



## The Assessment Of National Road Surface Conditions Analysis Based On The International Roughness Index (IRI) Method Using Roadroid Application

\*Didi Herianto Mahendra<sup>1</sup>, Komala Erwan<sup>1</sup>, and S. Nurlaily Kadarini<sup>1</sup>

<sup>1</sup>Fakultas Teknik, Universitas Tanjungpura, Pontianak  
\*didimahendra00@student.untan.ac.id

<b>Abstract</b>	<b>Article history:</b> <i>Submitted 23-11-2022</i> <i>Revise on 26-12-2022</i> <i>Published on 28-02-2023</i>
<p>Road infrastructure supports community needs and socioeconomic mobility. Given its importance, road construction and maintenance should be examined, planned, implemented, and maintained. Road maintenance requires surface measuring. For road maintenance and repair, it is necessary to measure the condition of the road surface, namely by analyzing the state of the road surface. One method to analyze the state of the road surface is the International Red Index (IRI) method using the Roadroid application.</p> <p>This study analyzes the road surface, particularly the National Road segment in West Kalimantan, Jalan Khatulistiwa, and compares it to BPJN's 2021 second-semester measurements. This study used primary and secondary data, including photo documentation of STA points on Jalan Khatulistiwa and Roadroid field surveys (road handling data from Bina Marga, data on the administration of the Jalan Khatulistiwa section by the Pontianak PUPR Office, Survey Guidelines for Collecting Road Network Condition Data, and BPJN IRI Data on Jalan Khatulistiwa).</p> <p>According to the study, 56 segments of Khatulistiwa Road need periodic maintenance, and 13 need routine upkeep. Pd-01-2021-BM states that Roadroid's IRI value meets class III unevenness measuring parameters (IRI). The Roadroid application tends to produce an IRI value higher than a laser profilometer. However, it approaches it with an average percentage difference per segment of 2.91% with two segments with distinct circumstances.</p>	<b>Keyword:</b> <i>Road Surface Condition, International Roughness Index (IRI), Roadroid.</i> <p>DOI: <a href="http://dx.doi.org/10.26418/jtsft">http://dx.doi.org/10.26418/jtsft</a></p>

### 1. Introduction

With the enormous benefits of roads for the life of the nation and the economic progress of the community, there are two main requirements for road pavement, namely: road surface condition requirements such as no waves, no holes, and

being able to withstand the frictional forces received from vehicles, then structural requirements related to the waterproof ability and strength of the road to withstand and spread the load of vehicles passing on it. The condition and quality of the constructed road are closely related to the pavement. The condition of the road surface

is closely related to the comfort of traffic users, so any damage to the road is directly related to the increased potential for accidents (Hasibuan & Surbakti, 2019).

One of the roads that are a transportation route that has a vital role in Kalimantan Barat Province is the Jalan Khatulistiwa section which has a length of 6,830 m and is a national road managed by the National Road Implementation Center (BPJN). With various factors, BPJN believes it vital to know the Jalan Khatulistiwa surface condition to analyze the damage depending on the kind and level of damage to serve as a foundation for maintenance and repair actions. In the second semester of 2021, BPJN measured the surface condition of the Jalan Khatulistiwa using the Laser Profilometer measuring instrument method. The Laser Profilometer is a road surface condition measuring instrument that has long been used and has proven its validity in various tests of road surface conditions in Indonesia. The measurement results found that most of the Jalan Khatulistiwa surface conditions were in the medium criteria.

In addition to the Laser Profilometer, one way to determine the condition of the pavement is by using the Roadroid application, an android (smartphone) application available on the Google Play Store. The application, developed by a Swedish company, was created to measure road roughness. The use of Roadroid to measure the IRI value cannot be used as a basis for the primary testing tool because the standard tool used in Indonesia must be class 1.

This research is a study to understand how to survey, process, and analyze road conditions based on the International Roughness Index (IRI) method with the Roadroid application to obtain the shape of the road under review. As a result, it is possible to ascertain whether or not the Roadroid application is reliable in accurately assessing the state of the road surface layer.

## 2. Materials and Methods

### 2.1. Theoretical Frame Work

The road surface condition is closely related to traffic users' convenience, so any damage that occurs to Roads is directly related to the increased potential for accidents. Based on the Direktorat Bina Marga (2011), there are four types of roads based on surface conditions: roads in reasonable, moderate, slightly damaged, and heavily damaged conditions. This classification is similar to the IRI parameters used in assessing road conditions. The International Roughness Index is a type of road condition assessment that refers to the IRI value obtained from field observations. One of the tools used to obtain IRI

values is Roadroid, a smartphone application with sensors and systems that can record road conditions used efficiently, which in its use to measure IRI values must be validated.

### 2.2. Research Location

This study was done on Jalan Khatulistiwa, one of the national roads in Kota Pontianak, Kalimantan Barat Province.



Fig. 1 Research Location

### 2.3. Data

This study used primary and secondary data, including photo documentation of STA points on Jalan Khatulistiwa and Roadroid field surveys (road handling data from Bina Marga, data on the administration of the Jalan Khatulistiwa section by the Pontianak PUPR Office, Survey Guidelines for Collecting Road Network Condition Data, and BPJN IRI Data on Jalan Khatulistiwa).

Direct observation surveys at the research site provide primary data, whereas literature studies in books, journals, and reference data from selected parties provide secondary data.

The equipment used by using the IRI method in this study is as follows: android smartphone, Roadroid application, phone holder, Fortuner car (Jeep type with engine specifications of 2000 cc and tire pressure of 30-33 psi).

### 2.4. Analysis Method

After the necessary data has been collected, the analysis steps needed to obtain the surface condition of Equator Road according to the IRI parameters in order to provide recommendations for repairing road damage are:

- Upload the data obtained to the Roadroid application provider for error checking and data validity.
- Compile the data recorded and checked by the Roadroid app in a customized table per 100m segments of the total measured distance.
- Adjust the numbers obtained in each segment with the IRI parameter table found in the following table;

**Table 1.** IRI Values for Road Surface Conditions

Category	IRI	Recommendation
Good	IRI ≤ 4	Routine Maintenance
Fair	4 ≤ IRI ≤ 8	Periodic Maintenance
Slightly Damage	8 ≤ IRI ≤ 12	Reconstruction/Upgrade
Heavily Damage	>12	Reconstruction/Upgrade

- d. Collect all road conditions in each segment and enter them into the IRI value data graph.
- e. Determine the road condition for each segment based on the IRI parameters as shown in the following table:

**Table 2.** Relationship between all methods for measuring road conditions

PCI	Road Condition	RCI	Visual Condition of Road	IRI	Description	PSI	Service Function	SDI	Road Condition
86-100	Excellent	8-10	Very Flat and organized.	< 4	Excellent	4-5	Excellent	< 50	Good
71-85	Good	7-8	Very good, generally flat.	4-8	Good-Fair.	3-4	Good	50-100	Fair
56-70	Fair	6-7	Good.	8-12	Fair-Poor.	2-3	Fair	50-100	Fair
41-55	Bad	5-6	Fair, very few potholes but uneven road surface.	12-16	Poor-Bad	1-2	Bad	100-150	Slightly Damage
26-40	Very Bad	4-5	Poor road surface with occasional potholes and unevenness.	16-20	Bad	1-2	Bad	100-150	Slightly Damage
11-25	Serious	3-4	Damaged, with many potholes, and bumpy.	≥ 20	Very Bad	0-1	Very Bad	≥ 150	Heavily Damage
			2-3 Damaged, with many potholes, and bumpy.						
0-10	Failed	≤ 2	It is impassable except by 4WD vehicles.	Any	Unsealed				

- f. Each road condition category based on the IRI parameter is compiled as a percent and put into a pie chart with the following conditions; Good, Moderate, lightly damaged, severely damaged.
- g. After obtaining data on all road surface conditions for each segment, the road category that has the most significant percent value is used as a parameter to determine the type of road handling.
- h. Testing the validity of the Roadroid as an IRI measurement tool according to Pd-01-2021-Bm is carried out by regression testing.

$$RM = SE \times A + B \dots\dots\dots (1)$$

With:

- RM : Measurements using tools
- SE : Measurements using tools validated

A : The most similarity of lines close/close

B : The intercept of line best fit (regression offset)

The regression test based on the limits set out in Pd-01-2021-Bm with a tolerance limit for a value difference of less than 0.3, as shown in the following table:

**Table 3.** Validation Acceptance Limit

Slope (A)	Intercept (B)	Correlation (R <sup>2</sup> )	Acceptance Limit
0,98-1,02	0,5 IRI	Min 0,93	≤ 0,3 IRI

1. Calculating Slope (A)

$$A = \frac{\sum Y (\sum X^2) - \sum X \cdot \sum Y}{n \sum X^2 - (\sum X)^2} \dots\dots\dots (2)$$

2. Calculating Intercept (B)

$$B = \frac{n \sum XY - \sum X \cdot \sum Y}{n \sum X^2 - (\sum X)^2} \dots\dots\dots (3)$$

3. Calculating Correlation (R<sup>2</sup>)

$$R^2 = \frac{n \sum XY - \sum X \cdot \sum Y}{\sqrt{[n(\sum x^2) - (\sum X)^2][n(\sum y^2) - (\sum Y)^2]}} \dots\dots\dots (4)$$

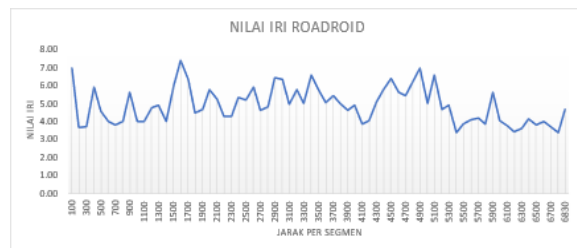
In this research, Microsoft Excel is used for regression testing on Roadroid. Regression in the Data Analysis feature is employed.

**3. Result and Methods and Discussion**

Roadroid measured the IRI value twice on Jalan Khatulistiwa's 69 segments. These two measurements showed that Jalan Khatulistiwa had the same IRI in each segment but different speeds. Only field survey results from the first experiment are listed.

**3.1. IRI, Road Surface Condition, and Roadroid Maintenance Recommendations for Jalan Khatulistiwa**

The following figure shows Roadroid IRI values for each segment:



**Fig 2.** IRI Roadroid Value in Each Segment

**Table 4.** Conditions and Recommendations on Segments

Total Segment	Percentacy	Condition	Recommendation
13	18.84%	Good	Routine Maintenance
56	81.16%	Medium	Periodic Maintenance
0	0	Lightly Damaged	Reconstruction/Up grade
0	0	Heavily Damaged	Reconstruction/Up grade
<b>Total Segment: 69 Segments</b>			

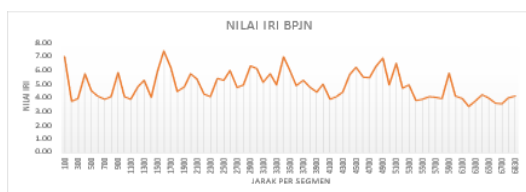
From the analysis results presented in Table 4, it turns out that the surface condition of Equator Road in this study is about 81% in moderate disease and 19% in good condition. Thus, there is a need for periodic maintenance on 56 segments and routine maintenance on 13 segments of the Jalan Khatulistiwa section.

### 3.2. Comparison of pavement condition of Jalan Khatulistiwa from Roadroid Application and Laser Profilometer Reading

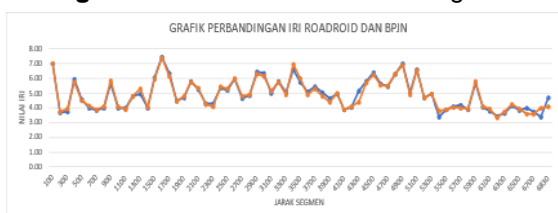
The following is the BPJN IRI value in each Equatorial Road Segment (BPJN, 2021) and a comparison of the IRI values obtained using the Roadroid application and the laser profilometer in each segment.

**Table 5.** Data of Jalan Khatulistiwa by BPJN

Total Segment	Percentacy	Condition	Recommendation
15	21.74%	Good	Routine Maintenance
54	78.26%	Medium	Periodic Maintenance
0	0	Lightly Damaged	Reconstruction/Up grade
0	0	Heavily Damaged	Reconstruction/Up grade
<b>Total Segment: 69 Segments</b>			



**Fig. 3** IRI BPJN Value in Each Segment



**Fig. 4** Comparison of IRI Roadroid and Laser Profilometer Values

From Table 4, the surface condition of Equator Road, according to the laser profilometer method by BPJN, is around 78% in moderate condition and 22% in good condition. As a result, the surface condition of Jalan Khatulistiwa should be handled in 54 segments for periodic maintenance and 15 segments for regular maintenance. There are three (three) areas of concern based on the data received from both methodologies;

#### a) *Tendency*

- The IRI Roadroid value, which is smaller than the BPJN IRI value, is 33 segments with an average percentage difference of 2.87% per segment.
- The IRI Roadroid value is 36 segments higher than the BPJN IRI value, with an average percentage difference of 2.95% each segment.
- The findings reveal that the IRI value achieved by Roadroid is higher than the IRI value produced by BPJN using a laser profilometer.

#### b) *Cumulative data*

- Roadroid reported a total IRI value of 340, 10, whereas BPJN achieved a total IRI value of 339.28 using a laser profilometer.
- The difference in total IRI values between the two tools is 0.82.
- The percentage difference between Roadroid and BPJN data utilizing a laser profilometer based on the cumulative IRI number is 0.24%. As a result, the accuracy of the IRI value derived by Roadroid compared to BPJN data is 99.75%.

#### c) *Percentage difference per segment*

- The average percentage difference per segment is 2.91%.
- The average proportion of IRI values in Roadroid close to IRI values in BPJN data is 97.09%.

Based on IRI data gathered with the Roadroid and Laser Profilometer apps, as many as 67 segments (97.10%) are the same. In comparison, two segments (2.90%) have distinct circumstances, notably in STA 1+100 and 6+600, where the two segments diverge on Roadroid readings. These segments are in fair condition, according to BPJN statistics, whereas the other two are in excellent condition.

### 3.3. Roadroid Validity Test

According to the requirements of Pd-01-2021-BM, the IRI measuring instrument may be evaluated in two ways: by comparing the IRI value to the provisions included in the Road Network Condition Data Collection Survey Guidelines, and



by testing with a class I measuring instrument (laser profilometer). Pd-01-2021-BM requires class I measuring instruments (laser profilometer) to be used to test class III measuring instruments to achieve a minimum similarity rate of 80%. Comparing Roadroid and the laser profilometer based on the IRI value, a similarity level of 97.10% is obtained, indicating that the Roadroid has complied with these requirements.

In the Roadroid test, regression testing is carried out by comparing the IRI value with the provisions contained in the Guidelines for the Road Network Condition Data Collection Survey. Regression testing on Roadroid in this study uses Microsoft Excel. The tools used are Regression in the Data Analysis feature. The following graph depicts the outcomes of the variables A, B, and R<sup>2</sup> calculations:

<i>Regression Statistics</i>	
Multiple R	0.98005953
R Square	0.96
Adjusted R Squ	0.95992738
Standard Error	0.19940207
Observations	69

Fig. 5 Calculation Results of R<sup>2</sup>

ANOVA					
	df	SS	MS	F	Significance F
Regression	1	64.80751663	64.80752	1629.919	9.45428E-49
Residual	67	2.66399931	0.039761		
Total	68	67.47151594			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%
Intercept	0.2	0.120457961	1.256988	0.213122	-0.089020922
X Variable 1	0.97	0.023948502	40.37226	9.45E-49	0.919053696

Fig. 6 Calculation Results of A and B

From the above calculation results obtained:

A = 0.97  
 B = 0.2  
 R<sup>2</sup> = 0.96

The three variables are then compared with the validation acceptance limit contained in Table 2, with the provisions of the tolerance limit of 0.3, as follows:

A = 0.98-1.02  
 B = 0.5

R<sup>2</sup> = 0.93

With these provisions, the three variables produced from the regression test satisfy the criteria for the validation acceptance limit specified in Pd-01-2021-BM. With the completion of the two validity testing requirements, Roadroid is shown valid in measuring the IRI value.

**4. Conclusion**

Based on the outcomes of the preceding chapter's computations and analyses, the following conclusions may be drawn:

- a) Most of the Jalan Khatulistiwa's surface conditions are moderate, with 56 segments (81.16%) in excellent condition and 13 segments (18.84%) in poor condition. With 56 segments of Jalan Khatulistiwa in moderate condition, there is a need for periodic maintenance on these road segments. Conversely, 13 road segments need maintenance, and the remaining segments are in excellent condition.
- b) Roadroid tends to produce higher IRI values than those obtained using a laser profilometer because the measurement results of 69 segments of the Jalan Khatulistiwa section, which show variations in the comparison of Roadroid IRI values with BPJN data IRI values using a laser profilometer as follows;
  - 36 segments showed better Roadroid IRI values than BPJN IRI data using a laser profilometer with an average percentage difference per segment of 2.95%.
  - 33 segments showed Roadroid IRI values smaller than the BPJN data obtained using the laser profilometer. With an average percentage difference per segment of 2.87%.
- c) IRI Roadroid's overall value is 340.10 m/km, whereas BPJN's total value is 339.28 m/km. The difference in the overall IRI value of the two data was determined to be 0.82 m/km or 0.24% based on the cumulative IRI value of Roadroid and BPJN. As a result, the IRI value acquired by Roadroid is likely to be similar to the IRI value produced by BPJN using a laser profilometer.
- d) The average percentage difference in IRI values per segment between Roadroid and BPJN data using a laser profilometer is 2.91%.
- e) Based on the level of similarity of road surface conditions of 69 segments as measured by Roadroid and laser profilometer, 67 segments (97.10%) are the same. There are two segments (2.90%) with different conditions, namely in STA 1+100 and 6+ 600 where on the Roadroid readings the two segments are in moderate condition, while the BPJN data

states that the two segments are in good condition.

- f) According to the validity conditions of the IRI value measuring tool given in Pd-01-2021-BM, the tool is deemed valid if the A, B, and R2 values are within the range indicated in Table 2. The IRI value test is based on this. Testing the IRI Roadroid value on these three variables yields a slope (A) of 0.97, an intercept (B) of 0.2, and a correlation (R2) of 0.96. Based on the results of the tests, it is possible to conclude that Roadroid is genuine and meets the standards for a class III unevenness measurement equipment (IRI).

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### 6. Author's Note

Everything written in this article is original because it sums up my studies with Ir. Komala Erwan, M.T., IPM., ASEAN Eng, and S. Nurlaily Kadarini, S.T., M.T., IPM. The contents of this article have been reviewed in a thesis defense at the Department of Civil Engineering, The University of Tanjungpura, on 27 October 2022 by Dr.Ing. Ir. Slamet Widodo, M.T., IPM. and Heri Azwansyah, S.T., M.T., IPM.

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