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EVALUATION OF PAVEMENT CONDITION BASED ON THE VALUE OF SURFACE DISTRESS INDEX AND PAVEMENT CONDITION INDEX ON THE ROAD SECTION OF GEDONG TATAAN - KEDONDONG, PESAWARAN

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Abstract

Good road infrastructure conditions can stimulate the economic growth of an area. Therefore, routine road maintenance is carried out by its administrators. One of the road sections that needs improvement is the Gedong Tataan - Kedondong road section. The Gedong Tataan - Kedondong section is a provincial road with a length of 16.67 kilometers. To predict the pavement condition on the road section, an assessment method is required for identification. This method is used as one of the tools to assess pavement damage on a road section, and the methods used are the Surface Distress Index (SDI) and the Pavement Condition Index (PCI). The research results show a PCI (Pavement Condition Index) value of 73%, indicating that the road pavement condition is very good, and routine maintenance is required. Meanwhile, with the SDI (Surface Distress Index) method, a value of 65 is obtained, indicating that the road falls into the fair category, and the appropriate treatment options include patching and overlay. Another implication is to allocate the budget wisely for road maintenance. Information from these two indices helps in determining improvement priorities. Routine maintenance can be a better investment in the long term than letting road conditions deteriorate.

Keywords: *Road Damage, Road Quality, PCI, SDI*

1. INTRODUCTION

Good road infrastructure conditions can stimulate the economic growth of an area. Where most of the local population works as farmers due to the region's richness in agricultural, plantation, and forestry natural resources (Appiah et al., 2022). Based on the Road Stability Data from the BMBK (Bina Marga and Bina Konstruksi) Department, 2021, the Gedong Tataan – Kedondong road section has a length of 16.67 km with the level of road stability was 89.2%, while unstable was 10.8%. This can potentially trigger economic growth for the local community. It is clearly required action to evaluate the road surface conditions by assessing the existing road conditions.

To predict the condition of road pavement, initial identification is required and then an assessment is carried out. The method used as a tool to assess pavement damage on a road section, and the methods used are the Surface Distress Index (SDI) and Pavement Condition Index (PCI)(Shrestha and Khadka, 2021).

The Surface Distress Index (SDI) method is a performance scale obtained from visual observations of road damage that occurs in the field. Determining factors for the SDI index value include the condition of cracks on the road surface (total area and average width of cracks), as well as other damage that occurs (number of holes per 100 meters of road length) (Johnson, 2000).

Meanwhile, the Pavement Condition Index (PCI) is conducted on the road surface condition through visual surveys (Kumar and Sharma, 2022, Astor et al., 2023), The aim of this research is to observe and analyze damage to the road and then draw conclusions based on the results of the processed data analysis. Conclusions are made based on the theory used to overcome the problems that arise. The road condition value will then be used as a reference to determine the type of maintenance program required, whether in the form of reconstruction, patching and resurfacing, or routine maintenance.

2. METHODOLOGY

2.1 Data Collection

This research was conducted on the flexible pavement layer of the Gedong Tataan - Kedondong section, spanning 1.5 kilometers, starting from the Pesawaran Regent's Office to the Pesawaran Regional General Hospital (RSUD Pesawaran)

The primary data used in this research include images of road damage types, and data on the dimensions of the damage (length, width, depth, and area). Secondary data refers to data obtained from the BMBK (Bina Marga dan Bina Konstruksi) of Lampung Province, which includes the research location map and the dimensions of the road under review.

2.2 Analysis of Road Conditions using the SDI Method

Here are the steps that need to be taken to analyze road conditions using the SDI method (Johnson, 2000):

1. Divide the road section into several segments.
2. Identify the existing types of distress.
3. Document each type of distress.
4. Calculate and measure the dimensions of distress for each road segment.
5. Determine the total amount of distress.

2.3 Analysis of Road Conditions using the PCI Method

The steps for analyzing road damage data using the PCI (Pavement Condition Index) method are as follows (Kumar, 2022):

1. Calculate the density.
2. Determine the deduct value for each type of distress.
3. Calculate the allowable minimum deducted value (m).
4. Calculate the total deduct value.
5. Determine the corrected deduct value (CDV).
6. Calculate the PCI value.
7. Determine the type of treatment using the Asphalt Institute method.

The Density of pavement was calculated based on Hardiyatmo (2015) using Equation 1 and 2, where A_d is total area of damage types for each level of damage (m^2), A_s is total area of segment units (m^2), Ld is total length of type of damage for each level of damage (m).

$$A_d/A_s \quad (1)$$

$$L_d/A_s \quad (2)$$

The PCI was established using Equation 1 (Johnson, 2000), where PCIs is pavement condition index for each unit, CDV is Corrected DeductValue for each unit. PCI is Overall pavement PCI value can see in Figure 1, N is Number of Units. To obtain PCI in each segmen Equation 5 was employed.

$$PCI_s = 100 - CDV \quad (3)$$

$$\frac{\sum PCI\ (s)}{N} \quad (4)$$

$$\frac{\sum PCI\ (s)}{number\ of\ segmen} \quad (5)$$

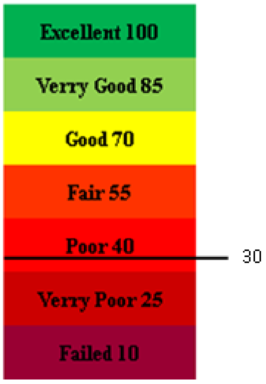

Figure 1. Ratting Condition PCI (Shahin, 1996)

3. RESULT AND DISCUSSION

3.1 PCI Result

Data on the condition of road pavement damage were obtained from a visual survey by observing and measuring the extent of damage along the observed road. Data collection was carried out on Thursday, June 20, 2023, at 13:00 WIB (Western Indonesia Time). The data was collected during daylight hours. The survey results revealed various types of damage, including light (Low), moderate (Medium), and severe (High) levels of damage. The observation results can be seen in Table 1.

Table 1. Observation Results for Segment 1 (STA +000 – 0+100)

No.	Damage Type	Volume of Damage	*Severity Level*
1	Joint Cracks	1.22 x 0.87	L
2	Transverse Longitudinal Crack	1.13 x 0.54	L
3	Hole	0.31 x 0.28	L
		0.36 x 0.39	M
		1.37 x 1.75	H

3.2 Density

According to (Hardiyatmo, 2015) Density is the total area or length of one type of damage to the total area or length of the road section being measured (Equation 1 and 2) (Sivagnanasuntharam et al., 2023).

The results of density calculations at STA 0+000 – 0+100 can be seen in Table 2, Table 3, and Table 4.

Table 2. Density Values in Joint Cracks

Severity Level	Total Area (As) m^2	Damage Area (Ad) m^2	*Density* (%)
L	450	1.06	0.24

Table 3. Density Values for Longitudinal Transverse Cracks

Severity Level	Total Area (As) m^2	Damage Area (Ad) m^2	*Density* (%)
L	450	0.61	0.136

Table 4. Density Values in Holes

Severity Level	Total Area (As) m^2	Damage Area (Ad) m^2	*Density* (%)
L	450	0.09	0.019
M	450	0.140	0.031
H	450	2.40	0.533

3.3 Deduct Value

The deducted value was determined based on AASHTO (1993) as represented in Figure 2. The distress of density (<10%) expresses any minor crack at level 1. The insignificant damage was supported by value of transversal crack at value 0.136 (Figure 3). On the other hand, pothole damage on roads contributes to the greatest damage to roads with a deductive value reaching 92 as in Figure 4

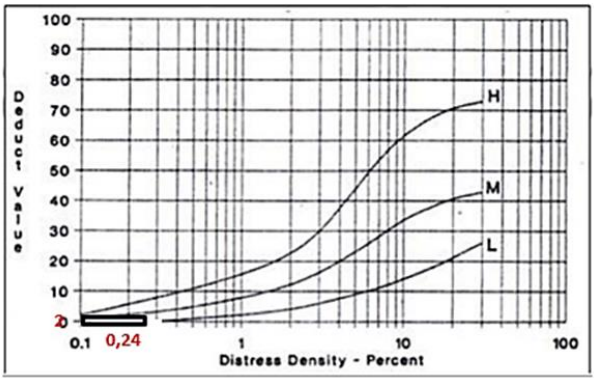

Figure 2. Deduct Value for Joint Cracks

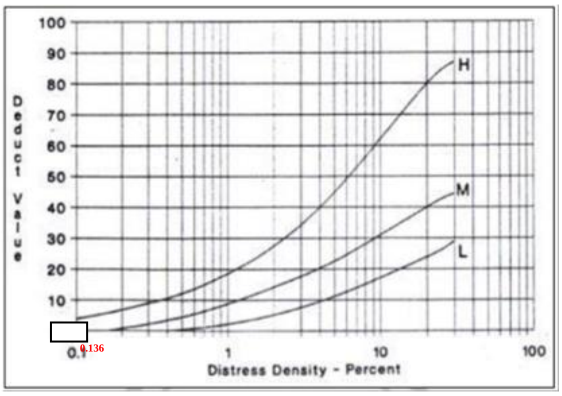

Figure 3. Deduct Value for Longitudinal Transverse Cracks

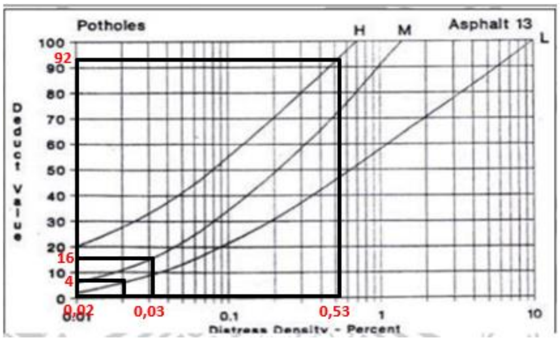

Figure 4. Deduct Value for Holes

3.4 Total Deduct Value

The total deduct value is used to determine the type of damage and the overall or total level of damage to a segment unit, for more details, see Table 5 below.

Table 5. Total Deduct Value Segment 1

Damage Type	*Severity Level*	*Density (%)*	*Deduct Value*
Joint Cracks	L	0.24	2
Transverse Longitudinal Crack	L	0.136	0
Hole	L	0.019	4
Hole	M	0.031	16
Hole	H	0.533	92
Total Deduct Value			114

3.5 Corrected Deduct Value

Corrected Deduct Value is obtained from the relationship curve between TDV and CDV values, for more details, see Figure 5 below.

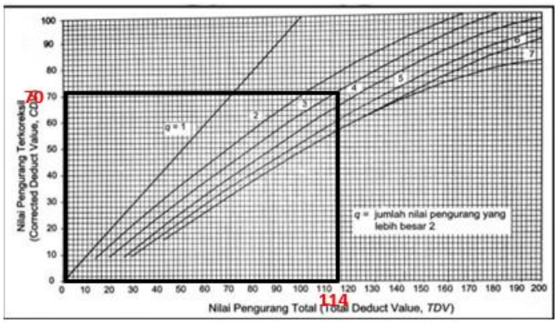

Figure 5. Correlation Curve of Corrected Deduct Value and TDV

3.6 Pavement Condition Index (PCI)

Based on the results obtained, the Pavement Condition Index (PCI) value in segment 1 is 70 (Equation 3). Hence, based on Figure 6 PCI Ratting Condition, it can be concluded that the ratting for the PCI value in segment 1 is poor.

The recapitulation results of PCI value calculations (Equation 4) for segments 1 to 15 can be seen in Table 6.

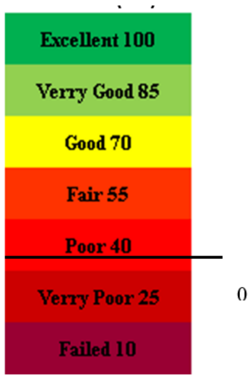

Figure 6. Ratting Condition PCI (Shahin, 1994)

Table 6. Recapitulation of Segment PCI Values 1 to 15

No Segment	STA	CDV	PCI	*Ratting*
1	0+000 - 0+100	70	30	*Poor*
2	0+100 - 0+200	62	38	*Poor*
3	0+200- 0+300	38	62	*Good*
4	0+300- 0+400	0	100	*Excellent*
5	0+400- 0+500	7	93	*Excellent*
6	0+500- 0+600	90	10	*Failed*

No Segment	STA	CDV	PCI	*Ratting*
7	0+600- 0+700	12	88	*Excellent*
8	0+700- 0+800	0	100	*Excellent*
9	0+800- 0+900	4	96	*Excellent*
10	0+900- 1+000	46	54	*Fair*
11	1+000- 1+100	0	100	*Excellent*
12	1+100- 1+200	38	62	*Good*
13	1+200- 1+300	38	62	*Good*
14	1+300- 1+400	0	100	*Excellent*
15	1+400- 1+500	0	100	*Excellent*

Based on Table 6, it can be seen that the overall average value of the Pavement Condition Index (PCI) on the STA.0+000 – STA.1+500 Jalan Gedong Tataan - Kedondong section is 73 (Equation 4) where total PCI and segment are 1095 and 15 respectively.

From the overall average calculation, the Pavement Condition Index (PCI) value obtained for the Jalan Gedong Tataan - Kedondong section at STA.0+000 – STA.1+500 is a value of 51.6, which means that the condition of the road is in the VERY GOOD category.

3.7 Handling Road Conditions

Based on the results of the analysis of the calculation of the average slope of the Pavement Condition Index (PCI) value above. To treat road conditions in the segment, the asphalt institute method will be used as follow,

a. Asphalt Institute Method

From the average calculation for all segments, the Pavement Condition Index (PCI) value for the Gedong Tataan - Kedondong road section is 51.6 with a very good rating. So based on Figure 7 Ratting Condition Asphalt Institute the type of treatment road section is Routine Maintenance.

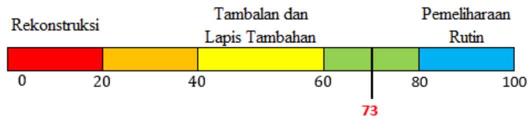

Figure 7. Ratting Condition Asphalt

b. SDI Result

From the results of a field survey carried out on June 20 2023 at 13.00 WIB. From the survey results, it was found that the types of damage that occurred were on the pavement surface, cracks, other damage, and damage to the shoulders/side channels. The results of observations on segment 1 STA 0+000 – 0+100 that have been carried out can be seen in Table 7 up to 18.

Table 7. SDI Observation Results Segment 1 STA 0+000 – 0+014

Pavement Surface	
Good Arrangement	Good
Condition	Good
No Decrease	Yes
Missing Patch	Yes
Crack – Crack	
Type	No
Width	No
Area	No
Other Damage	
Number of Holes	No
Hole Size	Missing
Pavement Surface	
No Wheel	Rims
Light Edge	Damage
Shoulder, Side Channel etc.	
Shoulder Condition Good / Even	Good
Shoulder Surface is Flat to the Road Surface	Yes
Side Channel Condition is Clean	Yes
No Slope Damage	Yes
No Sidewalks	Yes

Table 8. SDI Observation Results Segment 1 STA 0+014 – 0+029

Pavement Surface	
Good Arrangement	Good
Condition	Good
No Decrease	Yes
Missing Patch	Yes
Crack – Crack	
Type	No
Width	No
Area	No
Other Damage	
Number of Holes	No
Hole Size	Missing
No Wheel	Rims
Light Edge	Damage
Shoulder, Side Channel etc	
Number of Holes	No
Hole Size	Missing
No Wheel	Rims
Light Edge	Damage

Table 9. SDI Observation Results Segment 1 STA 0+029 – 0+043

Pavement Surface	
Good Arrangement	Good
Condition	Good
No Decrease	Yes
Missing Patch	Yes
Crack – Crack	
Type	No
Width	No
Area	No
Other Damage	
Number of Holes	< 10 / 100 m
Hole Size - Shallow	Small
No Wheel Rims	No
Pavement Surface	
Edge Damage	Light
Shoulder, Side Channel etc.	
Number of Holes	No
Hole Size	Missing
No Wheel	Rims
Light Edge	Damage
Number of Holes	No

Table 10. SDI Observation Results Segment 1 STA 0+043 – 0+057

Pavement Surface	
Good Arrangement	Good
Condition	Good
No Decrease	Yes
Missing Patch	Yes
Crack – Crack	
Type	Interconnected Types
Width	Medium Width 1 – 5 mm
Area	Area < 10% Area
Other Damage	
Number of Holes	< 10 / 100 m
Hole Size - Shallow	Small
Wheel Marks	1 – 3 cm deep
Edge Damage	Light
Shoulder, Side Channel, etc.	
Shoulder Condition	Good / Even
Shoulder Surface	is Flat to the Road Surface
Side Channel Condition	Clean
Slope Damage	No
Sidewalks	No

Table 11. SDI Observation Results Segment 1 STA 0+057 – 0+071

Pavement Surface	
Good Arrangement	Good
Condition	Good
No Decrease	Yes
Missing Patch	Yes
Crack – Crack	
Types	Interconnected Types
Width	Medium Width 1 – 5 mm
Area	< 10% Area
Other Damage	
Number of Holes	< 10 / 100 m
Small Hole Size	Shallow
Wheel Rims	No
Edge Damage	Light
Shoulder, Side Channel, etc.	
Shoulder Condition	Good / Even
Shoulder Surface	Flat to the Road Surface
Side Channel Condition	Clean
Slope Damage	No
Sidewalks	No

Table 12. SDI Observation Results Segment 1 STA 0+071 – 0+086

Pavement Surface	
Good Arrangement	Good
Condition	Good
No Decrease	Yes
Missing Patch	Yes
Crack – Crack	
Type	No
Width	No
Area	No
Other Damage	
Number of Holes	< 10 / 100 m
Hole Size - Shallow	Small

Pavement Surface	
No Wheel Rims	No
Edge Damage	Light
Shoulder, Side Channel etc	
Number of Holes	No
Hole Size	Missing
No Wheel	Rims
Light Edge	Damage
Number of Holes	No

Table 13. SDI Observation Results Segment 1 STA 0+086 – 0+10

Pavement Surfaces	
Good Arrangement	**Good**
Condition	Good
No Decrease	Yes
Missing Patch	Yes
Crack – Crack	
Type	Tidak Ada
Width	Tidak Ada
Area	Tidak Ada
OtherDamage	
Number of Holes	< 10 / 100 m
Small Hole Size	Shallow
Wheel Rims	No
Edge Damage	Light
Shoulder, Side Channel etc	
Shoulder Condition Good / Even	Good / Even
Shoulder Surface is Flat to the Road Surface	Flat to the Road Surface
Side Channel Condition is Clean	Clean
No Slope Damage	No
No Sidewalks	No

3.8 Calculating SDI Crack Area

The crack was calculated based on SDI which the value of area has range 1 to 4 as presented at Table 14.

Table 14. Calculating SDI of Crack Area

STA		% Area (1-4)	SDI Value (1=0) (2=5) (3=20) (4=40)
0+000	0+014	1	0
0+014	0+029	1	0
0+029	0+043	1	0
0+043	0+057	2	5
0+057	0+071	2	5
0+071	0+086	1	0
0+086	0+100	1	0

3.9 Calculating SDI Crack Width

The crack width has range SDI value from 1 to 40 as seen at Table 15.

Table 15. Calculating SDI of Crack Area

STA		% Area (1-4)	SDI Value (1=0) (2=5) (3=20) (4=40)
0+000	0+014	1	0
0+014	0+029	1	0
0+029	0+043	1	0
0+043	0+057	3	0
0+057	0+071	3	0
0+071	0+086	1	0
0+086	0+100	1	0

3.10 Calculating SDI Number of Holes

The number of SDI value on holes peaked at 30 and placed lowest value at 0 (Table 16).

Table 16. Calculating SDI Number of Holes

STA		% Area (1-4)	SDI Value (1=0) (2=5) (3=20) (4=40)
0+000	0+014	1	0
0+014	0+029	1	0
0+029	0+043	2	15
0+043	0+057	2	20
0+057	0+071	2	20
0+071	0+086	1	0
0+086	0+100	2	15

Table 17. Calculating SDI of Wheel Rims

STA		% Area (1-4)	SDI Value (1=0) (2=5) (3=20) (4=40)
0+000	0+014	1	0
0+014	0+029	1	0
0+029	0+043	1	0
0+043	0+057	2	30
0+057	0+071	2	0
0+071	0+086	1	0
0+086	0+100	1	0

Table 18. Calculating the Total SDI Number

STA		SDI	SDI value
0+000	0+014	0	80
0+014	0+029	0	
0+029	0+043	15	
0+043	0+057	30	
0+057	0+071	20	
0+071	0+086	0	
0+086	0+100	15	

Based on the Table 18, it is known that the Surface Distress Index (SDI) value in segment 1 is 80. So, it can be concluded that the rating for the SDI value in segment 1 is medium.

The recapitulation results of SDI score calculations for segments 1 to 15 can be seen in Table 19 below.

Table 19. Recapitulation of SDI Values for Segments 1 to 15

STA		SDI	*Rating*
0+000	0+100	80	Ratings
0+100	0+200	115	Currently
0+200	0+300	90	Light Damage
0+300	0+400	70	Currently
0+400	0+500	0	Currently
0+500	0+600	230	Good
0+600	0+700	38	Heavy Damaged
0+700	0+800	188	Good
0+800	0+900	10	Currently
0+900	1+000	45	Good
1+000	1+100	35	Good
1+100	1+200	15	Good
1+200	1+300	55	Good
1+300	1+400	0	Currently
1+400	1+500	0	Good

Based on Table 19, it can be seen that the overall average value of the Surface Distress Index (SDI) on the STA.0+000 – STA.1+500 Jalan Gedong Tataan - Kedondong From the overall average calculation, is a value of 65, which means that the condition of the road is in the ADEQUATE (FAIR) category.

3.11 Handling Road Conditions

Based on the results of the analysis of the calculation of the average slope value of the Surface Distress Index (SDI), the action to treat road conditions throughout the segment was taken following the asphalt institute method.

The method concludes that from the average calculation for all segments, the Pavement Condition Index (PCI) value for the Gedong Tataan - Kedondong road section is 65 with a fair rating. So, based on Figure 8 Ratting Condition Asphalt Institute, the types of treatment on the Gedong Tataan - Kedondong road section are Patches and Additional Layers.

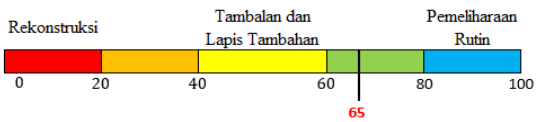

Figure 8. Ratting Condition Asphalt

3.12 Discussion

Based on research that has been carried out, assessing the condition of road pavement using the Pavement Condition Index (PCI) and Surface Distress Index (SDI) methods is based on the results of direct surveys in the field which are carried out visually by observing and measuring the area of damage and depth of damage along the road. thorough. During the survey, 7 types of damage were found with levels of damage ranging from light (low), moderate (medium), or heavy (high). The results of the survey carried out showed various types of surface damage on the Gedong Tataan - Kedondong road section with a total area of damage of 110.93 m2, that the types of damage that often occurred were holes and patches. Based on the results of calculating PCI values and road conditions, researchers identified the type, level and percentage of damage calculated based on the reduction in the CDV value of each road segment. So the calculation of the overall average pavement condition index value on the Gedong Tataan - Kedondong road section is 73, namely the condition of the road is in the

Very Good category with routine maintenance handling. Meanwhile, the SDI calculation results obtained a final result of 65, namely that the road condition was in the fair category and the type of treatment used was patches and additional layers. The surface damage of the flexible pavement should be treated using the Asphalt Institute method.

4. Conclusion

Based on the research results and research data processing, it can be concluded as follows.

1. Research results show that there are 7 types of damage that occurred on the sections observed. The types of damage are Alligator Cracks of 0.38 m2, Potholes of 10.72 m2, Bumps and Sags of 1.31 m2, Patching of 88 m2, Weathering / Loose Granules (Weathering and Raveling) were 0.20 m2, Longitudinal and Transverse Cracks were 9.26 m2, and Joint Reflection Cracks were 1.06 m2.
2. After analyzing calculations using the Pavement Condition Index (PCI) and Surface Distress Index (SDI) methods, an average PCI value of 73 was obtained. This value shows that the road is in very good pavement condition. Meanwhile, the SDI value was obtained at 65 with road conditions included in the fair category.
3. Road repairs use the Asphalt Institute MS-17 method. For roads that have been analyzed using the Pavement Condition Index (PCI) method, road repairs with Routine Maintenance are recommended. Meanwhile, for the Surface Distress Index, it is recommended that additional patches and layers are needed.

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