Comparison of road inequality values using roughometer III and roadroid applications

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Abstract. Roads are essential in the development of an area, where driving safety and comfort are a measure of road construction. We can check road construction by getting an IRI value on a road segment. IRI (International Roughness Index) is the roughness index that most commonly obtained from measured longitudinal road profiles. Roughometer III and Roadroid applications are the tools to collect IRI data. Roughometer III has more precision than Roadroid, but the Roughometer III is more expensive and more complex than Roadroid. This study tries to make a comparison of IRI values and their correlation between the Roughometer III and Roadroid. The results show that the comparison of IRI Roughometer III values and Roadroid Applications is slightly different. The linear correlation analysis of IRI values on Roughometer III and eIRI values on Roadroid is IRI = 0.8999eIRI + 0.5786 with a correlation level of = 0.8391.

1. Introduction
Roads are very important in the development of an area. Therefore, road pavement as the main structure in a road construction is very important to be maintained so that vehicle travel across an area can run well. In the structure of road pavement there are many factors causing construction damage such as: traffic volume, vehicle overloading, water, pavement material, climate and original soil conditions.

Road construction will not always last, where damage to the road structure is often found on a road segment that is often used. Repairing a road section needs to be done to overcome road damage such as cracking and rutting. Inequality of roads is one factor that is very calculated from a road pavement. this factor affects the comfort of the driver (riding quality). The uneven value of a road can affect the speed of vehicles that pass through it, this will certainly affect the travel time and economic cost of an item and in turn affects the economy of a larger area.

Before carrying out maintenance / repair of roads, first measuring the value of road roughness is measured, to find out whether the road is still suitable and comfortable to use or must make improvements to the surface / structure of the road. Measurement of road inequality is still rarely carried out continuously, this is due to the limitations of the tool, or the costs required to implement it.

Bina Marga agency and AASHTO recommend a number of measurement methods to determine the level of surface roughness of the road structure, including using the NAASRA method (SNI 03-3426-1994), Rolling Straight Edge, Slope Profilometer (AASHO Road Test), CHLOE Profilometer, and Roughometer (Suwardo) and Sugiharto, 2004).

Another technology used to measure road inequality is to use a tool known as Roughometer III and Roadroid applications that are in Android. We can evaluate each part of the road using the roughometer III and using the Roadroid application. This study compares the IRI values generated from the Roughometer III tool with the roadroid application located on android. By comparing the value of road roughness on the Roughometer III device with the roadroid application, the relationship or correlation between the roughometer III device and the roadroid application is sought.
1.1. Research purposes
1. Know how the Rouhometer III tool is applied in the field
2. Know how the Roadroid application is used in the field
3. Knowing the comparison of uneven road values using the Roughometer III tool and the roadroid application.

1.2. Scope of problem
1. This research was conducted on national roads
2. Tools used in application to determine the International Roughness Index (IRI), namely Roughometer III and Roadroid applications on android.
3. Types of road pavement layers used in this study are flexible pavement layers.
4. Research is carried out on the slow lane and the fast lane
5. Assessment of road roughness (IRI) with tools from the Directorate General of Highways in the Implementation of National Road II using Roughometer III.

2. Literature review

2.1. Road Conditions
Road conditions are things that need to be considered in determining road maintenance programs. According to the Department of Public Works of the Director General of Highways (1992), road conditions can be classified as follows:
- Roads with good condition are roads with pavement surfaces that are completely flat, not bumpy and have no surface damage.
- Roads with moderate conditions are roads with moderate pavement surface smoothness, starting to bumpy but there is no surface damage.
- Roads with mildly damaged condition are roads with pavement surfaces that have begun to surge, begin to have surface damage and fillings (less than 20% of the road area reviewed).
- Roads with heavily damaged conditions are roads with pavement surfaces that have suffered a lot of damage such as bumpy, crocodile cracks, and quite large peeling (20-60%) of the road segments reviewed) are accompanied by damage to the foundation layers such as collapsed and so on.

2.2. Structural and functional damage
in general, types of road damage can be divided into two categories, namely:
A. Structural Damage
Structural damage is damage to the road structure, in part or in whole, which causes the road pavement is no longer able to support the traffic load. For this reason, it is necessary to strengthen the structure of the pavement by overlaying or repairing the existing pavement.
B. Functional Damage
Functional damage is damage to the road surface that can cause disruption of the function of the road. This damage can be related or not with structural damage. In functional damage, road pavement is still able to withstand working loads but does not provide the desired level of comfort and safety. For that the surface layer of the pavement must be treated so that the surface returns to good.

2.3. The importance of road roughness
According to the World Bank road roughness is a defect consisting of surface irregularities that affect, and are relevant to the movement and operation of a moving vehicle, and also affect:
- Through the user's perception of the quality of driving, where safety and comfort of driving are the main drivers.
• The cost of using and operating the vehicle used
• Road safety

2.4. Road roughness (international roughness index)
Wambold, et al (1981) in the journal Tanan (2005) generally states that road roughness can be defined as the road surface deviation measured from a flat plane, plus other parameters that can influence such as: vehicle dynamic movement, travel quality, dynamic load construction and water drainage on surface. The International Roughness Index (IRI) is used to measure road surface roughness, the roughness measured at each location is assumed to represent all the physical properties at that location.

Hikmat Iskandar (2005) said that the level of road smoothness (IRI) is one of the factors / functional services (functional performance) of a road pavement that greatly influences riding quality. One technical indicator for assessing road surface performance is the International Roughness Index (IRI) value, which is a measure of size that illustrates the value of surface roughness indicated as the cumulative length of rise and fall of surfaces per unit length. Flatness of road surface is considered as a result of overall road pavement conditions. If it is flat enough, the road is considered good starting from the bottom layer to the top layer of pavement and vice versa. The IRI value is expressed in meters of ups and downs per kilometer of road length (m / km). if the value of IRI = 10 m / km, this means that the amount of amplitude (up and down) of the road surface is 10 m in each km of road length. The greater the IRI value, the worse the surface condition of the pavement.

To calibrate the response type system to provide a similar IRI value, the ideal system is defined to develop mathematical models of vehicles and road meters. This system is called a quarter car (Sayers, M. and Karamihas, S., 1998). It calculates a mechanical system simulation suspension deflection with a response similar to a passenger car. The simulation suspension motion is accumulated and divided by the distance traveled to provide the IRI value. Figure 1 shows the estimated range of IRI roughness on various types of roads (Sayers, M. and Karamihas, S., 1998).

![Figure 1. International Roughness Index (Sayers, 1998).](image-url)

2.5. Roughometer III
Roughometer III is a tool used to determine the value of road unevenness (Roughness / IRI) on roads covered by flexible pavement / Rigid or not coated by pavement. This tool is very simple and practical to use because its installation is simple and can be assembled quickly on all types of four-wheeled vehicles (portable) quickly, does not require calibration like a device with a Bump Integrator system (ROMDAS, NAASRA, etc.) which requires calibration with IRI reference values from the DIPSTICK tool. This tool is also equipped with an accurate proximity sensor and GPS.
2.6. **Roadroid application**

Roadroid is an application made on Android developed from a company in Sweden, where this application aims to measure the unevenness of a road (Umi Tho’atin. 2016). This application can only be used on certain types of mobile phones that have certain specifications, the way this application works is by using a built-in vibration sensor on a smart phone to collect road roughness data that can be an indicator of road conditions to grade 2 or 3 level effectively and efficiently. Roadroid installation tool as shown in the following figure.

![Roadroid installation](image)

**Figure 3.** Roadroid installation on vehicles and roadroid logos on Android smartphones.

The Roadroid application measures in two ways namely eIRI and cIRI where the IRI estimate (eIRI) uses a linear conversion formula and takes more road texture, while the calculated IRI (cIRI) uses a quarter of the car formula. eIRI has a speed compensator (20 - 80 km / h) for paved roads - and cIRI requires consistent speed, eIRI is more sensitive to micro roughness, has a speed compensator for paved roads with limited settings (only vehicle types) and to make IRI readings that are more accurately, you need to work with cIRI. In a previous study conducted by (Forslöf & Jones, 2015), the estimated correlation of IRI (eIRI) on laser light measured by IRI was around 70-80% depending on the type of road surface and further developed IRI (cIRI) which was calculated to increase the value of the correlation factor.

3. **Research methods**

This research was conducted on one of the national road sections ranging from post intersections to Hairos, with flexible pavement layers on slow and fast lanes in one direction. The survey is carried out during the day and night, this is done to keep the survey vehicle speed can be more than 40 km / hour, in accordance with the conditions that have been determined. Sample segmentation for instrument readings is used per 100 meters. Thus the comparison of the two tools is in terms of reading the Roughness of the data for every 100 meter.
4. Results and discussion
The results of the comparative analysis of the uneven road values can be seen in Figures 5 to 8. In the figure the comparison of the Unevenness values for each of the lane (4 lane roads), for each reading of the two tools; Rouhometer III and Roadroid.

![Flow chart of the research](image)

**Figure 4.** Flow chart of the research.

**Figure 5.** Comparison of IRI and eIRI value for Fast lane (Pos Intersection to Hairos Park).

**Figure 6.** Comparison of IRI and eIRI Value for Fast lane (Hairos Park to Pos Intersection)
Figure 7. Comparison of IRI and eIRI value for Slow Lane (Pos Intersection to Hairos Park).

Figure 8. Comparison of IRI and eIRI Value for Slow lane (Hairos Park to Pos Intersection).

From the results shown in the graph, then the comparison of the Roughometer III tool with the Roadroid application, we can analyze by comparing the average value of the IRI, as in Figure 5 with the average ratio (IRI: eIRI = 3.05: 2.59), in Figure 6 with the average ratio (IRI: eIRI = 3.5: 3.16), in Figure 7 with the average ratio (IRI: eIRI = 3.3: 2.86), and at Figure 8 with a comparison of averages (IRI: eIRI = 4.09: 3.91).

4.1. Correlation analysis
IRI values obtained from the two tools show values that are not much different. The linear correlation equation to get the correlation between the Roughometer III tool and the Roadroid application can be seen in figures 9 through 12.

Figure 9. Linier correlation between IRI and eIRI at Fast lane (Pos Intersection to Hairos Park).
Figure 10. Linier correlation between IRI and eIRI at Slow lane (Hairos Park to Pos Intersection).

Figure 11. Linier correlation between IRI and eIRI at Slow lane (Pos Intersection to Hairos Park).

Figure 12. Linier Correlation between IRI and eIRI at slow lane (Hairos Park to Pos Intersection).

5. Conclusions and recommendation

5.1. Conclusion

• Based on the uniformity of data from the results that have been surveyed, it can be concluded that; damage occurs dominantly on slow lanes.
• From the comparison analysis above we can see the average value of IRI from using the Roughometer III tool, not much different from the average value of eIRI from using the Roadroid application.
From the IRI and elIRI values, a correlation equation for the Roughometer III and Roadroid applications is obtained, where the correlation equation for each lane is:

- Fast lane starts from Pos Intersection to Hairos
  \[ IRI = 0.9168eIRI + 0.6752 \approx 0.5362 \]

- Fast lane starting from Hairos to Pos Intersection
  \[ IRI = 0.5935eIRI + 1.6924 \approx 0.6470 \]

- Slow lane from Pos Intersection to Hairos
  \[ IRI = 0.9482eIRI + 0.6189 \approx 0.5829 \]

- Slow lane from Hairos to Pos Intersection
  \[ IRI = 0.8999eIRI + 0.5786 \approx 0.8391 \]

There is a moderate to strong correlation between the Roughometer III device and the Roadroid application.

5.2. Recommendation

- Further studies are needed to get a correlation of IRI values on sampling every 50 meters.
- The level of correlation of Roughometer and Roadroid application is quite high; it is necessary to research the roadroid correlation with other survey tools which have a higher level of accuracy such as hawkeye.

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