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EVALUATION OF FUNCTIONAL CONDITIONS OF THE ROAD BASED ON THE VALUE OF NAASRA ROUGHMETER II AND IRI ROADROID (A CASE STUDY OF THE WESTERN RING ROAD, SOUTHERN RING ROAD, AND THE MAIN ROAD OF PALEMBANG CITY)

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ABSTRACT

Maintenance of street is the program that planning based on the field technical data, so obtained the priority of street preservation by corresponding with the real condition. Road conditions are valued at the International Roughness Index (IRI) or level of flatness road which is one of the factors/functional performance. This study aimed to compare the value of IRI from *roughometer II* tool used by Dirjen Bina Marga to the value of IRI using *smartphone* applications *(Roadroid)* as a reference in evaluating the functional condition of national roads in the framework of the national road maintenance that is efficient and save budget. This research was descriptive survey method for primary data collection and analysis of secondary data by used the results of both measurement on national roads in Palembang. Conducted regression analysis and correlation of data obtained then presented in the form of tables, images, and narration to explain the result. The research showed that the road condition survey is based on the value of IRI *Roughmeter II* and the value of IRI by *smartphone (roadroid)* shows the diversity of values, but the difference is not so significant. Both of the measurement results indicate a value that varies but the majority have 4-8 IRI value range. From the correlation analysis known positive correlation of the measurement results with the strength of the relationship is different from the correlation is low, moderate, strong to very strong correlation. This shows that the IRI value survey results using smartphones with Roadroid applications can be used as a reference or preliminary study to predict the actual IRI value. This study suggested that the next study which will take the same research themes to conduct research on *a smartphone* application *(roadroid)* related to the speed of the vehicle is used.

Keywords: Roughometer II, Roadroid, Road Functional Condition

1. INTRODUCTION

Intensive and routine road handling is needed so that the road functions can have a long and sustained service period. There is still a uniform and perfect execution of road maintenance, causing premature deterioration of road construction in Indonesia [1, 2, 3].

Handling of the road maintenance planning program is performed by the technical data in order to obtain a priority field handling road maintenance in accordance with real conditions. Road conditions are assessed based on the *International Roughness Index* (IRI) or flatness road level [2, 15]. The flatness level is one of the service functions *(functional performance).* The IRI is used to determine the prolonged profile

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characteristics of the path through which the vehicle wheel passes to determine a standard level of surface alignment [3, 1 6, 1 7].

Determining of the road surface flatness level can be measured by using of various methods that have been recommended by Dirjen Bina Marga (Highways General Director) [14]. Road surface flatness measurement method known generally include of methods NAASRA (SNI 03-3426-1994), *Rolling Straight Edge, Slope profilometer* (AASHO *Road Test),* CHLOE *profilometer,* and *Roughmeter* [4, 5].

Ministry of Indonesian Public Works and Public Housing (PUPR) from Dirjen Bina Marga has applications *Indonesian Integrated Road Management System* (IIRMS) in managing the assets of the road. IRI value is one of the main indicators of the data that determines value of the road functional condition is needed to run the application IIRMS is output from one survey tools that are commonly used in the Ministry of PUPR through the Directorate General of Highways is NAASRA *Roughmeter II*.

Along with the development of application technology was created an application on a smart phone that based on Android *(Roadroid)* to measure the degree of flatness of the road that can be used in a practical, inexpensive, and can be used in various road conditions, traffic conditions and other vehicles. By using the vibration sensor of smart phone *(Smartphone),* probably to collect the data roughness or flatness of the road [6, 7]. *Roadroid* application reliability is widely tested and studied by several international institutions around the world, such as the World Bank, the United Nations University and the companies road engineering [8, 9, 1 0]. In Indonesia *Roadroid* application has been socialized in the Ministry of Public Works and Public Housing (PUPR) as an alternative in conducting surveys to measure the road flatness to obtain IRI data.

The study was conducted on 12 national road segments in Palembang. This study aims to determine the functional condition of each national road Metropolitan Palembang that is surveyed based on the value of IRI from NAASRA *Roughmeter II* and based on the value of IRI smart phones *(Roadroid)* to get comparison survey between them, and then analysis of data relationships both of these survey results

2. METHODOLOGY/ EXPERIMENTAL

The study was conducted on Palembang Metropolitan City National Road In accordance with the Decree (SK) of the Minister of PUPR No. 248 / KPTS / M / 2015 on Establishment of the Roads in Primary Road Network According to it's functions As Arterial Road (JAP) and Collector Roads-1 (JKP-1) and derivatives regulation in the form of Decree the National Road Implementing Agency Head (BBPJN) V 645 / KPTS / Bu.02 / 2016 of the Zoning Management of National Roads in BBPJN V [18].

Research Sites consist of 12 National Road Sections Palembang City i.e.:

1. Letjen. Alam RPN street (3.15 Km)
2. Soekarno Hatta street (8.32 Km),
3. Mayjen Yusuf Singadekane street (5.20 Km),
4. Sijaya Raya street (6.30 Km),
5. Ki Wahid Hasyim street (2.20 Km),
6. Southern Ring Road (11.83 Km),
7. Kol. H. Burlian street (5.20 Km),
8. Jenderal Sudirman street (5.03 Km),
9. Governor of HA Bastari street (8.40 Km),
10. Ki Merogan street (3.60 Km),
11. Rasid Sidik street (0.64 Km)

12. Ryacudu street (1.55 Km)

The data that required in this study are primary data and secondary data as shown in the Table 1

Tabel 1. The data that used in the study

Various of Data	Collecting Method
Road Data	Secondary Data from Satker P2JN Province of South Sumatra & KDP P2JN Metropolitan Palembang
Road Length Data	Secondary Data from Satker P2JN Province of South Sumatra & KDP P2JN Metropolitan Palembang
IRI value *Roughometer II*	Secondary Data from Satker P2JN Province of South Sumatra & KDP P2JN Metropolitan Palembang
IRI value *RoadRoid*	Primary Data From Field Survey Results

The parameters and variables used in the study are

Table 2. Parameters and research variables

N o	Terms	Analysis connection	Source
I.	**Research Parameter**		
1	Roads	Functional Condition and Stability of the Road	Secondary Data
2	Road length	Functional Condition and Stability of the Road	Secondary Data
II	**Research variable**		
1	Value of IRI *Roughometer II*	Assessment of the Functional Conditions and Correlation	Secondary Data
2	Value of the IRI *RoadRoid*	Assessment of Functional Conditions and Correlation	Primary data

Generally, the data analysis was divided into three (3) stages: analysis of functional condition roads data, based on the value of IRI *Roughmeter II*, the data on functional condition roads, based on the value of IRI from the *Roadroid smartphones* application and correlation analysis or comparison between the both.

Road functional conditions analysis using the descriptive method. IRI data from *Roughmeter II* that is secondary data from Working Unit for Planning and Supervision of the National Road South Sumatra province were obtained from the survey results within one period that is the period of July-December 2016 in the condition of Survey on October 2016 for each road segment to the normal direction and the *opposite* transfer to excel then tabulated and rated the condition of functional running per segment (100 meters). IRI value data via application *Roadroid* done directly (primary data) on each of the national road of Palembang in the same survey by using *Roughmeter II* for normal and *opposite* directions, then transferred to an excel program to be tabulated and rated the condition of functional running 100 meters per segment.

3. RESULTS AND DISCUSSION

3.1 Functional Condition of Metropolitan National Road Palembang Based on IRI Roughmeter II Value

IRI data is secondary data that obtained from National Road Implementation Center V through Satker P2JN of South Sumatera Province. This data is functional condition of road in Semester 2 in 2016 period of survey on October.

IRI value-based measurement of the normal and *opposite* direction. The tables presenting its road conditions hindered seen in Table 3 below in the form of values IRI on Alamsyah RPN street by normal direction.

Table 3. IRI value from *Roughmeter II* on Alamsyah RPN street for normal direction

Distance	IRI Roughmeter	Functional Condition of the Road
100	6.4	Medium
200	3.1	Good
300	4.5	Medium
400	3.4	Good
500	3.9	Good
600	3.5	Good
700	2.4	Good
800	2.9	Good
900	4.9	Medium
1000	9.2	Light Damage
1100	14.1	Heavy Damage
1200	9.1	Light Damage
1300	3.3	Good
1400	3.9	Good
1500	7.3	Medium
1600	11.9	Light Damage
1700	9.1	Light Damage
1800	10.3	Light Damage
1900	10.1	Light Damage
2000	4.5	Medium
2100	9.1	Light Damage
2200	12.8	Heavy Damage
2300	3.9	Good
2400	3.8	Good
2500	3.3	Good
2600	7	Medium
2700	4.2	Medium
2800	3.2	Good
2900	4.2	Medium
3000	4	Good
3100	3.9	Good
3150	3.5	Good

Based on Table 3 above in mind that the value of IRI NAASRA *Roughmeter II* shows the functional condition of the road towards the normal conditions along1.45 km is good, along 0.8 km medium, along 0.7 km Light Damage and 0, 2 km heavy damage. The graph of the road surface roughness. Alamsyah RPN street can be seen in Figure 1.

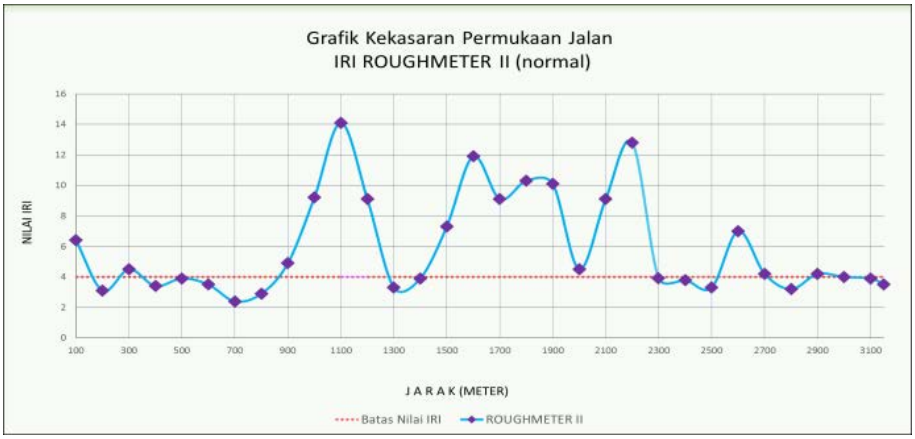

Figure 1. Road surface roughness graph of Alamsyah RPN street from normal direction (*Roughmeter II)*

Based on Figure 1 above is known that the IRI results from *roughometer II* Alamsyah RPN street on the normal direction varies. IRI value is known of the light damage condition until good condition but in general the value of the flatness of the road is medium. The presentation of IRI Value *Roughmeter II* for Alamsyah RPN street from the *opposite* direction in the same way a presentation on Table 2 and Figure 1.

Once all the data is collected, it is known that the road Functional condition based on IRI data from *Roughmeter II* at 12 National Highways along 61.420 Km is the object of the study was overall good functional condition of the road for normal and *opposite* direction, in conditions Medium with IRI average value of 5.86 to the normal direction and IRI average of 5, 99 for *opposite* direction. The total length of the normal direction road which is in Good condition throughout 21.150 km, medium condition 29.980 km, along 8.060 km Light Damaged condition and Heavy Damage along the 2.230 Km. While the total road length in *opposite* direction that Good condition along 17.730 Km, along 30.090 km Medium condition, along 8.00 Km light Damaged and Heavy Damage condition throughout 3, 60 Km.

3.2 Functional Condition of Metropolitan National Road Palembang based on IRI Roadroid value

Survey research conducted directly by using *a smartphone* with *Roadroid* applications at 12 National roads that is similar with Roughmeter appliance from the normal and *opposite* direction in the same survey period on October 2016. The table presenting the road conditions that can be seen in Table 4 below in the form of the IRI *Roadroid* value on Alamsyah RPN street for normal direction.

Table 4. IRI value *Roadroid* Alamsyah RPN street for normal direction

Distance	IRI Roadroid	Functional Condition of the Road
100	5.35	Medium
200	4.39	Medium
300	3.36	Good
400	1.82	Good
500	1.94	Good
600	2.18	Good
700	3. 0 5	Good
800	3.43	Good
900	3.08	Good
1000	4.82	Medium
1100	10.60	Light Damage
1200	10.17	Light Damage
1300	2.56	Good
1400	2.02	Good
1500	2. 04	Good
1600	9.22	Light Damage
1700	7:00	Medium
1800	7.21	Medium
1900	8.32	Light Damage
2000	3.42	Good
2100	7.49	Medium
2200	9.22	Light Damage
2300	4.64	Medium
2400	1.76	Good
2500	1.84	Good
2600	2.43	Good
2700	4.17	Medium
2800	1.55	Good
2900	3.61	Good
3000	0.80	Good
3100	1.90	Good
3150	1.75	Good

Table 4 above shows that the value of IRI results from *Roadroid smartphone* app for road good conditions along 1.850 km, medium condition throughout 0.80 km, light damaged conditions along 0.50 km and heavy damaged along 0 km. The graph roughness of the road can be seen in Figure 2

Figure 2. Surface Roughness Graph of Alamsyah RPN street for normal direction *(Roadroid)*

From Figure 2 above can be seen that the value of IRI *smartphones* attend to be smaller. IRI value of *smartphones* attend the below of the standard value (value of 4), which means that the conditions is Good to unpaved road which indicates that the value is smaller or running surface roughness index is smaller which means that the road conditions are better. To serve IRI *Roadroid* value of Alamsyah RPN street for *opposite* direction together with the presentation in the Table 4 and Figure 2.

After all data *Roadroid* calculation of each roads are collected, it is known that the condition of the 12 national road overall in good functional condition both of normal and *opposite* direction included in the Medium conditions IRI average value of 4.15 for normal direction road and IRI Average 4.27 for the *opposite*. The total length of the road on normal direction which is in Good condition throughout 40.150 Km, Medium condition along 15.730 km, light damage condition along 4.640 km and Heavy Damage condition along 0, 90 Km. While the total length of the road in *opposite* direction which is the good condition throughout 35.050 Km, along 20.770 in medium condition, light damage condition along 5,20 Km and Heavy Damage conditions along the 0.4 Km.

3.3 Comparison For The Functional Of The Road Conditions And The Relationship Analysis of NAASRA Roughmeter II and IRI Roadroid Values

After learning the results of the IRI *Roughmeter* II and *Roadroid,* then performed the identification and determination of variables. where X is set as the value of IRI *Roughmeter* II and the Y value as the value of IRI *Roadroid.* Further more done to Letjen Alamsyah RPN street for normal direction that analyzed as follows:

1. The regression analysis, using the equations of simple linear regression:

$$Y = a - bX \quad (1)$$

Then the linear regression equation is:

Y = -0, 2037 + 0.7534 X

2. The correlation analysis to examine the strong linear relationship between two variables IRI value correlation analysis is carried out using the equation

$$r = \frac{N\sum_{i=1}^{N}(X_iY_i) - \sum_{i=1}^{N}(X_i).\sum_{i=1}^{N}(Y_i)}{\sqrt{\left[N\sum_{i=1}^{N}(X_i^2) - \left(\sum_{i=1}^{N}(X_i)\right)^2\right]\left[N\sum_{i=1}^{N}(Y_i^2) - \left(\sum_{i=1}^{N}(Y_i)\right)^2\right]}} \quad (4)$$

r = 0.873

guidelines to provide interpretation of the correlation coefficient as shown in Table 5 [11]

Table 5. Interpretation of correlation coeficient

Coefecient Correlation Value (r)	Interpretation of correlation coeficient
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

3. Calculation of the coefficient of determination ($R^{2)}$ by using equation below:

$$R^2 = r^2 \times 100\% \quad (5)$$

$R^2 = r^2 \times 100\%$
$R^2 = (0.873)^2$
$R^2 = 0.762$

The correlation value of IRI *Roadroid* and *Roughmeter* II Letjen Alamsyah RPN street for normal direction and the regression equation can be seen in the picture below:

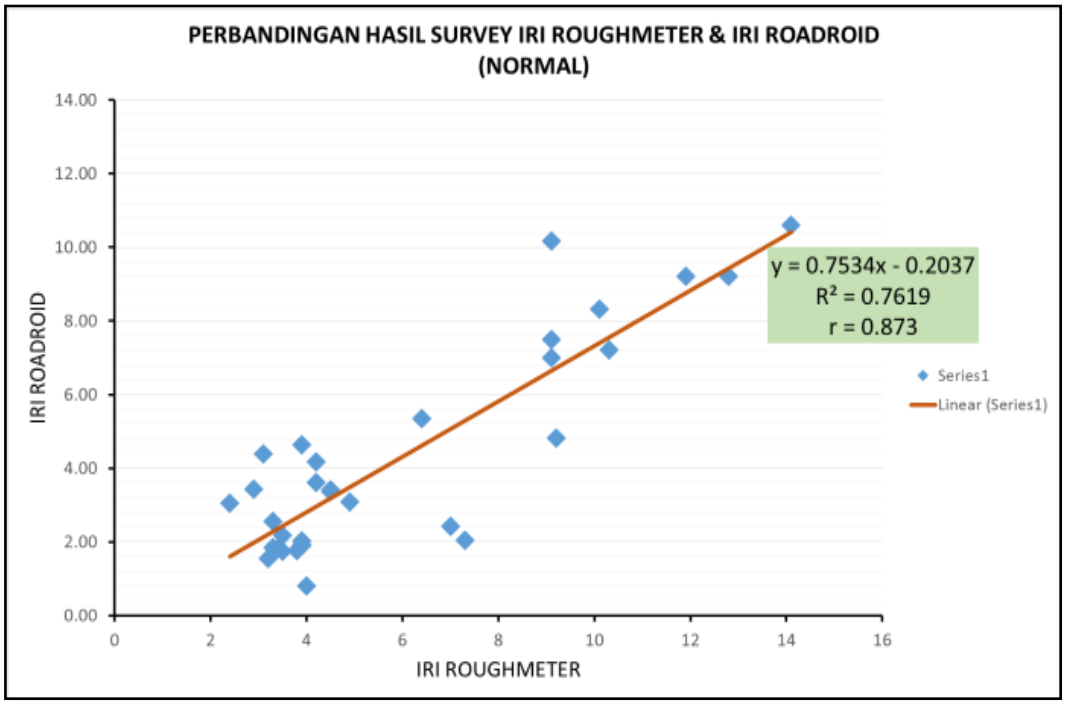

Figure 3. Correlation and the regression equation for the value of IRI *Roughmeter II* and *IRI Roadroid* Letjen Alamsyah RPN street for normal direction

For the *opposite* direction determination coefficient analysis was done in the same way as the normal direction. The coefficient of determination for *opposite direction is known* of $R^2 = 0.659$

4. The T test analysis, to determine whether the correlation coefficient obtained a linear or no linkages between the two variable. Significance level of 0, 95, α = 5% = 0.05

Furthermore done to Letjen Alamsyah RPN street for *opposite* direction to do the same analysis phases as follows:

1. Regression analysis, using simple linear regression analysis equations:
2. Then the linear regression equation is:

$$Y = 0, 0839 + 0.5648\ X$$

3. The correlation analysis to examine the strong linear relationship between two variables IRI value, the correlation analysis is obtained

r = 0.812

4. Calculation of the coefficient of determination ($R^{2)}$ obtained:

R^2= 0.659

The correlation value of IRI *Roadroid* and *Roughmeter* II Letjen Alamsyah RPN street for *opposite* direction and the regression equation can be seen in the picture below

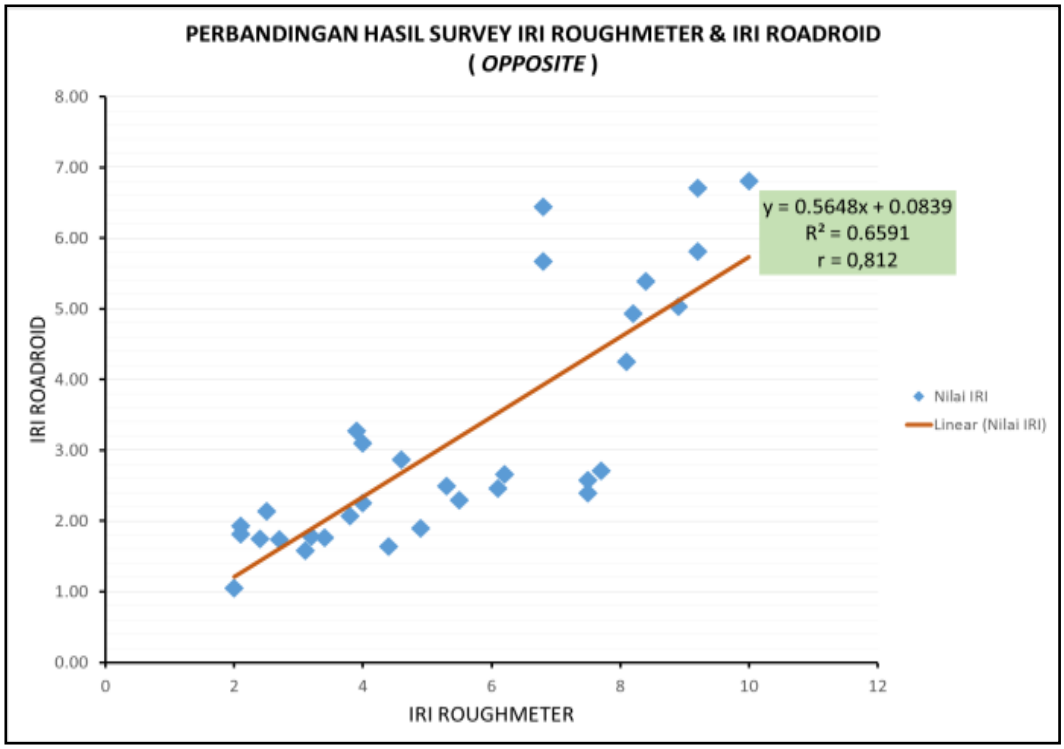

Figure 4. Correlation and Regression equation of IRI value *Roughmeter II* and *Roadroid* for Letjen Alamsyah RPN street in *opposite* direction

5. Analysis of the T test, is conducted to determine whether the correlation coefficient obtained have a linear or no linkages between the two variable. Significance level of 0, 95, α = 5% = 0.05

Then, for 11 roads under study other correlation and regression analysis were performed by the same analysis step by stage analysis performed on Letjen Alamsyah RPN street, then the results of the analysis for the 12 roads that investigated to the normal and *opposite* are labeled as follows:

Table 6. The relationship between IRI *Roughmeter* II and IRI Roadroid value

Jalan	Arah	Pers. Regresi	Nilai r	Nilai R^2	Daerah Kritis	t_{hit}	Hub.	Interpretasi
Alamsyah RPN	Normal	Y = 0.75 X - 0.02	0.873	0.762	-2.04 ≥ t ≤ 2.04	8.173	Ada Korelasi	Sangat Kuat
	Opposite	Y = 0.56 X + 0.08	0.812	0.659	-2.04 ≥ t ≤ 2.04	7.616	Ada Korelasi	Sangat Kuat
Sukarno Hatta	Normal	Y = 0.59 X + 2.17	0.633	0.401	-1.99 ≥ t ≤ 1.99	7.403	Ada Korelasi	Kuat
	Opposite	Y = 0.66 X + 2.17	0.612	0.374	-1.99 ≥ t ≤ 1.99	6.998	Ada Korelasi	Kuat
Mayjen Yusuf S	Normal	Y = 0.26 X + 2.48	0.458	0.210	-2.01 ≥ t ≤ 2.01	3.647	Ada Korelasi	Sedang
	Opposite	Y = 0.46 X + 0.80	0.783	0.612	-2.01 ≥ t ≤ 2.01	8.889	Ada Korelasi	Kuat
Srijaya Raya	Normal	Y = 0.32 X - 0.05	0.636	0.405	-1.99 ≥ t ≤ 1.99	6.437	Ada Korelasi	Kuat
	Opposite	Y = 0.32 X + 0.41	0.640	0.410	-1.99 ≥ t ≤ 1.99	6.509	Ada Korelasi	Kuat
Wahid Hasyim	Normal	Y = 0.98 X + 1.34	0.726	0.528	-2.09 ≥ t ≤ 2.09	4.728	Ada Korelasi	Kuat
	Opposite	Y = 1.22 X + 1.71	0.731	0.534	-2.09 ≥ t ≤ 2.09	4.791	Ada Korelasi	Kuat
Lingkar Selatan	Normal	Y = 0.57 X + 0.08	0.642	0.412	-1.98 ≥ t ≤ 1.98	9.048	Ada Korelasi	Kuat
	Opposite	Y = 0.49 X + 0.94	0.420	0.176	-1.98 ≥ t ≤ 1.98	5.006	Ada Korelasi	Sedang
Kol.H. Burlian	Normal	Y = 0.60 X + 0.34	0.690	0.475	-2.01 ≥ t ≤ 2.01	6.732	Ada Korelasi	Kuat
	Opposite	Y = 0.47 X + 1.30	0.735	0.540	-2.01 ≥ t ≤ 2.01	7.667	Ada Korelasi	Kuat
Sudirman	Normal	Y = 0.33 X + 1.24	0.685	0.470	-2.01 ≥ t ≤ 2.01	6.589	Ada Korelasi	Kuat
	Opposite	Y = 0.44 X - 2.46	0.639	0.408	-2.01 ≥ t ≤ 2.01	5.812	Ada Korelasi	Kuat
Gub H.Bastari	Normal	Y = 0.95 X - 0.81	0.616	0.380	-1.99 ≥ t ≤ 1.99	7.084	Ada Korelasi	Kuat
Ki Merogan	Normal	Y = 0.86 X + 0.96	0.705	0.496	-2.03 ≥ t ≤ 2.03	5.789	Ada Korelasi	Kuat
	Opposite	Y = 0.34 X + 1.46	0.522	0.272	-2.03 ≥ t ≤ 2.03	3.568	Ada Korelasi	Sedang
Rasid Sidik	Normal	Y = 0.57 X + 1.57	0.811	0.658	-2.57 ≥ t ≤ 2.57	3.104	Ada Korelasi	Sangat Kuat
	Opposite	Y = 1.22 X + 0.38	0.802	0.644	-2.57 ≥ t ≤ 2.57	3.004	Ada Korelasi	Sangat Kuat
Ryacudu	Normal	Y = 0.95 X + 0.13	0.969	0.938	-2.14 ≥ t ≤ 2.14	14.565	Ada Korelasi	Sangat Kuat
	Opposite	Y = 0.65 X + 1.46	0.674	0.455	-2.14 ≥ t ≤ 2.14	3.417	Ada Korelasi	Kuat

Based on the correlation analysis, regression, coefficient of determination and T test that was done on 12 roads studied in the normal and *opposite* direction, it is known that the value of IRI *Roughmeter II* and IRI *Roadroid* are closely correlated positively to all

roads, with the strength of the different correlation from the correlation of moderate to very strong correlation. For a strong correlation there are three roads those are Letjen Alamsyah RPN street for normal and *opposite* directions, Rasid Sidik street for normal and *opposite* directions and Ryacudu street for normal direction. Correlates strongly on Sukarno Hatta street for normal and *opposite* directions, Mayjen Yusuf Singadekane street for *opposite* direction, Srijaya Raya for normal and *opposite directions,* Wahid Hasyim street for normal and *opposite* directions, the Southern Ring Road for normal directions, Kol. H Burlian street for normal and *opposite direction,* Sudirman street for normal and *opposite* directions, Gub. H Bastari street for normal direction, Ki Merogan street for normal direction, and Ryacudu street *opposite* direction, to which correlates were among others on the road, Mayjen Yusuf Singadekane for normal direction, Southern Ring road for *opposite* directions, Gub H Bastar for *opposite* direction and Ki Merogan street for *opposite* direction.

Percentage correlation value of IRI *Roughmeter II* and *Roadroid* against all the roads under review of 12 National road in both directions review (normal and *opposite),* it can be concluded that the very strong correlation for about 20,833%, which correlates strongly 62,50 %, and the medium correlation was 16,667%. But generally attend to have a strong and very strong correlation. This indicates that the value of IRI using *Roadroid smartphone* application can be used as a reference or initial assessment to predict the actual value of IRI.

4. CONCLUSION

From the research that has been done can be summed up things as follows:

1. Functional condition of the National road that becomes the object of research by IRI of NAASRA Roughmeter II have varietely with values between 4 to 8, which means that the condition of each roads being simulated for normal and *opposite* direction in a medium condition.
2. Functional condition of the National road that becomes the object of research by IRI from smart phones *(Roadroid)* value is also varied with value range 4 to 8, which means that the conditions are medium conditions.
3. Overall the second road condition survey measuring devices showed the diversity of values, but the different is not so significant. Value of IRI survey results using *smart phone* with *Roadroid* application can be used as a reference or initial assessment to predict the actual value of IRI.

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