Analysis of Road Damage Treatment
(Case Study: National Road Segment Bts. Kab. Subang/Karawang – Bts. Kota Pamanukan STA 2350 – STA 3352)

Abdu Somad Rajabilah[1*], Juang Akbardin[1], Yudi Sekaryadi[1]
[1]Civil Engineering Study Program, Indonesia University of Education
*Corresponding Author: Abdu Somad Rajabilah. Email: rajabilah@upi.edu

Abstract

A national road segment located between BTS. Kab. Subang/Karawang and BTS. Kota Pamanukan (STA 2350 – STA 3352) was evaluated to determine its pavement condition, prompted by surface degradation likely caused by increasing traffic loads and aging infrastructure. The evaluation used three established methods: the International Roughness Index (IRI), the Road Condition Index (RCI), and the Pavement Condition Index (PCI). Data were collected at 100-meter intervals across a 10,2 km stretch in both directions. Results showed that 92% of the segment in the normal direction and 96% in the opposite direction were categorized as "fair" based on IRI values. Similarly, the RCI classification placed 84% (normal) and 88% (opposite) of the segment in the same category. PCI values ranged from 53,9 to 99,5, averaging 81,96, indicating that the pavement is generally in good condition. According to the Ministry of Public Works Regulation No. 13/PRT/M/2011, these conditions are suitable for periodic maintenance, primarily in the form of asphalt overlay. To determine the required overlay thickness, CESAL (Cumulative Equivalent Single Axle Load) and allowable rebound deflection were calculated, yielding values of 376.726.050,77 and 0,81 mm, respectively. Based on these values, the needed overlay thickness was determined to be 10,38 cm and rounded to 11 cm for implementation. A detailed cost estimate was developed for all related work items including preparation, binder and wearing course layers, and road markings, resulting in a total project cost of Rp60.851.525.000,00.

Keywords: Roads, International Roughness Index, Road Condition Index, Pavement Condition Index, Overlay

1. INTRODUCTION

Roads are a vital component of the transportation system, supporting the movement of people and goods across regions. Good road conditions reflect the quality of transportation infrastructure development [2]. However, roads have a limited service life and are vulnerable to damage due to excessive vehicle loads, weather conditions, and inadequate maintenance. Therefore, a comprehensive study on road damage analysis and treatment methods is essential to ensure the infrastructure remains functional.

The Pantura National Road in the Subang area has recently experienced severe damage at several points, exacerbated by high rainfall intensity. The damage ranges from peeled asphalt to potholes of various sizes [7]. Road condition evaluations must be carried out to assess both current surface conditions and future structural capacity. In accordance with the Ministry of Public Works Regulation No. 13/PRT/M/2011, road authorities are required to prepare a road maintenance plan[5].

Sustainable road maintenance is critical to preventing further damage, though excessive traffic loads and volumes are also major contributing factors. To evaluate road conditions, methods such as the Pavement Condition Index (PCI), which identifies types and severity of damage based on ASTM D6433-07 standards, are needed. Additionally, the RCI and IRI methods are also applied to assess surface condition.

1.1. Road Condition Assessment

The assessment of pavement condition is a crucial step in designing maintenance and repair programs for transportation infrastructure. In this study, three evaluation methods are employed: the International Roughness Index (IRI) and Road Condition Index (RCI), and Pavement Condition Index (PCI). These methods provide comprehensive information on ride quality and the extent of surface damage. The results of this assessment serve as a primary reference for determining the most appropriate treatment strategy, whether it involves routine maintenance, periodic maintenance, or full-scale rehabilitation.

1.1.1. IRI Method (International Roughness Index)

The International Roughness Index (IRI) is a globally recognized index that measures road surface roughness, expressed in meters per kilometer. This method is used to evaluate pavement condition based on the level of surface irregularity or unevenness [4].

1.1.2. RCI Method (Roughness Condition Index)

The Road Condition Index (RCI) is a measure of pavement functional performance developed by the American Association of State Highway Officials (AASHO) in 1960 [6]. The RCI serves as a scale indicating the level of ride comfort or road performance, which can be obtained using a roughness meter or through visual assessment. The RCI value is derived from the conversion of IRI (International Roughness Index) values [4]. Sukirman illustrated the correlation between RCI and IRI using the following equation:

$$RCI = 10 \times Exp(-0{,}0501 \times IRI^{1{,}220921}) \quad (1)$$

1.1.3. PCI Method (Pavement Condition Index)

The Pavement Condition Index (PCI) is a quantitative (numerical) indicator of pavement condition, with a value range from 0 to 100. A score of 0 represents the worst possible pavement condition, while a score of 100 indicates the best possible condition that can be achieved [3]

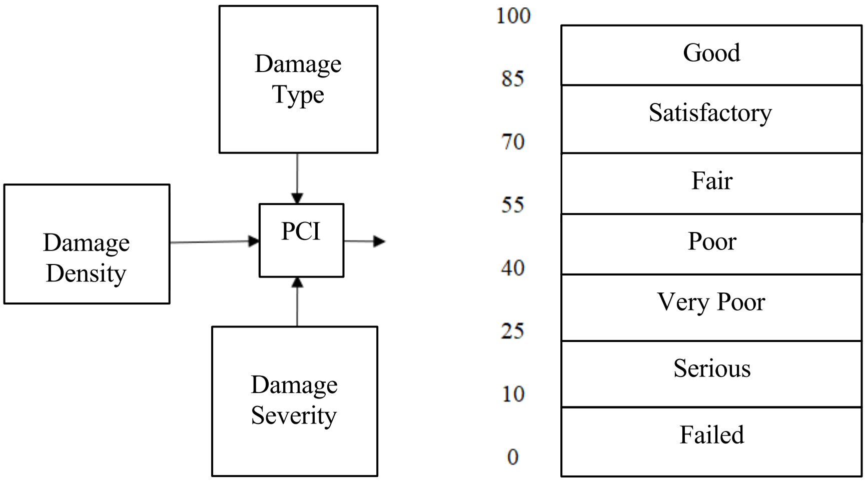

Figure 1. Correlation Between PCI and Condition Classification

1.2. Pavement Damage Treatment

Referring to the Regulation of the Minister of Public Works and Public Housing No. 13/PRT/M/2011, road authorities are required to develop a road maintenance plan to ensure the road remains in optimal condition throughout its service life. Road maintenance includes activities such as preservation, rehabilitation, improvement, and repair to maintain the road's functionality. The scope covers routine maintenance, periodic maintenance, and rehabilitation, including auxiliary structures and road equipment. The maintenance plan also involves information systems, asset management, and treatment planning, with road inventory and condition data serving as the foundation for formulating treatment recommendations[5].

1.2.1. Periodic Maintenance

Periodic road maintenance is a preventive treatment activity aimed at avoiding more extensive damage and addressing all forms of deterioration considered in the design, so that the road condition can be restored to the planned serviceability level. This type of maintenance is intended to enhance the road's structural integrity. According to the Regulation of the Minister of Public Works No. 13/PRT/M/2011, road segments that require periodic maintenance fall under the following criteria: resurfacing (overlay), shoulder repair, thin asphalt layer application, surface roughening (regrooving), crack/joint sealing, repair of auxiliary structures, replacement/repair of damaged or missing road equipment, remarking, pothole patching, scarifying, adding and remixing materials for unpaved roads, and routine vegetation cleaning and maintenance[5].

1.2.2. Damage Treatment

The appropriate treatment for damage in each sample unit can be determined based on the IRI value of each segment, referring to the Bina Marga Pavement Design Manual. The following presents the determination of road segment conditions, required treatment actions, and corresponding pavement performance levels

Table 1: Road Maintenance Planning

Road Condition	IRI	Treatment Requirements	Road Serviceability Level
Good	IRI Average 4,0	Routine Maintenance	Serviceable Road
Fair	4,1 IRI Average 8,0	Periodic Maintenance	
Lightly Damage	8,1 IRI Average 12	Periodic Maintenance	Unserviceable Road
Severely Damage	IRI Average 12	Road Improvement	

1.3. Design of Additional Pavement Layer Thickness (Overlay)

Overlay, or resurfacing, is one of the treatment measures for damage on flexible pavements that can enhance the structural condition and serviceability of the road. In its planning, the CESAL value is used to determine the required pavement thickness. The thickness of the flexible pavement structure can be determined by calculating the allowable rebound deflection (Dizin) [1].

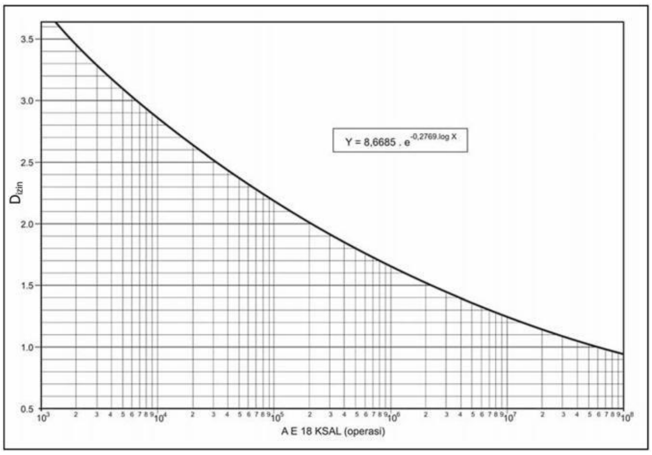

Figure 2. Graph of Allowable Rebound Deflection

$$Y = 8{,}6685 \,.\, e^{-0{,}2769.\log X} \quad (2)$$

After obtaining the CESA value and the allowable rebound deflection, the required overlay thickness can then be determined as follows:

$$T = \frac{2.303 \log D - 0.408(1 - \log CESA)}{0.8 - 0.013 \log CESA} \quad (3)$$

T : Overlay Thickness
D : Allowable Rebound Deflection
CESA : Cumulative Equivalent Single Axle Load

1.4. Project Cost Estimation

The Project Cost Estimate is an estimation of the funds required for a specific project. It calculates project costs based on the unit volume of each project task, serving as an effective control tool to identify, measure, and manage project expenses. With accurate and proper cost estimation, the project implementation can be better controlled and optimized according to the planned scope and objectives [4]

2. METHOD

This case study comprises several systematic stages aimed at evaluating road damage and determining appropriate maintenance actions. The first stage involves analyzing pavement conditions using the Pavement Condition Index (PCI), International Roughness Index (IRI) method, which quantifies surface irregularities to assess ride quality. Subsequently, the IRI values are converted into Road Condition Index (RCI) scores to provide a more interpretable scale of road performance. Based on the outcomes of these assessments, the appropriate treatment actions—such as routine maintenance, periodic overlay, or rehabilitation—are determined in accordance with national standards. In the final stage, overlay thickness is planned using traffic projection data and vehicle classification to calculate the Cumulative Equivalent Single Axle Load (CESA). This ensures that the proposed structural enhancement meets future traffic demands and restores the pavement to its intended performance level. Through this multi-step approach, the study aims to offer a comprehensive and technical framework for managing road maintenance.

In this study, the method used is a quantitative descriptive approach. Quantitative descriptive research is a method employed to describe or explain phenomena occurring at the time of the study without manipulating or altering the variables being examined. The aim of this research is to portray the characteristics of an object, event, or population based on numerical data collected through techniques such as surveys, observations, or document analysis. The results of this study are typically presented in the form of descriptive statistics, such as averages, percentages, and frequency distributions [8].

2.1. Research Object

This research was conducted on the national road segment from BTS. Kab. Subang/Karawang to BTS. Kota Pamanukan, specifically between STA 2350 – STA 3352, with a total road length of 10,2 kilometers. This segment is part of the national road network managed by the Directorate General of Highways (BBPJN) for the DKI Jakarta – West Java region. The location of the study is illustrated in the following figure.

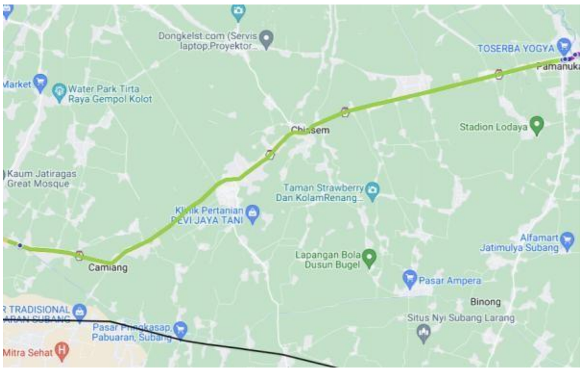

Figure 3. Research Object

2.2. Research Stage

This research was conducted through several systematic stages. The first stage involved identifying the pavement condition using three methods: IRI (International Roughness Index), RCI (Road Condition Index), and PCI (Pavement Condition Index). Once the pavement condition values were obtained from these three methods, the overall pavement performance level could be assessed. Based on the identified performance or damage level, the appropriate type of treatment for the road section could then be determined.
Next, the overlay thickness was planned by calculating the CESA (Cumulative Equivalent Single Axle Load), which required VDF (Vehicle Damage Factor) data. After obtaining the CESA value, the following step was to determine the allowable rebound deflection. From that deflection value, the required overlay thickness could be accurately determined, and then calculate how much project cost estimation needed

3. Research And Discussion

3.1. International Roughness Index

In this study, the collection of IRI data was divided into two categories: IRI data for the Normal direction and IRI data for the Opposite direction. Data collection was carried out at 100-meter intervals along a 10.2 km stretch. The data obtained are as follows:

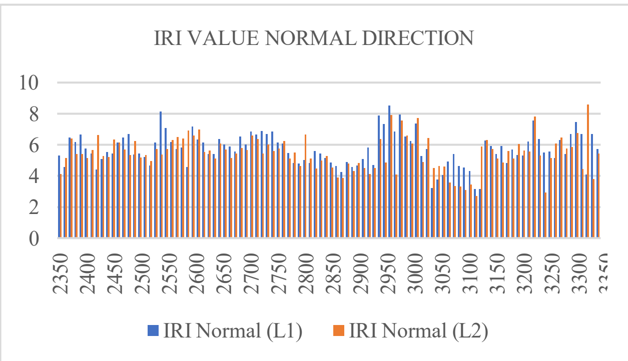

Figure 4. IRI Value Graph – Normal Direction

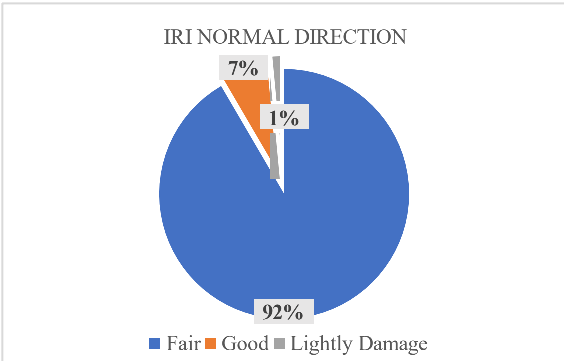

Figure 5. IRI Value Diagram – Normal Direction

Based on the two presented graphs and diagram, it was found that the highest IRI value occurred at STA 3340–3350 in the normal direction (L2) with an IRI of 8,58, while the lowest IRI value was recorded at STA 3260–3270 in the normal direction (L2) with a value of 2,92. The majority of IRI values—92%—for the BTS. Kab. Subang/Karawang – BTS. Kota Pamanukan road segment in the normal direction fall within the Fair condition category.

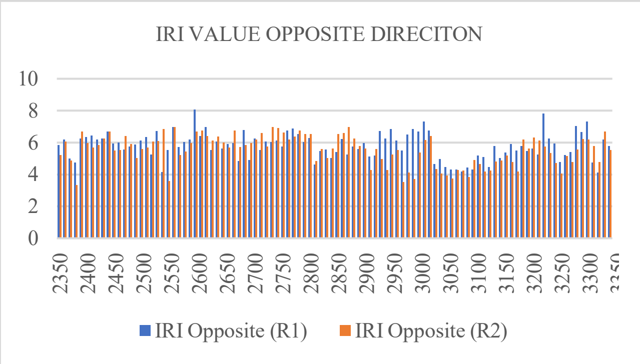

Figure 6. RCI Value Graph – Opposite Direction

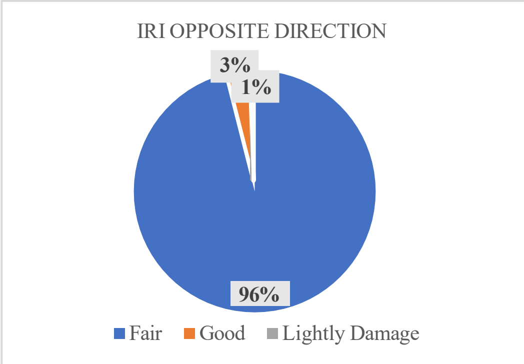

Figure 7. RCI Value Diagram – Opposite Direction

Based on the presented graphs and diagram, it was found that the highest IRI value occurred at STA 2600–2610 in the normal direction (R1) with an IRI of 8,09, while the lowest IRI value was recorded at STA 2380–2390 in the normal direction (R2) with a value of 3,35. The majority of the IRI values—96%—for the BTS. Kab. Subang/Karawang – BTS. Kota Pamanukan road segment in the opposite direction fall within the Fair condition category.

3.2. Road Condition Index

The Road Condition Index (RCI) is obtained by correlating the IRI values to RCI values using Equation (1)

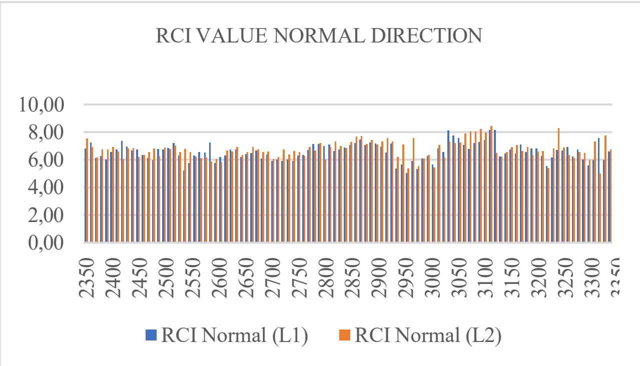

Figure 8. RCI Value Graph – Normal Direction

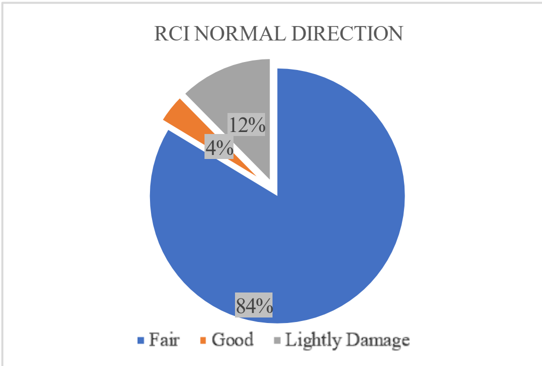

Figure 9. RCI Value Diagram – Normal Direction

Based on the presented graphs and diagram, it was found that the highest RCI value occurred at STA 3130–3140 in the normal direction (R2) with an RCI value of 8,45, while the lowest RCI value was recorded at STA 3340–3350 in the normal direction (R2) with a value of 5,01. The largest percentage of RCI conditions—84%—for the BTS. Kab. Subang/Karawang – BTS. Kota Pamanukan road segment in the normal direction falls into the Fair condition category.

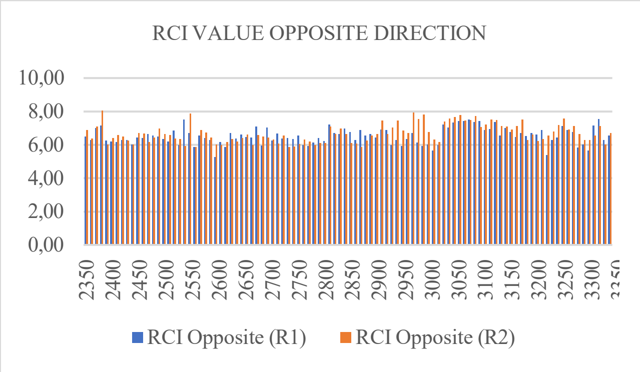

Figure 10. RCI Value Graph – Opposite Direction

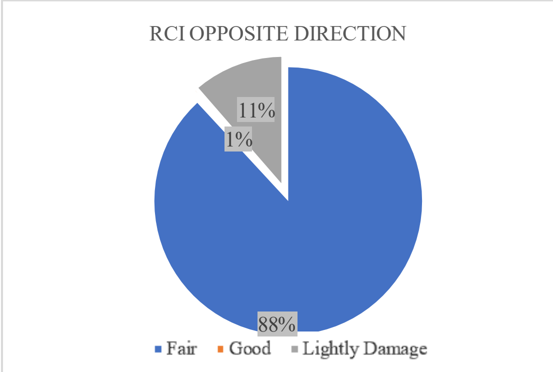

Figure 11. RCI Value Diagram – Opposite Direction

Based on the presented graphs and diagram, it was found that the highest RCI value occurred at STA 2380–2390 in the normal direction (R2) with an RCI value of 8,03, while the lowest RCI value was recorded at STA 2600–2610 in the normal direction (R1) with a value of 5,26. The largest percentage of RCI conditions—88%—for the BTS. Kab. Subang/Karawang – BTS. Kota Pamanukan road segment in the opposite direction falls into the moderate condition category.

3.3. Pavement Condition Index

The PCI values obtained from the pavement condition survey range from 53,9 to 99,5. The lowest PCI value, 53,9, was found at STA 2350–2360, while the highest PCI value, 99,5, was recorded at STA 3350–3352. The average PCI value is 81,96, indicating that the road is in good condition. The PCI values for the road segment are illustrated in the graph shown in the following figure:

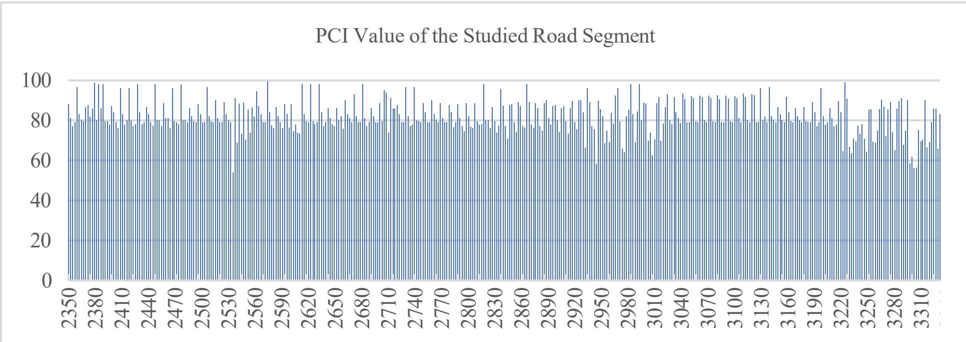

Figure 12. PCI Value Graph – Opposite Direction

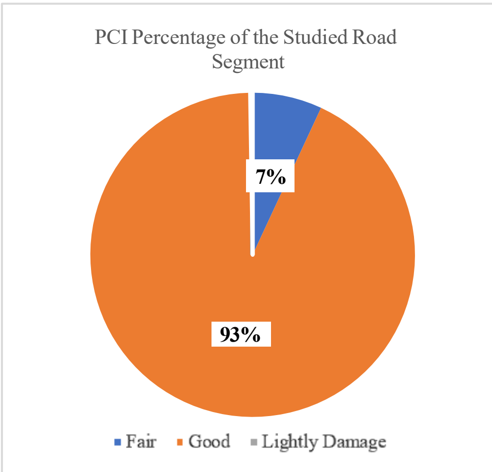

Figure 13. PCI Value Diagram – Opposite Direction

3.4. Road Damage Treatment

The appropriate treatment is determined based on the IRI value, referring to the Bina Marga Pavement Design Manual. The road condition classification according to the IRI method, as previously explained in Section 3.1, leads to the following damage treatment requirements:

Table 2: Determination of Road Maintenance Program

Road Condition	IRI	Treatment Requirements	Road Serviceability Level
Good	IRI Average 4,0	Routine Maintenance	Serviceable Road
Fair	4,1 IRI Average 8,0	Periodic Maintenance	
Lightly Damage	8,1 IRI Average 12	Periodic Maintenance	Unserviceable Road
Severely Damage	IRI Average 12	Road Improvement	

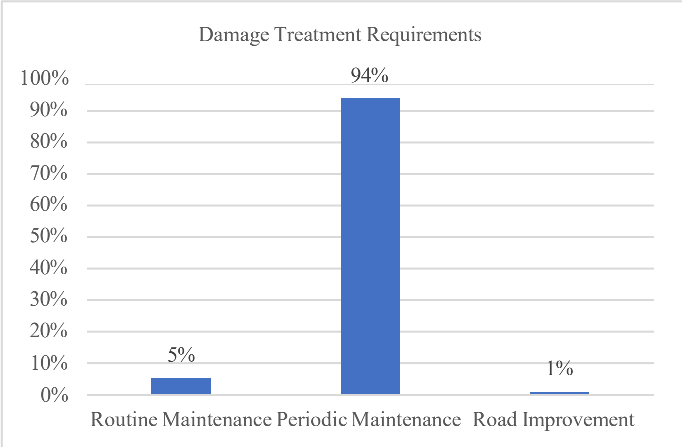

Figure 14. Percentage of Road Damage Treatment Needs

From the figure, it is shown that 94% of the segments require periodic maintenance. Therefore, the appropriate treatment that can be implemented is through overlay planning.

3.5. Overlay Thickness Design

The overlay design is carried out by first calculating the planned CESA value, which requires the VDF (Vehicle Damage Factor) for its computation. The VDF value is obtained from the 2024 Pavement Design Manual. In the overlay planning process, actual load data is used, as the pavement is designed to withstand the real or excessive loads encountered in the field. A VDF of 5 is applied, as it is designated for national roads. To calculate the CESA value, traffic volume data for the design year is required. Once all the necessary data is collected, the results are presented in the following table:

Table 3: Calculation of CESA Value

No	Vehicle Type	Axle Code	Gol	LHR 2025	LHR 2035	VDF 5 Faktual	ESA 2025 Faktual	ESA 2035 Faktual
1	Motorcycles, Scooters, and Three-Wheeled Vehicles	1.1	1	32,629.13	52,145.68	-	-	-
2	Sedans, Jeeps, and Station Wagons (Passenger Vehicles)	1.1	2	8,980.18	14,351.51	-	-	-
3	Oplet, Pick-up Oplet, Combi Vans, and Minibuses	1.1	3	938.65	1,500.09	-	-	-
4	Micro Trucks, Delivery Vans, and Box Pick-ups	1.1	4	3,498.53	5,591.12	-	-	-
5	Small Bus	1.2	5a	391.52	625.70	-	-	-
6	Big Bus	1.2	5b	510.43	815.73	1.30	96,878.71	1,929,289.75
7	Small 2-Axle Truck	1.2	6a	1,670.51	2,669.70	0.40	97,558.01	1,942,817.73
8	Medium 2-Axle Truck	1.2	6b	8,012.23	12,804.60	5.50	6,433,819.73	128,126,213.77
9	3-Axle Truck	1.22	7a	3,706.53	5,923.52	12.30	6,656,183.36	132,554,471.36
10	4-Axle Truck (Trailer Truck)	1.2+2.2	7b	577.80	923.41	18.90	1,594,392.72	31,751,511.82
11	5-Axle Truck (Semi-Trailer Truck)	1.2.22	7c	2,235.91	3,573.28	9.60	3,133,852.46	62,409,061.33
CESA							18,012,685.00	358,713,365.77
							376,726,050.77	

The determination of overlay thickness is based on the previously calculated CESA value and the rebound deflection. Using the CESA value, the rebound deflection under failure conditions (with asphalt surface layer) can be identified. The allowable rebound deflection (D) is then calculated using Equation (2).

$$Y = 8{,}6685 \cdot e^{-0{,}2769.\log 376{,}726{,}050.77}$$

Thus, the value of D, or the allowable rebound deflection obtained based on the CESA value, is 0.81. Subsequently, the calculation to determine the required overlay thickness was carried out using Equation (3).

$$T = \frac{2.303\log(0{,}81) - 0.408(1 - \log 376{,}726{,}050.77)}{0.8 - 0.013\log 376{,}726{,}050.77}$$

$$T = 103{,}80 \text{ mm}$$

$$T \approx 11 \text{ cm}$$

Thus, it was determined that an additional overlay thickness of 11 cm is required to improve the pavement on the road section from BTS. Kab. Subang/Karawang to BTS. Kota Pamanukan.

3.6. Project Cost Estimation

To calculate the project cost estimate, several components must be prepared, namely the work volume and the unit price analysis for each type of work. Once both are known, the total cost for each item can be obtained by multiplying the unit price by the corresponding work volume. Summing up the total costs of all work items will result in the overall budget required to carry out the road repair project.

In this case study, the required road repair involves applying an 11 cm thick overlay. However, prior to this, preparation and site cleaning works must be carried out, and after the overlay installation, road marking repainting is also necessary. Therefore, the detailed cost estimate for this project is as follows:

Table 4: Project Cost Estimation

No	Type of Work	Volume	Unit	Unit Price (Rp)	Total Price (Rp)
I	**Preparation Work**				
I	Site Cleaning and Leveling (per 1 m²)	142.800	m2	Rp8.945,39	Rp1.277.401.488,00
				Sub Total I	Rp1.277.401.488,00
II	**Existing Road Repair Work**				
I	1 Liter of Adhesive Prime Coat	6.704,32	Liter	Rp14.317,55	Rp95.989.405,96
II	1 Ton of Asphalt Concrete Binder Course (A C-BC) Levelling	965,42	ton	Rp1.214.011,51	Rp1.172.032.988,95
				Sub Total II	Rp1.268.022.394,91
III	**Additional Pavement Layer Work**				
I	1 Liter of Tack Coat	285.600	Liter	Rp21.385,76	Rp6.107.774.305,50
II	1 m³ of Asphalt Concrete Binder Course (AC-BC), Thickness = 7 cm	9.996	m3	Rp3.228.825,66	Rp32.275.341.312,48
III	1 m² of Asphalt Concrete Wearing Course (AC-WC), Thickness = 4 cm	142.800	m2	Rp132.478,10	Rp18.917.873.112,10
				Sub Total III	Rp57.300.988.730,09
IV	**Road Marking Work**				
I	1 m² of Thermoplastic Road Marking	4.845,60	m2	Rp207.427,70	Rp1.005.111.659,66
				Sub Total IV	Rp1.005.111.659,66

After summing up the total costs of all individual work items, the final result is Rp60.851.524.272,66 which is rounded to Rp60.851.525.000,00

4. CONCLUSSION

The condition of the national road segment between BTS. Kab. Subang/Karawang and BTS. Kota Pamanukan using IRI, RCI, and PCI evaluation methods. The results consistently indicated that the majority of the road segment is in fair to good condition, with IRI and RCI data showing over 90% of the road falling under the “fair” category, and PCI scores averaging 81.96. According to the standards set by the Ministry of Public Works, these conditions justify the need for periodic maintenance. Further analysis was conducted to determine the structural requirements for the overlay, using CESAL and allowable rebound deflection calculations. The analysis concluded that an overlay thickness of 11 cm is needed to restore the pavement's serviceability and structural capacity. A detailed cost estimate was prepared, covering all necessary construction items, and resulted in a total project budget of Rp60.851.525.000,00 This research highlights the importance of integrating multiple evaluation methods (IRI, RCI, and PCI) for a more comprehensive understanding of road conditions. It also provides a structured approach for determining appropriate treatments and budgeting, supporting more effective and efficient pavement maintenance planning.

ACKNOWLEDGMENT

The author sincerely expresses deep gratitude and appreciation to Dr. Ir. Juang Akbardin, S.T., M.T., IPM., ASEAN.Eng and Dr. Ir. H. Yudi Sekaryadi, S.T., M.T., IPU for their invaluable guidance, continuous encouragement, and unwavering support throughout the course of this research. His expert advice and thoughtful feedback have been essential in shaping the direction and enhancing the quality of this work. The author is truly honored and thankful to have had the opportunity to learn under his supervision.

REFERENCES

Cindikiawati, F. (2023). Analisis Kondisi Kerusakan Jalan Pada Perkerasan Lentur Menggunakan Metode PCI (Pavement Condition Index) (Studi Kasus: Ruas Jalan Lintas Barat Sumatera, Provinsi Bengkulu).

Gutama, D. S., Sutrisno, W., Rizqy, M., Apriadin, & Tommy, N. W. (2023). Analisis Kerusakan Jalan Menggunakan Metode IRI dan RCI (Studi Kasus Ruas Jalan Klangon-Tempel).

Kementrian PUPR. (2016). Pedoman Penentuan Indeks Kondisi Perkerasan (IKP)(Pd 01-2016-B).

Patmawati, F. P. (2024). Analisis Tingkat Kerusakan Jalan dan Perhitungan Anggaran Biaya Penanganan Jalan (Studi Kasus: Ruas Jalan Letkol Eddie Soekardi (Bts. Kota/Kab Sukabumi - Cibolang))

Peraturan Menteri Pekerjaan Umum Republik Indonesia. (2011). Tentang Cara Pemeliharaan dan Penilikan Jalan.

Permadi, D., Widianto, B. W., & Hudayat, y. (2021). Analisis Kondisi Permukaan Perkerasan Jalan Dengan Menggunakan Metode Survey SDI dan RCI Serta Penanganannya.

Rahmadani, H. (2025, February 14). Retrieved from TVRI News: https://daerah.tvrinews.com/berita/tk1u82a-kerusakan-parah-di-jalan-nasional-pantura-subang-pengendara-diminta-waspada

Sugiyono. (2013). Metode Penelitian Kuantitatif, Kualitatif dan R & D.