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Analysis of Pavement Damage and Maintenance Priorities Using the Pavement Condition Index Method: A Case Study of Jalan Datuk Setia Maharaja, Pekanbaru

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ABSTRACT: Road pavement deterioration reduces transportation safety, ride quality, and operational efficiency, making systematic condition assessment essential for maintenance planning. This study evaluates pavement condition along Jalan Datuk Setia Maharaja, Pekanbaru using the Pavement Condition Index (PCI) method, identifies dominant distresses, and recommends segment-level maintenance strategies. A quantitative descriptive approach analyzed secondary survey data from eight segments covering approximately 1.62 km, applying standardized PCI procedures based on Total Deduct Value and Corrected Deduct Value, with maintenance priority determined through a Priority Score calculated as 100 − PCI. Results show an average PCI of 53.5, indicating overall Fair condition, with individual values ranging from 40 to 76. Segments 1 and 5 recorded the lowest PCI values and highest priority scores, requiring urgent intervention, while Segment 3 needed only routine maintenance. Among 225 identified distress occurrences across fourteen categories, patching dominated at 33.78%, followed by potholes (16.00%), longitudinal cracking (14.22%), and ravelling (13.33%), indicating recurring localized repairs and continuing structural deterioration. The study concludes that integrating PCI with Priority Score and distress analysis enhances maintenance decision-making and resource allocation. Future research should incorporate traffic loading, drainage, and environmental factors to develop predictive pavement management models.

Keywords: Pavement Condition Index, Pavement Distress, Maintenance Priority, Flexible Pavement, Pavement Management System, Road Maintenance, Pavement Evaluation.

INTRODUCTION

Road transportation infrastructure plays a fundamental role in supporting economic growth, regional connectivity, and social mobility. The performance of road networks largely depends on the physical condition of pavement surfaces, which directly influences traffic safety, travel comfort, vehicle operating costs, and overall transportation efficiency. As pavements are continuously subjected to traffic loading, environmental exposure, and material aging, their condition gradually deteriorates throughout their service life. Without timely maintenance, minor surface defects may evolve into more severe structural failures that require substantially higher rehabilitation costs. Consequently, transportation agencies require reliable and standardized methods to evaluate pavement conditions and allocate limited maintenance resources effectively. Among the available pavement evaluation methods, the Pavement Condition Index (PCI) has become one of the most widely adopted approaches because it provides a quantitative and standardized measure of pavement surface condition based on observed distress characteristics. PCI converts distress type, severity, and density into a numerical score ranging from 0 to 100, where higher values indicate better pavement conditions. This standardized representation enables consistent comparison among road sections and supports maintenance decision-making at both the project and network levels (Abaza, 2023; Aden et al., 2024; Miah et al., 2020; Qabaja & Labeedi, 2020).

The importance of PCI extends beyond simple condition assessment because it serves as one of the principal indicators within Pavement Management Systems (PMS). Modern PMS frameworks rely on objective condition indicators to inventory pavement assets, forecast deterioration, prioritize maintenance, and optimize budget allocation over the pavement life cycle. The PCI methodology, originally developed by the U.S. Army Corps of Engineers and later incorporated into the PAVER system, has become a cornerstone of pavement asset management due to its transparent and reproducible evaluation procedure (ASADA et al., 2022). Numerous studies have demonstrated that PCI-based assessments support maintenance planning by identifying pavement sections requiring immediate intervention while simultaneously enabling agencies to forecast future network performance under financial constraints (Al-Hamdan et al., 2024; Gaber et al., 2023). Consequently, PCI has been applied not only to urban road networks but also to airport pavements and other transportation infrastructures, demonstrating its flexibility and broad applicability across different pavement management contexts (Mascio et al., 2021).

Within urban transportation systems, pavement management has evolved from periodic inspections toward integrated decision-support frameworks that combine condition assessment with optimization techniques. Contemporary PMS generally operates through two complementary stages. The first stage evaluates pavement conditions using indicators such as PCI, International Roughness Index (IRI), and Present Serviceability Index (PSI), while the second stage prioritizes maintenance alternatives under financial constraints using optimization, life-cycle cost analysis, or multi-criteria decision-making approaches (Huang et al., 2024; Liu et al., 2022; Roberts et al., 2021). Although additional indicators have been incorporated into recent PMS developments, PCI remains the most widely accepted metric because it provides a standardized representation of pavement condition that can be consistently compared across road segments and administrative jurisdictions. Accordingly, PCI serves as the principal input for maintenance prioritization, deterioration forecasting, and long-term infrastructure planning within many urban pavement management frameworks (Bao et al., 2021; Heidari et al., 2022).

Pavement deterioration is governed by the interaction of traffic loading, environmental conditions, material characteristics, drainage performance, and maintenance history. These factors are particularly significant in tropical and high-rainfall regions, where frequent wetting-drying cycles, elevated temperatures, and moisture infiltration accelerate pavement deterioration. Moisture penetration into pavement layers weakens structural capacity, promotes stripping and ravelling, and accelerates crack propagation, while repeated heavy-vehicle loading further increases fatigue damage and permanent deformation ((Hosseini & Smadi, 2020; Miah et al., 2020; Shadhar & Mahjoob, 2020). Inadequate drainage and delayed maintenance can intensify these processes by allowing water accumulation within pavement structures, ultimately leading to potholes, rutting, and widespread structural cracking. Consequently, proactive pavement evaluation is particularly important in tropical environments because timely maintenance can substantially reduce deterioration rates and extend pavement service life.

The PCI methodology evaluates pavement condition through detailed observation of pavement distress, recognizing that different distress types represent different deterioration mechanisms and maintenance requirements. Surface defects such as potholes, longitudinal cracking, alligator cracking, ravelling, and patching contribute differently to pavement performance and serviceability. Potholes directly affect user safety and ride quality while facilitating water infiltration into the pavement structure. Longitudinal cracks may originate from fatigue or construction deficiencies and often expand into more extensive deterioration if left untreated. Alligator cracking is generally considered an indicator of structural fatigue requiring more intensive rehabilitation, whereas ravelling reflects progressive surface material loss that accelerates moisture ingress and pavement aging. The PCI framework incorporates these distress characteristics by considering both severity and extent, thereby producing a comprehensive condition index capable of supporting maintenance planning and deterioration forecasting (Qabaja & Labeedi, 2020; Al-Hamdan et al., 2024; ASADA et al., 2022). Consequently, understanding distress composition is essential because pavement sections with similar PCI values may require different maintenance strategies depending on the dominant distress mechanisms.

Recent advances in pavement management have expanded the role of PCI from a descriptive indicator to an integral component of sophisticated decision-support systems. Numerous studies have combined PCI with multi-criteria decision-making techniques such as the Analytic Hierarchy Process (AHP), Analytic Network Process (ANP), fuzzy approaches, and optimization models to prioritize maintenance while considering traffic, safety, economic, and environmental factors (Heidari et al., 2022; Khahro et al., 2021). Furthermore, machine learning, Bayesian models, digital twins, Building Information Modeling (BIM), and web-based pavement management platforms increasingly use PCI as a primary input for predictive deterioration modeling and maintenance optimization ((Alimohammadi, 2020; Oreto et al., 2023). These developments demonstrate that PCI remains the central quantitative indicator connecting field observations with strategic asset-management decisions. Nevertheless, many practical applications continue to rely primarily on aggregate PCI values without fully considering the spatial distribution of pavement distress or differences among individual road segments.

Despite the extensive application of PCI in pavement management, several research gaps remain. Current literature identifies limitations related to high-resolution pavement-condition data, uncertainty in deterioration prediction, integration of sustainability and equity considerations, network-level optimization, interoperability among PMS platforms, and real-time condition monitoring using digital technologies (Arezoumand & Smadi, 2024; Topu, 2025). At the project level, many PCI-based studies focus on reporting average condition indices and assigning maintenance categories, whereas comparatively fewer investigations develop transparent segment-level maintenance-priority frameworks that simultaneously consider pavement condition, distress composition, and engineering judgment. In addition, roads exhibiting identical PCI values may differ substantially in corrected deduct values, distress types, severity levels, and associated safety risks. Therefore, maintenance prioritization should not rely exclusively on aggregate PCI values but should incorporate supporting indicators capable of distinguishing the urgency of intervention among segments with similar condition ratings.

This study addresses these gaps through a detailed pavement-condition assessment of Jalan Datuk Setia Maharaja, Pekanbaru, using the Pavement Condition Index method. The study evaluates pavement conditions for eight road segments, identifies dominant distress types, establishes maintenance priorities using a Priority Score calculated as 100 − PCI, and recommends maintenance actions according to established PCI criteria. Rather than interpreting the mathematical relationship between PCI and Corrected Deduct Value as a causal model, the study emphasizes descriptive pavement assessment, maintenance prioritization, and distress-distribution analysis. The findings are intended to provide a transparent framework for supporting maintenance planning at the segment level while illustrating how PCI and distress-frequency information can be integrated into practical pavement management decisions. By combining standardized PCI evaluation with explicit maintenance-priority ranking, the study contributes to the broader development of evidence-based pavement management practices that support more efficient allocation of maintenance resources in urban road networks.

METHOD

Research Design

This study employed a quantitative descriptive design to evaluate pavement condition and establish maintenance priorities along Jalan Datuk Setia Maharaja, Pekanbaru. The analysis was based on secondary pavement-survey data containing segment-level Total Deduct Value (TDV), Corrected Deduct Value (CDV), Pavement Condition Index (PCI), pavement-condition category, recommended maintenance type, and maintenance-priority ranking. A descriptive approach was selected because the principal objectives were to characterize the existing pavement condition, identify the dominant forms of distress, compare conditions among road segments, and determine the relative urgency of maintenance interventions.

The study did not interpret the mathematical relationship between CDV and PCI as a causal association. PCI is derived directly from the corrected deduct value; therefore, regression of PCI on CDV would largely reproduce the calculation procedure rather than identify an independent deterioration mechanism. Accordingly, the analytical framework emphasized PCI calculation, descriptive statistics, distress-frequency analysis, segment-level comparison, and maintenance-priority ranking. Similar descriptive procedures are commonly used to summarize pavement-network condition, identify outlying segments, quantify distress composition, and establish a baseline for subsequent multi-criteria or optimization analyses (Ali & Milad, 2023; Mandloi et al., 2024).

Study Location and Pavement Segmentation

The study area comprised Jalan Datuk Setia Maharaja in Pekanbaru, Indonesia. The assessed road section had a total length of approximately 1,620 m. For condition evaluation, the road was divided into eight segments according to station intervals. Segments 1–7 were each approximately 200 m long, while Segment 8 covered the remaining section from STA 1+400 to STA 1+620.

Dividing a pavement section into survey units or analysis segments is an essential preliminary stage in PCI assessment. Segmentation allows pavement distress to be recorded consistently and enables the condition of individual sections to be compared spatially. The dimensions of survey units may vary according to pavement type, project requirements, and applicable technical guidance, but each unit should be sufficiently homogeneous to support a representative condition assessment (Al-Obaedi et al., 2020; Choiri et al., 2024).

The segment intervals used in this study were STA 0+000–0+200, 0+200–0+400, 0+400–0+600, 0+600–0+800, 0+800–1+000, 1+000–1+200, 1+200–1+400, and 1+400–1+620. Segment-level analysis was retained throughout the study to avoid concealing localized deterioration through exclusive reliance on the overall road-average PCI.

Data Sources and Variables

The dataset included two principal groups of information. The first group consisted of pavement-condition data for each of the eight road segments, including TDV, CDV, PCI, condition category, maintenance recommendation, and priority ranking. The second group contained the observed frequency and percentage of 14 pavement-distress types recorded along the road.

The primary analytical variable was PCI, which represented the surface condition of each road segment on a scale from 0 to 100. Higher PCI values indicated better pavement conditions. TDV represented the sum of the deduct values assigned to the observed distresses within a survey unit, while CDV represented the adjusted deduct value obtained after correcting TDV for the number and combined effect of significant deduct values. Supporting variables included segment number, station interval, distress type, distress frequency, pavement-condition classification, maintenance category, and maintenance-priority score.

The recorded distress types comprised patching, potholes, longitudinal cracking, ravelling, block cracking, alligator cracking, diagonal cracking, slip cracking, bleeding, transverse cracking, edge cracking, shoving, depression, and bumps. Frequency and percentage distributions were used to identify the dominant pavement-distress profile and to support interpretation of the maintenance requirements.

Pavement Distress Identification and Density Determination

The PCI procedure begins with the identification of visible pavement distress within each survey unit. Each distress is classified according to its type and, where available, its severity level and extent. Distress density is normally calculated as the affected quantity divided by the survey-unit area or another relevant dimensional basis, expressed as a percentage. Density is subsequently used with the appropriate distress curve to determine the corresponding deduct value.

Standard PCI-based surveys require each observed distress to be recorded consistently because the resulting PCI score depends not only on the presence of damage but also on its severity and density. Distress-density and deduct-value relationships are defined through standardized or locally adapted curves for specific pavement-distress types (Rahmawati et al., 2024; Yvonne et al., 2023). In the present study, the available secondary dataset already contained the resulting TDV and CDV values. Therefore, the analysis did not reconstruct every distress-density curve but adopted the completed PCI calculations contained in the source data.

The distress-frequency dataset was analyzed separately from the segment-level PCI results. The number of occurrences for each distress type was divided by the total number of recorded distress occurrences and multiplied by 100:

$$P_j=\frac{f_j}{\sum f_j}\times 100$$

where (P_j) is the percentage of distress type (j), (f_j) is its observed frequency, and ($\sum f_j$) is the total number of distress occurrences. The total recorded frequency was 225 occurrences.

Determination of Deduct Value and Total Deduct Value

For each distress type, severity, and density combination, a Deduct Value (DV) is conventionally obtained from the applicable PCI distress curve. The DV expresses the reduction in pavement condition associated with a particular distress observation. Larger values indicate a greater adverse effect on pavement condition.

When more than one distress is observed in a survey unit, the individual deduct values are summed to obtain the TDV:

$$TDV=\sum_{i=1}^{n}DV_i$$

where (DV_i) represents the deduct value of the (i)-th distress observation and (n) is the number of applicable deduct values within the survey unit. This procedure is widely described in ASTMaligned PCI applications and regional pavement-condition studies (Al-Obaedi et al., 2020; Al-Obaidi et al., 2023).

TDV cannot always be subtracted directly from 100 because multiple distress deductions may interact and produce an excessive combined deduction. Consequently, a correction procedure is required to obtain the CDV.

Corrected Deduct Value Procedure

The CDV was determined using TDV and the number of significant deduct values, commonly denoted by (q). In many flexible-pavement applications, (q) is defined as the number of deduct values greater than 2, although some implementations may apply a different threshold depending on the pavement type or adopted guideline. The correction process uses a standard graph or equivalent function that relates TDV and (q) to a corrected value (Al-Obaedi et al., 2020; Choiri et al., 2024; Rosyidi, 2021).

Where several deduct values are present, the correction may be conducted iteratively. The smallest eligible deduct value is progressively reduced, TDV and (q) are recalculated, and a new CDV is obtained at each stage. The maximum corrected value produced by this process, denoted as (CDV_{\max}), is then used for PCI calculation. This iterative procedure prevents the combined effect of numerous minor distresses from being overstated and ensures that the final condition score remains consistent with the PCI methodology (Karballaeezadeh et al., 2020; Choiri et al., 2024; Rosyidi, 2021).

Because the present study used a ready-to-analyze secondary dataset, the CDV values were accepted as reported. Their consistency was examined descriptively by comparing them with the corresponding PCI values and reported condition classifications.

Statistical Analysis

The analysis included the mean, minimum, maximum, range, frequency, percentage, and rank of the observed values. The mean PCI summarized the overall road condition, while the minimum and maximum identified the most and least deteriorated segments. Frequency and percentage analyses characterized the composition of pavement distress. Cross-segment comparisons were used to identify spatial variations in PCI, TDV, CDV, and maintenance need.

No inferential test was used to estimate a causal relationship between CDV and PCI because PCI is mathematically computed from CDV. Correlation or regression involving these two variables would therefore have limited explanatory value. Future predictive research should instead incorporate independent deterioration factors such as pavement age, traffic volume, heavy-vehicle proportion, drainage quality, rainfall, axle loading, material characteristics, and maintenance history. Regression, nonparametric testing, or machine-learning methods may then be appropriate, subject to sample size, distributional assumptions, and data quality (Kiende et al., 2023; Medina et al., 2021).

Methodological Limitations

The analysis was limited by its reliance on a secondary dataset and the small number of road segments. Detailed distress severity, distress density by segment, traffic loading, drainage condition, pavement age, and maintenance history were not available for independent verification. Accordingly, the findings were interpreted as a descriptive condition assessment and maintenance-priority framework rather than a causal pavement-deterioration model. Nevertheless, the use of segment-level PCI, TDV, CDV, and distress-frequency information provided an adequate basis for identifying critical sections and supporting transparent maintenance planning.

RESULT AND DISCUSSION

Pavement Condition Assessment

Segment-Level PCI Values

The pavement-condition assessment covered eight segments of Jalan Datuk Setia Maharaja with a total evaluated length of approximately 1,620 m. The Pavement Condition Index values ranged from 40 to 76, indicating substantial spatial variation in pavement performance along the road corridor. The arithmetic mean of the eight segment values was 53.5, which was rounded to 54 in the source study. On the adopted PCI rating scale, this average placed the road in the fair condition category.

The segment-level results are presented in Table 1. Segments 1 and 5 recorded the lowest PCI values, with each obtaining a score of 40. Segment 4 had a PCI of 47, Segment 2 had a PCI of 48, and Segment 6 recorded a PCI of 54. The remaining segments exhibited comparatively better conditions. Segment 7 recorded a PCI of 58, Segment 8 obtained a PCI of 65, and Segment 3 had the highest PCI value of 76.

Table 1. Pavement-condition assessment by road segment

Segment	STA	TDV	CDV	PCI	Condition	Recommended treatment
1	0+000–0+200	136	70	40	Poor	Periodic maintenance
2	0+200–0+400	85	50	48	Fair	Periodic maintenance
3	0+400–0+600	89	45	76	Very good	Routine maintenance
4	0+600–0+800	118	61	47	Fair	Periodic maintenance
5	0+800–1+000	182	89	40	Poor	Periodic maintenance
6	1+000–1+200	86	45	54	Fair	Periodic maintenance
7	1+200–1+400	56	30	58	Good	Periodic maintenance
8	1+400–1+620	32	22	65	Good	Periodic maintenance

The overall average was calculated as:

$$
\overline{PCI}=
\frac{40+48+76+47+40+54+58+65}{8}
=53.5
$$

The observed distribution is consistent with findings from urban flexible-pavement studies in developing-country contexts, where road networks commonly contain a mixture of fair, poor, and good segments rather than a uniform condition profile. Previous studies have similarly reported wide PCI ranges across Indonesian and comparable urban roads, reflecting variation in distress density, maintenance history, drainage performance, traffic loading, and survey-unit characteristics (Balzarini et al., 2021; Iqbal et al., 2022).

Distribution of Pavement Conditions

Of the eight evaluated segments, two segments were classified as poor, three as fair, two as good, and one as very good. Thus, five of the eight segments, or 62.5%, were in the poor-to-fair range. Two segments, representing 25%, were classified as good, while one segment, or 12.5%, was classified as very good.

Table 2. Distribution of pavement-condition categories

Condition category	Number of segments	Percentage
Poor	2	25.0%
Fair	3	37.5%
Good	2	25.0%
Very good	1	12.5%
Total	**8**	**100.0%**

The findings indicate that the overall fair average concealed meaningful differences among the individual road sections. The two poor segments had PCI values at the lower boundary of the adopted periodic-maintenance category, while the very-good segment had a score 36 points higher than the minimum value observed. This difference confirms that network- or corridor-level averages should not replace segment-level assessment when maintenance actions are assigned.

Published evidence from developing-country road networks similarly shows that PCI values often span several condition classes within the same corridor or administrative area. Fair and poor pavement categories frequently dominate, although isolated good or very-good sections may occur where maintenance has been more effective or distress exposure is lower (Rahmawati et al., 2024; Yvonne et al., 2023; Iqbal et al., 2022). The present findings therefore fall within the broad pattern reported for heterogeneous urban pavement networks.

TDV and CDV Patterns

The Total Deduct Value ranged from 32 to 182, whereas the Corrected Deduct Value ranged from 22 to 89. Segment 5 recorded the highest TDV and CDV values, at 182 and 89, respectively.

Segment 1 had the second-highest TDV of 136 and a CDV of 70. By contrast, Segment 8 had the lowest TDV of 32 and the lowest CDV of 22.

The TDV and CDV distributions broadly reflected deterioration severity. Segments with higher deduct values generally had lower PCI scores. However, the reported Segment 3 values require careful interpretation. Segment 3 had a CDV of 45 and a reported PCI of 76, although the simplified relation (PCI=100-CDV) would yield 55. Because this study relied on the ready-to-use secondary dataset, the reported PCI value of 76 was retained. Nevertheless, this discrepancy should be checked against the original calculation sheets before journal submission to verify whether the reported CDV, PCI, or transcription is incorrect.

Maintenance Priority

Priority-Score Results

Maintenance urgency was ranked using the Priority Score:

[Priority\ Score=100-PCI]

Under this formulation, lower PCI values produced higher priority scores. Segments 1 and 5 each received the maximum score of 60, making them the highest-priority sections. Segment 4 ranked third with a score of 53, followed by Segment 2 with a score of 52. Segment 6 obtained a score of 46, Segment 7 obtained 42, and Segment 8 obtained 35. Segment 3 had the lowest Priority Score of 24 and therefore represented the least urgent maintenance candidate.

Table 3. Maintenance-priority ranking

Rank	Segment	STA	PCI	Priority Score	Priority interpretation
1	1	0+000–0+200	40	60	Highest
2	5	0+800–1+000	40	60	Highest
3	4	0+600–0+800	47	53	High
4	2	0+200–0+400	48	52	High
5	6	1+000–1+200	54	46	Moderate
6	7	1+200–1+400	58	42	Moderate
7	8	1+400–1+620	65	35	Low
8	3	0+400–0+600	76	24	Lowest

The results demonstrate that the priority ranking followed the inverse ordering of PCI. This approach is consistent with the general practice of using PCI as a principal quantitative input for maintenance prioritization. Previous studies have used PCI directly in ranking systems, optimization models, life-cycle planning, and multi-criteria decision frameworks to identify pavement sections requiring the earliest intervention (Bao et al., 2021; Saadati & Karimi, 2024).

Differentiation of Equal-PCI Segments

Segments 1 and 5 had identical PCI and Priority Score values, but their TDV and CDV values differed substantially. Segment 5 had a TDV of 182 and a CDV of 89, whereas Segment 1 had a TDV of 136 and a CDV of 70. On the basis of the available supporting data, Segment 5 may warrant earlier technical investigation because its deduct values indicate a greater accumulated distress burden.

Nevertheless, PCI, TDV, and CDV alone are insufficient to determine the final intervention sequence when two segments receive the same priority score. Previous maintenance-priority research commonly supplements PCI with additional criteria such as traffic volume, heavy-vehicle loading, pavement age, safety risk, roughness, drainage condition, maintenance cost, road function, socioeconomic importance, and life-cycle implications ((Bao et al., 2021; Mascio et al., 2021). Therefore, the ranking of Segments 1 and 5 should be interpreted as a preliminary condition-based priority rather than a complete investment decision.

Recommended Maintenance Programs

Seven of the eight segments were assigned to periodic maintenance, while Segment 3 was assigned to routine maintenance. No segment was classified within the reconstruction range under the treatment thresholds used in the dataset. However, the two segments with PCI values of 40 were located at the lower boundary of the periodic-maintenance interval. These sections require close technical inspection to determine whether localized structural rehabilitation is necessary, particularly where potholes, severe alligator cracking, drainage defects, or repeated patch failures are present.

The results show that PCI-based classification can provide a transparent initial treatment category, but detailed engineering design remains necessary before implementation. Optimization and multi-criteria studies similarly indicate that PCI is most effective when combined with cost, safety, traffic, and service-life considerations rather than used as the sole determinant of project selection (Aad & Abbas, 2022; Alimohammadi, 2020).

Pavement Distress Distribution

Frequency of Recorded Distress

A total of 225 distress occurrences were recorded across 14 categories. Patching was the most frequent condition, with 76 occurrences or 33.78% of the total. Potholes ranked second, with 36 occurrences or 16.00%, followed by longitudinal cracking with 32 occurrences or 14.22% and ravelling with 30 occurrences or 13.33%.

Block cracking accounted for 17 occurrences or 7.56%, while alligator cracking was recorded 15 times or 6.67%. The remaining distress types each represented less than 3% of all observations.

Table 4. Distribution of pavement distress

No.	Distress type	Frequency	Percentage
1	Patching	76	33.78%
2	Potholes	36	16.00%
3	Longitudinal cracking	32	14.22%
4	Ravelling	30	13.33%
5	Block cracking	17	7.56%
6	Alligator cracking	15	6.67%
7	Diagonal cracking	6	2.67%
8	Slip cracking	3	1.33%
9	Bleeding	2	0.89%
10	Transverse cracking	2	0.89%
11	Edge cracking	2	0.89%
12	Shoving	2	0.89%
13	Depression	1	0.44%
14	Bump	1	0.44%
Total		**225**	**100.00%**

The four most frequent categories patching, potholes, longitudinal cracking, and ravelling accounted for 174 occurrences, equivalent to 77.33% of all recorded distress. Therefore, the pavement-distress profile was strongly concentrated in a limited number of categories.

Dominant Distress Characteristics

The prominence of potholes, longitudinal cracking, ravelling, and alligator cracking was broadly consistent with distress patterns reported in other urban flexible-pavement investigations. Previous studies have identified alligator cracking, potholes, longitudinal and transverse cracking, edge cracking, patching, and surface disintegration as common urban-road defects, although their relative frequencies vary according to climate, pavement structure, traffic, drainage, and maintenance history (Balzarini et al., 2021; Rahmawati et al., 2024).

Patching differed from the other categories because it represented evidence of previous intervention as well as a pavement-surface condition. Its dominance suggested that localized corrective works had been repeatedly undertaken along the road. Prior research associates recurrent patching with repeated pothole formation, cracking, edge deterioration, weak base or subgrade conditions, moisture infiltration, and inadequate drainage. In such cases, patching can restore short-term ride quality and safety but may not eliminate the mechanism responsible for recurring deterioration(Abohamer et al., 2022; Kristina et al., 2021).

Maintenance Implications of Distress Composition

The recorded distress distribution indicated that maintenance planning should distinguish between surface correction and structural treatment. Potholes require prompt intervention because they directly affect safety, vehicle operation, ride quality, and water infiltration. Longitudinal cracking and ravelling require sealing or surface treatment where deterioration remains limited. By contrast, severe or extensive alligator cracking may indicate fatigue damage that cannot be addressed adequately through crack sealing alone.

Because the dataset reported aggregate distress frequencies rather than distress type, severity, and density for each individual segment, direct statistical testing between particular distress types and segment-level PCI was not possible. The results therefore support corridor-level interpretation of the distress profile but do not establish which distress category was primarily responsible for the PCI score of each segment. A future survey should link every distress observation to its segment, severity, density, and repair history so that distress-specific effects on maintenance priority can be assessed more rigorously.

The pavement-condition assessment of Jalan Datuk Setia Maharaja revealed an average Pavement Condition Index of 53.5, placing the road in the fair category, while individual segment values ranged from 40 to 76. This variation demonstrates that the overall corridor condition was heterogeneous and that reliance on a single average value would conceal important differences in maintenance urgency. The concentration of five segments within the poor-to-fair range is broadly consistent with previous PCI-based assessments of urban flexible pavements in developing and tropical regions, where maintenance limitations, high traffic exposure, rainfall, and drainage deficiencies frequently produce mixed condition profiles within the same network (Gaber et al., 2023; Miah et al., 2020). Although the present dataset did not contain direct measurements of rainfall, drainage performance, or traffic loading, the observed distress composition is compatible with deterioration mechanisms commonly reported in humid urban environments.

Patching, potholes, longitudinal cracking, and ravelling accounted for 77.33% of the 225 recorded distress occurrences. This pattern corresponds with earlier studies identifying potholes, alligator cracking, longitudinal cracking, and surface disintegration as important contributors to PCI decline in urban flexible pavements (Rahmawati et al., 2024; Yvonne et al., 2023; Iqbal et al., 2022). These distress types affect pavement performance through different mechanisms. Potholes create immediate safety and serviceability problems, longitudinal cracks permit water infiltration and may propagate under repeated loading, ravelling reflects progressive loss of surface material, and alligator cracking may indicate fatigue-related structural deterioration. Consequently, pavement sections with similar PCI values may require different interventions depending on distress severity, spatial concentration, and underlying failure mechanism. This reinforces the argument that aggregate PCI values should be interpreted together with detailed distress information when selecting maintenance treatments (Qabaja & Labeedi, 2020; Al-Hamdan et al., 2024).

The predominance of patching is particularly important because patching represents both a pavement condition and evidence of previous maintenance. Repeated patching may indicate that localized failures have been treated several times without fully correcting contributing factors such as inadequate drainage, weak base or sub-base materials, poor compaction, water infiltration, or recurrent traffic loading. Previous studies similarly describe patching as a common corrective response to potholes and localized cracking, particularly where agencies must restore safety and ride quality under constrained budgets (Azam et al., 2023; Suseno, 2023). Although patch repairs can provide immediate functional improvement, frequent recurrence reduces their cost effectiveness and may signal the need for more comprehensive intervention. Therefore, engineering investigations on the highest-priority segments should examine drainage, layer integrity, and the condition of previously repaired areas before additional surface patching is undertaken.

The 36 pothole occurrences also have direct implications for maintenance planning. Potholes reduce ride quality, create sudden vehicle-manoeuvring hazards, increase the risk of vehicle damage, and provide pathways for water to enter lower pavement layers. In tropical conditions, this process can accelerate deterioration because repeated wetting and loading weaken the pavement structure and enlarge existing defects. Timely pothole repair is therefore justified not only by its effect on PCI but also by safety and user-cost considerations. The literature supports incorporating safety, traffic exposure, and serviceability indicators alongside PCI in maintenance-priority systems, particularly where surface defects create risks disproportionate to their contribution to the aggregate condition score (Gaber et al., 2023; Bao et al., 2021).

The priority analysis identified Segments 1 and 5 as the most urgent because both had PCI values of 40 and Priority Scores of 60. However, Segment 5 recorded higher TDV and CDV values than Segment 1, suggesting a greater accumulated distress burden in the available dataset. This distinction illustrates both the usefulness and limitation of the equation (100-PCI). The Priority Score provides a simple, transparent, and reproducible ranking, but identical scores cannot distinguish between segments with different distress compositions or operational significance. Previous pavement-management research has addressed this limitation by combining PCI with indicators such as traffic volume, road function, roughness, safety, pavement age, maintenance cost, drainage, heavy-vehicle percentage, and socioeconomic importance through multi-criteria or optimization frameworks (Bao et al., 2021; Khahro et al., 2021). Accordingly, the present ranking should be viewed as a condition-based screening tool rather than a complete investment-allocation model.

Under constrained maintenance budgets, this screening approach can still improve pavement management by directing detailed investigation toward the most deteriorated segments and preventing available funds from being distributed uniformly across sections with different needs. PCI offers a comparable numerical basis for ranking projects, while treatment thresholds help distinguish routine maintenance from periodic maintenance or rehabilitation. When linked to life-cycle cost analysis and optimization, PCI-based prioritization can support intervention sequencing that delays expensive reconstruction and preserves network performance for longer periods (Liu et al., 2022; Shadhar & Mahjoob, 2020). For Jalan Datuk Setia Maharaja, this implies directing the earliest technical and financial attention to Segments 1 and 5, followed by Segments 4 and 2, while maintaining Segment 3 through lower-intensity routine actions.

Future predictive modelling should incorporate variables that are independent of the PCI calculation. Traffic volume, axle loading, and heavy-vehicle percentage are required to represent cumulative load-related deterioration, while pavement age and maintenance history are necessary to estimate deterioration trajectories and treatment effectiveness (Komba et al., 2024; Maliq et al., 2022). Drainage quality, rainfall, temperature, and moisture exposure should also be included because they strongly influence pothole formation, stripping, ravelling, and subgrade weakening in tropical environments (Miah et al., 2020; Iqbal et al., 2022). Structural indicators such as subgrade strength, pavement-layer condition, or deflection measurements would further improve the distinction between surface and structural failure (Ali & Milad, 2023; Abohamer et al., 2022).

Finally, future studies should improve data resolution by linking every distress observation to its segment, severity, density, and repair history. Probabilistic or Bayesian methods could then be used to represent uncertainty arising from survey error, incomplete maintenance records, and variable deterioration rates (Elmansouri et al., 2022; Philip & Jassmi, 2024). Digital PMS platforms, geographic information systems, and automated survey technologies could further support spatial monitoring and scenario-based budgeting (Roberts et al., 2021; Aden et al., 2024). Thus, the present study provides a practical descriptive foundation, but a more comprehensive pavement-management model would combine PCI with traffic, environmental, structural, financial, and historical variables to support more durable and cost-effective maintenance decisions.

CONCLUSION

This study evaluated the pavement condition of Jalan Datuk Setia Maharaja, Pekanbaru, using the Pavement Condition Index (PCI) method and established maintenance priorities based on segment-level pavement performance. The analysis demonstrated that the PCI method provides a standardized and transparent framework for assessing pavement condition, identifying deterioration patterns, and supporting maintenance planning. The evaluated road exhibited an average PCI value of 53.5, corresponding to an overall Fair condition. However, the segment-level analysis revealed considerable spatial variation, with PCI values ranging from 40 to 76, indicating that deterioration was not uniformly distributed along the road.

The maintenance-priority analysis identified Segments 1 and 5 as the most critical sections because both recorded the lowest PCI values and the highest Priority Scores. These segments therefore require the earliest maintenance intervention. In contrast, Segment 3 achieved the highest PCI value and requires only routine maintenance. The Priority Score approach (100 − PCI) proved to be an effective and easily interpretable tool for ranking maintenance urgency. Nevertheless, segments with identical PCI values may differ in their underlying deterioration characteristics, suggesting that engineering judgment should complement PCI-based rankings by considering factors such as distress severity, drainage condition, traffic loading, and safety implications.

The pavement-distress analysis identified 225 distress occurrences across fourteen distress categories. Patching was the dominant distress type, accounting for 33.78% of all observations, followed by potholes (16.00%), longitudinal cracking (14.22%), and ravelling (13.33%). The predominance of patching suggests that previous maintenance activities have largely consisted of localized corrective repairs rather than treatments addressing the underlying deterioration mechanisms. Meanwhile, the relatively high occurrence of potholes and cracking indicates the need for more durable maintenance strategies that mitigate moisture ingress, structural weakening, and progressive pavement deterioration.

From a practical perspective, the study demonstrates that PCI-based assessment can support evidence-based maintenance planning by enabling road agencies to prioritize limited maintenance resources objectively. Rather than relying solely on average network condition, segment-level PCI evaluation allows maintenance programs to target the most deteriorated locations first, thereby improving resource allocation and potentially extending pavement service life. The integration of pavement-distress frequency with PCI further strengthens maintenance decision-making because it provides additional insight into the mechanisms responsible for pavement deterioration.

The principal contribution of this study is the development of a practical maintenance-priority framework that combines standardized PCI evaluation with a simple Priority Score and detailed pavement-distress characterization. This integrated approach enhances the transparency of maintenance prioritization and provides a reproducible procedure that can be adopted by local governments and road-management agencies for routine pavement-condition assessment and maintenance programming.

Several limitations should be acknowledged. The analysis was based on a secondary dataset comprising eight road segments and did not include explanatory variables such as traffic volume, heavy-vehicle percentage, pavement age, drainage condition, environmental exposure, structural capacity, or maintenance history. Consequently, the study should be interpreted as a descriptive pavement-condition assessment rather than a causal deterioration model. In addition, the available dataset did not link each distress observation to segment-specific severity and density, limiting the ability to quantify the influence of individual distress types on PCI variation.

Future research should expand the analytical framework by incorporating independent deterioration variables, including traffic loading, axle-load characteristics, pavement age, drainage performance, climatic conditions, and historical maintenance records. The application of geographic information systems, automated pavement surveys, machine-learning techniques, digital twin technologies, and optimization-based Pavement Management Systems could further improve deterioration prediction, maintenance scheduling, and budget allocation. Comparative studies involving multiple road corridors and longer monitoring periods would also provide stronger evidence for developing predictive pavement-performance models and more sustainable infrastructure asset-management strategies.

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