Evaluation of Road Pavement Condition Using the Pavement Condition Index (PCI) Method: A Case Study of the Taebenu Road Section in Kupang City

Ari Esclesias Sinaga[1]*

[1] Civil Engineering Study Program, Akademi Teknik Kupang, Kupang, Indonesia
* Corresponding author: sinaga.ari@gmail.com

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ABSTRACT

Road pavement inevitably deteriorates under repeated traffic loading, drainage deficiencies, and climatic exposure, requiring systematic condition assessment to guide maintenance priorities. This study aims to evaluate the pavement condition of the Taebenu road section in Kupang City using the Pavement Condition Index (PCI) method and to formulate priority-based maintenance recommendations. A field distress survey was conducted along 3.473 km (STA 0+000–3+473), divided into four sample units of 1 km each (the last unit 473 m), following Shahin's (1994) visual survey procedure. Density, deduct value (DV), total deduct value (TDV), and corrected deduct value (CDV) were calculated for each segment to obtain the PCI score. The results show that PCI values ranged from 35 (Poor) to 78 (Very Good) across the four segments, with an overall average PCI of 56.75, classified as Fair. Segment STA 2+000–3+000 recorded the lowest PCI (35) due to a high density of Medium-severity alligator cracking and High-severity potholes, making it the top priority for rehabilitation. These findings indicate that segment-level PCI assessment reveals critical conditions that a single road-average value can obscure, which is essential for cost-effective pavement management planning. This study contributes an empirically grounded, segment-based PCI application that can support local road authorities in prioritizing maintenance budgets for urban roads in the Nusa Tenggara Timur region.

Keywords: *pavement condition index; road distress; pavement maintenance; deduct value; Taebenu road*

ABSTRAK

Perkerasan jalan secara bertahap mengalami penurunan kondisi akibat beban lalu lintas berulang, kekurangan sistem drainase, dan paparan iklim sehingga diperlukan penilaian kondisi yang sistematis untuk menentukan prioritas pemeliharaan. Penelitian ini bertujuan mengevaluasi kondisi perkerasan ruas Jalan Taebenu di Kota Kupang menggunakan metode Pavement Condition Index (PCI) serta merumuskan rekomendasi pemeliharaan berbasis prioritas. Survei kerusakan lapangan dilakukan sepanjang 3,473 km (STA 0+000–3+473), yang dibagi menjadi empat unit sampel masing-masing 1 km, dengan unit terakhir sepanjang 473 m, mengikuti prosedur survei visual Shahin (1994). Density, deduct value (DV), total deduct value (TDV), dan corrected deduct value (CDV) dihitung pada setiap segmen untuk memperoleh nilai PCI. Hasil menunjukkan bahwa nilai PCI berkisar antara 35 (Poor) hingga 78 (Very Good), dengan rata-rata keseluruhan sebesar 56,75 yang diklasifikasikan sebagai Fair. Segmen

STA 2+000–3+000 memiliki nilai PCI terendah, yaitu 35, akibat dominasi retak kulit buaya tingkat Medium dan lubang tingkat High, sehingga menjadi prioritas utama rehabilitasi. Temuan ini menunjukkan bahwa penilaian PCI per segmen mampu mengidentifikasi kondisi kritis yang dapat tersamarkan oleh nilai rata-rata ruas dan dapat mendukung penetapan prioritas anggaran pemeliharaan jalan perkotaan di Nusa Tenggara Timur.

Kata Kunci: *indeks kondisi perkerasan; kerusakan jalan; pemeliharaan perkerasan; deduct value; Jalan Taebenu*

1. INTRODUCTION

Roads are land transportation infrastructure that play an important role in supporting the economic, social, and governmental activities of a region. As infrastructure subjected to repeated traffic loading, road pavement naturally deteriorates, marked by the emergence of cracks, potholes, ruts, and raveling (Shahin, 1994). If not identified and addressed early, such damage will worsen over time and increase maintenance costs in the future (Ministry of Public Works, Directorate General of Highways, 2011). One method commonly used to quantitatively assess road pavement condition is the Pavement Condition Index (PCI), developed by Shahin and widely adopted in research in Indonesia because it is able to combine the type, severity level, and density of damage into a single index (Shahin, 1994; Santosa, Sujatmiko, & Krisna, 2021). The Taebenu road section in Kupang City was selected as the study location because of its strategic role as an inter-regional connector, as well as its hilly and undulating topography, which makes it prone to surface damage due to repeated loading, suboptimal drainage, and surface runoff during the rainy season.

Previous studies generally present PCI values as a single average figure for the entire road section, so that variations in critical conditions between segments may not be adequately identified (Jannah, Yermadona, & Dewi, 2022). Based on this gap, this study aims to evaluate the pavement condition of the Taebenu road section on a per-segment basis using the PCI method, starting from the distress survey, density–deduct value–CDV calculation, to the formulation of maintenance recommendations. The novelty of this study lies in the application of the complete PCI procedure, including iterative CDV correction, to primary data from a 2026 field survey, which has not been widely documented for road sections in Kupang City. The results of this study are expected to serve as a technical reference for road authorities in determining the priority and type of pavement maintenance for urban roads in the Nusa Tenggara Timur region.

2. METHODS

This study uses a visual distress survey approach to assess the pavement condition of the Taebenu road section using the Pavement Condition Index (PCI) method, following Shahin's (1994) standard procedure supplemented by Bina Marga's (2011) technical guidelines.

2.1 Research Design

This study employs a descriptive-quantitative design to evaluate the condition of flexible pavement based on the PCI method. The study was conducted on the Taebenu road section, Kupang City, in 2026 through direct field surveys and density–deduct value–CDV data processing.

2.2 Location / Object of Study

The study location is the Taebenu road section located in Kupang City, East Nusa Tenggara Province, with a reviewed length of 3.473 km (STA 0+000–3+473). This section is an urban road with a strategic role for resident mobility and logistics distribution, situated in hilly and undulating topography, making it relatively prone to soil movement, erosion, and surface water runoff during the rainy season.

2.3 Data Collection

The data used consist of primary and secondary data. Primary data were obtained through direct visual field surveys, including the identification of distress type, severity level, and quantity of damage in each segment. Secondary data were obtained from road section length data as well as literature and previous studies relevant to the PCI method (Shahin, 1994; Jannah, Yermadona, & Dewi, 2022; Santosa, Sujatmiko, & Krisna, 2021).

2.4 Data Analysis

Survey data were analyzed using Shahin's (1994) PCI procedure through the following stages: (1) dividing the road section into four segment units based on stationing (STA); (2) calculating the density of each distress type; (3) determining the deduct value (DV) from Shahin's standard curves; (4) summing to obtain the Total Deduct Value (TDV); (5) iterative correction to obtain the maximum Corrected Deduct Value (CDV); and (6) calculating PCI = 100 − CDV for each segment as well as the average PCI of the road section.

2.5 Standards and Technical References

The classification of flexible pavement distress types refers to the ASTM D6433 standard, which groups damage into 19 types, including alligator cracking, potholes, and rutting, which are the focus of this study. The analysis also refers to Construction and Building Manual No. 001-01/M/BM/2011 on Road Condition Surveys for Routine Maintenance (Ministry of Public Works, Directorate General of Highways, 2011), particularly regarding the procedures for conducting visual surveys and classifying damage severity levels in the field.

3. RESULTS

The visual survey results along the 3.473 km Taebenu road section identified three active distress types: alligator cracking, potholes, and rutting. Raveling/weathering was not found on this section.

The recapitulation of distress types and quantities is presented in Table 1, while the PCI calculation results for each segment are presented in Table 2. The highest PCI value was obtained in Segment STA 0+000–1+000 (PCI = 78, Very Good), while the lowest PCI value was obtained in Segment STA 2+000–3+000 (PCI = 35, Poor), with an overall average PCI of 56.75 (Fair).

Deduct value (DV) was not obtained from a formula, but rather by reading values from Shahin's (1994) standard deduct value curves for each distress type and severity level, with the X-axis representing density (%) on a logarithmic scale and the Y-axis representing deduct value (0–100). Figures 1–3 illustrate this reading method for the three distress types found on the Taebenu road section.

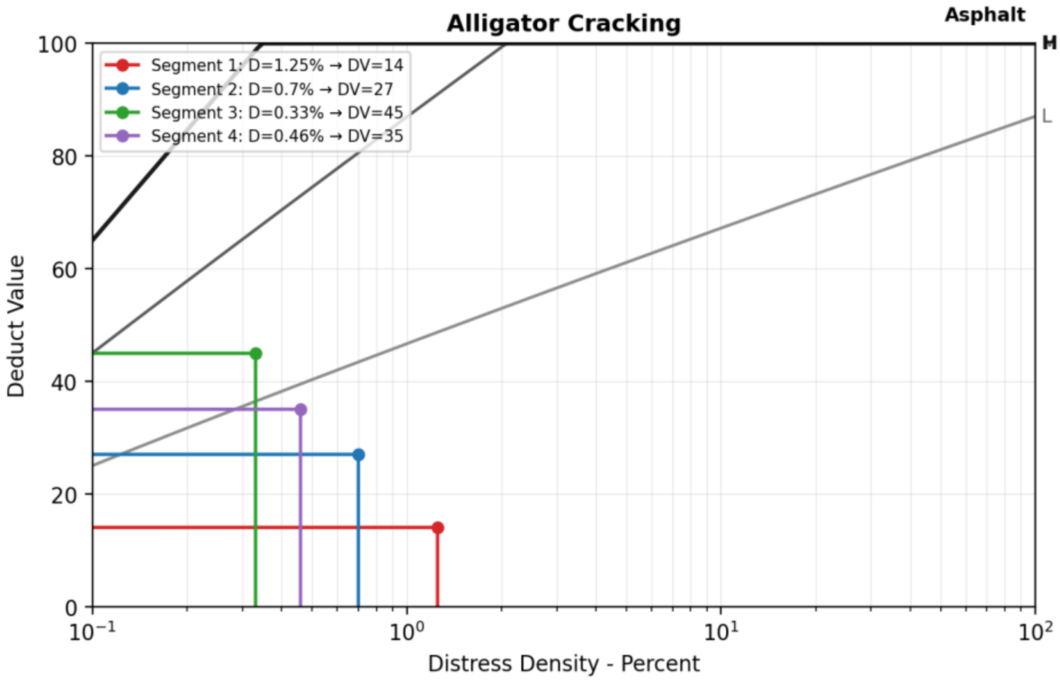

Figure 1. Deduct value curve for Alligator Cracking with density–DV reading points for each segment (Medium severity).

Figure 1 shows the DV reading for alligator cracking at Medium severity for the four segments: Segment 1 at a density of 1.25% reads DV = 14, Segment 2 at a density of 0.70% reads DV = 27, Segment 3 at a density of 0.33% reads DV = 45, and Segment 4 at a density of 0.46% reads DV = 35.

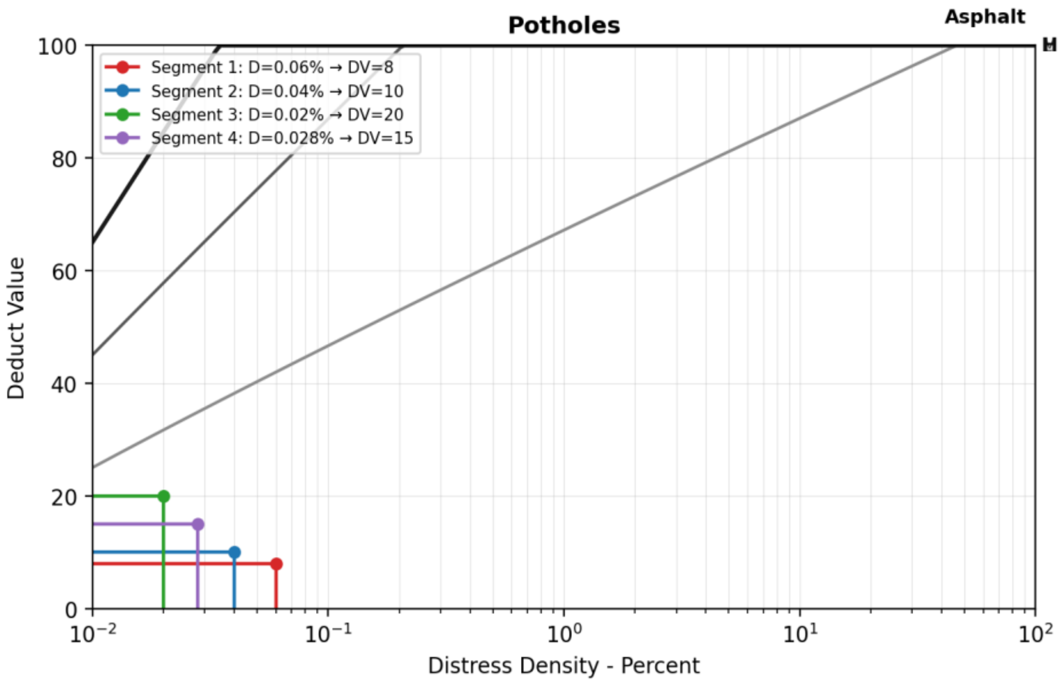

Figure 2. Deduct value curve for Potholes with density–DV reading points for each segment (High severity).

Figure 2 shows the DV reading for potholes at High severity: Segment 1 at a density of 0.060% reads DV = 8, Segment 2 at a density of 0.040% reads DV = 10, Segment 3 at a density of 0.020% reads DV = 20, and Segment 4 at a density of 0.028% reads DV = 15.

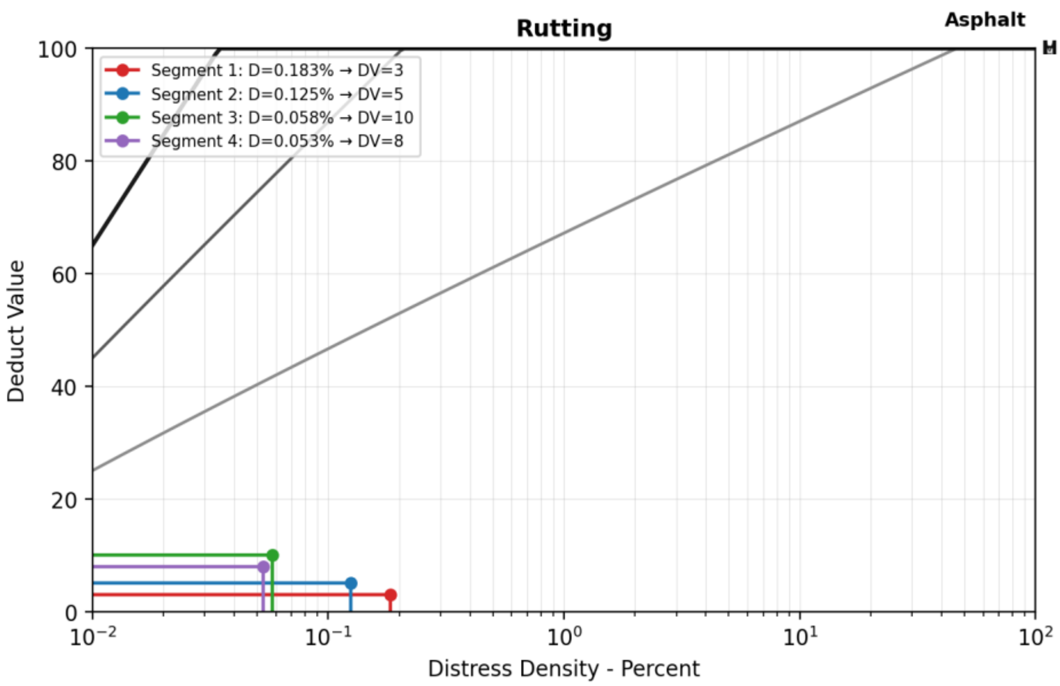

Figure 3. Deduct value curve for Rutting with density–DV reading points for each segment (Low severity).

Figure 3 shows the DV reading for rutting at Low severity: Segment 1 at a density of 0.183% reads DV = 3, Segment 2 at a density of 0.125% reads DV = 5, Segment 3 at a density of 0.058% reads DV = 10, and Segment 4 at a density of 0.053% reads DV = 8. These DV values are summed to obtain the Total Deduct Value (TDV) and subsequently corrected to obtain the Corrected Deduct Value (CDV), as presented in Table 2.

Table 1. Recapitulation of Distress Types and Quantities

No.	Distress Type	Severity Level	Total Quantity	Percentage (%)
1	Alligator Cracking	Medium	150 m²	45%
2	Potholes	High	20 points	30%
3	Rutting	Low	47 m	25%
	Total			100%

Source: Primary field survey data, Taebenu Road, Kupang City (2026).

Table 2. Recapitulation of PCI Values per Road Segment

Segment (STA)	TDV	Maximum CDV	PCI = 100 − CDV	Condition Rating
STA 0+000 – 1+000	25	22	78	Very Good
STA 1+000 – 2+000	42	38	62	Good
STA 2+000 – 3+000	75	65	35	Poor
STA 3+000 – 3+473	58	48	52	Fair
Average of Section	–	–	56.75	Fair

Source: Calculation results based on primary field survey data of Taebenu Road (2026); Shahin (1994).

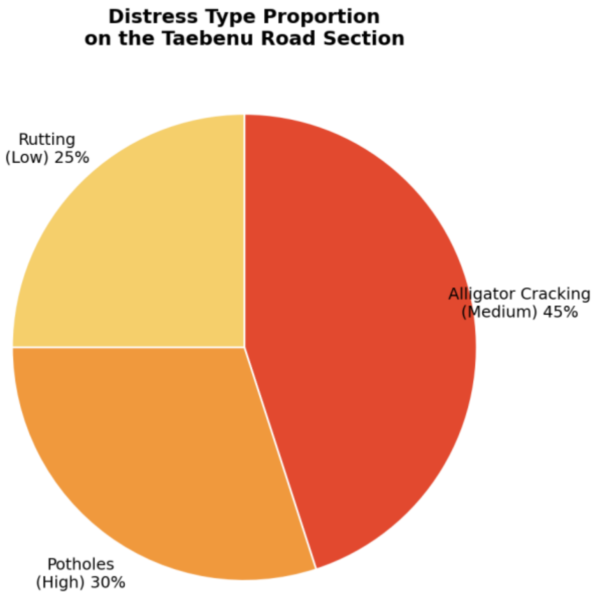

Figure 4. Proportion of distress types on the Taebenu road section based on Table 1.

Figure 4 clarifies that alligator cracking (45%) and potholes (30%) dominate the damage on the Taebenu road section, so these two distress types contribute the most to the deduct value in the subsequent calculation stage.

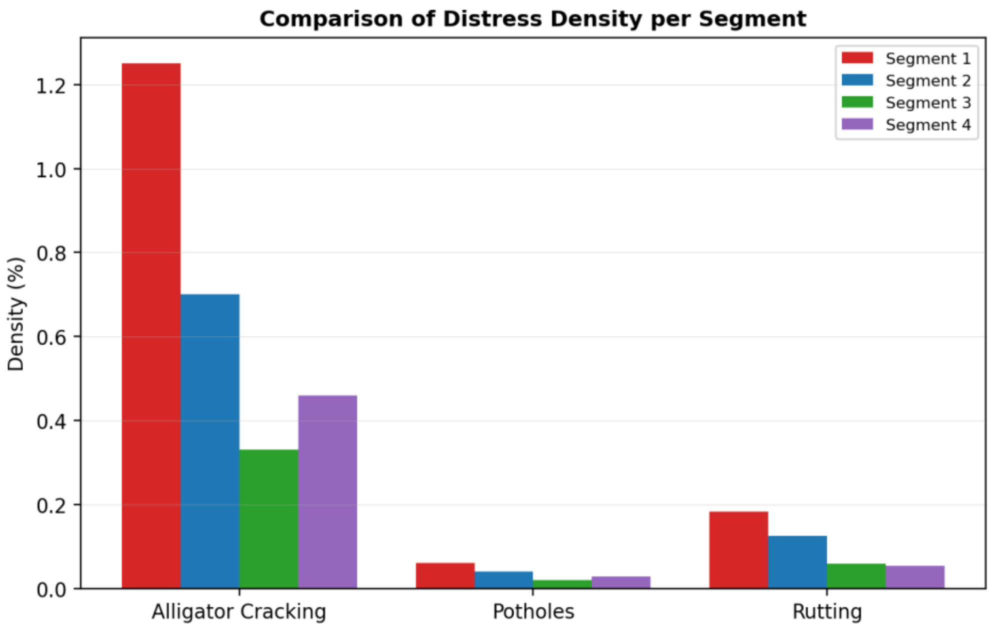

Figure 5. Comparison of density for each distress type across the four segments.

Figure 5 shows that the density of alligator cracking in Segment 1 (1.25%) is the highest among the four segments; however, because its severity level is classified as Medium, the resulting deduct value (DV=14) is smaller than Segment 3, which has a lower density (0.33%) but produces a DV of 45. This confirms that the deduct value in the PCI method is not determined solely by density, but also by the combination of distress severity level (Shahin, 1994).

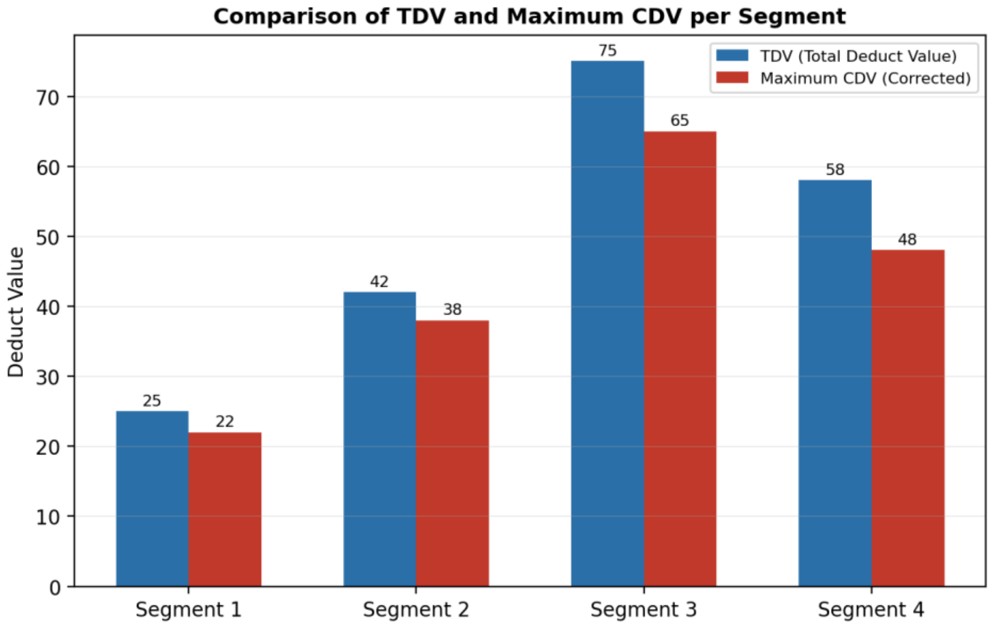

Figure 6. Comparison of TDV and maximum CDV resulting from the correction iteration for each segment.

Figure 6 shows that the CDV correction process does not always significantly reduce the TDV value; in Segments 1 and 2, the maximum CDV is actually slightly higher than the initial TDV due to the replacement of small deduct values with a value of 2 in the second iteration (q=2). Meanwhile, in Segments 3 and 4, the maximum CDV is below the initial TDV, consistent with the purpose of the CDV correction, which is to prevent excessive reduction in the PCI value due to the large number of distress types in a single segment.

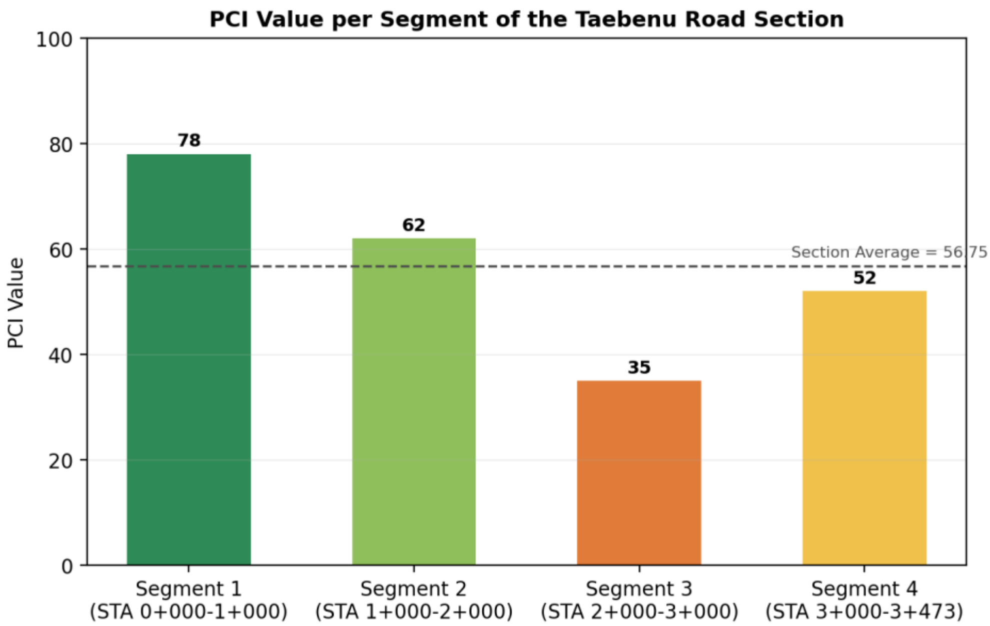

Figure 7. PCI values per segment of the Taebenu road section compared to the section average line (56.75).

Figure 7 visually shows that PCI values vary considerably between segments, from 35 (Segment 3) to 78 (Segment 1), with three of the four segments falling below the section average line. This indicates that the average value of 56.75 is somewhat more optimistic than the condition of most segments, as it is “lifted” by the much better condition of Segment 1.

4. DISCUSSION

Segment STA 0+000–1+000 obtained a PCI of 78 (Very Good) with a TDV of 25, the smallest among the four segments, where the dominant DV value came from Medium-severity alligator cracking (DV=14). Segment STA 1+000–2+000 obtained a PCI of 62 (Good) with a TDV of 42. Segment STA 2+000–3+000 is the segment with the worst condition (PCI = 35, Poor), with the highest TDV (75), dominated by Medium-severity alligator cracking at a density of 1.25% (DV=45) and High-severity potholes (DV=20), requiring urgent priority handling. Segment STA 3+000–3+473 obtained a PCI of 52 (Fair) with a TDV of 58.

The PCI pattern shows quite significant condition variation between segments, with Segment STA 2+000–3+000 as the worst segment (PCI=35), while Segment STA 0+000–1+000 is in fact the best segment (PCI=78). This is consistent with the findings of Santosa, Sujatmiko, and Krisna (2021) as well as Jannah, Yermadona, and Dewi (2022), which show that per-segment PCI assessment produces a more detailed picture of condition compared to the Bina Marga method or a single average value. Practically, this finding confirms that the section average value of 56.75 (Fair) should not be used as the sole basis for decision-making, as it can conceal critical conditions in certain segments.

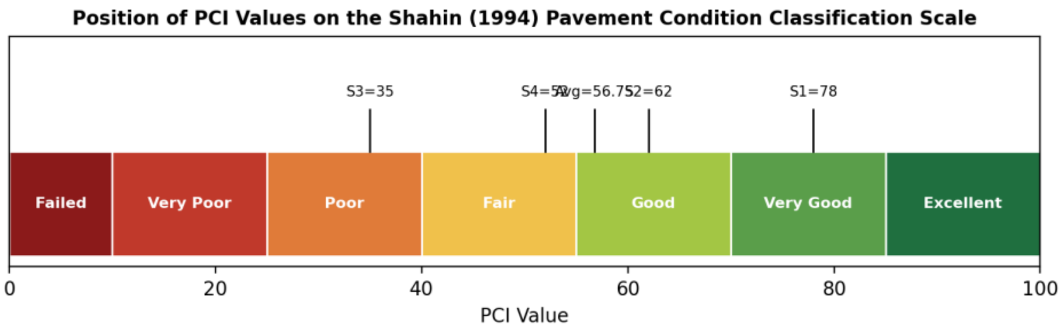

Figure 8. Position of the PCI value for each segment and the section average on the Shahin (1994) pavement condition classification scale.

Figure 8 confirms that although the section average value (56.75) falls within the Fair category, Segment 3 actually falls into the Poor category, which requires improvement/rehabilitation, while Segment 1 falls into the Very Good category. This visualization helps confirm that road maintenance decisions must be based on the PCI value per segment, not merely on the overall section average value.

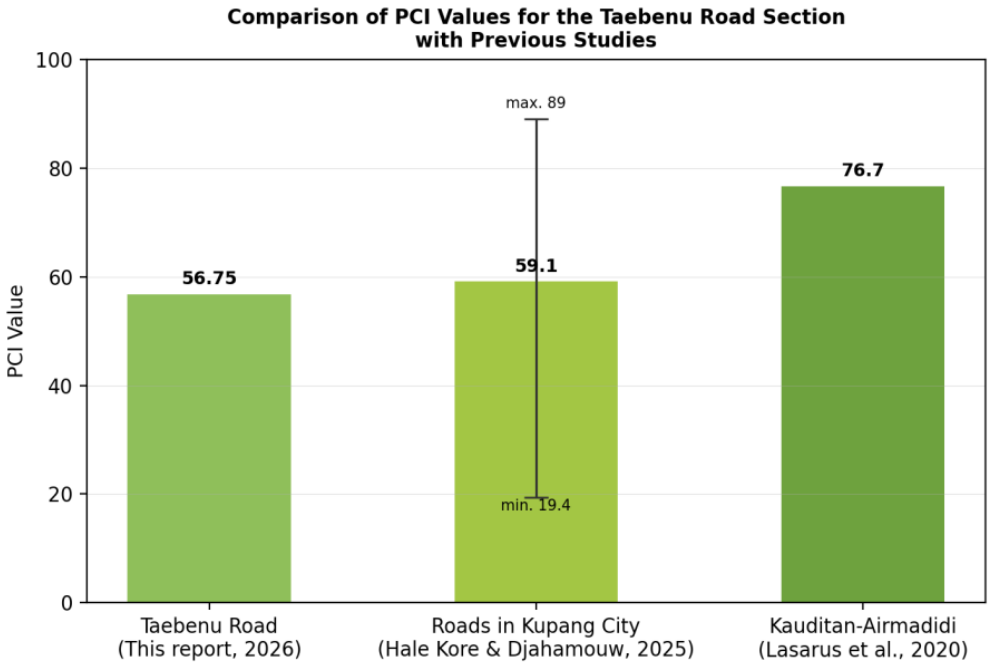

Figure 9. Comparison of PCI values for the Taebenu road section with previous studies (Hale Kore & Djahamouw, 2025; Lasarus et al., 2020).

Figure 9 shows that the average PCI value of the Taebenu road section (56.75) is just below the average of eight road sections in Kupang City in the study by Hale Kore and Djahamouw (2025) of 59.1, but still falls within the variation range of those sections (19.4–89). Meanwhile, the much higher PCI value of the Kauditan–Airmadidi section (76.7) indicates that the lower PCI value on the Taebenu road section is more appropriately attributed to hilly topography and suboptimal local drainage systems, rather than solely to heavy traffic loading.

A limitation of this study is that the survey coverage was limited to three dominant distress types (alligator cracking, potholes, and rutting) without covering all 19 distress types according to ASTM D6433, as well as a relatively large segment division (1 km). Future research is recommended to use smaller segment units and cover all distress types that may occur in the field.

5. CONCLUSION

The application of the Pavement Condition Index (PCI) method on the Taebenu road section, Kupang City, produced PCI values of 78 (Very Good) at STA 0+000–1+000, 62 (Good) at STA 1+000–2+000, 35 (Poor) at STA 2+000–3+000, and 52 (Fair) at STA 3+000–3+473, with an overall section average PCI of 56.75 (Fair).

These results show that the PCI method is able to provide a more detailed picture of pavement condition per segment, so that the critical condition of Segment STA 2+000–3+000 is not concealed behind the section average value. This finding has implications for road infrastructure management, namely the need for rehabilitation/improvement of the pavement structure and drainage system in Segment STA 2+000–3+000 as the top priority, followed by periodic and routine maintenance in the other segments. Future research is recommended to use smaller segment units and cover more complete distress types to obtain a more precise picture of condition.

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AUTHOR CONTRIBUTIONS

The author contributed to conceptualization, methodology, field survey and data collection, data analysis, manuscript writing, and final editing.

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This research received no external funding.

CONFLICT OF INTEREST STATEMENT

The author declares no conflict of interest related to the publication of this article.

DATA AVAILABILITY STATEMENT

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

ETHICAL STATEMENT

This research was conducted in accordance with academic research ethics. All data sources used have been properly cited. This research did not involve human respondents.

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