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

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Abstract

Roads are infrastructure that has a vital role for the community in supporting social and economic activities. Therefore, appropriate handling information is needed for road maintenance and improvement to be on target. One of the methods used is the International Roughness Index (IRI) method with the help of the Road bump application. The purpose of this study is to analyze and recommend handling road surface conditions, as well as to test the validity of the Road bump application with a Laser Profilometer. This research was conducted on the 10 KM section of Trans Kalimantan Road. Comparative data is obtained from secondary data issued by BPJN in 2021 using the Laser Profilometer tool. This study found that the condition of the Trans Kalimantan Road was 80% in the excellent category, 18% in the moderate category, and 2% in the slightly damaged category, and had similarities with the BPJN IRI value of 95%. Road bump also tends to the IRI value to be greater than the BPJN IRI value. Based on the results of this study, the Road bump application can be used as an alternative tool for measuring road surface conditions using the International Roughness Index (IRI) method.

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1. Introduction

Roads are one of the critical infrastructures in supporting human needs in economic and social terms. Good road conditions will make it easier for people to do activities.

The road surface means that vehicles repeatedly pass, both with a significant weight to a small weight. Therefore, road infrastructure is usually burdened by repeated traffic volumes that can decrease road surface quality. One of the road sections that experienced this problem was the Trans Kalimantan Road section. The Trans Kalimantan Road section has a length of about 94430 m. National Road is managed by the Balai Pelaksanaan Jalan Nasional (BPJN).

Because of the importance of road handling, it is necessary to use methods to be on track for handling; the International Roughness Index (IRI) Method is used. BPJN, as the national road manager, uses a Laser Profilometer to determine the condition of the road surface. In addition to the Lase Profilometer, one way of assessing the state of the road surface is obtained using the Road bump application. Road Bump is an application produced and developed by David Grimmer. The app works by utilizing the GPS feature on the smartphone that will record the unevenness of the road after being calibrated with some adjustments. With the Road bump application, road condition values can be measured effectively and efficiently.

2. Materials and Methods

2.1. Theoretical Frame Work

Based on the importance of road infrastructure to the community, the road sector's research and development should be a priority, including the

planning, implementation of construction, and maintenance. The Trans Kalimantan Road is a road that has a vital role in transportation routes in West Kalimantan, so periodic maintenance and repairs are needed to help assess and maintain the condition of the road; a method of measuring road surface conditions is needed, which can be done with the Road bump application. With this application, the IRI value of the road will be obtained, as well as recommendations for proper maintenance of the road and check the validity of the Road bump as a measuring tool for IRI.

2.2. Research Location

The research location used in this study is one of the national roads in West Kalimantan Province, namely the Trans Kalimantan Road, Pontianak, along 10 KM.

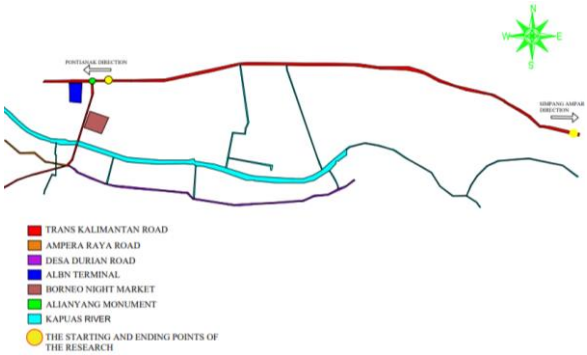

Fig. 1 Research Location

2.3. Data

This study has two types of data used: primary and secondary. Primary Data consists of IRI value data from each STA obtained through surveys and field documentation. In contrast, secondary data is obtained from BPJN IRI Data on Trans Kalimantan Road, 2021, and Road Network Condition Data Collection Survey Guidelines, 2021This 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.

2.4. Analysis Method

Data analysis was carried out after a survey in the field to find IRI values using the Road bump application was completed. After that, data analysis was carried out by comparing the IRI value obtained from the Road bump application with the IRI value from BPJN. Then test the validity of the Road bump application as an IRI measuring. Through analysis, it can be determined if the road conditions are within expectations and if the appropriate handling strategy has been implemented.

The use of the Road Bump application in data retrieval is carried out by pairing a smartphone device with the phone holder on the vehicle's dashboard, activating the Road Bump application, and starting data recording from the initial STA point to the last. After that, the survey data will be uploaded to the web and processed. After processing, the data can be downloaded as Microsoft Excel.

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

a. 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, and severely damaged.
b. After obtaining data on all road surface conditions for each segment, the road category with the most significant percent value is used to determine the type of road handling.
c. Testing the validity of the Road bump as an IRI measurement tool according to Pd-01-2021-Bm is carried out by regression testing.

RM=SE x A+B ……..…… (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 2. Validation Acceptance Limit

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

$$A = \frac{\sum Y\,(\sum X^2) - \sum X.\sum Y}{n\sum X^2 - (\sum X)^2} \quad (2)$$

2. Calculating Intercept (B)

$$B = \frac{n\sum XY - \sum X.\sum XY}{n\sum X^2 - (\sum X)^2} \quad (3)$$

3. Calculating Correlation (R^2)

$$\frac{n\sum XY - \sum X.\sum XY}{\sqrt{[n(\sum x^2) - (\sum X)^2][n(\sum y^2) - (\sum y)^2]}} \quad (4)$$

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

3. Result and Methods and Discussion

The research was conducted on one of the national roads in West Kalimantan, namely the 10 km Trans Kalimantan Road. Measurement of IRI values is carried out twice with the number of 100 segments on each path, the measurement starts from STA 0+100 – STA 9+1000 and STA 9+1000 – STA 0+000.

3.1. IRI value of the Road bump application and recommendations for handling it

The following figure shows Roadroid IRI values for each segment:

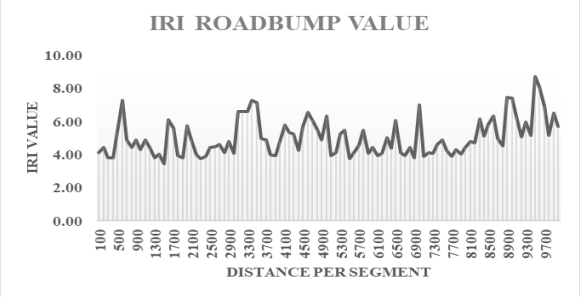

Fig 2. IRI Road bump Value in Each Segment

Table 3. Conditions and Recommendations on Segments

Total Segment	Persentacy	Condition	Handling Reccomendation
18	18%	Good	Routine Maintenance
80	80%	Medium	Periodic Maintenance
2	2%	Lightly Damaged	Reconstruction / Update
0	0%	Heavily Damaged	Reconstruction / Update

With these data, it can be concluded that the surface condition of the Trans Kalimantan Road in this study is around 80% in a condition of routine maintenance, 18% is in good condition for periodic maintenance and 2% is in a condition of minor damage, an increase is carried out.

3.2. IRI Value from BPJN and Recommendations for Handling

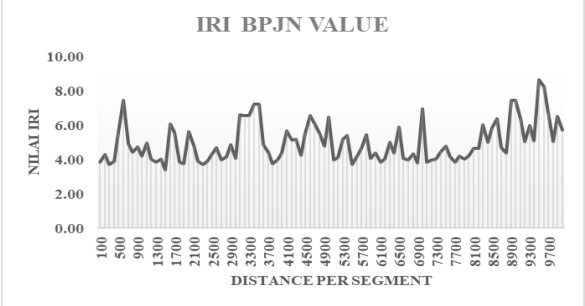

Fig. 3 IRI BPJN Value in Each Segment

Table 5. Data of Jalan Khatulistiwa by BPJN

Total Segment	Persentacy	Condition	Handling Reccomendation
23	23%	Good	Routine Maintenance
75	75%	Medium	Periodic Maintenance
2	2%	Lightly Damaged	Reconstruction / Update
0	0%	Heavily Damaged	Reconstruction / Update

With this data, it can be concluded that the surface condition of the Trans Kalimantan Road according to BPJN data ranges from 75% to being in a condition of routine maintenance, 23% is in good condition for periodic maintenance and 2% is in a condition of minor damage to be increased.

3.3. Comparison of IRI Road bump Value and IRI Value of BPJN

Based on the IRI data that has been collected, it can be seen that the comparison of the IRI values of the two tools can be seen as follows

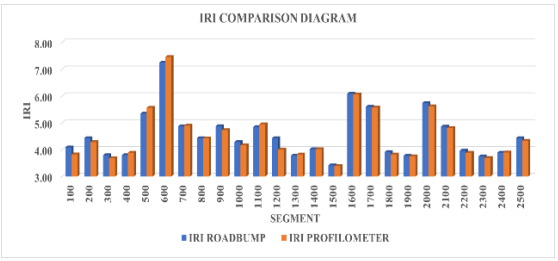

Fig. 4 IRI Road bump STA 0+100 – STA 2+500

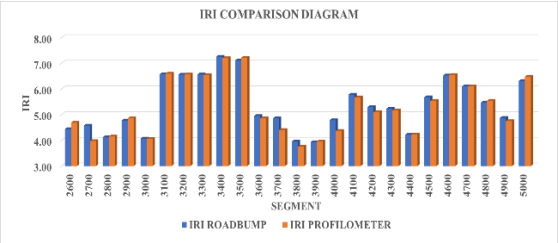

Fig. 5 IRI Road bump STA 2+600 – STA 5+000

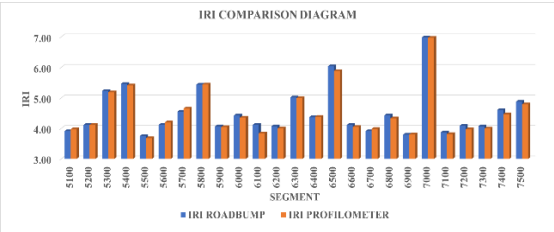

Fig. 6 IRI Road bump STA 5+100 – STA 7+500

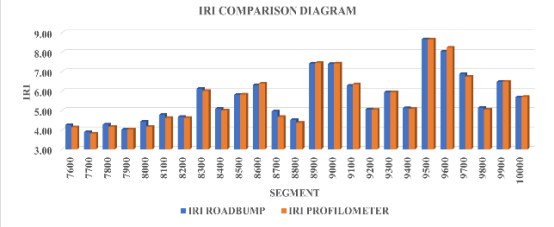

Fig. 7 IRI Road bump STA 7+600 – STA 10+000

From the data obtained from both methods, 2 (two) aspects can be assessed

a) Tendency

- The IRI Road bump value is smaller than the IRI BPJN value of 31 segments with an average percentage difference per segment of 1.36%.
- The IRI Road bump value is greater than the IRI BPJN value of 69 segments with an average percentage difference per segment of 2.32%.

b) Percentage difference per segment

- The average percentage difference per segment is 2.01%.
- The average proportion of IRI values in Road bump close to IRI values in BPJN data is 97.99%.

Based on the level of similarity in the surface condition of the Trans Kalimantan Road, as many as 100 segments, it was found that 95 details had the same conditions. Five components had different conditions, namely at STA 0 + 100, 2 + 700, 6 + 200, 7 + 200, 7 + 300 where the five segments were in moderate condition according to the assessment of the Road bump Application. At the same time, BPJN data stated that the five segments were in good condition.

3.4. Road bump Validity Test

According to practice, testing the validity of a tool for the International Roughness Index (IRI) method can be done in two ways, such as

- Testing validity by comparing it with a class I measuring instrument (Laser Profilometer)
- Contained in the Road Network Condition Data Collection Survey Guidelines (PD-01-2021-BM)

Based on the provisions of Pd-01-2021-BM which states that class III measuring instruments must be tested with class I measuring instruments (Laser Profilometer) by achieving a minimum similarity level of 80%.

a) Testing Validity by comparing it with class I measuring instruments

From the comparison of the IRI Road bump value with the IRI BPJN value, it was found that the IRI Road bump value has a similarity level of up to 95% as shown in the following figure

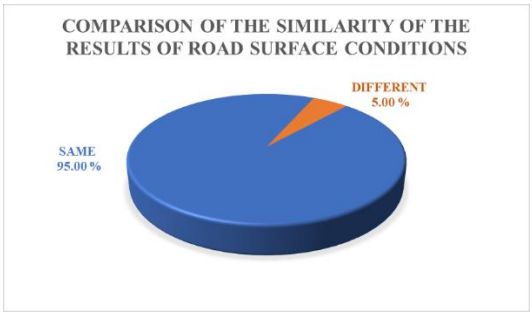

Fig. 7 Comparison of similarity results

With this data, it can be concluded that the Road bump application meets the requirements issued by Pd-01-2021-BM as a class III IRI measuring instrument that can be used as an alternative to measuring IRI values.

b) Comparing the value of IRI with the provisions of the road network condition data collection survey guidelines

The IRI value test based on the provisions of Pd-01-2021-BM was carried out using the Regression method (Square Regression). Regression testing is carried out with the equations contained in formula (1) of which each variable can be obtained using Microsoft Excel. The tool used is Regression on the Data Tab. The calculation results of variable Slope (A), Intercept (B), and Correlation (R2) are shown in the following figure

Regression Statistics	
Multiple R	0.9940529
R Square	0.99
Adjusted R Square	0.9880189
Standard Error	0.1228346
Observations	99

Fig. 8 Calculation Results of R^2

ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	121.9525209	121.95252	8082.5615	3.16954E-95
Residual	97	1.463569991	0.0150884		
Total	98	123.4160909			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	0.2	0.054805296	4.1925034	6.097E-05	0.120998052
X Variable 1	0.96	0.010714307	89.903067	3.17E-95	0.941984116

Fig. 9 Calculation Results A and B

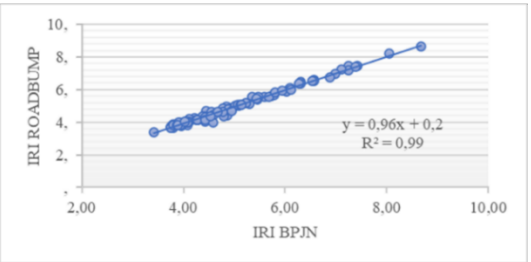

Fig. 10 IRI Correlation

From the above calculation results obtained:
A = 0.96
B = 0.2
R2 = 0.99
With these provisions, the three variables obtained from the regression test meet the requirements of the validation acceptance limit according to Pd-01-2021-BM. With the fulfillment of these two validity test provisions, the Roadroid is proven to be valid in measuring the value of IRI

4. Conclusion

The analysis results show that road bumps produce higher IRI values than those measured using a laser profilometer. Based on the calculations and analysis conducted, it can be concluded that most of the surface conditions of the Trans Kalimantan Road are in moderate condition, with a total of 80 segments (80%), indicating a recommendation for periodic maintenance. There are 18 segments (18%) in good condition, suggesting routine maintenance, and two segments (2%) with minor damage, indicating a need for improvement. The number of details correlates with the IRI values, as 69 out of 100 components have higher Road Bump scores. In comparison, 31 elements show lower IRI values from Road Bump compared to the BPJN data obtained using a Laser Profilometer. The average percentage difference is 2.32% for higher IRI values from Road Bump. The reason for the tendency of higher IRI values from Road Bump compared to the IRI BPJN values is that the IRI BPJN values were taken in 2021, while the research using the Road Bump application was conducted in December 2022. Therefore, there is a high probability of differences due to the significant period and possibly minor repairs or changes in road conditions from initially good to moderate on the Trans Kalimantan Road during that period. Using the Laser Profilometer, the analysis also revealed an average percentage difference of 2.01% in IRI values per segment between Road Bump and BPJN data. Based on the level of similarity in road surface conditions, out of the 100 components measured by Road Bump and laser profilometer, 95 segments (95%) have the same conditions.

In contrast, five elements (5%) show different conditions. These differences occur at STA 0+100, 2+700, 6+200, 7+200, and 7+300, where the Road Bump readings indicate moderate conditions. At the same time, the BPJN data states that these segments are in good condition. Regarding the validity provisions of the IRI value, the measurement tool said in Pd-01-2021-BM, which considers the device valid if the values of A, B, and R2 fall within the range listed in Table 2, the testing of Road Bump's IRI value against these three variables resulted in a slope value (A) of 0.96, intercept (B) of 0.2, and correlation (R2) of 0.99. Therefore, based on the test results, Road Bump can be considered valid and meets the requirements as a class III unevenness measurement tool (IRI).

5. Acknowledgment

First, I thank my parents, sister, and brother for their unwavering support and for ensuring the successful completion of this study. I am immensely thankful to Dr. Elsa Tri Mukti, S.T., M.T., and S. Nurlaily Kadarini, S.T., M.T., IPM., for their invaluable guidance and imparting their knowledge, which contributed to the creation of this study that can serve as a valuable reference in assessing national road structures in West Kalimantan Province, Indonesia. Additionally, I extend my appreciation to the Jurnal Teknik Sipil UNTAN (JTS) Team for their willingness to publish the findings of this study, thus making it a valuable resource for all, particularly for the assessment of national road structures in West Kalimantan Province, Indonesia.

6. Author's Note

Everything written in this article is original because it sums up my studies with Dr. Elsa Tri Mukti, S.T., M.T., 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 01 February 2023 by Dr.Ing. Ir. Slamet Widodo, M.T., IPM. and Heri Azwansyah, S.T., M.T., IPM.

I as the author of this journal state that no conflict occurs in the publication of this journal and no other party publishes this journal, this journal is free from plagiarism.

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