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Analysis of Road Damage Levels Using the SDI (Surface Distress Index) Method for Evaluation and Handling of Potholes

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ABSTRACT

Highways are land transportation infrastructure that is very important in facilitating economic relations activities. The method used is the SDI (Surface Distress Index) method. The purpose of this study is to identify the types of road damage, analyze the level of road damage using the SDI method, and evaluate the SDI value and handling potholes. The length of the road studied in this research is 1000 ± m which is divided into 10 segments with a segment length of 100 m each. The data required for this research is secondary data and primary data. Based on the results of processed field data, 6 types of road damage were obtained. The percentage results on Jalan Ciremai Ujung with an average SDI value of 34 and categorized as having a value in good and moderate conditions so that the percent value (%) in damaged conditions is 90%, moderate 10%, slightly damaged 0% and seriously damaged 0%. And carry out handling using routine maintenance on segments 1,2,3,5,6,7,8,9,10 and periodic maintenance on segment 10.

Keywords: road damage; SDI method; flexible pavement; sample.

INTRODUCTION

Highways are land transportation infrastructure that is very important in facilitating economic relations activities. Good road conditions will facilitate population mobility in carrying out economic relations and other social activities. Damage to road infrastructure that is burdened by high and repeated traffic volumes will cause a decline in road quality. As an indicator, it can be seen from the condition of the road surface, both functional and structural conditions that are damaged.

Many regencies/municipal road pavements in Indonesia have been damaged due to the repetition of traffic loads, in line with increasing economic growth in regions, including the Jalan Ciremai Ujung area, Tanah Sareal District, Bogor City. Jalan Ciremai Ujung is a road that connects two sectors, such as the Education sector, namely the Bina Profesi Vocational School, SMA PGRI 4 Bogor City, SMP PGRI 16 Bogor City, SDN Bantarjati 1, Pondok Pesantren Tarbiyatu Wad Da'wah Al Kautsar and SMPN 20 Kota Bogor. And the Government sector, namely the Bogor City Nursery and the Department of Industry and Trade.

This research aims to identify the types of damage that exist on the pavement layer of the Ciremai Ujung road, analyze the level of road damage on the Ciremai Ujung road section to determine the level of road damage to compare with the results of calculations using the SDI (Surface Distress Index) method and evaluate the SDI value (Surface Distress Index) and handling on potholes.

According to Guide Number SDM-03 / RCS regarding road condition surveys in 2011, the Surface Distress Index (SDI) Method is an inspection carried out visually with parameter data, namely crack width, average crack, total area of cracks, number of holes, and depth. vehicle wheel marks. In implementing the SDI method, the data used is based on the results of the Road Condition Survey (SKJ). The SDI value is calculated from several data obtained in the survey. One of the backgrounds of this research is conducting an analysis of SDI values related to data acquisition sources, data processing systems, and the results obtained. There are 4 main variables for SDI calculations, namely the percentage of the crack area (%), average crack width (mm), number of holes per 100 m and average groove depth (cm). The following is how SDI is calculated:

$$\% \, r = \frac{Ar}{100 \, x \, At} \quad (1)$$

Calculation of the area of each type of damage using the following formula:
Ar = Pr x Lr
At = Pt x Lt
Known: Ar = Damaged area of the road
At = Total area of the road
Pr = Length of damaged road
Pt = Length of total road area
Lr = Width of damaged road
Lt = Total width of the road
1. Crack area.
a. Crack area < 10% then, SDI1 = 5
b. The crack area is 10-30% then, SDI1 = 20
c. Crack area > 30% then, SDI1 = 40
2. Crack width.
a. Crack width > 3 mm, then SDI2 = SDI1 x 2
3. Number of holes.
a. Number of holes < 10 / 100 meters, then SDI3 = SDI2 + 15
b. Number of holes 10-50 / 100 meters, then SDI3 = SDI2 + 75
c. Number of holes > 50 / 100 meters, then SDI3 = SDI2 + 225
4. Wheel ruts
a. Depth of ruts < 1 cm, then SDI4 = SDI3 + 5 x X with X = 0.5
b. The depth of the ruts is 1-3 cm, then SDI4 = SDI3 + 5 x
c. Wheel rut depth > 3 cm, then SDI4 = SDI3 + 20

After obtaining the SDI value, the road conditions can be determined as in Table 1 below.

Table 1. Road conditions based on SDI values

Road condition	SDI value
Good	< 50
Moderate	50 – 100
Slight damage	100 – 150
Severe damage	> 150

(Source: Bina Marga 2011)

As for determining the type of road treatment from the value of road damage using the Surface Distress Index (SDI) method, see Table 2 below.

Table 2. Types of road handling

Handling	SDI value
Routine maintenance	< 50
Periodic maintenance	50 - 100
Road rehabilitation	100 - 150
Road reconstruction	> 150

(Source: Bina Marga 2011)

The Impact of High Traffic Volumes on Road Infrastructure

Road infrastructure plays a critical role in the economic and social development of communities. However, it is subject to wear and tear, especially when exposed to high and repeated traffic volumes. This constant strain can significantly degrade road quality over time, leading to various forms of damage that affect both the structural and functional conditions of the road surface (Syaiful S, Rusfana H, 2022; Syaiful S et.al, 2024).

Functional and Structural Road Damage

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Road damage can manifest in two primary forms: functional and structural. Functional damage refers to surface-level issues that impair the comfort and safety of road users. This includes potholes, cracks, rutting, and surface roughness. These defects may not immediately threaten the overall stability of the road but can deteriorate rapidly if not addressed. Structural damage, on the other hand, affects the integrity of the road's underlying layers. This type of damage can result in subsidence, major cracking, and deformation of the road base, compromising the entire structure (Syaiful S, et.al, 2024; Malaiholo D et.al, 2024; Paikun P, Perkasa RW, 2024).

Factors Contributing to Road Deterioration

The primary factor contributing to road degradation is the excessive load imposed by heavy vehicles, such as trucks and buses. These vehicles exert significant pressure on the road surface, causing gradual deformation and material fatigue. In areas with high commercial or industrial activity, the frequency of such heavy traffic accelerates the rate of deterioration. Additionally, the impact of repeated braking, turning, and acceleration further stresses the road, leading to surface damage. Environmental conditions also play a significant role in road quality decline. Temperature fluctuations, freeze-thaw cycles, and water infiltration can exacerbate existing cracks and weaken the road structure. When water seeps into the pavement and freezes, it expands, causing cracks to widen and further damaging the surface. In warmer climates, prolonged exposure to high temperatures can soften the asphalt, making it more susceptible to rutting and deformation under heavy loads (Tripradipta R et.al, 2024; Brahmana ICS et.al, 2024).

RESEARCH METHODS

This research uses the Surface Distress Index (SDI) method. The SDI method is a visual assessment of road conditions through road condition surveys which produces SDI values. The factors that determine the SDI amount are the condition of cracks on the road surface in terms of total area, average crack width, number of holes per 100m and depth of ruts/rutting. This research stage is divided into 4 stages, namely:

1. The literature review stage is collecting sources of information related to the research topic to help facilitate research. In the form of journals, scientific articles, and other sources.
2. The data collection stage is the collection of primary and secondary data in order to obtain the information needed to achieve the research objectives.
3. Data analysis stage, is the stage in obtaining research results after conducting a survey of road damage conditions, in the form of types of road surface damage and values of road pavement conditions.
4. The conclusion and suggestion stage is obtaining a conclusion from the results of data analysis with road condition values in accordance with the Surface Distress Index (SDI) method. Along with suggestions that can be submitted for road maintenance.

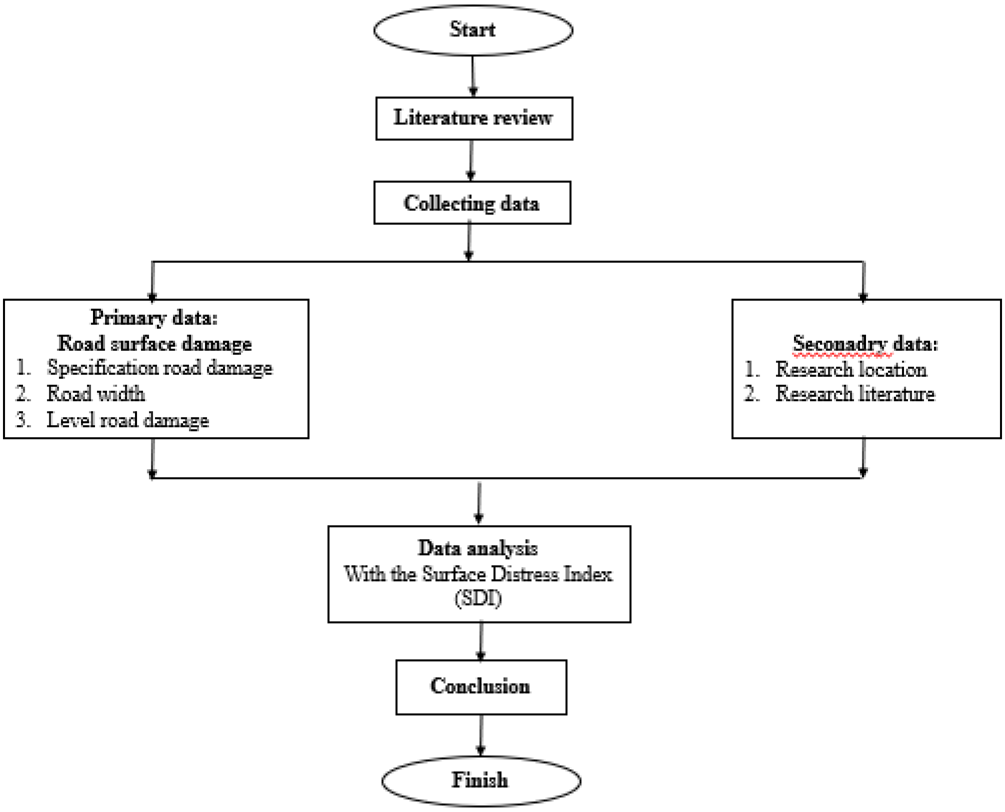

Figure 1. Research Flow Diagram

The location of this research was carried out on Jalan Ciremai Ujung, Tanah Sareal District, Bogor City, West Java. According to the Decree (Decree) of the Mayor of Bogor number 620.45-63 of 2016, the Ciremai Ujung road with road section number 22.02.391 has a road length of 1650m and this research only analyzes the road length of ± 1 km. The research implementation time begins in March 2023. The research location is shown in Figure 2 below.

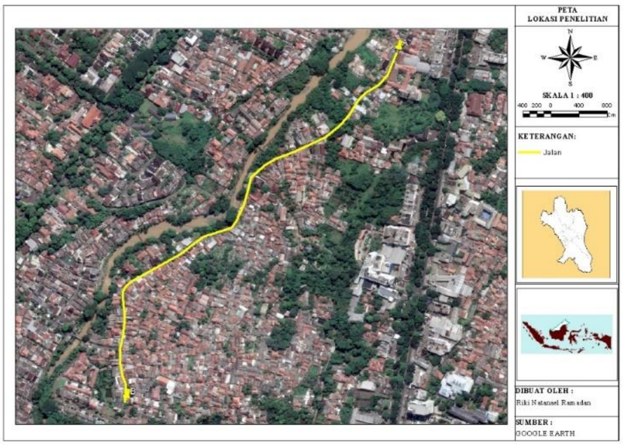

Figure 2. Research Location

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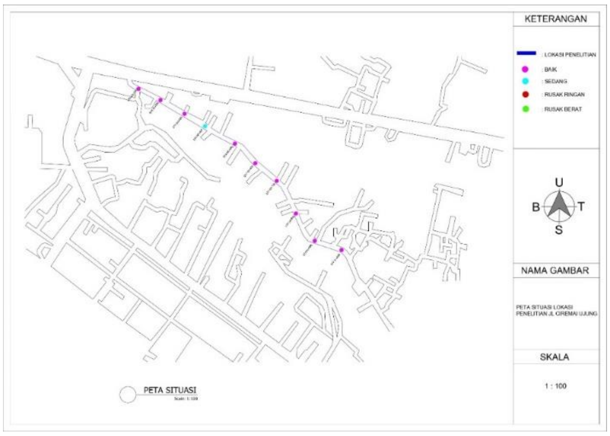

Figure 3. Sketch of Research Location

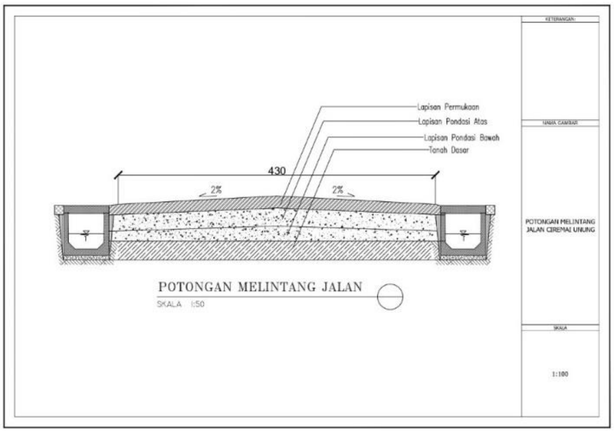

Figure 4. Cross section

RESULTS AND DISCUSSION

Types of Damage Results from Road Condition Surveys

To determine the condition of road damage, this can be done by identifying the condition of the flexible pavement and measuring the damage to the road pavement. The following are the types of damage found on Jalan Ciremai Ujung, Tanah Sareal District, Bogor City:

Figure 5 shows documentation of the type of damage that occurred on the flexible pavement on Jalan Ciremai Ujung, namely holes caused by a poor mixture of surface layer material and traffic loads which resulted in the release of surface layer material.

Figure 5. Holes (Source: Research Results)

Figure 6 shows documentation of the type of damage that occurred on the flexible pavement on Jalan Ciremai Ujung, namely cracking caused by poor pavement materials and the tensile stress that occurs in the asphalt layer exceeds the maximum tensile stress that the pavement can withstand.

Figure 6. Cracking (Source: Research Results)

Figure 7 shows documentation of the types of damage that occurred on the flexible pavement on Jalan Ciremai Ujung, namely side cracks caused by poor support from the side, poor drainage, and soil shrinkage.

Figure 8. Side Cracks (Source: Research Results)

Figure 9 shows documentation of the type of damage that occurred on the flexible pavement on Jalan Ciremai Ujung, namely peeling of the surface layer caused by a lack of bond between the surface layer and the layer beneath it or the surface layer being too thin.

Figure 9. Peeling of the Surface Layer (Source: Research Results)

Figure 9 shows documentation of the type of damage that occurred on the flexible pavement on Jalan Ciremai Ujung, namely the release of grains due to the reduction or loss of the sticky power of the

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asphalt binder, so the rock grains began to come off, the road surface became rough, had holes and leaked water.

Figure 10. Grain Release (Source: Research Results)

Figure 10 shows documentation of the type of damage that occurred on the flexible pavement on Jalan Ciremai Ujung, namely wear caused by aggregates made from materials that are not resistant to wear and tear from vehicle wheels or the aggregates used are round in shape and result in the road becoming slippery.

Figure 11. Wear and tear (Source: Research Results)

Analysis Results Using the SDI (Surface Distress Index) Method

The following is the calculation of the SDI (Surface Distress Index) method assessment on the Jalan Ciremai Ujung section at STA 0+000 – 0+1000 where the data can be seen in the calculations below:

Table 3. Calculation of Data Results in the Field

Field Data Results									
Road Length			1000 m						
Road Width			4,3 m						
Interval			100 m						
STA	Crack (m)		Crack Area (m^2)	Segment Area (m^2)	Crack Area (m)	Total % Crack Area	Holes	Tire Grooves
	P	L						
0+100	0,9	0,06	0,054	430	0,006	0,638	1	0
	0,6	0,35	0,21					
	0,7	0,35	0,245					
	1,6	0,5	0,8					

Field Data Results

Road Length	1000 m
Road Width	4,3 m
Interval	100 m

STA	Crack (m)		Crack Area (m^2)	Segment Area (m^2)	Crack Area (m)	Total % Crack Area	Holes	Tire Grooves
0+200	0,38	0,2	0,076	430	0,024	2,437	2	0
	1,3	0,35	0,455					
	0,4	0,35	0,14					
	0,8	0,2	0,16					
	1,3	0,08	0,104					
	0,83	0,6	0,498					
	2,5	0,6	1,5					
	5,7	0,6	3,42					
	3	1,5	4,5					
	0,6	0,4	0,24					
	2,7	0,15	0,405					
	1,3	0,2	0,26					
	0,35	0,33	0,12					
	0,27	0,14	0,04					
0+300	4,4	0,4	1,76	430	0,011	1,15	2	0
	3,7	0,6	2,22					
	1,3	0,2	0,26					
	1,1	0,6	0,66					
	0,2	0,13	0,03					
	0,13	0,13	0,02					
0+400	0,87	0,72	0,626	430	0,003	0,328	11	0
	0,3	0,23	0,069					
	0,3	0,07	0,021					
	0,38	0,33	0,125					
	0,2	0,2	0,04					
	0,28	0,27	0,076					
	0,28	0,22	0,062					
	0,4	0,3	0,12					
	0,3	0,3	0,09					
	0,29	0,15	0,044					
	0,29	0,22	0,064					
	0,3	0,24	0,072					
0+500	0,8	0,38	0,304	430	0,002	0,192	2	0
	0,82	0,28	0,23					
	0,6	0,26	0,16					
	0,54	0,25	0,14					
0+600	1,1	1,1	1,21	430	0,009	0,933	0	0
	4	0,7	2,8					
0+700	2,9	0,5	1,45	430	0,01	0,966	1	0
	2,4	1	2,4					
	1,3	0,05	0,065					

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Field Data Results								
Road Length		1000 m						
Road Width		4,3 m						
Interval		100 m						
STA	Crack (m)		Crack Area (m^2)	Segment Area (m^2)	Crack Area (m)	Total % Crack Area	Holes	Tire Grooves
0+800	0,8	0,3	0,24	430	0,008	0,818	3	0
	1,7	1,3	2,21					
	1	0,9	0,9					
	0,4	0,35	0,14					
	0,7	0,38	0,27					
0+900	0,24	0,23	0,06	430	0,003	0,273	6	0
	0,3	0,3	0,09					
	0,6	0,22	0,13					
	0,9	0,6	0,54					
	0,63	0,3	0,19					
	0,58	0,29	0,17					
1+000	4,6	0,9	4,14	430	0,041	4,056	2	0
	1	0,7	0,7					
	5,2	0,7	3,64					
	2,4	0,8	1,92					
	0,6	0,27	0,162					
	3,6	1,9	6,84					
	0,17	0,13	0,022					
	0,13	0,13	0,017					

(Source: Analysis results)

From the data above we can take segment 1 STA 0+100 as an example of calculation by determining the SDI (Surface Distress Index) value as follows:

Table 4. Example of calculating SDI values in segment 1

STA	Crack area			Segment area			Crack area percentage	
	P	L	Result	P	L	Result	Crack area/segment area	Result x100%
0+100	0,9	0,06	0,054	4,3	100	430	0,00013	0,013
	0,6	0,35	0,21	4,3	100	430	0,00049	0,049
	0,7	0,35	0,245	4,3	100	430	0,00057	0,057
	1,6	0,5	0,8	4,3	100	430	0,00186	0,186
	0,38	0,2	0,08	4,3	100	430	0,00018	0,018
	1,3	0,35	0,455	4,3	100	430	0,00106	0,106
	0,4	0,35	0,14	4,3	100	430	0,00033	0,033
	0,8	0,2	0,16	4,3	100	430	0,00037	0,037
	1,3	0,08	0,104	4,3	100	430	0,00024	0,024
	0,83	0,6	0,498	4,3	100	430	0,00116	0,116
Average	0,881	0,304						
Amount			2,244					0,638

(Source: Analysis results)

The above results can be added up to 0.013 + 0.049 + 0.057 + 0.186 + 0.018 + 0.106 + 0.033 + 0.037 + 0.024 + 0.116 = 0.638 %

1. Determine SDI 1 based on crack area:
   The percentage of crack area at STA 0+100 is 0.638% based on table 2.4 if < 10%, then the SDI value 1 = 5
2. Determine SDI 2 based on the average crack width:
   Because the crack width is at a heavy level, namely > 3 mm at STA 0+100, namely 0.304 m, the SDI 2 value = SDI 1 x 2 so that the SDI 2 value = 5 x 2 = 10
3. Set SDI 3 based on the number of holes:
   The number of holes in STA 0+100 is 1, if < 10/100m, then the SDI 3 value = SDI 2 + 15 so the SDI 3 value = 10 + 15 = 25
4. Establish SDI 4 based on rut depth:
   Because there are no ruts at STA 0+100, the value of SDI4 = SDI3 where SDI3 = 25 then SDI4 = 25

Table 5. Results of calculating SDI (Surface Distress Index) values

STA	SDI 1 Crack area	SDI 2 Crack width	SDI 3 Number of holes	SDI 4 Wheel marks	SDI per segment	Road Condition
0+000 - 0+100	5	10	25	25	25	Good
0+100 - 0+200	5	10	25	25	25	Good
0+200 - 0+300	5	10	25	25	25	Good
0+300 - 0+400	5	10	85	85	85	Medium
0+400 - 0+500	5	10	25	25	25	Good
0+500 - 0+600	5	10	25	25	25	Good
0+600 - 0+700	5	10	25	25	25	Good
0+700 - 0+800	5	10	25	25	25	Good
0+800 - 0+900	5	10	25	25	25	Good
0+900 - 1+000	5	10	25	25	25	Good
Average					31	Baik

(Source: Analysis results)

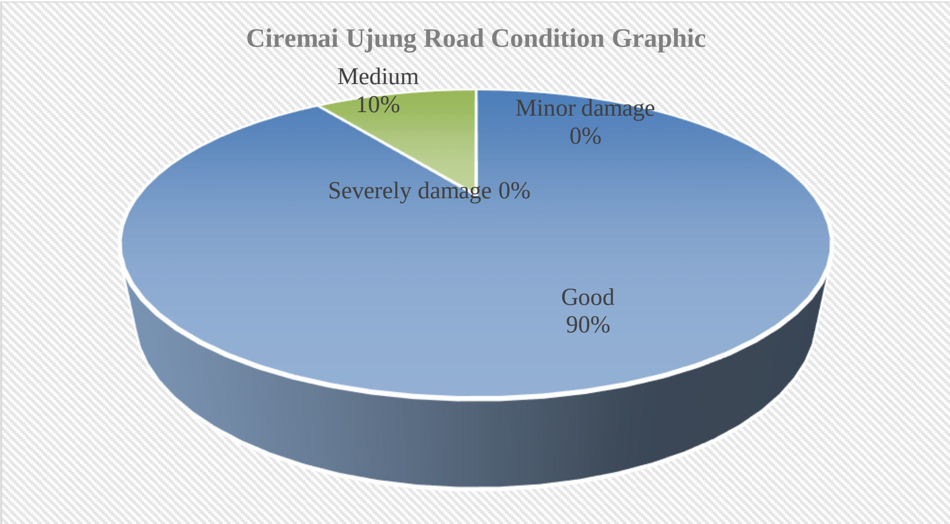

Figure 11. Graphic of the condition of the Ciremai Ujung road (Source: Research results)

Results of Evaluation and Handling of SDI (Surface Distress Index) Values on Potholes

The following are the results of evaluating the SDI (Surface Distress Index) value on potholes with the results of the number of holes, hole area and percentage of hole area in table 6 below:

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Table 6. Evaluation of SDI values for number of holes

Segment	Number of Holes	Hole Area	Total % of Hole Area	SDI Value
1	1	0,0012	0,12	25
2	2	0,0004	0,04	25
3	2	0,0001	0,01	25
4	11	0,0018	0,18	85
5	2	0,0007	0,07	25
6	1	0,0004	0,04	25
7	1	0,0006	0,06	25
8	3	0,0030	0,30	25
9	6	0,0027	0,27	25
10	2	0,0001	0,01	25

(Source: Analysis results)

The results of the percentage of potholes in the 10 segments have different % values, where the largest percentage of potholes is in segment 8, namely 0.30% with a total of 3 holes and the smallest in segment 3 and segment 10, namely 0.01% with the number of holes is 2 holes. The following is a graph of the percentage of hole area on the damaged Ciremai Edge road which can be seen in Figure 12 below:

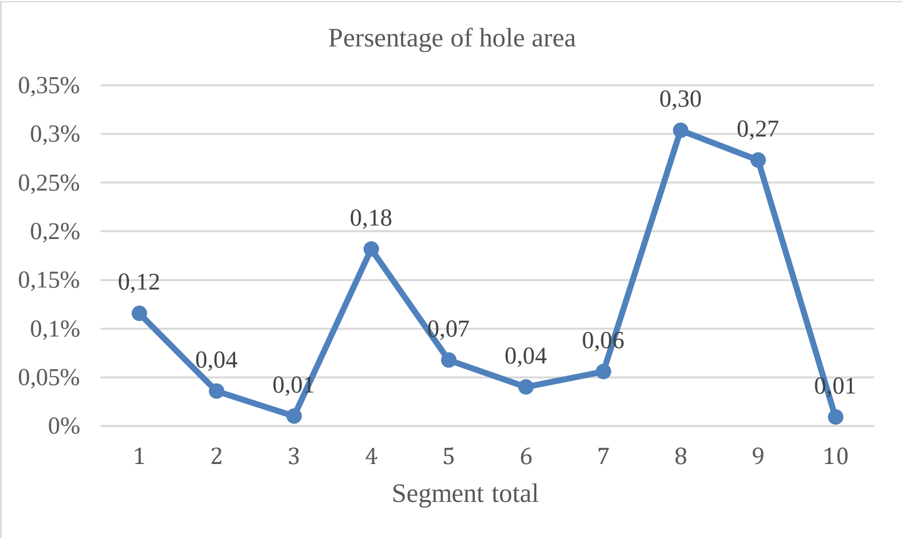

Figure 12. Percentage of Hole Area (Source: Analysis results)

Table 7. Types of treatment

Segment	**Holes total**	**Value SDI**	**Handling**	**Treatment Methods**
1	1	25	Routine Maintenance	Crack Filling and Crack Coating
2	2	25	Routine Maintenance	Crack Filling and Crack Coating
3	2	25	Routine Maintenance	Crack Filling and Crack Coating
4	11	85	Periodic Maintenance	Pothole Patching and Crack Filling
5	2	25	Routine Maintenance	Spothole Asphalt Coating and Crack Filling

Segment	Holes total	Value SDI	Handling	Treatment Methods
6	1	25	Routine Maintenance	Spothole Asphalt Coating and Crack Filling
7	1	25	Routine Maintenance	Crack Filling and Crack Coating
8	3	25	Routine Maintenance	Crack Filling and Crack Coating
9	6	25	Routine Maintenance	Pothole Patching and Crack Coating
10	2	25	Routine Maintenance	Crack Filling and Crack Coating

(Source: Analysis results)

CONCLUSION

From the results of the analysis carried out by researchers using the SDI (Surface Distress Index) method on the Jalan Ciremai Ujung section, it can be concluded that: 1). On the Jalan Ciremai Ujung section there are 6 road damages, namely holes, cracks, side cracks, peeling of the surface layer, grain release and wear.2). The percentage results on Jalan Ciremai Ujung using the SDI (Surface Distress Index) method with an average value of 34, then the Jalan Ciremai Ujung section is categorized as having a value in good and moderate condition so that the percent value (%) in the condition of damage is good 90%, moderate 10%, slightly damaged 0% and seriously damaged 0%. 3). The results of the evaluation of the percentage of potholes in the 10 segments have different % values, where the largest percentage of potholes is in segment 8, namely 0.30% with a total of 3 holes and the smallest in segment 3 and segment 10, namely 0.01% with a total of 2 holes. And carry out road maintenance and road surveillance by handling routine and periodic maintenance.

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