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Integrated Strategy in Road Assesment for Tameroddo-Majene City Boundary Road Section Preservation

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Tameroddo – Majene City boundary road section is a national road in West Sulawesi, a road connecting South Sulawesi and Central Sulawesi provinces. Its existence is essential for increasing accessability and mobility between regions, for it does not only support economic growth in the West Sulawesi Province, but it also has some positive impacts on socioeconomic development for surrounding areas. Traffic volume, overload, and rainfall are factors that accelerate intensity of road surface irregularities. An analysis of road pavement conditions is, therefore, required to provide existing data for road preservation, to ensure its optimum function in accordance with planned durability. This research is aimed at providing assessment results of the road section conditions, and to compare the results between IRI and PCI measures, as well as to provide an overview or description of the road section conditions. This can, thereafter, be used as an important database for a better planning and implementation. Road assessment had been conducted using an integrated method, by IRI measure performed by using 'The Hawkeye' vehicle equipped with high precision laser profilers and accelerometers, DMI, and high-speed cameras along with GPS, incorporating Dinamic Time Warping (DTW) technique, to automatically detect and classifies road irregularities on paved roads. This method, however, followed by manual inspection (or subjective measures). Survey result shows that based on IRI method, 'fair' condition reaches 67%, and lightly damaged reaches 33%. While based on PCI method, 'good' (equivalent with 'fair') condition reaches 66%, and 'bad' condition (or equivalent with 'lightly damaged') condition reaches 34%. This means that the study found some differences, even though it was only a little. Based on analysis result, amongst total lenght of the road lane had been under assesment (81,8 km), 74,4 km is of 'fair' condition, thus it requires a routine maintenance, while the rest 8,4 km is of 'lightly damaged' and it requires a regular maintenance.

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1. Introduction

Damaged roads decreased traffic convenience quality, increased vehicle fuel consumption, and have an impact on vehicle handling. According to a report in the UK, road 'patholes' caused more than £ 1 million damage to vehicles every day in 2010.

According to WHO (2022), traffic accidents on the road were the main cause of death among children, teenagers and adults, aged between 5-29 years. Around 1.3 million people die every year from traffic accidents (Ahmed, S. K., Mohammed, M. G., Abdulqadir, S. O., El-Kader, R. G. A., El-Shall, N. A., Chandran, D., ... & Dhama, K. 2023). Most of the victims died due to traffic accidents were pedestrians, cyclists, and motorcycle riders. Traffic accidents cause losses of 3% of GDP in many countries.

Therefore, road preservation efforts are not only for convenience in carrying vehicles, but also to avoid or reduce the number of traffic accidents. This is in accordance with the UN mission, as it was said that "The United Nation General Assembly has set an ambitious target of halving the global number of deaths and injuries from road traffic crashes by 2030."

From previous study, Mahardi P. et. al. (2019) explained that it is necessary to conduct evaluation of road pavement conditions, for monitoring road irregularities. In order to know damage intensity and to provide maintenance proposal, particular methods are required as a guidance for conducting survey on road pavement conditions, making damage classification and analysis.3 Assessment on existing conditions of the road is one of the stages in revaluating road surface conditions. Those assessment results will be used as a reference to determine the type of revaluation program that must be carried out, whether it is a development program, periodic maintenance, or routine maintenance.

From previous studies by Tho'atin U., (2019), it was reported that a common problem faced by technical services of public works department in a number of district areas was the unavailability of database on road conditions. The existence and function of Tameroddo–Majenne City boundary road section is very strategic for sectoral movements in southern part of Mamuju Regency. This road section is a national road of which management is under the National Road Development (Public Works) Office of West Sulawesi.

An appropriate road maintenance to implement would be based on the assessment on the road surface conditions using International Roughness Index (IRI). Beside the IRI method, another method can be used for road assessment is called Pavement Condition Index (PCI).

A preliminary observation found that at a number of segments of Tameroddo – Majene City bondary road section, some 'damaged' conditions on the road surface were identified. Therefore, to assess the level of damage conditions, it is necessary to identify and classify overall types of existing conditions of the road.

The aim of this study is, theoretically to provide assessment results of the Tameroddo-Majene city boundary road conditions, to compare the results between IRI and PCI measures, and to provide an overview or description of the road section conditions. Thereafter, this assessment result can be used as an essential database for both the planning and the implementation of road maintenance. In addition, the results of this study can also be used as a reference by road experts and relevant stakeholders for conducting road maintenance more effectively.

In this study, data collection was conducted to classify surface irregularities in 'quasi-real-time condition' by using three separate techniques: laser profilers and accelerometers with

DTW, along with imaging-based systems, as well as manual surveys for data validation from each segment of the road. The first technique is an application of laser sensors and accelerometers, GPS and Arduino which are connected to the monitor display module. This system is not only of higher precision, better, faster, and more reliable, to obtain data on road surface irregularities but it is also far better in view of 'working safety' (or in accordance with new standardized safety in construction work for sustainable development), compared to that of manual survey (a subjective measures or visual inspection).

For data processing, a set of data with image patterns which resembles certain types of road surface irregularities, were immediately transferred to 'Dynamic Time Warping' (DTW) to identify the types of patterns and similarities. This method uses an automatic frame, to identify whether or not there are particular types of road damage from existing image processing techniques. This image processing method functions to detect and classify the road surface irregularities, supported by a logical processing had been set based on the user's design.

Acquisition of logical decisions depends on three specific visual properties of the type of road irregularities detected, namely standard deviation of fixel intensity circularity (CIRC) to calculate average shape and size of image dimensions. A smart video separator algorithm which is also referred to as 'Irregularity Frame Selection' (IFS)], which fuction to determine whether the object in the image is classified as a type of road surface damage. With the third technique, however, a series of visual inspections were conducted manually for comparison and for data validation as well.

2. Research Method

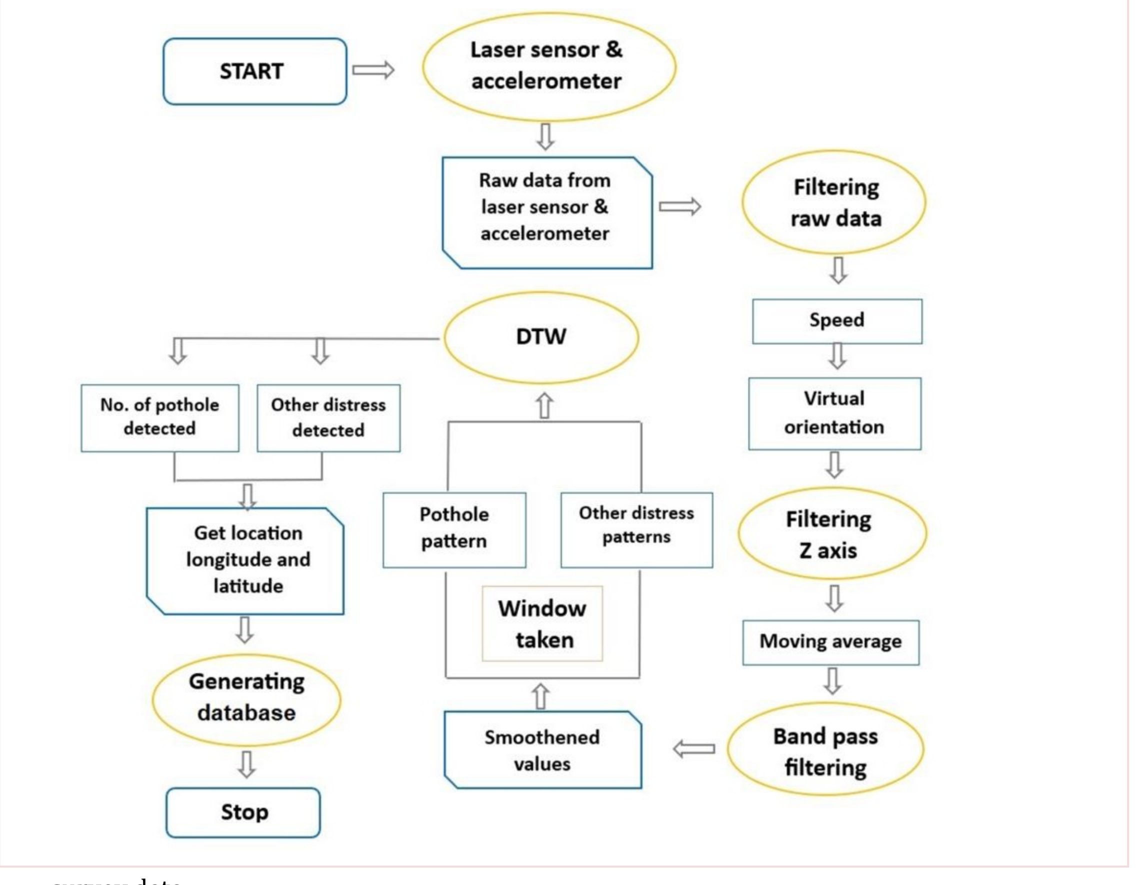
This research used a quantitative method through application of integrated methods, of International Roughness Index (IRI) and Pavement Condition Index (PCI) to obtain relevant data needed, then they were used as materials for data analysis. An effective and efficient treshold-based road assessment system was used to detect road surface conditions. Figure 1 shows a review of the methodology of information obtained from the results of laser sensors and accelerometers.

Next, data collection and analysis were processed using a main server. This is where the application of the DTW algorithm and 'noise filtering' techniques were applied.

These series of surveys and road assessments were carried out using high precision laser sensors along with accelerometers, DTW, IFS (algorithm), and filters to authomatically detect and classifies road irregularities. The laser profilers were placed at the rear part, while the high speed cameras were placed at both the rear and the front part of 'The Hawkeye' vehicle.

After informations were collected, then they are sent to a central server for further processing. And then, other things of which consist of sound, vibration, and gravity were separated using filters. DTW helps get proximity scores through analysis of image patterns of road surface irregularities. Next, detection of road irregularities were processed with information support from GPS. Finally, the results were displayed as

Figure 1. Flow chart of how laser profilers and accelerometer with DTW works



survey data.

In addition to laser profilers and accelerometer, 'The Hawkeye' vehicle, also equipped with high speed cameras with a GPS, DMI, as well as a Monitor Screen (industrial PC), as shown in Figure 2. In more detail, the system consists of four parts: laser profilers and accelerometer, server module, and monitoring display screen module. These laser profilers and accelerometers were used to authomatically detect and collect some informations on road conditions. Next, these informations along with their geographicallocation were sent to the server. Eventually, the server module received those informations from the microcontroller module, undertake processing and store information in a database as well.

Figure 2. 'The Hawkeye' survey vehicle equipped with laser profilers,high speed cameras, a GPS, and a monitoring screen.

Source: Sharma, S. K. et.al. (2020)

(b) *GPS antenna*, (c) *Laser profilers*, (d) *Monitor screen (Industrial PC)*

(a) (b) c) d)

Gambar 3. Komponen yang digunakan dalam system survey IRI: (a) *High speed cameras,*

Pavement roghness

Pavement roughness is a measurement of road surface pavement irregularities that affects traffic quality of vehicles and road users. *Roughness* is a deviation on the roadsurface from ideal condition, of which normally should be in even condition, with particular disparities that affect the dynamic nature of vehicles, the ride quality, and transportation, which is stated as International Roughness Index (IRI).

The survey vehicle used to assess road quality was a four-wheeled vehicle, since it has two-dimensional angles which capable of detecting shocks on the Y axis of road conditions, with better results compared to that of a two-wheeled vehicle. The smallervalue of IRI indicates the better road quality.[13] IRI index parameters can be seen in Figure 4. IRI value is calculated from longitudional profile measurement, as the accumulation of vertical movement of the suspension divided by traveling distance of the four-wheeled vehicle, expressed in millimeter per meter (mm/m) or equivalent to meters per kilometer (m/km).

Pavement Data Collection

Pavement condition assessment were conducted by using 'The Hawkeye' vehicle with responsive type profilometer to collect automated pavement surface distress, International Roghness Index (IRI), and digital image logs for the road segments. The Hawkeye collected the pavement condition data from both Semester I and Semester II of 2021 on road lane of 81.8 km. The object for this study was Tameroddo–Majene City boundary road section, section number 010 with a length of 42 .790 M. The road is located in Majene City, West Sulawesi. The map of the research site for this road segments can be seen in Figure 9.

Paved Road Distress Assessment

A survey teamwork conducted assessment on paved road surface conditions using 'The Hawkeye' vehicle, of which using high speed cameras, laser profilers and accelerators of which work is similar with that of a 3D Laser Crack Measurement System [LCMS]. The LCMS produces 3D road surface elevation images in detail, while it is also used to detect and classify types of road irregularities. The system detects and classifies cracks based on changes in road pavement elevation and surface color differences. Then, this elevation data is processed automatically to calculate severity and size of crack and other types of road irregularities (see Fig.3) 'The Hawkeye' collected network level distress data on paved roads consistent with ASTM E1926-08, whereby individual distresses are rated based on severity and extent. Surface distresses were inventoried for the width of the surveyed lane. Data is presented at a maximum interval of 100m. 'The Hawkeye' vehicle is particularly designed to assess both 'rigid pavement' and 'asphalt pavement road.

(i) For 'asphalt paved road', types of road irregularities recorded in this function, include:

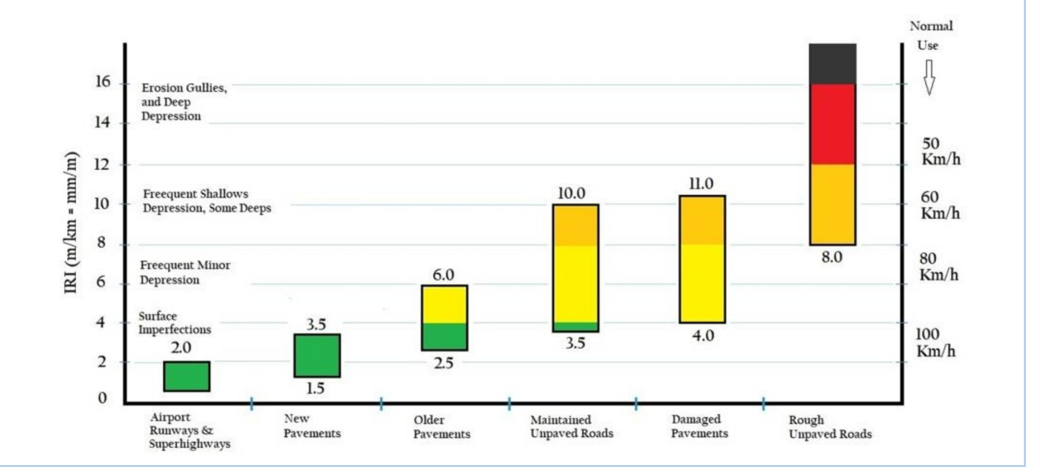
- Alligator cracking
- Bleeding
- Block cracking
- Bumps and fall down
- Curling
- Depression
- Side cracking
- Reflection cracking
- Shoulder dropping
- Longitudional cracking
- Transverse cracking
- Patching
- Weathering
- Potholes
- Rail crossing
- Rutting
- Shoving
- Skid cracking
- Expansion
- Ravelling

(ii) For concrete or 'rigid paved road', types of road irregularities recorded, include:

- Corner cracking
- Plate separating
- Durability cracking
- Stepping formation
- Joints blockages
- Shoulder/lanes
- Line cracking
- Weathering
- Pumping
- Corner cracking
- Corner chipped
- Joint chipped
- Big patches
- Small patches
- Pop out
- Shrinkage cracking
- Corner breaking
- Joint breaking

IRI value is influenced by road unevenness and speed of vehicle passing on the road. IRI Value 2.0 is for a type of toll road and aircraft runways quality. A road quality with an IRI value of 2.0 is classified as ‘very good’, it can be used for vehicles to run up to a speed of more than 80 km/h. Road quality with an IRI value of more than 2.0 is due to detection of a mound or uneven conditions of the road surface. Such road conditions affect the speed rate of vehicle on the road when it is passed by.[15] The higher density of road surface irregularities, the slower speed of the vehicle.

Figure 4. IRI scale parameter



Source: Greene S. et.al (2013)

International Roughness Index (IRI) Calculation Method

International Roughness Index (IRI) is a parameter used for calculating uneven value of road surface, from the cumulative number of ups and downs of the road in logitudional profile divided by the distance /length of road surface being measured.

Classification of road conditions based on IRI values is shown in Table 1 below.

Table 1. Category of Road Conditions Based on IRI Values in Paved Surface Type

IRI Value	Category of Road Conditon
< 4	Good
4 - 8	Fair
8 - 12	Lightly Damaged
> 12	Heavily damaged

Source : Directorate General of Highways

Pavement Condition Index (PCI) Calculation Method

Type of road irregularities and dimensions of road surface damage obtained by conducting direct surveys in the field. Equipment used in survey includes: meters, paper, stationery, cameras and survey forms for PCI assessment.

Assessment of road damage conditions by PCI method, following these three steps:

(i) The road was divided into segments, where each segment was100m lenght

(ii) The road surface irregularities were identified and measured, and

(iii) The roads condition were evaluated based on PCI methods.

Classiification of road condition based on PCI value can be seen in Table 2

Table 2. Category of Road Condition Based on PCI Values in Paved Surface Type

PCI Value	Category of Road Conditions
86 - 100	Very Good
71 - 85	Good
56 – 70	Mediu
41 - 55	mFair
26 - 40	Bad
11 - 25	Very Bad
0 - 10	Failed

Source: Directorate General of Highways

Data Analysis

Assessment of Road Condition by IRI Mesures

IRI value is the sum of all sampling intervals divided by distance values (S) with the following formula.[16]

$$IRI = \frac{\sum_{i=2}^{n} Vh_i}{S} = \frac{\sum_{i=2}^{n} |h_i - h_{i-1}|}{S} \quad (2)$$

When calculating IRI, it requires a total distance traveled (S) and the results from average vertical movements transferred by accelerometer for each sampling time. Distance travelled can also be calculated from GPS. However, vertical movements arenot the value can be obtained directly from the accelerometer sensor. In Physics formula:

$$Vv = \frac{dVh}{dt}$$
$$\alpha v = \frac{dVv}{dt} = \frac{d^2Vh}{dt^2} \quad (3)$$

With: t = time, αv = vertical acceleration, danVv = vertical velocity, Vh = vertikal movement.

Then:

$$\sum Vh = \iint_{t_{first}}^{t_{end}} |\alpha_v| (dt^2) \quad (4)$$

By using distance travelled (S), the formula above can be modified as follows:

$$IRI = \frac{\sum_{i=2}^{n} Vhi}{S} = \frac{\iint_{t_{first}}^{t_{end}} |\alpha_v|(dt^2)}{S} \quad (5)$$

How to get IRI value from GPS Accelerator

a. *How to count Distance travelled (S)*

Distance travelled can be counted by using *Velocity* from point one to poit two referring to GPS by formula:

$$S = \int_0^t V_t \, dt \quad (6)$$

V_t is *Velocity* measured at *t (time),* can be obtained directly from the GPS sensor.

b. *How to get Vertical Value Transfer*

The accelerometer sensor was recording vertical movement acceleration, it provides more data sampling. Vertical acceleration (αv) can arise from three-dimensional axes, especially the y axis, in other words, the y axis acceleration data from the accelerometer can not be retrieved directly because the vertical acceleration data requires a method to obtain αv from the overall acceleration value of the three axes. When starting to record data, the vehicle must be ensured to be in a stable position. The force received by the accelerometer is only one gravitational force, that is the vertical direction and downward with the value 2, with the formula: [20] (7)

$$\overline{A}x * \overline{A}x + \overline{A}y * \overline{A}y + \overline{A}z * \overline{A}z = 1$$

Āx, Āy, Āz are average acceleration value x, y, and z axes in every 5 seconds, obtained from a accelerometer sensor. Obtaining the vertical acceleration (αv) from each axis, value A = (Āx, Āy, Āz) can be interpreted as vector A projections, with vector references Ā = (Āx, Āy, Āz), measurements at the beginning of the data collection process, in other words, αv is a scalar projection of vector A and Ā, then it can be obtained formula as follows:[15]

$$Av = \frac{A \cdot \overline{A}}{|A|} = \frac{Ax * \overline{Ax} + Ay * \overline{A}y + Az * \overline{A}z}{\sqrt{\overline{A}x * \overline{Ax} + \overline{A}y * \overline{A}y + \overline{A}z * \overline{A}z}} = Ax * \overline{Ax} + Ay * \overline{A}y + Az * \overline{A}z$$

Assessment of Road Condition by PCI Measures

The PCI value was the output resulted from visual observation on the road conditions by identifying various types of road irregularities. The stages for calculating PCI values: Firstly, calculating the quantity of damage type; Secondly, classifying the level of road damage, (i.e. low, medium, and high); Thirdly, calculating density of road damage;

Fourthly, calculating 'deduct value'; Fifthly, calculating total deduct value (TDV); Sixthly, calculating corrected deduct value (CDV); Lastly, calculating the PCI values.

3. Result and Discussion

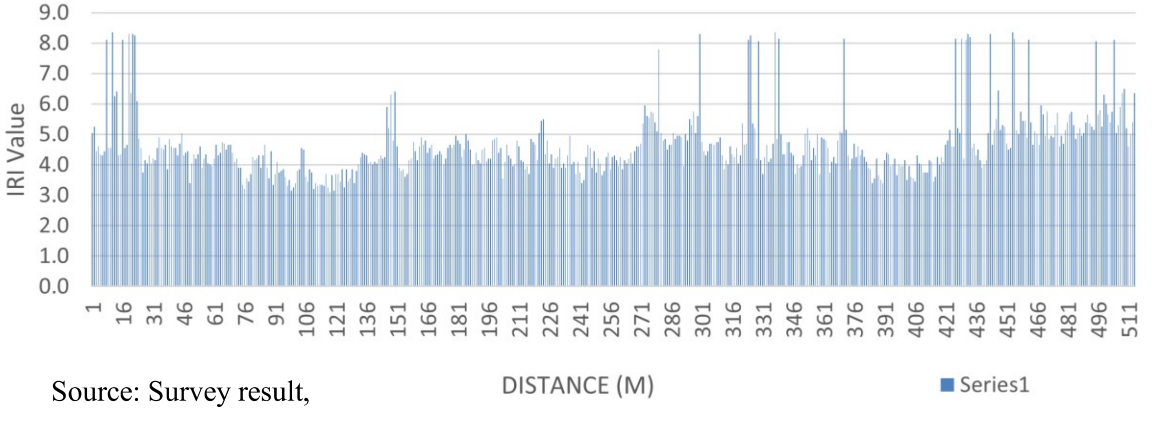
Study Result using IRI Measures

The result showed that of 'good' condition was only 5%, of 'fair' condition reached 85%, of 'lightly damaged' was 10%. However, there was no 'heavily damaged' found. Overall assessment value of road conditions based on IRI recapitulation for Tameroddon-Majene City boundary road section can be seen in Figure 5 below:

Figure 5 shows that for the Tamareddo-Majene City boundary road section, the lowest IRI value was
3.0 – 4.0, classified as of 'good' conditions were found at STA 25, STA 37, STA 48, STA 540, STA 58 – STA 59, STA 72 – STA 78, STA 83, STA 85 – STA 87, STA 89 – STA90, STA 92 – STA 102, STA 105 – STA131, STA 138, STA 151 – STA 155, STA 173, STA 187 – STA 188, STA 202, STA 207 – STA 208, STA 213 – STA 215, STA 227, STA 231, STA 233, STA 236, STA 238, STA 240 – STA 241, STA 246, STA 248, STA 251 0 STA 251, STA 259, STA 291, STA 311, STA 313, STA 330, STA 346 – STA 349, STA 358, STA 363, STA 373, STA 382 – STA 385, STA 387 – STA 389, STA 393 – STA394, STA 396 – STA 399, STA 401 – STA 405, STA 408 – STA 411, STA 414 – STA 415, STA 417, and STA 438 – STA
439. While the road segment classified as 'heavily damaged' conditions was zero (0). The highest IRI value was 8.1 – 8.4 classified as 'slightly damage' were found at STA 700, ST A 1000, STA 1500, STA 1800, STA 2000 – STA 2100, STA 29900, STA 23200 – STA 23400, STA 32800, STA 33600, STA 33800, STA 37000, STA 42500, STA 42800, STA 43000 – STA 43200, STA 42200, STA 45300 – STA 45400, STA 46100and STA 49400.

Average IRI value obtained was between 4.0 – 6.0, classified as 'fair' conditions. The road conditions in percentage (%) are described in the following pie charts (data was taken from Semester I and Semester II in 2021).

Figure 5. IRI value from Hawkeye for Tameroddo–Majene City boundary road section



Source: Survey result,

Figure 6 shows that based on IRI measures, road conditions in percentage (%) for the Tomareddo- Majene City boundary road section in Semester I (2021), that of good condition was only 6%, of 'fair' condition reached 84%, of 'lightly damaged' was 10%. However, non (0%) in 'heavily damaged' was found. In Semester II (2021), that of in good condition was 0%, of 'fair' condition reached 67%, of 'lightly damaged' was 33%, and 'heavily damaged' was 0%.

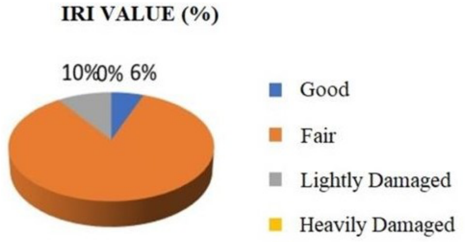


Figure 6A. IRI value (%) of Tameroddo-Majene Boundary road section, in semester I (2021)

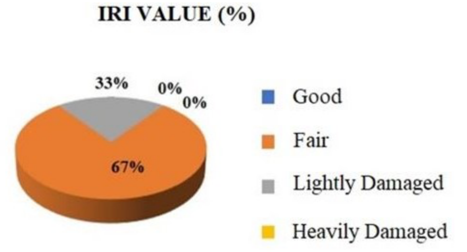


Figure 6B. IRI value (%) of Tameroddo-Majene City boundary road section, in semester II (2021)

Road Assessment Result by PCI Mesures

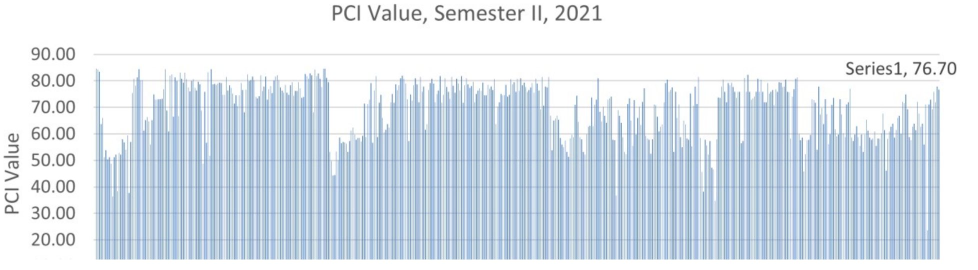
Based on PC I measures, road segments of 'medium' condition was 29%. Neither of the road segments was in 'lightly damaged', nor in seriously damaged were found. Recapitulation of road conditions for Tameroddon-Majene City boundary road section can be seen in Figure 7. It shows that the lowest value was between 36.45 – 40.00, classified as 'bad' conditions was found at STA 1100, STA 1400, STA 2100, STA 14500, STA 31700, and STA 50600.

Road conditions classified as the highest value was between 71.50 – 85.00, classified as of 'good' conditions was found at STA 0 – STA 300, STA 230 – STA 290, STA 360 – STA 430, STA 460 – STA 470, STA 4900 – STA 6400, STA 6700, STA 6900, STA 7100 – 7655, STA 9200 – STA 13200, STA 16400, STA 16600 – STA 16900, STA 1700 – STA 17100, STA 17300 – STA17400, STA 1800 – STA 1900, STA 19200 – STA 20000, STA 20300 – STA 24300, 24500 – STA 27000, STA 27100 – STA 27600, STA 29200 – STA 29300, STA 30200, STA 30400 – STA 30600, STA 30900, STA 31200 – STA 31400, STA 32400 – STA 32500, STA 32800, STA 32800, STA 33100, STA 33300 – STA 33400, STA 34000 – STA 34100, STA 34600 – STA 35200, STA 35500, STA 36200, STA 36400 – STA 36600, STA 37900 – STA39200, STA39500 – STA 42200, STA 42400 – STA 42700, STA 43600 – STA43900, STA 44400, STA 44800 – STA 44900, STA 45300, STA 45700 – STA 45900, STA 49100 – STA 49300, STA 50000, STA 50500, STA 50700 – STA 50800, and STA 51000 – STA 51300.

Road conditions classified as 'fair' with PCI value of 43.30 – 54.80 were found at STA 600 – STA1000, STA 1200 – STA 1300, STA 1500 – STA 1600, STA1900, STA 6600, STA 7000, STA 14300 – STA 14800, STA 27800, STA 28700 – STA28800, STA 29700 – STA 29800, STA 32200 – STA 32300, STA 33800, STA 35200, STA 36900, STA 37300, STA 37500 – STA 37600, STA 43100 – STA 43200, STA 43900, STA 46700, and STA 48100. While road conditions classified as 'medium' condition with PCI value of 56.20 – 68.10 were found at STA 600 – STA 1000, STA 1200 – STA 1300, STA 1500 – STA 1600, STA 1900, STA 6600, STA 7000, STA 14300 – STA 14800, STA 15400, STA 27800, STA 28700 – STA 28800, STA 29700 – STA 29800, STA 32200 – STA 32300, STA 33800, STA 35200, STA

36900, STA 37300, STA 37500 – STA 37600, STA 43100 – STA43200, STA 43900, STA 46700, and
STA 48100. Based on PCI measures, the average value was 81.75. Thus, averall the road condition was categorized as 'good' condition.

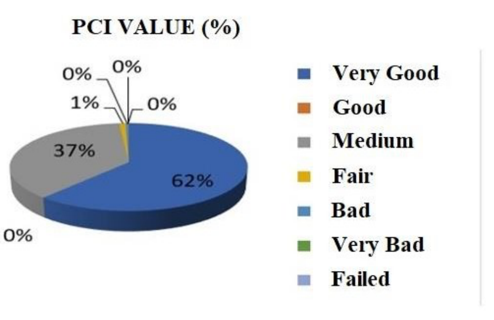
Figure 7. PCI Value for Tameroddo–Majene City bondary road section

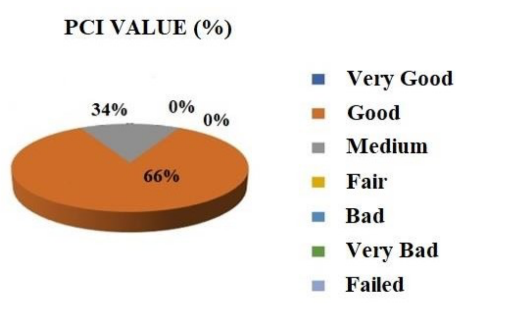


Source: Survey result, 2021

Figure 8 shows that in semester I (2021), road segments with 'very good' condition was 62%, while in semester II (2021) it became 0%, at the same time, for some road segments, their condition decrease from 'very good' to simply 'good' were 66%. Road segments in 'medium' condition in semester I reached 37%, but in semester II it decreased to only 34%. In sementer I, road in 'fair' condition was only 1%, however in semester II, it became 0%.

Assessment value (%) can be seen in Figure 8A and 8B as follows:





gure 8A. PCI Value (%) for Tameroddo – Majene City boundary road section in Semester I 2021

gure 8B. PCI Value (%) for Tameroddo – Majene City boundary road section In Semester II 2021

Comparison of Road Conditions by IRI vs. PCI Measures

Road asssesment value (%) and category of road conditions for Tameroddo-Majene City boundary roadsection, based on the IRI and PCI methods are presented in Table 4 below.

Table 4. Comparison of Assessment Value (%) for Tameroddo-Majene City boundaryroad section based on IRI vs. PCI methods.

Cathegories / Measures	Very good	Good	Fair	Lightly damaged	Bad	Heavily damaged
IRI		-	67%	33%		-
PCI	-	66%	-		34%	

Note:

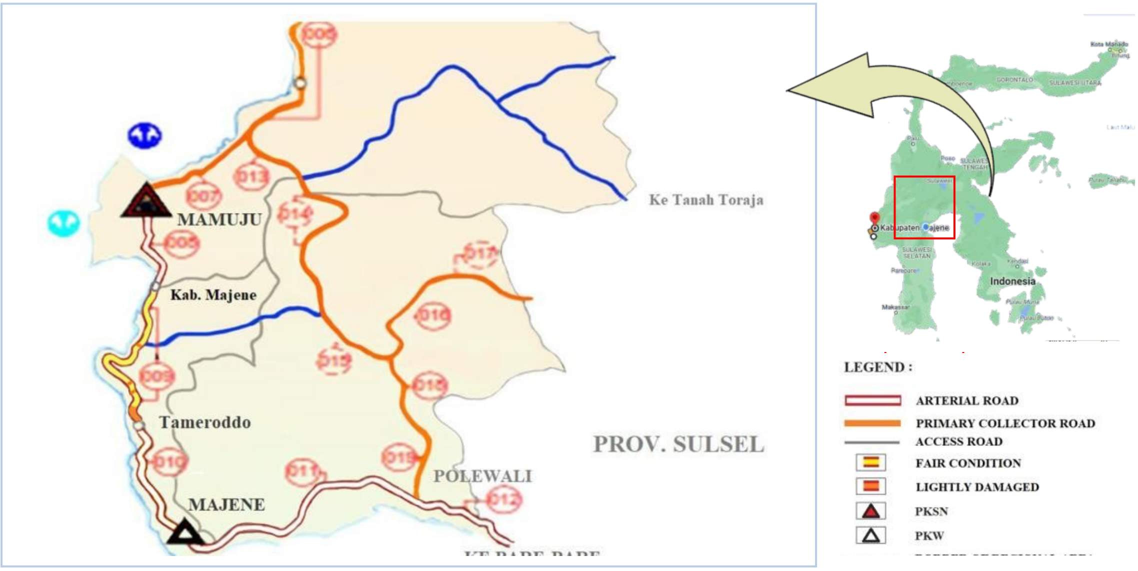
By IRI measures, ‘fair’ is equivalent with ‘good’ cathegory in PCI.
By IRI measures, ‘lightly damaged’ is equivalent with ‘bad’ cathegory in PCI.

Table 4 shows that based on IRI method, road segments of ‘fair’ condition reached 67% and that of ‘lightly damaged’ was 33%. While based on PCI method, road segments of ‘good’ conditions reached 66% and that of ‘lightly damaged’ reached 34%.

From those two methods, each method provides a slightly different value of road conditions. Since based on IRI method, survey was conducted using technology-based system. While survey by PCI method was conducted manually, and it is more subjective, in other words more or less surveyor’s subjectivity could influence assessment results.

Based on road assessment result by IRI measures, the road conditions can be seen in the following map. Road segments marked with orange color indicates of ‘slightly damaged’ condition, while those marked with yellow color indicates of ‘fair’ condition.

Figure 9. Road Condition of Tameroddo-Majene City boundary road section



Source: Survey Report (2021)

4. Conclusion

Study results showed that assessment result by IRI measures, road of 'fair' condition reached 67%, of 'lightly damaged' condition was 33%. While by PCI measures, road of 'good' (equivalent with 'fair) condition reached 66%, and of 'bad' (equivalent with 'lightly damaged') condition was 34%. Thus, there are some differences, inspite of only about 1%. Assessment results on the road conditions using both IRI and PCI measures provide an idea that from total length (81,8 km) of road lane under assessment, 73.4 km is classified as 'fair' condition, hereafter it requires routine maintenance. While the rest, 8.4 km is classified as 'lighly damaged' condition, thereafter it requires periodic maintenance. Theoretically, the purpose of this research is to provide an an assessment results on the road conditions by application of IRI and PCI methods, while practically, to provide an overview or description about existing conditions of Tameroddo– Majene City bondary road section, to be used as data base for road preservation. In addition, the results of this study can also be used as reference by road experts and relevant stakeholders for handling implementation of road maintenance more effectively.

List of Technical Abreviation

APP: Automated pavement profiler;CIRC: Circularity;

DMI: Distance Measuring Instrument;DTW: Dynamic time warping;

DWT: Discrete wavelet transforms;

FFT: Fast Fourier transform;FNR: False Negative Rate; FPR: False Positive Rate;

GPS: Global Positioning System;

GZERO: The sensor senses a 0-g vibration;IFS: Irregularity Frame Selection;

IRI: International roughness index;

KF: Kalman filter; LPA: Longitudinal profile analyser; LCMS: Laser Crack Measurement System;

MLs: Machine-learning techniques;PD: Pothole detection;

PCI: Pavement Condition Index; PNN: Probabilistic neural network; PSP : Pavement Surface Profiler;

PR: Road profile reconstruction/estimation or road roughness classification; RE: Roughness index estimation;

STD: Standard Deviation; SVM: Support vector machine;TF: Transfer function;

TWIT: Time-wavelength-intensity-transform;UI: Unimportan Irregularity;

VDC: Vehicle dynamics control;W: Average Width;

Z-acc/ Z-thresh: Vertical acceleration/vertical threshold;

Z-DIFF: The difference of consecutive Z-acc above threshold.

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