

ASSESSMENT OF ROAD PAVEMENT DAMAGE USING THE PAVEMENT CONDITION INDEX (PCI) METHOD ON THE SOEKARNO-HATTA ROAD SECTION, LAMPUNG

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Abstract

Pavement deterioration is an issue that can compromise the level of service, comfort, and safety for road users. Consequently, a systematic assessment of pavement condition is required to determine the extent of damage and identify necessary maintenance or repair needs. This study aims to identify the types and severity levels of damage and assess the pavement condition on the Bandar Lampung By pass road section (Km 6+000 to Km 9+000) using the Pavement Condition Index (PCI) method. Data collected included the type, area, severity, and location of damage for each road segment. The data were subsequently analyzed using the PCI method, involving calculations for density, Deduct Value (DV), Total Deduct Value (TDV), Corrected Deduct Value (CDV), and the final PCI value. The results indicate three primary types of damage on the surveyed road section: potholes, patches, and alligator cracking. The total identified damage area was 2,091.50 m², with the following distribution: potholes (12.10%), patches (58.95%), and alligator cracking (28.95%). Based on the segment-by-segment assessment, the lowest conditions among the surveyed segments were found at STA 0+700–0+800 (PCI 60, "Good" category), STA 1+000–1+100 (PCI 56, "Good" category), and STA 2+800–2+900 (PCI 82, "Very Good" category). Meanwhile, the lowest PCI values were recorded at STA 0+200–0+300 (20) and STA 1+900–2+000 (22) both falling into the "Very Poor" category and STA 2+500–2+600 (28), which falls into the "Poor" category. Overall, the average PCI value for the road section was 37.27, classifying the pavement condition as "Poor." Based on these results, remedial action is required for the damaged pavement sections, particularly in locations with low PCI values.

Keywords: Road pavement damage, Pavement Condition Index, PCI, Bypass Road, Bandar Lampung.

INTRODUCTION

Road pavement is a fundamental component of transport infrastructure designed to directly support wheel loads and distribute traffic stresses to the underlying subgrade. During its service life, pavement experiences progressive deterioration driven by repeated traffic loadings, growing vehicle volumes, heavy vehicle axle loads, environmental exposure, weather fluctuations, material quality variations, sub-optimal drainage performance, and execution factors during construction and maintenance. If emerging pavement distresses are not promptly identified and repaired, minor defects can propagate into widespread structural failures, thereby reducing the road's level of service and increasing long-term lifecycle maintenance costs. Pavement distress manifests in various forms, including alligator cracking, longitudinal and transverse cracking, potholes, patching, rutting, depressions, weathering and raveling, among others. Each distress mode exhibits distinct physical characteristics, severity levels, spatial extent, and impact on structural integrity. Consequently, a systematic evaluation methodology is necessary to objectively identify defects and yield quantitative condition indices.

A stable road section minimizes congestion and delays, which must be matched by adequate transportation infrastructure to foster regional economic growth. A well-maintained road network enhances economic efficiency, whereas deteriorated pavements impede mobility, increase logistics costs, and heighten the risk of fatal accidents. Within this context, the Soekarno-Hatta Road section in Lampung forms a vital link in the National Road network, serving an essential role in regional connectivity and freight movement. The specific segment evaluated in this study spans STA 6+000 to STA 9+000, with a total length of 3,000 meters (3.00 km) and a pavement width of 7.00 meters.

As an arterial segment of the National Road network, periodic condition evaluations are critical to monitor performance degradation over time. Field condition surveys provide empirical data regarding distress types, severity levels, and spatial extents. Evaluating STA 6+000 to STA 9+000 using the PCI method provides both descriptive insights and standardized quantitative metrics to inform technical decision-making and maintain service standards across National Road corridors in Lampung Province.

2. LITERATURE REVIEW

2.1 Road Definitions and Legal Classifications

Roads are land transportation infrastructures comprising all constituent parts, including auxiliary structures and equipment designated for public traffic on, above, or below ground and water surfaces, excluding railways and cableways. Under Indonesian regulations (Law No. 2 of 2022 amending Law No. 38 of 2004, and Government Regulation No. 30 of 2021), functional classifications include:

- **Arterial Roads:** Public roads serving primary trunk transport characterized by long-distance travel, high average speeds, and controlled access points.
- **Collector Roads:** Public roads serving collector and distributor functions characterized by medium-distance travel, moderate speeds, and restricted access.
- **Local Roads:** Public roads serving local travel with short journey lengths, low average speeds, and unrestricted access.
- **Environmental Roads:** Public roads serving localized neighborhood mobility at low speeds.

Roads are further classified by load-bearing capacity and vehicle dimension limits into Class I, Class II, Class III (III A, III B, III C), and Special Class roads, as established in Directorate General of Bina Marga guidelines and Law No. 22 of 2009:

Table 2.1 Road Class Classification and Maximum Axle Load Capacities

Road Class	Functional Category	Max Length (m)	Max Width (m)	Maximum Axle Load (MST)
Class I	Arterial	18.0	2.50	> 10 Tons
Class II	Arterial	18.0	2.50	10 Tons
Class III A	Arterial / Collector	18.0	2.50	8 Tons
Class III B	Collector	12.0	2.50	8 Tons
Class III C	Local	9.0	2.10	8 Tons

Source: *Geometric Design Standards for Intercity Roads*, Directorate General of Bina Marga, Law No. 22 of 2009.

2.2 Pavement Types and Structural Layers

Pavements are categorized into three primary structural types based on binder properties, load distribution mechanisms, and composite behavior:

1. Flexible Pavement: Flexible Pavement utilizes asphaltic materials as binders. Traffic loads are transferred through grain-to-grain contact down through the structural layers to the subgrade. According to Silvia Sukirman (1999) and Bina Marga standards (No. 03/MN/B/1983), the typical structure comprises:

- **Surface Course (Lapis Permukaan):** The uppermost layer resisting vertical wheel loads, providing skid resistance, functioning as a waterproof seal, and distributing loads downward.
- **Base Course (Lapis Pondasi Atas):** Positioned between the surface course and subbase to resist lateral and vertical shear forces and provide structural stability.
- **Subbase Course (Lapis Pondasi Bawah):** Spreads stresses to the subgrade, optimizes material economy, improves drainage, and prevents fine subgrade soil particles from migrating into the base course.
- **Subgrade (Tanah Dasar):** The prepared natural or compacted soil foundation supporting the entire pavement system.

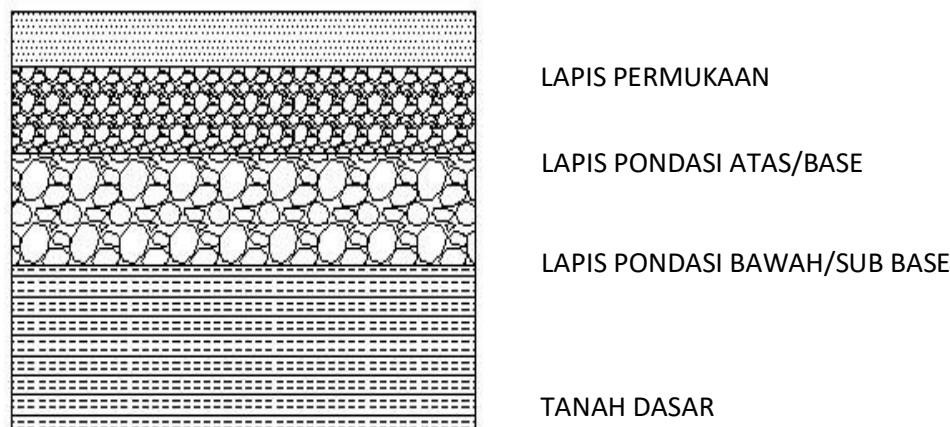


Figure 2.1 Structural Layer Layout of Flexible Pavement (Source: Bina Marga No. 03/MN/B/1983)

2. Rigid Pavement: Rigid Pavement utilizes Portland cement concrete slabs placed over a subbase or directly on the subgrade. Due to the high flexural rigidity of the concrete slab, wheel loads are distributed over a wide area, generating low stresses on the subgrade. Components include subgrade, subbase (working platform / drainage layer), concrete slab, and bond breakers (plastic sheeting to eliminate interface friction).

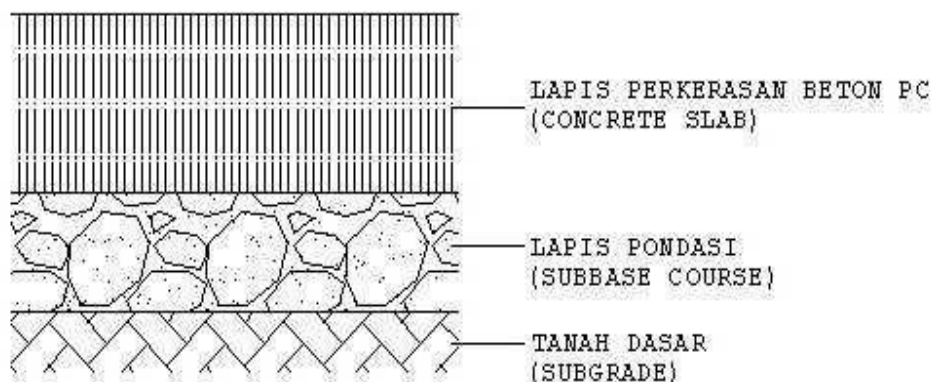


Figure 2.2 Structural Layer Layout of Rigid Pavement (Source: Bina Marga No. 03/MN/B/1983)

3. Composite Pavement: Composite Pavement combines flexible asphalt surface courses placed over rigid concrete base slabs, leveraging the high riding quality of asphalt while utilizing the high load-carrying capability of concrete.

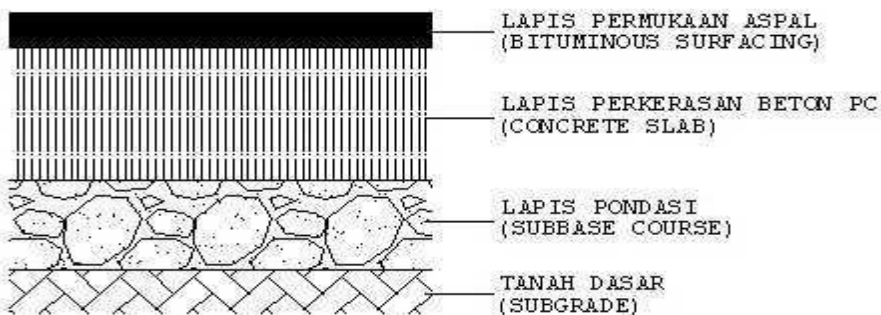


Figure 2.3 Structural Layer Layout of Composite Pavement (Source: Bina Marga No. 03/MN/B/1983)

Table 2.2 Structural and Performance Differences Between Flexible and Rigid Pavements

No.	Evaluation Parameter	Flexible Pavement	Rigid Pavement
1	Binding Agent	Asphalt binder	Portland cement
2	Load Repetition Effect	Wheel path rutting and permanent deformation	Surface fatigue cracking
3	Subgrade Response	Undulating surface (conforms to subgrade deformation)	Behave as a rigid beam bridging subgrade gaps
4	Temperature Sensitivity	Stiffness modulus varies with temperature; low internal stress	Stiffness modulus remains constant; high thermal stresses

Source: Sukirman, S. (1992), *Highway Flexible Pavement*.

2.3 Pavement Condition Index (PCI) Evaluation Method

The Pavement Condition Index (PCI) method, developed by Shahin (1994) and standardized under ASTM D6433, provides a numerical rating from 0 to 100 representing structural integrity and surface operational condition. Ratings are categorized into seven standardized condition classes: Failed (0–10), Very Poor (11–25), Poor (26–40), Fair (41–55), Good (56–70), Very Good (71–85), and Excellent (86–100).

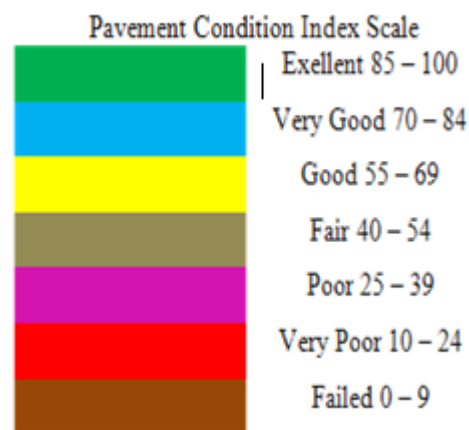


Figure 2.23 Pavement Condition Index (PCI) Rating Scale and Categories (Source: Shahin, 1994; Bina Marga No. 03/MN/B/1983)

The computational procedure involves five sequential formulation steps:

1. Density Calculation: Density represents the proportion of damaged surface area (or length) relative to the total area of the sample unit:

$$\text{Density (\%)} = (\text{Ad} / \text{As}) \times 100\% \quad \text{or} \quad \text{Density (\%)} = (\text{Ld} / \text{As}) \times 100\% \quad (\text{Eq. 2.1 \& 2.2})$$

Where Ad is total distress area (m²), Ld is total distress length (m), and As is total sample unit surface area (m²).

2. Deduct Value (DV): Deduct Values reflect the negative impact of specific distress types and severity levels (Low, Medium, High) on pavement condition, derived from standard curves.

3. Total Deduct Value (TDV): Total Deduct Value is the arithmetic sum of individual DVs recorded within a sample unit.

4. q-value and Corrected Deduct Value (CDV): The q-value represents the number of individual DVs exceeding 5. Corrected Deduct Value is determined from TDV vs CDV curves based on q.

5. PCI Score Computation: The PCI score for an individual segment and the overall mean PCI for the entire road section are calculated as:

$$\text{PCI}_{\text{segment}} = 100 - \text{CDV} \quad (\text{Eq. 2.3})$$

$$\text{Mean PCI} = (\sum \text{PCI}_{\text{segment}}) / N \quad (\text{Eq. 2.4})$$

Where N is the total number of evaluated sample units along the road section.

Table 2.3 Maintenance Intervention Thresholds Based on PCI Scores and Road Classifications

Action / Repair Horizon	Arterial (PCI)	Road Collector (PCI)	Road Local Road (PCI)
No Action Required	> 80	> 80	> 80
Routine Maintenance (6 – 10 years)	76 – 85	71 – 80	66 – 80
Periodic Maintenance (1 – 5 years)	56 – 75	51 – 70	46 – 65
Immediate Rehabilitation	50 – 55	45 – 50	40 – 45
Immediate Reconstruction	< 50	< 45	< 40

Source: Bina Marga Standards No. 03/MN/B/1983.

3. RESEARCH METHODOLOGY

This study evaluated the Soekarno-Hatta (Bypass) National Road section, Bandar Lampung, from Km 6+000 to Km 9+000 (STA 0+000 to STA 3+000, direction Panjang to Rajabasa). The surveyed corridor covers a length of 3,000 meters (3.00 km) with a pavement width of 7.00 meters, yielding a total evaluation area of 21,000 m².

Visual field surveys were conducted in July 2026 utilizing a descriptive-analytical approach. The survey procedure followed these systematic steps:

- **Step 1: Literature Review & Preliminary Planning** — Establishing functional road classifications, defining spatial boundaries, and compiling base maps.
- **Step 2: Corridor Partitioning** — Dividing the 3,000-meter road corridor into 30 standardized sample units, each measuring 100 meters in length and 7.00 meters in width (700 m² per unit).
- **Step 3: Field Visual Walkaround Inspection** — Recording distress types, severity levels (Low, Medium, High), physical dimensions (length, area, depth), and precise location for each segment.
- **Step 4: Quantitative PCI Parameter Calculation** — Computing Density (%), Deduct Values (DV), Total Deduct Value (TDV), q-value, Corrected Deduct Value (CDV), and segment PCI score.
- **Step 5: Section Synthesis & Maintenance Strategy** — Calculating mean section PCI, identifying dominant distress modes, mapping condition ratings, and selecting intervention strategies.

4. RESULTS AND DISCUSSION

4.1 Sample Calculation (STA 0+000 to STA 0+100)

To illustrate the application of the PCI methodology, detailed field measurements and calculations for the first sample unit (STA 0+000 to STA 0+100) are presented below:

- **Sample Unit Dimensions:** Length = 100.0 m, Width = 7.00 m, Total Sample Area (As) = 700.0 m².
- **Identified Distress 1:** Potholes (Low Severity, Code 13L) — Total Area = 19.00 m².
- **Identified Distress 2:** Patching (Medium Severity, Code 11M) — Total Area = 51.00 m².

Density Calculations:

$$\text{Density_Potholes (13L)} = \frac{(19.00}{700.0)} \times 100\% = 1.90\%$$

$$\text{Density_Patching (11M)} = \frac{(51.00}{700.0)} \times 100\% = 5.10\%$$

Deduct Value (DV) Determination from Curves:

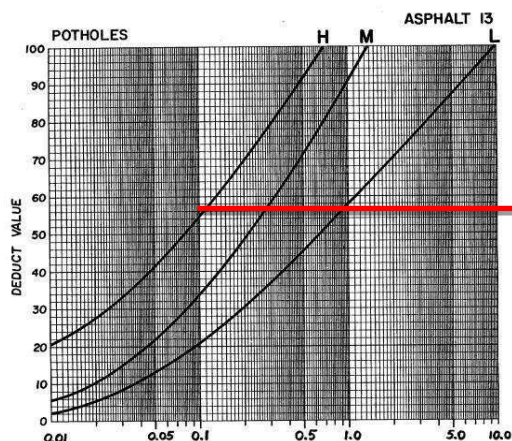


Figure 4.2 Deduct Value Curve for Low-Severity Potholes (Density = 1.90% $\Rightarrow$ DV = 70)

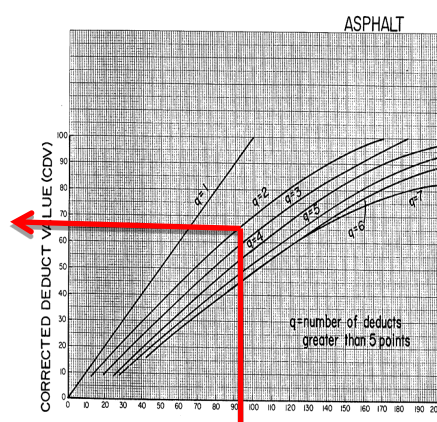


Figure 4.3 Deduct Value Curve for Medium-Severity Patching (Density = 5.10% $\Rightarrow$ DV = 23)

Total Deduct Value (TDV) & Corrected Deduct Value (CDV):

$$\begin{aligned} \text{TDV} &= \text{DV}_{\text{Potholes}} + \text{DV}_{\text{Patching}} = 70 + 23 = 93 \\ \text{Number of DVs} &> 5 \quad (q\text{-value}) = 2 \quad (\text{both } 70 \text{ and } 23 \text{ exceed } 5) \\ \text{From CDV curves (TDV} &= 93, q = 2) \Rightarrow \text{CDV} = 66 \end{aligned}$$

Segment PCI Calculation:

$$\text{PCI}_{\text{segment}} = 100 - 66 = 34 \text{ ('Poor' Condition Category)}$$

4.2 Recapitulation of Road Condition Across All Segments

Field survey data across all 30 sample units along the 3.00 km corridor were systematically processed. The complete segment-by-segment recapitulation is presented below:

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Table 4.1 Complete Recapitulation of Pavement Condition Assessment (PCI Method)

STA	Identified Distress Types	Area (m ²)	Density (%)	DV	TDV	CDV	PCI	Category
0+000	– Potholes (13L)	19.00	1.90	70	93	66	34	Poor
0+100	Patching (11M)	51.00	5.10	23				
0+100	– Potholes (13L)	23.00	2.30	74	116	72	28	Poor
0+200	Patching (11M)	33.00	3.30	18				
	Alligator Cracking (1M)	14.00	1.40	24				
0+200	– Potholes (13L)	28.50	2.85	76	134	80	20	Very Poor
0+300	Patching (11M)	136.00	13.60	36				
	Alligator Cracking (1M)	10.50	1.05	22				
0+300	– Potholes (13L)	17.00	1.70	66	116	74	26	Poor
0+400	Patching (11M)	49.00	4.90	20				
	Alligator Cracking (1M)	25.50	2.55	30				
0+400	– Potholes (13L)	19.00	1.90	70	93	66	34	Poor
0+500	Patching (11M)	55.00	5.50	23				
0+500	– Potholes (13L)	14.00	1.40	63	91	64	36	Poor
0+600	Patching (11M)	87.00	8.70	28				
0+600	– Potholes (13L)	8.00	0.80	53	108	68	32	Poor
0+700	Patching (11M)	39.00	3.90	19				
	Alligator Cracking (1M)	41.00	4.10	36				
0+700	– Patching (11M)	57.00	5.70	23	55	40	60	Good
0+800	Alligator Cracking (1M)	28.00	2.80	32				
0+800	– Potholes (13L)	10.00	1.00	58	114	70	30	Poor
0+900	Patching (11M)	65.00	6.50	24				
	Alligator Cracking (1M)	31.00	3.10	32				
0+900	– Potholes (13L)	5.00	0.50	45	92	58	42	Fair
1+000	Patching (11M)	79.00	7.90	27				
	Alligator Cracking (1M)	10.00	1.00	20				
1+000	– Patching (11M)	66.00	6.60	24	58	44	56	Good
1+100	Alligator Cracking (1M)	31.00	3.10	34				
1+100	– Potholes (13L)	11.00	1.10	58	105	65	35	Poor
1+200	Patching (11M)	75.00	7.50	27				
	Alligator Cracking (1M)	9.00	0.90	20				
1+200	– Potholes (13L)	14.00	1.40	64	106	73	27	Poor
1+300	Alligator Cracking (1M)	67.00	6.70	42				
1+300	– Potholes (13L)	7.50	0.75	52	110	68	32	Poor
1+400	Patching (11M)	45.00	4.50	20				
	Alligator Cracking (1M)	46.50	4.65	38				
1+400	– Patching (11M)	79.00	7.90	27	67	50	50	Fair
1+500	Alligator Cracking (1M)	56.00	5.60	40				
1+500	– Patching (11M)	21.00	2.10	14	58	44	56	Good
1+600	Alligator Cracking (1M)	81.00	8.10	44				
1+800	– Potholes (13L)	16.00	1.60	66	130	78	22	Very Poor
1+900	Patching (11M)	84.00	8.40	28				
	Alligator Cracking (1M)	45.00	4.50	36				

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1+900	– Potholes	(13L)	12.00	1.20	60	118	74	26	Poor
2+000	Patching	(11M)	78.00	7.80	26				
	Alligator Cracking (1M)		35.00	3.50	32				
2+000	– Potholes	(13L)	6.00	0.60	50	99	62	38	Poor
2+100	Patching	(11M)	24.00	2.40	15				
	Alligator Cracking (1M)		38.00	3.80	34				
2+100	– Potholes	(13L)	9.00	0.90	54	100	64	36	Poor
2+200	Patching	(11M)	37.00	3.70	18				
	Alligator Cracking (1M)		20.00	2.80	28				
2+200	– Potholes (13L)		20.00	2.00	72	72	72	28	Poor
2+300									
2+300	– Patching	(11M)	19.00	1.90	12	34	25	75	Very Good
2+400	Alligator Cracking (1M)		10.00	1.00	22				
2+500	– Potholes (13L)		26.00	2.60	77	77	72	28	Poor
2+600									
2+600	– Patching	(11M)	48.00	4.80	21	53	40	60	Good
2+700	Alligator Cracking (1M)		27.00	2.70	32				
2+700	– Patching	(11M)	21.00	2.10	14	34	25	75	Very Good
2+800	Alligator Cracking (1M)		8.00	0.80	20				
2+800	– Patching	(11M)	6.00	0.60	7	25	18	82	Very Good
2+900	Alligator Cracking (1M)		7.00	0.70	18				
2+900	– Patching (11M)		57.00	5.70	24	24	24	76	Very Good
3+000									

Source: Field Survey Data Analysis, Allamah Adjie Pamungkas et al., 2026.

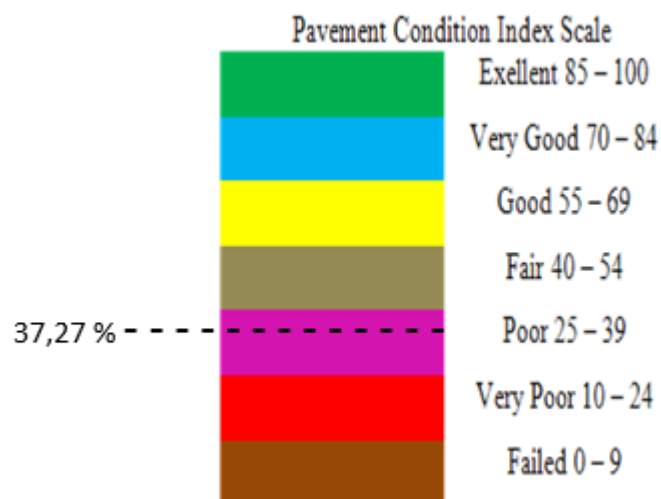


Figure 4.5 Pavement Condition Index (PCI) Score Profile Across All Surveyed Road Segments

4.3 Distress Mode Distribution and Overall Section Rating

Field inspection across the 3.00 km road section identified three major distress modes affecting a total surface area of 2,091.50 m²:

Table 4.2 Breakdown of Identified Pavement Distress Types and Quantities

Distress Code	Distress Description	Affected Surface Area (m ²)	Percentage Contribution (%)
11M	Patching / Tambalan	1,233.00	58.95%
1M	Alligator Cracking / Retak Kulit Buaya	605.50	28.95%
13L	Potholes / Lubang	253.00	12.10%
Total	All Distress Types Combined	2,091.50	100.00%

Source: Field Survey Data Analysis, Allamah Adjie Pamungkas et al., 2026.

Chart 4.1 Percentage Distribution of Road Pavement Distress Types

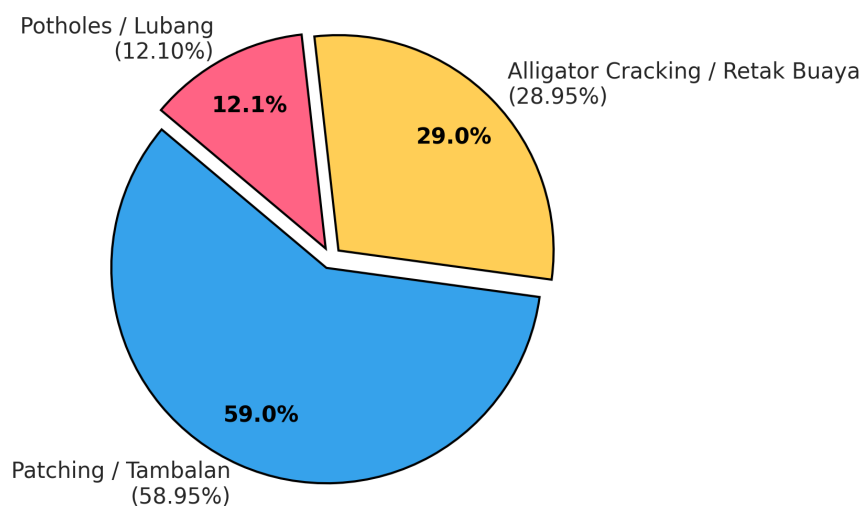


Chart 4.1 Percentage Share of Pavement Distress Modes on Soekarno-Hatta Bypass Road

Overall Section PCI Score: Summing the individual segment scores across the surveyed corridor yields an overall mean PCI score of 37.27. Under PCI classification criteria (Shahin, 1994; Bina Marga No. 03/MN/B/1983), a score of 37.27 categorizes the pavement condition as 'Poor'. Required Technical Intervention: For national arterial roads exhibiting an average PCI score below 50 ($PCI < 50$), standard maintenance guidelines mandate immediate Reconstruction. Structural overlay and localized patching are insufficient due to extensive subgrade/base fatigue reflected by widespread patching (58.95%) and alligator cracking (28.95%).

5. CONCLUSION

- Three primary distress types were identified on the Soekarno-Hatta National Road section (Km 6+000 to Km 9+000): patching (1,233.00 m², 58.95%), alligator cracking (605.50 m², 28.95%), and potholes (253.00 m², 12.10%), with a total damaged area of 2,091.50 m².
- Segment-by-segment evaluation revealed high variability along the 3.00 km corridor: the highest condition ratings occurred at STA 2+800–2+900 (PCI 82, 'Very Good'), STA 0+700–0+800 (PCI 60, 'Good'), and STA 1+000–1+100 (PCI 56, 'Good'). The lowest condition scores occurred at STA 0+200–0+300 (PCI 20, 'Very Poor'), STA 1+900–2+000 (PCI 22, 'Very Poor'), and STA 2+500–2+600 (PCI 28, 'Poor').
- The overall average PCI score for the entire road corridor is 37.27, placing the overall pavement condition in the 'Poor' category. Under Bina Marga and PCI standards, immediate structural reconstruction is required to restore traffic safety, riding quality, and structural capacity.

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