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Analysis of Rigid Pavement Using the Bina Marga and PCI Methods (Case Study: Jalan Lanud Sukani STA 1+500 – STA 4+500)

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ABSTRACT

As a developing country, Indonesia requires quality roads and adequate quantities to meet the needs of the community in carrying out various economic activities, both in terms of accessibility and the movement of goods and services. Accurate evaluation can identify types of damage such as cracks, potholes, or other deformations that can affect road performance. Routine maintenance may include filling cracks and repairing potholes, while periodic maintenance can involve resurfacing or partial reconstruction. The aim of this study is to determine the types of surface damage on Jalan Lanud Sukani STA 1+500 – STA 4+500. Data sources were obtained from primary data through surveys and secondary data. Data collection was conducted in November-December 2024. The research analysis used the Bina Marga (BM) method and the Pavement Condition Index (PCI) method.The results of the study using the Bina Marga method showed a priority value of 3. Meanwhile, the PCI method yielded a result of 16, which is classified as very poor. Therefore, the road condition value based on the PCI method is 8.

1. Introduction

Roads are essential infrastructure that supports economic growth and plays a vital role in the progress and development of a region (Purnama, Rifai, & Nasrun, 2022). Indonesia, as a developing country, requires roads of high quality and adequate quantity to meet the transportation needs of its people, both in terms of accessibility and the movement of goods and services for economic activities. Road damage can cause many direct losses for users, as it will hinder the smoothness and comfort of their journey and may lead to accidents if not promptly repaired by the authorities (Adiputra, Rifai, & Bhakti, 2022). Therefore, it is essential to carry out regular and effective maintenance to ensure that road infrastructure continues to function properly and can optimally support economic activities and road user safety, thereby maintaining the sustainability and efficiency of transportation in Indonesia.

Jalan Lanud Sukani is a strategic route that connects several important regions, making it crucial to maintain its quality. Spanning the segment from STA 1+500 to STA 4+500, this road is frequently traversed by heavy and dense traffic, making its pavement susceptible to damage. Road damage can lead to significant direct losses for users, as it disrupts smooth and comfortable travel and may result in accidents if not promptly repaired by the authorities (Adiputra, Rifai, & Bhakti, 2022). Therefore, this evaluation study is essential to understand the current pavement conditions along this route. With such evaluations, relevant stakeholders can more effectively plan and implement appropriate and efficient repair measures. Timely and effective maintenance ensures the road continues to meet transportation needs while reducing the risks of accidents and traffic congestion (Sony, Rifai, & Handayani, 2022).

The Bina Marga and PCI methods each have their advantages in analyzing road pavement damage. The Bina Marga method emphasizes visual assessment of surface damage, making it straightforward to apply in the field. Meanwhile, the PCI method provides a numerical score or index that represents the overall condition of the road, ranging from excellent to very poor. By using both methods, the evaluation results are expected to offer a comprehensive overview of the extent of road damage. This understanding is crucial for more accurate and effective maintenance budget planning. Toll roads are public roads managed by the government, categorized into major highways, primary roads, toll roads, and national strategic roads (Nurjannah, Rifai, & Akhir, 2022). Essentially, on-road surface lifespan planning is adjusted to traffic conditions and capacity, typically designed for a period of 10–20 years (Hermawan, Rifai, & Handayani, 2022)

Damaged road conditions not only affect the comfort of road users but also have significant economic impacts. Severely damaged roads can hinder transportation activities and increase vehicle maintenance costs for users. Moreover, if a road experiences damage within the first five years, it can be assumed that the road will face serious problems in the future (Dewantoro, Rifai, & Akhir, 2022). In the long term, poor road conditions can tarnish the image of the area and reduce its attractiveness for investment. Evaluating road conditions using appropriate methods will help ensure that road maintenance is carried out according to urgent priorities. Thus, the quality of transportation infrastructure can be maintained, providing positive impacts for the surrounding community.

This study aims to analyze the level of pavement damage on Jalan Lanud Sukani STA 1+500–STA 4+500 using the Bina Marga and PCI methods. The results of this study are expected to provide accurate information about the road pavement condition, serving as a basis for decision-making by relevant stakeholders in addressing road damage. The methods employed include field surveys to identify the types of damage and data analysis to determine the PCI score for the road. Additionally, this study will compare the results of both methods to identify the strengths and weaknesses of each in evaluating road damage. Good road conditions also enhance the safety and comfort of road users while reducing vehicle operational costs. Road maintenance is an effort to restore the functional and structural condition of the road (Isradi, Nareswari, Rifai, & Prasetijo, 2021).

2. Literature Review

2.1 Road Pavement

Road pavement is a structure positioned between the subgrade and vehicle wheels, functioning to provide a transportation path capable of withstanding traffic loads without significant damage during its service period (Salum, Kitali, Bwire, Sando, & Alluri, 2019). Pavement serves to evenly distribute vehicle loads to the subgrade. In addition to being strong enough to support increasing traffic loads, pavement must also withstand weather changes such as high temperatures and heavy rainfall. It is a vital structure that not only distributes vehicle loads uniformly to the subgrade but also endures the challenges of fluctuating weather conditions like heat and rain. Success in designing and maintaining road pavement is crucial to ensuring the safety and reliability of an efficient and effective transportation network for the community.

The main components of pavement include the surface layer, base layer, and subbase layer. Materials used for pavement can include asphalt, concrete, or other aggregate mixtures (Sumantri, Rifai, & Ferial, 2022). The pavement construction process requires careful planning and rigorous material testing. Pavement quality greatly affects the comfort and safety of road users. High-quality pavement reduces maintenance costs and extends the lifespan of the road. Good drainage in pavement is crucial to prevent damage caused by water pooling. Routine maintenance is necessary to ensure that pavement conditions remain optimal (Zhang, et al., 2022). The durability of pavement is also influenced by the quality of

materials and the precision of construction techniques. Proper compaction and adherence to design standards during construction are essential to achieving a strong and long-lasting pavement structure.

Roads are an essential part of transportation, enabling drivers to reach their destinations more quickly (Immanuel, Rifai, & Prasetijo, 2022). Damage to pavement, such as cracks or potholes, must be addressed promptly to prevent further deterioration. New technologies in pavement, such as the use of eco-friendly materials, are increasingly being implemented. Studies on traffic loads and subgrade conditions are the initial steps in pavement design. The use of heavy equipment such as compactors and asphalt pavers is crucial in the pavement construction process (Miladiyah & Mawardi, 2022). Improving pavement quality also enhances logistics and transportation efficiency. Good pavement supports economic growth by facilitating the smooth flow of goods and services.

In recent years, the integration of smart technology into pavement construction and maintenance has gained significant attention (Syarif, Rifai, & Handayani, 2022). Innovations such as smart sensors embedded in pavement can monitor traffic loads in real-time, temperature fluctuations, and material conditions, providing valuable data for proactive maintenance strategies. Additionally, the development of self-healing materials, which can automatically repair cracks and minor damages, is expected to revolutionize the longevity and durability of road surfaces. These advancements not only improve the efficiency of maintenance operations but also contribute to sustainable infrastructure development by reducing the frequency and cost of repairs (Milad, Taib, Ahmeda, Solla, & Yusoff, 2020).

2.2 Bina Marga Methods

The Bina Marga method is an approach applied in Indonesia to establish the priority levels and road maintenance programs based on the results of visual surveys of damage types and the Average Daily Traffic (ADT) survey. This approach integrates the values from both surveys to assess the condition of a road with an ADT classification. The priority level is determined using the formula: Priority Order (PO) = 17 - (ADT Class + Road Condition Value). This method helps in determining the priority for road repairs based on the severity of the damage (Muho & Beskou, 2024). The visual survey is conducted by trained experts who can analyze and classify the types and levels of damage on the road surface.

The ADT survey measures the volume of vehicles passing through the road each day, providing an overview of traffic load. The combination of data from the visual survey and the ADT survey results in a more accurate assessment of road maintenance needs. The road condition value reflects the severity of damage identified during the visual survey. The ADT class is divided into several categories based on the number of vehicles passing, ranging from very low to very high. The priority order calculation helps allocate resources effectively and efficiently (Christine, Rifai, & Handayani, 2022). This integrated approach allows for a more targeted allocation of maintenance efforts, focusing on the roads that require immediate attention based on both traffic volume and the extent of damage. Additionally, it helps in optimizing the use of funds by prioritizing repairs that will have the greatest impact on road safety and traffic efficiency.

Roads with high priority order values will receive earlier attention in the maintenance program. The Bina Marga method is used by both local and central governments to plan road maintenance budgets (Choiri, Yusuf, Sari, Artanti, & Hapsari, 2024). The maintenance program includes repair actions such as filling potholes, replacing asphalt layers, and repairing drainage systems. This method also considers the road's age and the frequency of previous maintenance in its assessment. This approach aims to reduce extended road damage and enhance the safety of road users (Germaldus, Hasa, & Langga, 2022). Furthermore, this method supports the sustainable management of road infrastructure by ensuring that limited resources are directed toward the most critical maintenance needs.

2.3 PCI Methods

The Pavement Condition Index (PCI) is an evaluation system used to classify the condition of roads based on the types and severity of damage experienced, and it serves as a reference for maintenance efforts (Davidović, Bogdanović, Garunović, Papić, & Pamučar, 2021). Generally, the PCI method uses a scale ranging from 0 to 100, where a score of 0 indicates a very poor road condition, and a score of 100 signifies an excellent road condition. PCI is a crucial instrument for road infrastructure managers to make more informed decisions when allocating road maintenance budgets (Maria, Amelia, & Vembrie, 2020). By providing a clear and standardized assessment of road conditions, PCI helps prioritize maintenance tasks, ensuring that resources are focused on the most critical areas in need of repair.

Through routine evaluations using PCI, authorities can identify many roads in need of repair and prioritize repairs based on the severity of damage (Nurhijriyah, Putra, & Agusdini, 2024). PCI not only helps in road maintenance planning but also in monitoring the performance of roads over time, allowing for corrective actions before road conditions worsen. By using PCI, authorities can optimize resource allocation, ensuring that available funds are used efficiently and effectively to extend the lifespan of the pavement (Reta, Rifai, Taufik, & Prasetijo, 2024). This proactive approach helps in minimizing the overall maintenance costs by addressing issues early, preventing more expensive repairs in the future.

In addition, PCI provides a solid foundation for conducting cost-benefit analysis of various road maintenance options available. PCI is often used in the procurement of new road projects or in the planning process for road rehabilitation, involving the selection of appropriate maintenance strategies (Isradi, Subhan, & Prasetijo, 2020). In some cases, PCI is also used as a performance indicator in road maintenance contracts between the government and contractors. Timely and targeted maintenance based on PCI evaluation results can reduce long-term road repair costs. PCI is also used as a tool for routine road condition monitoring, enabling authorities to identify potential issues early and take action to prevent them accordingly. This proactive approach not only enhances road durability but also improves the overall safety and efficiency of the transportation network (Kharisma, Rifai, Taufik, & Prasetijo, 2024).

With the increasing complexity and volume of traffic, it is crucial to use evaluation methods like PCI to ensure the sustainability of existing road infrastructure. PCI plays an important role in ensuring the safety of road users by ensuring that roads are safe to use (Aryan, Dikshit, & Shinde, 2023)Additionally, routine maintenance based on PCI evaluations can help reduce traffic congestion caused by road damage. PCI can be integrated with Geographic Information Systems (GIS) to facilitate the monitoring and spatial analysis of road conditions. The use of digital and mobile technology in PCI surveys has accelerated and simplified the data collection process in the field. By using the PCI method, authorities can optimize road maintenance strategies by considering factors such as traffic volume, climate, and road user needs.

3. Method

Jalan Lanud Sukani is a flexible pavement road with a 2/2 UD type, measuring a total length of 3 km and a width of 7.5 meters. This road serves as a heavily trafficked route, used by various types of vehicles, from small to large-scale ones. It connects Kecamatan Jatiwangi, Ligung, and the surrounding areas. Additionally, it is one of the main access routes for the people of Majalengka traveling to Indramayu Regency.

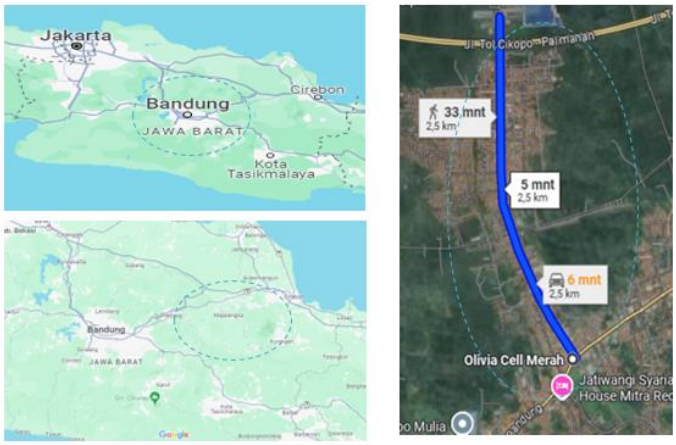

Figure 1. Research Location

The primary data for this study were collected directly from the research site on Jalan Lanud Sukani, Majalengka Regency, through surveys and field observations. This data remained unchanged throughout the study and includes the recording of types of damage in several road segments, with a road width of 7.5 meters and a total length of 3 kilometers. The survey was conducted by directly observing the damage on Jalan Lanud Sukani. It was carried out in a single day during daytime on a weekday, with the expectation that traffic would be relatively light. Each type of damage was then categorized based on its characteristics. Subsequently, the dimensions of each type of damage were recorded, including length, width, and area. Data for this study was collected by obtaining both primary and secondary information as research sources. Data analysis was conducted using BM Number 03/M/BM/2024 and Government Regulation Number 79 of 2013 on Pavement Condition Survey (Pavement Condition Index or PCI).

4. Result and Discussion

This survey involves visual inspections to identify the types and severity of damages, such as cracks, potholes, or deformations, as well as technical measurements like the thickness of the layers and the strength of the pavement. Field conditions, such as heavy traffic, the presence of obstacles like parked vehicles or activities around the road, can affect the smoothness of the survey process. Weather conditions at the time of the survey are also highly influential; clear weather facilitates visual inspection and the use of measuring tools, while rain or wet conditions can obscure damages and complicate data collection. Therefore, survey planning typically considers the season and weather forecasts to ensure accurate results.

4.1 Analisis Data Metode Bina Marga

Silakan unggah atau tuliskan data yang dimaksud, sehingga saya dapat membantu menganalisisnya lebih lanjut.

Table 1. Bina Marga Analysis Methods

Analisis	Keterangan
Sapmple Unit	Dividing the Samper Unit using 10 segments, each with a width of 7.5 meters, a length of 0.3 meters, and an area of 2.25 m^2 per segment.
Nilai Kelas Lalu Lintas	The traffic class is determined based on the information obtained from the LHR survey, which is 7,850 smp/day, meaning the traffic class value is 6.

Analisis	Keterangan
Penilaian Tingkat Kerusakan	The flow class is used to assess damage from plastic deformation such as waves and bumps, while drying damage is assessed based on the grain separation class. The level of damage for crack types is calculated based on the type, width, and severity of the damage.
Nilai Keadaan Jalan	The damage level in both directions is 22.00, so the road condition value is set at 8.
Urutan Prioritas	The priority order (UP) is calculated using the formula: UP = 17 - (Traffic Flow + Road Condition) = 17 - (6+8) = 3. The priority level for the Majalengka-Rajagaluh Road in Majalengka Regency is 3, meaning the Majalengka-Rajagaluh Road is included in the road repair program.
Penentuan Program Pemeliharaan Jalan	Maintenance is part of the program conducted periodically.

This is based on the National and Rural Road Maintenance Guidelines No. 002/T/BT/1995, which states that road rehabilitation and maintenance include sandblasting (P1), asphalting (P2), crack sealing (P3), pothole patching (P5), and leveling (P6).

4.2 Analisis Data Metode Pavement Condition Index (PCI)

The Pavement Condition Index (PCI) method is a technique used to evaluate the physical condition of road pavement. This method is very useful in road maintenance because it provides objective information regarding the level of road damage, which can be used to plan timely repairs and maintenance. A summary analysis of the channel determination results is presented in the table below, and an explanation of the types of crocodile cracking damage is provided in the table below.

Table 2. Recapitulation of Reduction Value Determination

No.	Damage Type	Severity	Total Damage (m2)	Density (%)	Reduction Value
1	Alligator Cracking	Low	192,5	0,26	10
		Medium	141	0,19	15
		High	807,5	1,08	38
2	Transverse Cracking	Low	3	0,40	0
		Medium	15,8	2,11	0
		High	42,5	5,67	4
3	Longitudinal Cracking	Low	50	0,07	0
		Medium	20	0,03	0
		High	140	0,19	9
4	Patching	Low	108,1	0,14	0
		Medium	142,5	0,19	2
		High	278	0,37	12
5	Aggregate Loss	Low	27,5	0,04	0
		Medium	22,5	0,03	0
		High	75	0,10	8
6	Potholes	Low	1,519	0,01	2

		Medium	7,39	0,01	8
		High	17,71	0,02	28
		Low	0	0,00	0
	Ruts or	Medium	0	0,00	0
7	Grooves	High	110	0,15	10
		Low	0	0,00	0
		Medium	87,5	0,12	9
8	Subsidences	High	0	0,00	0

To calculate the Approval of the Reduction Value (m), the value of m is obtained using the equation. The calculation of the reduction state value, along with the sequential order starting from the highest, is presented as shown in the table below.

Table 3. Comparison (DV - m)

No.	Reduction Value	Reduction Value-m	(DV - m)<m
1	38	31,31	No
2	28	20,39	No
3	15	7,19	No
4	11	2,92	No
5	10	1,73	No
6	9	-0,36	No

On table above, the reduction value of the Lanud Sukani road segment in Majalengka Regency shows a fairly good result. Since the difference in the reduction value is less than m, the information about the reduction value of the Lanud Sukani road segment is accessible to everyone.

4.3 Menentukan CDV (Corrected Nilai Reduksi)

The determination of the CDV itself involves several steps, including the first one. The number of reduction values greater than 2 or q for this segment has 6 reduction values greater than 2, which means the value obtained from q is 6. The next step is the sum of the Deductible Value (TDV) for the road segment, by adding all the deductible values. Therefore, TDV = 112. The CDV value itself can be seen in the table below.

Table 4. Calculating Values

Iterasi	q					
	5	**4**	**3**	**2**	**1**	**0**
1	38	38	38	38	38	38
2	28	28	28	28	28	9
3	15	15	15	15	9	9
4	12	12	12	9	9	9
5	10	10	9	9	9	9
6	9	9	9	9	9	9
TDV	112	112	111	108	102	83

The table shows that the TDV values for q5 and q4 are the same, each at 112, q3 at 111, q2 at 108. The TDV values for q1 and q0 are 102 and 83, respectively. The determinate on the CDV value is based on the values of q and TDV, using the CDV diagram. Meanwhile, the results on the CDV iteration can be seen in the table below.

Table 5. Iteration Results CDV

Iterasi	Q	TDV	CDV
1	6	112	52
2	5	112	60
3	4	111	64
4	3	108	76
5	2	102	72
6	1	83	84

Based on the table above, the CDV value obtained in iteration 1 is 52, while in iteration 2 the value is 60. In iteration 3, the value obtained is 64. In iteration 4, the value is 76, in iteration 5 it is 72, and in iteration 6 the value is 8.

5. Conclusion

The calculation of the pavement condition value is based on a pavement test conducted in Majalengka from the damage survey results. The Lanud Sukani road segment from STA 1+500 to STA 4+500, using both the Bina Marga and PCI methods, has been assigned a priority value of 3, which places it within the road repair program. The pavement condition calculation source on the PCI (Pavement Condition Index) results in a value of 16, indicating a very poor condition. Therefore, the road condition score according to the PCI method is 8. The goal of periodic repair or maintenance work is to prevent further deterioration of the pavement. Thus, based on the compare between the Bina Marga and PCI methods, it can be concluded that the maintenance approach is the same, which is road repair.

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