p–ISSN: 2723 - 6609 e-ISSN: 2745-5254
Vol. 5, No. 3 March 2024 http://jist.publikasiindonesia.id/

Maintenance Strategy for the Muliama-Wa2e-Makki Road Section in Jayawijaya Regency, Papua Province, Highlands

Elias Komba, Bahtiar, Harmonis Rante, Mujiati, Dewi Ana Rusim
Universitas Cendrawasih Jayapura, Indonesia
Email: eliaskomba02@gmail.com, bahtiarpati2015@gmail.com, harmonisrante72@yahoo.co.id, muji_js@yahoo.com, dewianarusim@yahoo.co.id

*Correspondence: eliaskomba02@gmail.com

Keywords:
Road, PCI, Maintenance Strategy

ABSTRACT

In Jayawijaya Regency, there are several prioritized road sections, including national, provincial, and district roads. The Muliama-Wame-Makki road section is classified as a provincial road serving as an alternative route, with a total length of 22 kilometers connecting Jayawijaya Regency and Lanni Jaya Regency. The traffic on this road is quite heavy with a diverse composition (Mixed Traffic). An analysis using the Pavement Condition Index (PCI) was conducted based on field survey data, including measurements of the extent, types, and quantities of surface damage per 200 meters along each road segment. The types of damage observed on the Muliama-Wame-Makki road section include patching, longitudinal cracks, alligator cracking, and pavement subsidence, with a total damage percentage of 1.684%. The maintenance strategy is determined based on the PCI calculation and Bina Marga method, suggesting that routine maintenance is sufficient for addressing the observed issues.

Introduction

Roads are pathways intentionally constructed by humans on the Earth's surface, varying in forms, sizes, and constructions, designed to facilitate the swift and easy movement of people, animals, and vehicles carrying goods from one place to another. Planning a road is essential to ensure the construction supports smooth and comfortable travel for road users (Ekonomis, 2016).

The current road damages occurring in various areas, particularly in Jayawijaya Regency and generally in Papua Province, pose highly complex issues. These damages lead to hindered activities such as travel time, traffic congestion, among others, which accumulate to have an impact on the global economy (Betaubun & Paresa, 2019).

In Jayawijaya Regency, there are several prioritized road sections, including national, provincial, and district roads. The Muliama-Wame-Makki road section is classified as a provincial road serving as an alternative route, with a total length of 22 kilometers connecting Jayawijaya Regency and Lanni Jaya Regency. The traffic on this road is quite heavy with a diverse composition (Mixed Traffic). The frequent damages on the Muliama-Wame-Makki road section can affect the safety and comfort of road users;

hence, addressing the road construction is essential, requiring analysis and maintenance methods that are maintenance-oriented, enhancing, or rehabilitation can be optimally performed when the factors causing damage to the road section are identified (Mubarak, 2016).

Causes of road damage include: road layer aging, water pooling on the road surface, excessive traffic loads (overloaded), improper planning, inadequate supervision of implementation, and implementation not in accordance with the plan. Additionally, insufficient maintenance costs, delayed financing, improper handling, and climate change accelerate road damage (RONDI, n.d.).

Periodic assessments of road conditions, both structural and non-structural, are necessary. Non-structural inspections aim to examine smoothness, roughness, and skid resistance. Proper analysis and maintenance methods are required to ensure roads accommodate movement needs with a certain level of service, thus efforts are needed to maintain road quality by re-evaluating the construction surface condition by assessing the existing road conditions. The road condition value will be used as a reference to determine the type of evaluation program, whether it is an improvement program, periodic maintenance program, or routine maintenance program (Velmurugan & Dhingra, 2015).

The aim of this research is to identify and analyze the types and levels of damage on provincial roads and to formulate the necessary maintenance strategies according to the road damage levels on the Muliama-Wame-Makki section. The benefits of this research include the identification and analysis of the types and levels of damage on provincial roads, as well as the analysis of necessary maintenance strategies for those roads (Shafiee, 2015).

Previous research has been conducted by Adolf Wakum (2009) titled "Evaluation of Pavement Conditions on the Nimbontong - Taja Road Section at STA 17 + 500 - STA 20 + 500 in Jayapura Regency." The study found various types of damage, including Alligator Cracking and Moderate Cracking on the surface layer with significant damage levels, Disintegration in the form of Fine Particle Release, Coarse Particle Release, flaking, Potholes with extensive, deep, and deformation types of damage on the Surface Layer, Upper Foundation Layer, and Lower Foundation Layer (Lee & Scott, 2009).

According to the findings of (Wiyono, 2012) in the field, out of 52 segment units, visually observed damage types included alligator cracking, block cracking, depression, long and transversal cracking, patching, raveling & weathering, and rutting. The dominant type of damage was alligator cracking covering an area of 4068.61 m2 or 14.23%.

In the evaluation of road damage level as the basis for determining road maintenance by (Ashakandari, 2016), visual observations on the Yogyakarta-Barongan road section revealed 7 types of damage: alligator cracking, block cracking, depression, longitudinal and transverse cracking, patching, weathering and particle release, and finally shoving. The largest damage was alligator cracking covering an area of 1405.749 m2 or 44.12% of the total damage area, occurring almost evenly across the road, while the smallest damage was depression covering an area of 0.77 m2 or 0.02% of the total damage area (Tan, Li, Wu, Zheng, & He, 2011).

Research Methods

The research object is the Muliama-Wame-Makki road section in the year 2021 (STA. 00 + 000 to 22 + 000). The research location can be seen in Figure 1.

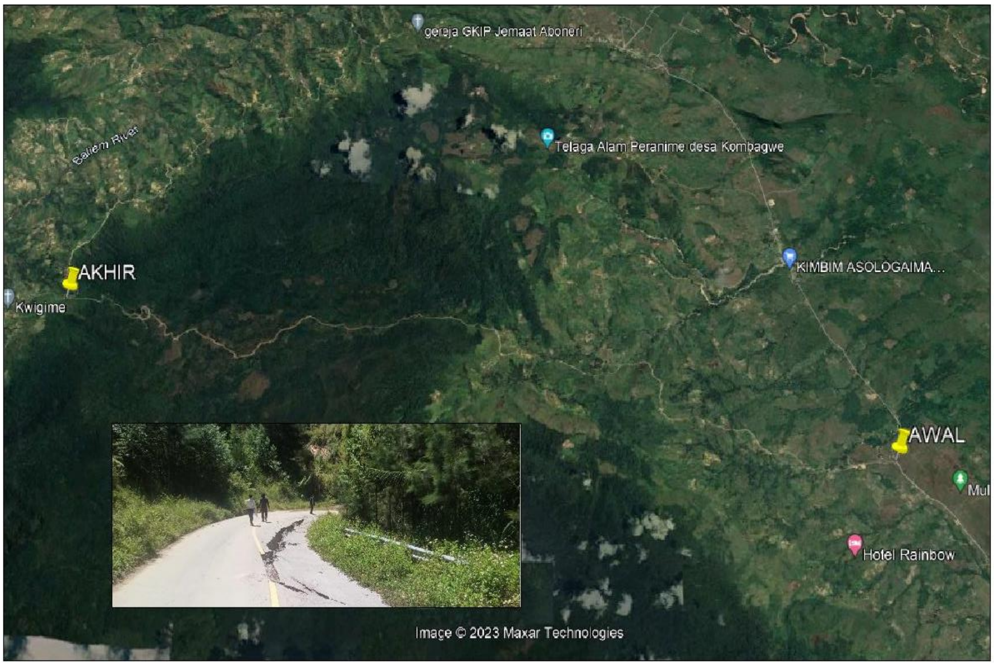


Figure 1. Research Location
(Location survey)

The damages occurring on the Muliama-Wame-Makki road section in 2021 (STA. 00 + 000 to 22 + 000) mostly consist of grade depressions, ruts, and a small portion of alligator cracks. The damages on the Muliama-Wame-Makki section can be seen in Figure 3.2, and the road depression damages can be observed in Figure 2 (Patil, Soni, Prakash, & Karwasra, 2022).

Figure 2. Road Damage: Ruts
(Survey 2021)

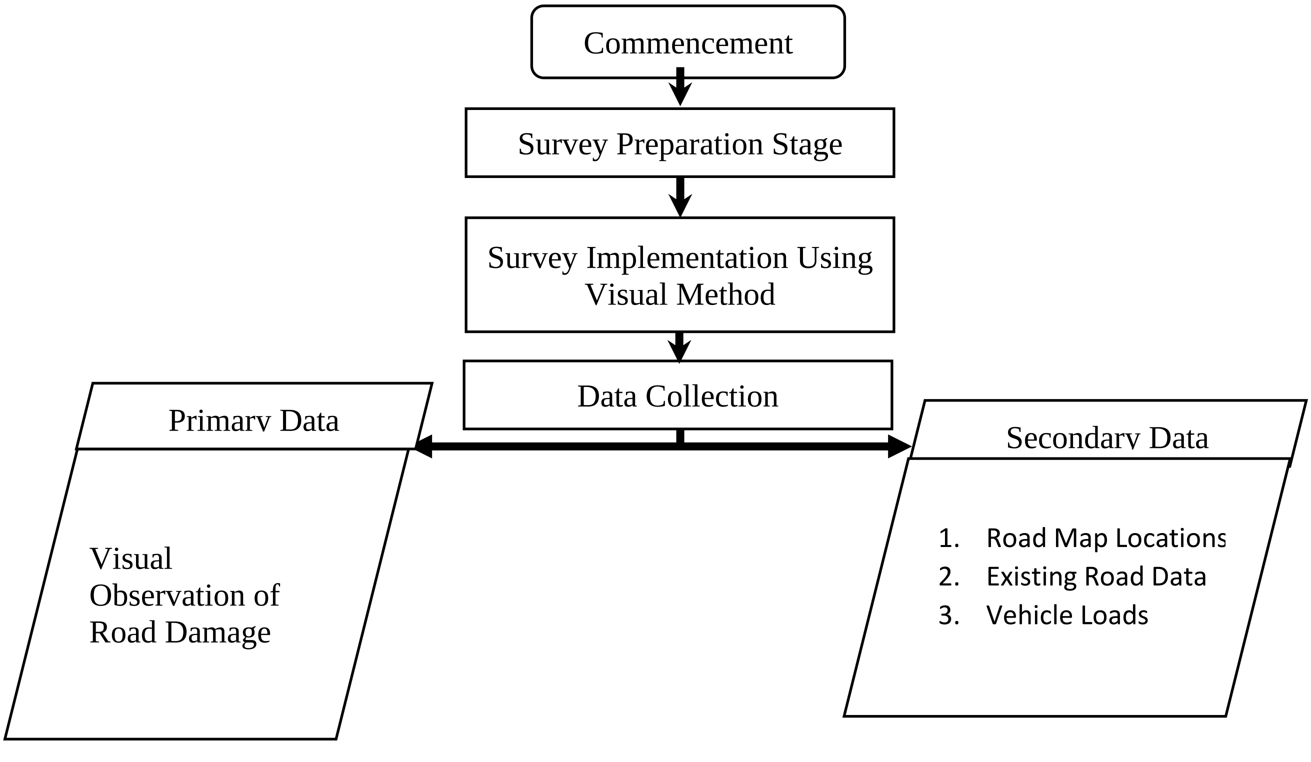
Figure 3. Road Damage: Grade Depressions (Survey 2021)

The data collected for road planning consists of Primary Data, obtained firsthand, including the project location to be surveyed. Secondary Data, obtained from relevant parties, encompasses Soil Data, Traffic Data, and Vehicle Count Data by type (Rastegari & Salonen, 2015).

Subsequently, the preparation phase involves planning to achieve efficiency and effectiveness in time and work. Preliminary observations are also conducted to gain a general overview in identifying and formulating existing field problems (Zhou & Yin, 2019).

Next, data analysis is carried out through three analyses: Pavement Condition Index (PCI) Analysis, Additional surveys for maintenance strategies, including Dynamic Cone Penetrometer (DCP) Survey and Traffic Survey, followed by analyzing road maintenance methods based on PCI damage levels (Do, Voisin, Levrat, & Iung, 2015).

Research Flow



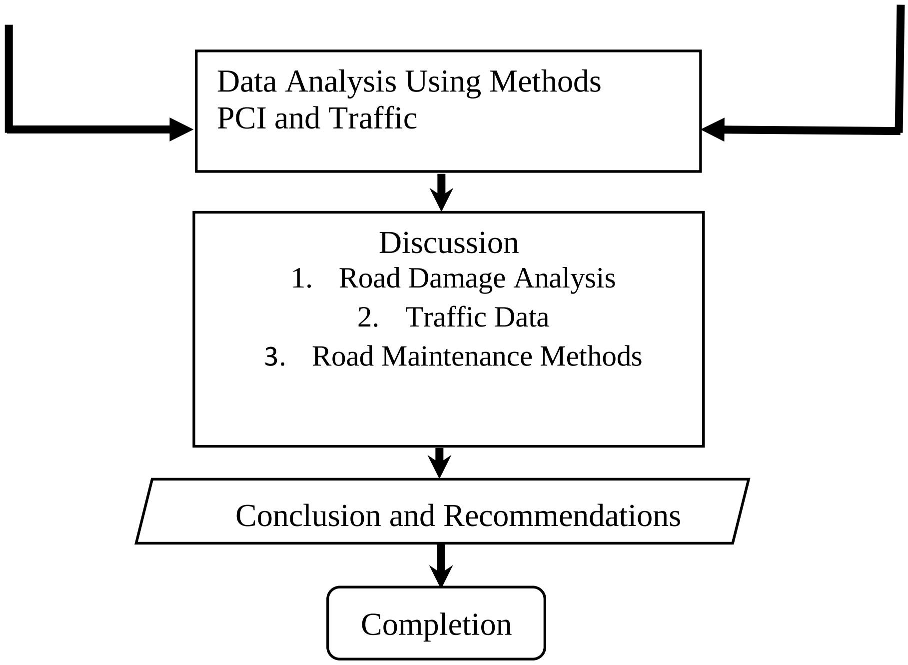


Figure 4 Research Flowchart

Results and Discussion

Overview of the Location

The Muliama-Wame-Makki road section serves as an arterial road, connecting Jayawijaya Regency and Lanni Jaya Regency, with a total length of 22 km and a road width of 7 m. The road was initially constructed by clearing the path in 2010 without asphalt covering. Subsequently, in 2012, the road was upgraded to an asphalt-covered road. The road section often experiences damages, which inevitably affect the safety and comfort of road users. The research object focuses on the Muliama-Wame-Makki road section from STA. 00 + 000 to 12 + 400, aiming to analyze the types and levels of road damage (Nguyen & Chou, 2018).

Figure 5 Research Location

The analysis conducted at the research location includes the types and levels of road damage and the handling strategies based on the analysis results.

1. Analysis of Road Damage Types and Levels

   The analysis of road damage types and levels at the research location on the Muliama-Wame-Makki road section from STA. 00 + 000 to 12 + 400 begins with analyzing the Pavement Condition Index (PCI) and traffic analysis.

   a. Pavement Condition Index (PCI)

      Analysis using the Pavement Condition Index (PCI) involves field survey data consisting of measurements of the extent, types, and quantities of surface damage on the road, divided per 200-meter road segment.

      According to Hardiyatmo, the Pavement Condition Index (PCI) method provides information on pavement condition only at the time of the survey but cannot provide predictive insights for the future.

      Based on field surveys, the observed types of damage include patching, longitudinal cracks, alligator cracking, and depressions.

      The calculation of the Pavement Condition Index (PCI) method at the research location on the Muliama-Wame-Makki road section from STA. 00 + 000 to 12 + 400 based on the type of damage per segment is as follows:

      1) Density Calculation

         Density calculation is performed by dividing the area of damage by the sample area per segment, with the unit in percentage (%). Examples of calculations for each type of damage are as follows:

         Patching located at STA 1+200 to STA 1+400 measured a patching area of 1.8m wide and 7m long. The damage falls into the category L (Low) because the patching is still new. Thus, the density is calculated as (1.8 x 7)/ (4 x 200) x 100% = 1.58%.

         Longitudinal cracks located at STA 1+600 to STA 1+800 measured a longitudinal crack area of 0.7m wide and 9.8m long. The damage falls into the category M (Medium) because its width exceeds 7.6 cm and is surrounded by light random cracks. Thus, the density is calculated as (0.7 x 9.8)/ (4 x 200) x 100% = 0.86%.

         Alligator cracking located at STA 2+600 to STA 2+800 measured an alligator crack area of 2m wide and 9.3m long. The damage falls into the category H (High) because the crack width exceeds 3 mm and there has been particle release. Thus, the density is calculated as (2 x 9.3)/ (4 x 200) x 100% = 2.33%.

         Depressions located at STA 6+000 to STA 6+200 measured a depression area of 1.8m wide and 17.3m long. The damage falls into the category H (High) because the depth of the damage exceeds 5 cm. Thus, the density is calculated as (1.8 x 17.3)/ (4 x 200) x 100% = 3.89%.

      2) Deduct Value (DV)

         After calculating the density, the density results are inputted into the deduct value curve for each type of damage. Examples of curves for each type of damage are as follows:

         Patching located at STA 1+200 to STA 1+400 with a density of 1.58% obtains a DV of 4.

         To find the DV value on the graph, a straight line is drawn towards the damage category curve based on the density result. Then, after hitting the category line, a horizontal line is drawn towards the DV and the DV nominal value intersecting the horizontal line is read. Thus, for a density of 1.58% with category L, a DV of 4 is obtained.

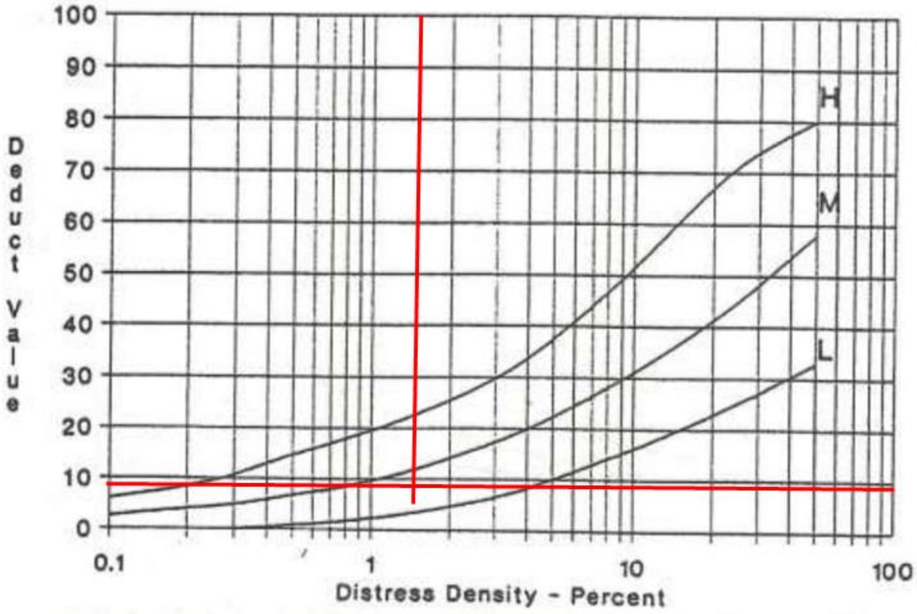


Figure 6 Deduct Value Curve for Patching Type

Longitudinal cracks located at STA 1+600 to STA 1+800 with a density of 0.86% obtain a DV of 8.

To find the DV value on the graph, a straight line is drawn towards the damage category curve based on the density result. Then, after hitting the category line, a horizontal line is drawn towards the DV, and the DV nominal value intersecting the horizontal line is read. Thus, for a density of 0.86% with category M, a DV of 8 is obtained.

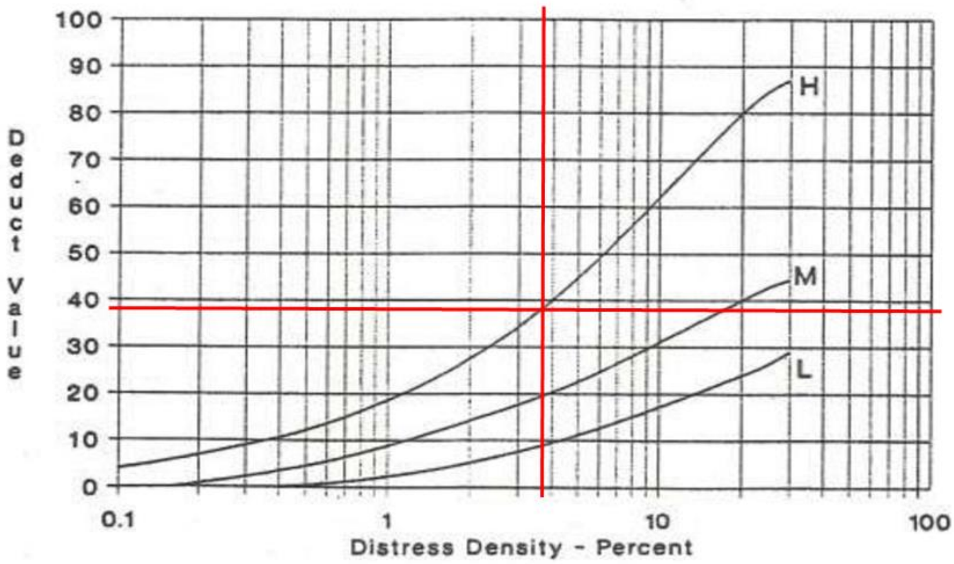


Figure 7 Deduct Value Curve for Longitudinal Crack Type

Alligator cracking located at STA 2+600 to STA 2+800 with a density of 2.33% obtain a DV of 42.

To find the DV value on the graph, a straight line is drawn towards the damage category curve based on the density result. Then, after hitting the category line, a horizontal line is drawn towards the DV, and the DV nominal value intersecting the horizontal line is read. Thus, for a density of 2.33% with category H, a DV of 42 is obtained.

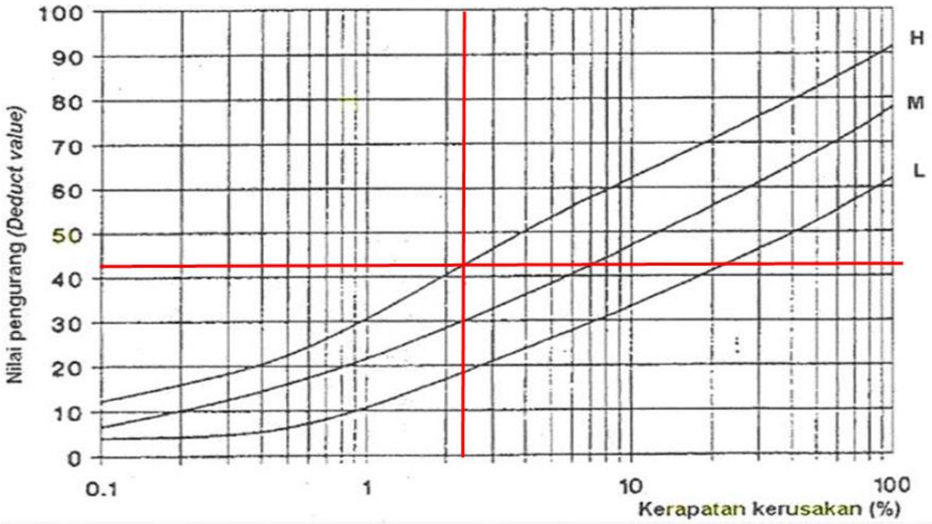


Figure 8 Deduct Value Curve for Alligator Crack Type

Depressions located at STA 6+000 to STA 6+200 with a density of 3.89% obtain a DV of 28.

To find the DV value on the graph, a straight line is drawn towards the damage category curve based on the density result. Then, after hitting the category line, a horizontal line is drawn towards the DV, and the DV nominal value intersecting the horizontal line is read. Thus, for a density of 3.89% with category H, a DV of 28 is obtained.

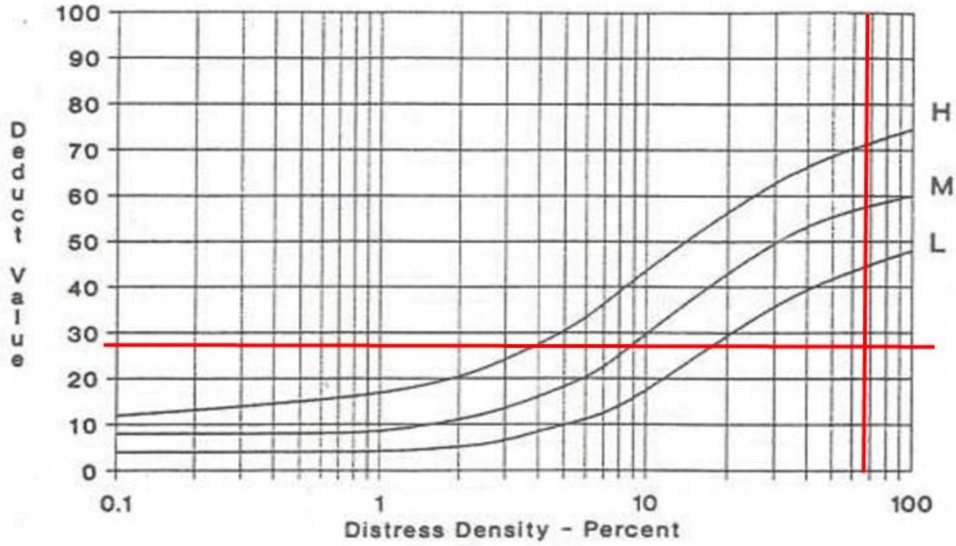


Figure 9 Deduct Value Curve for Depressions

3) Total Deduct Value (TDV)

The total deduct value is the sum of individual deduct values for each type of damage, arranged in descending order. To determine the allowable number of deducts (m), the equation is used:

M = 1+ (9/98) (100-HDVi)

where:

m = allowable number of deducts, including fractions, for the reviewed sample unit.

HDVi = Highest individual deduct value for sample i

1. Patching located at STA 1+200 to STA 1+400 with HDVi=4 obtains an m value of 1+ (9/98) (100-4) = 9,82 = 10. Since the total deduct value for patching in that segment is 1, TDV=4 is used for calculating the corrected deduct value.
2. Longitudinal cracks located at STA 1+600 to STA 1+800 with HDVi=8 obtains an m value of + (9/98) (100-8) = 9,45 = 10, Since the total deduct value for longitudinal cracks in that segment is 1, TDV=8 is used for calculating the corrected deduct value.
3. Alligator cracking located at STA 2+600 to STA 2+800 with HDVi=42 obtains an m value of 1+ (9/98) (100-42) = 6,33 = 7. Since the total deduct value for alligator cracking in that segment is 1, TDV=42 is used for calculating the corrected deduct value.
4. Depressions located at STA 6+000 to STA 6+200 with HDVi=28 obtains an m value of 1+ (9/98) (100-28) = 7,61 = 8. Since the total deduct value for depressions in that segment is 1, TDV=28 is used for calculating the corrected deduct value.

4) Corrected Deduct Value (CDV)

The CDV value is obtained from the curve relationship between the total deduct value (TDV) and the corrected deduct value (CDV) for asphalt. The line connecting touches the q equation line, which is the number of deducts on one segment.

1. Patching located at STA 1+200 to STA 1+400 with TDV=4 obtains a CDV value of 4.

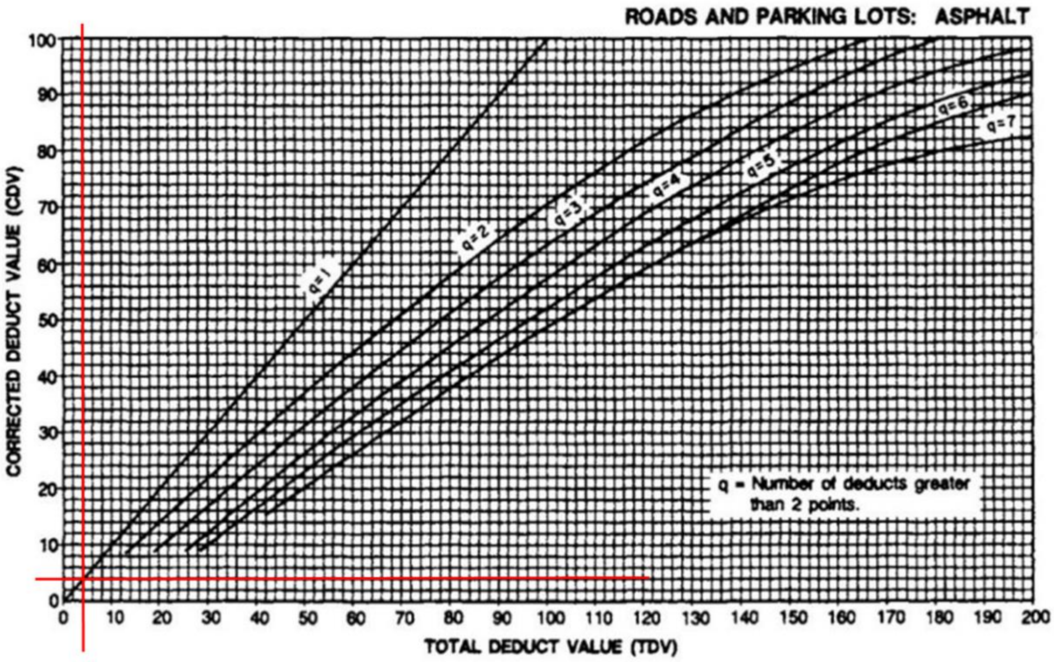


Figure 10 TDV Graph with Patch Type CDV

2. A longitudinal crack located at STA 1+600 to STA 1+800 with TDV = 8 resulted in a CDV value of 8.

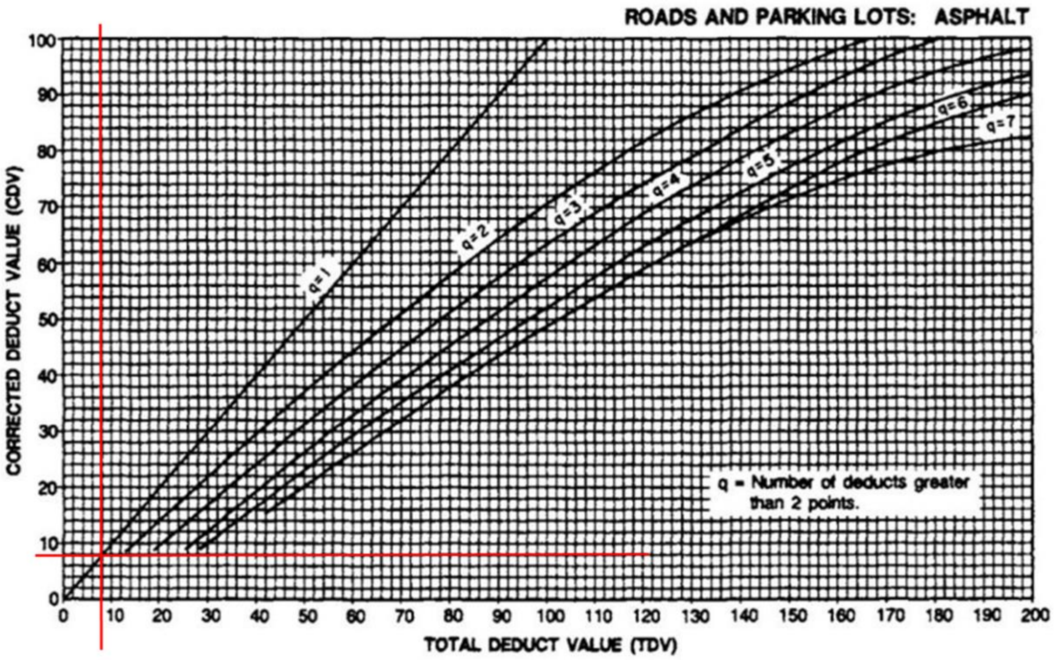


Figure 11 TDV Graph with CDV for Longitudinal Crack Type

3. A crocodile skin crack located at STA 2+600 to STA 2+800 with TDV = 42 resulted in a CDV value of 42.

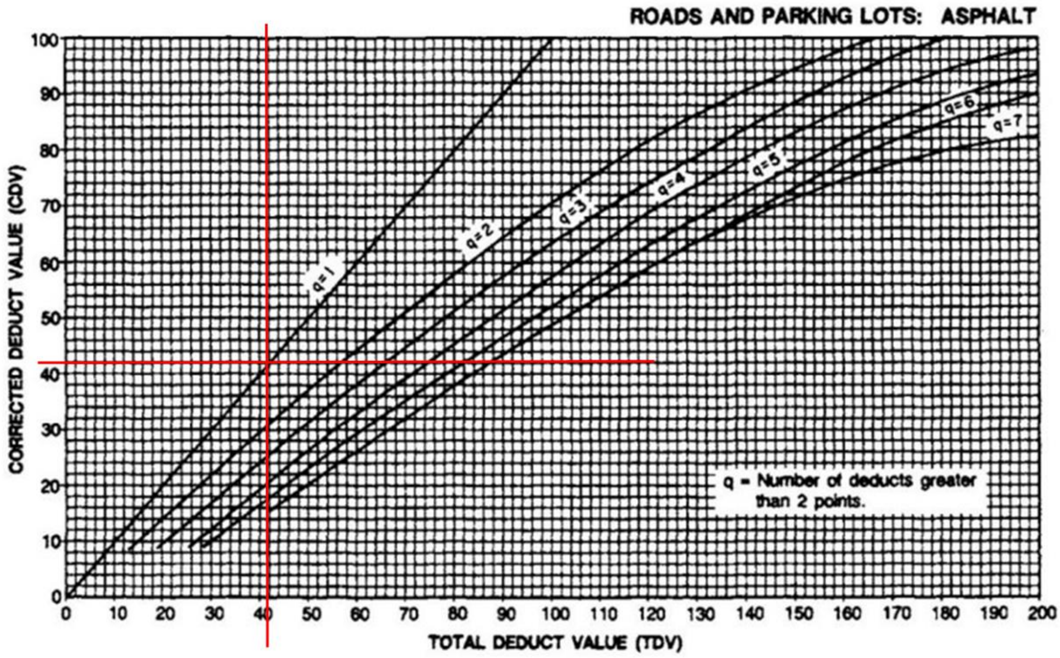


Figure 12 TDV Graph with CDV for Crocodile Crack Type

4. A depression located at STA 6+000 to STA 6+200 with TDV = 28 resulted in a CDV value of 28.

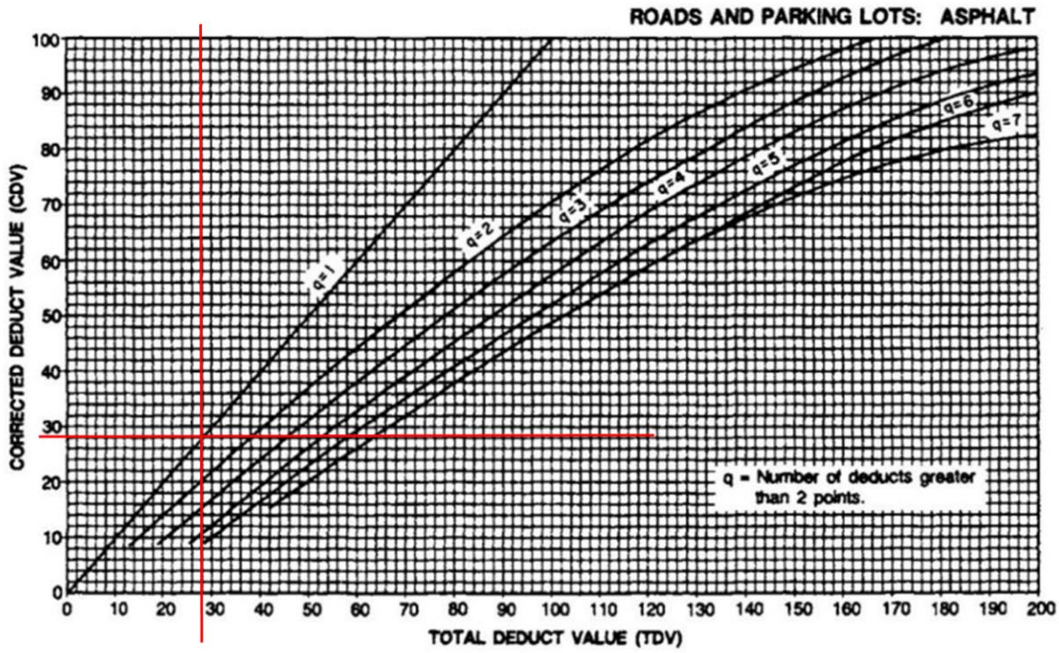


Figure 13 TDV Graph with CDV for Depression Type

5) Rating (PCI and condition value)

After obtaining the CDV, the PCI for each segment is calculated using the equation PCI = 100 - CDV. From the PCI value, the condition of the road is determined as follows:

1. Patch located at STA 1+200 to STA 1+400 obtains a PCI value of 100 – 4 = 96 with perfect condition.

2. Longitudinal crack located at STA 1+600 to STA 1+800 obtains a PCI value of 100 - 8 = 92 with perfect condition.
3. Crocodile skin crack located at STA 2+600 to STA 2+800 obtains a PCI value of 100 – 42 = 58 with good condition.
4. Depression located at STA 6+000 to STA 6+200 obtains a PCI value of 100 – 28 = 72 with very good condition.

b. Traffic The traffic analysis for the Muliama - Wame - Makki road section is conducted according to the VDF (Vehicle Damage Factor) to obtain the ESA (Equivalent Standard Axle) value.

1) Average Daily Traffic

Based on the conducted survey on average daily traffic, the total number of average daily traffic can be determined as shown in the following table:

Table 1 Average Daily Traffic

RUAS MULIAMA - WAME - MAKKI	
Vehicle Type	**Volume**
Motorcycle	632
Saloon/steam car/pick-up/station wagon	223
Medium axis 2 truck	54
TOTAL	**909**

From table 1 the total average daily traffic volume is 909.

2) Prediction of traffic growth

The Muliama - Wame - Makki road section is a rural collector road, where the predicted traffic growth according to the road pavement design manual is 3.5%. Therefore, the traffic growth on that road section can be tabulated as follows:

Table 2 Prediction of Traffic Volume Growth

No	Year	i (%)	Light cargo 2 axis truck	Light 2 axis truck	Light cargo 2 axis truck	Medium axis 2 truck
			0.2	**0.8**	**0.7**	**1.7**
0	2023	3.5	0	0	0	54
1	2024	3.5	0	0	0	57
2	2025	3.5	0	0	0	59
3	2026	3.5	0	0	0	62
4	2027	3.5	0	0	0	65
5	2028	3.5	0	0	0	68
6	2029	3.5	0	0	0	71
7	2030	3.5	0	0	0	74
8	2031	3.5	0	0	0	77
9	2032	3.5	0	0	0	80
10	2033	3.5	0	0	0	83
11	2034	3.5	0	0	0	86
12	2035	3.5	0	0	0	90

No	Year	i (%)	Light cargo 2 axis truck	Light 2 axis truck	Light cargo 2 axis truck	Medium axis 2 truck
			0.2	**0.8**	**0.7**	**1.7**
13	2036	3.5	0	0	0	94
14	2037	3.5	0	0	0	98
15	2038	3.5	0	0	0	102
16	2039	3.5	0	0	0	106
17	2040	3.5	0	0	0	110
18	2041	3.5	0	0	0	114
19	2042	3.5	0	0	0	118
20	2043	3.5	0	0	0	123

3) Traffic design calculations

INFORMATION:

Number of Vehicles per year	= Kend/day x 365
Fd	= 0.5 (Directional Distribution factor
FI	= 1 (path distribution factor)
ESA/Tahu	= Thon on Wave X VDF Safduxfi
Total Column	= 2

From the traffic design calculation results in table 4.4, according to the road pavement design manual, if the traffic volume is greater than 105 ESA and less than or equal to 107 ESA, then there is a potential for asphalt fatigue.

2. Bina Marga Method

The calculation of the Bina Marga Method for the reviewed road section is as follows:

1) Determining the road type and road class (Road Type: Rural Collector).
2) Calculating the LHR for the road section and determining the road class value. Before calculating the LHR, the peak hour volume (VJP) is calculated. Peak hour volume is the highest traffic volume occurring during one hour of observation. In this survey, the peak hour is taken at 09:00 - 10:00 WIT because it is a busy time on the road section under review. MC = 90 vehicles/hour, LV = 30 vehicles/hour, and MHV = 9 vehicles/hour.
3) Calculating parameters for each type of damage and assessing each type of damage. Here are some types of damage found on the road section:
   a. Potholes - First Patch Area of 12.6 m2
   b. Longitudinal Cracks Area of 6.86 m2
   c. Alligator Cracks Area of 18.6 m2
   d. Depression Area of 31.14 m2

Table 3 Percentage of Road Damage Area to Total Road Area

Total Area of Road Sections: 86800 m²		
Damage	Broad (m²)	Persentase (%)
Tambalan	245.19	0.28
Elongated Crack	168.06	0.19
Crocodile Skin Crack	18.6	0.02
Amblas	1030.18	1.19

The percentage of the total road area is 86,800 m2, and the total damaged area is 1,462.025 m2.

The percentage of damage is calculated using the following formula:

$$\frac{(\text{Whole Area} - \text{Total Damage Area})}{Total\ Area} \text{ x } 100\%$$

The percentage obtained is 98.316% of ((86,800 - 1,462.025) / 86,800) * 100%. So, the road damage is 100% - 98.316% = 1.684%.

The calculation of the damage value for surface roughness, potholes and patches, as well as plastic deformation, is based solely on the type of damage. Meanwhile, for crack damage, the calculation considers the type of crack, crack width, and area of damage. The value for the crack group is determined by the highest value among the three components mentioned above.

4) Determining the road condition value based on Table 3. With a damage value of 13.3, the road condition value is 5.
5) The priority value for road condition is calculated as 17 - (LHR Class + Road Condition). The road condition value is 17 - (5 + 5) = 7. A priority value > 7 indicates that the road is in good condition and therefore suitable for inclusion in routine maintenance programs.

3. Maintenance Strategy

The road maintenance strategy implemented to address the research site on the Muliama-Wame-Makki Road from STA. 00 + 000 to 12 + 400 includes both technical and socio-economic aspects.

1) Technical Aspect
   a. Based on the calculation of the Pavement Condition Index (PCI), decision making for handling grouped between 0 – 25 is carried out by handling reconstruction on road pavements, which ranges from 25 – 55 rehabilitation handling is carried out on the road pavement, while for handling in the range of 55 – 100 routine maintenance is carried out
   b. According to the Bina Marga Road Pavement Design Manual table number L3, the selection of the type of treatment for the existing flexible pavement on the Muliama-Wame-Makki road section with a traffic load of less than 1 million ESA4 is as follows:
      1) Only routine maintenance if the serious damage area is < 5% of the total area.
      2) Heavy patching if the deflection exceeds the deflection trigger 2 or if the surface is heavily damaged and the total area requiring heavy patching does not exceed 30% of the total area.
      3) Excavation and replacement of material in certain areas are required if the elevation needs to be the same as the structure elevation or kerb elevation, etc.; also if the existing pavement conditions have deep grooves and severe cracks.

Based on the PCI calculation and Bina Marga method, the handling strategy that can be done is only routine maintenance.

1) For the short term, the handling strategy involves excavation and replacement of material in certain areas where the pavement conditions have cracks and deep grooves, as well as routine maintenance for roads in very good to perfect condition.
2) For the medium term, the handling strategy involves rehabilitating the road pavement with fair to good conditions, as well as routine maintenance.

3) For the long term, the handling strategy involves increasing road capacity so that the road can accommodate a maximum of 30% increase in total vehicle weight passing through currently and routine maintenance.

2) Social and Economic Aspects

The communities residing along the Muliama-Wame-Makki road section and those using this road are located in Jayawijaya Regency and Lanny Jaya Regency. Communities engaged in farming and animal husbandry reside on the outskirts of vast agricultural land along the road, aiming to facilitate the transportation of harvests through this road.

Meanwhile, employees and traders often use this road for commuting between the two cities. As for the economic aspect, the income source of the population along this road is farming, evident from the coffee plantations along the Muliama-Wame-Makki road.

Conclusion

The types of damage occurring on the Muliama-Wame-Makki Road section are patches, longitudinal cracks, alligator cracks, and depressions, with the following levels of damage.

Total Area of Road Sections: 86800 m²		
Damage	Broad (m²)	Persentase (%)
Tambalan	245.19	0.28
Elongated Crack	168.06	0.19
Crocodile Skin Crack	18.6	0.02
Amblas	1030.18	1.19

Based on the Pavement Condition Index (PCI) calculation and the Bina Marga method, the maintenance strategy that can be implemented is limited to routine maintenance only.

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