Assessment of the road based on PCI and IRI roadroid measurement

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Abstract. There are two methods of road assessment, ie, visually and using tools. Visual assessment makes use of the PCI (Pavement Condition Index), while assessment with the Roadroid app can be used to obtain the value of IRI (International Roughness Index) with less cost. Functional assessment of roads in the field more use of visual methods. This method is influenced by the subjectivity of surveyors. Therefore, the assessment using the visual method should be correlated with the assessment method using tools, in order to reduce the subjectivity of road assessment. The research location used is Magetan District Road consisting of 5 road segments. The result shows that the r road assessment using the PCI method has a very good condition, and using IRI Roadroid has a Medium condition. There is a negative (r) correlation between PCI and IRI Roadroid, valued at -0.23. The negative correlation shows that both judgments reversed. Comparison of PCI assessment with IRI Roadroid has a low correlation value and with t-test, yields no comparison of correlation. This result is because the PCI and IRI equally assess the pavement, using different methods.

1 Introduction

1.1 Background

Implementation of road maintenance is part of road operations that serve to monitor whether or not the road can be used properly. The provincial roads are a nationally integrated network of supporters required to meet established minimum service standards.

Puddles and excessive vehicle loads are external factors that accelerate damage, resulting in a short road life and are incompatible with the age of the plan [1]. The internal factors (pavement carrying capacity) that maintain the road are the most important. Therefore, the road is not too easily influenced by both external factors [2].

The PCI (Pavement Condition Index) is a system of assessment of pavement conditions based on type, and extent of damage occurring and can be used as a reference in the maintenance business [3].

The IRI (International Roughness Index) is an assessment of road quality using tools. Therefore, there is a need for comparison of correlation between the two methods. IRI is

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expressed in the amount of vertical change of road surface for each unit of road length (m / km). M that can be used to find the value of IRI include the NAASRA Roughness meter, Roadroid (Android Smartphone Application) and others. The IRI used in this study is the IRI Roadroid, used as a national reference to get the value of IRI because the cost is relatively cheap and still efficient [4].

Functional assessments in the field more use of visual methods. This method is influenced by the subjectivity of the surveyors. While assessment using IRI Roadroid is done only in one path on each road. Therefore, the assessment of the visual method is correlated with the assessment method by using tools to reduce subjectivity, in addition to the IRI Roadroid value required in each road path review [5].

1.2 Objectives and benefits

The objectives of this research are to understand the condition of pavement assessment on Magetan Road with PCI and IRI Roadroid assessment method. In addition, this study searches for correlations between PCI and IRI Roadroid road assessments with variations in speed, and back and forth in the assessment of functional road conditions.

1.3 Literature review

According to Shahin (1994), a condition survey is a survey intended to determine the condition of the pavement at any given time. This survey does not assess pavement strength, only surface conditions. Further assessment is used as to reference the road maintenance phase.

Road assessment by the PCI method can classify the type and extent of pavement damage and improvement efforts. The assessment also serves as a determining factor of if the road segment needs maintenance priority [2].

Roadroid is a service that provides quality road measurements through an app installed on a regular smartphone. This smartphone is calibrated and positioned in the vehicle. At the start of the measurement, the accelerometer analyzes the vibrations and compares the data to the International Roughness Index (IRI) [6]. This Roadroid calculated IRI correlated with a laser measurement system with an accuracy of 81%.

Assessment of road conditions using vibration sensors and GPS on smartphones is expected to provide early warnings of road pavement damage, as well as cost and time, that are highly effective in the assessment process [6].

PCI and IRI are assessments of functional conditions of roads that can be used as road damage takers. IRI is the value generated from the survey using a specific tool, while PCI is generated from a visual survey. Assessment of pavement conditions by the PCI method can be used as a decision-making metric for road improvement based on the type and extent of pavement damage [3].

2 Research method

2.1 PCI and IRI roadroid data acquisition

The research location used was Magetan Regency Road. The roads are Parang-Kalipucang, Ngariboyo-Tamanarum, Bangsri-Plaosan, and Mategal-Troso. The location of the road is in the Magetan Regency of East Java Province, where the road is traversed by large and heavy vehicles, so special attention is often required.

The types of damage and the dimensions of road surface damage are obtained by conducting direct surveys in the field. Equipment used in the road surface damage survey includes meter, paper, stationery, camera and survey form for PCI assessment, while for IRI Roadroid uses Android smartphones and cameras. Assessment of road damage conditions according to the PCI method with the following steps [7]:

- (1) Divide the road segment per 100 m on the road of research object,
- (2) Determination and measurement of damage quantity, and
- (3) Evaluate the road according to road surface damage

2.2 Statistical analysis

Statistics are defined as a method used in the collection and analysis of data so that information obtained can be used. Here is a statistical analysis of road pavement assessments that use PCI and IRI Roadroid.

2.2.1 Pearson correlation coefficient analysis (r)

Suspect of the relationship between variables in the population through the data relationships variables in the sample is suspect it is called an associative hypothesis. The first step then is to calculate the correlation coefficient between variables in the sample, then test its significance. While the correlation is a number that shows the direction and strength of the relationship between two or more variables, the direction is expressed in the form of a positive or negative relationship, and the strength of the relationship is expressed in the magnitude of the correlation coefficient [8].

The relationship of two or more variables is positive if the value of one variable increases, it raises the other variable, and vice versa, if one variable is lowered, it decreases the other variable. Meanwhile, negatively correlated, the value of one variable is raised, it decreases another variable, and vice versa if one variable is lowered it increases another variable.

The strong relationship between variables is expressed in the correlation coefficient, the values range from -1 to 1 ($-1 \leq r \leq 1$). If the value of the correlation coefficient is -1 or 1, then the relationship between variables is perfect, while if the value of correlation coefficient is 0, then there is absolutely no relationship. The smaller the correlation coefficient, the greater the error to make predictions. The direction of the relationship between two variables is divided into three, namely:

a *Direct Correlation (Positive Correlation)*

Changes to one variable are followed by changes in the other variable, consistently and in the same direction of movement, with $r = +1$.

b *Inverse Correlation (Negative Correlation)*

Changes to one variable are followed by changes in the other variable, consistently and in the opposite direction of movement, with $r = -1$.

c *Nihil Correlation*

Nihil Correlation is the absence of direction of movement between the two variables tested or the direction of the relationship is irregular, with the value $r = 0$.

This correlation coefficient technique is used to find the relationship and prove the hypothesis of a two-variable relationship when the data in the form of interval or ratio and the data source is two or more variables that are similar. The equation used in calculating the correlation coefficient is shown in Eq. 1.

$$r = \frac{n\sum x_i.y_i-(\sum x_i).(\sum y_i)}{\sqrt{[(n\sum x_i^2)-(\sum x_i)^2].[n\sum y_i^2)-(\sum y_i)^2]}} \tag{1}$$

where xi: Value of variable x (Assessment of functional path of method A); yi: The variable value y (Road functional assessment method B); n: Amount of data
 Guidelines provide interpretation of correlation coefficients shown in Table 1.

Table 1. Interpretation of correlation coefficients.

Correlation Coefficient Value (r)	Interpretation of Correlation Coefficients
0,00-0,199	Very Low
0,20-0,399	Low
0,40-0,599	Medium
0,60-0,799	Strong
0,80-1,000	Very Strong

(Source: Sugiyono, 2013)

2.2.2 Coefficient of determination (R^2)

The coefficient of determination is the square of the correlation coefficient of Pearson (r). This statistic is used to find out how much influence the variable X has on the variable Y, or how much variation in Y can be explained by X. Calculation of the correlation coefficient is shown in Eq. 2.

$$R^2 = \frac{SSE}{SST} \tag{2}$$

$$SSE = \sum_{i=1}^n (y_i - \hat{y})^2 \tag{3}$$

$$SST = \sum_{i=1}^n (y_i - \bar{y})^2 \tag{4}$$

with yi: variable value y; $\hat{y}$: dependent variable based on value xi; $\bar{y}$: average y value.

2.2.3 t-test

A t-test is done to find out if the correlation coefficient is significant ($\neq 0$), which means there is a linear comparison between the two variables. Then we determine the significance level of 0.95, $\alpha = 5\%$ and calculate the test statistic using Eq. 5. or by using the Excel Program help.

$$t_{hit} = r \sqrt{\frac{n-2}{1-r^2}} \tag{5}$$

With the hypothesis above, we then made the rule that with H0 rejected if $t_{hit} < -t_{table}$ or $t_{hit} > t_{table}$. It can be concluded that there is a linear correlation between the variables x and y in the population. Conversely, if t_{hit} enters the distribution area t ($-t_{table} < t_{count} < +t_{table}$), then there is no linear correlation between the variables x and y in the population.

3 Results and discussion

3.1 Results functional condition of street PCI and IRI roadroid

The location review used in this research is Magetan District Road, which is in the Public Works Department of Magetan Regency, a road connecting Magetan Regency. The acquisition of road function conditions in this study are as follows; segment is divided into several segments, while the length of the segment is divided into every 100 m.

3.1.1 Functional condition of paths based on PCI

Road assessment using PCI is done directly on a road review, by measuring and recording based on the type of damage seen in the field. The PCI value on the road section of the review can be seen in Table 2.

Table 2. PCI value.

No	Segment Name	PCI Value	PCI Condition
1	Ngariboyo-Tamanarum	70,51	Very Good
2	Bangsri-Plaosan	73,87	Very Good
3	Parang-Kalipucang	75,00	Very Good
4	Mategal-Troso	62,07	Good

3.1.2 Road functional condition based on IRI roadroid

The functional assessment using IRI is conducted by using several tools. In this study, IRI values obtained by using an android smartphone with the Roadroid application. This tool was used with a sedan as a vehicle tool at the time of the survey took place. Measurements of the Roadroid IRI score were performed on November 6, 2016. The IRI Roadroid value is then converted to a scale of 1 to 10 from a previous scale of 0 to>12. Its conversion can be found using Eq.6.

Base 10 IRI = 10- $\frac{\text{IRI Value} \times 10}{16}$

(6)

The Roadroid IRI score can be observed in Table 3.

Table 3. IRI roadroid value

No	Segment Name	IRI Value	Base 10 IRI	IRI Condition
1	Ngariboyo-Tamanarum	5,81	63,67	Medium
2	Bangsri-Plaosan	4,14	74,13	Medium
3	Parang-Kalipucang	2,84	82,27	Good
4	Mategal-Troso	4,12	74,23	Medium

3.2 Descriptive statistics

3.2.1 Comparison of PCI and IRI roadroid

Functional assessment of the road in this study is divided into three combinations: with the Pearson correlation coefficient (*r*), the coefficient of determination (*R*²), and the *t*-value of the *t*-test, to determine whether or not there is a comparison between the three. Data from PCI and IRI of Roadroid are primary data, obtained by varying road conditions from each assessment method as shown in Table 4.

Table 4. PCI and IRI roadroid value

No	Segment Name	PCI Value	PCI Condition	IRI Value	Base 10 IRI	IRI Condition
1	Ngariboyo-Tamanarum	70.51	Very Good	5.81	63.67	Medium
2	Bangsri-Plaosan	73.87	Very Good	4.14	74.13	Medium
3	Parang-Kalipucang	75.00	Very Good	2.84	82.27	Good
4	Mategal-Troso	62.07	Good	4.12	74.23	Medium

Table 5. Summary of comparative analysis calculations.

Correlation Types	r Value	r ²	t count	Critical Area
Correlation of PCI with base 10 IRI	-0,325	0,105	-3,109	-1,968 ≤ t _{count} ≤ 1,968

Table 5. shows summary of the comparative analysis calculations between correlation types, *r* value, *r*², *t* count and critical area. The value of Pearson coefficient (*r*) is -0.325, which means there is linear correlation with low correlation level, the coefficient of determination value (*R*²) is equal to 0.105, and the *t*count of -3.109 with hypothesis *H*₀ rejected, so there is difference between the assessments of functional conditions of a road using PCI and IRI Roadroid (*H*₀ rejected).

3.2.2 Effect of IRI roadroid speed

Variations of speed Roadroid IRI used in this study were 20 km/h and 60 km/h. Rozi IRI data are summarized in Table 6.

Table 6. IRI roadroid value speed 20 km/h and 60 km/h

No	Segment Name	IRI Value 20 km/h	IRI Condition 20 km/h	IRI Value 60 km/h	IRI Condition 60 km/h
1	Ngariboyo-Tamanarum	2.52	Good	2.37	Good
2	Bangsri-Plaosan	3.44	Good	2.94	Good
3	Parang-Kalipucang	2.29	Good	2.22	Good
4	Mategal-Troso	4.71	Medium	4.97	Medium

Table 7. Summary of speed comparison analysis

Correlation Types	r Value	R ²	Critical Area	t Count
IRI Correlation 20 km/h with IRI 60 km/h	0.7267	0.528099	-1,968 ≥ t ≤ 1,968	1.628

Pearson coefficient value (*r*) was 0.7267, which means there is a linear correlation and the level of correlation is strong. The coefficient of determination is obtained. The value of *t*

count is 1.628 after consultation within a critical area at -1.968 until 1.968 which is shown in Table 7.

3.2.3 Influence differences lane IRI roadroid

Often Roadroid IRI surveys only analyze one lane, and not back and forth or both lanes, while the flatness of the road between the left and right lanes are not necessarily the same. Therefore, this study also calculates the correlation of the two lanes to measure IRI Roadoid. In summary, the assessment of the left and right rows of the review road can be seen in Table 8.

Table 8. IRI values of the left and right lanes.

No	Segment Name	Left Road IRI Value	Left IRI Condition of the Road	Right Road IRI Value	Right Road IRI Condition
1	Ngariboyo-Tamanarum	2.69	Good	2.37	Good
2	Bangsri-Plaosan	2.80	Good	2.94	Good
3	Parang-Kalipucang	2.04	Good	2.22	Good
4	Mategal-Trosoono	5.22	Medium	4.97	Medium

Table 9. Summary of calculation of comparative analysis on both sides of the road.

Type Correlation	r Value	R ²	Critical Area	t Count
IRI Correlation 20 km/h with IRI 60 km/h	0.493	0.243039	-1,968 ≥ t ≤ 1,968	-1.118

Pearson coefficient value (r) is 0.493. This means there is a linear correlation with the level of correlation Medium. The coefficient of determination is obtained, and the tcount - 1,118 after consultation with ttable is -1,968 to 1,968 thit is inside ttable.

3.3 Discussion

Table 5 shows the value point r there is a negative correlation value, it can be interpreted the lower the IRI value of Roadriod then the PCI value will be higher and the lower the IRI value of Roadroid. The value obtained in the analysis, the correlation (r) and R² did not show significant results.

There are similarities between IRI Roadroid with speed 20 and 60 km/h. So it can be concluded that the use of Roadroid IRI can use speeds between 20 to 60 km/h.

There is an equation between IRI Roadroid lane right and lane left. So it can be concluded that the use of Roadroid IRI can use the right lane or the left lane in sampling.

4 Conclusions

Based on the results and discussion the assessment of the functional condition of Magetan District Road the assessment of road conditions based on the value of PCI into category Very Good, the assessment using IRI Roadroid category Medium. While the correlation of road assessment PCI IRI Roadroid resulted in low correlation. Variations in data retrieval speeds using IRI Roadroid had no effect on the functional assessment of the road, data retrieval back and forth on the same road segment.

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