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EVALUATION OF ROAD DAMAGE LEVEL USING PCI AND BINA MARGA METHOD ON BM MUDA ROAD, PADANGSIDIMPUAN CITY

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Abstract
Jalan BM Muda is an urban road in Padangsidimpuan City that supports community mobility and local activities. Increasing service age and traffic have produced various pavement distresses that may reduce road performance. This study evaluates the pavement condition of Jalan BM Muda STA 0+000–2+000 using the Pavement Condition Index (PCI) and Bina Marga methods. Field surveys identified distress type, severity, and extent, while a traffic survey provided average daily traffic (LHR) data. The PCI analysis produced an average score of 37.91, classified as Poor. The Bina Marga analysis produced a Priority Order (UP) of 10, indicating routine maintenance. The different results arise from the distinct parameters and purposes of the two methods. PCI measures physical pavement condition from the type, severity, and extent of distress, whereas Bina Marga combines road condition and traffic volume to determine treatment priorities. Thus, the road section is physically Poor under PCI and is assigned routine maintenance under Bina Marga.

Keywords: Highways; distressed pavement; Pavement Condition Index (PCI)

INTRODUCTION

Roads are a vital transportation infrastructure that plays a vital role in supporting economic and social activities, as well as community mobility. Good road conditions facilitate transportation flow, increase travel time efficiency, and support regional development. Conversely, damaged roads can hinder traffic flow, reduce user comfort and safety, and increase vehicle operating costs. Increased traffic volume, vehicle load, service life, rainfall, and temperature changes can all degrade pavement quality. Damage to flexible pavement can include cracks, potholes, grooves, grain detachment, and other surface deformations. If not addressed promptly, the damage can progress to more severe levels and require higher repair costs. The BM Muda road section in Padangsidimpuan City supports public mobility and economic activity in the surrounding area. The high traffic volume on this section is accompanied by various surface damages that reduce comfort and potentially endanger road users. Therefore, an evaluation of the pavement condition is necessary to determine the extent of the damage and the type of treatment needed.

Previous research has shown that the PCI method produces a more detailed physical condition assessment, while the Bina Marga method outputs a priority order for treatment programs. These differences in output are also found across various road sections, so using both methods simultaneously is necessary to obtain a more comprehensive picture of conditions and treatment needs (Hafiza & Sholichin, 2022; Rendy et al., 2023; Hadi et al., 2025). This study used the Pavement Condition Index (PCI) based on ASTM D6433 (ASTM International, 2007) and the Bina Marga 1990 method (Directorate General of Highways, 1990). PCI assesses the type, severity, and extent of damage on a scale of 0–100, while Bina Marga combines road conditions and Average Daily Traffic (ADR) to determine the priority order for treatment. The objectives of the study were to determine the pavement condition of Jalan BM Muda STA 0+000–2+000, compare the results of the two methods, and determine appropriate maintenance recommendations.

LITERATURE REVIEW

Road Paving and Flexible Pavement Damage

Road pavement is a system of multiple layers of material laid over the subgrade to provide a level surface with adequate roughness, a long service life, and minimal maintenance requirements. Over the course of service,

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pavement performance can decline due to repeated vehicle loads, material composition, design, drainage conditions, weather, and the environment.

Flexible pavement damage in the thesis is grouped into cracks, distortions, and surface defects according to the pavement condition identification guidelines (Ministry of Public Works and Public Housing, 2016). Cracks include alligator cracks, edge cracks, block cracks, reflection cracks, longitudinal or transverse cracks, and slip cracks. Distortions include grooves, curls, dents, bumps and grooves, lane or shoulder settlement, and sinkage. Surface defects include potholes, grain detachment, wear, rail crossings, expansion, fat, and patches. Water entering through cracks can accelerate aggregate detachment and pothole formation. Damage can also develop due to poor interlayer bonding, low mix stability, weak subgrade, or inadequate drainage. Identifying the type and severity of cracks provides the basis for assessing the pavement's condition and determining treatment options.

Table 1. Summary of previous research

Researchers	Method and location	Main results
Putra et al. (2022)	PCI, East Ring Road I, Jambi	PCI 67,333; good category.
Hafiza & Sholichin (2022)	Comparison of PCI and Bina Marga, Sampang–Ketapang	PCI provides damage details; Bina Marga sets priorities.
Purnomo & Putra (2022)	PCI, SDI, and Highways, Gresik–Lamongan	UP 7; routine maintenance. PCI <60; rehabilitation.
Lutfie (2022)	Highways, Pagimana–Biak	Damage rating 7; priority 9; routine maintenance.
Rendy et al. (2023)	PCI and Highways, Jepara–Bangsri	PCI 55.523; fair. UP 7.2; routine maintenance.
Yono et al. (2024)	PCI, 21 primary local roads in Sidoarjo	4 excellent, 7 very good, 8 good, and 2 fair.
Novianti et al. (2024)	Highways 1990, Margomulyo–Kediri	Damage: holes, cracks, sinkage, grain detachment, edges, and peeling.
Setya & Haratama (2024)	Highways, Ponco–Jatirogo	LHR 27,461.6 smp/day; UP 6.77; periodic maintenance.
Hadi et al. (2025)	PCI and Bina Marga, Kaligawe Raya	Moderate–severe conditions; handling adjusted per segment.
Nuruzzaman et al. (2025)	PCI, IKP, and Bina Marga, Ciawi–Singaparna	Results vary depending on the parameters, details, and objectives of the method.

Previous studies have shown that PCI and Bina Marga can be used simultaneously to obtain an overview of physical conditions and prioritize treatment. Putra et al. (2022) obtained a PCI value of 67.333 on the East Ring Road I, while Purnomo and Putra (2022) found different outcomes between PCI, SDI, and Bina Marga on the Gresik–Lamongan section. Lutfie (2022) and Setya and Haratama (2024) used Bina Marga to determine maintenance programs based on damage and traffic figures. Rendy et al. (2023), Hafiza and Sholichin (2022), and Hadi et al. (2025) showed that the output of the two methods was not always the same due to different analysis parameters and objectives. These findings form the basis for the simultaneous use of PCI and Bina Marga on the BM Muda Road Section.

Pavement Condition Index (PCI)

PCI is a quantitative method for assessing pavement condition based on the type of damage, severity, and extent of damage (ASTM International, 2007). The index value is on a scale of 0–100; high values indicate better condition, while low values indicate more severe damage. The analysis stages include damage identification, density calculation, determination of Deduct Value (DV), Total Deduct Value (TDV), Corrected Deduct Value (CDV), and PCI value.

Table 2. PCI values, conditions, and types of treatment

PCI Value	Condition	Type of handling
0–10	Failed (Destroyed)	Reconstruction
11–25	Very Poor (Very Bad)	Structural reconstruction/upgrades
26–40	Poor (Ugly)	Structural improvements
41–55	Fair (Moderate)	Periodic maintenance
56–70	Good	Routine/periodic maintenance
71–85	Very Good	Routine/preventive maintenance
86–100	Excellent	Routine maintenance

Area-based and length-based damage densities are expressed as a percentage of the sample unit area. PCI values are then calculated from the maximum CDV.

$$\text{Density} = (A\_d / A\_s) \times 100\% \quad (1)$$

$$\text{Density} = (L\_d / A\_s) \times 100\% \quad (2)$$

$$m = 1 + (9/98)(100 - \text{HDV}) \quad (3)$$

$$\text{PCI} = 100 - \text{CDV\_max} \quad (4)$$

Description: A_d is the total area of the damage type, A_s is the area of the sample unit, L_d is the total length of the damage, m is the maximum number of DVs allowed, HDV is the highest DV, and CDV_max is the maximum CDV value.

Highway Construction Method

The Highways (Bina Marga) method assesses road conditions through visual surveys and LHR data (Directorate General of Highways, 1990). The percentage of damage is used to determine the damage rate for each segment. The damage values are summed to form a road condition score, then combined with the LHR class to obtain a Priority Order (UP).

$$\text{UP} = 17 - (\text{LHR Class} + \text{Road Condition Value}) \quad (5)$$

Table 3. Classification of priority order of Highways

Order of priority	Handling program
0–3	Improvement program
4–6	Periodic maintenance program
>7	Routine maintenance program

The fundamental difference between the two methods lies in the focus of the assessment. PCI describes the physical condition of the pavement, while Bina Marga is used to determine program priorities based on road and traffic conditions.

METHOD

Research Location and Design

The study was conducted on the BM Muda Road Section, Padangsidimpuan City, North Sumatra Province, from STA 0+000 to STA 2+000. The length of the observed section was 2 km with a width of 6 m. The section was divided into 40 segments, each 50 m long, so that damage identification and measurement could be carried out in detail and systematically.

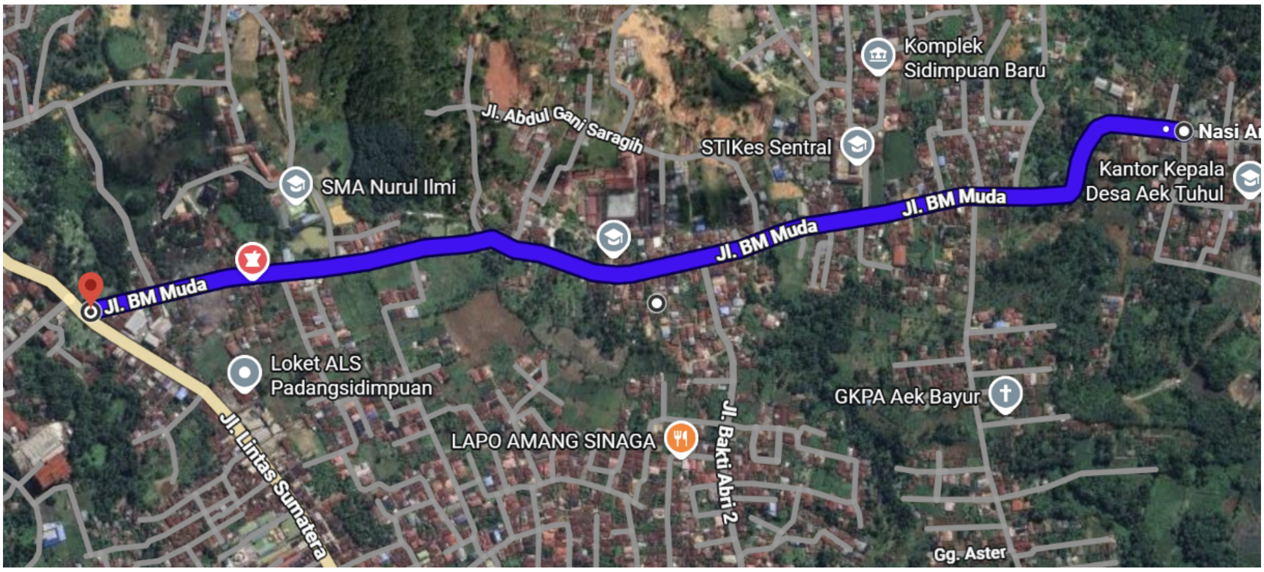


Figure 1. Research location of the BM Muda Road Section

Table 4. Characteristics of the research section

Parameter	Information
Length of road	2 km (STA 0+000–2+000)
Road width	6 m
Road type	2 lanes, 2 directions undivided (2/2 UD)
Road status	City streets
Road function	Collector
Types of pavement	Flexible pavement
Observation unit	40 segments × 50 m

Data and Equipment

Primary data included damage type, severity, length, width, extent, and depth, documentation, and traffic volume. Secondary data included general road information and PCI and Bina Marga guidelines. The equipment used included a laptop, Microsoft Excel, a 50-meter tape measure, a ruler, PCI survey forms, and Bina Marga survey forms.

Data Collection and Analysis Procedures

The field survey began with the establishment of road safety points (STA) every 50 m. Visual observations, damage type and extent identification, dimensional measurements, and documentation were conducted at each segment. The LHR survey was conducted over three days: Friday, Saturday, and Sunday, from 6:00 a.m. to 8:00 p.m. Western Indonesian Time (WIB). Observations were conducted at STA 0+000, STA 1+000, and STA 2+000 to ensure traffic volumes were representative of the entire section.

PCI analysis is conducted through determining the type and severity level, calculating density, reading DV, determining m and q, calculating TDV and CDV, and determining PCI values and categories. Bina Marga analysis is conducted through determining road class, collecting LHR, calculating damage figures and condition values, calculating UP, and establishing maintenance programs.

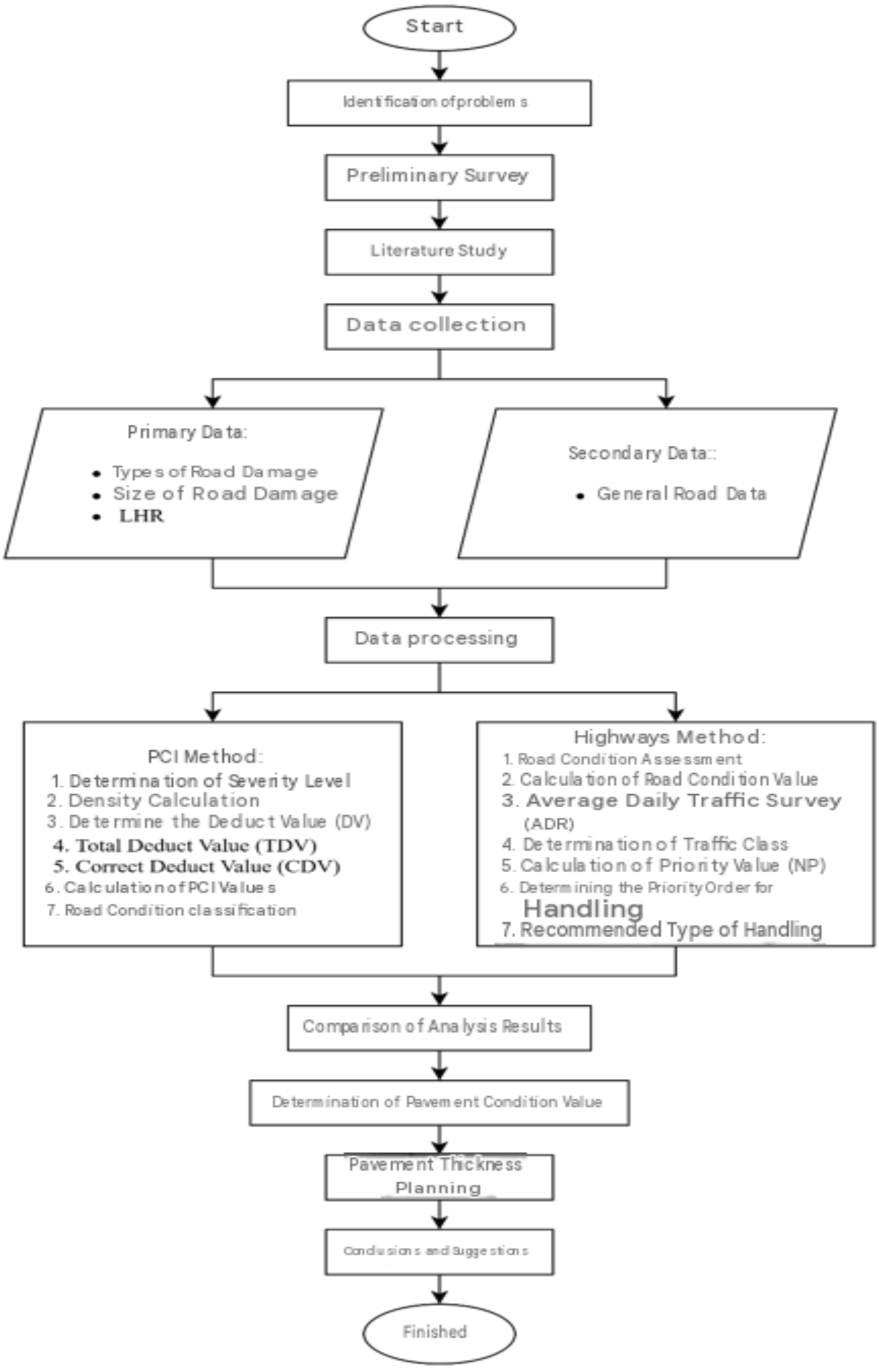


Figure 2. Research flowchart

Data processing was performed quantitatively using Microsoft Excel. A comparison of the two results was used to explain the physical condition of the pavement and prioritize road section management.

RESULTS AND DISCUSSION

Pavement Conditions Based on PCI

The survey found variations in damage between segments, including alligator cracking, edge cracking, longitudinal cracking, block cracking, slip cracking, depressions, patches, aggregate wear, holes, and grain detachment. The density and DV of each damage were calculated, then the maximum CDV and PCI values were determined. A summary of segments 1–20 is presented in Table 5.

Table 5. Recapitulation of PCI values per segment (segments 1–20)

Segmen	STA	PCI	Rating
1	0+000 - 0+050	100	Excellent
2	0+050 - 0+100	67.2	Good
3	0+100 - 0+150	31.5	Poor
4	0+150 - 0+200	67.5	Good
5	0+200 - 0+250	74	Very Good
6	0+250 - 0+300	89.2	Excellent
7	0+300 - 0+350	91.2	Excellent
8	0+350 - 0+400	29.5	Poor
9	0+400 - 0+450	100	Excellent
10	0+450 - 0+500	25	Very Poor
11	0+500 - 0+550	0	Failed
12	0+550 - 0+600	76.2	Very Good
13	0+600 - 0+650	0	Failed
14	0+650 - 0+700	0	Failed
15	0+700 - 0+750	0	Failed
16	0+750 - 0+800	1.2	Failed
17	0+800 - 0+850	0	Failed
18	0+850 - 0+900	0	Failed
19	0+900 - 0+950	91.4	Excellent
20	0+950 - 1+000	0	Failed

In the first 20 segments, the PCI values range between 0 and 100. Segments 11, 13, 14, 15, 17, 18, 20, and 21 in the following section indicate very severe or failed conditions, while some segments without damage obtain a value of 100. This variation confirms that the average segment value does not replace the need for treatment per segment.

Table 5 (continued). Recapitulation of PCI values per segment (segments 21–40)

Segmen	STA	PCI	Rating
21	1+000 - 1+050	0	Failed
22	1+050 - 1+100	21.2	Very Poor
23	1+100 - 1+150	97	Excellent
24	1+150 - 1+200	76.2	Very Good
25	1+200 - 1+250	0	Failed
26	1+250 - 1+300	100	Excellent
27	1+300 - 1+350	0	Failed
28	1+350 - 1+400	43.3	Fair
29	1+400 - 1+450	0	Failed
30	1+450 - 1+500	0	Failed
31	1+500 - 1+550	0	Failed
32	1+550 - 1+600	34	Poor

Segmen	STA	PCI	Rating
33	1+600 - 1+650	18	Very Poor
34	1+650 - 1+700	69	Good
35	1+700 - 1+750	100	Excellent
36	1+750 - 1+800	0	Failed
37	1+800 - 1+850	0	Failed
38	1+850 - 1+900	14	Very Poor
39	1+900 - 1+950	0	Failed
40	1+950 - 2+000	100	Excellent

Mean Value and Condition Distribution

The total PCI value for all segments is 1,516.6, with an average value of 37.91. Based on the PCI classification, the general condition of the BM Muda Road Section is categorized as Poor. The category distribution shows 17 Failed segments, 4 Very Poor, 3 Poor, 1 Fair, 3 Good, 3 Very Good, and 9 Excellent.

Table 6. Distribution of PCI categories across 40 segments

Category	Number of segments	Implications of handling
Failed	17	Reconstruction
Very Poor	4	Structural improvements/reconstruction
Poor	3	Structural improvements
Fair	1	Periodic maintenance
Good	3	Routine/periodic maintenance
Very Good	3	Routine/preventive maintenance
Excellent	9	Routine maintenance and inspection

The average value of 37.91 indicates a significant decline in physical condition in the study section. However, heterogeneity between segments requires that technical recommendations be based on the PCI values of each segment, not just the average value of the entire section.

Road Conditions Based on the Highways Method

The Highways analysis was conducted by identifying damage in each segment, calculating the percentage of damage, assigning damage numbers, and converting them to road condition scores. A summary of condition scores for segments 1–20 is shown in Table 7.

Table 7. Damage figures and condition scores of Bina Marga (segments 1–20)

Segmen	STA	Total number	Condition value
1	0+000 - 0+050	0	1
2	0+050 - 0+100	0	1
3	0+100 - 0+150	0	1
4	0+150 - 0+200	0	1
5	0+200 - 0+250	0	1
6	0+250 - 0+300	2	1
7	0+300 - 0+350	2	1
8	0+350 - 0+400	0	1
9	0+400 - 0+450	0	1

Segmen	STA	Total number	Condition value
10	0+450 - 0+500	12	4
11	0+500 - 0+550	14	5
12	0+550 - 0+600	2	1
13	0+600 - 0+650	5	2
14	0+650 - 0+700	0	1
15	0+700 - 0+750	2	1
16	0+750 - 0+800	18	6
17	0+800 - 0+850	3	1
18	0+850 - 0+900	4	2
19	0+900 - 0+950	10	4
20	0+950 - 1+000	3	1

In the initial segment, the highest total damage score was in segment 16 at 18 with a condition value of 6. Segment 11 had a total of 14 with a condition value of 5, while segments 10 and 19 had a condition value of 4. Segments without damage or with low damage scores generally received a condition value of 1.

Basis of Assessment

The damage assessed includes cracks, grooves, patches, holes, surface roughness or damage, and sinkholes. The condition score for each segment is input, along with the LHR class, into the UP calculation.

Table 7 (continued). Damage figures and condition scores of Highways (segments 21–40)

Segmen	STA	Total number	Condition value
21	1+000 - 1+050	9	3
22	1+050 - 1+100	9	3
23	1+100 - 1+150	0	1
24	1+150 - 1+200	2	1
25	1+200 - 1+250	8	3
26	1+250 - 1+300	0	1
27	1+300 - 1+350	4	2
28	1+350 - 1+400	4	2
29	1+400 - 1+450	4	2
30	1+450 - 1+500	11	4
31	1+500 - 1+550	4	2
32	1+550 - 1+600	9	3
33	1+600 - 1+650	6	2
34	1+650 - 1+700	4	2
35	1+700 - 1+750	0	1
36	1+750 - 1+800	5	2
37	1+800 - 1+850	3	1
38	1+850 - 1+900	6	2
39	1+900 - 1+950	12	4
40	1+950 - 2+000	0	1

Average Daily Traffic and Priority Order

The three-day survey yielded an average volume of 8,928 vehicles. The vehicles recorded included motorcycles, passenger cars, public transportation (angkot) or minibuses, microtrucks or pick-ups, light two-axle trucks, heavy two-axle trucks, and three-axle trucks.

Table 8. Recapitulation of vehicle volume

Type of vehicle	Day 1	Day 2	Day 3	Average
Motorcycle	7,138	7,490	7,317	7,315
Passenger car	1,512	1,495	1,538	1,515
Public transport/minibus	12	10	8	10
Microtruck/pick-up	40	40	43	41
Light 2 axle truck	18	20	22	20
Heavy 2 axle truck	17	21	22	20
3 axle truck	3	9	9	7
Amount	8,740	9,085	8,959	8,928

After being converted to Passenger Car Equivalence, the LHR value used in the study is 3,500.5 and is in traffic class 5. The average road condition value is 1.9. Thus:

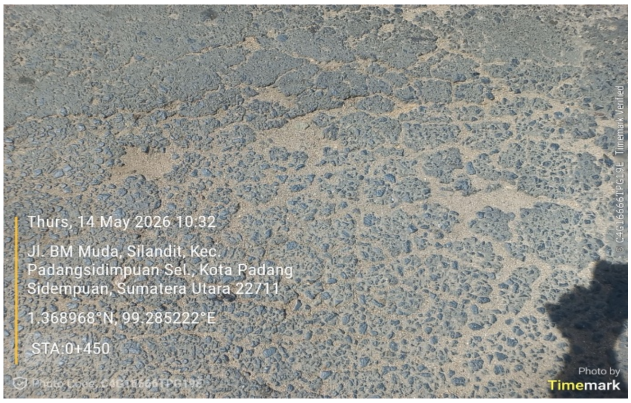
$$UP = 17 - (5 + 1.9) = 10.1 \approx 10 \quad (6)$$

A UP value of 10 (>7) places the BM Muda Road Section in the routine maintenance program according to the Bina Marga method.

Types of Damage Identified

Field documentation demonstrates some of the major forms of damage used in the analysis. The following examples are from the research segment and are retained in the thesis documentation.

Hole in Segment 2



Crocodile skin crack on Segment 10

Patch on Segment 20

Item release in Segment 28

Figure 3. Example of pavement damage on the BM Muda Road Section

Handling Recommendations

Table 9. Treatment recommendations according to PCI category

Category	Recommendation
Failed	Reconstruction of pavement layers and repair of foundation layers if necessary.
Very Poor	Structural overlay or reconstruction on sections that have damaged the foundation layer.
Poor	Structural improvements; local repairs are made before overlay.
Fair	Periodic maintenance, crack sealing, patching, drainage repair, or thin overlay.
Good	Routine maintenance and local damage handling.
Very Good	Routine maintenance, inspections, and preventive measures.
Excellent	Periodic inspection, surface cleaning and drainage.

Table 10. Handling recommendations according to Bina Marga

UP	Program	Form of handling
>7	Routine maintenance	Crack sealing, patching, drainage cleaning, shoulder treatment, and local repairs.
4–6	Periodic maintenance	Overlay, surface layer repair, and moderate damage treatment.
0–3	Improvement	Structural improvement, rehabilitation, or reconstruction.

Comparison and Interpretation of Results

The PCI and Bina Marga results differ because the two methods assess different aspects, as also seen in previous comparative studies (Hafiza & Sholichin, 2022; Rendy et al., 2023; Hadi et al., 2025). PCI produced an average score of 37.91 and a Poor category, indicating physical damage requiring structural improvements or reconstruction in certain segments. Bina Marga produced a UP of 10 and recommended routine maintenance because the prioritization combines road condition and traffic class values. PCI values per segment show highly heterogeneous conditions. Some segments are in the Failed category, while segments without damage are in the Excellent category. Therefore, PCI-based recommendations need to be implemented segmentally. Failed and Very Poor segments require structural action, while Good to Excellent segments can be maintained through routine maintenance and preventive measures.

The Bina Marga method provides program output at the segment level. An average condition score of 1.9 and a traffic class of 5 yield an UP of 10. These results do not invalidate the PCI findings, but rather demonstrate that the two methods serve different purposes: PCI provides a detailed physical diagnosis, while Bina Marga supports program prioritization. The LHR survey was conducted on Fridays, Saturdays, and Sundays because the sections are located near areas with increased tourist and community activity on weekends. For sections without the influence of special activities, the thesis recommends conducting the survey on Tuesdays, Wednesdays, and Thursdays because traffic volumes tend to be more stable. Practically, the research results can be used as a reference by relevant agencies to develop treatment plans based on the conditions of each segment while maintaining the overall function of the section. Regular monitoring is necessary to identify and address any damage developments promptly.

Table 11. Comparison of PCI and Bina Marga output

Aspect	PCI	Highways
Focus	Physical condition of pavement	Priority handling program
Parameter	Type, severity, and extent of damage	Road conditions and LHR
Research result	Average 37.91; Poor	UP 10; routine maintenance
Interpretation unit	Per segment and average section	Priority sections/programs
Utility	Determine the level of damage and technical needs	Determining the sequence of maintenance programs

CONCLUSION

Evaluation of the BM Muda STA 0+000–2+000 road segment showed an average PCI score of 37.91, categorizing the pavement as Poor. The Bina Marga method resulted in a UP of 10 and recommended a routine maintenance program. The difference in results occurred because PCI assesses physical conditions based on the type, severity, and extent of damage, while Bina Marga combines road conditions and LHR to determine priorities. Treatment needs to be tailored to the conditions of each segment, accompanied by regular monitoring to prevent damage from progressing.

Suggestion

Damage handling needs to be done immediately, monitoring of pavement conditions needs to be scheduled periodically, and the LHR survey days need to be adjusted to the characteristics of activities on the road section being studied.

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