu City, which is 2.6% and a growth rate of 5% for the sensitivity of growth to pavement thickness requirements.

Table 2 Aircraft Traffic Data at Fatmawati Soekarno Airport

No	Aircraft Type	Weight (tons)	Annual Departure (2022)	% Annual Growth
1	B737-800	79,243	675	2,6 and 5
2	A320-200 Opt	78,400	476	2,6 and 5
3	B737-900 ER	85,366	857	2,6 and 5
4	B737-900	79,243	16	2,6 and 5
5	C-130	70,307	2	2,6 and 5
6	Gulfstream G-V	41,232	6	2,6 and 5
7	ATR 42 300	18,600	8	2,6 and 5
8	Cessna 208B	3,969	352	2,6 and 5
9	Beechcraft 350	6,849	6	2,6 and 5

Source: Detail Engineering Design Overlay Report on Fatmawati Soekarno Airport Runway, PT Angkasa Pura Indonesia dan PT Nur Straits Engineering, 2023

The aircraft traffic data for Radin Inten II airport that will be used as input is aircraft traffic data in 2022. The aircraft growth rate value is taken based on the average GRDP of Lampung City, which is 2.2% and a growth rate of 5% for the sensitivity of growth to pavement thickness requirement. The growth rate using the GRDP approach is carried out with the justification that the economic development of a region is positively correlated with the movement of people.

Table 3 Aircraft Traffic Data for Radin Inten II Airport

No	Aircraft Type	Weight (tons)	Annual Departure (2022)	% Annual Growth
1	B737-800	79,243	948	2,2 and 5
2	A320-200 Opt	78,400	1270	2,2 and 5
3	B737-900 ER	85,366	532	2,2 and 5
4	B737-900	79,243	18	2,2 and 5
5	C-130	70,307	8	2,2 and 5
6	ATR 72	22,680	148	2,2 and 5
7	Cessna 208B	3,969	121	2,2 and 5
8	Cessna 172	1,160	104	2,2 and 5
9	BeechJet-400	7,031	4	2,2 and 5

Source: Detail Engineering Design Overlay Report on Radin Inten II Airport Runway, PT Angkasa Pura Indonesia and PT Nur Straits Eengineering, 2023

4.4. Input data on the bearing capacity of the subgrade

The basic soil bearing capacity data used as input to the FAARFIELD computer program is the CBR value obtained through field surveys or secondary data. The survey carried out was DCP at 9 points spread across the Fatmawati Soekarno airport runway and 9 points on the Radin Inten II airport runway. Field DCP values are converted to CBR with the formula and graph in Figure 7.

The average runway CBR value is 5.99% with a standard deviation of 2.62%. Based on the 2022 TKG airport AIP, the PCN value of the runway is PCN 63/F/C/X/T. The third column of the PCN value shows code C, which indicates that the subgrade CBR of the pavement is in the range of 4% to 8%. The CBR value from the DCP test is considered less representative of the existing CBR value of the airside pavement because the test was carried out at the edge of the runway. However, based on the results of the analysis above, the average runway CBR value obtained is 5.99% with a standard deviation of 2.62%. This result is in line with the CBR value declared in the PCN, namely category C subgrade which has a CBR value between 4% – 8%. This gives an indication that the pavement condition at the edge of the runway is similar to the pavement condition at the runway body. The CBR value used in the ACR - PCR system calculation modeling is 6% to provide more conservative analysis results.

Basic soil carrying capacity data for FAARFIELD program input is in the form of CBR values used at Tjilik Riwut airport and H. AS Hanandjoeddin airport was obtained through secondary data because a field survey was not carried out. CBR value data from the 2022 APMS report and AIP data. For Tjilik Riwut airport, the CBR value declared in the PCN is subgrade category B which has a CBR value of between 8% - 13%, used in the ACR - PCR system calculation modeling, namely 10%. For H. AS. Hanandjoeddin airport, the CBR value declared in the PCN is subgrade category C which has a CBR value of between 4% – 8%, used in modeling calculations for the ACR - PCR system, namely 6%.

Table 4 CBR DCP Runway Test Results at Fatmawati Soekarno Airport

Test Location	Range CBR (%)	Test Location	Range CBR (%)
DCP - 01	3,01 – 3,89	DCP – 06	3,38 – 11,42
DCP – 02	2,95 – 8,89	DCP – 07	3,36 – 7,68
DCP – 03	2,96 – 3,83	DCP – 08	7,50 – 14,63
DCP – 04	4,60	DCP – 09	3,93 – 10,14
DCP - 05	3,88 – 5,40		
Average = 6,02%			

Source: Detail Engineering Design Overlay Report on Fatmawati Soekarno Airport Runway, PT Angkasa Pura Indonesia and PT Nur Straits Engineering, 2023

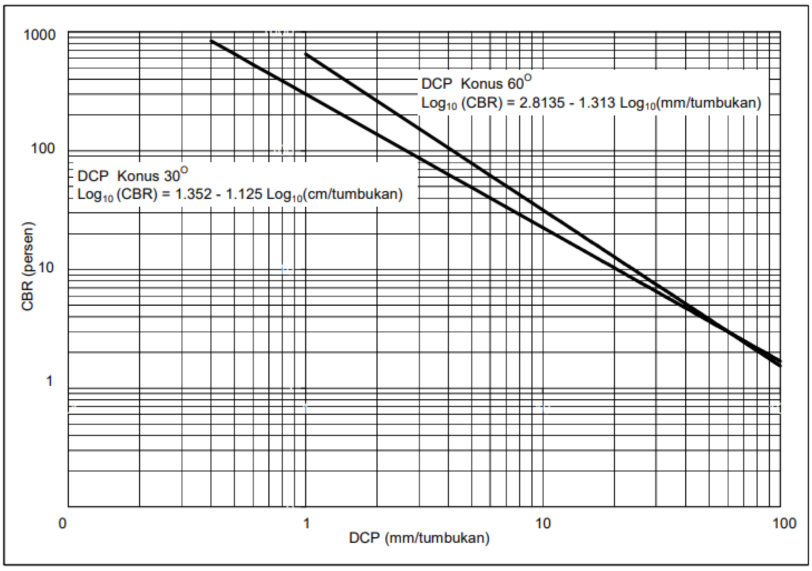
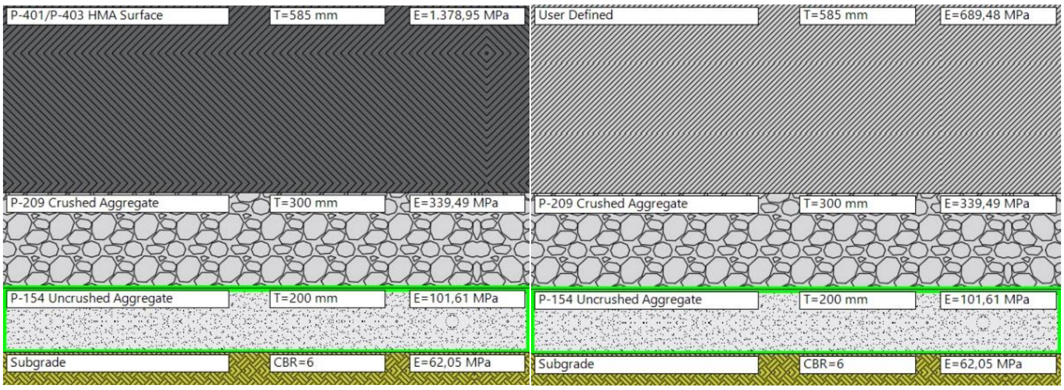


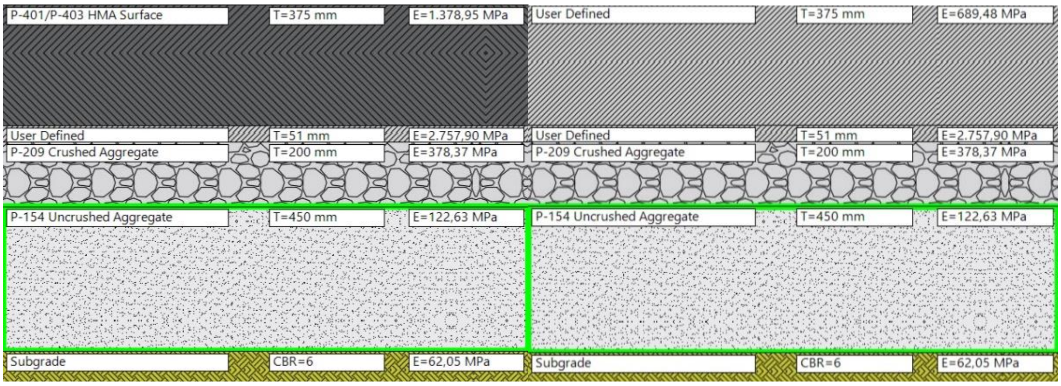
Figure 7 Graph of the relationship between DCP and CBR
Source: Circular Letter of the Minister of Public Works No. 04/SE/M/2010

Figure 8 Layout and Segments 1, 2, 3, 4 and 5 of the Radin Inten II Airport Runway (PCR Input)
Runway Segment 1 Radin Inten II Airport Modeling 1 and 2

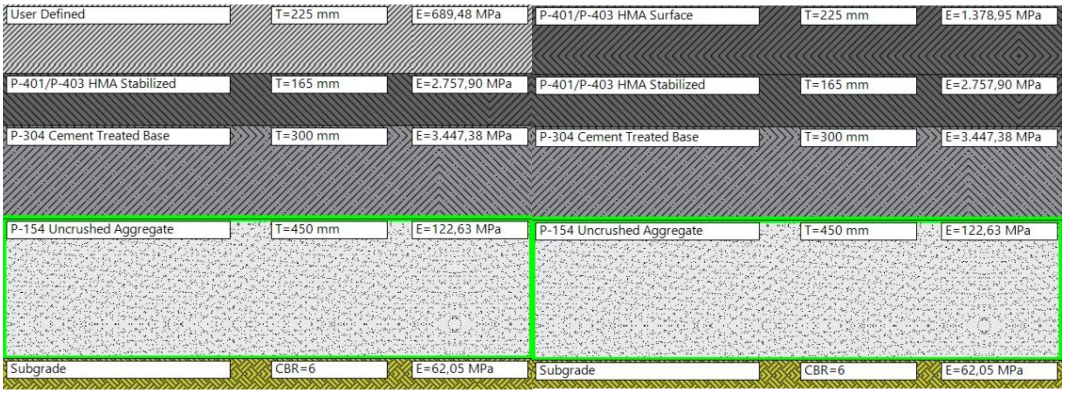


Runway Segment 2 Radin Inten II Airport Modeling 1 and 2

E-ISSN : 2454-6135
DOI: 10.31695/IJERAT.2024.2.1
Volume. 10, No.2
April - 2024



Runway Segment 3 Radin Inten II Airport Modeling 1 and 2



4.5. Comparison of ACN – PCN and ACR – PCR Systems

Summary of limitations on airport pavement strength conditions due to operational aircraft traffic represented by the following four criteria (Qassim, 2012):

1. (ACN / PCN) < 1: the pavement has satisfactory performance and only requires routine maintenance.
2. (1 < ACN / PCN < 1,25): Pavement has minimal impact on the life of the pavement.
3. (1,25 < ACN / PCN < 1,5): aircraft operations should be limited to 10 passes and the pavement surface inspected after use by each aircraft operation.
4. (ACN / PCN > 1,5): the use of pavement is not permitted except in emergencies.

Aircraft ACN value data used was the ACN aircraft at Tjilik Riwut airport, H. AS. Hanandjoeddin airport, Fatmawati Soekarno airport and Radin Inten II airport, and based on ACN Tables General Airway Manual Jeppesen a Boeing Company and ACN's Transport Canada Technical Evaluation Engineering. Meanwhile, PCN data is based on AIP at the four airports.

The results of calculating the ACN/PCN ratio at Radin Inten II airport are as shown in table 5, the Boeing 737-900ER aircraft type weight 85,366 tons with the largest ACN value contribution of 56 F/C compared to the runway PCN value of 63 F/C/X/T produces the largest ACN/PCN ratio value, namely 0.8888. Based on the pavement strength condition limits, the ACN/PCN ratio value of 0.8888 is included in the criteria (ACN / PCN) < 1, so that the pavement has satisfactory performance and only requires routine maintenance.

International Journal of Engineering Research and Advanced Technology (IJERAT)

DOI: 10.31695/IJERAT.2024.2.1

E-ISSN : 2454-6135

Volume. 10, No.2
April - 2024

Table 5 ACN / PCN Ratio at Radin Inten II Airport

No	Aircraft Type	Weight (tons)	ACN Value	PCN Value	ACN/PCN	Limitations on Pavement
1	B737-800	79,243	50	**63 F/C/X/T**	0,7937	Criteria (1) Has satisfactory performance, only requires routine maintenance
2	A320-200 Opt	78,400	47		0,7460	
3	B737-900 ER	85,366	56		**0,8888**	
4	B737-900	79,243	50		0,7937	
5	C-130	70,307	37		0,7255	
6	ATR 72	22,680	14		0,2222	
7	Cessna 208B	3,969	-		-	
8	Cessna 172	1,160	-		-	
9	BeechJet-400	7,394	7		0,1111	

Source: Researcher Analysis, 2024

The results of calculating the ACR/PCR ratio at Fatmawati Soekarno airport are as shown in table 6, the Boeing 737-900ER aircraft type which weight 85,366 tons with the largest ACR value contribution of 503 F/C compared to the runway PCR value of 712 F/C/X/T produces the largest ACR/PCR ratio value is 0.7065. Based on the pavement strength condition limits, the ACR/PCR ratio value of 0.7065 is included in the criteria (ACR / PCR) < 1, so that the pavement has satisfactory performance and only requires routine maintenance. The complete calculation results of the ACR/PCR ratio value for Fatmawati Soekarno airport can be seen in table 6.

Table 6. ACR / PCR ratio at Fatmawati Soekarno Airport

No	Aircraft Type	Weight (tons)	ACN Value	PCN Value	ACN/PCN	Limitations on Pavement
1	B737-800	79,243	448 F/C	**712 F/C/X/T**	0,6292	Criteria (1) Has satisfactory performance, only requires routine maintenance
2	A320-200 Opt	78,400	426 F/C		0,5983	
3	B737-900 ER	85,366	503 F/C		**0,7065**	
4	B737-900	79,243	454 F/C		0,6376	
5	C-130	70,307	314 F/C		0,4410	
6	Gulfstream G-V	41,232	296 F/C		0,4157	
7	ATR 42 300	18,600	84 F/C		0,1179	
8	Cessna 208B	3,969	31 F/C		0,0435	
9	Beechcraft 350	6,849	33 F/C		0,0463	

Resource: Researcher Analysis, 2024

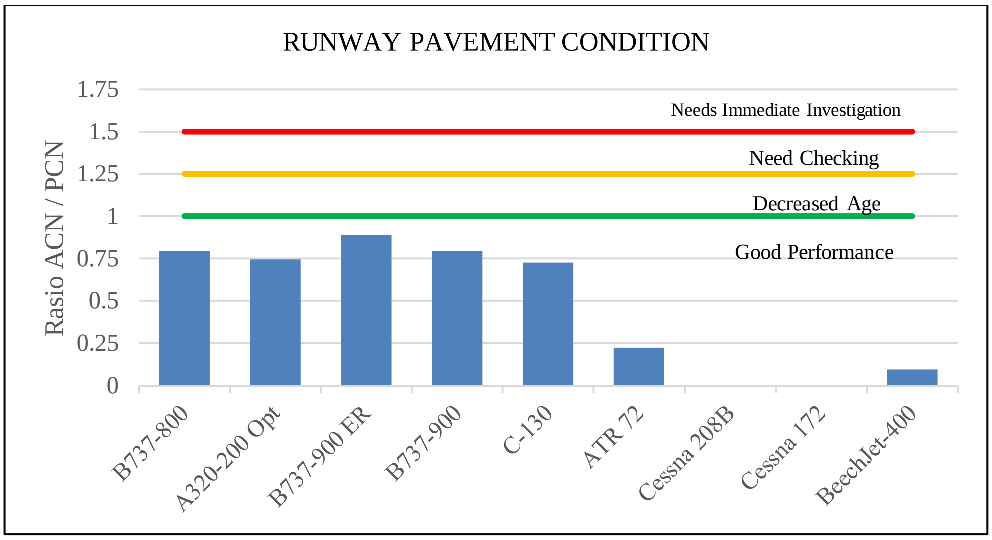


Figure 9 Radin Inten II Airport ACN / PCN Ratio, Source: Researcher Analysis, 2024

Figure 9 explains the influence of each operating aircraft on the runway pavement conditions at Radin Inten II airport. The type of aircraft in operation produces an ACN/PCN ratio value below 1, so

International Journal of Engineering Research and Advanced Technology (IJERAT)
DOI: 10.31695/IJERAT.2024.2.1
E-ISSN : 2454-6135
Volume. 10, No.2
April - 2024

the graph falls in the area below the green line, meaning that the runway pavement condition is still in good performance to accept the ACN load of all aircraft.

Figure 10 explains the influence of each aircraft operating on the Fatmawati Soekarno airport runway pavement. The types of aircraft operating at these airports produce ACR/PCR ratio values below 1, so that graphically they are in the area below the green line, meaning that the condition of the runway pavement at these airport is still in good performance to accept the ACR load of all aircraft which operates.

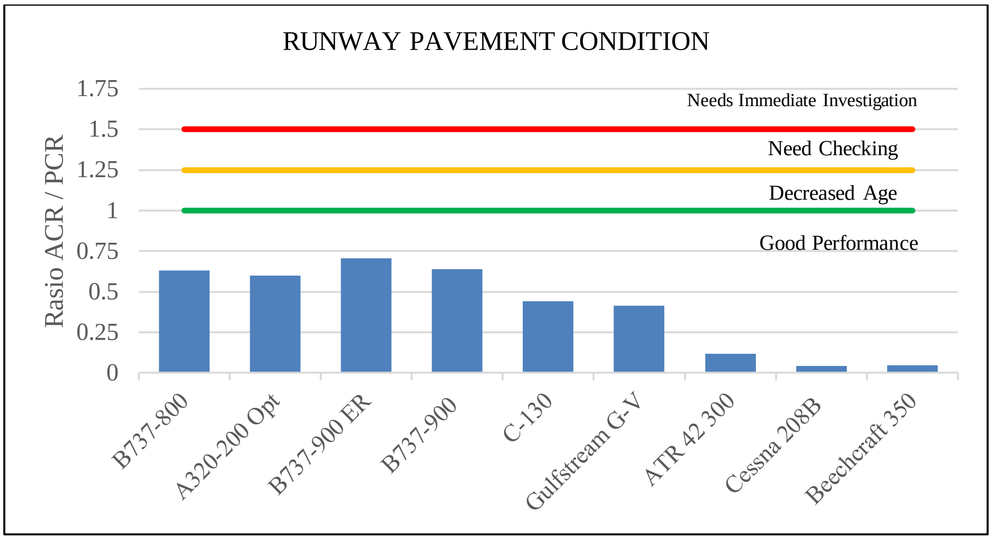


Figure 10 ACR / PCR ratio at Fatmawati Soekarno Airport, Source: Researcher Analysis, 2024

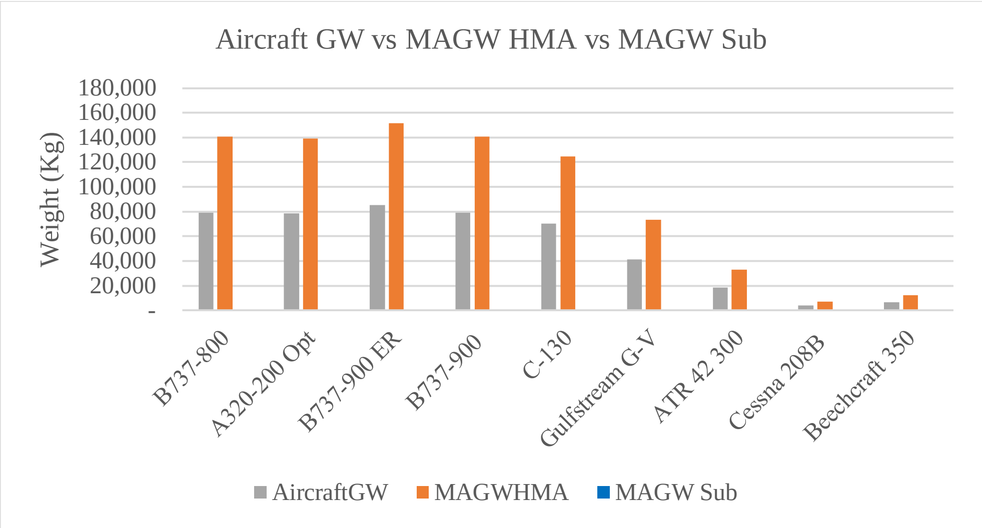


Figure 11 Aircraft Gross Weight VS Maximum Allowable Gross Weight of Structure Runway Pavement Segment 1 Fatmawati Soekarno Airport

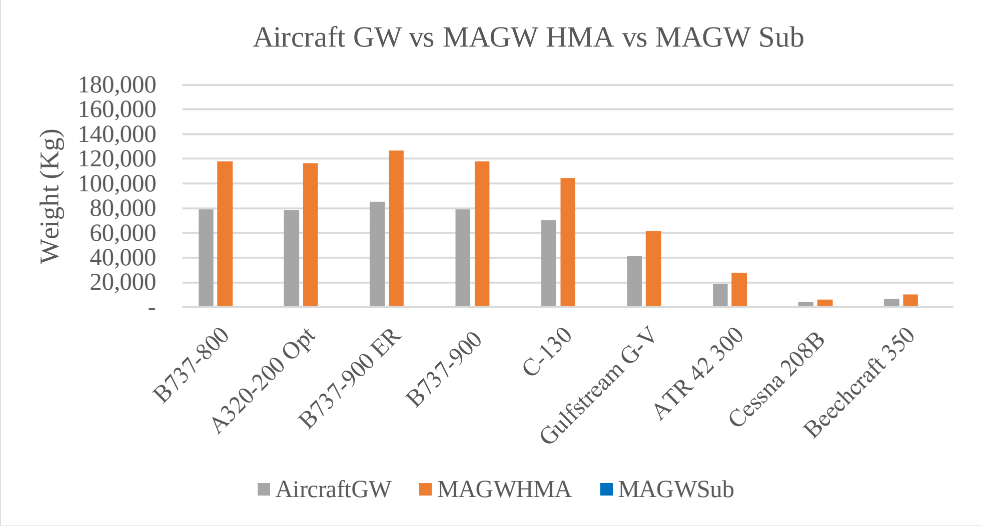


Figure 12 Aircraft Gross Weight VS Maximum Allowable Gross Weight of Structure Runway Pavement Segment 2 Fatmawati Soekarno Airport

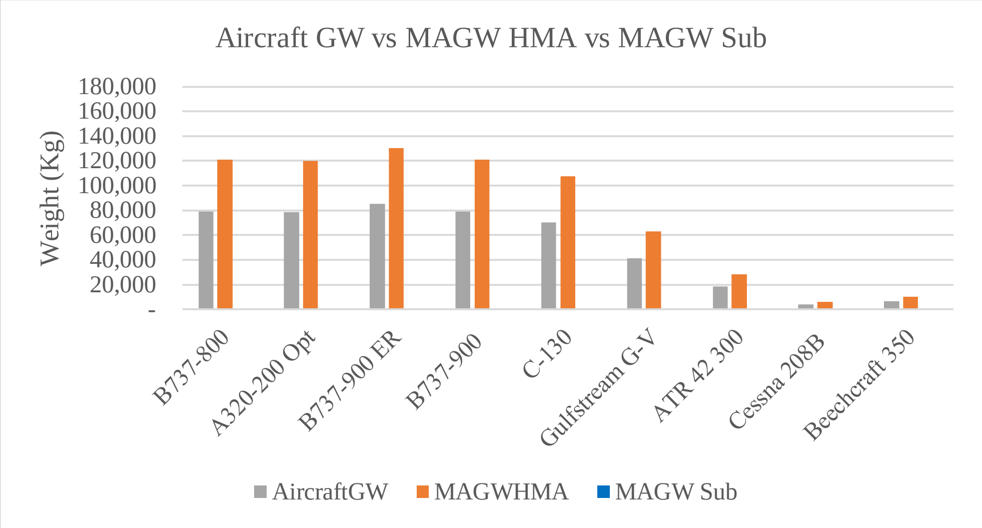


Figure 13 Aircraft Gross Weight VS Maximum Allowable Gross Weight of Structure Runway Pavement Segment 3 Fatmawati Soekarno Airport

Figures 11, 12 and 13 show Aircraft Gross Weight compared to Maximum Allowable Gross Weight at Fatmawati Soekarno airport. It can be seen that based on the asphalt layer fatigue cracking criteria, the average maximum weight permitted is ±60% exceeding the operational weight (figures 11, 12 and 13). Meanwhile, based on the permanent deformation criteria of the subgrade, the structural performance of the runway is still very good, indicated by a CDF value = 0.00. From this information it can be concluded that the asphalt layer is a critical layer and the most critical pavement structure is on runway segment 2 according to Figure 12. The runway pavement structure is in a very strong condition relative to the requirements for use by aircraft traffic as indicated by a CDF value = 0.00 in all segment runway pavement (based on permanent subgrade deformation criteria). The actual calculation of the CDF can be ignored.

International Journal of Engineering Research and Advanced Technology (IJERAT)
DOI: 10.31695/IJERAT.2024.2.1
E-ISSN : 2454-6135
Volume. 10, No.2
April - 2024

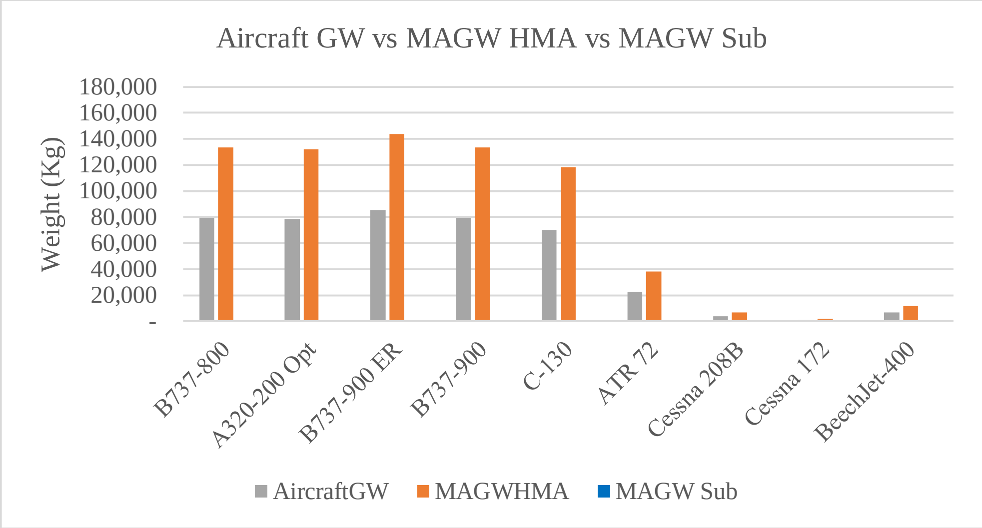


Figure 14 Aircraft Gross Weight VS Maximum Allowable Gross Weight of Structure Runway Pavement Segment 1 Radin Inten II Airport

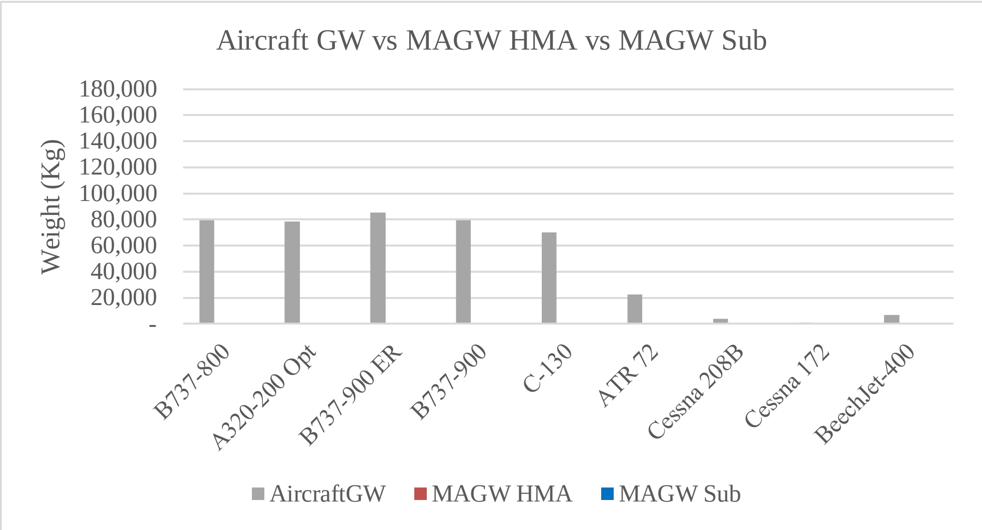


Figure 15 Aircraft Gross Weight VS Maximum Allowable Gross Weight of Structure Runway Pavement Segments 2, 3, 4 and 5 Radin Inten II Airport

Figures 14 and 15 show Aircraft Gross Weight compared to Maximum Allowable Gross Weight at Radin Inten II airport. It can be seen that based on asphalt layer fatigue cracking criteria, the average maximum weight permitted is ±68% exceeding the operational weight (figure 14). Meanwhile, based on the permanent deformation criteria of the subgrade, the structural performance of the runway is still very good, indicated by a CDF value = 0.00. From this information it can be concluded that the asphalt layer is a critical layer and the most critical pavement structure is on runway segment 1 according to Figure 14. The runway pavement structure is in a very strong condition relative to the requirements for use by aircraft traffic as indicated by a CDF value = 0.00 in all segment runway pavement (based on permanent subgrade deformation criteria) and CDF value = 0.00 on runway segments 2, 3, 4 and 5 (based on asphalt layer fatigue crack criteria). The actual calculation of the CDF can be ignored.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusion

Comparison of the two pavement strength rating systems (ACN–PCN and ACR–PCR) obtained a ratio at the four airports reviewed, namely 1.0625; 1.1363; 1.0980; 0.8888 for the ACN/PCN ratio and 0.8787; 0.6967; 0.7065; 0.5918 for the ACR/PCR ratio. These results provide two criteria for pavement capacity, namely having a minimal impact on the age of the pavement and having no impact on the existing pavement, only requiring routine maintenance. The airside pavement capacity reviewed using the ACR–PCR system increased by 1.4746 compared to the existing pavement capacity.

The application of the ACR-PCR system to the evaluation of airside pavement structures based on the criteria for fatigue cracking of the asphalt layer and permanent deformation of the subgrade layer resulted in PCR values at the four airports reviewed, namely 668 F/B/X/T and 575 F/B/X/T at Tjilik Riwut airport, 675 F/C/X/T and 560 F/C/X/T at H. AS Hanandjoeddin airport, 862 F/C/X/T and 629 F/C/X/T at Fatmawati Soekarno airport and 1027 F/C/X/T and 629 F/C/X/T at Radin Inten II airport. The B737-900ER and B737-800 aircraft types contribute significantly to the service life of pavement structures. Asphalt layers are predicted to have a shorter service life than subgrade layers. The case studies, comparisons and evaluations carried out show that the structural performance of the four airports pavements is still very good for supporting aircraft traffic.

Airports that do not know the carrying capacity of the subgrade, pavement layering and historical aircraft data regarding current PCN values, to make the transition to ACR - PCR require field surveys and testing as well as analysis by pavement experts. Airports that will carry out assessments of pavement conditions are estimated to require costs. Although ACR-PCR does not replace pavement evaluation procedures, it can be used to evaluate aircraft operational loads that pavement can accept, thereby improving flight operational safety.

5.2. Recommendations

The process of implementing the ACR-PCR system actually requires in-depth investigation of the characteristics of the pavement structure. Therefore, it is recommended that airports prepare historical pavement data and aircraft operational data as input for the characteristics of the existing pavement structure used. This research only considers damage criteria to the asphalt layer and subgrade. PCR determination at Tjilik Riwut airport, H. AS. Hanandjoeddin airport, Fatmawati Soekarno airport and Radin Inten II airport should also consider damage to the foundation layer and need to consider the functional condition of the pavement. Current research can be expanded by considering the application of the ACR-PCR system to rigid pavement structures and other airport locations with different pavement layering, material characteristics and aircraft type traffic.

ACKNOWLEDGEMENT

Many thanks are expressed to respondents and expert construction on my title Analysis of Implementation Plans for ACR – PCR System on Flexible Pavement Runways at Utilization Cooperation Airport who were willing to help run this research smoothly.

REFERENCE

[1] Achmadi, A. & N. (2011). Teori Metodologi Penelitian. *Teori Metodologi Penelitian*, 1–21.

[2] Adu, A. S., Barnabas, P. L., & Setiawan, A. (2012). Tinjauan Pengembangan Landasan Pacu Bandar Udara Kasiguncu Kabupaten Poso. *Jurnal Rekayasa Dan Manajemen Transportasi*, *2*(2), 115–127.

[3] Ariansyah, Y., Dharmawansyah, D., Mawardin, A., Studi, P., Sipil, T., Teknologi, F., & Teknologi, U. (2022). Jurnal Teknik Sipil. *Jurnal Teknik Sipil Universitas Syah Kuala*, *11*(2), 107–116.

[4] Armeni, A., & Loizos, A. (2022). Preliminary evaluation of the ACR-PCR system for reporting the bearing capacity of flexible airfield pavements. *Transportation Engineering*, *8*(March), 100117. https://doi.org/10.1016/j.treng.2022.100117

[5] Baiq Setiani. (2015). Prinsip-Prinsip Pokok Pengelolaan Jasa Transportasi Udara. *Jurnal Ilmiah Widya*, *3*(2), 103–109.

[6] Bandar, D. I., El, U., & Kupang, T. (2012). *Dosen Jurusan Teknik Sipil Fakultas Sains dan Teknik Universitas Nusa Cendana*. *1*, 1–10.

[7] Dani, S., & Muis, Z. A. (2018). Potensi Pengaruh Beban Overloading Terhadap Perkerasan (Studi Kasus : Jalan Raya Lubuk Pakam , Sumatera Utara). *Jurnal Teknik Sipil USU*, *7*(1), 1–12.

[8] FAA. (2005). Standard naming convention for aircraft landing gear configurations. *Federal Aviation Administration*, *1*, 1–11.

[9] FAA. (2020). Standardized Method of Reporting Airport Pavement Strength - PCR. *Advisor Circular 150/5335-5D, Standardized Method of Reporting Airport Pavement Strength-PCR*, 101.

[10] Fabre, C. (2018). The Aircraft Classification Rating – Pavement Classification Rating. *The Aircraft Classification Rating – Pavement Classification Rating*.

[11] Gunawan, N. (2019). Evaluasi Tebal Perkerasan Landas Pacu Pada Bandar Udara Internasional Jawa Barat Kabupaten Majalengka. *Prosiding Seminar Intelektual Muda*, *1*(1), 7–24. https://doi.org/10.25105/psia.v1i1.5979

[12] Horonjeff, R. (2010). *Planning and Design of Airports, Fifth Edition*. http://books.google.com/books?hl=en&lr=&id=-uhsAwAAQBAJ&pgis=1

[13] ICAO. (2019). Working Paper Assembly — 40Th Session. *Secretary*, *19*(August), 1–4. https://www.icao.int/Meetings/AMC/MA/Assembly 36th Session/wp123_en.pdf

[14] Jain, H., & Purohit, P. (2020). *A Study of an Airfield Pavement Evaluation*. *7*(9), 1451–1456. www.jetir.org

[15] Kawa, I. (2017). *Development of New Subgrade Failure Model for Flexible Pavements in FAARFIELD*. 51.

[16] Kusuma Rini, F. D., Herianto, & Hendra. (2020). Analisis Ulang Runway Bandar Udara Wiriadinata Menggunakan Metode FAA. *Jurnal Ilmiah Teknik Sipil*, *2*(1), 45–54.

[17] Landasan Bandar Udara : Studi Kasus Bandar Udara Kertajati – Majalengka. *Warta Penelitian Perhubungan*, *28*(6), 413. https://doi.org/10.25104/warlit.v28i6.306

[18] Lestari, I. G. A. A. I. (2013). Perbandingan Perkerasan Kaku dan Perkerasan Lentur. *Jurnal Transportasi*, *7*(1), 128–134. http://unmasmataram.ac.id/wp/wp-content/uploads/18.-I-Gusti-Agung-Ayu-Istri-Lestari.pdf

[19] Najamudin, I. (2019). Prosedur Pemeliharaan Landas Pacu (Runway) Bandar Udara SM. Badaruddin II. Palembang (Mengacu Pada Prosedur Teknis). *Warta Penelitian Perhubungan*, *24*(5), 462. https://doi.org/10.25104/warlit.v24i5.1026

[20] Nurhayati, Y. (2012). *WARTA ARDHIA Perhitungan Panjang Landas Pacu Untuk Operasi Pesawat Udara The Measurement Of Runway Length For Aircraft Operations*. *38*(4), 373–381.

[21] Park, R. O., & Gardens, A. (2022). *INVESTIGATION INTO THE VARIATION IN AIRFIELD PAVEMENT STRENGTH RATING CALCULATION*. *July*.

[22] Perhubungan, M., & Indonesia, R. (2021). *(Civil Auiation Safety Regulation Part 139)*. *3*, 1–62.

[23] Kementerian Perhubungan. (2023). *PR 21 Tahun 2023 Manual Of Standard CASR 139 Volume I Aerodrome Daratan*.

[24] Prabasari. (2022). *https://lib.mercubuana.ac.id/. 41120110032*.

[25] Pradana, M. F., Intari, D. E., & Akbar, F. A. (2020). Analisa Perkerasan Bandar Udara Menggunakan Metode Acn-Pcn Dan Cbr (Studi Kasus Bandar Udara Internasional Husein Sastranegara Bandung). *Jurnal Fondasi*, *9*(1). https://doi.org/10.36055/jft.v9i1.7296

DOI : 10.31695/IJERAT.2024.2.1

[26] Prieto, A. J., Guiñez, F., Ortiz, M., & González, M. (2022). Fuzzy Inference System for Predicting Functional Service Life of Concrete Pavements in Airports. *Infrastructures*, *7*(12), 1–16. https://doi.org/10.3390/infrastructures7120162

[27] Qassim, G. J. (2012). Pavement Strength Evaluation of Selected Iraqi Airports Depends on ICAO (ACN/PCN) Method. *Journal of Babylon University/Engineering Sciences*, *20*.

[28] Saputra. (2022). *https://lib.mercubuana.ac.id/*. *41117120096*.

[29] Setiawan M, D., Rahmawati, A., & Bagus Setiawan, I. (2018). Perbandingan Tebal dan Analisis Kerusakan Perkerasan Lentur Menggunakan Program KENPAVE dan Metode Asphalt Institute. *Semesta Teknika*, *21*(2), 106–113. https://doi.org/10.18196/st.212216

[30] Tarlie, S. (2022). *New method to reportpavement strength (ACR-PCR)*. *October*, 0–13.

[31] Udara, P. B., & Valerian, A. A. (2022). *ANALISIS PERBANDINGAN METODE ACN-PCN DAN ACR-PCR PADA RATING SYSTEM PERKERASAN BANDAR UDARA ALFIAN AUFA VALERIAN, 1. Prof. Ir. Teuku Faisal Fathani, S.T., M.T., Ph.D., IPU., ASEAN Eng. I*, 2018–2019.

[32] Wesołowski, M., & Iwanowski, P. (2020). Evaluation of asphalt concrete airport pavement conditions based on the Airfield Pavement Condition Index (APCI) in scope of flight safety. *Aerospace*, *7*(6). https://doi.org/10.3390/AEROSPACE7060078

[33] White, G. (2021). Practical implications for the implementation of the new international airport pavement strength rating system. *Eleventh International Conference on the Bearing Capacity of Roads, Railways and Airfields, Volume 1*, *1*(Crow 2003), 210–225. https://doi.org/10.1201/9781003222880-20

* C. Author Edy Arif Nugroho

DOI : 10.31695/IJERAT.2024.2.1