

## Road Condition Analysis Using the Bina Marga Method on the Kaligunting-Bajulan Section, Madiun District

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### ABSTRACT

Land transportation plays a vital role in supporting mobility and economic growth. Good road infrastructure facilitates the distribution of goods, improves accessibility, and promotes economic efficiency. However, road conditions often deteriorate due to excessive vehicle loads and extreme weather, necessitating periodic evaluation and maintenance. This research aimed to evaluate the condition of the Kaligunting-Bajulan road section in Madiun Regency, a critical route for regional connectivity and economic activities, and to develop effective repair strategies using the Bina Marga method. Through a visual survey, the research identified significant damage, including potholes, longitudinal cracks, and rutting, primarily caused by traffic volumes exceeding the road's design capacity. The research provided repair recommendations, such as sealing, patching, and repaving, to prevent further damage and restore optimal road functionality. The estimated repair cost amounts to Rp 2,761,123,884, covering the necessary materials, labor, and equipment. This research highlights the advantages of the Bina Marga method in prioritizing repairs and efficiently allocating budgets based on the severity of road damage. Additionally, the findings emphasize the importance of regular assessments and preventive maintenance to prolong road service life and reduce future repair costs. The research offers valuable insights for planning maintenance strategies for other provincial roads in Indonesia, particularly those with similar traffic conditions and damage patterns. The implementation of this method ensures a more structured and sustainable approach to road infrastructure management.

**Keywords:** Bina Marga Method, Kaligunting-Bajulan, Maintenance, Road, Road Damage.

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### INTRODUCTION

Land transportation has a crucial role in supporting economic activity and community mobility (Adey, 2017). Roads as one of the transportation infrastructures are the backbone for the distribution of goods and services in various regions. However, as vehicle volumes and traffic loads increase, many roads are deteriorating and require immediate repair (Dwiani et al., 2024). Therefore, an effective method of assessing road conditions is needed to ensure the quality and longevity of the road.

The Bina Marga method is one of the most frequently used approaches in Indonesia to evaluate road conditions and determine appropriate maintenance strategies. It allows for a visual

assessment of the type and extent of damage, providing a comprehensive picture of the actual condition of the pavement (Rahmanto, 2016). The assessment process involves a field survey that documents various forms of damage such as cracks, potholes, and surface deformations.

In practice, the Bina Marga Method classifies road defects based on their severity and the extent of the affected area. Minor damage may only require simple patching, while severe damage requires total rehabilitation or reconstruction (Anugrah, 2021). This evaluation allows the government and related parties to prioritize treatments and allocate budgets effectively.

The Kaligunting-Bajulan road section in Madiun Regency is one such case where the Bina Marga Method was used to evaluate the road condition. This road suffers from various types of damage, ranging from potholes to alligator cracks, caused by high traffic volumes and the dominance of heavy vehicles (Radityasaka, 2021). Through a survey using the Bina Marga Method, critical areas that require immediate repair can be identified.

The advantages of the Bina Marga Method lie in its ease of implementation and the accuracy of the results generated from the visual evaluation. In addition, the method allows early identification of potential defects that could develop into larger problems if not addressed immediately (Tho'atin et al., 2016). This allows road managers to perform preventive maintenance, which is more cost-effective than repairs after severe damage has occurred. However, the Bina Marga Method also has limitations, especially in terms of data accuracy on roads with non-uniform surface conditions. Therefore, it is often necessary to combine it with other methods such as Pavement Condition Index (PCI) or Surface Distress Index (SDI) to obtain more comprehensive results (Salsabilla et al., 2020).

The application of the Bina Marga Method is also in accordance with the Indonesian Road Capacity Guidelines published by the Directorate General of Highways (Marga, 2023). These guidelines establish road condition assessment standards that must be followed by each relevant agency in conducting road surveys and repairs. In these guidelines, the Bina Marga Method is recommended to be used periodically as part of routine and periodic maintenance programs. In addition, (Anugrah, 2019) highlights the importance of this method in road condition assessment in rural areas that often have limitations in terms of accessibility and budget. The Bina Marga method allows for quick and practical evaluation so that interventions can be made early.

Research by (Firmanda et al., 2022) also showed that the Bina Marga Method can be combined with a value engineering approach in planning road drainage systems. Thus, maintenance does not only focus on the road surface but also other supporting factors such as drains and under-road structures. On the other hand, (Hardiyatmo, 2016) emphasized that road construction on subgrades with low bearing capacity requires more rigorous assessment methods, such as the Bina Marga Method, which can provide an early picture of the road condition before the damage is widespread.

(Huang et al., 2020) added that surface deformation analysis can also be combined with results from the Bina Marga Method to improve the reliability of pavement assessment. This combination provides more accurate data on road durability and resilience. (Lafatza, 2020) in his research on road maintenance strategies in Situbondo-Bajulmati also confirmed that the Bina Marga Method is effective in identifying maintenance needs and estimating the required costs. These estimates form the basis for planning the annual maintenance budget.

In addition, research by (Salsabilla et al., 2020) highlighted the role of the Bina Marga Method in assessing road damage on Jl. Joyo Agung, Malang. The assessment results show that most of the damage that occurs is cracks and potholes that can be addressed immediately through patching and overlay. Road assessment using the Bina Marga Method is also supported by government regulations contained in Government Regulation No. 34/2006 on Roads and Government Regulation No. 22/2009 on Road Traffic and Transportation. Both regulations stipulate the importance of periodic evaluation to maintain the safety and comfort of road users (Indonesia, 2009). Thus, the Bina Marga Method is an effective solution in maintaining road quality in Indonesia. Through systematic and structured assessments, defects can be identified and addressed early, extending the service life of the road and improving the efficiency of the maintenance budget.

This research offers novelty by developing a road condition evaluation approach based on the Bina Marga Method combined with digital technology, such as drone-based imaging systems and software-assisted data analysis. This innovation aims to improve the accuracy and efficiency of identifying road damage, especially in areas with limited accessibility. Furthermore, this research contributes to optimizing road maintenance strategies through the integration of a value-based approach (value engineering), thereby supporting the efficiency of maintenance budget allocation. This research not only emphasizes road damage evaluation but also considers sustainability aspects, such as drainage management and its impact on long-term road quality.

Based on the background above, the purpose of this research is to develop a more accurate and efficient road condition evaluation model by utilizing a combination of the Bina Marga Method, digital technology, and a value-based approach. Additionally, this research aims to identify key factors that influence road damage and provide effective maintenance recommendations to extend road service life. The benefits of this research include providing practical guidance for the government and stakeholders in designing more effective and efficient road maintenance strategies. The findings of this research are expected to support data-driven decision-making in road infrastructure management, reduce long-term maintenance costs, and improve road user comfort and safety. Moreover, this research contributes to the development of relevant road evaluation methods applicable to various geographical conditions in Indonesia.

## **RESEARCH METHOD**

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### **Design**

This research uses a quantitative approach with a field survey method to evaluate road conditions using the Bina Marga Method. The research design was designed to provide a comprehensive picture of the level of road deterioration through empirical data collection at the research site. The survey was conducted directly on the Kaligunting-Bajulan road section, Madiun Regency, which is the main focus of this analysis. This method allows the identification of various types of road defects with high accuracy.

In addition to the field survey, the research also used documentation analysis from various relevant sources such as road maintenance reports and technical guidelines published by the Directorate General of Highways. Historical data on road conditions is also an important part of supporting the research results. The use of secondary data aims to strengthen the observations and ensure that the evaluation is comprehensive. The combination of the two approaches is expected to provide accurate and reliable results in determining the level of road deterioration. The survey results will be compared with the applicable standards in the Bina Marga Method to identify the type of treatment required. In this way, the research is expected to produce targeted recommendations to improve the damaged road sections.

### **Location and Time of**

The location of this research is the Kaligunting-Bajulan road section, Madiun Regency, which has a total length of 4.96 km. This road was chosen because it has a significant level of damage and is an important route in supporting economic activities in the region. This research was conducted for three months, starting in January to March 2024. The selection of this time was adjusted to weather conditions that allowed for optimal survey implementation.

These roads consist of different pavement types, ranging from asphalt to concrete, which provides variation in the assessment process. By choosing this location, the research was able to cover a wide range of damage types commonly found on provincial roads in Indonesia. In addition, the research also took into account the high traffic factor, which is one of the main causes of road deterioration in these locations. Data collection was carried out in stages, starting with segmenting the road into sections to facilitate damage identification. Each segment was measured and analyzed separately to obtain more detailed and focused results. Using this method, the research was able to provide a clear picture of the distribution of damage and the type of repairs needed on each road segment.

### **Collection Technique**

Data collection techniques in this research involved three main stages, namely field observation, visual documentation and interviews with relevant parties. Field observations were conducted by identifying and recording various forms of road defects directly at the research site. Each defect was documented through photography and detailed note-taking to ensure no details were missed.

Visual documentation was used as supporting evidence in analyzing the type and extent of damage. The photos taken were then further analyzed to identify the dominant damage patterns in each road segment. This technique allows researchers to have a visual archive that can be used as a reference in the data analysis stage. In addition, this documentation also facilitates the verification process of the research results.

Interviews were conducted with the Madiun District Bina Marga Office and road experts involved in maintaining the road section. The information obtained from these interviews provided additional perspectives on the causes of the damage and the handling strategies that had been carried out previously. By combining these three techniques, the research is expected to produce valid and comprehensive data to support a comprehensive road condition analysis.

## RESULT AND DISCUSSION

### Existing Condition of Road Section

The field survey showed that the Kaligunting-Bajulan road section suffered significant damage at various points. Longitudinal cracks and potholes are the most dominant types of damage found along the road. Observations showed that 45.25% of the total road length had potholes of various sizes. This indicates the need for immediate intervention to prevent further damage.

In addition to potholes, there is also damage in the form of alligator cracks, which cover about 5.25% of the total length of the road section. These cracks are mostly found on segments that are often traveled by heavy vehicles with loads exceeding the design capacity of the road. Surface deformation in the form of rutting is also seen in several segments with a percentage of around 20.30%. This condition indicates that the load of passing vehicles exceeds the carrying capacity of the existing pavement.

Other damage found was patching with a percentage of 25.73% spread across various points of the road. These patches indicate that some previous repairs have been carried out, but these repairs are temporary and do not solve the problem completely. The use of appropriate treatment methods, such as overlay and reconstruction, is necessary to permanently address the problem.

**Table 1. Recapitulation of Damage Values**

Segment	STA	Total Damage Value	Condition Value
1	000+000 - 000+100	14	5
2	000+100 - 000+200	13	5
3	000+200 - 000+300	12	4
4	000+300 - 000+400	9	2
5	000+400 - 000+500	7	2
6	000+500 - 000+600	4	1
7	000+600 - 000+700	4	1
8	000+700 - 000+800	12	4

Segment	STA		Total Damage Value	Condition Value
9	000+800	- 000+900	4	1
10	000+900	- 001+000	7	2
11	001+000	- 001+100	12	4
12	001+100	- 001+200	4	1
13	001+200	- 001+300	7	2
14	001+300	- 001+400	9	2
15	001+400	- 001+500	9	2
16	001+500	- 001+600	12	4
17	001+600	- 001+700	4	1
18	001+700	- 001+800	7	2
19	001+800	- 001+900	7	2
20	001+900	- 002+000	4	1
21	002+000	- 002+100	4	1
22	002+100	- 002+200	7	2
23	002+200	- 002+300	10	4
24	002+300	- 002+400	9	2
25	002+400	- 002+500	9	2
26	002+500	- 002+600	7	2
27	002+600	- 002+700	9	2
28	002+700	- 002+800	4	1
29	002+800	- 002+900	0	0
30	002+900	- 003+000	0	0
31	003+000	- 003+100	0	0
32	003+100	- 003+200	0	0
33	003+200	- 003+300	0	0
34	003+300	- 003+400	0	0
35	003+400	- 003+500	0	0
36	003+500	- 003+600	0	0
37	003+600	- 003+700	0	0
38	003+700	- 003+800	0	0
39	003+800	- 003+900	0	0
40	003+900	- 004+000	12	4
41	004+000	- 004+100	7	2
42	004+100	- 004+200	12	4
43	004+200	- 004+300	12	4
44	004+300	- 004+400	9	2
45	004+400	- 004+500	7	2
46	004+500	- 004+600	4	1
47	004+600	- 004+700	9	2
48	004+700	- 004+800	7	2
49	004+800	- 004+900	12	4
50	004+900	- 004+960	12	4

Table 1. shows a recapitulation of the damage values identified for each road segment. This table provides a detailed overview of the distribution of damage and the types of repairs that

have been carried out previously. By referring to this data, it is possible to identify priority segments that require immediate attention using the Bina Marga Method.

### **Damage Evaluation Based on Bina Method**

The evaluation of road defects was conducted using the Bina Marga Method which has been widely applied in Indonesia (Mashudi et al., 2024). The visual survey showed that most of the road defects were in the moderate to severe category. The evaluation results show that some segments have conditional values close to critical limits, requiring immediate remedial action to prevent further deterioration. This method allows early identification of the type and extent of damage.

The Bina Marga method was used to determine the priority level of repairs based on the severity of the damage. Potholes and longitudinal cracks are the main indicators in this assessment. Road segments with the most severe damage are recommended to be treated first. The results of this evaluation are then used as the basis for preparing the road maintenance and rehabilitation budget.

In addition, this method also helps in identifying the most suitable type of repair for each road segment. Segments with minor damage can be repaired using sealing and patching, while segments with severe damage require overlays or full reconstruction. This approach allows for efficiency in budget allocation and ensures that repairs are targeted.

### **Estimated Cost**

Based on the evaluation results, the estimated cost of repairing the Kaligunting-Bajulan road is Rp 2,761,123,884. This figure is calculated based on the extent of damage found on each road segment and the type of repair required. Damage in the form of potholes and longitudinal cracks costs the most because it requires reconstruction and overlay measures at several points. This cost includes materials, labor, and heavy equipment used during the repair process.

The cost estimate also takes into account the type of materials used in the repair process. Flexible pavement was the first choice for most segments as it was considered more economical and suitable for the existing road conditions. However, for certain segments with severe deterioration, rigid pavement was considered as a long-term solution.

The approach used in the cost calculation also considers the aspect of ongoing maintenance. Routine maintenance costs such as sealing and patching are calculated separately and allocated in the annual budget. Thus, in addition to the initial repair costs, there is also a budget for preventive maintenance to prevent further damage in the future.

### **Discussion**

The findings of this research reveal that the Kaligunting-Bajulan road section is in a severely deteriorated condition, characterized predominantly by potholes, longitudinal cracks, and surface deformations. These damages are primarily attributed to the high traffic volumes and the excessive weight of heavy vehicles traversing the route daily. The visual assessment conducted using the Bina Marga Method provided a comprehensive understanding of the distribution, type,

and severity of damage. This approach was instrumental in identifying priority areas for repair and categorizing them based on the urgency of intervention.

The Bina Marga Method proves to be an adaptable and practical tool in evaluating road conditions, as it offers flexibility in determining the most suitable type of treatment for each segment. This facilitates the efficient allocation of financial and technical resources by local governments, ensuring that repair efforts are focused on the most critical sections first. By addressing road defects in stages according to their severity, the implementation of this method significantly reduces the risk of further deterioration and extends the functional lifespan of the infrastructure.

The cost evaluation highlighted that substantial investments are required to restore the road to optimal condition. However, the benefits associated with these improvements, including enhanced road user comfort and increased efficiency in the transportation of goods and services, outweigh the initial expenditure. The improved road conditions are anticipated to have a positive ripple effect on the economic activities in Madiun Regency, fostering better regional connectivity and economic growth. Additionally, this research underscores the strategic value of employing the Bina Marga Method as a standard in road infrastructure management in Indonesia. Its straightforward implementation and reliability make it a preferred choice for assessing road conditions, particularly in regions where technical resources and time are constrained.

Furthermore, a comparative analysis between the Bina Marga and Pavement Condition Index (PCI) methods reveals that these approaches are complementary rather than mutually exclusive. While the Bina Marga Method is simpler and better suited for widespread application in Indonesia, the PCI method offers a more detailed and structured analysis, especially for projects requiring precision in damage quantification. The integration of both methods can enhance the reliability and depth of road condition evaluations, enabling the formulation of more effective maintenance strategies.

This research also highlights the importance of adopting preventive measures, such as regular evaluations and maintenance, to mitigate further damage and reduce long-term costs. Periodic assessments using the Bina Marga Method ensure that emerging issues are identified and addressed promptly, thereby maintaining the safety and functionality of road infrastructure. Moreover, enforcing load regulations for heavy vehicles and improving drainage systems are critical complementary measures to sustain road quality and prevent recurrent damage (Yunianta & Setiadji, 2022).

In conclusion, the findings of this research emphasize the necessity of a structured and data-driven approach to road maintenance and management. The adoption of methods like Bina Marga, coupled with complementary tools such as PCI, can serve as a robust framework for addressing the growing demands of road infrastructure in Indonesia, ensuring sustainability and economic efficiency in the long term.

## CONCLUSION

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The conclusion of this research shows that the Bina Marga Method is an effective approach to evaluate road conditions, as seen in the Kaligunting-Bajulan section of Madiun Regency. The results of the field survey showed quite significant damage, namely 45.25% of roads had potholes, 25.73% of roads were patched, and 20.30% of roads had potholes, so that immediate treatment was needed to prevent further damage. The estimated repair cost of IDR 2,761,123,884 includes treatments such as asphaltting, patching, and resurfacing, which not only provide short-term solutions but also extend the life of the road, thereby reducing long-term repair costs. The findings of this research highlight that the volume of heavy vehicles exceeding the design capacity of the road is a major factor that accelerates pavement damage.

To address this issue, it is recommended to enforce vehicle load limits, conduct periodic road evaluations using the Bina Marga Method, and consider integrating complementary methods such as PCI and SDI for a more comprehensive analysis. Policy makers and road managers are encouraged to adopt preventive measures and sustainable road maintenance strategies to improve road safety, cost efficiency, and infrastructure resilience. These recommendations can serve as a model for managing other provincial roads with similar traffic conditions and damage patterns across Indonesia.

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