Road Pavement Condition Analysis Using PCI to Determine Maintenance Strategies for Wonogiri Dam Road, Malang

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ABSTRACT

Bendungan Wonogiri Road is one of the neighborhood roads in Lowokwaru District, Malang City, which has experienced a decline in pavement conditions due to increased traffic activity. This study aims to analyze the condition of the road pavement and determine the appropriate type of treatment using the Pavement Condition Index (PCI) method. The study was conducted through a field survey on a 500 m long road section divided into five observation segments. The types of damage found included potholes, patches, alligator cracks, and longitudinal cracks. The analysis stage was carried out by calculating the density value, deduct value (DV), total deduct value (TDV), corrected deduct value (CDV), and PCI value for each segment. The results showed that the PCI value on Bendungan Wonogiri Road was in the range of 58–100. The STA 0–100 segment obtained a PCI value of 64, STA 100–200 of 58, STA 200–300 of 59, STA 300–400 of 65, and STA 400–500 of 100. Based on these values, the condition of the road pavement is generally included in the good category. The dominant damage found is potholes and longitudinal cracks with a moderate level of damage. The recommended treatment is road rehabilitation in the damaged segment.

Keywords pavement condition index, road pavement, road damage, road maintenance, pavement rehabilitation.

INTRODUCTION

Roads play a vital role in supporting various social and economic activities [1]. High-quality roads must provide a sense of safety and comfort for road users [2]. Increasing traffic volume and vehicle loads can accelerate damage to road pavement structures [3]. Common types of road pavement damage include cracking, deformation, potholes, surface texture damage, and damage to the road pavement edges [4]. Road pavement damage that is not properly addressed can cause traffic congestion, increase the risk of accidents, and result in economic losses [5].

Bendungan Wonogiri Road is one of the local roads in Lowokwaru District, Malang City, used as the main access route for the activities of the surrounding community. The increasing population and economic growth of the community can lead to an increase in the number of vehicles and traffic flow on the road [6]. These conditions have the potential to accelerate the deterioration of road pavement performance if proper evaluation and management are not conducted. Therefore, a method is needed to evaluate road pavement conditions systematically and quantitatively.

One of the most widely used methods for assessing road pavement conditions is the Pavement Condition Index (PCI). PCI is used as a measurement tool to determine road pavement maintenance strategies based on damage surveys [7]. Road condition surveys need to be conducted periodically to determine the condition and level of road service [8]. The PCI method assesses pavement condition based on the type of damage, severity level, and extent of damage, thereby producing an index value that quantitatively describes road condition [9]. PCI values range from 0 to 100, where a higher PCI value indicates better road pavement condition.

Several previous studies have used the PCI method to evaluate road pavement conditions. Research by Mz and Tjendani indicates that the PCI method can be effectively used to determine the severity of damage and provide recommendations for road maintenance [2]. Additionally, a study by Fitriani and Widayanti stated that the PCI method can provide a detailed picture of road conditions based on the type and severity of damage in each road segment [3]. However, no research has been conducted

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on the evaluation of pavement conditions on the Wonogiri Dam Road, making it necessary to conduct a study to determine the actual condition of the pavement on that section. Therefore, this study aims to analyze and classify the pavement condition on the Wonogiri Dam Road section using the Pavement Condition Index (PCI) method. The results of this classification and damage identification can serve as a basis for determining appropriate maintenance recommendations to improve road pavement conditions and effectively extend the road's service life.

RESEARCH METHODS

Materials

The study was conducted on the Bendungan Wonogiri road section in Malang City. The method used was a field survey employing the Pavement Condition Index (PCI) approach. To facilitate the study, the research stages are presented in the form of a research flowchart, as shown in Figure 1.

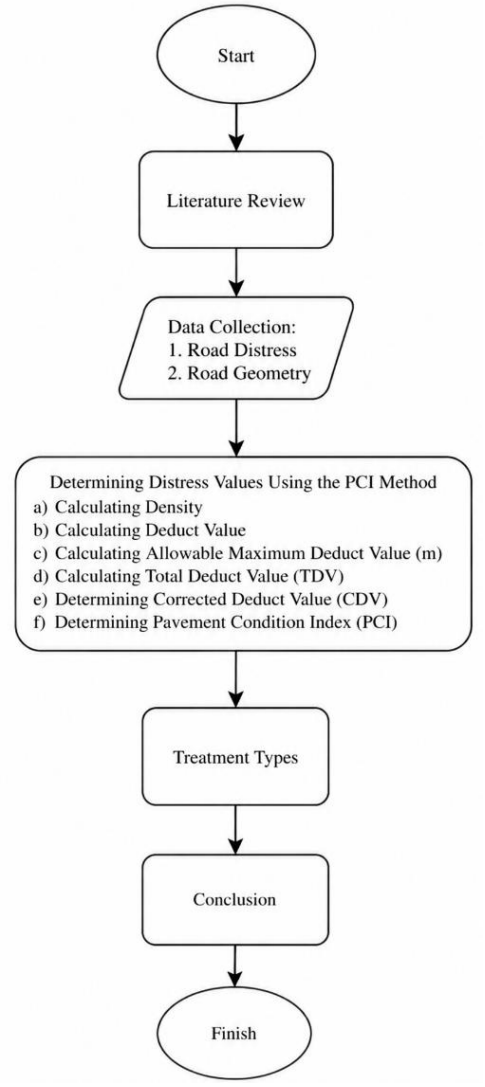


Figure 1. Research Plan Source: Personal analysis, 2026

Pavement Condition Index (PCI)

The Pavement Condition Index (PCI) is a method for assessing the condition of road pavement based on the type, level, and extent of road damage [10]. Each type of damage is evaluated based on the extent of the damage and its severity. Damage values vary depending on the severity of the damage occurring on the road pavement. The damage levels used in PCI calculations consist of light damage

(*Low*/L), moderate damage (*Medium*/M), and severe damage (*High*/H) [11]. The quality of the pavement layer can be determined from the PCI value for each study unit. PCI values range from 0 to 100, with road condition classifications including Excellent, Very Good, Good, Fair, Poor, Very Poor, and Failed [12].

Table 1. PCI Values and Pavement Conditions

PCI Score	Pavement Conditions
0 – 10	Failed
10 – 25	Very Poor
25 – 40	Poor
40 – 55	Fair
55 – 70	Good
70 – 85	Very Good
85 – 100	Excellent

Source: Shahin (1994)

Damage Density

Density is calculated by dividing the area of damage (Ad) by the area of the sample unit (Ld). The damage density value varies depending on the severity of the damage to the pavement. Formula 1 is used to calculate the density value.

Density= AD/(As)× 100%.....(1)

Deduct Value (DV)

A deduction value that indicates the impact of a specific type of damage on the condition of the road pavement [13]. The Deduct Value (DV) is derived from the relationship between density values and the severity of damage based on the graph in the PCI method [14].

Total Deduct Value (TDV)

Total Deduct Value (TDV) is the total accumulation of deduct values from all types and severity levels of damage found in a single study unit [15]. Before determining the TDV and CDV values, the DV value is examined by calculating the Allowable Maximum Deduct Value (m) [16].

m = 1 + (9/98) x (100-DV Max).....(2)

Corrected Deduct Value (CDV)

The corrected deduct value (CDV) is obtained by plotting the total deduct value (TDV) on a graph of the relationship between TDV and q until the intersection point is found.

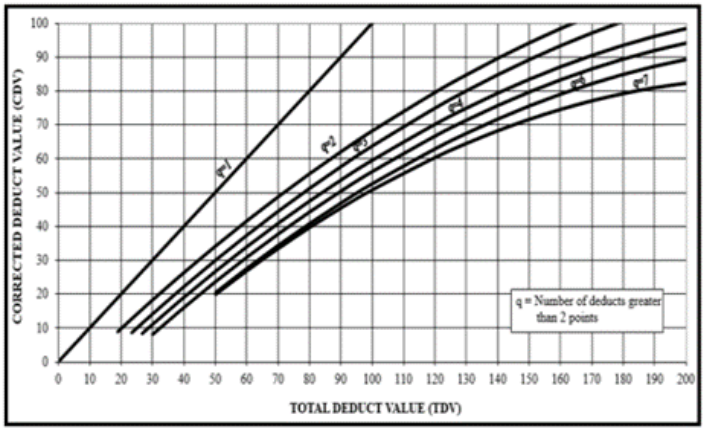


Figure 2. CDV Curve Source: ASTM D6433

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Pavement Condition Index (PCI) Value

After calculating the CDV value, the PCI value is then calculated. To obtain the PCI value for a specific road section, use Equation 3.

Types of Damage Remediation

Once the pavement condition rating has been obtained through the PCI calculation, the next step is to determine the appropriate road maintenance measures based on the actual condition of the pavement. Based on Regulation of the Minister of Public Works of the Republic of Indonesia No. 13 of 2011 concerning procedures for road maintenance and supervision, road maintenance activities include routine maintenance, periodic maintenance, road rehabilitation, and road reconstruction, as presented in Table 2.

Table 2. Types of road damage repairs

Pavement Condition Index	Type of Treatment
85 – 100	Routine maintenance
70 – 85	Routine Maintenance
55 – 70	Road rehabilitation
0 – 55	Reconstruction/recycling

Source: Permen PU No.13/PRT/M/201

RESULT AND DISCUSSION

Existing Conditions

Inspections of road damage on the Wonogiri Dam section in Malang City were conducted every 100 meters. Analysis of the damage at STA 0–500 revealed several types of damage, as shown in Table 3.

Table 3. Survey Results

STA	Type of Damage	Damage Level	Extent of Damage
0 -100	Hole	M	5,295
	Patch	M	6,165
	Cracked Crocodile	M	2,717
	Longitudinal Crack	There was no damage	0,000
100-200	Hole	M	4,325
	Patch	M	3,234
	Cracked Crocodile	M	0,506
	Longitudinal Crack	L	13,530
200-300	Hole	L	8,211
	Patch	M	2,135
	Cracked Crocodile	M	2,346
	Longitudinal Crack	M	2,570
300-400	Hole	M	1,842
	Patch	There was no damage	0,000
	Cracked Crocodile	M	1,928
	Longitudinal Crack	M	4,100
400 - 500	Hole	There was no damage	0,000
	Patch	There was no damage	0,000
	Cracked Crocodile	There was no damage	0,000
	Longitudinal Crack	There was no damage	0,000

Source: Personal analysis, 2026

Calculating the Density Value

Once the type of damage and its severity level have been clearly identified, the next step is to calculate the density value. For example, in segment 2, there are several types of damage at the medium and low levels, as shown in Table 3.

a. Hole Damage

$$\text{Density} = AD/(As) \times 100\%$$
$$= 4{,}32/400 \times 100\%$$
$$= 1{,}081$$

b. Filling Damage

$$\text{Density} = AD/(As) \times 100\%$$
$$= 3{,}23/400 \times 100\%$$
$$= 0{,}808$$

c. Alligator Cracking Damage

$$\text{Density} = AD/(As) \times 100\%$$
$$= 0{,}50/400 \times 100\%$$
$$= 0{,}127$$

d. Longitudinal Cracks

$$\text{Density} = AD/(As) \times 100\%$$
$$= 13{,}53/400 \times 100\%$$
$$= 3{,}383$$

Table 4. Density Calculation Results

	Density (%)			
STA	**Hole**	**Patch**	**Cracked Crocodile**	**Longitudinal Crack**
0 - 100	1,324	1,541	0,679	0,000
100 - 200	1,081	0,808	0,127	3,383
200 - 300	2,053	0,534	0,586	0,643
300 - 400	0,460	0,000	0,482	1,025
400 - 500	0,000	0,000	0,000	0,000

Source: Personal analysis, 2026

Determining the Deduct Value (DV)

The deduct value is determined using a chart showing the relationship between density percentage and deduct value based on the type of damage.

a. Hole Damage (Medium)

Based on a density value of 1.081%, the Deduct Value (DV) is 32, indicating a moderate (Medium) level of damage.

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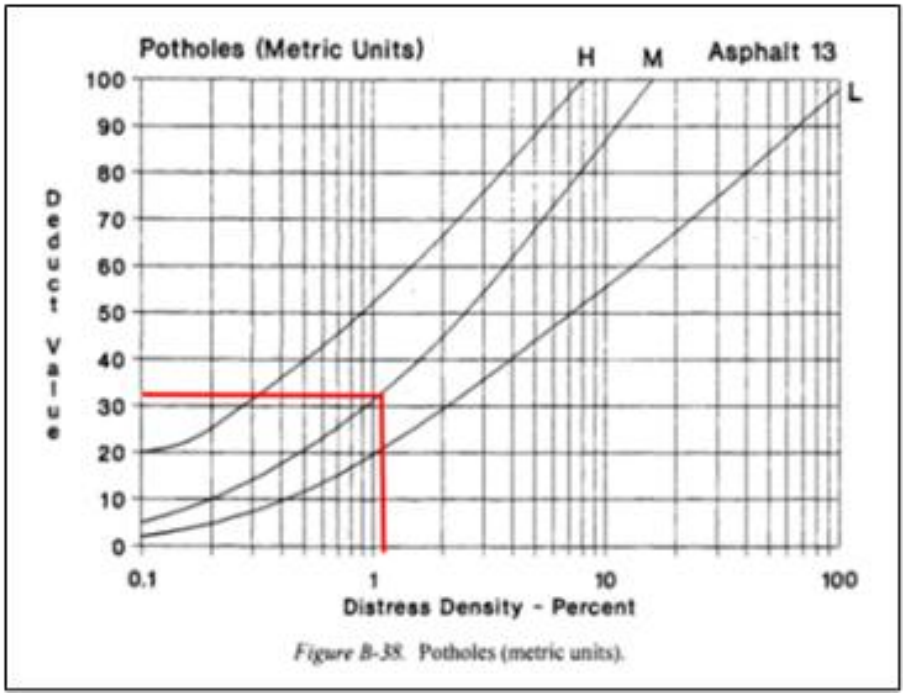


Figure 3. Relationship Graph Source: Personal analysis, 2026

b. Damage to the Patch (Medium)

Based on a density value of 0.808%, a Deduct Value (DV) of 8 was obtained, indicating a moderate level of damage (Medium).

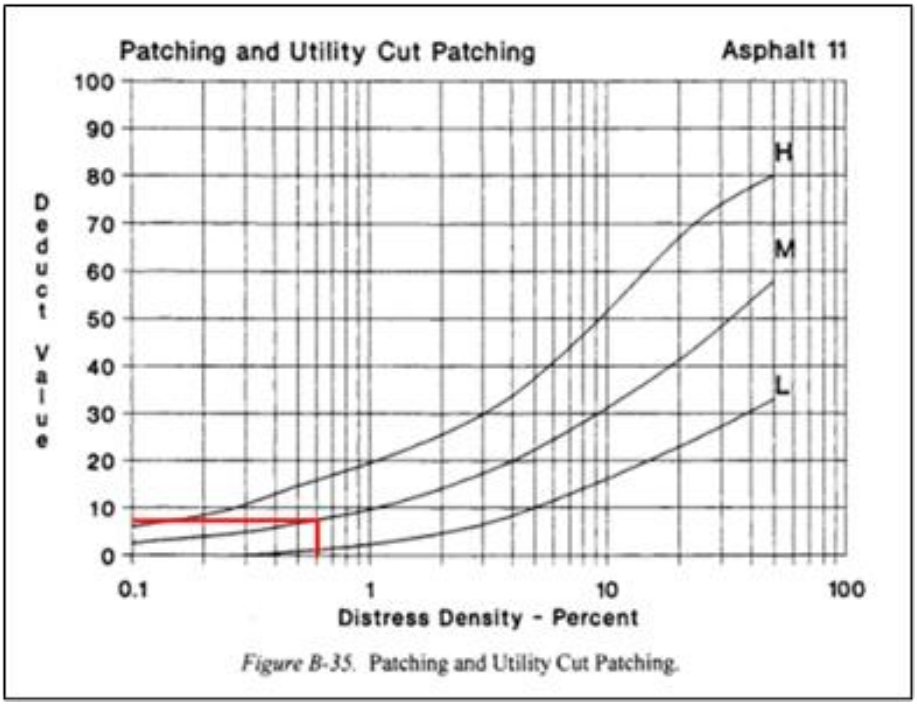


Figure 4. Graph of the Relationship Between Density Values and DV Values Source: Personal analysis, 2026

c. Crack Damage (Low)

Based on a density value of 0.127%, the Deduct Value (DV) is 4, indicating a low level of damage (Low).

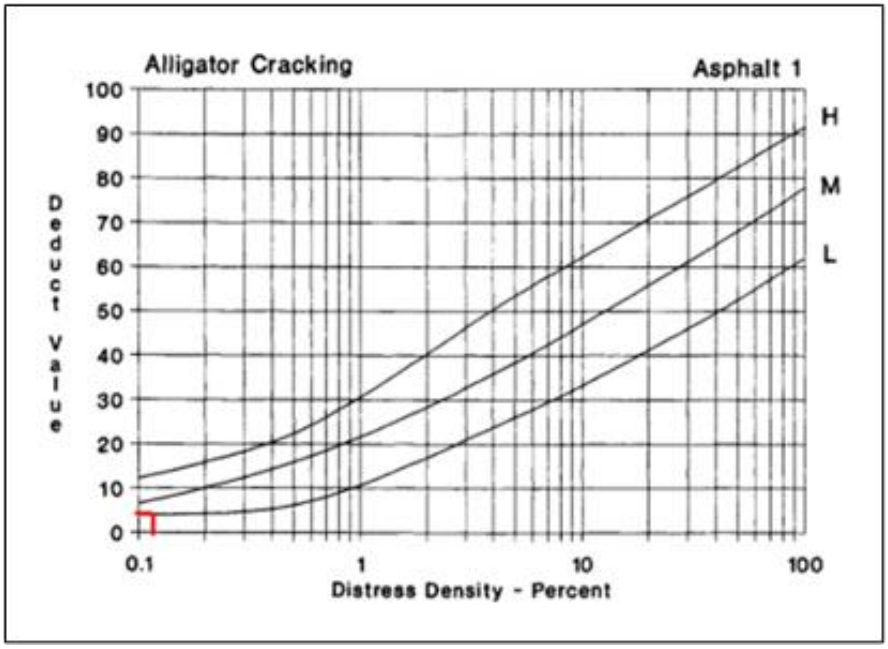


Figure 5. Graph Showing the Relationship Between Density Values and DV Values Source: Personal analysis, 2026

d. Longitudinal Cracking (Low)

Based on a density value of 3.383%, a Deduct Value (DV) of 25 was obtained, indicating a low level of damage (Low)

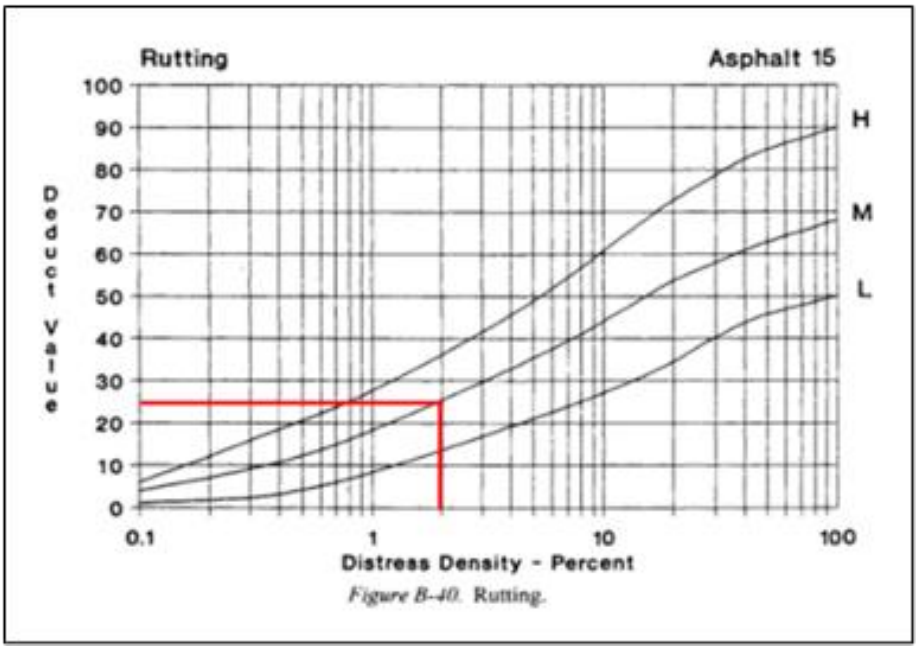


Figure 6. Graph Showing the Relationship Between Density Values and DV Values Source: Personal analysis, 2026

Table 5. Results of the Deduct Value Calculation

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STA	Deduct Value			
	Hole	Patch	Cracked Crocodile	Longitudinal Crack
0 - 100	32	11	14	0
100 - 200	31	8	4	25
200 - 300	35	7	13	11
300 - 400	12	0	12	19
400 - 500	0	0	0	0

Source: Personal analysis, 2026

Finding the Maximum Allowable Deduction Value (m)

The maximum allowable deduction value (m) is determined using Equation 2.

$$m = 1 + (\frac{9}{98})\, x\, (100 - DV\ Max\ )$$

$$m = 1 + (\frac{9}{98})\, x\, (100 - 31\ )$$

$$m = 6{,}33$$

The maximum DV value is determined by the largest deduct value occurring in the damage to each segment.

Table 6. Results of the Calculation of the Value of m

STA	m
0 - 100	6,24
100 - 200	6,33
200 - 300	5,96
300 - 400	7,43
400 - 500	0

Source: Personal analysis, 2026

Calculating the TDV

The calculated value of m is 6.33, which is then rounded to 6. The number of deduct values used in determining the TDV is the 6 largest values. If the value of m is greater than the number of available data points, then the value of q in the curve-fitting process is determined based on the number of *deduct values* (DV) greater than 2.

Table 7. TDV Calculation Results

q	Iteration				TDV
4	31	25	8	4	68,00
3	31	25	8	2	66,00
2	31	25	2	2	60,00
1	31	2	2	2	37,00

Source: Personal analysis, 2026

Calculating the CDV

Once the TDV has been calculated, the CDV is then determined based on the q-value for each segment.

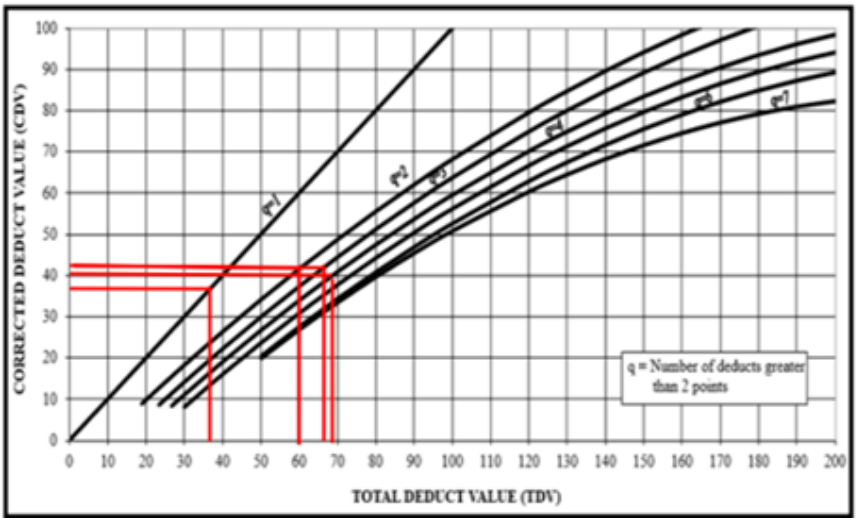


Figure 7. Graph Showing the Relationship Between TDV and CDV
Source: Personal analysis, 2026

Table 8. CDV Values

STA	Deduct Value				q	TDV	CDV
0 - 100	32	11	14	0	3	57	36
100 - 200	31	25	8	4	4	68	42
200 - 300	35	13	11	7	4	66	41
300 - 400	19	12	12	0	3	43	35
400 - 500	0	0	0	0	0	0	0

Source: Personal analysis, 2026

Calculating the PCI Value

Once the CDV value has been obtained, the PCI is calculated using formula 3.

$$PCI = 100 - CDV$$

$$PCI = 100 - 42$$

$$PCI = 58$$

Based on the calculation results, the PCI value for STA100–200 is 58, indicating that the pavement condition is in the "good" category.

Table 9. PCI Calculation Results

STA	PCI Score	Description
0 - 100	64	Good
100 - 200	58	Good
200 - 300	59	Good
300 - 400	65	Good
400 - 500	100	Perfect

Source: Personal analysis, 2026

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Type of Treatment

Based on the PCI values obtained, the STA 0–400 segment has a PCI value of 58–65, which falls into the "Good" category; therefore, road rehabilitation is recommended. The STA 400–500 segment is classified as "Excellent," so routine maintenance is performed.

Discussion

Based on the results of a field survey on the 500-meter section of Jalan Bendungan Wonogiri, divided into 5 segments, several types of damage were found, including potholes, patches, alligator cracking, and longitudinal cracks. The most prevalent damage consists of potholes and longitudinal cracks, with damage levels ranging from low to moderate. These conditions indicate that the road pavement is beginning to degrade in quality due to continuous vehicle traffic.

Density calculation results show that each segment has a different damage level. The highest density value was found in longitudinal cracks at STA 100–200 at 3.383%, while the lowest value of 0% was found in the segment with no damage. The higher the density value, the more extensive the damage on the road surface. This aligns with the research by Mulyana et al., which states that the density value is influenced by the extent of damage and traffic conditions on the road section [14].

Based on the deduct value (DV) calculation results, pothole damage has the highest DV value compared to other types of damage. At STA 200–300, potholes had a DV value of 35, while longitudinal cracks at STA 100–200 had a DV value of 25. The high deduct value indicates that these damages significantly contribute to the deterioration of the road pavement condition. According to ASTM D6433, the DV value is influenced by the severity and extent of damage on the road surface [9].

PCI calculation results show a PCI value of 64 at STA 0–100, 58 at STA 100–200, 59 at STA 200–300, 65 at STA 300–400, and 100 at STA 400–500. These values indicate that the condition of the Wonogiri Dam Road is generally in the "Good" category, with an average PCI value of 69.2. According to the ASTM International PCI standard, a PCI value of 55–70 falls within the "Good" category but still requires maintenance to prevent more severe damage.

According to Regulation of the Minister of Public Works of the Republic of Indonesia No. 13 of 2011, segments with a PCI value of 55–70 are recommended for road rehabilitation, while segments with a PCI value of 85–100 are recommended for routine maintenance. Therefore, the STA 0–400 segment is recommended for road rehabilitation, while the STA 400–500 segment is recommended for routine maintenance. The results of this study are also consistent with the research by Anisa Safaati et al., which states that road rehabilitation is necessary on road sections with moderate damage levels to prevent road conditions from deteriorating into severe damage. The results of this study indicate that the Pavement Condition Index (PCI) method can be used to evaluate road pavement conditions systematically and quantitatively [5]. Additionally, the PCI method can serve as a basis for determining the appropriate road treatment based on the extent of damage present.

CONCLUSION

Based on the results of the data analysis and discussion conducted, it can be concluded that the types of damage found on the Wonogiri Dam Road section include potholes, patches, alligator cracking, and longitudinal cracks. The results of the Pavement Condition Index (PCI) analysis on this 500-meter road section—divided into 5 segments, each 100 meters long—show varying levels of damage, ranging from perfect condition with a PCI value of 100 to good condition with the lowest PCI value of 58. Based on the calculations, an average PCI value of 69.2 was obtained, indicating that the road pavement condition is generally in the "Good" category. The recommended treatment for the Wonogiri Dam Road section is tailored to the existing road pavement condition, specifically through road rehabilitation measures.

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