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Analysis of Road Damage in Majalengka Regency, West Java

Muhamad Reyhan Sunowo[1], Ickbal Maulana[2], Reyhan Yogas Bestari[3], Martinus Agus Sugiyanto[4], Shinta Novriani[5]*

Universitas Swadaya Gunung Jati, Indonesia[1,2,3,4,5]

Email: mreyhan522@gmail.com, ickbalmaulana61@gmail.com, agas270916@gmail.com, martinus@gmail.com, shinta.novrianii@gmail.com*

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ABSTRACT

Road damage on the Maja-Sukahaji route, exacerbated by overloaded vehicles, compromises safety and pavement longevity. This study evaluates flexible pavement conditions using the Pavement Condition Index (PCI) and recommends cost-effective treatments. Visual surveys and PCI assessments were conducted across 10 segments (100 m each), analyzing damage types, severity, density, and deduct values. Treatments were prioritized using Bina Marga guidelines, and costs were calculated via the Majalengka AHSP. Segments 6 and 7 were in poor condition (PCI 51–54), while segment 10 failed (PCI 1). Recommended interventions included patching (P5), paving (P2), and leveling (P6), with a total budget of Rp. 142,381,914.12. The study offers a replicable framework for localized road maintenance, combining PCI analysis with budgetary precision, and underscores the need for proactive repairs to prevent further deterioration. Future research should explore predictive maintenance models and alternative materials (Fadillah *et al.*, 2024; Mutoharoh *et al.*, 2022).

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INTRODUCTION

Roads are a means of land transportation that includes various components, including supporting infrastructure and facilities built to help with public traffic on land and water. Basically, a road is a pavement construction to support vehicle loads. The increase in traffic flow and volume every year shows that roads play an important role in the regional economy (Nawir et al., 2022; Pan et al., 2021; Wang et al., 2022). Transportation is the main factor needed, considering that the economic sector is closely related to roads. Transportation facilities are an important component in supporting regional development. A well-maintained road pavement can provide various benefits, such as smooth transportation flow, efficiency in logistics, comfort in travel, and increased safety for mesh users (Hidayatulloh & Ariostar, 2021; Novriani et al., 2024; Rival et al., 2023).

The Maja-Sukahaji road section includes class III roads, which are Primary Local Roads (JLP) using flexible 2/2 UD road type pavement with a maximum vehicle load of 8 tons. The Maja-Sukahaji road section is one road that often suffers yearly damage. Some of the main causes of road damage on the Maja-Sukahaji road section are overloaded loads, increased weight of traffic volume, and construction materials that cause discomfort for motorists using the highway. These factors are the main cause of road damage, so that damage occurs before the planned lifespan.

Thus, this study aims to optimize and improve the road pavement structure on the Maja-Sukahaji Road section, refer to the Pavement Condition Index (PCI) value, and provide recommendations for handling road pavement damage by referring to the Highway guidelines for Routine Road Maintenance and calculating the cost budget plan for three segments that require handling.

This research aims to determine the flexible pavement condition on the Maja-Sukahaji road section, which refers to the Pavement Condition Index (PCI) value, and provide recommendations for handling damage. The current research distinguishes itself by focusing on the Maja-Sukahaji road section in Majalengka Regency, a specific case of flexible pavement deterioration due to overloaded vehicles, and employs the Pavement Condition Index (PCI) method to systematically evaluate damage severity, density, and deduct values across 10 segments (Elionara *et al.*, 2021; Fatikasari, 2021). Unlike prior studies, it provides segment-specific treatment recommendations (e.g., P2, P3, P5, P6) aligned with Bina Marga guidelines and a detailed Cost Budget Plan (RAB) of Rp. 142,381,914.12 for critical segments (6, 7, and 10), addressing both immediate

repairs and cost transparency (Gusnilawati *et al.*, 2021; Santosa *et al.*, 2021). Additionally, it highlights the failed condition of segment 10 (PCI = 1), emphasizing urgent intervention, while prior works often generalized road conditions without granular financial analysis or targeted remediation strategies (Shanin, 1994; Zaid *et al.*, 2021).

METHOD

In conducting research related to the analysis of the level of road damage, various types of data are needed to assess the condition of the road on the Maja-Sukahaji Road section. To facilitate the analysis process, this study is divided into several stages:(Yuono & Sungkono, 2019)

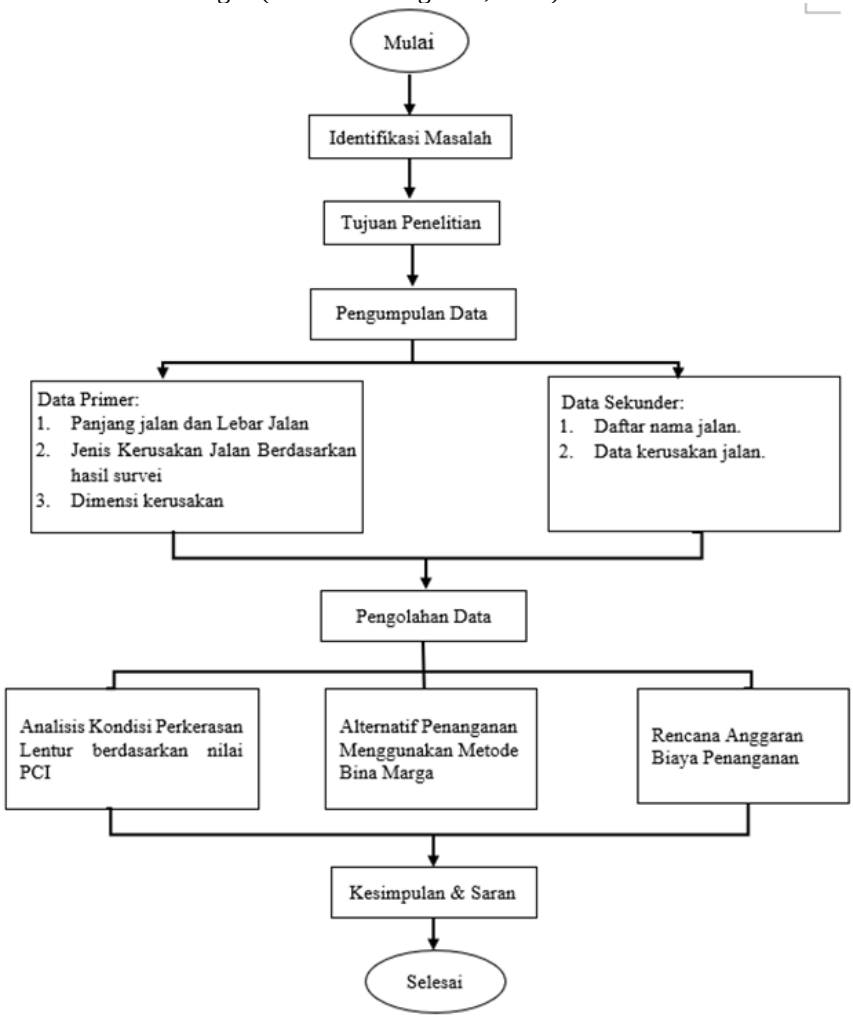


Figure 1. Research Flow Chart

Road damage on the Maja-Sukahaji road section occurs due to various causative factors, such as increased vehicle volume and lack of maintenance. Lack of information regarding the extent of damage can hinder repairs. This study was conducted in an effort to identify damage to the pavement surface of the Maja-Sukahaji road section by applying the Pavement Condition Index (PCI) method, analyzing the value of the pavement damage index on the Maja-Sukahaji road section, providing handling that refers to the Bina Marga guidelines, and calculating the budget plan for handling.

Data collection was carried out through a visual survey consisting of two stages, namely an initial survey that aimed to identify the location and determine the length of each bending pavement segment. Next, a damage survey focuses on identifying the type of damage, measuring dimensions, and documenting each type of damage to the sample unit. The damage survey process was carried out with the following steps: the research began at STA 8 + 740 – 9 + 740, then divided each road segment with a distance of 100 m from a total sample distance of 1 km, so that 10 segments were obtained. Then, record and record each type of damage found. Identify the *level* of damage or *severity* of the existing damage. Assess the damage dimensions of each sample unit. Document the results of observations and measurements on the survey sheet. The data used in the analysis of the level of road damage consists of primary data, which is obtained directly from the results of observation

and measurements at the location. This data includes visual documentation of the type of damage as well as measurements of the dimensions of the damage, including length, width, and depth. Secondary data was obtained through the Public Works and Spatial Planning Office (PUTR) of Majalengka Regency. This data includes information about the list of names in Majalengka Regency. (Kahar) et al, 2024)

The analysis was carried out by applying the pavement condition index (PCI) assessment method and handling recommendations referring to highway guidelines. The *Pavement Condition Index* (PCI) method is a reference in evaluating the condition of the road surface, referring to the type and scale of damage that occurs. To determine the PCI value and analyze the condition of the road surface that is studied, it begins to look(Elionara et al ., 2021) *for density*, determine the deduct *value*, calculate the maximum permit value, and determine the total deductible value (TDV). Highway Guidelines are a method that compiles a list of priorities and appropriate maintenance programs based on the values obtained. Based on the results of the analysis of the Maja-Sukahaji road section, the (Gusnilawati et al ., 2021)(Jannah et al ., 2022)*The value of the Pavement Condition Index (PCI) showed that in segments 6 and 7, the pavement condition was not good, while in segment 10,* the pavement condition failed. So that in segment 6, recommendations were obtained for handling hole patching (P5), crack closure (P3), paving (P2), then in segment 7, namely hole patching (P5), leveling (P6), paving (P2). Meanwhile, in segment 10, paving (P2), hole patching (P5), and leveling (P6) are recommended. Calculate the cost budget plan by referring to the unit price in the AHSP of Majalengka Regency and then multiply it by the volume needed for the three segments that require more handling, so that the RAB value will be obtained.

RESULTS AND DISCUSSION

This study applies the *Pavement Condition Index* (PCI) method, which is used as an indicator of road surface conditions, referring to the level, type, and extent of damage that occurs.(Fatikasari, 2021)

Severity Level

The damage level for each damage category in the PCI calculation includes Low Severity Level (L), Medium Severity Level (M), and *High Severity Level* (H). Based on the results of the study, (Yusra C et al ., 2018)*the severity level values* were obtained as follows:

Table 1. *Severity Level* Results of Damage Type

Segment	Damage Type	Classification
1	Side cracks	M
	Side cracks	M
	Side cracks	M
	Side cracks	M
	Hole	L
2	Grain release	H
	Crocodile crack	L
	Stripping	
	Hole	L
	Stripping	
3	Grain release	H
	Stripping	
	Wear	
	Stripping	
	Flow	L
4	Side cracks	M
	Hole	L
5	Hole	L
	Hole	L
	Crocodile crack	M
	Grain release	H
6	Hole	M
	Side cracks	L
	Grain release	H
7	Hole	M
	Bumps and Derivatives	M
	Grain Release	M

Segment	Damage Type	Classification
8	Hole	L
	Crocodile crack	M
	Hole	L
	Grain release	H
9	Grain release	H
	Grain release	H
	Hole	L
	Hole	L
10	Grain release	H
	Grain release	H
	Grain release	H
	Hole	M
	Hole	H

Density

Road damage density is the ratio between the area and the total length of the damage to the total area of the road. Based on the results of the study, (Zaid et al ., 2021)*the density values* were obtained as follows:

Table 2. Density Results

Segmen	Damage Type	Classification	Total Moons (As)	Damage Area (Ad)	*Density (%)*
1	Side Cracks	M	500	7,29	3,76
	Side Cracks	M	500	3,41	3,76
	Side Cracks	M	500	6,24	3,76
	Side Cracks	M	500	1,85	3,76
	Hole	L	500	1,85	0,37
2	Grain Release	H	500	1,85	0,37
	Crocodile crack	L	500	2,73	0,55
	Stripping		500	13,4	3,7
	Hole	L	500	2,81	0,56
	Stripping		500	5,1	3,7
3	Grain Release	H	500	0,88	0,18
	Stripping		500	3,92	0,98
	Wear		500	7,5	1,5
	Stripping		500	0,98	0,98
	Flow	L	500	1,89	0,38
4	Side Cracks	M	500	7,5	1,50
	Hole	L	500	0,83	0,17
5	Hole	L	500	0,63	0,50
	Hole	L	500	0,36	0,50
	Hole	L	500	1,5	0,50
	Crocodile crack	M	500	2,09	0,42
	Grain Release	H	500	50,6	10,12
6	Hole	M	500	3,61	0,72
	Side Cracks	L	500	3,68	0,74
	Grain Release	H	500	15,3	3,06
7	Hole	M	500	3	0.60
	Bumps and Derivatives	M	500	6	1.20
	Grain Release	M	500	5.7	1.14
8	Hole	L	500	1,7	0,54
	Crocodile crack	M	500	2	0,40
	Hole	L	500	0,99	0,54
	Grain Release	H	500	2	0,40
9	Grain Release	H	500	24,5	7,84
	Grain Release	H	500	14,7	7,84

Segmen	Damage Type	Classification	Total Moons (As)	Damage Area (Ad)	*Density (%)*
	Hole	L	500	1	0,24
	Hole	L	500	0,21	0,24
10	Grain Release	H	500	92,5	20,19
Segmen	**Damage Type**	**Classification**	**Total Moons (As)**	**Damage Area (Ad)**	***Density* (%)**
	Grain Release	H	500	3	20,19
	Grain Release	H	500	5,46	20,19
	Hole	M	500	1,4	0,28
	Hole	H	500	11,88	2,38

(Density) = $\frac{\text{Ad}}{\text{As}} \times 100\%$

Description:

Ad = Overall area of the type for each damage (m2)

AS = Total unit area of damage sample (m2)

The following is an example of the density calculation in segment 10:

a. Hole (M)

$\frac{Ad}{As} \times 100\% = \frac{1,4}{500}\ x\ 100\% = 0,28\%$

b. Hole (H)

$\frac{Ad}{As} \times 100\% = \frac{11,8}{500}\ x\ 100\% = 2,38\%$

c. Grain release

$\frac{Ad}{As} \times 100\% = \frac{9,25x3x5,46}{500}\ x\ 100\% = 20,19\%$

Deduct Value

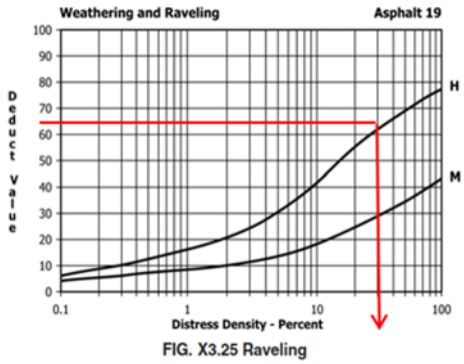


Figure 2. DV Graph Grain Release

Source: Source of Calculation Analysis(Shanin, 1994)

The total deduction value is obtained through a curve that describes the relationship between the density level and the amount of damage for each type of damage.(Fadillah et al ., 2024)

The following is a *graph of the deduct value* in segment 10:

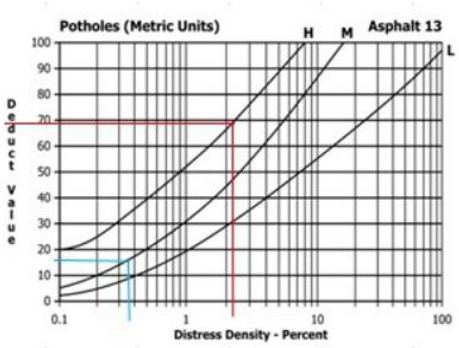


Figure 3. DV *Hole* Graph
Source: Source of Calculation Analysis(Shanin, 1994)

Table 3. DV Results

Segmen	Damage Type	Classification	*Density*	*DV*
1	Side Cracks	M	3,76	18
	Side Cracks	M	3,76	18
	Side Cracks	M	3,76	18
	Side Cracks	M	3,76	18
	Hole	L	0,37	9
2	Grain Release	H	0,37	10
	Crocodile crack	L	0,55	5
	Stripping		3,7	
	Hole	L	0,56	11
	Stripping		3,7	
3	Grain Release	H	0,18	8
	Stripping		0,98	
	Wear		1,5	0
	Stripping		0,98	
	Flow	L	0,38	3
4	Side Cracks	M	1,50	*10*
	Hole	L	0,17	*2*
5	Hole	L	0,50	*10*
	Hole	L	0,50	*10*
	Hole	L	0,50	*10*
	Crocodile crack	M	0,42	*12*
	Grain Release	H	10,12	*43*
6	Hole	M	0,72	25
	Side Cracks	L	0,74	2
	Grain Release	H	3,06	25
7	Hole	M	0,60	23
	Bumps and Derivatives	M	1,20	38
	Grain Release	M	1,14	8
8	Hole	L	0,54	19
Segmen	**Damage Type**	**Classification**	**Density**	***DV***
	Crocodile crack	M	0,40	15
	Hole	L	0,54	19
	Grain Release	H	0,40	11
9	Grain Release	H	24,5	36
	Grain Release	H	14,7	36
	Hole	L	1	5
	Hole	L	0,21	5
10	Grain Release	H	20,19	68
	Grain Release	H	20,19	68
	Grain Release	H	20,19	68
	Hole	M	0,28	16
	Hole	H	2,38	69

Maximum Permit Reduction (m)

The maximum permit value limit is set as a reference to determine the allowable reduction value in the assessment of road conditions. The value of the deductible permit can be calculated by the formula:(Tjahjono et al ., 2024)

The following is an example of the calculation of the maximum permit reduction in segment 10:

$$m = 1 + (\frac{9}{98}) \times (100 - HDV)$$

$$m = 1 + (\frac{9}{98}) \times (100 - 69)$$

= 3,9

Description:

m = Nilai izin *deduct value*

HDV = Highest *deduct value*

The value of m calculated from STA 9 + 640 to STA 9 + 740 is 3.9. The q-value after iteration is shown in **Table 4.**

Total Deductible Value

Total *deduction value or total deduction value, where the total deduction for each damage category* in a road segment is deducted. **Table 4** shows the calculation of all *deduct values* in segments 1 to 10 for each iteration.

***Corrected Deduct Value* (CDV)**

The CDV value is obtained by calculating the TDV into the CDV curve, where the vertical line is drawn from the CDV value until it intersects with the q line, then continued by drawing the horizontal line. The q value for road pavement is 2. The results of the CDV analysis for segments 1 to 10 are shown in (Mutoharoh et al ., 2022)**Table 4.**

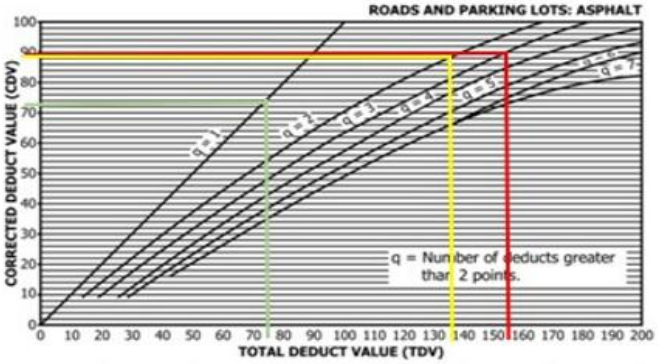


Figure 5. TDV Image, Q, and *CDV Values*
Source: Calculation Analysis

Table 4. TDV Recapitulation, Q and CDV Values

Segmen	Iteration	DV			TDV	q	CDV
1	**#1**	18	9		27	2	18
	#2	18	2		20	1	20
2	**#1**	11	10	5	26	3	12
	#2	11	10	2	23	2	17
	#3	11	2	2	15	1	16
3	**#1**	8	3		11	2	19
	#2	8	2		10	1	10
4	**#1**	10			10	1	10
5	**#1**	43	12	10	65	3	41
	#2	43	12	2	57	2	40
	#3	43	2	2	47	1	44
6	**#1**	25	25		50	2	39
	#2	25	2		27	1	27
7	**#1**	38	23	8	69	3	41
	#2	38	23	2	63	2	46
	#3	38	2	2	42	1	43
8	**#1**	19	15	11	45	3	28
	#2	19	15	2	36	2	26
	#3	19	2	2	23	1	24
9	**#1**	36	5		41	2	31
	#2	36	2		38	1	36
10	**#1**	69	68	16	153	3	99

	#2	69	68	2	139	2	98
	#3	69	2	2	73	1	72

Nilai *Pavement Condition Index* (PCI)

To find out the PCI assessor, the following formula is used:(Sigh) et al ., 2021)

PCI = 100 – *CDVmax*

Description:

PCI = Nilai *Pavement condition index*

CDVmax = Nilai *Corrected deduct value*

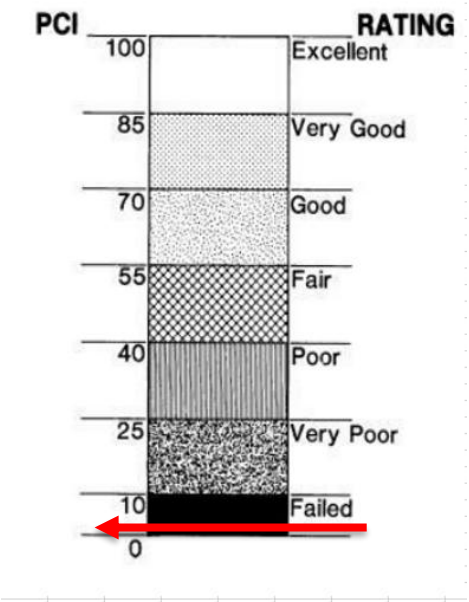


Figure 6. PCI Assessment Segment 10
Source: Calculation analysis

Based on the results of the analysis of PCI values from STA 9+640 to STA 9+740, a value of 1 was obtained, which showed that the pavement condition in the segment was in the failed category.

Table 5. PCI Results of Each Segment in the Maja-Sukahaji Section

Segmen	IS			PCI Value	Pavement Conditions
1	8+740	n/a	8+840	80	Excellent
2	8+840	n/a	8+940	83	Excellent
3	8+940	n/a	9+040	81	Excellent
4	9+040	n/a	9+140	90	Sempurna
5	9+140	n/a	9+240	56	Good
6	9+240	n/a	9+340	51	Enough
7	9+340	n/a	9+440	54	Enough
8	9+440	n/a	9+540	72	Excellent
9	9+540	n/a	9+640	64	Good
10	9+640	n/a	9+740	1	Fail

Source: Calculation Analysis

Based on the analysis results in Table 6, the PCI assessors in segments 1 and 4 range from 80 to 90, which indicates very good road conditions. In segments 6 and 7, the PCI value was below 55, which indicates fair road conditions. The PCI values in segments 8 and 9 ranged between 64 and 72, indicating a good state of affairs.

Segment 10 has the lowest PCI value, 1, which indicates the condition of the failed road. Although most of the Maja-Sukahaji roads are in good condition, the condition of the damaged road pavement must be seriously investigated immediately to prevent the condition from becoming worse if not repaired immediately.

Road Damage Repair Handling

Road damage repair is carried out by referring to the Highway guidelines by the 2011 Routine Road Maintenance standards. The guidelines were issued by the Directorate General of Highways, Ministry of Public Works and Public Housing (PUPR). The purpose of routine road maintenance is to ensure that the road continues to function according to minimum service standards and avoid more serious damage.

Table 6. Road Damage Handling

Segmen	IS			Damage	Damage Handler
6	9+240	s/d	9+340	Hole Depth (>50 mm)	Hole Patching (P5)
				Side Crack (< 2 mm)	Crack Closure (P3)
				Grain Release	Paving (P2)
7	9+340	s/d	9+440	Lumps and Depth Derivatives (< 30 mm)	Leveling (P6)
				Grain Release	Paving (P2)
				Hole Depth (>50 mm)	Hole Patching (P5)
10	9+640	s/d	9+740	Grain Release	Paving (P2)
				Grain Release	Paving (P2)
				Hole Depth (>50 mm)	Hole Patching (P5)
Segment	**STA**			**Damage**	**Damage Handling**
				Hole Depth (< 50 mm)	Leveling (P6)

Source: Damage Analysis

Based on the results of the analysis on the Maja-Sukahaji road section, *the Pavement Condition Index (PCI) value showed that the pavement condition in segments 6 and 7 was not good, while in segment 10, it* failed.

Cost Budget Plan (RAB)

Table 7. Cost Budget Plan

No	Job Type	Volume		Unit Price (Rp)	Amount (Rp)
1	**Prep Work**				
1	Project signage	1,00	bh	347.670,00	347.670,00
2	Procurement of SMKK	1,00	ls	1.750.000,00	1.750.000,00
	Sub Total I				**2.097.670,00**
II	**Construction Work**				
	Segment 6 Length 100 m Width 5 M				
1	Emulsion work	32,31	m3	18.106,91	585.079,67
2	Coarse sand work	17,87	m3	135.469,05	2.421.170,63
3	Mixed aggregates for cold asphalt	14,44	m3	916.886,82	13.239.845,67
4	Class A aggregate jobs	14,44	m3	923.310,17	13.332.598,84
	Sub Total II				**29.578.694,80**
	Segment 7 Length 100 m Width 5 m				
1	Emulsion asphalt work	36,15	m3	18.024,91	651.600,32
No	**Job Type**	**Volume**		**Unit Price (Rp)**	**Amount (Rp)**
2	Class A aggregate jobs	10,50	m3	923.218,52	9.693.794,47
3	Aggregate cold asphalt mixture	33,30	m3	916.886,82	30.523.331,08
	Sub Total III				**40.887.725,86**
	Segment 10 Length 100 m Width 5 M				
1	Emulsion asphalt work	159,56	m3	18.024,91	2.876.089,91
2	Class A aggregate jobs	5,60	m3	932.218,52	5.170.023,72
3	Aggregate cold asphalt mixture	50,74	m3	916.886,82	46.526.504,75
	Sub Total IV				**54.572.618,38**
	Total Segment 1 S/D IV				**127.126.709,04**
	Excess Tax (12% VAT)				**15.225.205,08**
	Total Job Price				**142.381.914,12**

Source: Calculation Analysis

CONCLUSION

The study evaluated the Pavement Condition Index (PCI) on the Maja-Sukahaji road in Majalengka, finding segments 6 and 7 in fair condition but segment 10 failing, with recommended treatments (e.g., patching, paving, leveling) and a total budget of Rp. 142,381,914.12. Future research should optimize maintenance strategies by analyzing cost-effectiveness, long-term treatment performance, alternative materials, traffic/environmental impacts, and predictive modeling using machine learning to enhance durability and budget efficiency.

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