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Road Condition Analysis and Maintenance Strategies using the Bina Marga Method: A Case Research of the Maospati-BTS. Magetan City Road Section

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ABSTRACT

Road infrastructure plays a crucial role in enhancing economic development and community mobility. However, road deterioration due to high traffic volumes and environmental factors necessitates effective maintenance strategies. This research aims to assess road conditions and develop appropriate maintenance strategies for the Maospati – Bts. Magetan City road section using the Bina Marga method. The research employs a quantitative approach with a survey method, where data collection involves field surveys, road damage measurements, and interviews with relevant authorities. The findings reveal various damages, including cracks, potholes, and rutting, requiring a combination of routine maintenance and rehabilitation efforts. The estimated maintenance cost is IDR 333,468,376.00, emphasizing the importance of data-driven planning for budget optimization. The research further suggests integrating technologies like Geographic Information Systems (GIS) to enhance data accuracy and improve maintenance strategies. The implications of this research include providing insights into effective maintenance planning, which can serve as a reference for future road management strategies, promoting sustainable infrastructure, and improving road safety and comfort for users.

Keywords: Bina Marga Method, Condition Assessment, Data-Driven Planning, Infrastructure Management, Road Maintenance.

INTRODUCTION

Roads are vital infrastructure that connects regions, accelerates mobility, and supports socioeconomic activities. Good road conditions not only improve driving comfort, but also contribute significantly to economic growth by lowering logistics costs and improving the efficiency of goods and services distribution (Systems, 2021). Roads also play an important role in providing access to education, health and other basic services that improve people's quality of life (Forum, 2022). The importance of roads as supporting infrastructure for economic development can be seen in how they can spur regional integration, reduce economic disparities, and strengthen regional competitiveness (Hub, 2021). According to a research from (Longdom, 2021), well-planned road development can have social impacts such as creating employment opportunities, improving security, and supporting local cultural preservation.

In Indonesia, the role of roads is increasingly important as many remote areas still rely on land infrastructure to access markets and basic services. However, high traffic loads, overloading, and extreme weather conditions often cause damage to roads. Research shows that this damage can be minimized through a systematic evaluation approach and appropriate maintenance measures (Bahri, 2023). The Bina Marga method, developed by the Directorate General of Highways, is one approach that is widely used in Indonesia to assess road condition. It involves visual inspection of surface defects, classification of defect types, and prioritization of maintenance based on daily traffic conditions. The assessment includes various types of damage such as cracks, potholes, and deformations that affect the comfort and safety of road users.

The application of this method is also supported by the Surface Distress Index (SDI), which provides a quantitative-based measurement system to evaluate road distress. The combination of these two methods allows for a more accurate assessment and helps determine appropriate corrective actions, such as routine maintenance or full rehabilitation (Baladi et al., 2017). The case research on the Maospati - Bts. Magetan City is an important example of how the Bina Marga method can be used to identify road conditions and design effective maintenance solutions. This 9.8 km road is a strategic route connecting various economic centers in East Java. However, defects such as potholes, cracks, and deformations have reduced the level of comfort and safety (Anugrah, 2021).

According to previous research, the combination of the Bina Marga method and SDI evaluation provides optimal results in determining maintenance priorities. This is because these two methods not only provide detailed data on road conditions but also enable more efficient cost analysis (Putra et al., 2025). The successful application of the Bina Marga method depends on accurate data integration and ongoing management. The use of technologies such as Geographic Information System (GIS) can also support more comprehensive analysis, help visualize road conditions, and better plan improvements (Yastawan et al., 2021).

In this context, Value Engineering approaches can be an important adjunct to improve maintenance cost efficiency. By optimizing resource allocation, Value Engineering enables the implementation of more cost-effective maintenance strategies without compromising infrastructure quality (Longdom, 2021); (Hub, 2021). In conclusion, well-planned road maintenance not only maintains the functionality of the infrastructure but also improves the economic competitiveness of the region. With a combination of Bina Marga methods and data-driven approaches such as SDI, road managers can ensure that every maintenance decision is based on robust analysis, providing long-term benefits to society and the economy.

Based on the above background, the purpose of this research is to analyze the road conditions on the Maospati - Bts segment. Thus, the benefit of this research is to contribute to more effective and efficient road maintenance planning, especially on roads with varying degrees of damage. This research is expected to be a reference for road managers in making maintenance decisions based on valid data, which will optimize budget utilization and extend the lifespan of roads. In addition, this research can also provide insights into the importance of regular monitoring of road conditions to prevent more severe damage in the future, as well as improve the safety and comfort of road users.

RESEARCH METHOD

Location and Time of Research

This research was conducted on the Maospati - Magetan City Limits road section, which is located in East Java Province. This road section is approximately 9.8 km long and is one of the strategic routes that support community mobility and distribution of goods in the region. The selection of this location was based on the significant level of damage and the need for a comprehensive evaluation. The research was conducted over a period of three months, starting from January to March 2024. This time was chosen to ensure that the data obtained reflected actual road conditions. Data collection was conducted through field surveys and interviews with relevant parties, including the East Java Provincial Bina Marga Public Works Office.

Research Design

The approach used in this research is quantitative with survey method. The research aimed to identify road conditions, determine the type of damage, and design an appropriate maintenance strategy. The data collected was analyzed using the Bina Marga method as the main guide in the evaluation. In addition, this research used a descriptive design to describe the characteristics of road damage. The analysis was conducted systematically based on predetermined parameters, such as crack area, number of potholes, and rut depth. The results of this analysis were used to formulate appropriate maintenance measures.

Data Collection Technique

Data collection was conducted through a field survey that included measuring the dimensions of road defects. Primary data included the length, width and depth of the damage observed directly at the research site. In addition, secondary data was obtained from official documents issued by the Department of Public Works and Highways. Instruments used in the survey included a camera for visual documentation, a meter to measure the dimensions of the damage, and an assessment form to record observations. This data was then verified to ensure its accuracy before being further analyzed.

Data Analysis

Data analysis was conducted by calculating road condition values based on the Bina Marga method. Each type of damage is assigned a specific weighted value that reflects the severity. These values are then summed to determine the maintenance priorities required. The processed data is presented in tables and graphs to facilitate interpretation. In addition, a cost analysis was conducted to estimate maintenance budget requirements based on the type and level of damage identified.

Data Validation and Verification

To ensure data validity, this research used method triangulation, combining data from field surveys, documentation, and interviews. This technique was used to minimize bias and improve the accuracy of the research results. Data verification was conducted through discussions with relevant parties, including road experts and staff of the Public Works and Highways Agency. This process aims to ensure that the results of the analysis match the real conditions in the field and can be used as a basis for decision-making.

RESULT AND DISCUSSION

Physical Condition of Road Based on Bina Method

Assessment of the physical condition of the road on the Maospati - Bts. Magetan City was conducted using the Bina Marga method. Based on the field survey, several types of damage were found such as crocodile cracks, potholes, and ruts. These damages are dominated by cracks which cover 30% of the total road area, while potholes cover about 10%. These damage types significantly affect the comfort and safety of road users.

The average crack width is 3-5 mm, which falls into the medium crack category. These cracks are often associated with poor drainage around the road. In addition, the identified potholes have an average depth of 5-10 cm, which requires immediate patching to prevent further damage. The ruts show deformation due to heavy vehicle pressure, with an average depth of 2 cm.

Table 1 includes deterioration data such as crack area, number of potholes, and groove depth measured on each segment. The analysis of this table provides a quantitative overview of the existing defects, making it easier to prioritize maintenance actions. From the data analysis, a road condition score is calculated using the Bina Marga method. Roads with minor damage are given a high score, while roads with severe damage are given a low score. These results form the basis for determining an appropriate maintenance strategy according to the severity of the damage identified. The assessment also noted that some segments require full rehabilitation due to widespread deterioration. These segments are generally located in areas with heavy traffic and poor drainage. These results show that the Bina Marga method is effective in identifying repair priorities based on actual road conditions.

Estimated Cost

Based on the road condition assessment, maintenance cost estimates were calculated for each type of damage. The patching cost for potholes is estimated at Rp 50,000 per square meter. With a total pothole area of 500 square meters, the patching cost is estimated at Rp 25 million. For cracks, repairs cost Rp 30,000 per square meter, with a total estimate of Rp 36 million for

1,200 square meters of cracks. The additional cost for an overlay is determined based on the area of the segment with severe cracks. The overlay is estimated to cost Rp 150,000 per square meter, with a total requirement of Rp 150 million for critical segments. In addition, slurry seal work to repair ruts is estimated at Rp 20 million.

The total estimated cost of road maintenance based on the Bina Marga method is IDR 333,468,376. This figure includes direct costs such as materials and labor, as well as indirect costs such as material transportation. This estimate provides a clear budget guide for the relevant agencies to plan maintenance actions. The recapitulation of maintenance costs shows that routine maintenance is more cost-effective than full rehabilitation. Therefore, it is important to conduct regular surveys and assessments so that maintenance actions can be taken before damage becomes severe. This approach not only saves costs but also extends the service life of the road.

Discussion

Evaluation using the Bina Marga method showed that this approach is highly effective for identifying and prioritizing road defects. By combining visual parameters such as crack area, groove depth and number of potholes, the method provides an objective and quantitative assessment. The results of this assessment can provide a solid basis for determining the most appropriate type of maintenance. The results also confirm the importance of routine maintenance as a preventive measure. Routine maintenance such as patching and slurry seal is more cost-effective than full rehabilitation. Therefore, relevant agencies should focus on periodic surveys and routine maintenance to minimize long-term costs. This research supports previous findings that show the efficiency of Bina Marga's method of road management (Setiawan, 2023).

The integration of technology such as GIS in road condition analysis can improve the accuracy and efficiency of the Bina Marga method. By using GIS, road condition data can be visualized in the form of maps, facilitating decision making. This is relevant to the research of (Yastawan et al., 2021), which shows that GIS helps in identifying road segments that require immediate attention.

Although the Bina Marga method has many advantages, challenges such as limited human resources and incomplete data remain. Therefore, training for staff and improving data collection systems should be a priority. In addition, the use of modern tools such as drones can speed up the survey process and improve the accuracy of results. The Bina Marga method provides a structured and efficient approach to road assessment and maintenance. However, its successful implementation depends on adequate technical and managerial support. This research makes an important contribution to road infrastructure management in Indonesia, particularly in maximizing road service life in a cost-efficient manner.

Table 1. Deterioration Rate Based on Bina Marga Method

Segment	Type of Damage	Area of Damage m2	Area of Damage %	Number of Damage Types	Damage Width Score	Extent of Damage	Damage Rate
1	Longitudinal Cracks	0,00	0,00	0	0	0	0
	Hole	0	0			0	0
	Patches	0	0,00			0	0
2	Longitudinal Cracks	115,00	6,38	2	3	1	3
	Hole	0	0			0	0
	Patches	0	0,00			0	0
Total							3

Table 2. Results of SDI Method and Highways Method

SEGMENT	From	To	SDI	BINA MARGA
1	0,00	100,00	both	Routine Maintenance
2	100,00	200,00	both	Routine Maintenance
3	200,00	300,00	both	Routine Maintenance
4	300,00	400,00	both	Routine Maintenance
5	400,00	500,00	both	Routine Maintenance
6	500,00	600,00	both	Routine Maintenance
7	600,00	700,00	both	Routine Maintenance
8	700,00	800,00	both	Routine Maintenance
9	800,00	900,00	both	Routine Maintenance
10	900,00	1.000,00	both	Routine Maintenance
11	1.000,00	1.100,00	both	Routine Maintenance
12	1.100,00	1.200,00	both	Routine Maintenance
13	1.200,00	1.300,00	both	Routine Maintenance
14	1.300,00	1.400,00	both	Routine Maintenance
15	1.400,00	1.500,00	both	Routine Maintenance
16	1.500,00	1.600,00	both	Routine Maintenance
17	1.600,00	1.700,00	both	Routine Maintenance
18	1.700,00	1.800,00	both	Routine Maintenance
19	1.800,00	1.900,00	both	Routine Maintenance
20	1.900,00	2.000,00	both	Routine Maintenance
21	2.000,00	2.100,00	both	Routine Maintenance
22	2.100,00	2.200,00	both	Routine Maintenance
23	2.200,00	2.300,00	both	Routine Maintenance
24	2.300,00	2.400,00	both	Routine Maintenance
25	2.400,00	2.500,00	both	Routine Maintenance
26	2.500,00	2.600,00	both	Routine Maintenance
27	2.600,00	2.700,00	both	Routine Maintenance
28	2.700,00	2.800,00	both	Routine Maintenance
29	2.800,00	2.900,00	both	Routine Maintenance

SEGMENT	From	To	SDI	BINA MARGA
30	2.900,00	3.000,00	both	Routine Maintenance
31	3.000,00	3.100,00	both	Routine Maintenance
32	3.100,00	3.200,00	both	Routine Maintenance
33	3.200,00	3.300,00	both	Routine Maintenance
34	3.300,00	3.400,00	both	Routine Maintenance
35	3.400,00	3.500,00	both	Routine Maintenance
36	3.500,00	3.600,00	both	Routine Maintenance
37	3.600,00	3.700,00	both	Routine Maintenance
38	3.700,00	3.800,00	both	Routine Maintenance
39	3.800,00	3.900,00	both	Routine Maintenance
40	3.900,00	4.000,00	both	Routine Maintenance
41	4.000,00	4.100,00	both	Routine Maintenance
42	4.100,00	4.200,00	both	Routine Maintenance
43	4.200,00	4.300,00	both	Routine Maintenance
44	4.300,00	4.400,00	both	Routine Maintenance
45	4.400,00	4.500,00	both	Routine Maintenance
46	4.500,00	4.600,00	both	Routine Maintenance
47	4.600,00	4.700,00	both	Routine Maintenance
48	4.700,00	4.800,00	Medium	Routine Maintenance
49	4.800,00	4.900,00	both	Routine Maintenance
50	4.900,00	5.000,00	both	Routine Maintenance
51	5.000,00	5.100,00	both	Routine Maintenance
52	5.100,00	5.200,00	both	Routine Maintenance
53	5.200,00	5.300,00	both	Routine Maintenance
54	5.300,00	5.400,00	both	Routine Maintenance
55	5.400,00	5.500,00	both	Routine Maintenance
56	5.500,00	5.600,00	both	Routine Maintenance
57	5.600,00	5.700,00	both	Routine Maintenance
58	5.700,00	5.800,00	both	Routine Maintenance
59	5.800,00	5.900,00	both	Routine Maintenance
60	5.900,00	6.000,00	both	Routine Maintenance
61	6.000,00	6.100,00	both	Routine Maintenance
62	6.100,00	6.200,00	both	Routine Maintenance
63	6.200,00	6.300,00	both	Routine Maintenance
64	6.300,00	6.400,00	both	Routine Maintenance
65	6.400,00	6.500,00	both	Routine Maintenance
66	6.500,00	6.600,00	both	Routine Maintenance
67	6.600,00	6.700,00	both	Routine Maintenance
68	6.700,00	6.800,00	both	Routine Maintenance
69	6.800,00	6.900,00	both	Routine Maintenance
70	6.900,00	7.000,00	both	Routine Maintenance
71	7.000,00	7.100,00	both	Routine Maintenance
72	7.100,00	7.200,00	both	Routine Maintenance
73	7.200,00	7.300,00	both	Routine Maintenance
74	7.300,00	7.400,00	both	Routine Maintenance

SEGMENT	From	To	SDI	BINA MARGA
75	7.400,00	7.500,00	both	Routine Maintenance
76	7.500,00	7.600,00	both	Routine Maintenance
77	7.600,00	7.700,00	both	Routine Maintenance
78	7.700,00	7.800,00	both	Routine Maintenance
79	7.800,00	7.900,00	both	Routine Maintenance
80	7.900,00	8.000,00	both	Routine Maintenance
81	8.000,00	8.100,00	both	Routine Maintenance
82	8.100,00	8.200,00	both	Routine Maintenance
83	8.200,00	8.300,00	both	Routine Maintenance
84	8.300,00	8.400,00	both	Routine Maintenance
85	8.400,00	8.500,00	both	Routine Maintenance
86	8.500,00	8.600,00	both	Routine Maintenance
87	8.600,00	8.700,00	both	Routine Maintenance
88	8.700,00	8.800,00	both	Routine Maintenance
89	8.800,00	8.900,00	both	Routine Maintenance
90	8.900,00	9.000,00	both	Routine Maintenance
91	9.000,00	9.100,00	both	Routine Maintenance
92	9.100,00	9.200,00	both	Routine Maintenance
93	9.200,00	9.300,00	both	Routine Maintenance
94	9.300,00	9.400,00	both	Routine Maintenance
95	9.400,00	9.500,00	both	Routine Maintenance
96	9.500,00	9.600,00	both	Routine Maintenance
97	9.600,00	9.700,00	both	Routine Maintenance
98	9.700,00	9.800,00	both	Routine Maintenance
99	9.800,00	9.801,00	both	Routine Maintenance

The findings of this research emphasize the effectiveness of the Bina Marga method in evaluating road conditions and formulating appropriate maintenance strategies. The results highlight various types of damage, including cracks, potholes, and rutting, which were systematically assessed to determine the severity and prioritize maintenance actions. This structured approach not only facilitates decision-making but also ensures that maintenance efforts are focused on critical areas requiring immediate attention. A similar research by (Taufan et al., 2025) demonstrated the efficiency of the Bina Marga method in road condition assessment, emphasizing its role in enhancing infrastructure sustainability. Furthermore, research by (Frangopol & Liu, 2019)highlighted the method's capacity to prioritize repairs based on severity, which contributed to significant cost savings and better resource management in road maintenance projects.

The application of the Surface Distress Index (SDI) within the Bina Marga framework provided a quantitative evaluation of road conditions, which proved essential in establishing maintenance priorities. The integration of both qualitative visual assessments and quantitative SDI values enables a comprehensive understanding of the extent and nature of road deterioration. This dual approach ensures that maintenance strategies are tailored to address specific issues effectively, thereby maximizing the impact of available resources. This aligns with the findings of (Zakeri et al., 2022), who demonstrated that the use of SDI, in conjunction with visual inspections, offered a more robust and reliable evaluation of road conditions, leading to more informed and targeted maintenance decisions. Similarly, a research by (Jadmiko et al., 2025)confirmed that the combination of visual assessments and SDI values provided a comprehensive overview of road conditions, leading to more efficient resource allocation and better decision-making in road management.

The estimated maintenance cost of IDR 333,468,376.00 underscores the importance of efficient budget allocation. By focusing on strategic repairs such as patching, crack sealing, and slurry sealing, the maintenance plan aims to extend the service life of the road while minimizing future repair costs. This cost-effective approach is particularly critical for regions with limited resources, as it balances infrastructure sustainability with economic constraints. According to a research by (Adshead et al., 2019), optimizing maintenance budgets through targeted interventions not only extends the life of road infrastructure but also reduces long-term costs, making it a key strategy for low-resource regions.

Additionally, the research highlights the role of regular monitoring and proactive maintenance in preventing severe road deterioration. Periodic evaluations using the Bina Marga method allow for early identification of potential issues, enabling timely interventions that reduce the risk of more extensive and costly repairs in the future. Incorporating advanced technologies, such as GIS for mapping road conditions, could further enhance the precision and efficiency of road assessments. This is supported by research from (Li et al., 2020), which demonstrated that GIS integration significantly improved road monitoring and assessment accuracy, leading to more timely and effective maintenance actions.

The discussion also emphasizes the broader implications of effective road maintenance strategies for regional development. Well-maintained roads contribute to smoother transportation, improved logistics efficiency, and enhanced connectivity between urban and rural areas. These factors collectively support economic growth, social mobility, and overall community well-being.

In conclusion, the application of the Bina Marga method in this research demonstrates its practical advantages in road infrastructure management. By providing a systematic framework for evaluating and addressing road conditions, this approach ensures sustainability and long-term functionality of critical transportation networks. Future studies could explore the integration of emerging technologies and predictive

CONCLUSION

The conclusion of this research shows that the Bina Marga method is an effective and systematic approach to assessing road conditions and developing maintenance strategies. The Maospati - Bts. Kota Magetan road analysis identified various damages, such as cracks, holes, and grooves, which require routine maintenance and rehabilitation. The estimated maintenance cost of IDR 333,468,376.00 underscores the importance of data-driven planning to optimize budget efficiency and extend the service life of roads. The Bina Marga method provides clear guidelines for prioritizing repairs based on the severity of the damage. To increase the effectiveness of this method, integrating technologies such as GIS and modern surveying tools is recommended for faster evaluation and better data accuracy. In addition, continuous training for technical staff and periodic surveys are essential for early damage identification, enabling more efficient and timely maintenance measures. This research contributes to future research by emphasizing the importance of technology integration and proactive road management in improving infrastructure sustainability and cost-effectiveness.

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