Deterioration Analysis of Rigid Pavement using Roadroid based on PCI

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Keywords: International Roughness Index (IRI), Pavement Condition Index (PCI), Roadroid, Road Deterioration

Abstract: The Indonesian government's limited funds mandate efficient budget planning based on accurate data. However, the Central Government (General Directorate of Highways) has no measurable, accurate data on district roads, which can be used as the basis of evaluating proposals from provincial, regent, and city administrations. The purpose of this research is to analyze the value of rigid pavement conditions based on the International Roughness Index (IRI) which was carried out using the Roadroid application. The type of deterioration is determined based on the Pavement Condition Index (PCI). Data were collected from Jalan Raya Babelan for 2 km. Assessment of rigid pavement conditions throughout Jalan Raya Babelan using the IRI and conducted with the Roadroid application produced an IRI value between 6.31 (medium) and 33.81 (heavy deterioration). Road deterioration survey conducted using Pavement Condition Index (PCI) shows several types of road deterioration, such as broken corners, split slabs, damaged joint mantles, sloping roadsides, linear cracking, slippery aggregate, pop-outs, punch-outs, bent corners, and bent joints. Circumstantial assessment utilizing the Pavement Condition Index (PCI) method produces PCI values in the range of 0 (failed) to 22 (severe). Both methods demonstrate that Jalan Raya Babelan needs to be included minor reconstruction program. Deteriorations need to be repaired by renewing the pavement layer. Actions taken to repair deteriorations include sealing cracks, partial as well as full-scale depth patching, reconstructing or replacing slabs, resealing joints, smoothing flows, and reinforcing layers.

1 INTRODUCTION

Road maintenance is a series of strategic, technical and operational decisions (Langevin,2016). Road maintenance requires high costs, but it must still be done by paying attention to relevant department maintenance policies, material resources, competent and experienced human resources, and appropriate technology (Purboyo, H et al, 2017, Hadjidemetrieou, 2019, Siswanto et al., 2019). Road maintenance is also a fulfillment of road user comfort requirements (Yasuda, et al, 2018). The assessment of road pavement conditions is an important aspect of determining maintenance activities for road improvement. In assessing pavement conditions the first is to determine the type of deterioration, density and severity (Setianingsih et al., 2017). Road geometry, uneven surfaces, driving behavior, vehicle characteristics, weather, also affect (Stachova, 2017, Vignisdottir, et al, 2018, 2019, Yin, et al, 2020, Shi, 2018). Road maintenance management is needed that takes all of these (Jokanovic, 2019, Thankgod, 2019).

The Ministry of PUPR's 2020-2024 Strategic Plan data shows that there are 47,000 km of national roads in active maintenance; 3,200 km with increased capacity; and 3,800 km of new roads under construction. The construction and maintenance of national roads as of the end of 2019 increased stability to 92.81% and accessibility to 87%. National roads cost around 40 trillion rupiahs to operate. However, only 22 km of regional roads are handled with a budget of 10 billion rupiahs.

Indonesian government's limited funds issue requires optimization of budgeting based on accurate data. On the other hand, the Central Government (General Directorate of Highways) does not have measurable and accurate data about the regency roads, which can be used as the basis of evaluating the Province/ Regency /City Governments' proposal (Rudjito et al., 2017).

Based on the background, this study was conducted to analyze the rigid pavement condition of Jalan Raya Babelan located in Bekasi Regency. The analysis is based on International Roughness Index

Latifa, E., Heryes, C. and Prihutomo, N.
Deterioration Analysis of Rigid Pavement using Roadroid based on PCI.
DOI: 10.5220/0010510100003153
In *Proceedings of the 9th Annual Southeast Asian International Seminar (ASAIS 2020)*, pages 31-36
ISBN: 978-989-758-518-0

(IRI) using Roadroid application. Types of deterioration were analyzed based on the Pavement Condition Index (PCI). Rigid pavement condition value and the type of deterioration will later be used as a reference to determine the appropriate response to the existing type of deterioration.

1.1 Prior Research

This study refers to previous research that discussed the assessment and identification of factors that cause road deterioration, as well as solutions for road deterioration (Agustyawan and Hartantyo 2016). The assessment of the functional condition of roads used the International Roughness Index (IRI) method with the application of Roadroid, Surface Distress Index (SDI) and Pavement Condition Index (Tho'atin, dkk 2016). Assessment of road conditions and network surveys in regions/cities on Java using Roadroid (Widjajanto, 2017).

Subsequent research to determine the performance of the road based on the function obtained from the comparison of IRI values with the level of road service (V/C ratio) and the physical condition of the road obtained from the SDI survey results and then used as a consideration in determining priorities for handling road rehabilitation (Achmadi, F, 2017). Evaluates the surface condition that is deteriorated using the Pavement Condition Index (PCI) method as well as local factors that influence the deterioration (Mulyadi and Saleh, 2018).

1.2 Causes of Rigid Pavement Road Deterioration

Rigid pavement is a construction with aggregate raw materials and use of cement as a binding material (Suryawan 2009). Rigid pavement consists of Portland cement concrete slab which is laid directly above the subgrade, or land base (Hardiyatmo, 2015). Deterioration to rigid pavement construction can be resulted from traffic, which can include increased load (vehicle axis) that exceeds the design load, and load repititions (vehicle volumes) that exceeds the volume of the plan so that the age of the road plan is not reached (Sukirman, 1999; Direktorat Jendral Bina Marga 2017). Besides, the poor road drainage system are predicted to cause water to get into the pavement structure through cracks, joints, and the road sides, will damp the soil base and reduce pavement strength, resulting in rapid deterioration of pavement (Hardiyatmo, 2015).

The nature of the pavement construction materials or poor material processing system can also be the caused this deterioration. Temperatures and precipitation are generally high, unstable subgrade conditions, poor soil properties, also, the bending of the rod straightness or incorrect use of the dowel and stressing caused by the expansion and shrinkage, rupture of the corner of the slab, deterioration to connections, and others conditions caused by reduced quality due to the strength of the concrete pavement (Hardiyatmo, 2007)

1.3 International Roughness Index (Iri)

International Roughness Index (IRI) is a parameter used by the world banks in the process of assessment of the pavement condition in 1980 (UMTRI. 1998). Pavement roughness is measured by the longitudinal profile which is a representation of the comfort of driving on highways. The roughness quantitative values are expressed in International Roughness Index (IRI), which is the cumulative length of the surface per unit length expressed in meters per kilometers (Suherman, 2008)

1.4 PAvement Condition Index (PCI)

The PCI value is determined by calculating and iterating the area and severity of the deterioration. According to Shahin (1994), there are 17 distress types to the rigid pavement, among others: blow-up/buckling, corner breaks/corner cracks, divided slab, durability "D" cracking, settlement or faulting, seal joint damage, lane/shoulder drop-off, linear cracking: longitudinal, transverse, and diagonal crack, patching and utility cuts, polished aggregate, popouts, pumping, punch-out, railroad crossing, scaling, map cracking, crazing, shrinkage cracks, and spalling. The damage level is expressed as light, medium and heavy. After that, determine the density, then determine the deduct value, reduce it, then correct the deduct value. All of these calculation steps use different formulas at each stage. PCI value is 100 - correction deduct value.

2 METHOD

2.1 Research Design

The primary data were obtained by site survey, a survey carried out with a car equipped with Roadroid application to identify the type of deterioration by walking along the research site. After collecting the

primary data, the data were analyzed. Road deterioration data were analyzed using International Roughness Index (IRI) method to obtain the value of rigid pavement conditions and using Pavement Condition Index (PCI) method to obtain the type of deterioration.

2.2 Research Stage

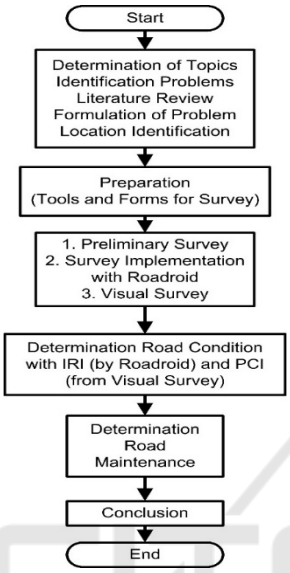

Figure 1. Flowchart of Survey Implementation with Roadroid Application

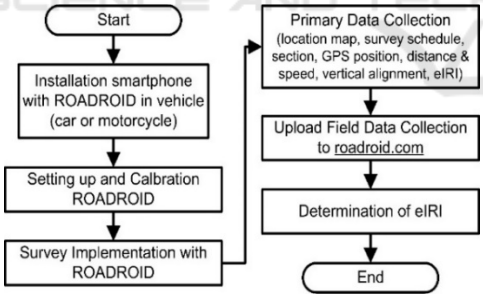

Figure 2. Flowchart of Visual Preliminary Survey Implementation according to Sample Selection Analysis Results

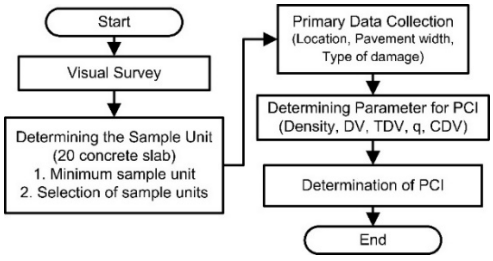

Figure 3. Flowchart of Research

2.3 Maintenance Program Type Determination

IRI value and maintenance program show in table 1 in appendix, table show PCI value with rigid pavement condition, and table 3 show the corelation of PCI value with maintenance program.

3 RESULT AND DISCUSSION

Rigid Pavement Condition Determination and Maintenance Program

3.1 Using International Roughness Index (IRI) Method

The results of rigid pavement condition assessment obtained from the rigid pavement condition survey results using Roadroid application show below. The percentage using International Roughness Index (IRI) method can be seen in Figure 4 appendix.

The data analyzed using IRI method indicated that values obtained ranged from 6.31 (moderate) to 33.81 (heavy deterioration). At STA 1+500 - 1+520, the largest IRI value (33.81) indicated the heaviest road deterioration condition. This stated that most of the Jalan Raya Babelan requires a minor reconstruction program, by repairing the deterioration that occurred in the form of the pavement overlay. Figure 5 and 6 in appendix shows IRI value at STA 1=500-1+520

3.2 Using Pavement Condition Index (PCI) Method

Based on the analysis of road deterioration, the results of the rigid pavement conditions value of the Pavement Condition Index (PCI) method from sample units 1 to 10 is gathered (see Figure 6). From the data analyzed using PCI method, obtained between 0 (failed) - 22 (serious. Sample unit 8 (STA 1+400 - 1+600) has the smallest PCI value of 0, which stated that the sample unit 8 is on the heaviest deterioration level.) This stated that Jalan Raya Babelan needs to be included in the minor reconstruction program, by repairing the deterioration that occurred in the form of the pavement overlay. The correlation of PCI value and maintenance program shows in fig.7 in appendix.

According to the two methods applied to the Jalan Raya Babelan, a comprehensive maintenance program can be recommended by re-coating the pavement, commonly referred to as an overlay.

3.3 Deterioration Handling

From the research results, detailed deterioration handling in the road segment can be seen in table 4 in appendix. However, as described above, for economical and efficiency, an overlay is a right step.

4 CONCLUSIONS

The results of condition assessment of Jalan Raya Babelan based on the International Roughness Index (IRI) and Pavement Condition Index (PCI) using Roadroid application shown that the value of IRI obtained between 6.31 (moderate) - 33.81 (heavy deterioration) which is 90% heavy deterioration condition.

According to the survey on Jalan Raya Babelan Sta 0+000 to 2+000 using Pavement Conditions Index (PCI), there are some types of deterioration such as (corner breaks/corner cracks), divided slab, seal joint damage, lane/shoulder drop-off, linear cracking, polished aggregate, popouts, punch-out, corner spalling, and joint spalling with high severity.

The deterioration handling that should be done to the Jalan Raya Babelan are cracks seal, full-depth patch, slab replacement/reconstruction, reseal joints, grove surface, overlay and partial-depth patch corresponding segments.

However, for economical and efficiency most of the Jalan Raya Babelan needs to be included in the minor reconstruction program, by repairing the deterioration that occurred in the form of the pavement overlay.

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APPENDIX

Table 1: IRI Maintenance Program

IRI value	Pavement condition	Handling Types
= 4	Good	Routine Maintenance
4-8	Moderate	Periodical Maintenance
8-12	Light Deterioration	Road Rehabilitation / Periodic
= 12	Heavy Deterioration	Road Reconstruction

(Source: General Directorate of Highways, 2011)

Table 2. PCI value

CONDITION CATEGORY	PAVEMENT CONDITION INDEX (PCI)	
	Upper Limit	Lower Limit
Excellent	100	86
Good	85	75
Fair	74	58
Poor	57	40
Failed	39	0

(Source:http://dpw.lacounty.gov/Pavement Management System)

Table 3 PCI Maintenance Program

Condition Value	Maintenance Program
100-86	Routine
85-75	Routine
74-58	Periodic
57-40	Rehabilitation/Periodic
39-0	Reconstruction/Improvement

(Source:http://dpw.lacounty.gov/Pavement Management System)

Table 4. Jalan Raya Babelan Deterioration

No.		Type of Deterioration	Sampel Unit	Deterioration Handling
1	22	*Corner Breaks/Corner Cracks*	1, 2, 3, 4, 5, 6, 7, 8, 9, 10	Seal cracks; full-depth patch.
2	23	*Divided Slab*	1, 2, 3, 4, 5, 7, 8, 9, 10	Slab replacement/reconstruction.
3	26	*Joint Seal Damage*	3	Reseal joints.
4	27	*Lane/Shoulder Drop-off*	7, 8, 10	Regrade and fill shoulders to match lane height.
5	28	*Linear Cracking*	1, 2, 3, 4, 5, 6, 7, 8, 9, 10	Seal cracks; full-depth patch; slab replacement.
6	31	*Polished Aggregate*	1, 2, 3, 4, 5, 6, 7, 8, 9, 10	Grove surface; overlay.
7	32	*Popouts*	1, 2, 3, 5	Do nothing.
8	34	*Punch-out*	1, 2, 3, 4, 5, 6, 7, 8, 9, 10	Full-depth patch.
9	38	*Spalling Corner*	1, 4, 9, 10	Partial-depth patch.
10	39	*Spalling Joint*	1, 2, 3, 4, 5, 6, 7, 8, 9, 10	Partial-depth patch; Reconstruct joint.

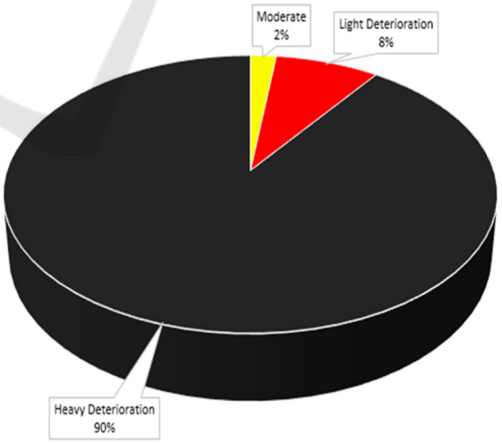

Figure 4. Rigid Pavement Condition Percentage Using IRI Method

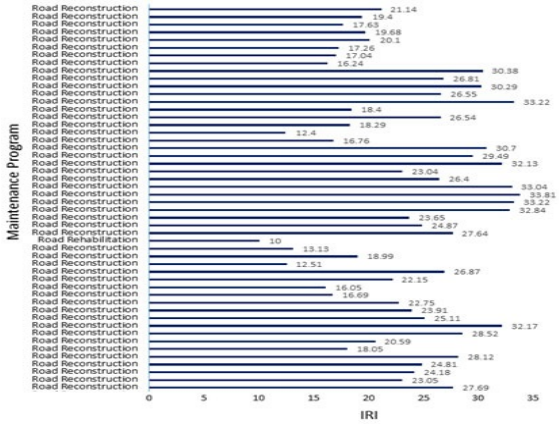

Figure 5. IRI Value at STA 1+500-1+520

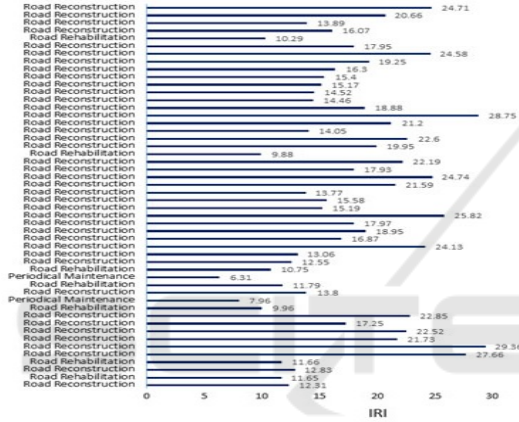

Figure 6. IRI Value at STA 1+500-1+520