The Priority of Road Rehabilitation in Karanganyar Regency Using IRI Estimation from Roadroid

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Abstract. The IRI (International Roughness Index) is a road roughness index commonly obtained from measured longitudinal road profiles. This is one of the functional performance a surface of road pavement. Therefore, needs to be done evaluation and monitoring periodically to getting priority of road rehabilitation right on target. The IRI standard has commonly been used worldwide for evaluating road system. The Roadroid is an application to measure road quality with a website to view road quality. It is designed for Android smartphones, so we can easily measure and monitor the road and also use the camera for GPS-tagged photo. By using the built-in vibration sensor in smartphones, it is possible to collect IRI value which can be an indicator road conditions. This study attempts to explain the priority of road rehabilitation in Karanganyar Regency. The location of the study focused on a collector street (primary, secondary and locally road). The result of IRI estimation will be combined with other aspects that influences; land use, policy, the connectivity of road and traffic average daily. Based on IRI estimation using Roadroid, the road conditions in Karanganyar Regency can be described 59.60% were good (IRI<4.5); 21.30% fair (4.5<IRI<8), 11.40% bad (8<IRI<12), and 7.70% poor (IRI>12).

1. Introduction
The road is basic infrastructure in which supported regional economy without adequate was not optimal. Not all regions having enough budget, so it might impact on the ability of allocating budget in road infrastructures. Therefore, they had to have a proper priority to available budget in order to maintenance optimal road.

Karanganyar is one of the regencies in Central Java province, about 14 kilometers from Surakarta City. It bounded with Sragen Regency in the north, Ngawi Regency and Magetan Regency (East Java) in east, Wonogiri Regency in south and Boyolali Regency, Surakarta City and Sukoharjo Regency in the west. Karanganyar has topography diverse partly in the form of lowlands and highlands in Lawumountain. Its geographical location needs to be supported facilities and infrastructure sufficient especially road management.

A preliminary step to determine the priorities of road rehabilitation is the survey road conditions. It needs as a part of rehabilitation and maintenance planning. Usually the level of road damaged determined through the visual observation. Limited equipment, minimal cost and human resource
ability became an absolute consideration in which visual observation a basis of the rehabilitation program. Whereas visual observation has many insufficiency.

The modern traditional techniques for measuring roughness may be categorized as either specially built trucks or wagons with laser scanners, bump-wagons or even manually operated rolling straight edges. Specially built measurement equipment is expensive, due to heavy and complex hardware, low volume of production and the need of sophisticated systems and accessories.

Roadroid is an application to measure road quality and a home page where we can see the road quality on a map. This application is designed for a smartphone with Android operating system. Roadroid is based on the result of several years of research for The Swedish National Road Administration (SNRA). It can be collecting data and give an IRI estimation for road rehabilitation references. During the IRI survey need the complex equipment, more expensive, and take a long time. Measuring roads with smartphones can provide a simple method, efficient, scalable and cost-effective way for road organization to deliver road condition data. In other side, the result of IRI estimation can be accountable and approaching the real-IRI.

The objective of this study is how making a priority system of road rehabilitation in Karanganyar Regency. The study location in road Karanganyar Regency, focused in a collector street (primary, secondary and locally road).

1.1. Evaluation of Road Conditions
The assessment of road conditions is an important step how to know the level of road damage. Depending on which characteristic is being surveyed, a pavement evaluation can be classified as functional or structural. Functional evaluation provides information about surface characteristics that directly affect the users safety and comfort or serviceability. Safety is evaluated in terms of skid resistance and surface texture, while serviceability is quantified through roughness measures. Table 1 shows the road performance condition categories.

Structural evaluation provides information on whether the pavement structure is performing satisfactorily under the traffic load and environmental conditions. This includes surveys on pavement distresses and mechanical/structural properties of pavements.

Evaluating structural conditions and functional conditions of existing, in-service pavements continuously a major part of the maintenance and rehabilitation activities undertaken by Highways Agencies. The structural and functional condition of the pavement changes with the passage of time due to the combined effects of its structural adequacy, composition and loading characteristics of traffic, environmental conditions and the maintenance inputs provided. The process of accumulation of damage is called deterioration and the failure of the pavement is said to have reached at the limiting stage of serviceability level. The physical sign of internal damage, for example, cracking, rutting, potholes, etc. are known as distress, which are indicators of the pavement condition [1].

Pavement evaluations are performed in the field through manual surveys or using specialized equipment. Evaluated characteristics of the pavement are quantified by means of indicators or condition indices. Data collection equipment should be reliable, efficient and secure. To ensure cost effective surveys and data referencing consistency, it is recommended to collect multiple pavement characteristics during a single pass of the data collection vehicle [2].
1.2. The Influences of IRI Value on Road Rehabilitation

The ride quality is one of the most important conditions used by the travelling public to judge roadway pavements. Rough pavements have a significant impact on public satisfaction, safety, and also on the economy. The International Roughness Index (IRI) established in 1986 by the World Bank. IRI is defined as an expression or irregularities in the longitudinal profile of pavement surface that adversely affects the ride quality of a vehicle thus causing discomfort to the user. The IRI is a scale for roughness based on the simulated response of a generic motor vehicle to the roughness in a single wheel path of the road surface. IRI true value is determined by obtaining suitably accurate measurements of the profile of the road, processing it through an algorithm that simulates the way a reference vehicle would respond to the roughness inputs, and accumulating the suspension travel. It is normally reported in inches/mile or meters/kilometers [1].

The measurement of the properties of road roughness was going to be beneficial to road rehabilitation and maintenance program. In Indonesia, the local government has not done this measurement because the network of roads is so fast. In addition, equipment of roughness is very expensive and limited [4].

The road conditions survey must be done periodically, both in structural and functional survey. It’s to know the level of road service. The functional road evaluations aim of checking of roughness, road texture and skid resistance. It would be useful to determine the priority of rehabilitation and maintenance program.

Roadroid was developed by the Swedish National Road Administration (SNRA). It can be an alternative for the road maintenance decision support. The asset management of a road can be optimized with the right decision and its huge money to be saved. The right decision can be taken with access to up to date data of good quality [5].

Roadroid has two options for roughness data calculation: eIRI (estimated IRI), based on a peak and RMS (root mean square) vibration analysis—which is correlated to laser measurements on paved roads, and c-IRI (calculated IRI), based on the quarter car simulation (QCR), the sensitivity of the device can be calibrated by the operator to a known reference. IRI can be expressed as a summary of a road's standard. Other input to decision support might be traffic volume and other road condition parameters, as rutting, cracking, edge brakes, culvert inspections, etc. In the correlation studies between Roadroid and IQL1/Laser Data, to the same spatial road links, we can see an illustration in Figure 1.
Based on *The Technique Management Series Guide of Regional Road Maintenance*, 2005, the road conditions minimum was being fair with the range of IRI between 4.5 m/km till 8 m/km, hanging from the function of the road. If the IRI value under 4.5, it means the road was under routine maintenance, and if the IRI value between 4.5 to 8 it means the road have to be done a periodic road maintenance or overlay. And the IRI value more than 12, the road was poor conditions and it have to be reconstructions. The explanation can seen in Figure 2.

1.3. Other Influences Factors

For the implementation in local government, the policy of road rehabilitation priority, not only based to technical aspect like road conditions, it is also being affected by the other aspect. Based on Wahyudiana [6], the aspect that has some influences to road rehabilitation as follows:

1) Technical aspect. This factor, including road conditions and topography. The lower this aspect, the more important to rehabilitation priority.

2) Land uses aspect. This factor is used many activities, the higher of their land-use of the more important as well.

3) The policy aspect. Political factors were very needed in policy budgeting.
4) Road connectivities. This factor was needed to improve the road networking for the future.
5) Emergency aspect. Emergency factors can be a natural disaster or the other factors that cause the urge to repaired.

2. Experimental

2.1. The Location of Study

The location of the study was on the road Karanganyar Regency focussed in collector street (primary, secondary and locally road).

2.2. Instrument of Measurements

IRI estimation was obtained using Roadroid for Android smartphone. It puts on the windshield of a car or other vehicle. The next step is setting Roadroid by adjusting the type of the car, the distance of automatic documentations and a segment of IRI estimations.

3. Result and Discussion

The result of the IRI survey using Roadroid will get data as follows:
- a. Date Time
- b. Latitude
- c. Longitude
- d. Distance
- e. Speed
- f. Altitude
- g. Grade
- h. e-IRI
- i. c-IRI
- j. Road

The example of the IRI survey result can be seen in Table 2.

Table 2. The example of IRI survey-result using Roadroid at Colomadu-Banyuanyar road

| Date Time     | Latitude | Longitude | Distance (m) | Speed (km/h) | Altitude (m) | Grade (%) | eIRI | cIRI |
|---------------|----------|-----------|--------------|--------------|--------------|-----------|------|------|
| 06/11/2015 13:56 | -752.991.471.832.532 | 11.074.937.935.612 | 20 | 21.3 | 140.11 | 0 | 1.88 | 0.35 |
| 06/11/2015 13:56 | -752.990.717.215.126 | 11.749.728.765.123 | 40 | 21.38 | 140.7 | 2.95 | 2.44 | 0.35 |
| 06/11/2015 13:56 | -752.990.079.210.511 | 11.749.718.910.529 | 60 | 21.21 | 141.16 | 2.33 | 3.03 | 0.35 |
| 06/11/2015 13:56 | -752.988.488.668.056 | 11.750.041.932.126 | 80 | 21.21 | 141.16 | 0 | 3.03 | 0.35 |
| 06/11/2015 13:56 | -752.988.336.063.382 | 11.750.076.929.464 | 100 | 21.34 | 143.35 | 10.92 | 2.84 | 0.49 |
| 06/11/2015 13:56 | -752.987.317.546.356 | 11.750.322.838.232 | 120 | 26 | 144.82 | 7.35 | 1.85 | 0.54 |
| 06/11/2015 13:56 | -752.986.783.780.621 | 11.750.400.358.373 | 140 | 23.31 | 145.28 | 2.32 | 1.92 | 0.54 |
| 06/11/2015 13:56 | -752.983.750.853.005 | 11.750.711.100.958 | 160 | 20.76 | 145.02 | -1.28 | 2.15 | 0.57 |
| 06/11/2015 13:56 | -752.982.751.489.626 | 11.750.866.358.811 | 180 | 22.04 | 143.83 | -5.95 | 3.18 | 0.63 |
| 06/11/2015 13:56 | -752.981.566.099.216 | 11.750.048.589.374 | 200 | 24.1 | 142.69 | -5.73 | 3.51 | 0.63 |
| 06/11/2015 13:56 | -75.298.014.131.202 | 11.751.227.763.892 | 220 | 24.84 | 141.4 | 6.45 | 3.03 | 0.63 |
| 06/11/2015 13:56 | -752.978.278.157.321 | 11.751.419.519.228 | 240 | 23.55 | 140.15 | -6.24 | 2.29 | 0.63 |
| 06/11/2015 13:56 | -752.977.457.524.586 | 11.751.502.061.422 | 260 | 24.14 | 139.56 | -4.45 | 2.6 | 0.63 |
| 06/11/2015 13:57 | -752.976.879.477.996 | 11.751.694.902.763 | 280 | 22.84 | 139.31 | -1.26 | 5.46 | 0.69 |
| 06/11/2015 13:57 | -752.977.570.899.747 | 11.751.919.848.741 | 300 | 20.98 | 140.17 | 4.31 | 3.12 | 0.76 |
| 06/11/2015 13:57 | -752.979.464.265.367 | 11.751.218.398.978 | 320 | 20.57 | 140.97 | 4 | 7.94 | 0.76 |
| 06/11/2015 13:57 | -752.980.446.576.279 | 11.752.270.706.538 | 340 | 21.32 | 141.74 | 3.83 | 3.76 | 0.76 |
| 06/11/2015 13:57 | -752.981.877.752.693 | 11.752.436.197.291 | 360 | 20.77 | 142.59 | 4.27 | 8.77 | 0.76 |
| 06/11/2015 13:57 | -752.984.742.996.673 | 11.752.650.625.275 | 380 | 20.8 | 142.75 | 0.81 | 7.82 | 0.81 |
| 06/11/2015 13:57 | -752.986.912.628.848 | 11.752.767.603.378 | 400 | 21.09 | 141.45 | -6.53 | 7.72 | 0.96 |
From the table, we can see that IRI value under 4.5, it means the road was good condition, the IRI value between 4.5 to 8 it means the road is fair condition, the IRI between 8 until 12 was bad condition and the IRI more than 12 was poor condition. Have to be done at periodic road maintenance or overlay. And IRI value more than 12, the road was poor conditions.

4. Conclusion
Based on IRI estimation using Roadroid, the road conditions in Karanganyar Regency can be described as follows: the local road to the long 386.83 kilometers or 59.60% were good conditions (IRI<4.5); then the road about 139.98 kilometers or 21.30% fair conditions (4.5<IRI<8); the road about 77.63 kilometers or 11.40% bad (8<IRI<12), and the road about 53.27 kilometers or 7.70% poor (IRI>12).

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