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Analysis of Types of Flexible Pavement Damage Using the Pavement Condition Index Method

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Abstract

Roads are land transportation infrastructure that is very important in facilitating economic relations and other social activities. If road damage occurs, it will not only result in the obstruction of other economic and social activities but can also cause accidents for road users. The aim of this research is to explain the types of damage to the surface layer of flexible pavement and to find out the index value of the pavement condition index for Jalan Kreteg-Lebak Jaya based on the PCI (Pavement Condition Index) method so that the results can be used in preparing road maintenance programs. The results of this research in segment 1 showed 4 types of damage, namely edge cracks, patches, holes, weathering, and loose granules, with a PCI value of 22, very poor pavement conditions using this type of treatment. reconstruction/recycling. In segment 2, there were 4 types of damage, namely edge cracks, patches, holes, weathering, and loose granules with a PCI value of 26 in poor pavement conditions using the type of reconstruction or recycling treatment. In segment 3, there were 3 types of damage: holes, slip cracks, weathering, and loose granules with a PCI value of 46. Fair pavement conditions using reconstruction or recycling treatment in segment 4, there were 4 types of damage, namely crocodile skin cracks, edge cracks, holes, weathering, and loose granules, with a PCI value of 29 for poor pavement conditions using the type of reconstruction or recycling treatment.

Keywords: road, flexible pavement, damage, value, index

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1 Introduction

The road is a land transportation infrastructure that is very important in facilitating the activities of economic relations and other social activities. However, if there is damage to the road, it will not only in hinder other economic and social activities but can cause accidents for road users. For comfort and safety for the driver, the road must be supported by good pavement [1].

Based on Law of the Republic of Indonesia Number 2 of 2022, Article 1 Paragraph (1) explains that roads are land transportation infrastructure that includes all parts of the road, including connecting buildings, complementary buildings, and equipment intended for traffic, which are at ground level, above the ground surface below the ground surface, and/or above the water surface, except for railways, truck roads, and cable roads [2].

Flexible pavement is an element in transportation that is used as a place to facilitate economic activities in moving passengers and goods from one area to another [3]

Pavement characteristics are special properties of pavement that can determine whether the quality of the pavement is good or bad. The characteristics of good pavement are that it can provide services to the planned traffic, both in terms of strength, durability, and comfort. Characteristics cannot be separated from the quality of the constituent materials, especially during the manufacturing process. The characteristics that flexible pavement must have are as follows [4]:

(1). Stability, (2). Durability, (3). Flexibility, (4). Skid resistance, (5). Waterproof, (6) workability.

The research location is located on the Kreteg-Lebak Jaya road, Bogor district, West Java Province. The road itself was only repaired about a year ago through the Bogor Regency Public Works Department with APBD funds for the 2022 fiscal year, but currently several points on the Kreteg-Lebak Jaya road in Bogor Regency, West Java Province, have experienced damage again. Damage to the road on the Kreteg-Lebak Jaya road, Bogor Regency, West Java Province, can hinder travel and potentially cause accidents due to several collapsed roads and the high surface of the Jembul road. This can be influenced by several factors, including traffic growth that does not match predictions, traffic loads that exceed limits (overloading), poor subgrade conditions, inappropriate materials used, environmental factors, and implementation that is not in accordance with planning. There are various types of damage that can occur on flexible pavement; therefore, research is needed to determine the condition of the road surface by making visual observations.

The research was carried out along a 400-meter stretch of the Kreteg-Lebak Jaya road. Research on types of damage was carried out on flexible pavement surfaces. The method for assessing the condition of flexible pavement surface damage uses the pavement condition index (PCI) method.

The aim of this research is to identify the type of damage that exists on the flexible pavement surface layer on the Kreteg-Lebak Jaya road, Bogor Regency, and calculate the value of road damage using the pavement condition index (PCI) method and repair handling solutions.

The previous researcher, research on road pavement condition analysis using the PCI method in Sukolilo District, Surabaya City, East Java Province. The research location is in Sukokilo District, Jl. Nginden Semolo, Jl. Raya Nginden, Jl. Raya ITS, Jl. Semolowaru, and Jl. Arif Rahman Hakim. Surabaya has an area of around 350.54 km2 and a population of 2,765,487 people (in 2018). The city of Surabaya consists of 31 sub-districts and 163 sub-districts. Because the population continues to increase, this will certainly have an impact, one of which is that traffic volume can affect the strength and planned life of the pavement structure. The aim of the research is to determine the condition of the pavement on secondary arterial roads in Sukolilo District using the PCI method, along with maintenance treatment and the costs required for maintenance treatment. From the results of a survey of secondary arterial roads in Sukolilo District, the following conditions were obtained: The condition of Jl. Nginden Semolo is perfect with a PCI score of 83; the condition of Jalan Raya Nginden is perfect with a PCI score of 97; the condition of Jalan Raya ITS is perfect with a PCI score of 95; the condition of Jalan Semolowaru is perfect with a PCI score of 99; and the condition of Jalan Arif Rahman Hakim is average, though the average is very good with a PCI value of 74 [5]. Research on the analysis of road damage repair Using the PCI Method (Case Study: Jln. Babat-Batas Jln. Kab. Jombang Sta. 10-Sta. 25) Roads are transportation infrastructure that plays a very important role in traffic flow. When a road section is damaged, it will have a significant impact on traffic flow. Road damage can be analyzed to determine the causes of its occurrence and alternative solutions. This research aims to determine the types of road damage and the condition of the road pavement so that we can determine how to repair it, calculate the required budget, and calculate losses due to increased vehicle operational costs. The method used in this research is the pavement condition index (PCI) method. The results of the damage to Jalan Babat and Jalan Kab, Jombang STA 10+000–25+000 The PCI value for this section is 92.1, with good condition based on the rating. Types of maintenance that can be carried out to improve the level of road service according to road development on these road sections are local asphalt coating, filling cracks, patching holes, and leveling, while the types of work include latasir, filler, infiltration layer with liquid asphalt, worn layer laston, and cold asphalt mix. The total budget required to handle the damage is IDR 147,621,328.36 [6]. Research on road damage analysis using the Highways and Pavement Condition Index (PCI) method. The research location is Jl. Raya Denpasar-Gilimanuk, Tabanan Regency, Bali Province. Denpasar Gilimanuk Highway, Tabanan Regency, Bali, is a national road that connects Tabanan Regency to Gilimanuk. This road is the main access point for public transportation, such as inter-city buses. This road section also plays an important role in economic access in Tabanan Regency. This can be seen from the fairly dense traffic volume on the road every day. However, this also results in the condition of the road surface decreasing because the load received by the road is quite high. Road damage has several factors, including the load from traffic volume and the natural conditions around the road section. The aim of the research is to evaluate the level of road damage using the PCI method and the 1990 Bina Marga method. Planning the additional layer thickness using the SKBI Component Analysis method (2.3.26.1987) The results of the research showed that the types of damage found in the PCI method were more numerous and varied compared to the Bina Marga method [7]. Research on damage analysis of flexible road pavement using the pavement condition index (PCI) method (case study: Jalan Dusun Batu Alang, Sumbawa). The research location is Jl. Batu Alang Hamlet, Sumbawa. Roads are land transportation infrastructure that is often used by the community as a connection between one place and another. Road conditions have an influence on speeding up the smooth and safe mobilization of goods and services. However, as time goes by, the population becomes denser, causing drivers on these roads to become uncontrolled, which results in higher traffic volumes. Roads that are burdened with traffic volumes that exceed capacity affect the quality of the road, resulting in damage to the road. The aim of the research is to identify the types of damage that occur on the Batu Alang Hamlet road to the Sumbawa University of Technology campus as well as repair solutions for any damaged road pavement. The results of the research showed that some damage was severe enough to require reconstruction, and some required other maintenance [8]. Research on evaluating the level of road damage on the surface layer of the Tegar Beriman road in Bogor Regency. This research uses the pavement condition index (PCI) method. Roads are one of the land transportation infrastructures used to support vehicle traffic. Basically, road pavement life planning is adjusted to existing traffic conditions and needs and generally designed within a period of 10–20 years ([9]; [10]; [11]). If, in reality, the existing road is damaged

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before the first 5 years, then it is certain that the road will experience big problems in the future. So it is necessary to carry out initial research on the condition of the road surface, namely by carrying out a visual survey, which means looking at and analyzing the damage based on the type and level of damage to be used in basic maintenance activities for repairing the Tegar Beriman road. The results of evaluating the condition of the Tegar Beriman road, fast lane and slow, are for the slow lane, which has a level of damage with a lower PCI value with a rating of 71.8 (very good) and the fast lane, 81.4 (very good). From the results of this rating, it means that the slow lane has a higher level of damage. The follow-up plan obtained to overcome the dominant type of damage is patching at all depths, crack closure, and demolition [12, 13].

2 Research Methods

2.1 Place and Time

The research location is located on the Kreteg-Lebak Jaya road section in Bogor Regency, West Java Province. The research was carried out for one month in May 2023. Based on the 2018 Bogor Regent's Decree, the Kreteg-Lebak Jaya road section is categorized as a district road, no. section 01.22.208 [14]. The location selection took a 400-meter sample from STA 0+674 to STA 1+074 lane to represent the 1,074-kilometer-long Kreteg-Lebak Jaya road, Bogor Regency.

2.2 Tools and materials

The tools required consist of:

1) A push meter is used to measure the length of the road under study.
2) Roll meter, used to measure the width of the damage and the width of the road.
3) Stationery, used for writing, namely a pen or ballpoint. 35.
4) Form (working paper), used as a data collection tool.
5) Board or hard board, used as a tool for writing.
6) Mobile camera, used for the documentation process.
7) Pilox is used to mark each STA.

The materials used are primary data, namely data obtained by direct observation and measurement in the field in the form of:

1) Picture the types of damage.
2) Dimensional data for each road damage.
3) Road length and width data.

This implementation method contains data collection activities, how to discuss problems, and how to make decisions based on the results. In this method, when carrying out case studies, there are several ways, including:

1) Analyze the condition of the road's damage.
2) Repair solutions for handling road damage.

The research flow diagram is shown in Figure 1.

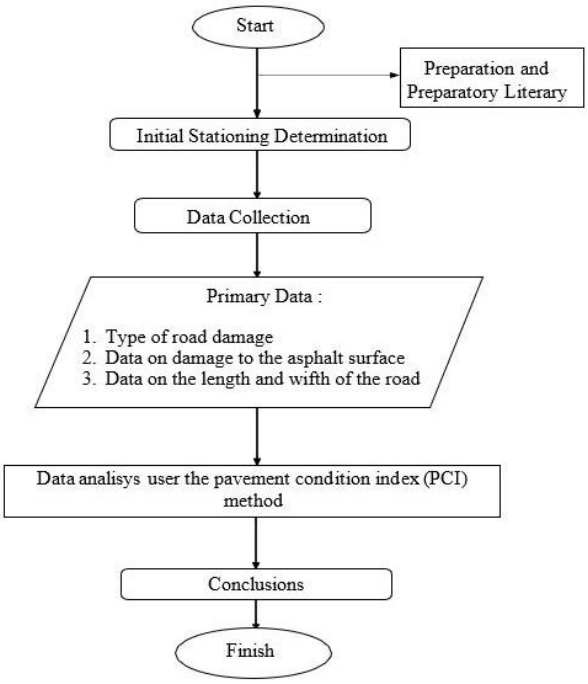

Figure 1 Research flow diagram

3 Resuls and Discussion

3.1 Identify the types of damage that occur on the Kreteg-Lebak Jaya road, Bogor Regency.

Based on data obtained from primary data in the form of research location plans, types and dimensions of damage on the Kreteg – Lebak Jaya road, Bogor Regency, STA 0+674 – STA 1+074, the condition of the Kreteg – Lebak Jaya road, Bogor Regency, starts from STA 0+ 674 – STA 1+074. The condition of the road sections is shown in Table 4.1.

Table 1 Road condition

Roads	Road Length	The width of the road	STA	Pavement Type
Jalan Kreteg-Lebak Jaya, Bogor Regency	1,074 km	5 m	0+674 – 1+074	Flexible pavement

Based on Table 1, the next division is carried out first for each segment by means of an observation survey carried out directly or visually in the field and dividing each segment of pavement damage by 100 meters. The division into each segment is shown in Figure 2.

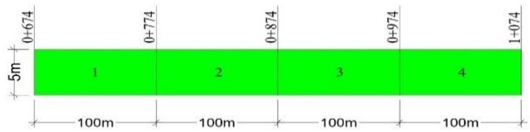

Figure 2 Division into each segment

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3.2 Calculating the value of road damage using the PCI method.

Table 2 Data on type, dimensions, and level of damage in segment 1

No	STA(m)	Damage Type	Damage Level	Size			Ad (m²)
				P (m)	L (m)	A (m²)	
1		Edge crack	H			7	7
2		Patch	L	1.2	1	1.2	2.4
3		Patch	L	1.2	1	1.2	
4		Potholes	H			19	24
5		Potholes	H			1.1	
6		Potholes	H			3.1	
7		Potholes	H			0.1	
8		Potholes	H			0.3	
9		Potholes	H			0.1	
10		Potholes	H			0.1	
11		Potholes	H			0.2	
12	0+674 s.d 0+774.	weathering and raveling	L	4	3.2	12.8	30.3
13		weathering and raveling	L	5	3.5	17.5	
14		weathering and raveling	M	3.9	3	11.7	11.7
15		weathering and raveling	H	4.5	3.2	14.4	24.4
16		weathering and raveling	H	4	2.5	10	

Information:
P = length of damage
L = width of damage
A = Area of damage
Ad = total area of damage based on type of damage in 1 segment

Based on Figure 1, Table 1, and Table 2, which were obtained from an observation survey and used as examples of calculations using the pavement condition index (PCI) method, calculations were then carried out to obtain values for density, deduct value (DV), total deduct value (TDV), reduction (q), corrected deduct value (CDV), and final pavement condition index (PCI) values as follows:

3.2.1 Looking for the percentage of damage (density)

Is known:

Road width = 5 m
Length of each segment = 100 m
as (5m x 100m) = 500 m²
Calculation of density based on equation 2.1 shows:
Edge cracking damage
With a high level of damage (H)
ad = 7 m²
as = 500 m²
Density = 7 / 500 x 100% = 1.4%
Damage to utility excavation patches and patches (patching & untility cut patching)
With a low level of damage (L)
ad = 2.4 m²
as = 500 m²
Density = 2.4 / 500 x 100% = 0.5%
Pothole damage
With a low level of damage (L)
ad = 2.4 m²
as = 500 m²
Density = 24 / 500 x 100% = 4.8%
Weathering damage and loose granules (weathering and raveling)
With a low level of damage (L)
ad = 30.3 m²
as = 500 m²
Density = 30.3 / 500 x 100% = 6.1%
With medium damage level (M)
ad = 11.7 m²
as = 500 m²
Density = 11.7 / 500 x 100% = 2.3%
With a high level of damage (H)
ad = 11.7 m²
as = 500 m²
Density = 24.4 / 500 x 100% = 4.9%

3.2.2 Determining the deduct value (DV)

a. Edge cracking damage

Based on the calculation of the density value above and plotted or entered into the deduct value (DV) graph, a high damage level (H) of 1.4% is obtained with a DV value of 18. The results of the deduct value (DV) graph for edge crack damage are shown in Figure 3.

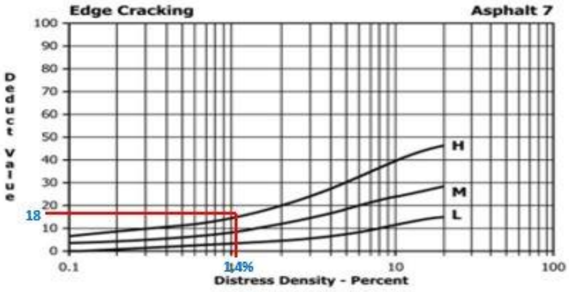

Figure 3 DV graph of edge crack damage

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b. Patch damage (patching and untility cut patching)

Based on the calculation of the density value above and plotted or entered into the deduct value (DV) graph, a low damage level (L) of 0.5% is obtained with a DV value of 1. The results of the deduct value (DV) graph for edge crack damage are shown in Figure 4.

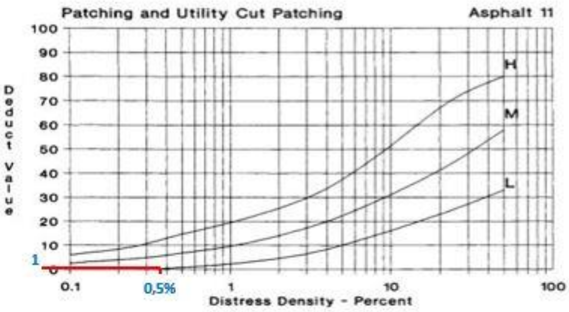

Figure 4 DV graph of patch damage

c. Damage to holes (potholes)

Based on the calculation of the density value above and plotted or entered into the deduct value (DV) graph, the high damage level (H) of 4.8% obtained a DV value of 88. The results of the deduct value (DV) graph for edge crack damage are shown in Figure 5.

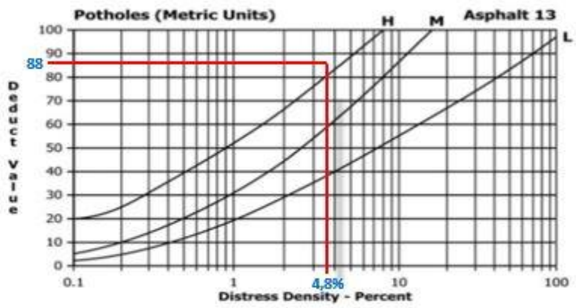

Figure 5 DV graph of hole damage

d. Weathering damage and loose granules (weathering and raveling)

Based on the calculation of the density value above and plotted or entered into the deduct value (DV) graph, the low damage level (L) is 6.1%, resulting in a DV value of 4, the medium damage level (M) is 2.3%, obtaining a DV value of 10, and the high (H) damage level is 4.9%, obtaining a DV value of 30. The results of the deduct value (DV) graphic for edge crack damage are shown in Figure 6.

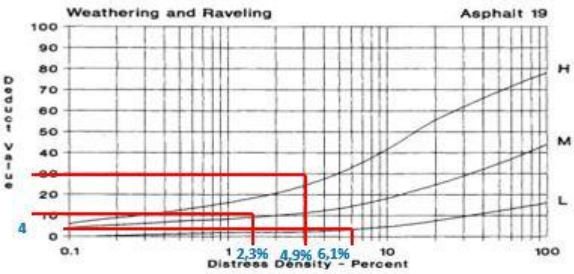

Figure 6 DV graph of weathering damage and loose grains

3.2.3 Add up the total deduct value (TDV)

Based on the DV value obtained from edge crack damage of 18, patch damage of 1, hole damage of 88, weathering crack damage, and grain release of 4, 10, and 30, the total deduct value (TDV) is 18 + 1 + 88 + 4 + 10 + 30 = 151.

3.2.4 Determine the reduction value (q)

Based on the TDV value of 6, namely 18, 1, 88, 4, 10, and 30, the reduction value (q) and deduct value (DV) that are greater than 2 have a TDV of 5.

3.2.5 Looking for the corrected deduct value (CDV)

Based on the TDV value of 151 and the deduction value (q) of 5, the CDV graph shows 78. The results of the corrected deduct value (CDV) graph are shown in Figure 7.

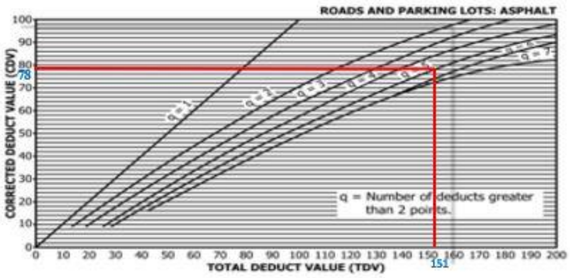

Figure 7 Corrected deduct value (CDV) graphic results

3.2.6 Determine the pavement condition index (PCI) value

Based on the calculation results of density, DV, TDV, reduction value (q), and CDV in segment 1 (STA 0+674 to STA 0+774), the pavement condition index (PCI) value can be calculated using the following equation: 2.2.

CDV = 78

so:

PCIs = 100 – CDV
= 100 – 78
= 22

So it can be concluded that STA 0+674–0+774 has a PCI value of 22, which means the pavement condition in that segment is very poor.

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Table 3 Pavement condition classification value according to PCI [15]

PCI value	Pavement Condition	Type of Treatment
0 s.d 10	Failed	Reconstruction/ recycling
11 s.d 25	Very Poor	Reconstruction/ recycling
26 s.d 40	Poor	Reconstruction/ recycling
41 s.d 55	Fair	Reconstruction/ recycling
56 s.d 70	Good	Structural improvements
71 s.d 85	Very Good	Regular maintenance
86 s.d 100	Exellent	Routine Maintenance

In this study, road damage was calculated on the Kreteg-Lebak Jaya road section STA 0+674–STA 1+074 (400 m), and the PCI on the Kreteg-Lebak Jaya road section is shown in Table 4.

Table 4 PCI values on the Kreteg Lebak Jaya road section.

sample	Sample Area(m2)	Pci value	Ratting
1	500	22	Very Poor
2	500	26	Poor
3	500	46	Fair
4	500	29	Poor
Total PCI Value		123	
Average PCI Value		30,75	Poor

Based on the calculation table above, it can be concluded that the pavement value of the Kreteg-Lebak Jaya STA 0+674–STA 1+074 road section using the PCI method is poor.

4 Conclusion

Based on the results and discussion for damage to STA 0+674–0+774 (segment 1), there are 4 types of damage, namely edge cracks, patches, holes, weathering, and loose grains. STA 0+774–0+874 (segment 2) contains 4 types of damage, namely edge cracks, patches, holes, weathering, and loose grains. STA 0+874–0+974 (segment 3) contains 3 types of damage, namely holes, slip cracks, weathering, and loose grains. STA 0+974–1+074 (segment 4) contains 4 types of damage, namely crocodile skin cracks, edge cracks, holes, weathering, and loose grain.

Based on the results and discussion for the PCI value at STA 0+674 – 0+774 (segment 1), there are 22 very poor pavement conditions using the type of reconstruction/recycling treatment; the PCI value at STA 0+774 – 0+874 (segment 2) is 26 poor pavement conditions using the reconstruction/recycling treatment type; the PCI value at STA 0+874 – 0+974 (segment 3) is 46 fair pavement conditions using the reconstruction/recycling treatment type; and the PCI index value at STA 0+974 – 1+074 (segment 4) is 29 poor pavement conditions using the type of reconstruction/recycling treatment.

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