PLANNING OF RUNWAY PAVEMENT REHABILITATION USING THE PAVEMENT CONDITION INDEX (PCI) METHOD AT ATUNG BUNGSU AIRPORT, PAGAR ALAM, SOUTH SUMATRA

Arya Wahyu Dwi Kusumo [1], Agus Triyono [2], Ranatika Purwayudhaningsari [3]

[1,2,3] *Politeknik Penerbangan Surabaya*
[*]*Corresponding author. Email: author@example.com*

ABSTRACT
The airside facility of Atung Bungsu Pagar Alam Airport has a runway of 1500 meters and a width of 30 meters with a PCN of 24 F/C/X/T. Pagar Alam Atung Bungsu Airport currently has a problem, namely the presence of Loss Material that occurs on almost the entire runway surface. The purpose of this study was to analyze the condition of the runway pavement using the PCI (Pavement Condition Index) method. PCI is a runway pavement assessment system based on the type, level, and extent of damage that occurs, and can be used as a maintenance effort.
In assessing the condition of the runway using the Pavement Condition Index (PCI) method, data on the characteristics of the runway and direct field conditions are used. The calculation is done by dividing the runway into several segments, namely every 100 m. Then, each segment is observed (visually) and measured to identify the type of damage that exists and conduct an assessment according to the PCI method.
The results of this study indicate that the overall average value of the runway STA of Atung Bungsu Airport is 33.83 with a poor category. The maintenance program includes an overlay with a thickness of 5 cm and the need for routine and scheduled supervision at each STA so that the budget plan for the overlay cost is estimated at Rp. 14,066,667,092.16 (Fourteen Billion Sixty Million Six Hundred Sixty Seven Ninety Two Point Sixteen) based on the basic unit price of wages and construction materials of the Pagar Alam City Government in 2024 and PM 78 of 2014.

Keywords: *Runway, Material Loss, Analysis, Pavement Condition Index.*

1. FIRST LEVEL HEADING (HEAD 1)

One of the pioneer airports in South Sumatra Province is Atung Bungsu Airport, located in Pagar Alam City. It features a runway measuring 1,500 meters in length and 30 meters in width (AIP, n.d.). Despite its vital role in enhancing regional accessibility, the runway currently suffers from surface deterioration, including weathering and raveling, caused by aircraft traffic loads and environmental factors (Directorate General of Civil Aviation, 2015). If left unaddressed, such damage may accelerate pavement degradation and reduce service levels. Therefore, a pavement condition evaluation method is needed—one that not only identifies the extent of damage but also provides a technical basis for repair decision-making (Directorate General of Civil Aviation, 2019). Runway pavement damage can compromise service quality, increase accident risk, and raise operational costs due to urgent maintenance needs (Directorate General of Civil Aviation, 2005). This condition also affects the reliability of air transport services, which are crucial to regional economic development.

The Pavement Condition Index (PCI) method, recommended by the Federal Aviation Administration (2014), has become an international standard for pavement condition assessment. Since its introduction by Shahin (2005), PCI has been widely used to evaluate both road and airport pavements due to its ability to provide easily interpretable quantitative assessments. Previous studies have demonstrated the effectiveness of this method, including those by Ashakandari (2016), Mubarak (2016), Bolla (2012), and Prakosa (2018), which show that PCI yields more objective evaluation results compared to conventional inspection methods. Furthermore, a recent study by Politeknik Penerbangan Surabaya, Fatimah, Rozi, and Surabaya (2022) confirmed that PCI can be effectively applied to runway pavement analysis at pioneer airports.

However, most prior research has focused on large-scale airports with high traffic intensity. The application of PCI at pioneer airports such as Atung Bungsu remains relatively rare, even though smaller airports often face resource and budget constraints in infrastructure maintenance. This research gap highlights the need for studies that adapt the PCI method to the context of regional airports in Indonesia, enabling more targeted and efficient maintenance strategies.

The novelty of this study lies in the direct application of the PCI method to Atung Bungsu Airport, with a focus not only on pavement damage analysis but also on the development of a cost estimation plan based on the Unit Cost of Activity (HSPK) of Pagar Alam City and applicable pavement maintenance regulations. This approach provides both technical evaluation and economic justification for decision-making.

The objectives of this study are to evaluate the runway pavement condition at Atung Bungsu Airport using the PCI method, identify the types and severity levels of damage, determine appropriate repair methods, and develop a cost estimation plan. The results are expected to contribute meaningfully to runway maintenance efforts at pioneer airports, while also supporting improvements in aviation safety, comfort, and operational efficiency. Academically, this research may serve as a reference for similar studies at other small airports in Indonesia facing comparable infrastructure maintenance challenges.

2. METHODOLOGY

This study adopts a quantitative approach with a descriptive-analytical design, aiming to evaluate the runway pavement condition at Atung Bungsu Airport in Pagar Alam using the Pavement Condition Index (PCI) method.

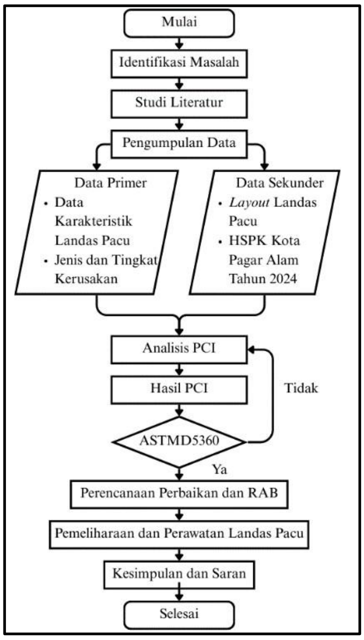

Figure 1. Flowchart of Planning

As illustrated in Figure 1, the conceptual framework is based on analyzing the relationship between the severity of pavement distress and the planning of maintenance needs and repair costs. In general, the research flow includes a literature review, field data collection, pavement condition analysis using the PCI method, determination of appropriate repair strategies, and preparation of a cost estimation plan (Shahin, 2005; ASTM, 2020).

The research population comprises the entire runway area of Atung Bungsu Airport, which measures 1,500 meters in length and 30 meters in width, resulting in a total area of 45,000 m^2. From this population, the research sample consists of pavement study units determined according to the segment division standards of the PCI method, ensuring that each unit has a representative area for analysis. This sampling technique is designed to yield accurate results while maintaining efficiency in field survey implementation. Through this approach, each pavement unit can quantitatively reflect the overall condition of the runway.

Research data were collected using two primary methods: literature review and field observation. The literature review involved examining relevant documents, journals, standards, and regulations, such as KP 94 of 2015 on airport pavement maintenance (Directorate General of Civil Aviation, 2015), SKEP/77/VI/2005 on technical standards for pavement (Directorate General of Civil Aviation, 2005), and PM 78 of 2014 concerning cost standards within the Ministry of Transportation (Minister of Transportation of the Republic of Indonesia, 2014). Field observations were conducted directly on the runway of Atung Bungsu Airport to identify the types, locations, and severity levels of pavement distress (AIP, n.d.; AM, n.d.). The research subject is the runway pavement area measuring 1,500 meters by 30 meters, while the unit of analysis consists of pavement segments divided according to the PCI method standard (Federal Aviation Administration, 2014).

Pavement condition analysis was carried out using the Pavement Condition Index (PCI) method, a quantitative assessment system that produces an index value ranging from 0 to 100 to represent pavement condition (Shahin, 2005). A value of 0 indicates a failed condition, while a value of 100 indicates excellent condition. The assessment involves identifying the types of distress, severity levels (low, medium, high), and the extent of damage (Bolla, 2012; Ashakandari, 2016). The predominant types of damage found on the runway at Atung Bungsu Airport are weathering and raveling, caused by aggregate loss and asphalt binder degradation (Mubarak, 2016; Prakosa, 2018).

The PCI analysis is conducted systematically. The first step involves calculating the Density, or the percentage of damaged area relative to the total area of the study unit, using the following formula:

$$\textbf{\textit{Dencity}}\ (\%) = \frac{A_d}{A_s} \times \mathbf{100} \qquad (1)$$

Where *Ad* represents the damaged area (m²) and *As* is the total area of the study unit (m²).

Second, determine the Deduct Value (DV) based on the curve that relates distress density to severity level. Third, calculate the Total Deduct Value (TDV), which is the sum of all DV values within the study unit. Fourth, adjust the TDV to obtain the Corrected Deduct Value (CDV) using the curve that correlates TDV and CDV (Shahin, 2005). Fifth, calculate the PCI value for each study unit using the following formula:

$$\boldsymbol{PCI = 100 - CDV} \qquad (2)$$

The average PCI value from all study units serves as a representation of the overall runway pavement condition. Previous studies have also employed similar approaches to determine maintenance strategies for both roads and airports (Ashakandari, 2016; Mubarak, 2016; Politeknik Penerbangan Surabaya, Fatimah, Rozi, & Surabaya, 2022).

Interpretation of PCI values refers to standard classification criteria (see Table 3.1), where a score of 0–10 is categorized as failed, 11–25 as very poor, 26–40 as poor, 41–55 as fair, 56–70 as good, 71–85 as very good, and 86–100 as excellent. This classification is essential for determining the appropriate type of repair. For example, pavements in fair condition may be treated with an overlay, while failed conditions require full reconstruction.

Table 1. PCI Rating Classification

PCI VALUE RANGE	CONDITION
0 - 10	*Failed*
11 - 25	*Very Poor*
26 - 40	*Poor*
41 - 55	*Fair*
56 - 70	*Good*
71 - 85	*Very Good*
86 - 100	*Excellent*

Based on the PCI analysis results presented in Table 1, the repair methods were selected with reference to KP 94 of 2015 concerning airport pavement maintenance (Directorate General of Civil Aviation, 2015). Several repair alternatives include crack sealing and filling, overlay, patching, and full reconstruction, depending on the severity level of the damage. Additionally, drainage aspects are considered a critical component of maintenance efforts to prevent recurring damage (Directorate General of Civil Aviation, 2019).

The maintenance budget planning is formulated based on the volume of damage identified through the PCI survey. Cost estimates are calculated using the 2024 Unit Cost of Activity (HSPK) for Pagar Alam City and the Minister of Transportation Regulation No. 78 of 2014 (Minister of Transportation of the Republic of Indonesia, 2014). Through this approach, the research not only provides a technical assessment of pavement conditions but also offers financial recommendations that can serve as a basis for airport management decision-making.

This study was conducted at Atung Bungsu Airport, located in Mingkik Village, Dempo Selatan District, Pagar Alam City, South Sumatra Province. The research period spanned from late 2024 to mid-2025, covering the stages of problem identification, data collection, PCI analysis, repair planning, and report preparation (AIP, n.d.; AM, n.d.). The complete research activity schedule is presented in Table 2.

Table 2. Research Period

Kegiatan	2024			2025						
	10	11	12	01	02	03	04	05	06	07
Identifikasi Masalah	■	■								
Studi Literatur		■	■	■						
Pengumpulan Data			■	■	■	■				
Analisis dan Hasil PCI						■	■	■		
Perencanaan Perbaikan								■	■	
RAB dan Perawatan Landas Pacu									■	■
Kesimpulan dan Saran										■

With this methodological approach, the study is expected to produce a comprehensive evaluation that effectively links the actual pavement condition with technical maintenance strategies and accountable cost estimations.

3. RESULT / DISCUSSION

Field survey results indicate that the runway pavement at Atung Bungsu Airport exhibits predominant damage in the form of weathering and raveling across nearly all segments, from STA 0+000 to STA 1+500. The inspection was conducted by dividing the 1,500-meter runway into 15 sample segments, each measuring 100 meters in length and 30 meters in width (see Figure 3). Visual documentation was used to capture the actual surface distress conditions.

Figure 3. Number of Samples (Left); Damage Examples (Right)

The types and dimensions of damage were recorded in detail, as presented in Table 3 below.

Table 3. PCI Rating Classification

Further analysis of each segment indicates that the extent of damage is not entirely uniform. Several segments near the runway threshold, particularly STA 0+000 to STA 0+300, tend to have lower PCI values compared to the central segments. This can be attributed to the threshold area frequently receiving aircraft wheel loads during landing and take-off, where repeated stress accelerates pavement degradation. Additionally, the presence of suboptimal drainage systems along the runway edges allows rainwater to accumulate more easily, exacerbating stripping and aggregate loss.

The Pavement Condition Index (PCI) method was applied to each segment, considering the damage area, severity level, deduct value, and corrected deduct value. The analysis results show that PCI values across nearly all segments fall within the "poor" category, ranging from 30 to 33. Only one segment, STA 1+400 to STA 1+500, recorded a PCI value of 100, classified as "excellent" (see Table 4.31 and Figure 4.33). Therefore, the overall condition of the runway is generally categorized as "poor" and requires immediate corrective action.

The average PCI value of 33.83 confirms that Atung Bungsu runway is approaching the critical threshold that may compromise flight safety. According to FAA standards (2014), a PCI value below 40 is considered a high-priority case for rehabilitation. Delays in overlay implementation may increase the risk of Foreign Object Damage (FOD) to aircraft engines, potentially resulting in economic losses and reputational harm to the airport operator.

Based on the findings, the appropriate repair method refers to KP 94 of 2015 concerning airport pavement maintenance, recommending a 5 cm overlay. This method was selected considering the widespread and severe material loss. Prior to overlay application, the existing surface layer must be cleaned of debris and dust through initial treatment to ensure proper bonding of the new layer.

The decision to apply a 5 cm overlay aligns with Mubarak's (2016) study on urban roads experiencing similar raveling, where overlay proved more effective than partial patching. In the airport context, this method is also supported by research from Politeknik Penerbangan Surabaya et al. (2022), which demonstrated that overlay on runways with PCI < 40 can extend service life by up to 10 years when accompanied by routine maintenance programs. Thus, the overlay recommendation is not only technically sound but also economically viable in the medium term.

No	Uraian Pekerjaan	Volume	Satuan	Harga Satuan (Rp)	Jumlah Harga (Rp)
1	Pengukuran	42,000	m2	Rp4,150.00	Rp174,300,000.00
2	Pembersihan	42,000	m2	Rp5,890.00	Rp247,380,000.00
3	Tack Coating 1,5kg	42,000	m2	Rp95,633.30	Rp4,016,598,600.00
4	Overlay Aspal Penetrasi Tebal 4cm Padat	42,000	m2	Rp178,393.30	Rp7,492,518,600.00
5	Pengecatan / Marking	3,414	m2	Rp217,304.00	Rp741,875,856.00
				JUMLAH	**Rp12,672,673,056.00**
				PPN 11%	**Rp1,393,994,036.16**
				TOTAL	**Rp14,066,667,092.16**
				PEMBULATAN	**Rp14,070,000,000.00**

Figure 4. Overlay Cost Estimation Results

From a managerial perspective, the substantial budget requirement of approximately IDR 14 billion presents a significant challenge for the local government, given the limitations in budget allocation. Therefore, a phased repair strategy may be designed, starting with segments exhibiting the most severe damage. An alternative approach involves submitting a funding proposal to the Ministry of Transportation to ensure that the runway rehabilitation project does not fully burden the regional budget. A partnership scheme with airlines operating in Pagar Alam may also be considered, as improvements in safety and comfort will positively impact all stakeholders.

The cost estimation for the overlay work was based on the 2024 Pagar Alam City Standard Activity Unit Prices (HSPK) and PM 78 of 2014. The calculation results indicate that the total cost required for the overlay work amounts to IDR 14,066,667,092.16 (fourteen billion sixty-six million six hundred sixty-seven thousand ninety-two point sixteen rupiah) (see Table 4.32). This estimate reflects the significant scale of resource needs for the airport operator to restore optimal runway functionality.

The findings of this study directly address the objectives outlined in the Introduction. First, the pavement condition evaluation shows that the majority of the runway falls into the "poor" category with PCI values below 40, indicating severe material degradation. Second, the appropriate repair method is overlay, in accordance with KP 94/2015, which stipulates that widespread material loss cannot be resolved through localized patching alone. Third, the repair cost estimation has been calculated, making this study both technically and financially applicable for airport management.

Scientifically, the identified damage types—weathering and raveling—are the result of asphalt binder degradation and aggregate particle dislodgement. This phenomenon aligns with pavement theory as proposed by Shahin (1994) and research by Miah (2020), which indicate that such damage typically occurs on runways subjected to aircraft load intensity and environmental factors affecting pavement quality. The low PCI values suggest a significantly reduced service life, and without repair intervention, flight safety risks may increase.

Compared to similar studies, this research shares common findings. For instance, studies at several pioneer airports in Southeast Asia also reported PCI values below 40 due to dominant raveling damage on asphalt layers. However, this study differs in its context: Atung Bungsu Airport is a pioneer airport with low flight frequency, which should theoretically experience lighter structural loads than major airports. The fact that PCI values remain low indicates that maintenance and environmental conditions play a more dominant role in damage progression than aircraft traffic volume.

This study offers practical implications for airport operators. By quantifying pavement conditions, operators can better prioritize maintenance budgets. Additionally, the findings reinforce the urgency of routine inspections, as recommended in KP 94/2015, to detect damage early before it worsens. Academically, this research fills a gap in the literature regarding PCI method application at pioneer airports in Indonesia, which has received limited attention in pavement studies.

The findings also highlight the importance of preventive maintenance. If corrective actions have traditionally been taken only after damage becomes extensive, this approach should be replaced with periodic inspections, routine cleaning, drainage improvements, and crack sealing to prevent further deterioration. Implementing a preventive maintenance model will help reduce long-term costs and enhance airport operational reliability. This aligns with KP 94/2015 recommendations, which emphasize the need for a Pavement Management System (PMS) at every airport, including pioneer airports.

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