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Evaluation of Flexible Pavement Condition of Sultan Muhammad Kaharuddin Sumbawa Airport Runway Using Pavement Condition Index (PCI) Method

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ABSTRACT

Sultan Muhammad Kaharuddin Airport Sumbawa is a Technical Implementation Unit within the Ministry of Transportation, which is under the auspices of the Director General of Air Transportation. Sultan Muhammad Kaharuddin Airport Sumbawa has a runway dimension of 1800 x 30 m with a PCN of 30 F/C/X/T and a Hotmix Asphalt surface. There are several factors that can affect the condition of the pavement, namely aircraft load, number of aircraft repetitions, soil conditions, and material conditions. One method used to determine the condition of the runway at an airport is the Pavement Condition Index (PCI) value parameter. The results of the analysis carried out by Sultan Muhammad Kaharuddin Airport Sumbawa found several types of damage, namely ravelling/weathering and an alligator crack with an average value of 62.44 in good condition. Therefore, the repair method in accordance with the KP 94 of 2015 regulation is patching. The Budget Plan (RAB) obtained from the calculation results is Rp. 8,585,000,000.00

1. INTRODUCTION

Geographically, Sultan Muhammad Kaharuddin Airport Sumbawa is located at coordinates 08029”38.438” LS 117”24'59.258” BT. Under the direction of the Directorate General of Air Transportation, Sultan Muhammad Kaharuddin Airport Sumbawa is the Environmental Technical Implementer of the Ministry of Transportation. Sultan Muhammad Kaharuddin Airport, the Environmental Technical Implementer of the Ministry of Transportation, has a runway measuring 1800 x 30 m with PCN 30 F/C/X/T and Asphalt Hotmix pavement.

Sultan Muhammad Kaharuddin Airport is ± 2.5 km from Sumbawa Besar. The airlines currently operating are PT. Wings Air with a flight route Sumbawa-Lombok once a day. Aircraft or rotary wing (helicopter) from the Fly Bali Office and PT. Sayap Garuda Indah and training aircraft from PT. LIFT and PT. BP3 Banyuwangi.

The condition of the runway pavement is an important factor in determining the maintenance program to be implemented. Runway using flexible pavement as pavement construction. There are several factors that can affect the condition of the pavement, including, but not limited to, aircraft load, number of repetitions, and soil and material conditions. The soil condition index (PCI) value is one way to find out the condition of an airport runway.

The Pavement Condition Index (PCI) method calculates the level of pavement damage based on three factors, namely the type of damage, level of damage, severity of damage, and amount or density of damage.

2. LITERATURE REVIEW

To find out the type of damage to flexible pavement on the runway is to analyze the level of damage and understand how to carry out maintenance and repairs on the sidewalk. As per KP Regulation 94 of 2015 concerning Maintenance of Airport Pavement Construction, there are various types of damage to flexible pavement construction, including: long and trans cracks, alligator cracks, peeling and cracked blocks, and holes.

Longitudinal and Transverse Cracks: These cracks often arise from environmental factors and structural stresses, especially in pavements over large areas of land, leading to reduced lifespan and bearing capacity. Djellali et al. (2023). Alligator Cracks, Characterized by interconnected cracks resembling crocodile skin, these usually indicate severe structural stress due to repeated loading. Lahna et al. (2023). Spalling and Cracking Blocks: These surface problems can occur due to material degradation and inadequate interlayer bonding, requiring timely intervention. Lahna et al. (2023). Potholes: Often caused by water infiltration and freeze-thaw cycles, potholes can pose an immediate safety risk and require prompt repair. Lahna et al. (2023).

Maintenance and Repair Strategies with Nondestructive Testing (NDT) Techniques such as Falling Weight Deflectometer (FWD) can assess pavement condition without invasive methods, guiding maintenance decisions, Gkyrtis et al. (2024). Automatic Detection System: Advanced imaging techniques and machine learning models improve crack detection accuracy, improve maintenance planning, (Sharma & Bansal, 2024) (Zhai & Xu, 2024).

2.1. Pavement Condition Index (PCI) Method

The PPCI method only provides information about the condition of the pavement at the time of the survey; it cannot predict what will happen next. However, pavement condition data can be incorporated into deeper measurements by conducting periodic condition surveys. This technique improves prediction accuracy by utilizing historical data, allowing for better estimates of future pavement conditions. Lee et al. (2022).

According to the Federal Aviation Administration (2012) (Airport and Division 2014), PCIn (Pavement Condition Index) is a value used as a parameter to assess pavement damage. The PCI value indicates the condition of the pavement surface, with a range of values 0-100. Higher values indicate better pavement conditions, with the criteria excellent, very good, good, fair, poor, very poor, and failed. The following is a diagram of the Pavement Condition Index (PCI).

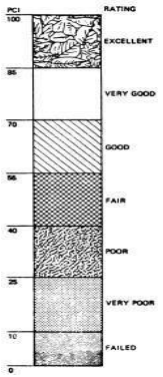

Figure 1. PCI Value Diagram

2.1.1. PCI Sample Distribution

According to ASTM D5340-98 (American Society for Testing and Materials (ASTM) 2005) on Standard Test Method for Airport Pavement Condition Index Survey as a reference for researchers to determine several samples, such as unit samples owned, and determine the minimum sample that must be surveyed as analysis.

In ASTM D5340-98, to determine the minimum number of PCI survey samples, we can determine the total sample owned using the following formula equation:

Total Sample = Total Area: Sample Unit Area

Given: The area of the sample unit uses 450 ± 180 m2.

To determine the minimum number of samples owned using the formula.

$$n = \frac{Ns^2}{\frac{e^2}{4}\,(N\_1) + s^2}$$

Given:

N : Total number of sample units in a pavement section

e : Allowable error in the estimation of the section PCI (e-5)

s : Standard deviation of PCI between sample units in the section (for AC,s = 10)

ASTM D5340-98 provides an alternative method for calculating the number of samples based on the total number of samples. The following table shows the alternative:

Table 1.Recommended Number of PCI Samples

Given	*Survei*
1 to 5 sample units	*1 sample units*
6 to 10 sample units	*2 sample units*
11 to 15 sample units	*3 sample units*
16 to 40 sample units	*4 sample units*
Over 40 sample units	*10%*

2.1.2. Pavement Condition Assessment

1) Calculate the density value

Density, or severity of damage, is the percentage of area affected by a particular type of damage relative to the total area of the sample units, measured in linear meters. The density value for a particular type of damage is also classified based on the severity of the damage. The formula for determining the density value is as follows:

Density = $\frac{Ad}{As}\ x\ 100\%$

Or

Density = $\frac{Ld}{As}\ x\ 100\%$

Where:

Ad: Total area of damage types for each damage

Ld: Total length of damage types for each damage

As: Total area of sample units

2) Calculating the Deduct Value

The reduction value or deduct is obtained from the density value that experiences a damage graph according to the level of damage. The deduct value is the result of reducing each type of damage obtained from the density curve and deduct value. The following is the level of damage to the type of flexible pavement construction.

The embedding of sensors in Portland cement concrete (PCC) pavements allows real-time monitoring of damage mechanisms, revealing flexible properties and failure modes through techniques such as acoustic emission and digital image correlation, Liu (2024). A study showed that utility cuts significantly reduced pavement condition, with an average reduction of 5.1 points in the Pavement Condition Index (PCI), leading to a 6% reduction in service life, Dunn et al. (2024). The flexural curve method evaluates fracture damage by analyzing the relationship between detection points and cracks, providing insight into the state of damage, Liu et al. (2024). For significant deflections, nonlinear theory is applied, which considers the resistance and curvature of the material, which is important for understanding flexural behavior under load, Pylypaka et al. (2024).

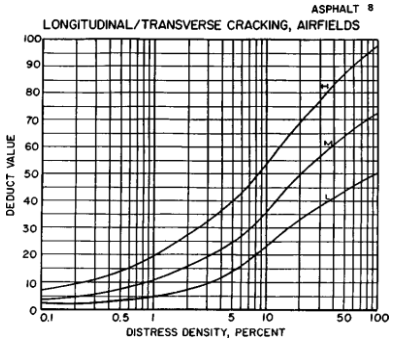

Figure 1. Longitudinal & Transverse Cracking

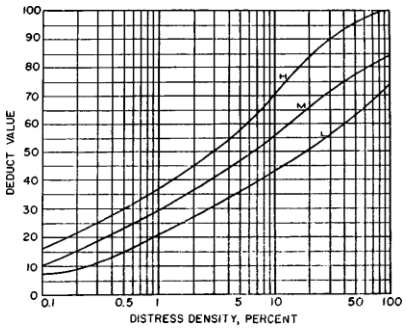

Figure 2. Aligator Cracks

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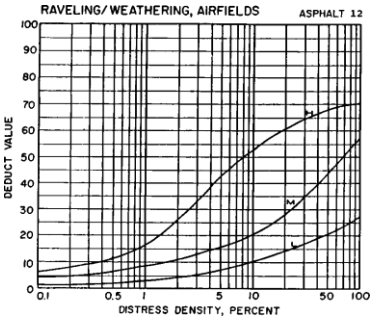

Figure 4. Weathering and Raveling

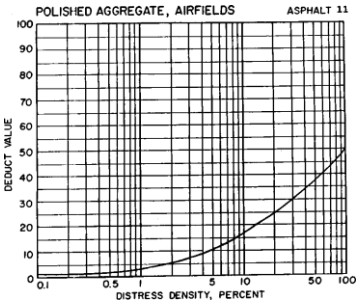

Figure 5. Block Cracking

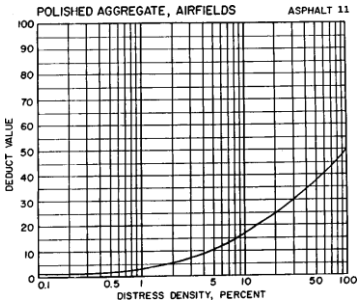

Figure 6. Polished Aggregate

3) Calculate the Allowable Reduction Value (mi)
4) Calculate the total Reduction Value and Corrected Reduction Value

2.1.3. Types of Flexible Pavement Damage

1) Longitudinal and Transverse Cracks

Longitudinal cracking occurs in line with the road axis while transverse cracking occurs perpendicular to the road axis. Individual cracks (not interconnected) that extend along the pavement. These cracks can be seen as one or several parallel cracks. The following are factors that cause damage:

a. Changes in the level of subgrade settlement.
b. Lateral shrinkage in the surface layer caused by temperature changes.
c. Longitudinal joints are too close to the track.
d. Transverse or longitudinal joints are too shallow.

Here is a picture of longitudinal and transverse cracking damage:

Picture 7. Longitudinal and Transverse Cracks

2) Crocodile Skin Cracks

Crocodile cracks have two levels of damage, namely low damage with characteristics of a series of fine cracks connected without broken cracks, and medium damage, namely medium damage characterized by a series of cracks connected that form squares and small patterns. Severe (high) damage is characterized by cracks resembling cost skin where all the cracks are broken. If left untreated, this can cause roots and even holes. The Cause of Damage Factors is Swelling, or liquefaction, of hard soil that was initially intact will affect the base soil if groundwater is controlled, making the layer unable to withstand the pressure load given. As a result, there is a decrease in the road body, which then develops into fine cracks, which over time turn into cracks similar to crocodile skin. Here is a picture and table of crocodile skin damage.

Figure 8. Crocodile Skin Cracks

3) Grain Release

Grain release (raveling), namely the asphalt pavement surface, by continuously releasing aggregate particles from the edge of the pavement inward or from the pavement surface downward. This damage often occurs because the aggregate is easily absorbent, its compaction is not good because it is done during the rainy season, and the asphalt layer material mixture is insufficient. After the damaged layer is cleaned and dried, an additional layer can be applied on top of it to repair it. The following is a picture and table of the level of grain release damage:

Figure 9. Grain Release Damage

4) Block Cracks

Block cracks usually occur in large asphalt areas that are rarely passed by traffic and consist of large blocks that are interconnected with side sizes between 0.20 and 3 meters. Crocodile skin cracks have a smaller shape and more sharp-angled fragments than this damage. Causes of damage include:

a. Volume changes in asphalt mixing with high fine aggregate content originating from low-penetration asphalt and easily absorbent aggregates. b) There are things that are influenced by the daily temperature cycle and asphalt hardening.
b. Cracks 1 are caused by fatigue on the asphalt surface/layer as shown in the following picture in the form of block crack damage:

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Figure 10. Block Crack Damage

5) Holes

due to a poor mixture of surface layer materials, such as bowl-shaped holes that collect and absorb water into the surface layer, causing more severe road damage. This hole can happen

a. Low asphalt content so that the asphalt film is thin and easily separated;
b. Dirty aggregate so that the bond between asphalt and aggregate is poor; And
c. If the surface layer is thin and the drainage system is poor, a lot of water will seep in and collect on the surface layer, so that the water seeps in and causes damage to the walls. The following describes the depth of hole damage:

Figure 11. Hole Damage

2.1.4. Budget Cost Planning Procedure

cost budget plan, is part of the development planning process, where a budget for development costs is made before the project begins. In calculating the building cost budget, it is necessary to conduct a detailed analysis or calculation of the amount of materials used and workers' wages. Calculating the volume of work will be easier. From here, the total price of materials/wages for all relevant work is calculated.

3. METHODOLOGY

The following is a flowchart in this study.

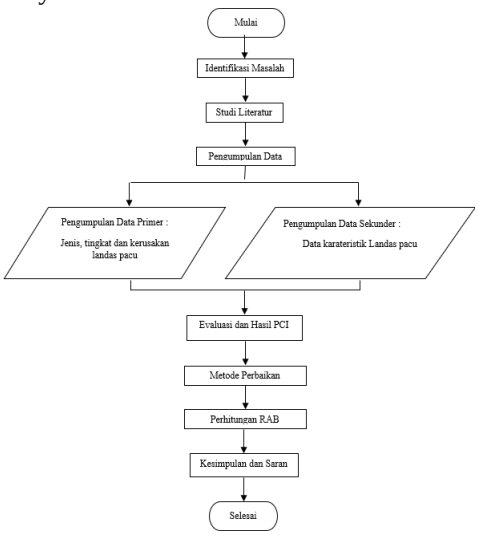

Figure 12. Research Flowchart

3.1. Method Used

The author uses a descriptive analysis method in compiling this final assignment. Descriptive research aims to collect information about existing phenomena (based on the status of the phenomenon at the time of the study). Descriptive research also analyzes existing issues based on standard theories that will be discussed in the field.

3.2. Data Collection

Data collection can be done in two stages: directly through observation and directly through analysis of relevant data at Sultan Muhammad Kaharuddin Airport, Sumbawa. The following are secondary data needed, namely the character of the runway data and the review of field conditions.

4. RESEARCH RESULTS

Maintenance Planning and How to Handle Repairs, According to KP 94 of 20151 concerning Airport Pavement Construction Maintenance, the following are repair methods that are appropriate to the type and level of damage to the pavement construction.

4.1. How to repair Ravelling/Weathering cracks

1. In cases of minor damage, where there are no cracks and the problem occurs in non-critical areas, regular cleaning and monitoring are required.
2. In cases of moderate to severe damage in limited areas, local cutting or patching should be done perpendicular to the thickness of the surface layer. Hot asphalt mix (AC/ATB) is then applied according to the technical specifications and implementation methods. If weathering and loose aggregates cover a large area, recoating or overlaying can be done after first treating the existing layer.

4.2. How to repair Alligator Cracking

If the crack width is less than 3 mm (in light conditions), it can be sealed with asphalt emulsion for temporary or emergency repairs. In moderate conditions, the pavement area that experiences alligator cracks due to water seepage into the foundation and subgrade must be repaired by cutting and removing the wet part. After that, the area must be re-coated with material that meets the technical specifications and implementation procedures.

The cracked area should be cut or patched locally perpendicular to the thickness of the surface layer 1 and filled with hot asphalt mixture (AC/ATB) according to the technical specifications and implementation methods. After that, an additional layer should be applied to increase the load-bearing capacity.

4.3. Calculation of Maintenance and Repair Volume

Based on the analysis of PCI results at Sultan Muhammad Kaharuddin Airport, there are 18 samples to be repaired, and 2 types of damage have been identified. The following are the areas found in the samples.

Table 2. Total Area of Damage

NO	TYPE OF DAMAGE	TOTAL AREA (m^2)
1.	*Raveling/Weathering*	2695
2.	*Alligator Crack*	305.6
Overall Total		3.001

Table 3. Area of Damage Repair

NO	TYPE OF REPAIR	TOTAL AREA (m^2)
1.	*Patching*	3.001
Overall Total		3.001

4.4. Calculation of Budget Plan

The calculation of the estimated cost is based on the Regional Unit Price Standard of West Nusa Tenggara Province for the 2024 Fiscal Year, as per Presidential Regulation No. 33 of 2020 concerning Regional Unit Price Standards. With the Governor's Decree concerning the Unit Price Standard of West Nusa Tenggara Province for the 2024 Fiscal Year, as well as PM 78 concerning Cost Standards within the Ministry of Transportation, with sidewalk analysis using the PCI method.

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Table 4. Calculation of Budget Plan

RENCANA ANGGARAB BIAYA (RAB)					
Pekerjaan	:	Perbaikan Perkerasan Landas Pacu			
Lokasi	:	UPBU Sultan Muhammad Kaharuddin Sumbawa			
Tahun	:	2023			
NO	**URAIAN PEKERJAAN**	**SAT**	**VOL**	**HARGA SATUAN**	**JUMLAH HARGA**
1	2		4	6	7
I	**PEKERJAAN PERSIAPAN**				**69.279.833**
1	Mobilisasi dan Demobilisasi	ls	1,000	23.806.220	23.806.220,00
2	Pengukuran	M2	3.001	15.154,840	45.473.612,90
II	**PEKERJAAN PATCHING**				**7.660.254.842**
1	Pembongkaran dan Pembuangan Aspal	M3	150	51.579	7.738.436,38
2	Tack Coating	M2	3.001	215.663	647.117.227,57
3	Aspal Beton (AC) tebal 5 cm	M2	3.001	2.334.666	7.005.399.177,68
III	**PEKERJAAN AKHIR**				**4.187.367**
1	Pembersihan Akhir	M2	3.001	1.396	4.187.367,31
					-
	Jumlah				7.733.722.041,83
	PPN 11%				850.709.424,60
	Total Jumlah				8.584.431.466,43
	Dibulatkan				8.585.000.000,00
Terbilang : Delapan Milyar Lima Ratus Delapan Puluh Lima Juta					

5. DISCUSSION

The calculated PCI value is used as a benchmark in determining the condition of the pavement in each sample to determine the type of appropriate treatment. The following are the results of the PCI calculation value along with the categories in each sample on the Sultan Muhammad Kaharuddin Sumbawa Airport Runway.

Table 5. PCI Calculation Results

No	STA	PCI	Tingkat Kerusakan	Jenis Kerusakan
1	0+000 - 0+100	46	CUKUP	*Aligator Crack*
2	0+100 - 0+200	44	CUKUP	*Weathering and Raveling*
3	0+200 - 0+300	40	CUKUP	*Weathering and Raveling*
4	0+300 - 0+400	40	CUKUP	*Weathering and Raveling*
5	0+400 - 0+500			
6	0+500 - 0+600	60	BAIK	*Weathering and Raveling*
7	0+600 - 0+629	75	BAIK	*Weathering and Raveling*
	0+681 - 0+700	48	CUKUP	*Weathering and Raveling*
8	0+700 - 0+750	70	BAIK	*Weathering and Raveling*
	0+750 - 0+760	80	SANGAT BAIK	*Weathering and Raveling*
	0+760 - 0+800			
9	0+800 - 0+810	58	BAIK	*Weathering and Raveling*
	0+839 - 0+849	58	BAIK	*Weathering and Raveling*
	0+849 - 0+890			
	0+890 - 0+900	58	BAIK	*Aligatpr Crcak*
10	0+900 - 0+910	58	BAIK	*Weathering and Raveling*
	0+950 - 0+960	40	CUKUP	*Aligatpr Crcak*
	0+960 - 1+000			
11	1+000 - 1+100	44	CUKUP	*Weathering and Raveling*
12	1+100 - 1+200	55	CUKUP	*Weathering and Raveling*
13	1+200 - 1+250	80	SANGAT BAIK	*Aligator Crack*
	1+250 - 1+300			
14	1+300 - 1+350	48	CUKUP	*Weathering and Raveling*
	1+350 - 1+400			
15	1+400 - 1+450			
	1+450 - 1+500	65	BAIK	*Weathering and Raveling*
16	1+500 - 1+550	80	SANGAT BAIK	*Weathering and Raveling*
	1+550 - 1+600			
17	1+600 - 1+700			
18	1+700 - 1+800			

Based on FAA AC 150/5320-6G, pavement with a PCI value of more than 70 is handled with routine checks; for pavement with a PCI value of less than 70 and more than 55, rehabilitation or repair can be carried out, while for PCI values below 55, reconstruction is required. However, sometimes reconstruction is needed at PCI values greater than 55 and rehabilitation at PCI values less than 55 according to the conditions in the field.

From the results of the analysis using the Pavementi Condition Index (PCI) method on the runway of Sultan Muhammad Kaharuddin Sumbawa Airport, it can be seen that STA 0+000–1+800 shows that the overall surface condition produces an average PCI value of 62.44% with a sufficient scale.

6. CONCLUSION AND RECOMMENDATION

6.1. Conclusion

Based on the results of the evaluation of the flexible pavement conditions of the Sultan Muhammad Dkaharuddin Sumbawa airport runway using the Pavementi Condition Index (PCI) method, the following conclusions can be drawn:

1. The value of the pavement condition using the PCI method was obtained on average 63.72% in the good scale category with damage almost on the entire surface of the runway, namely raveling/weathering and alligator crack.
2. obtained in this study can change. This change is caused by several things, such as a decrease in functional conditions (the emergence of new damage), patching work, or new construction. So in this case, it is

recommended to conduct PCI surveys or research periodically and routinely with the support of weakness data.

3. The budget plan obtained from the calculation for repairs is estimated to be worth Rp. 8,585,000,000.00

6.2. Recommendations

From the conclusions that have been presented, the following are recommendations that can be taken:

1. Improve maintenance and repairs are carried out immediately so that the damage that occurs in the runway area of Sultan Muhammad Kaharuddin Sumbawa Airport does not get worse because it is related to flight operation safety.
2. Further research is expected to obtain information on further pavement conditions and use other methods to compare the effectiveness of the analysis for pavement conditions.

FURTHER RESEARCH

Every study certainly has limitations. Therefore, it is recommended that further research take into account other factors such as weather, rainfall, and other related variables to obtain more comprehensive and in-depth results.

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