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# Analysis of Routine Maintenance Costs on the Maospati-Magetan-Cemorosewu Road Section, East Java Province

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**Abstract**

The Maospati - Magetan - Cemorosewu Road has experienced severe pavement damage, including potholes, surface undulations, peeling asphalt layers, and significant deflections when heavy vehicles pass. These issues disrupt road users, particularly during the rainy season when puddles pose risks, particularly for private vehicles and motorcycles, which frequently overturn. This study aims to assess the level of road damage using the PKRMS and Bina Marga methods. Following the assessment, recommendations for road damage handling will be provided, and the associated maintenance costs will be calculated, followed by a budget estimation for the necessary repairs. The results of this study show that the road surface damage on the Maospati - Magetan - Cemorosewu section, Km 180 + 040 to Km 219 + 100, is classified as low, with generally good road conditions based on both the Bina Marga and PKRMS methods. According to the Bina Marga Method, the recommended treatment is routine maintenance, with an estimated cost of IDR 2,635,786,094. To optimize fund allocation, a handling priority analysis was conducted, considering various alternatives to determine the most effective order of repairs. The findings suggest that prioritizing maintenance based on a structured assessment can enhance the effectiveness of road repair initiatives and ensure better allocation of limited resources.

**Keywords:** PKRMS, Highways, Road Maintenance Recommendations, Maintenance Costs, Multi Criteria Analysis (MCA).

## INTRODUCTION

Road damage assessment can be conducted through a variety of effective methods, including visual methods, non-destructive methods, and modeling methods. The visual method involves direct observation of the road surface to identify the type and extent of damage, such as cracks, potholes, and asphalt peeling. Non-destructive methods, on the other hand, use tools such as Ground Penetrating Radar (GPR) and deflectometers to evaluate structural conditions without damaging the road layer (Elseicy et al., 2022); (Hugenschmidt., 2010). Additionally, modeling methods, such as the use of damage analysis software, can be helpful in forecasting road life and determining maintenance priorities based on historical and simulation data. The combination of these methods can provide a comprehensive picture of road conditions and aid in better decision-making regarding maintenance and repairs (Arifin et al., 2021). Through

proper assessment, it is hoped that road damage can be handled effectively, thereby improving user safety and comfort.

Various road damage assessment methods have been applied to ensure optimal infrastructure conditions, including the *Bina Marga* method, the Pavement Condition Index (PCI) method, and the Visual Condition Assessment (VCA) method (Jarwoto et al., 2025). The *Bina Marga* method, developed by the Ministry of Public Works in Indonesia, uses special criteria to categorize road damage and provide maintenance recommendations based on the results of the assessment. Meanwhile, the PCI method is an international approach that assesses road conditions based on visual observations and provides a score that reflects the extent of damage, helping in determining maintenance priorities. The VCA method is also carried out through systematic visual observation, identifying various types of damage such as cracks, holes, and deformations. The combination of these methods, along with other analytical tools and techniques, can provide a better understanding of road conditions and aid in efficient maintenance planning (Latifa et al., 2021). With the right approach, road damage can be identified and dealt with effectively, thereby improving safety and comfort for road users.

Research conducted by Sutarno et al. (2016); Pinatt et al. (2020); Karim et al. (2016) reported that the analysis and calculation using the PCI (Pavement Condition Index) method showed that the average PCI value on the National Awakening Road was 30.44. Based on these results, the most appropriate repair action for the National Awakening Road is to carry out immediate reconstruction. On the other hand, research by Salsabilla et al. (2020) applied the *Bina Marga* 1990 method and the PCI method in road damage analysis. The results of these two methods were compared to determine the more significant extent of damage. In addition, research by Tho'atin et al. (2016) used the IRI (International Roughness Index) method, which refers to the LHR (Average Daily Traffic) value to assess road conditions and determine the appropriate maintenance program. The use of these methods demonstrates the importance of diverse approaches in assessing road conditions to ensure effective and efficient maintenance measures to improve the quality of transportation infrastructure (PUPR, 2018). Thus, the application of the right methods can help in identifying and dealing with road damage more accurately.

In a study conducted by Pembuain et al. (2018), the method applied is the calculation of the IRI (International Roughness Index) value, which is measured using the NAASRA Roughness Meter tool. The relationship between IRI and road damage values was analyzed using bivariate (best fit) and multivariate (multiple regression) approaches. This study produced two models of multivariate equations in the form of multiple regression, where the first model is based on factor analysis and the second model is based on correlation analysis. Each model showed $R^2$ values of 0.550 and 0.571, indicating a fairly strong relationship between IRI and road damage. These

findings emphasize the importance of using proper analytical methods to understand and predict road conditions, so that more effective maintenance measures can be taken to improve the quality of transportation infrastructure. The results of this study can be a reference for the development of a more accurate road damage assessment model in the future.

Based on the problems identified in this study, road repair measures are urgently needed to deal with the damage that occurs. The repair process begins with an assessment of road damage to identify the type and extent of damage. Furthermore, it is important to analyze traffic characteristics through surveys aimed at understanding patterns and intensity of road use. Once data on the extent of the damage and traffic characteristics are gathered, the next step is to calculate the maintenance costs for the detected damage, as well as assess the budget available for those repairs. With this structured approach, it is hoped that the repairs made are not only effective but also efficient, so that they can improve the quality and safety of road infrastructure in the future. A deep understanding of road conditions and traffic characteristics will allow for better maintenance planning, guaranteeing that the investments made can deliver maximum and sustainable results. This is very important to support economic growth and increase community mobility.

This study aims to analyze the level of road surface damage and provide recommendations for appropriate handling on the Maospati - Magetan - Cemorosewu road section, Km 180 + 040 to Km 219 + 100, using the PKRMS method and the *Bina Marga* method. In addition, this study also aims to determine the cost of handling roads based on the *Bina Marga* method and optimize the maintenance cost budget efficiently to improve the quality and service life of the road section.

## RESEARCH METHODS

This study aims to analyze the level of road damage, provide appropriate handling recommendations, and optimize the maintenance budget on the Maospati - Magetan - Cemorosewu Road section, Km 180 + 040 to Km 219 + 100, with a total length of 39.6 kilometers. The research began with a literature study to understand the concept of assessing road damage based on the *Bina Marga* method, including the calculation of maintenance costs and optimizing budget allocation. The data collection stage includes primary and secondary data. Primary data was obtained through a field survey using the *Bina Marga* method, which involved measuring road damage and drainage channel conditions. Secondary data was obtained from the official documents of the DPU *Bina Marga* Wilayah UPT PJJ Madiun, which included previous road damage data, average daily traffic data (LHR), and road maintenance budget.

A road damage survey was carried out to identify the type and extent of damage by measuring the length and extent of damage in each 100-meter segment. The assessment of the condition of the drainage channel was carried out in conjunction with a visual survey in the field. The collected data is then

analyzed to determine the value of road damage, and the scale of handling priorities based on damage value, LHR class, and road function. Handling priorities are grouped into three categories: road improvements for segments with priority values of 0–3, periodic maintenance for priority values 4–6, and routine maintenance for priority values 7–9.

In addition, the analysis was conducted to evaluate the suitability between the need for maintenance costs and the available budget. If the budget is insufficient, the recommendation for re-evaluation is submitted to the *Bina Marga*. This research is expected to produce recommendations for efficient road maintenance strategies, including the scale of handling priorities, appropriate types of maintenance, and budget optimization to maintain the quality of roads according to their functions.

## RESULTS AND DISCUSSION

### Calculation of Cost Budget Plan (RAB)

The calculation of the road pavement cost budget plan in this Thesis uses the HSPK of the Highway Public Works Office UPT PJJ Madiun. In the calculation of RAB, it is carried out by multiplying the volume of work with the HSPK of the Highway Public Works Office of UPT PJJ Madiun. There are several maintenance works, including: Kerb Checking, Sewer Maintenance, Repair with HRS B, Channel Maintenance, Repair with Cold Mix (CPAC), Hectometer Stake Maintenance, Road Shoulder Maintenance, Kilometer Stake Maintenance, Road Markings, and Shrub Tripe. Where on the Maospati – Magetan – Cemorosewu section, Km 180 + 040 – Km 219 + 100 in the UPT PJJ Madiun Area, the average maintenance carried out is routine maintenance. And here is an example of calculating the volume of work for each maintenance activity on Link 142:

- Kerb Checking ($m^2$)
  = Top Area + Bottom Area
  = (length x width) + (length x width)
  = (100 m x 0.15 m)+ (100 m x 0.15 m)
  = 15 m2 + 15 m2
  = 30 m2
- Sewer Maintenance (m')
  = left side length
  = 100 m'
- Repair with HRS B (tons)
  = length x width x thickness x specific gravity
  = 40 m x 3 m x 0.03 m x 2.2 tons/m3
  = 7.92 tons
- Duct Maintenance (m')
  = left side length
  = 100 m'
- Cold Mix (CPAC) repair (tons)

= length x width x thickness x specific gravity
= 20 m x 1.5 m x 0.04 m x 2.1 tons/m3
= 2.52 tons

- Hectometer Stake Maintenance (Bh)
  = right side length
  = 1300 Bh
- Road Shoulder Care ($^{m2}$)
  = length x width
  = 100 m x 1 m
  = 100 m2
- Kilometer Marker Treatment (Bh)
  = left side length
  = 375 Bh
- Road Markings (m2)
  - Middle
    = length x width x total
    = 3 m x 0.12 m x 300
    = 108 m2
  - Right
    = length x width x total
    = 4500 m x 0.12 m x 1
    = 540 m2
  - Left
    = length x width x total
    = 4500 m x 0.12 m x 1
    = 540 m2
- Tripe Bush(m2)
  = length x width
  = 100 m x 1.5 m
  = 150 m2

From the results of the example of calculation of the volume of work above, it is obtained that the volume of work is in accordance with the road conditions on the Maospati – Magetan – Cemorosewu section, Km 180 + 040 – Km 219 + 100 in the UPT PJJ Madiun Area, after that multiplied by the unit price obtained from the HSPK DPU Bina Marga UPT PJJ Madiun, which can be seen in Table 1. to Table 9.

**Table 1. Maintenance RAB Calculation Results on Link 141**

| **Link** | | | **Link 141** | |
|---|---|---|---|---|
| **Road Length Per Link (m)** | | | **9150** | |
| **Information** | **Unit Price** | **Unit** | **Total Volume** | **Total Price** |
| HRS B | IDR 1,746,598 | Ton | 145 | IDR 253,256,761 |

| | | | | |
|---|---|---|---|---|
| Cold Mix ( CPAC ) | IDR 1,942,994 | Ton | 51 | IDR 99.092.701 |
| TRIPE SHRUBS/PLANTS | IDR 1,406 | M2 | 5670 | IDR 7,973,923 |
| KERB PAINTING | IDR 52,309 | M2 | 609 | IDR 31,855,909 |
| SEWER MAINTENANCE | IDR 6,000 | M' | 3800 | IDR 22,800,000 |
| DUCT CARE | IDR 8,455 | M' | 4450 | IDR 37,624,750 |
| HECTOMETER STAKE MAINTENANCE | IDR 39,244 | BRASSIERE | 900 | IDR 35,319,240 |
| ROAD SHOULDER CARE | IDR 4,127 | M2 | 6000 | IDR24,760,980 |
| **Total Link Price 141** | | | | IDR 512,684,265 |

(Source: Processed Research)

**Table 2. Maintenance RAB Calculation Results on Link 141.11K**

| **Link** | | | | **141.11K links** |
|---|---|---|---|---|
| **Road Length Per Link (m)** | | | | **640** |
| **Information** | **Unit Price** | **Unit** | **Total Volume** | **Total Price** |
| KERB PAINTING | IDR 52,309 | M2 | 132 | IDR 6,904,729 |
| SEWER MAINTENANCE | IDR 6,000 | M' | 540 | IDR 3,240,000 |
| **Total Link Price 141.11K** | | | | IDR 10,144,729 |

(Source: Processed Research)

**Table 3. Maintenance RAB Calculation Results on Link 141.12K**

| **Link** | | | | **141.12K links** |
|---|---|---|---|---|
| **Road Length Per Link (m)** | | | | **440** |
| **Information** | **Unit Price** | **Unit** | **Total Volume** | **Total Price** |
| KERB PAINTING | IDR 52,309 | M2 | 94,5 | IDR 4,943,158 |
| SEWER MAINTENANCE | IDR 6,000 | M' | 460 | IDR 2,760,000 |
| **Total Link Price 141.12K** | | | | IDR 7,703,158 |

(Source: Processed Research)

**Table 4. Maintenance RAB Calculation Results on Link 141.13K**

| **Link** | | | | **141.13K links** |
|---|---|---|---|---|
| **Road Length Per Link (m)** | | | | **270** |
| **Information** | **Unit Price** | **Unit** | **Total Volume** | **Total Price** |
| KERB PAINTING | IDR 52,309 | M2 | 67,5 | IDR 3,530,827 |
| SEWER MAINTENANCE | IDR 6,000 | M' | 340 | IDR 2,040,000 |
| **Total Link Price 141.13K** | | | | IDR 5,570,827 |

(Source: Processed Research)

**Table 5. Maintenance RAB Calculation Results on Link 141.14K**

| **Link** | | | | **141.14K links** |
|---|---|---|---|---|
| **Road Length Per Link (m)** | | | | **790** |
| **Information** | **Unit Price** | **Unit** | **Total Volume** | **Total Price** |
| KERB PAINTING | IDR 52,309 | M2 | 168 | IDR 8,787,837 |

| | | | | |
|---|---|---|---|---|
| SEWER MAINTENANCE | IDR 6,000 | M' | 870 | IDR 5,220,000 |
| **Total Link Price 141.14K** | | | | IDR 14,007,837 |

(Source: Processed Research)

**Table 6. Maintenance RAB Calculation Results on Link 141.15K**

| **Link** | | | | **141.15K links** |
|---|---|---|---|---|
| **Road Length Per Link (m)** | | | | **540** |
| **Information** | **Unit Price** | **Unit** | **Total Volume** | **Total Price** |
| KERB PAINTING | IDR 52,309 | M2 | 120 | IDR 6,277,026 |
| SEWER MAINTENANCE | IDR 6,000 | M' | 520 | IDR 3,120,000 |
| **Total Link Price 141.15K** | | | | IDR 9,397,026 |

(Source: Processed Research)

**Table 7. Maintenance RAB Calculation Results on Link 141.16K**

| **Link** | | | | **141.16K links** |
|---|---|---|---|---|
| **Road Length Per Link (m)** | | | | **590** |
| **Information** | **Unit Price** | **Unit** | **Total Volume** | **Total Price** |
| KERB PAINTING | IDR 52,309 | M2 | 105 | IDR 5,492,398 |
| SEWER MAINTENANCE | IDR 6,000 | M' | 540 | IDR 3,240,000 |
| **Total Link Price 141.16K** | | | | IDR 8,732,398 |

(Source: Processed Research)

**Table 8. Maintenance RAB Calculation Results on Link 141.17K**

| **Link** | | | | **141.17K links** |
|---|---|---|---|---|
| **Road Length Per Link (m)** | | | | **2460** |
| **Information** | **Unit Price** | **Unit** | **Total Volume** | **Total Price** |
| KERB PAINTING | ‘ | M2 | 257.85 | IDR13,487,761 |
| SEWER MAINTENANCE | IDR 6,000 | M' | 2935 | IDR17,610,000 |
| DUCT CARE | IDR 8,455 | M’ | 2110 | IDR17,840,050 |
| **Total Link Price 141.17K** | | | | IDR 62,951,983 |

(Source: Processed Research)

**Table 9. Maintenance RAB Calculation Results on Link 142**

| **Link** | | | | **Link 142** |
|---|---|---|---|---|
| **Road Length Per Link (m)** | | | | **24180** |
| **Information** | **Unit Price** | **Unit** | **Total Volume** | **Total Price** |
| HRS B | IDR 1,746,598 | Ton | 546 | IDR 953,642,701 |
| Cold Mix ( CPAC ) | IDR 1,942,994 | Ton | 202 | IDR 392,484,814 |
| TRIPE SHRUBS/PLANTS | IDR 1,406 | M2 | 10470 | IDR 14,724,335 |
| ROAD MARKINGS | IDR 192,159 | M2 | 1188 | IDR228.285.120 |
| KERB PAINTING | IDR 52,309 | M2 | 1050 | IDR 54,923,981 |
| SEWER MAINTENANCE | IDR 6,000 | M' | 4870 | IDR 29,220,000 |
| DUCT CARE | IDR 8,455 | M' | 11800 | IDR 99,769,000 |
| MAINTENANCE OF KILOMETER PEGS | IDR103,350 | BRASSIERE | 750 | IDR 77,512,500 |
| HECTOMETER STAKE MAINTENANCE | IDR 39,244 | BRASSIERE | 2600 | IDR 102,033,360 |

| Link | | | Link 142 | |
|---|---|---|---|---|
| Road Length Per Link (m) | | | 24180 | |
| Information | Unit Price | Unit | Total Volume | Total Price |
| ROAD SHOULDER CARE | IDR 4,127 | M2 | 12600 | IDR 51,998,058 |
| Total Link Price 142 | | | | IDR 2,004,593,870 |

(Source: Processed Research)

From the results above, it is obtained that the maintenance needs of each Link on the Maospati – Magetan – Cemorosewu section, Km 180 + 040 – Km 219 + 100 in the UPT PJJ Madiun Area, and for the recapitulation on the section can be seen in Table 10.

**Table 10. Recapitulation of Maintenance RAB Calculation Results**

| Link | Total Price |
|---|---|
| Link 141 | IDR 512,684,265 |
| Link 141 (11K) | IDR 10,144,729 |
| Link 141 (12K) | IDR 7,703,158 |
| Link 141 (13K) | IDR 5,570,827 |
| Link 141 (14K) | IDR 14.007.837 |
| Link 141 (15K) | IDR 9.397.026 |
| Link 141 (16K) | IDR 8,732,398 |
| Link 141 (17K) | IDR 62,951,983 |
| Link 142 | IDR 2,004,593,870 |
| **Sum** | **IDR 2,635,786,094** |

(Source: Processed Research)

From the results of the recapitulation above, it was found that the maintenance needs on the Maospati – Magetan – Cemorosewu section, Km 180 + 040 – Km 219 + 100 in the UPT PJJ Madiun Area amounted to Rp. 2,635,786,094, and the existing budget for 2023 in the UPT PJJ Madiun Area amounted to Rp. 2,621,771,921. So the difference between the existing costs and the amount of maintenance activity needs is as follows:

Maintenance Needs in 2023 = Rp. 2,635,786,094

Available Budget in 2023 = IDR 2,621,771,921

The difference in the Fund Budget is = IDR 2,621,771,921 - IDR 2,635,786,094

= Rp. 14,014,173

So, the difference between the available Budget and Maintenance Needs in 2023 is Rp. 14,014,173

**Priority Selection of Road Handling Programs**

In this thesis, a multi-criteria analysis method is used to determine the priority of road management in the Maospati – Magetan – Cemorosewu section, Km 180 + 040 – Km 219 + 100 in the road handling maintenance plan. The analysis is carried out using a simple matrix with predetermined criteria

with a certain assessment system that will produce a value or weight which is then used as the basis for selecting road handling priorities.

To determine the choice of priority for road handling in the UPT PJJ Madiun area, there are several considerations that must be considered. These considerations are then used as criteria and sub-criteria in the assessment of each link so that the selected handling priorities in road maintenance planning will be obtained. The assessment criteria and sub-criteria are as described in Table 11.

**Table 11. Criteria and Sub-Criteria for Assessing Road Handling Priorities**

| Yes | Criterion | Code |
|---|---|---|
| **1** | **Road Condition Factors** | |
| | Road Damage Handling | A |
| | Side Channel Conditions | B |
| | Accident Rate | C |
| | Quality of Material | D |
| | Passing Vehicles | E |
| **2** | **Cost Factor** | |
| | Maintenance Costs | F |

(Source: Processed Research)

## Condition Analysis of Each Alternative

From the explanation of some of the criteria for assessing road maintenance above, it is necessary to analyze the condition of each alternative to be able to make an assessment according to the criteria that have been determined. for alternatives 1, 2, 3, 4, 5, 6, 7, 8, and 9. The following is an explanation of the conditions of each alternative. It can be seen in Table 11. to Table 19.

**Table 12. Alternative Data 1**

| Yes | Criterion | Code | Information |
|---|---|---|---|
| **1** | **Road Condition Factors** | | |
| | Road Damage Handling | A | 5.58% |
| | Side Channel Conditions | B | 4.34% |
| | Accident Rate | C | 0.62% |
| | Quality of Material | D | 1.86% |
| | Passing Vehicles | E | 53169 |
| **2** | **Cost Factor** | | |
| | Maintenance Costs | F | IDR512,684,265 |

(Source: Processed Research)

**Table 13. Alternative Data 2**

| Yes | Criterion | Code | Information |
|---|---|---|---|
| **1** | **Road Condition Factors** | | |
| | Road Damage Handling | A | 4.50% |
| | Side Channel Conditions | B | 3.50% |
| | Accident Rate | C | 0.50% |
| | Quality of Material | D | 1.50% |
| | Passing Vehicles | E | 49537 |

| Yes | Criterion | Code | Information |
|---|---|---|---|
| **2** | **Cost Factor** | | |
| | Maintenance Costs | F | IDR10,144,729 |

(Source: Processed Research)

**Table 14. Alternative Data 3**

| Yes | Criterion | Code | Information |
|---|---|---|---|
| **1** | **Road Condition Factors** | | |
| | Road Damage Handling | A | 4.50% |
| | Side Channel Conditions | B | 3.50% |
| | Accident Rate | C | 0.50% |
| | Quality of Material | D | 1.50% |
| | Passing Vehicles | E | 37348 |
| **2** | **Cost Factor** | | |
| | Maintenance Costs | F | IDR 7,703,158 |

(Source: Processed Research)

**Table 15. Alternative Data 4**

| Yes | Criterion | Code | Information |
|---|---|---|---|
| **1** | **Road Condition Factors** | | |
| | Road Damage Handling | A | 4.50% |
| | Side Channel Conditions | B | 3.50% |
| | Accident Rate | C | 0.50% |
| | Quality of Material | D | 1.50% |
| | Passing Vehicles | E | 31952 |
| **2** | **Cost Factor** | | |
| | Maintenance Costs | F | IDR 5,570,827 |

(Source: Processed Research)

**Table 16. Alternative Data 5**

| Yes | Criterion | Code | Information |
|---|---|---|---|
| **1** | **Road Condition Factors** | | |
| | Road Damage Handling | A | 4.50% |
| | Side Channel Conditions | B | 3.50% |
| | Accident Rate | C | 0.50% |
| | Quality of Material | D | 1.50% |
| | Passing Vehicles | E | 40391 |
| **2** | **Cost Factor** | | |
| | Maintenance Costs | F | IDR 14,007,837 |

(Source: Processed Research)

**Table 17. Alternative Data 6**

| Yes | Criterion | Code | Information |
|---|---|---|---|
| **1** | **Road Condition Factors** | | |
| | Road Damage Handling | A | 4.50% |
| | Side Channel Conditions | B | 3.50% |
| | Accident Rate | C | 0.50% |
| | Quality of Material | D | 1.50% |
| | Passing Vehicles | E | 23895 |
| **2** | **Cost Factor** | | |
| | Maintenance Costs | F | IDR9,397,026 |

(Source: Processed Research)

**Table 18. Alternative Data 7**

| Yes | Criterion | Code | Information |
|---|---|---|---|
| **1** | **Road Condition Factors** | | |
| | Road Damage Handling | A | 4.50% |
| | Side Channel Conditions | B | 3.50% |
| | Accident Rate | C | 0.50% |
| | Quality of Material | D | 1.50% |
| | Passing Vehicles | E | 23443 |
| **2** | **Cost Factor** | | |
| | Maintenance Costs | F | IDR8,732,398 |

(Source: Processed Research)

**Table 19. Alternative Data 8**

| Yes | Criterion | Code | Information |
|---|---|---|---|
| **1** | **Road Condition Factors** | | |
| | Road Damage Handling | A | 4.50% |
| | Side Channel Conditions | B | 3.50% |
| | Accident Rate | C | 0.50% |
| | Quality of Material | D | 1.50% |
| | Passing Vehicles | E | 42872 |
| **2** | **Cost Factor** | | |
| | Maintenance Costs | F | IDR48,937,811 |

(Source: Processed Research)

**Table 20. Alternative Data 9**

| Yes | Criterion | Code | Information |
|---|---|---|---|
| **1** | **Road Condition Factors** | | |
| | Road Damage Handling | A | 6.06% |
| | Side Channel Conditions | B | 4.71% |
| | Accident Rate | C | 0.67% |
| | Quality of Material | D | 2.02% |
| | Passing Vehicles | E | 41857 |
| **2** | **Cost Factor** | | |
| | Maintenance Costs | F | IDR 2,004,593,870 |

(Source: Processed Research)

## Numerical Scale Determination

Numerical scales are used to compare each assessment parameter to determine which parameters are considered more important than others. In this thesis, a numerical scale from numbers 1-9 is used with an explanation as explained in subchapter 2.

## Evaluation of Criteria

Criterion assessment is carried out using a pairwise comparison matrix, which is by assessing the level of importance of a criterion compared to other criteria. The pairwise comparison matrix is shown in Table 21. below.

**Table 21. *Pairwise Comparison Matrix***

| Criterion | A | B | C | D | E | F |
|---|---|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| **A** | 1.00 | 3.00 | 3.00 | 3.00 | 5.00 | 0.50 |
| **B** | 0.33 | 1.00 | 0.20 | 0.20 | 0.33 | 0.33 |
| **C** | 0.33 | 5.00 | 1.00 | 1.00 | 7.00 | 3.00 |
| **D** | 0.33 | 5.00 | 1.00 | 1.00 | 5.00 | 3.00 |
| **E** | 0.20 | 3.00 | 0.14 | 0.20 | 1.00 | 0.33 |
| **F** | 2.00 | 3.00 | 0.33 | 0.33 | 3.00 | 1.00 |

(Source: Processed Research)

Information:
A = Road Damage Management
B = Side Canal Condition
C = Accident Rate
D = Material Quality
E = Passing Vehicles
F = Maintenance Costs

**Weighting Calculation**

Based on the pairwise comparison matrix in Table 4.70 above, the eigenvector value of each criterion in each row is then calculated using the equation that has been described and the results of the weighting and importance ranking of each criterion are obtained as shown in Table 22.

**Table 22. *Eigenvector* and Weighting Criteria**

| Criterion | *Self-vector* | Weight | Rank |
|---|---|---|---|
| **A** | 2.018 | 0.272 | 1 |
| **B** | 0.338 | 0.046 | 6 |
| **C** | 1.809 | 0.244 | 2 |
| **D** | 1.710 | 0.230 | 3 |
| **E** | 0.423 | 0.057 | 5 |
| **F** | 1.122 | 0.151 | 4 |
| ∑ | 7.419 | 1.000 | |

(Source: Processed Research)

The following is an example of the eigenvector and weight calculation for criterion A, namely Road Damage Handling.

$$\textit{Self-vector A} = \sqrt[n]{a_{AB} x\ a_{AC}\ x\ a_{AD}\ x\ a_{AE} x\ a_{AF}}$$
$$= \sqrt[6]{1\ x\ 3\ x\ 3\ x\ 3\ x\ 5\ x\ 0{,}5}$$
$$= 2{,}018$$

$$\text{Weighting Criterion A} = \frac{Eigenvector\ \text{A}}{\Sigma}$$
$$= \frac{2{,}018}{\mathbf{7{,}419}}$$
$$= 0.272 = 27.2\%$$

Based on the results in the following Table 22, it was obtained that the 1st rank is criterion A, namely Road Damage Management, which is a criterion that has a great influence in the selection of road handling priorities.

**Assessment of the Limitations of Each Criterion**

In determining the relative weight for each criterion, limits are used to obtain low, medium and high limit values adjusted to the conditions of each alternative. The limitations of such assessment are as described in Table 23.

**Table 23. Rating Limitations for Relative Weight**

| Yes | Criterion | Limitation | | |
|---|---|---|---|---|
| | | ***Low*** | ***Medium*** | ***High*** |
| **1** | **Road Condition Factors** | | | |
| | Road Damage Handling | < 4.75% | 4,75% - 6% | > 6% |
| | Side Channel Conditions | < 3.75% | 3,75% - 4,5% | > 4.5% |
| | Accident Rate | < 0.55% | 0,55% - 0,65% | > 0.65% |
| | Quality of Material | < 1.75% | 1,75% - 2,00% | > 2.00% |
| | Passing Vehicles | < 30000 | 30000 - 50000 | > 50000 |
| **2** | **Cost Factor** | | | |
| | Maintenance Costs | < Rp. 8,000,000 | IDR 8,000,000 - IDR 10,000,000 | > Rp. 10,000,000 |

(Source: Processed Research)

The following is a description of the assessment limits of each criterion for relative weights shown in Table 23.

**a) Road Damage Handling Criteria**

Low = If the Road Damage Handling is less than < 4.75%
Medium = If the Road Damage Handling is between 4.75% - 6%.
High = If the Handling of Road Damage is more than > 6%.

From the limitations of the assessment, it can be concluded that if the handling of road damage is included in the low assessment, it will be given the smallest value, which is 1, because the less road damage is handled, the less maintenance there will be and a small amount of budget spent on maintenance costs.

Meanwhile, if the handling of road damage is included in the high assessment, it will be given the highest score, which is 3 because the better the road condition, the less maintenance there will be and a small amount of budget spent on maintenance costs. For the medium limit, a value between the two will be taken, which is 2.

**b) Criteria for Side Canal Conditions**

Low = If the Condition of the Side Channel is less than < 3.75%.
Medium = If the Condition of the Side Canal is between 3.75% - 4.5%.
High = If the Condition of the Side Canal is more than > 4,5%.

From the limitations of the assessment, it can be concluded that if the condition of the side channel enters the low assessment, it will be given the smallest value, which is 1, because the fewer the condition of the side channel, the less maintenance there will be and a small amount of budget spent on maintenance costs.

Meanwhile, if the condition of the side channel is included in the high assessment, it will be given the highest score, which is 3 because the better the road condition, the less maintenance and less budget will be spent on maintenance costs. For the medium limit, a value between the two will be taken, which is 2.

**c) Accident Rate Criteria**

Low = If the Accident Rate is less than < 0.55%.
Medium = If the Accident Rate is between 0.55% - 0.65%.
High = If the Accident Rate is more than > 0,65%.

From the limitations of the assessment, it can be concluded that if the accident rate is included in the low assessment, it will be given the smallest score, which is 3, because the lower the accident rate, the fewer accident victims.

Meanwhile, if the accident rate is included in the high assessment, it will be given the lowest score, which is 1 because the greater the accident rate, the more victims. For the medium limit, a value between the two will be taken, which is 2.

**d) Material Quality Criteria**

Low = If the Material Quality is less than < 1.75%.
Medium = If the Quality of the Material is between 1.75% - 2.00%.
High = If the Quality of the Material is more than > 2,00%.

From the limitations of the assessment, it can be concluded that if the quality of the material is included in the low assessment, it will be given the smallest value, which is 1, because the lower the quality of the material, the more maintenance and the more budget is spent on maintenance costs.

Meanwhile, if the quality of the material is included in the high assessment, it will be given the highest score, which is 3 because the better the quality of the material, the less maintenance and the small amount of budget spent on maintenance costs. For the medium limit, a value between the two will be taken, which is 2.

**e) Criteria for Passing Vehicles**

Low = If the Vehicle Passing is less than < 30000.
Medium = If the vehicle passes between 30000 - 50000.
High = If the Vehicle Passing is more than > 50000.

From the limitations of the assessment, it can be concluded that if the passing vehicle is included in the low assessment, it will be given the smallest

score, which is 3, because the fewer vehicles that pass, the smaller the level of damage that will occur.

Meanwhile, if the passing vehicle enters the high assessment, it will be given the smallest score, which is 1 because the larger the passing vehicle, the faster the road condition will be damaged. For the medium limit, a value between the two will be taken, which is 2.

**g) Maintenance Cost Criteria**

Low = If the maintenance cost is less than < Rp. 8,000,000.
Medium = If the maintenance cost is between Rp. 8,000,000 to Rp. 10,000,000.
High = If the maintenance cost is more than > IDR 10,000,000.

From the limitations of the assessment, it can be concluded that the maintenance cost is included in the low assessment, which will be given the smallest value, which is 3, because the less maintenance costs the amount of budget spent is much smaller.

Meanwhile, if the maintenance cost is included in the high assessment, it will be given the smallest value, which is 1 because the higher the maintenance cost, the greater the amount of budget spent. For the medium limit, a value between the two will be taken, which is 2.

Based on the description of the assessment limitations above, it can be seen that the value for each criterion is as shown in Table 24.

**Table 24. Multi Criteria Analysis Value**

| Yes | Criterion | Limitation | | |
|---|---|---|---|---|
| | | ***Low*** | ***Medium*** | ***High*** |
| **1** | **Road Condition Factors** | | | |
| | Road Damage Handling | 1 | 2 | 3 |
| | Side Channel Conditions | 1 | 2 | 3 |
| | Accident Rate | 3 | 2 | 1 |
| | Quality of Material | 1 | 2 | 3 |
| | Passing Vehicles | 3 | 2 | 1 |
| **2** | **Cost Factor** | | | |
| | Maintenance Costs | 3 | 2 | 1 |

(Source: Processed Research)

**Assessment of the Limitations of Each Alternative**

After getting weights and assessments for each criterion, then the assessment for each alternative is analyzed according to what was previously

explained. The weights for each criterion are based on the results of the analysis shown in Table 22 and can be written as shown in Table 25 below.

**Table 25. Weighting of Criteria for Multi-Criteria Analysis Assessment**

| Criterion | | Weight |
|---|---|---|
| **A** | Road Damage Handling | 27,20% |
| **B** | Side Channel Conditions | 4,55% |
| **C** | Accident Rate | 24,38% |
| **D** | Quality of Material | 23,05% |
| **E** | Passing Vehicles | 5,70% |
| **G** | Maintenance Costs | 15,13% |
| | ∑ | **100,00%** |

(Source: Processed Research)

Then an assessment calculation is carried out for each alternative by multiplying the value of each criterion obtained by the above analysis and the weight for each criterion. The results of the assessment of each alternative are shown in Table 26 to Table 34.

**Table 26. Results of *Alternative Multi Criteria Analysis* 1**

| Criterion | Ket | Value | Weight | ∑ |
|---|---|---|---|---|
| Road Damage Handling | 5.58% | 2 | 201.78 | 403.57 |
| Side Channel Conditions | 4.34% | 2 | 33.76 | 67.53 |
| Accident Rate | 0.62% | 2 | 180.86 | 361.72 |
| Quality of Material | 1.86% | 2 | 171.00 | 342.00 |
| Passing Vehicles | 53169 | 1 | 42.28 | 42.28 |
| Maintenance Costs | IDR512,684,265 | 3 | 112.25 | 336.74 |
| | | **Total Value** | | **1553.83** |

(Source: Processed Research)

**Table 27. Results of *Alternative Multi Criteria Analysis* 2**

| Criterion | Ket | Value | Weight | ∑ |
|---|---|---|---|---|
| Road Damage Handling | 4.50% | 1 | 201.78 | 201.78 |
| Side Channel Conditions | 3.50% | 1 | 33.76 | 33.76 |
| Accident Rate | 0.50% | 3 | 180.86 | 542.58 |
| Quality of Material | 1.50% | 1 | 171.00 | 171.00 |
| Passing Vehicles | 49537 | 2 | 42.28 | 84.56 |
| Maintenance Costs | IDR10,144,729 | 1 | 112.25 | 112.25 |
| | | **Total Value** | | **1145.94** |

(Source: Processed Research)

**Table 28. Alternative *Multi Criteria Analysis* Results 3**

| Criterion | Ket | Value | Weight | ∑ |
|---|---|---|---|---|
| Road Damage Handling | 4.50% | 1 | 201.78 | 201.78 |
| Side Channel Conditions | 3.50% | 1 | 33.76 | 33.76 |
| Accident Rate | 0.50% | 3 | 180.86 | 542.58 |
| Quality of Material | 1.50% | 1 | 171.00 | 171.00 |
| Passing Vehicles | 37348 | 2 | 42.28 | 84.56 |
| Maintenance Costs | IDR 7,703,158 | 3 | 112.25 | 336.74 |
| | | **Total Value** | | **1370.43** |

(Source: Processed Research)

**Table 29. Alternative *Multi Criteria Analysis* Results 4**

| Criterion | Ket | Value | Weight | ∑ |
|---|---|---|---|---|
| Road Damage Handling | 4.50% | 1 | 201.78 | 201.78 |
| Side Channel Conditions | 3.50% | 1 | 33.76 | 33.76 |
| Accident Rate | 0.50% | 3 | 180.86 | 542.58 |
| Quality of Material | 1.50% | 1 | 171.00 | 171.00 |
| Passing Vehicles | 31952 | 2 | 42.28 | 84.56 |
| Maintenance Costs | IDR 5,570,827 | 3 | 112.25 | 336.74 |
| | | **Total Value** | | **1370.43** |

(Source: Processed Research)

**Table 30. Alternative *Multi Criteria Analysis* Results 5**

| Criterion | Ket | Value | Weight | ∑ |
|---|---|---|---|---|
| Road Damage Handling | 4.50% | 1 | 201.78 | 201.78 |
| Side Channel Conditions | 3.50% | 1 | 33.76 | 33.76 |
| Accident Rate | 0.50% | 3 | 180.86 | 542.58 |
| Quality of Material | 1.50% | 1 | 171.00 | 171.00 |
| Passing Vehicles | 40391 | 2 | 42.28 | 84.56 |
| Maintenance Costs | IDR 14,007,837 | 1 | 112.25 | 112.25 |
| | | **Total Value** | | **1145.94** |

(Source: Processed Research)

**Table 31. Alternative *Multi Criteria Analysis* Results 6**

| Criterion | Ket | Value | Weight | ∑ |
|---|---|---|---|---|
| Road Damage Handling | 4.50% | 1 | 201.78 | 201.78 |
| Side Channel Conditions | 3.50% | 1 | 33.76 | 33.76 |
| Accident Rate | 0.50% | 3 | 180.86 | 542.58 |
| Quality of Material | 1.50% | 1 | 171.00 | 171.00 |
| Passing Vehicles | 23895 | 1 | 42.28 | 42.28 |
| Maintenance Costs | IDR9,397,026 | 2 | 112.25 | 224.49 |
| | | **Total Value** | | **1215.90** |

(Source: Processed Research)

**Table 32. Alternative *Multi Criteria Analysis* Results 7**

| Criterion | Ket | Value | Weight | ∑ |
|---|---|---|---|---|
| Road Damage Handling | 4.50% | 1 | 201.78 | 201.78 |
| Side Channel Conditions | 3.50% | 1 | 33.76 | 33.76 |
| Accident Rate | 0.50% | 3 | 180.86 | 542.58 |
| Quality of Material | 1.50% | 1 | 171.00 | 171.00 |
| Passing Vehicles | 23443 | 1 | 42.28 | 42.28 |
| Maintenance Costs | IDR8,732,398 | 2 | 112.25 | 224.49 |
| | | **Total Value** | | **1215.90** |

(Source: Processed Research)

**Table 33. Alternative *Multi Criteria Analysis* Results 8**

| Criterion | Ket | Value | Weight | ∑ |
|---|---|---|---|---|
| Road Damage Handling | 4.50% | 1 | 201.78 | 201.78 |
| Side Channel Conditions | 3.50% | 1 | 33.76 | 33.76 |
| Accident Rate | 0.50% | 3 | 180.86 | 542.58 |
| Quality of Material | 1.50% | 1 | 171.00 | 171.00 |
| Passing Vehicles | 42872 | 2 | 42.28 | 84.56 |
| Maintenance Costs | IDR48,937,811 | 1 | 112.25 | 112.25 |

| Criterion | Ket | Value | Weight | ∑ |
|---|---|---|---|---|
| | | **Total Value** | | **1145.94** |

(Source: Processed Research)

**Table 34. Alternative *Multi Criteria Analysis* Results 9**

| Criterion | Ket | Value | Weight | ∑ |
|---|---|---|---|---|
| Road Damage Handling | 6.06% | 3 | 201.78 | 605.35 |
| Side Channel Conditions | 4.71% | 3 | 33.76 | 101.29 |
| Accident Rate | 0.67% | 1 | 180.86 | 180.86 |
| Quality of Material | 2.02% | 3 | 171.00 | 512.99 |
| Passing Vehicles | 41857 | 2 | 42.28 | 84.56 |
| Maintenance Costs | IDR 2,004,593,870 | 1 | 112.25 | 112.25 |
| | | **Total Value** | | **1597.30** |

(Source: Processed Research)

From the results of the analysis and calculation of the selection of road handling priorities with multi criteria analysis (MCA), it was found that the greatest value was in alternative 9 with a value of 1597.30, so that alternative 9 which will be used as a priority for handling road maintenance was selected in the next stage of analysis. And for a recapitulation of each alternative can be seen in Table 35.

Recapitulation of the results of multi criteria analysis (MCA) of each alternative for the selection of priority road handling. After seeing that the priority order of handling road maintenance is alternative 9, alternative 1, alternative 6, alternative 7, alternative 3, alternative 4, alternative 5, alternative 2, and alternative 8. In accordance with sub-chapter 4.4, the need for maintenance costs is more than the available budget, and the difference from the budget is Rp. 14,014,173. Of the nine priority alternatives for road handling to adjust the available budget, there will be a reduction in the volume of work. From the results of Table 4.84 it shows that alternative 8 is an alternative with a very low priority, so to adjust the available cost budget, a reduction in the volume of work will be carried out on alternative 8.

The results show a reduction in the cost budget of Rp. 14,014,173, where initially the budget for maintenance needs incurred of Rp. 62,951,983 became lower, which was Rp. 48,937,811. From these results, the order of handling road maintenance on the Maospati – Magetan – Cemorosewu section, Km 180 + 040 – Km 219 + 100 in the UPT PJJ Madiun Area.

## CONCLUSION

Based on the formulation of the problem and the results of the analysis that have been carried out, it can be concluded that the level of road damage on the Maospati - Magetan - Cemorosewu section, Km 180 + 040 to Km 219 + 100, is relatively low, with the road condition in general being good. The assessment of road damage using the *Bina Marga* and PKRMS methods shows that the recommended handling is routine maintenance, in accordance with the condition of the damage, which is not too severe. In addition, the cost required

for the implementation of road maintenance on this section is estimated at Rp. 2,635,786,094, which includes maintenance actions to maintain the quality of the road and improve the comfort of road users.

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