Analysis of Runways Surface Conditions Using Pavement Condition Index Method (Case Study: I Gusti Ngurah Rai International Airports)

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Abstract

The growth of aircraft and passenger movements every year requires the runway pavement structure to go above and beyond to accept dynamic loads caused by each type of operating aircraft. As a result of the significant growth value, it often causes the runway pavement structure to fail prematurely. Early failure of the runway pavement structure can be detected through the distress on the asphalt surface of the runway's flexible pavement. In this study, an analysis was carried out on the surface runway at I Gusti Ngurah Rai International Airport to determine the Value of the runway pavement condition due to the soaring movement of aircraft and passengers at I Gusti Ngurah Rai International Airport after the loosening of government regulations on the Covid-19 pandemic situation in Indonesia. To obtain the Value of the runway pavement conditions at I Gusti Ngurah Rai International Airport, it was analyzed using the Pavement Condition Index (PCI) method by conducting a visual inspection of the runway at I Gusti Ngurah Rai International Airport, which is divided into 30 segments with an area of each segment is about 4500 m². The results of the analysis using the Pavement Condition Index (PCI) method are obtained that the runway at I Gusti Ngurah Rai International Airport has an average PCI value of 86.83, which is included in the very good category, the runway at I Gusti Ngurah Rai International Airport is considered to have disintegration and loss of skid resistance, with the most dominant types of damage in the form of patching, jet blast erosion, and bleeding.

Keywords: *Runway, Pavement Condition Index, Flexible Pavement, I Gusti Ngurah Rai International Airport*

INTRODUCTION

The rapid growth of the aviation industry often causes non-ideal conditions that can lead to premature failure of the runway pavement (Jihanny et al., 2021) and the dynamic effects of the aircraft's loads in the form of collisions, movements, and aircraft braking provide an impact factor of 1.5 of the aircraft's actual wheel load on the flexible pavement of the runway (Sultan, 2017). Distress commonly occurs in flexible runway pavement and could be in the form of cracking, distortion, disintegration, joint seal damage, and loss of skid resistance (FAA, 2007). The quantity of distress to the surface of the runway pavement reflects the pavement condition (Su et al., 2021). As an effort to obtain the Value of the runway pavement condition, one of the common methods often used by airport managers is the pavement condition index (PCI) method (Miah et al., 2020), a visual inspection-based method to acquire data in the field accurately by identifying the type of damage and the quantity of damage on the pavement surface so that the Value of the pavement

condition can be calculated (Amanah, 2019) with a value range of 0 representing the failed condition and 100 representing the best condition (Setyawan, 2015).

In this study, an analysis was carried out on the surface runway at I Gusti Ngurah Rai International Airport to determine the Value of the runway pavement condition due to the soaring movement of aircraft and passengers at I Gusti Ngurah Rai International Airport after the loosening of government regulations on the Covid-19 pandemic situation in Indonesia (Yarlina et al., 2021). To obtain the Value of the runway pavement conditions at I Gusti Ngurah Rai International Airport, it was analyzed using the Pavement Condition Index (PCI) method.

LITERATURE REVIEW
Pavement Condition Index (PCI) Method
Pavement condition index method developed by USA Army Corp of Engineers for highway and airport pavement. According to Sudika et al. (2021), PCI is the method used to assess runways condition rating with a value of 100 indicating the best condition and 0 indicating the worst condition (ASTM, 1998), PCI method is calculated based on the type of distress, and the quantity of distress that occurs on the runways surface that obtained by carrying out the visual assessment (Yanti et al., 2019). The PCI method aims to identify critical pavement areas (Rachman et al., 2020) that can be used to determine treatment needs to maintain the runways' pavement condition.

Pavement Condition Index (PCI) Method Parameters
Some parameters used to secure pavement condition index (PCI) rating (ASTM, 1998); those parameters being used as a step to step get the runways pavement condition index:

a. Density (%)
   Density is the distress area's percentage of the total segmented area. The density's distress is expressed by the equation below:

$$\frac{Ad}{As} \times 100$$

   Where:
   Ad = Total area of the pavement type for each severity level of distress (m^2)
   As = Total area of segmented unit (m^2)

b. Deduct Value (DV)
   Deduct Value is obtained by adjusting the density value obtained into each distress graph according to the severity of each distress type.

c. Total Deduct Value (TDV)
   Total Deduct Value is the amount of each sample unit deduct Value.

d. Corrected Deduct Value (CDV)
   Corrected Deduct Value obtained from the curve relations between the total TDV and DV by selecting the appropriate curve.

e. PCI value
   PCI value is 100 – corrected deduct Value.

Flexible pavement distress type

Generally, flexible pavement distress is divided into cracking, distortion, disintegration, joint seal damage, and loss of skid resistance (FAA, 2007)

a. Cracking on flexible pavement can be alligator cracking, block cracking, joint reflection cracking, longitudinal and transverse cracking, and slippage cracking
b. Disintegration on the flexible pavement can be ravelling/weathering, jet blast erosion, patching, and utility cut patching
c. Distortion on the flexible pavement can be rutting, corrugation, shoving, depression, and swelling distress.
d. Loss of skid resistance on the flexible pavement can be polished aggregate, bleeding, and oil spillage

Pavement condition index values category and handling type

The recommended handling treatments for the pavement condition index value are different and classified in several conditions based on the pavement condition index value, including:

a. PCI value at 86-100 is in good condition; it does not need any action.
b. PCI value at 71-86 is in satisfactory condition; it needs minor rehabilitation by doing any patching at the distress area.
c. PCI value at 56-70 is in fair condition; it needs a resurfacing with overlay addition and inlay-scrape and fills
d. PCI value at 41-55 is in poor condition; it needs major rehabilitation on the overall runway pavement areas.

RESEARCH METHOD

Visual inspection is a process to collect accurate type and quantity of distress data occurring in the runways' flexible pavement structure. This inspection aims to identify the distress severity level of runways flexible pavement surfaces such as high, medium, and low (Rachman et al., 2020) that can be used as a reason for maintenance activities in Airport airside facilities management (Babashamsi et al., 2022). The research location is at I Gusti Ngurah Rai International Airport, Bali. Located in Tuban Village, Badung, Bali (seen in Figure 1). The visual inspection data were collected from I Gusti Ngurah Rai International Airport runways. This field survey has been done at Runway 09 and 27, with the total areas observed, are 3000 x 45 m^2, divided into 30 segments, with an area about 4500 m^2 per segment. The Pavement Condition Index (PCI) method is calculated based on the type of distress and the quantity of distress that occurs on the runway surface obtained by carrying out the visual assessment. The PCI method aims to identify critical pavement areas that can be used to determine treatment needs to maintain the runways' pavement condition.

FINDINGS AND DISCUSSION

Based on the results of visual inspections carried out on August 8, 2022, to August 18, 2022, on the runway of the I Gusti Ngurah Rai International Airport, technically carrying out visual inspections, inspections are carried out on three segments every day to obtain the type of distress, distress levels, severity and the percentage density of each runway segment that is visually inspected. The table below shows the recapitulation of distress type, distress level, severity, and density percentage of every segment divided into 30 segments.

Figure 1. Layout I Gusti Ngurah Rai International Airports

Table 1. Visual inspections results on runway of the I Gusti Ngurah Rai International Airports STA 0+000 to STA 0+500

STA	Distress Type	Distress Code	Size (m²)	Density (%)
0+000 s/d 0+100	Bleeding	2	23,5	0,5
	Jet Blast	6	692,3	15,4
	Patching	10 L	48,8	1,1
0+100 s/d 0+200	Jet Blast	6	1021,9	22,7
	Patching	10 L	114,5	2,5
0+200 s/d 0+300	Jet Blast	6	606,6	13,5
	Patching	10 L	132,1	2,9
0+300 s/d 0+400	Jet Blast	6	345,6	7,7
	Patching	10 L	38,8	0,9
	Ravelling/ Weathering	12 L	11,4	0,3
0+400 s/d 0+500	Patching	10 L	16,2	0,4
	Ravelling/ Weathering	12 L	12,0	0,3

Source: Visual inspection (2022)

Table 2. Visual inspections results on runway of the I Gusti Ngurah Rai International Airports STA 0+500 to STA 1+000

STA	Distress Type	Distress Code	Size (m²)	Density (%)
0+500 s/d 0+600	Patching	10 L	208,8	4,6

STA	Distress Type			
0+600 s/d 0+700	Patching	10 L	14,6	0,3
	Ravelling/ Weathering	12 L	17,0	0,4
0+700 s/d 0+800	-	-	-	-
0+800 s/d 0+900	Alligator Cracking	1 L	75,0	1,7
	Jt. Reflection	7 L	7,5	0,2
	Patching	10 L	60,5	1,3
0+900 s/d 1+000	Bleeding	2	14,9	0,3

Source: Visual inspection (2022)

Table 3. Visual inspections results on runway of the I Gusti Ngurah Rai International Airports STA 1+000 to STA 1+500

STA	Distress Type	Distress Code	Size (m²)	Density (%)
1+000 s/d 1+100	Patching	10 L	95,3	2,1
	Polished Aggregate	11	0,1	0,0
1+100 s/d 1+200	Patching	10 L	262,5	5,8
1+200 s/d 1+300	Patching	10 L	117,7	2,6
1+300 s/d 1+400	Patching	10 L	338,4	7,5
	Polished Aggregate	11	0,5	0,0
	Ravelling/ Weathering	12 L	4,9	0,1
1+400 s/d 1+500	Patching	10 L	459,3	10,2

Source: Visual inspection (2022)

Table 4. Visual inspections results on runway of the I Gusti Ngurah Rai International Airports STA 1+500 to STA 2+000

STA	Distress Type	Distress Code	Size (m²)	Density (%)
1+500 s/d 1+600	Patching	10 L	98,8	2,2
1+600 s/d 1+700	Patching	10 L	31,2	0,7
1+700 s/d 1+800	Patching	10 L	9,9	0,2
1+800 s/d 1+900	Patching	10 L	38,4	0,9
1+900 s/d 2+000	Bleeding	2	26,3	0,6

Source: Visual inspection (2022)

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Table 5. Visual inspections results on runway of the I Gusti Ngurah Rai International Airports STA 2+000 to STA 2+500

STA	Distress Type	Distress Code	Size (m²)	Density (%)
2+000 s/d 2+100	Bleeding	2	107,9	2,4
	Patching	10 L	223,3	5,0
2+100 s/d 2+200	Bleeding	2	81,5	1,8
	Patching	10 L	307,1	6,8
2+200 s/d 2+300	Patching	10 L	38,3	0,9
2+300 s/d 2+400	Patching	10 L	76,2	1,7
2+400 s/d 2+500	Patching	10 L	175,7	3,9

Source: Visual inspection (2022)

Table 6. Visual inspections results on runway of the I Gusti Ngurah Rai International Airports STA 2+500 to STA 3+000

STA	Distress Type	Distress Code	Size (m²)	Density (%)
2+500 s/d 2+600	Block Cracking	3 L	3,8	0,1
	Patching	10 L	182,2	4,0
2+600 s/d 2+700	-	-	-	-
2+700 s/d 2+800	Bleeding	2	4,6	0,1
	Patching	10 L	46,0	1,0
2+800 s/d 2+900	Bleeding	2	31,7	0,7
2+900 s/d 3+000	Bleeding	2	3,5	0,1
	Patching	10 L	16,2	0,4
	Polished Aggregate	11	0,3	0,0

Source: Visual inspection (2022)

Based on the visual inspection results, several types of distress are inspected on the I Gusti Ngurah Rai International Airport runway surface, such as bleeding, jet-blast erosion, patching, ravelling/weathering, alligator crack, joint reflection, bleeding, polished aggregate, and block cracking. However, generally, the runway's pavement at I Gusti Ngurah Rai International Airport is disintegrated, and loss of skid resistance with the most dominant type of distress is patching, jet-blast erosion, and bleeding.

Figure 2. Dominant distress type in I Gusti Ngurah rai International Airports runway surfaces

The results of the visual inspection of 30 segments on the runway at I Gusti Ngurah Rai international airport obtained in the field become the parameters that will be used to determine the condition value of each segment being analyzed. The calculation is carried out using the pavement condition index method, and the pavement condition index values are obtained for 30 segments at I Gusti Ngurah Rai International Airport as follows:

Table 7. Pavement condition index (PCI) value on runway of the I Gusti Ngurah Rai International Airports STA 0+000 to STA 0+500

STA	Distress Type	Distress Code	Density (%)	DV	CDV	CDV max	PCI	Condition
	Bleeding	2	0,5	4	30			
0+000 s/d 0+100	Jet Blast	6	15,4	30	32	40	60	Fair
	Patching	10 L	1,1	4	40			
0+100 s/d 0+200	Jet Blast	6	22,7	35	32	40	60	Fair
	Patching	10 L	2,5	5	40			
0+200 s/d 0+300	Jet Blast	6	13,5	28	30	32	68	Fair
	Patching	10 L	2,9	7	32			
	Jet Blast	6	7,7	20	22			
0+300 s/d 0+400	Patching	10 L	0,9	4	28	30	70	Fair
	Ravelling/ Weathering	12 L	0,3	2	30			
0+400 s/d 0+500	Patching	10 L	0,4	3	8	10	90	Good
	Ravelling/ Weathering	12 L	0,3	2	10			

Source: Analysis results (2022)

Table 8. Pavement condition index (PCI) value on runway of the I Gusti Ngurah Rai International Airports STA 0+500 to STA 1+000

STA	Distress Type	Distress Code	Density (%)	DV	CDV	CDV max	PCI	Condition
0+500 s/d 0+600	Patching	10 L	4,6	9	9	9	91	Good
0+600 s/d 0+700	Patching	10 L	0,3	3	8	10	90	Good
	Ravelling/ Weathering	12 L	0,4	2	10			
0+700 s/d 0+800	-	-	-	0	0	0	100	Good
0+800 s/d 0+900	Alligator Cracking	1 L	1,7	22	22	30	70	Fair
	Jt. Reflection	7 L	0,2	0	26			
	Patching	10 L	1,3	4	30			
0+900 s/d 1+000	Bleeding	2	0,3	2	5	5	95	Good

Source: Analysis results (2022)

Table 9. Pavement condition index (PCI) value on runway of the I Gusti Ngurah Rai International Airports STA 1+000 to STA 1+500

STA	Distress Type	Distress Code	Density (%)	DV	CDV	CDV max	PCI	Condition
1+000 s/d 1+100	Patching	10 L	2,1	5	8	10	90	Good
	Polished Aggregate	11	0,0	1	10			
1+100 s/d 1+200	Patching	10 L	5,8	11	11	11	89	Good
1+200 s/d 1+300	Patching	10 L	2,6	5	5	5	95	Good
1+300 s/d 1+400	Patching	10 L	7,5	13	16	23	77	Satisfactory
	Polished Aggregate	11	0,0	1	18			
	Ravelling/ Weathering	12 L	0,1	1	23			
1+400 s/d 1+500	Patching	10 L	10,2	20	20	20	80	Satisfactory

Source: Analysis results (2022)

Table 10. Pavement condition index (PCI) value on runway of the I Gusti Ngurah Rai International Airports STA 1+500 to STA 2+000

STA	Distress Type	Distress Code	Density (%)	DV	CDV	CDV max	PCI	Condition
1+500 s/d 1+600	Patching	10 L	2,2	5	5	5	95	Good
1+600 s/d 1+700	Patching	10 L	0,7	4	5	5	95	Good
1+700 s/d 1+800	Patching	10 L	0,2	2	5	5	95	Good
1+800 s/d 1+900	Patching	10 L	0,9	4	5	5	95	Good
1+900 s/d 2+000	Bleeding	2	0,6	5	5	5	95	Good

Source: Analysis results (2022)

Table 11. Pavement condition index (PCI) value on runway of the I Gusti Ngurah Rai International Airports STA 2+000 to STA 2+500

STA	Distress Type	Distress Code	Density (%)	DV	CDV	CDV max	PCI	Condition
2+000 s/d 2+100	Bleeding	2	2,4	7	12	15	85	Satisfactory
	Patching	10 L	5,0	10	15			
2+100 s/d 2+200	Bleeding	2	1,8	7	16	18	82	Satisfactory
	Patching	10 L	6,8	13	18			
2+200 s/d 2+300	Patching	10 L	0,9	4	5	5	95	Good
2+300 s/d 2+400	Patching	10 L	1,7	5	5	5	95	Good
2+400 s/d 2+500	Patching	10 L	3,9	8	8	8	92	Good

Source: Analysis results (2022)

Table 12. Pavement condition index (PCI) value on runway of the I Gusti Ngurah Rai International Airports STA 2+500 to STA 3+000

STA	Distress Type	Distress Code	Density (%)	DV	CDV	CDV max	PCI	Condition
2+500 s/d 2+600	Block Cracking	3 L	0,1	5	12	14	86	Good
	Patching	10 L	4,0	9	14			

2+600 s/d 2+700	-	-	-	0	0	0	100	Good
2+700 s/d 2+800	Bleeding	2	0,1	0	8	10	90	Good
	Patching	10 L	1,0	4	10			
2+800 s/d 2+900	Bleeding	2	0,7	5	5	5	95	Good
2+900 s/d 3+000	Bleeding	2	0,1	0	11	15	85	Satisfactory
	Patching	10 L	0,4	3	13			
	Polished Aggregate	11	0,0	1	15			

Source: Analysis results (2022)

The analysis results using the pavement condition index (PCI) method show that runways I Gusti Ngurah Rai International Airport at STA 0+000 – STA 0+400 and STA 0+800 – STA 0+900 have PCI values between 56-70 it is in fair condition so that the runways at that area need treatment as like resurfacing with overlay addition and inlay-scrape and fill to increasing the PCI rating to reach the good condition. Runways I Gusti Ngurah Rai International Airport at STA 1+300 – STA 1+500, STA 2+000 – STA 2+200, and STA 2+900 – STA 3+000 have PCI value of 71-86; it is in satisfactory condition so that the runways at that areas need treatment as like a minor rehabilitation by doing patching at distress area to increase the PCI rating to reach the good condition. Runways I Gusti Ngurah Rai International Airport at STA 0+400 – STA 0+800, STA 0+900 – STA 1+300, STA 1+500 – STA 2+000, and STA 2+200 – STA 2+900 is having PCI value at 86-100 is in good condition that does not need any action, and the results show that I Gusti Ngurah Rai International Airport runways average PCI value is 86,83 overall the runway PCI value is in good condition that does not need any action.
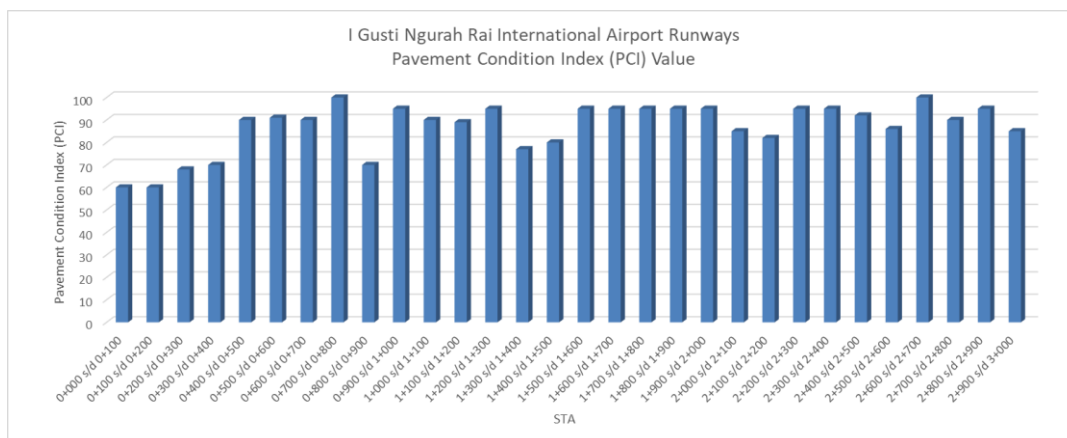

Figure 3. I Gusti Ngurah Rai International Airports each segments PCI value

CONCLUSION & FURTHER RESEARCH

The conclusions that can be drawn from this study are that Gusti Ngurah Rai International Airport runways that divided into 30 segments in this analysis, owned average PCI value is 86,83 overall, the runway is in good condition that does not need any action, and In general, the runway's pavement at I Gusti Ngurah Rai International Airport is disintegrated, and loss of skid resistance with the most dominant type of distress is patching, jet-blast erosion, and bleeding.

For further research, this study suggests the handling type of distress is generally by looking at the PCI rating only. For the following study, the suggestion for handling each distress is not in general, but by recommending the handling of each distress that occurs in accordance with the treatment of each type of distress, then it can be calculated for the analysis of the increases of the PCI value.

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