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Evaluation of rigid pavement damage using PCI and bina marga approaches (case study: Saketi–Malingping road, KM 17–27)

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ABSTRACT

This study aims to evaluate the damage condition of the Saketi - Malingping road section (KM 17-KM 27) using two assessment approaches: the Pavement Condition Index (PCI) and the Bina Marga method. This road section is a strategic arterial road in Pandeglang Regency, Banten, which experiences high operational pressure and shows signs of surface distress. Data were collected through field surveys across 42 segments. The PCI analysis results show an average value of 99.99, indicating the road is in a "Very Good" category structurally. Assessment using the Bina Marga method revealed that block cracking is the most dominant type of damage, accounting for approximately 89.31% of the total damaged area. Although the overall road condition value is still considered good, the presence of extensive block cracking indicates early signs of structural vulnerability. The study recommends preventive measures such as crack sealing, localized overlay, or reconstruction of severely cracked sections.

Keywords: road damage; rigid pavement; pavement condition index; bina marga method; block cracking

1 Introduction

Road infrastructure is a vital component in supporting economic growth, community mobility, and the distribution of goods and services in a region. Good road conditions not only improve transportation efficiency but also contribute to user safety and reduced vehicle operating costs. However, in many regions, including Indonesia, road deterioration remains a serious challenge due to high traffic loads, weather factors, limited maintenance budgets, and technical aspects of planning and construction. Regular monitoring and evaluation of pavement conditions are key to effective and sustainable road maintenance management. Without objective and methodological assessment, repair interventions often tend to be reactive, poorly targeted, and potentially wasteful of limited resources.

In Banten Province, the Saketi - Malingping road section serves as a strategic inter-district connector, facilitating the distribution of agricultural products, access to settlements, and local socio-economic activities. This road segment experiences significant operational pressure, particularly from heavy vehicles transporting agricultural commodities and construction materials. Symptoms of pavement surface distress such as cracking, potholes, and layer quality degradation have been observed in several segments, potentially disrupting traffic flow and increasing accident risks. Therefore, an assessment of the actual pavement condition along this section is necessary to develop data-based, systematic, and priority-driven treatment recommendations.

In road condition assessment practice, two methods commonly used in Indonesia are the Pavement Condition Index (PCI) and the Bina Marga method. PCI is a quantitative method developed by the U.S. Army Corps of Engineers, which evaluates the level of distress based on the type, severity, and density of damages, then converts it into an index value between 0 and 100 [19]. This method has been internationally adopted and provides a consistent and standardized score for comparing conditions across road segments. On the other hand, the Bina Marga method, issued by the Directorate General of Highways of the Indonesian Ministry of Public Works and Public Housing, is a national guideline widely used in Indonesia. This method classifies damage based on type and severity level, and provides a visual

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assessment guide that is easily applicable in the field, although it is more subjective compared to PCI.

Several previous studies have applied these two methods separately, but studies that directly compare the assessment results of both methods on road sections with similar characteristics and contexts are still limited. This comparison is important to understand the consistency of evaluation results, as well as the strengths and limitations of each method in the context of local road networks in Indonesia. Comparing these two methods on this specific arterial road yields fresh insights because arterial roads in Banten serve distinct operational pressures—sustained heavy agricultural truck traffic and tropical weathering—that demand a dual-method validation to capture both structural index precision (PCI) and distress-type severity ranking (Bina Marga), which a single-method evaluation might overlook. This dual validation is essential for accurately prioritizing budget allocation and treatment strategies in similar developing-region road networks. A recent comparative study by Pham and Nguyen [20] also emphasized the need for such dual-method assessments in developing Southeast Asian regions to capture both functional and structural deterioration indicators. Furthermore, the identification of dominant damage types and their causal factors on the Saketi - Malingping road section has not been widely addressed in the literature, so this research can fill that information gap.

Based on this background, this study aims to evaluate the level of pavement damage on the Saketi–Malingping road section (KM 17 — KM 27) using two assessment approaches: the Pavement Condition Index (PCI) method and the Bina Marga method. Specifically, this research aims to: (1) identify the types, distribution, and severity levels of road damage at the study location, (2) analyze the pavement condition values based on both methods, (3) compare the assessment results from both methods to examine their consistency and differences, and (4) formulate appropriate technical treatment recommendations according to the identified damage categories. The results of this study are expected to provide input for relevant agencies in developing data-based, effective, and efficient road maintenance programs, while also contributing to the academic discourse on the application and comparison of pavement condition assessment methods in Indonesia.

2 Data and Methods

2.1 Overall Research Design

This study uses a descriptive quantitative approach, aiming to evaluate the level of road damage based on field-collected data. This method was chosen because it can provide an objective picture of pavement conditions, which are then analyzed using two assessment approaches: the Pavement Condition Index (PCI) and the Bina Marga method.

2.2 Location of Research

This research was conducted on the Saketi - Malingping Road, specifically from KM 17 to KM 27, located in Pandeglang Regency, Banten Province. The road is a two-lane arterial road with a total length of 10 km and a width of 3.5 meters per lane. This segment was selected due to visible signs of pavement distress and its strategic importance for regional connectivity.

Figure 1. Location of Research
(Source: Google Maps, 2025)

2.3 Research Scope and Target

The entire 10-km road section was included in the research population. To facilitate systematic and repeatable analysis, the road was divided into 100 longitudinal segments, each 100 meters in length. Within each segment, both traffic lanes—the northbound lane and the southbound lane—were surveyed separately. Each lane constituted an independent survey unit with an area of 100 m × 3.5 m = 350 m^2. Consequently, the total number of survey units was 200 (100 segments × 2 lanes), covering the entire paved area of the road (70,000 m^2). This lane-wise approach ensures that the condition of each lane is distinctly recorded, and the methodology can be exactly replicated.

2.4 Data Collection Techniques

Data collection was carried out through comprehensive field surveys conducted between March and June 2024. The process was designed to capture both primary and secondary data.

Primary data were obtained through direct, systematic field observation and measurement. A visual survey was conducted to identify and record all types of surface distress on both the northbound and southbound lanes, including cracks, potholes, settlements, and stripping. The dimensions (length, width, and area) of each distress were measured using standard tools. Each identified distress was classified according to its severity level (low, medium, or high) per PCI and Bina Marga guidelines. To ensure organized data management, the entire corridor was subdivided into 200 lane-based survey units as described in Section 2.3. Photographic documentation was undertaken for every instance of damage.

Secondary data included official road classification documents and regional maps, and the process adhered to the technical manuals of both PCI [18] and Bina Marga methods. The data collection process was guided by the formal technical manuals and standards for both the Pavement Condition Index (PCI) and the Indonesian Bina Marga assessment method, ensuring that all evaluations adhered to established national and international protocols. This combination of rigorous field survey and supportive documentary review formed a robust foundation for the subsequent comparative analysis of pavement conditions.

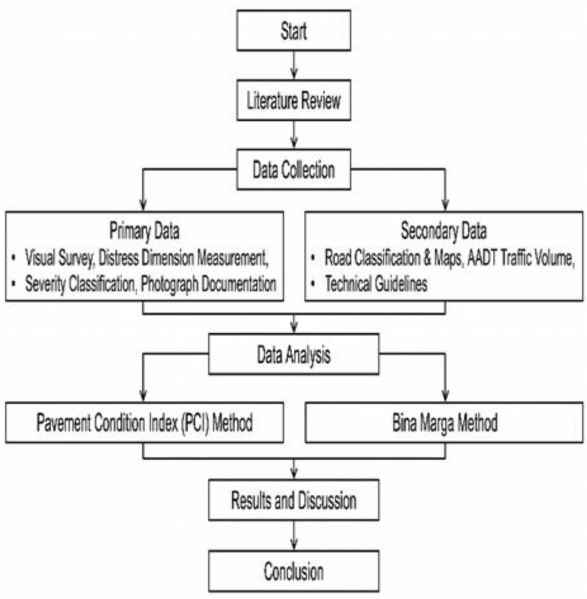

Figure 2. Flowchart

(Source: Processed from Research Stages, 2025)

To obtain primary data, direct field surveys were conducted using various systematic observation and measurement techniques, such as:

- Visual road condition survey: Observing and recording surface damage such as cracks, potholes, settlements, peeling, etc.
- Damage dimension measurement: Measuring the length, width, and area of damage using tools.
- Severity level classification: Damage is classified into mild, moderate, or severe levels based on PCI and Bina Marga method guidelines.
- Segment division: To facilitate recording and calculation, the road was divided into 100-meter segments for analysis.
- Photo documentation: To ensure classification accuracy and data validation, photo documentation was required for each damage.

To support and complement the analysis, secondary data were obtained from the following sources:

- Road classification data from Bina Marga or local Public Works Department to determine road status (e.g., national, provincial, or city road).
- Maps showing road location, administrative boundaries, and surrounding area functions.
- Technical guideline documents, such as road condition assessment standards based on the PCI method and Bina Marga method, were used as references for data processing.

2.5 Data Analysis Techniques

2.5.1 Pavement Condition Index (PCI) Method

The Pavement Condition Index (PCI) method assesses road pavement conditions based on the type, severity, and quantity of damage occurring on the road surface. A visual survey is used in this procedure, and the results are converted into a numerical value to indicate the level of pavement serviceability.

The primary data used in this study were obtained through direct field surveys on the Saketi–Malingping Road. To collect this data, two approaches were used: the PCI method and the Bina Marga method. The PCI method identifies the type of damage, severity level, and damage dimensions (area or length) for each survey unit. The Bina Marga method records the type and quantity of road surface damage, then calculates the area or length based on the observed damage type.

2.5.2 Identifying Road Condition Types

PCI values are used to classify road conditions into the following categories:

Table 1. Road Condition Categories

PCI Value	Road Condition
86 – 100	Excellent
71 – 85	Very Good
56 – 70	Good
41 – 55	Fair
26 – 40	Poor
11 – 25	Very Poor
0 – 10	Failed

(Source: Shahin, 1994)

2.5.3 Formula for Determining Pavement Condition Index (PCI)

1. Calculating Deduct Value (DV)

   The Deduct Value (DV) for each type of damage in a survey unit is determined based on three main factors: the type of damage, the severity level (low, medium, or high), and the density or percentage of the damage area relative to the entire unit. These DV values refer to the standard table in the PCI assessment system.

2. Calculating Total Deduct Value (TDV)
   If there is more than one type of damage in one survey unit, all Deduct Values (DV) resulting from each damage are summed to obtain the Total Deduct Value (TDV).

$$TDV = \sum DV \quad (1)$$

3. Determining Corrected Deduct Value (CDV)
   If the number of damage types (m) is more than one and the TDV is ≥ 40, then the calculation must be corrected to obtain the Corrected Deduct Value (CDV). This correction is made on the PCI correction chart by considering the number of damages and the maximum DV value, thereby preventing excessively high deduction values.
4. Calculating PCI Value
   After obtaining the CDV, the PCI value can be calculated using the following formula:

$$\text{PCI} = 100 - \text{CDV} \quad (2)$$

This value indicates that the road condition in the survey unit is worse with a lower PCI value.

2.6 Bina Marga Assessment System

According to the Directorate General of Highways (1990), the Bina Marga method assesses pavement conditions based on the type, severity, and dimensions of damage observed visually. This method has been widely used in Indonesia as a standard for evaluating road surface damage. Quantitatively, the assessment is carried out by evaluating each type of damage based on its impact on the structure and function of the road. This method is simple yet effective because it can be used to monitor road conditions in the field quickly and efficiently without requiring special equipment. The steps taken to conduct analysis using the Bina Marga method are explained as follows:

2.6.1 Identifying Damage Type and Severity Level

The first stage involves a visual inspection of the entire road section to record types of damage, such as potholes, longitudinal cracks, patching, and edge damage. According to the Bina Marga classification, each type of damage is grouped into three severity levels: mild, moderate, or severe.

2.6.2 Determination of Survey Unit

In the process, the road section is divided into survey units called segments, each with a standard length of 100 meters and a width adjusted to the lane size being analyzed. The collected data and subsequent calculations are based on this segment as the basis for analysis.

2.6.3 Identifying Damage Type and Level

For each predetermined survey unit, damage identification is carried out visually in the field. At this stage, the goal is to identify the type of damage occurring on the rigid pavement, i.e., cement concrete, and also to determine its severity level.

According to the Directorate General of Bina Marga, damage commonly found on rigid pavements is grouped into several categories, namely:

- Longitudinal and transverse cracks
- Alligator cracking
- Potholes
- Patching
- Settlement
- Edge damage

2.6.4 Determination of Damage Level

Each type of damage, along with its severity level, is assigned a specific weight value in the Bina Marga technical guidelines. This weight value indicates how much influence the damage has on the decline in road quality or condition.

2.6.5 Road Damage Value (NKJ)

The Road Damage Value (NKJ) is the result of the calculation between the damage dimension—either area or length—and the weight value that has been determined based on the type and severity level of the damage. This calculation is performed for each type of damage identified in a road segment. Mathematically, (Pusjatan, 1990; Directorate General of Bina Marga, 1993) NKJ is formulated as:

$$\frac{\text{Damage Dimension} \times \text{Weight}}{\text{Segment Area}} \quad (3)$$

2.6.6 Summation of Total Damage Value (NKJ)

Summation of Total Damage Value (ΣNKJ): All NKJ values from various damage types in one segment are summed.

2.6.7 Calculation of Road Condition Value (NCJ)

The Road Condition Value (NCJ) is obtained by subtracting the total damage value from the perfect condition value (100) and then dividing by the segment area.

$$\text{NCJ} = 100 - \frac{\sum \text{NKJ}}{\text{Segment Area}} \quad (4)$$

2.6.8 Road Condition Classification

Tabel 2. Road Condition Classification

NCJ Value	Condition Category	Recommended Action
86 – 100	Excellent	No Action Needed
71 – 85	Very Good	Routine Maintenance
56 – 70	Good	Periodic Maintenance
41 – 55	Fair	Local Structural Repair
26 – 40	Poor	Partial Reconstruction
11 – 25	Very Poor	Full Reconstruction
0 – 10	Failed	Total Overhaul

(Source: Bina Marga, 1993)

3 Results and Discussion

3.1 Pavement Condition Index (PCI) Method Results

3.1.1 Road Condition Data Analysis Results

To evaluate the pavement condition on the Saketi–Malingping Road, the PCI approach based on ASTM D6433 standard [21] was used. The identification results showed six types of damage: patching, block cracking, edge cracking, potholes, joint cracking, and longitudinal & transverse cracking. The total damage area was 28,177 m^2. The composition and area of each damage type are shown in **Table 3**.

Table 3. Damage Area and Percentage

Type of Damage	Area (m^2)	Percentage
Patching	6,402	1,8291
Block Cracking	13,0842	0,0374
Edge Cracking	1,2298	0,0035
Potholes	2,3837	0,0068
Joint Cracking	0,1345	0,0004
Longitudinal & Transverse Crack	0,1288	0,0004

3.1.2 PCI Calculation

After PCI method analysis, the Density, Deduct Value (DV), and Corrected Deduct Value (CDV) were calculated. **Table 4** and **Table 5** present these calculations.

Table 4. Density Calculation

Type of Damage	Density
Patching	1,2194
Block Cracking	2,4922
Edge Cracking	0,2342
Potholes	0,4540
Joint Cracking	0,0256
Longitudinal & Transverse Crack	0,0245

Table 5. CDV Calculation

Total Deduct Value	CDV
Patching	98,7806
Block Cracking	97,5078
Edge Cracking	99,7658
Potholes	99,5460
Joint Cracking	99,9744
Longitudinal & Transverse Crack	99,9755
Aggregate Wear	99,1806
Alligator Cracking	99,9025
Total	794,633

Thus, the PCI value for this road section is 99.99, as shown in **Table 6**.

Table 6. PCI Calculation

No	Type of Damage	PCI
1	Patching	1,2194
2	Block Cracking	2,4922
3	Edge Cracking	0,2342
4	Potholes	0,4540
5	Joint Cracking	0,0256
6	Longitudinal & Transverse Crack	0,0245
7	Aggregate Wear	0,8194
8	Alligator Cracking	0,0975

Based on the PCI value of 99.99 and referring back to **Table 1**, the pavement condition is in the "Excellent" category, indicating that the road does not require structural repair. The existing damage is classified as minor and local.

3.2 Road Damage Analysis Using Bina Marga Method

3.2.1 Data Analysis

The Bina Marga method was used to visually analyze the damage on the Saketi–Malingping Road (KM 17–KM 27. Field observation data were categorized according to damage type, and score values were calculated.

Survey results showed that block cracking was the largest damage with an area of 27,1593 m^2, approximately 91.51% of the total damaged area of 29,6767 m^2, classified as severe damage. Other damage types included edge cracking (4.14%), potholes (3.28%), and longitudinal cracking (0.16%), as detailed in **Table 7**.

Table 7. Road Damage Area and Percentage

Type of Damage	Area (m^2)	Damage (%)
Block Cracking	27,1593	91,51725091
Edge Cracking	1,22980	4,143991751
Potholes	0,97490	3,28506876
Joint Cracking	0,13450	0,45321751
Transverse Crack	0,12880	0,43401052
Longitudinal Crack	0,04940	0,16646056

3.2.2 Hypothesis Testing

Data processing results showed that the average damage score was 99.90. According to Bina Marga standards, the overall road condition is still considered good. The NKJ for each damage type is shown in **Table 8**.

Table 8. NKJ Calculation Based on Damage Type

Type of Damage	Damage (%)	NKJ
Block Cracking	91,51725091	2741,6
Edge Cracking	4,143991751	5,2191
Potholes	3,28506876	20,6994

Joint Cracking	0,45321751	1,7135
Transverse Crack	0,43401052	0,5470
Longitudinal Crack	0,16646056	0,2098

3.2.3 Field Problem Evaluation

These findings simultaneously answer the research question about the level of damage and how to handle it. The results clearly show that block cracking, due to its large area and high severity level, is the most common damage requiring special attention.

Other damage types such as edge cracking, potholes, and joint cracking fall into the mild to moderate damage category, which can be repaired with regular maintenance and quick repairs.

Table 9. Damage Classification and Repair Plan

Type of Damage	Damage (%)	Classification	Repair Plan
Block Cracking	91.5172	Very Poor	Reconstruction
Edge Cracking	4.14399	Good	Routine Maintenance
Potholes	3.28507	Good	Fast Patching, Cleaning
Joint Cracking	0.45322	Good	Joint Injection
Transverse Crack	0.43401	Good	Crack Sealing
Longitudinal Crack	0.16646	Good	Cleaning & Crack Filling

3.2.4 Field Findings

One important finding from this analysis is that one type of damage (Block Cracking) dominates almost all damage areas. This must be noted because this type of damage can develop into structural damage if not repaired immediately.

Additionally, from the calculation of total scores for each damage type, block cracking has the highest score of 65,858.9544 compared to other damages.

Table 10. Score × Area = Total Score

Type of Damage	Score	Area (m^2)	Total Score
Block Cracking	3083,7792	27,1593	83753,28551
Edge Cracking	99,949	1,22980	122,9173259
Potholes	499,986	0,97490	487,4362883
Joint Cracking	300,000	0,13450	40,349946
Transverse Crack	99,999	0,12880	12,879928
Longitudinal Crack	100,000	0,04940	4,939995938

3.2.5 Analysis Results

Although the overall road condition value is generally good, block cracking, which contributes nearly 90% of total damage, must be repaired immediately. This is because block cracking can develop into structural damage, which can accelerate the decline of road function.

Therefore, areas with significant damage should be repaired through layer reconstruction or overlay. For additional damage, routine maintenance, quick patching, or joint injection is sufficient, depending on field conditions.

4 Conclusion

The overall condition of the Saketi - Malingping road section (KM 17- KM 27) is classified as excellent, according to the road condition analysis conducted using two methods: the Bina Marga Method and the Pavement Condition Index (PCI). The PCI value of 99.99 indicates that the road pavement is structurally sound and does not require significant repair. Damage such as patching and fine cracks are only minor issues that slightly affect road performance. However, the evaluation using the Bina Marga Method revealed that block cracking is the most dominant type of damage, accounting for approximately 89.31% of the total damaged area. This block cracking is categorized as severe damage and represents the most critical finding of this study. Although the total average score of all damage types remains 99.90, the presence of extensive block cracking may indicate early signs of structural vulnerability. These results suggest that, while the general road condition is good, there are initial indicators of deterioration that require preventive action to prevent further progression. Therefore, targeted measures such as crack sealing, localized overlay, or reconstruction of severely cracked sections are recommended, alongside routine maintenance for other minor damages, to ensure long-term pavement durability and serviceability.

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