RUNWAY RELIABILITY ANALYSIS USING THE PAVEMENT CONDITION INDEX (PCI) METHOD AT YOGYAKARTA INTERNATIONAL AIRPORT

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ABSTRACT

Yogyakarta International Airport has airside facilities, namely a runway with a length of 3,250 meters and a width of 45 meters with a pavement strength of PCN 89 F/C/X/T. Yogyakarta International Airport currently has a runway pavement age of 5 years, where in pavement maintenance activities, pavement condition index values have never been tested during the life of the pavement. This study aimed to analyze the runway pavement condition at Yogyakarta International Airport using the Pavement Condition Index (PCI) method. The research methodology is qualitative descriptive, with data collection carried out by observation, interviews, documentation, and literature studies. The data analysis technique used is a comparative technique. The study results showed that the runway of Yogyakarta International Airport had a value of 99.7 based on the PCI calculation. However, there was still some damage, the most being the loose material with an area of 25.55 m2. The results of this study obtained measured values of pavement conditions and damage conditions on the pavement so that they can be used as a reference for the runway repair process. This research concludes that Yogyakarta International Airport is classified as good in accommodating operational activities.

Keywords: *Runway, Pavement Condition Index, Safety*

1. INTRODUCTION

Safety is the primary key in aviation. Aviation safety is a condition when all safety provisions and regulations in the use of aircraft, airspace, and air transportation are complied with; then, it can be said that the condition is in a state of aviation safety. [1]

Airports are required to conduct safety standard checks on flights, one of which is by conducting routine checks on the air side. Runway inspection activities are very important because the runway is the area most often used in flights. Airside inspections with airside inspections are necessary because they aim to ensure that the airport complies with flight safety standards set by civil aviation authorities and other regulatory bodies [2].

The runway at the airport must be strong enough to accommodate the movement and load of aircraft passing through. The increase in the number of passengers will have an impact on the increase in aircraft traffic at the airport. [3]. Runway maintenance is needed to maintain the runway performance requirements during its design life and ensure the safety and comfort of existing flights. [4].

Based on the author's observations during On The Job Training and secondary data from the 2022 inspection report, it is known that Yogyakarta International Airport (YIA) conducts inspections 3 (three) times a day, namely before operations, during operations, and after operations. Pre-operational inspections are carried out before flights start, operational inspections during the day when there are no flights, and post-operational inspections after the last flight. The inspections carried out are manual inspections by technicians that check the condition of the runway pavement surface, Foreign Object Debris, referred to as FOD in the future, types of damage, obstacles, markings, and pavement temperature. Inspection activities are included in the runway safety program, namely efforts or activities to prevent aircraft accidents. [5].

Based on data from the YIA Pavement Management System (PMS) Pavement Construction Maintenance Program in 2021 and 2022, Yogyakarta International Airport (YIA) has carried out pavement maintenance activities, namely serviceability inspections, runway surface roughness testing (skid resistance), and cleaning rubber deposits. One of the activities that has not been carried out at Yogyakarta International Airport (YIA) is a pavement condition index survey using the Pavement Condition Index (PCI) method in the age of its runway pavement. The pavement condition index survey is carried out as a preventive maintenance inspection. Based on KP 94 of 2015, it is explained that the Federal Aviation Administration (FAA) recommends using ASTM D5340 Concerning Airport Pavement Condition Index Surveys in calculating the pavement condition

index. The PCI method determines the value of runway pavement conditions based on the type and category of damage. The PCI method has 3 (three) criteria: type of damage, category of damage, and amount or density of damage. From the results of the PCI study, the pavement condition index can be determined based on the type of damage to the runway.

Based on movement data from the Airport Pavement Management System (APMS) in 2023, YIA Airport, in the last three years, has experienced an increase in the number of flights from 2020 to 2023, namely 18,853 flights with a percentage of 159.48% from 2020. High flight intensity affects the use of the runway, which can affect the pavement layer on the runway surface [6]. Flight service providers, namely airports, must ensure the readiness of the airport to serve flights. Airports are required to guarantee the safety and security of passengers who will fly at the airport [7]In this study, the authors obtained data on damage in the field during the on-the-job training activity by conducting a direct survey in the field. They then calculated the damage value to determine the runway's PCI value. The calculation of this PCI value is to determine the runway's condition in the field, which will be used for further analysis to ensure its reliability.

Runway

Based on Annex 14 Aerodrome, a runway is a surface area prepared for the takeoff or landing of an aircraft. [8]The runway is the core structure of an airport, and it functions as a runway for aircraft to take off and land. The load on the runway varies because it is only used for landing and take-off activities, unlike the apron used to park aircraft, which has a fixed load. [9] The runway has characteristics and features: length, width, direction, and pavement structure. The runway has facilities such as markings, lighting systems, and signs to identify and guide pilots when landing, taking off, and taxiing. The following are supporting facilities for the runway.

Flexible Pavement

Pavement consists of several layers of surfaces with different bearing capacities to accommodate the loads above them. The pavement on the runway is created to help flights with a safe surface for flights in any weather conditions, and the thickness of each layer must be able to accommodate aircraft passing over it without damaging the pavement layer below for the safety of flight operations. [10]. Setiap lapisan dalam struktur perkerasan lentur harus mampu melindungi lapisan pendukung dibawah ataupun diatasnya.

Pavement Condition Index (PCI) Method

The PCI method is used to determine the value of the pavement surface. The PCI method can be used to calculate the runway's pavement condition. The PCI analysis method carried out with periodic surveys can be a reference for a more detailed periodic condition curve. [11]. Based on KP 94 of 2015, the inspection guidelines for airside infrastructure pavement, pavement condition index survey (Pavement Condition Index), the pavement test method refers to ASTM D 5340 Standard Test Method for Airport Pavement Condition Index Surveys. PCI is a numeric indicator that reflects the structural value and operational condition of a pavement surface [12]. The PCI value is an indicator in the process of evaluating damage to pavement. [13]The PCI method assesses airside facilities, especially runway pavements, to subjectively evaluate pavement conditions, determine pavement maintenance, and compile rehabilitation needs. [13].

Pavement Condition Index

PCI is a method for determining the value of pavement surface conditions against damage to the pavement. The final PCI value is a numeric index that has a value ranging from 0 to 100. The value in PCI has a value parameter between 0 - 100, reflecting the pavement surface's condition from very bad to very good. A value of 0 indicates that the pavement is damaged and requires repair, and a value of 100 indicates that the pavement is good and does not require repair. The PCI value is obtained from the calculation of the pavement condition based on the type of damage obtained from the results of the visual condition survey at the time of observation. In calculating the PCI method, pavement damage is determined in 3 parameters: Type of damage, severity of damage, and density or size of damage.

PCI Calculation

PCI calculation is based on ASTM D 5340-12 regulations on Standard Test Methods for Airport Pavement Condition Index Surveys. The stages in calculating the PCI value start from Damage Identification, which determines the type and extent of damage and then processes the damage data by calculating the distress density. The results of the calculation of distress density get the deduct value (DV). After obtaining the deduct value, all the deduct values are added to get the Total Deduct Value (TDV). After obtaining the Total Deduct Value, the Corrected Deduct Value is determined with a graph of the relationship between the Total Deduct Value and the Corrected Deduct Value. The Corrected Deduct Value is used to reduce the final PCI value. PCI calculations are carried out per segment, where the total PCI value is the average value of each segment. The following are the stages in PCI research.

a. *Determine the Sample Unit*

Determining the number of samples is needed to determine the minimum number of samples before calculating and determining the type of damage. Calculations are carried out to determine the minimum number of samples. Determining the sample unit (n) refers to the ASTM D 5340-12 regulation on the Standard Test Method Pavement Condition Index. [14] For sample determination with sample unit area using the equation (450 ± 180 m2). The calculation of sample units is done with the following equation:

$$n = \frac{N\,s2}{\frac{e2}{4}(N-1)+s2} \quad (1)$$

with:

N = total number of sample units in a pavement section,

e = permissible error in the estimation of the section PCI (e = 5)

s = standard deviation of PCI between sample units within the section (for flexible pavement, s = 10)

n = minimum number of sample units

b. *Indentifying the Type of Damage*

Damage is determined during observation by determining the type of damage. Based on ASTM D 5340-12, there are 16 types of flexural pavement damage, namely alligator cracking, bleeding, block cracking, corrugation, depression, jet blast, oil spillage, joint reflection, longitudinal and transverse cracking, patching, polished aggregate, rutting, shoving, slippage cracking, swell, weathering, and ravelling. Observations are made by determining the level of damage; the level of damage is three levels, namely Low Severity Level (L), Medium Severity Level (M), and High Severity Level (H) [14].

c. *Menghitung Nilai Density*

Density is a percentage value obtained by dividing the total area of each type of damage by the area of the calculation location of each sample unit based on the type of damage. The calculation is carried out using the following formula to calculate the density value.

$$Density = \frac{Ad}{As}\ x\ 100\% \quad (2)$$

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$$Density = \frac{Ld}{As}\ x\ 100 \quad (3)$$

with:

Ad = Total area of damage type for each damage level (m^2)

Ld = Total length of damage type for each damage level (m)

As = Total area of segment unit (m^2).

d. *Calculate the Deduct Value*

Deduct Value is the reduction value of each type of damage obtained from the relationship curve between Density and Deduct Value. An example of a DV graph can be seen in the following image.

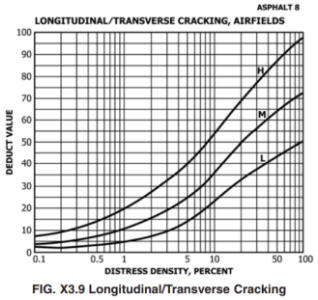

Figure 1. 1 DV Graphics

Source: ASTM D 5340-12

e. *Determining Total Deduct Value (TDV) and Corrected Deduct Value (CDV)*

TDV is the total value of each deductible in a calculation sample. CDV is the final value used for deduction in determining the sample's PCI value. CDV is obtained from the relationship curve between TDV and CDV values by determining the value according to the curve with the number of deduct values. The CDV value can be determined from the graph in the following Figure.

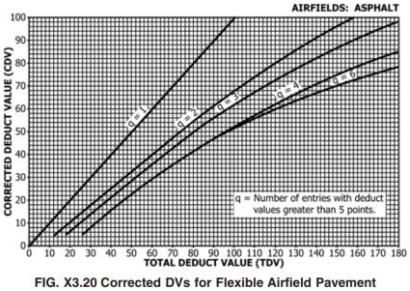

Figure 1. 2 TDV Graphics

Source: ASTM D 5340-12

f. *PCI Value Determination*

The next step is determining the PCI value by subtracting the known CDV value. The PCI value for each unit can be found using the equation below:

$$PCI(s) = 100 - CDV \quad (4)$$

with:

PCI(s) = Pavement Condition Index for each sample unit.

CDV = Corrected Deduct Value for each sample unit.

To determine the PCI value for the entire sample, the formula used is:

$$PCI = \frac{\Sigma PCI(s)}{N} \quad (5)$$

with:

PCI = Overall PCI value.

Σ PCI(s) = Total PCI value of all samples.

N = Number of sample unit.

Pavement Condition Assessment

The total PCI value is the average PCI value of each calculation sample. After the total PCI value is known, a comparison is made with the pavement condition parameters. The parameter table can be seen in the following table.

Table 1. 1 Parameters of Damage Conditions

Good 86 – 100
Satisfactory 71 – 85
Fair 56 – 70
Poor 41 – 55
Very Poor 26 – 40
Serious 11 – 25
Failed 0 – 10

Source: ASTM D 5340-12

2. RESEARCH METHODS

Research Design

Research design is a systematically structured framework to guide researchers in conducting research. This type of research uses qualitative research methods. Qualitative research analyzes a problem based on existing facts and historical data, which are then collected, analyzed, and interpreted. [15] Descriptive qualitative research is a method for exploring and understanding the meanings produced by individuals or groups regarding social or humanitarian issues. [16] The data in this study are field observation data, interview data, documentation studies, and literature studies. The following is the flow of this study.

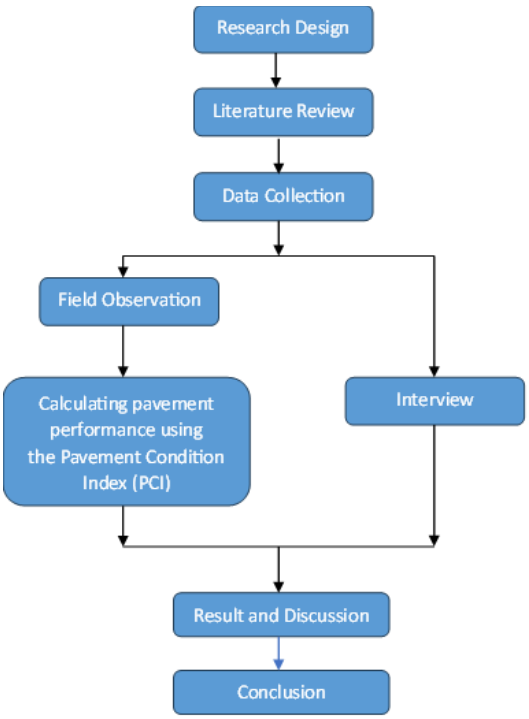

Figure 1. 3 Research flow

In this study, the author uses a qualitative method. The approach used is comparative. The comparative method is an approach used to analyze and compare two or more variables, which aims to find similarities and differences in these variables and to understand the interactions between variables in various conditions or contexts [15]In this study, the author compares the PCI method and the maintenance method using data from interviews.

3. RESULTS AND DISCUSSION

Minimum Sample Calculation

In determining the minimum sample area, use formula (1) with the following equation.

$$n = \frac{N\,s2}{\frac{e2}{4}(N-1)+s2}$$

$$n = \frac{325 \text{ x } (10)2}{\frac{(5)2}{4}(325-1)+(10)2}$$

$$n = \frac{32500}{2025+100}$$

$$n = \frac{32500}{2125}$$

$$n = 15{,}26$$

PCI Calculation

In the PCI calculation, samples were taken at STA 3+000 – 3+200. The calculation of the PCI value begins by calculating the area of damage based on the type of damage. In the sample example, the type of damage number 8 is Longitudinal/Transverse Cracking, with a total value of 40. The next step is to calculate density with formula (2) using the following equation.

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

$$Density = \frac{40}{9000}\ x\ 100\%$$

$$Density = \ 0{,}44444\ \%$$

Then, the density value is drawn into a graph to calculate the deduct value as follows.

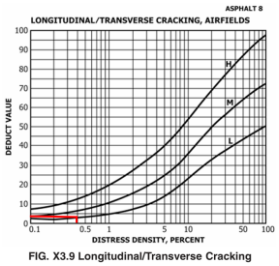

Figure 1. 4 LTC Graphics

Sumber: ASTM D 5340-12 ”telah diolah oleh penulis”

In the figure, the deduct value (DV) is 3. Then, the total deduct value (DV) is calculated from the deduct value (TDV). The TDV value is obtained from the total TDV of each damage.

DV1	DV2	DV3	q	TDV
3	0	-	1	3

Table IV.3 shows the total DV of 2 (two) samples. The DV value for the patching damage type is 0, so the TDV value is 3. The next step is determining the CDV value based on Figure IV.5.

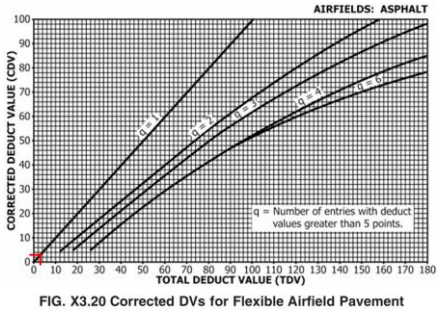

Figure 1. 5 CDV Graphics

Source: ASTM D 5340-12 ” has been processed by the author”

In Figure IV.5, the CDV value is 3. Then the CDV value is used to calculate the final PCI using formula (4) with the following equation.

$$PCI\ (s) = 100 - CDV$$

$$= 100 - 3$$

$$= 97$$

In the final calculation of PCI, the value obtained was 97 for the STA 3+000 – 3+200 sample. The PCI calculation of the entire sample can be seen in the Appendix. Based on the analysis results using the PCI method on the runway of Yogyakarta International Airport, it is known that the overall runway surface condition is in a Good category, with a total of 17 segments. STA 0+000 – 3+250 shows that the overall runway surface condition of all 17 samples is in the very good category. The results of calculating the PCI value of the Yogyakarta International Airport runway produced an average total PCI value of 99.7% (Nine Nine Point Seven Percent).

Based on interviews with informants about the PCI method used to determine the value of damage to a runway, the results of PCI calculations can be used as a reference in making repairs. The results of PCI calculations can be used as input when making repairs according to applicable regulations. Based on previous research, the Sudika 2021 PCI method states that early failure of runway pavement structure can be detected through damage to the asphalt surface of the flexible pavement of the runway. Damage that occurs on the runway that is not immediately handled can cause the damage to become more severe [17].

The maintenance methods implemented in the runway reliability testing are conducting daily routine inspections (serviceability inspections), testing the runway surface roughness, cleaning rubber deposits, and testing the pavement strength with the HWD test. Pavement inspection data is recapitulated weekly to assess pavement performance and areas with potential damage. Weekly data is recapitulated monthly regarding the type of damage or areas with the potential for damage to carry out repair planning. According to informants, the activities carried out to determine the reliability of the runway are by observing areas that are damaged or have the potential for damage. The steps used to determine the type of damage and type of repair to ensure runway reliability are routine observations of damaged areas or potential damage. This activity was carried out because

the type of damage on the YIA airport runway was still in the light category.

4. CONCLUSION

Based on the analysis results, it was found that the runway of Yogyakarta International Airport has a pavement value of 99.7%, which is classified as good. Based on the calculation results, the damage with the largest pavement area found during observation was the release of grains (raveling and weathering) with a total area of 25.55 m^2, which is located in the runway intersection area and touchdown area; repairs are needed by cutting the damaged area (patching) according to the thickness of the surface layer and filling with hot mix asphalt according to technical specifications and implementation methods.

Based on KP 94 of 2015 concerning Guidelines for Airport Pavement Construction Maintenance Programs, damage in critical areas requires handling to prevent damage from worsening. The maintenance method used to test the reliability of YIA Airport's pavement is through daily routine inspections (serviceability inspections) to determine the type and steps in the pavement repair method, testing the runway surface roughness to determine the ability of the pavement to accommodate passing aircraft, cleaning rubber deposits as a method to clean the remaining landing gear to maintain the pavement roughness value, and testing the strength of the pavement with a Heavy Weight Deflectometer to determine the pavement classification number (PCN) value of the pavement. Thus, based on the results of PCI calculations and maintenance carried out by YIA Airport, it can be concluded that YIA Airport has good reliability and can accommodate future flights.

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