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Identification and Repair of Road Damage Using the Pavement Condition Index Method

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Abstract- Harun Tohir Road is a very congested road with traffic. The traffic is very heavy with heavy vehicles passing through it. As a result of this vehicle load, road damage often occurs which sometimes also causes traffic accidents. For this reason, in this study, Harun Tohir Street is the location of this research. The method used in this research is the Pavement Condition Index (PCI). This method is an option because of its easy application with justifiable accuracy. From the research results, the types of damage that occurred were punch-out, spalling, scaling, corner cracks, and longitudinal cracks. Overall, this road segment is severely damaged with a PCI value of 33.11%. Efforts that need to be done by patching the part that is damaged are and adding waterproof material to the joints between the concrete slabs.

Keywords- *Road Damage, Pavement Condition Index Method, Rigid Pavement*

I. INTRODUCTION

Gresik City is a city with a fast industrial growth, supported by an integrated industrial area and an export and import port. Many industries need good transportation, especially roads. The road is an important factor that must be considered in its construction and maintenance [1]. In the maintenance process, road damage sometimes occurs earlier than the service period due to several factors, especially heavy vehicle loads that exceed the capacity and volume of vehicles that are increasing [2][3].

Harun Tohir Street is a regency road that connects the city of Gresik with the city of Surabaya with a road length of 1,8 kilometres with 1 lane and 2 lanes. This road section is a congested route because it is located industries areas and connects Gresik Port with the city of Surabaya. Along with the high volume of traffic on these roads, road damage often occurs. The cause of damage is influenced by excessive vehicle loads and drainage channels that are not functioning properly [4][5]. Therefore, it can be concluded that road infrastructure that is burdened by high and repetitive traffic volumes, heavy vehicles with excess loads and drainage that is not functioning properly will cause a decrease in road quality [6][7][8]. In this regard, it is necessary to increase both the quantity and quality of roads that meet the needs of the community, therefore it is necessary to conduct research on the analysis of road damage to the planned life of the pavement.

Harun Tohir Street is one of the sections of Gresik city roads that was badly damaged. The construction of this road uses rigid pavement because the road is a heavy vehicle lane from the direction of the city of Surabaya to Gresik Port. Analysis of the damage to the road will use the PCI method. The advantage of the PCI method is that it is a road pavement condition assessment system based on the type, level and extent of road damage that has occurred and can be used as a reference in maintenance efforts [9][10][11]. The PCI method ranges from 0 (zero) to 100 (one hundred) with criteria of excellent, very good, good, fair, poor, very poor, failed while the highways method has a value range of 0 (zero) to more than 7 (seven). The purpose of this study is to conduct an assessment to determine and classify the types and levels of pavement damage, as well as to determine the value of road pavement conditions using the PCI method and road repair efforts [12][13].

The steps for calculating the Pavement Condition Index (PCI) for rigid pavement are as follows:

A. Types of Road Damage

There are 19 types and levels of pavement damage for rigid pavement, namely: settlement or faulting, pumping, blow-up/buckling), corner crack, diagonal crack, longitudinal crack, transverse crack, shrinkage cracks, durability cracking, lane/shoulder drop-off, spalling, scaling, polished aggregate, patching and utility cuts and punch-outs[14][15].

B. Severity Level

Severity Level is the level of damage for each type of damage. The level of damage used in the calculation of PCI is the low severity level (L), medium severity level (M), and high severity level (H).

C. Pavement Condition Assessment

1) Density

Density or degree of damage is the percentage area or total length of one type of damage to the area or total length of the measured road section, which can be in ft^2 or m^2, or feet or

meters. The value of the density of a type of damage is also distinguished based on the level of damage. There is a difference in calculating the PCI for asphalt and concrete pavement sample units.

a) Asphalt Pavement

The formula for finding the density value:

$$\text{Density (\%)} = \frac{A_d}{A_s} \text{ x } 100 \quad (1)$$

or

$$\text{Density (\%)} = \frac{L_d}{A_s} \text{ x } 100 \quad (2)$$

with:

Ad = total area of damage types for each level of damage (m^2)

Ld = total length of damage type for each level of damage (m)

As = total area of the segment unit (m^2)

b) Concrete Pavement

$$\text{Density (\%)} = \frac{Ncsd}{Ncs} \text{x } 100 \quad (3)$$

with:

Ncsd = the number of concrete slabs that have suffered a certain type of damage

Ncs = the number of concrete slabs in the sample unit

1. Deduct Value (DV)

DV is the reduction value for each type of damage obtained from the relationship curve between density and deducts value. DV is also distinguished by the level of damage for each type of damage.

2. Total Deduct Value (TDV)

DV is the total amount of deducting value in each sample unit for each type of damage and level of damage in a study.

3. Corrected Deduct Value (CDV)

CDV is obtained from the relationship curve between TDV and DV by selecting the curve according to the number of individual deduct values that have a value greater than 2. If the CDV value is known, the PCI value for each unit can be found with the formula:

PCI_s = 100 – CDV

with:

PCI_s = Pavement Condition Index for each sample unit or research unit

CDV = Corrected Deduct Value of each sample unit.

The overall pavement PCI values for certain roads are:

$$PCI_f = \sum \frac{PCI_s}{N}$$

with:

PCI_f = mean PCI value of all research areas

PCI_s = PCI value for each sample unit

N = number of units

4. Pavement Quality Classification

From the PCI value for each research unit, it can be seen that the quality of the segment unit pavement layer is based on certain conditions, namely: excellent, very good, good, fair, poor, very poor, failed. Table 1 describes the relationship between PCI values, rating and treatment.

TABLE I. RELATIONSHIP BETWEEN PCI VALUES, RATING AND TREATMENT

PCI Value	Rating	Treatments
0 – 10	failed	Reconstruction
11 – 25	very poor	Reconstruction
26 – 40	poor	Periodic
41 – 55	fair	Routine
56 – 70	good	Routine
71 – 85	very good	Routine
86 – 100	excellent	Routine

II. METHODOLOGY

The steps in conducting this research are:

1. Identify the road damage problems that have occurred.

2. Conducting literature studies related to road damage problems on rigid pavement.

3. Collecting secondary data consisting of:

- List of street names and map of Gresik city
- LHR (Average Daily Traffic) data
- Rainfall data

4. Collecting primary data consisting of:

- Road inventory data
- Road damage data
- Analyze road damage obtained using the PCI method to obtain the value and level of road damage and find out the road damage solutions.

III. DISCUSSION

A. Road Damage Analysis

From the results of visual observations in the field, it is obtained the area of damage, depth and width of the cracks to determine the class of road damage. This damage value is influenced by the quantity of each type of damage and the area of the road segment under review. The deduct value determination can be calculated after the damage class and density are obtained.

Recapitulation of road conditions and damage in the form of a table containing the type, dimension, level and location of the damage. The recapitulation table of road conditions and the damage is the result of a survey of road conditions in each segment and is useful for making it easier to enter road damage data into the PCI table. Table 2 is an example of a form that must be filled in with a damage area value and a record of road conditions.

TABLE II. SAMPLE UNIT CONDITION SURVEY FORM ON RIGID PAVEMENT AT HARUN TOHIR STREET STA 0 + 000 - STA 0 + 050

Condition Survey Data Sheet for Sample Unit					
Branch	:	Section	:A01	Sample Unit	:001
Surveyed by	:	Date	:22/6/2020	Number of Slab	:20
Distress Types					
61. Faulting			69. Transverse Cracks		
62. Punch-out			70. Longitudinal Cracks		
63. Pumping			71. Lane/Shoulder-drop-off		
64. Blow-up/Buckling			72. Polished Aggregate		
65. Shrinkage Cracks			73.Scalling		
66. Corner Cracks			74.Spalling		
67.Diagonal Cracks			75.Patching and Utility Cuts		
68.Durability Cracks					
Distress Types	Severity	No. of Slab	Density (%)	Deduct Value	
62	H	12			
70	L	6			
73	H	2			
74	H	6			

Source: Research results

In Figure 1, the sample units are drawn using the points as the intersection of the concrete slab joints in the type of continuous concrete pavement. The code number for any visible defects on the plate surface is written in the plate rectangle representing the plate. Low (L), medium (M), high (H) fault codes are entered with the fault number to identify the degree of damage. Example: in sample unit 001, concrete pavement damage with code 70L indicates that the slab has a low level of transverse crack damage (L).

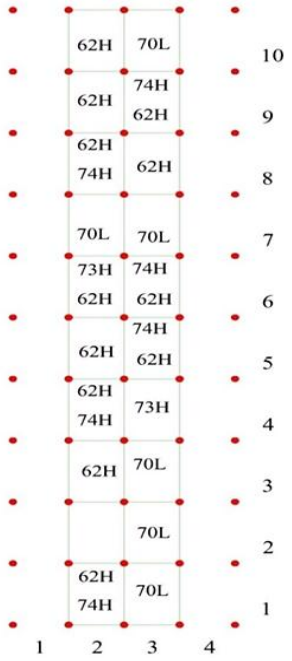

Figure 1. Division of Concrete Slabs to Simplify Calculations

To calculate the density of road damage with add up the plates that have the same damage and severity, then divide by the total number of concrete slabs in sample units, then multiply by 100, then a large proportion of the density per unit sample for each damage will be obtained, as in formula 1. Calculation of the density of road damage on Harun Tohir road at STA 0 + 000 - STA 0 + 050:

a. Punch-out damage (H) = $\left(\frac{12}{20}\ x\ 100\right)$ = 60%

b. Longitudinal crack damage (L) = $\left(\frac{6}{20}\ x\ 100\right)$ = 30%

c. Scalling (M) = $\left(\frac{2}{20}\ x\ 100\right)$ = 10%

d. Spalling (L) = $\left(\frac{6}{20}\ x\ 100\right)$ = 30%

The determination of the TDV value is obtained by entering the damage density value into the deduct value graph according to the level of damage to the road. Figure 2, 3, 4, 5 shows the deduct value of the high level of punch-out damage, longitudinal crack damage, scalling and spalling.

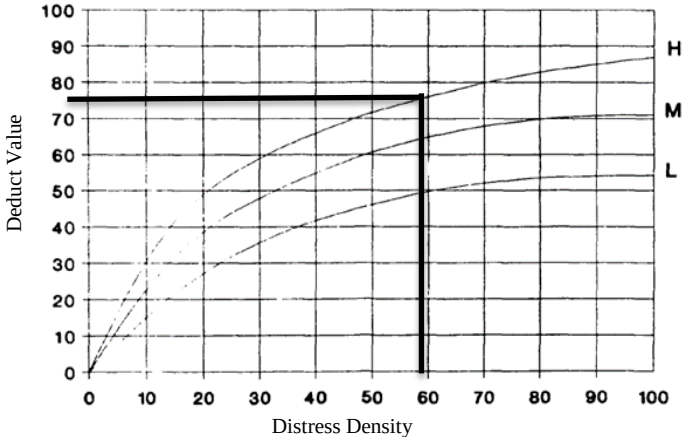

Figure 2. Graph of Punch-Out Damage Deduct Value

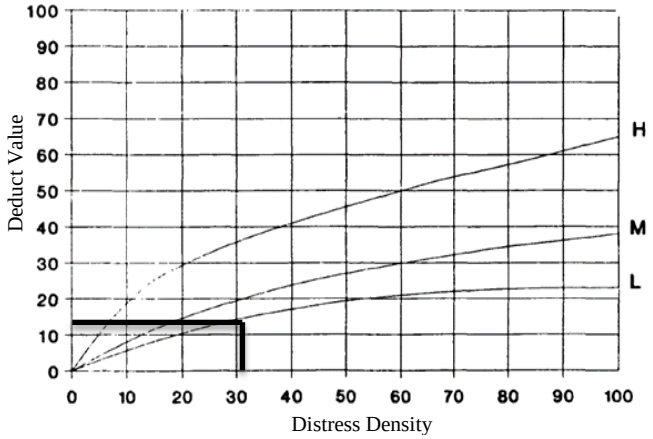

Figure 3. Graph of Longitudinal Crack Damage Deduct Value

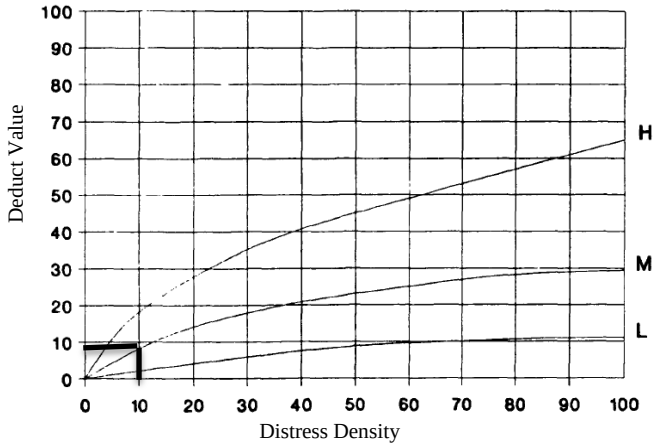

Figure 4. Graph of Scalling Damage Deduct Value

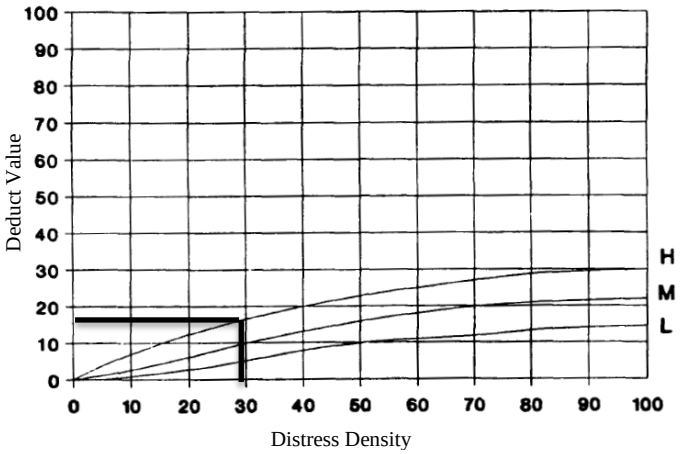

Figure 5. Graph of Spalling Damage Deduct Value

To determine the CDV value, a correction curve is used for concrete pavements. For example, for segment 1, STA 0 + 000 - STA 0 + 050 there are 4 deduct values, DV values greater than 2 are 4, then using the q = 4 graph, then from the corrected deduct value graph will get the CDV value. Figure 6 shows the CDV value on Harun Tohir Street at STA 0 + 000 - STA 0 + 050.

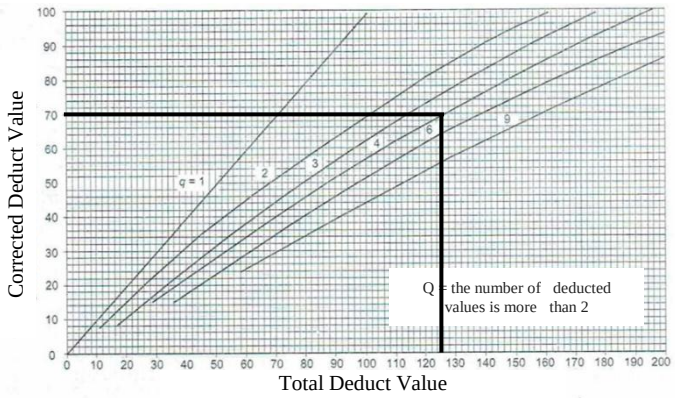

Figure 6. Graph of Corrected Deduct Value

The results of CDV calculations on Harun Tohir Street at STA 0 + 000 - STA 0 + 050 can be seen in table 3.

TABLE III. CDV VALUE FOR HARUN TOHIR STREET AT STA 0 + 000 - STA 0 + 050

STA	Deduct Value				Total	q	CDV
	Punch Out	Longitudinal Crack	Scalling	Spalling			
0+000-0+050	76	15	19	16	126	4	70

Source: Research results

For the calculation of the Pavement Condition Index (PCI) on the Harun Tohir road section at STA 0 + 000 - STA 0 + 050, PCI is calculated by subtracting the value 100 from the maximum CDV.

PCI Value = 100 – CDV = 100 - 70 = 30

So, the pavement condition index on the Harun Tohir road at STA 0 + 000 - 0 + 050 results in a 30 or poor condition. To get PCI values for all segments, it is done in the same way as above. Table 4 is a recapitulation of PCI values from segment 1 - segment 9.

TABLE IV. RECAPITULATION OF PCI VALUES

No	Segment	STA	CDV	PCI	Level	Treatment
1	I	0+000 - 0+050	70	30	Poor	Periodic
2		0+050 - 0+100	64	36	Poor	Periodic
3		0+100 - 0+150	72	28	Poor	Periodic
4		0+150 - 0+200	72	28	Poor	Periodic
5	II	0+200 - 0+250	71	29	Poor	Periodic
6		0+250 - 0+300	78	22	Very Poor	Reconstruction
7		0+300 - 0+350	60	40	Poor	Periodic
8		0+350 - 0+400	60	40	Poor	Periodic
9	III	0+400 - 0+450	64	36	Poor	Periodic
10		0+450 - 0+500	60	40	Poor	Periodic
11		0+500 - 0+550	62	38	Poor	Periodic
12		0+550 - 0+600	69	31	Poor	Periodic
13	IV	0+600 - 0+650	70	30	Poor	Periodic
14		0+650 - 0+700	70	30	Poor	Periodic
15		0+700 - 0+750	70	30	Poor	Periodic
16		0+750 - 0+800	66	34	Poor	Periodic
17	V	0+800 - 0+850	64	36	Poor	Periodic
18		0+850 - 0+900	64	36	Poor	Periodic
19		0+900 - 0+950	66	34	Poor	Periodic
20		0+950 - 1+000	72	28	Poor	Periodic
21	VI	1+000 - 1+050	66	34	Poor	Periodic
22		1+050 - 1+100	67	33	Poor	Periodic
23		1+100 - 1+150	60	40	Poor	Periodic
24		1+150 - 1+200	65	35	Poor	Periodic
25	VII	1+200 - 1+250	72	28	Poor	Periodic
26		1+250 - 1+300	69	31	Poor	Periodic
27		1+300 - 1+350	68	32	Poor	Periodic
28		1+350 - 1+400	60	40	Poor	Periodic
29	VIII	1+400 - 1+450	72	28	Poor	Periodic
30		1+450 - 1+500	63	37	Poor	Periodic
31		1+500 - 1+550	78	22	Very Poor	Reconstruction
32		1+550 - 1+600	71	29	Poor	Periodic
33	IX	1+600 - 1+650	60	40	Poor	Periodic
34		1+650 - 1+700	62	38	Poor	Periodic
35		1+700 - 1+750	61	39	Poor	Periodic
36		1+750 - 1+800	70	30	Poor	Periodic

Source: Research results

The average Pavement Condition Index (PCI) values in Harun Tohir Street are as follows:

$$\Sigma \text{ average PCI value} = \frac{\sum PCI}{Number\ of\ Road\ Segments}$$

$$= \frac{1192}{36} = 33{,}11\ \%\ \text{(poor)}$$

So, it can be concluded that the pavement value on this road is poor with the lowest pavement value at STA 0+250 - STA 0+300 and STA 1+500 - STA 1+550 with a classification of very poor levels of damage.

IV. CONCLUSION

Based on the research results, the following conclusions can be drawn:

1. The types of damage that occurred were punch-out, spalling, scaling, corner cracks, and longitudinal cracks.

2. Based on point 1, the road repair method is to fill in the cracks, overlay, adding waterproof material to the joints between the concrete slabs and seal the cracks. With continuous repairs, it is hoped that the damage will not get bigger and the costs that must be provided are also not large.

3. The average value of the Pavement Condition Index is 33.11%, which means it is included in poor conditions.

4. The lowest PCI value with a percentage of 22.0% is found in the STA 0 + 250 - STA 0 + 300 segment and the STA 1 + 500 - STA 1 + 550 segment with very poor.

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