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Road Damage Analysis Using the Roadroid Application

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Abstract

Perintis Kemerdekaan Road is one of the most important national roads in Makassar City, serving as a critical link between national and regional activity centers. However, rising traffic volumes and weather-related factors have led to significant pavement degradation. This study aims to identify the types of pavement distress present along the Perintis Kemerdekaan Roadsection in Makassar City. The research methodology combined field surveys with data analysis using the Roadroid application. The findings indicate the presence of 18 distinct types of road damage, including longitudinal cracking, transverse cracking, raveling, patching, rutting, among others. The highest damage density percentages were observed in the road sections oriented toward Makassar and Maros.

1. Introduction

The increasing traffic volume can lead to pavement structural damage [1], ranging from minor to severe, potentially reducing user comfort and compromising road safety[2]. If pavement deterioration occurs faster than its design life, this will also increase regional expenditure burdens due to the need for more frequent rehabilitation planning[3, 4].

A similar condition occurs along Perintis Kemerdekaan Road, the longest national road segment spanning 12.46 km. This arterial road serves as a primary connector between national activity centers or between national and regional activity hubs. The high traffic volume on this road, which links several universities and major shopping centers, has resulted in various types of pavement distress. Previous research documented 24 damage points covering a total area of 429 m² along Perintis Kemerdekaan Road. Similarly, the same conditions were also observed on Hertasning Road and in the study conducted in Tarakan reflecting poor road conditions at that time. Recent preliminary observations indicate that substantial damage remains prevalent along this road segment. In addition to traffic volume increases, weather factors, particularly recent high rainfall intensity, have further exacerbated pavement deterioration.

The evolution of pavement condition survey methodologies has undergone a significant shift from conventional methods toward more efficient and measurable technology-based approaches [5, 6]. Historically, functional and structural pavement assessments often relied on visual inspections to derive the Pavement Condition Index (PCI) or other manual methods, which are inherently prone to surveyor subjectivity and require extensive time. Within the context, cutting-edge research focuses on utilizing smart devices and inertial

sensors, such as the Roadroid application, to measure the International Roughness Index (IRI) as the primary indicator of road unevenness.

Roadroid has been acknowledged in the contemporary literature as a reliable tool capable of providing real-time data with an accuracy comparable to professional instruments like laser profilometers [7, 8], yet at a substantially lower cost and a survey speed that is often dozens of times faster[9, 10]. Comparative studies across various regions in Indonesia have successfully tested and validated the effectiveness of Roadroid in accurately assessing road conditions to support maintenance planning. Nevertheless, comprehensive research that integrates the detailed identification of distress types (such as the 18 damage types found in this study) with the objective evaluation of roughness (IRI) using the Roadroid application on a vital, heavily trafficked, and frequently degrading national road segment, specifically the Perintis Kemerdekaan Road Section in Makassar, remains limited. Therefore, this study offers a crucial contribution by providing an updated and detailed assessment of the pavement conditions for this specific road, strategically leveraging the advantages of Roadroid technology's efficiency and accuracy to establish a robust, data-driven foundation for maintenance strategies.

Road damage surveys are typically conducted using various methods, ranging from visual inspections where officers directly observe and record damage types and severity in the field, to manual methods employing standard forms such as the Pavement Condition Index (PCI) to assess road conditions[11, 12]. Furthermore, technology-based methods like the Roadroid application enable real-time data collection using GPS and smartphone accelerometer sensors [13]. The selection of methods depends on survey requirements, accuracy levels, and budget availability[14].

This study aims to identify the types of pavement distress occurring along the Perintis Kemerdekaan road segment in Makassar City. The research seeks to provide a detailed assessment of the road's physical condition, including the predominant types of damage such as cracks, potholes, or other surface deformations. The findings are expected to serve as a foundation for relevant authorities in developing appropriate road maintenance and rehabilitation strategies, ultimately enhancing both road quality and user safety. Table 1 displays the classification of road conditions and their recommended treatments according to IRI values.

TABLE 1. Road condition and corresponding treatment determination based on IRI values.

IRI Values	Condition	Maintenance
IRI < 4	Good	Routine Maintenance
4 ≤ IRI ≤ 8	Fair	Periodic Maintenance
8 ≤ IRI ≤ 12	Lightly Damaged	Rehabilitation
IRI > 12	Severe Damaged	Reconstruction

Road conditions and corresponding maintenance treatments are classified based on IRI values as follows: roads with IRI ≤ 4 are classified as good condition requiring routine maintenance; those with IRI between 4.1-8 as fair condition needing periodic maintenance; roads with IRI between 8.1-12 as lightly damaged requiring road rehabilitation; and roads with IRI >12 as severely damaged needing road reconstruction.

2. Research Methodology

2. 1. Research Location

The research location for this study is a section of the National Road in Makassar City, specifically Perintis Kemerdekaan Road, which spans 10.85 km. The survey was conducted in 2023.

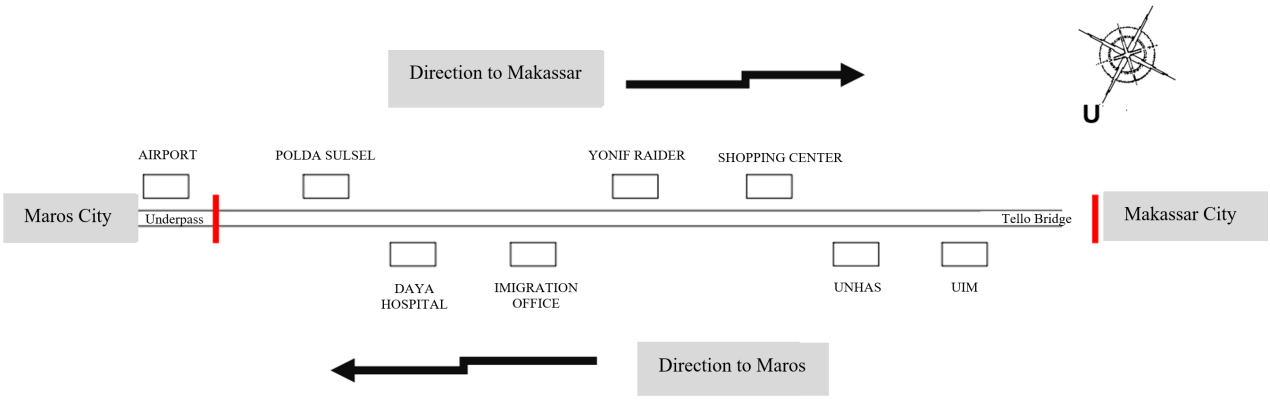


FIGURE 1. Research location sketch

The study area consists of two sections: the Makassar-bound and Maros-bound directions. For the Makassar-bound Lane of Perintis Kemerdekaan Road, the stretch covers STA 0+000 to 10+850, starting from the end of the road after the Simpang Lima Mandai Underpass to Tello Bridge. Meanwhile, the Maros-bound lane of Perintis Kemerdekaan Road spans STA 0+000 to 10+850, extending from Tello Bridge to the road section before the Simpang Lima Mandai Underpass.

The road segment division in this study involves dividing a one-way road into 217 sample units. Therefore, the total sample units for a two-way road amount to 434. Each sample unit consists of a 50-meter road section. For the Makassar direction, the sample units are numbered from 1 to 217, while for the Maros direction, they are numbered from 218 to 434.

2. 2. Data Analysis

Field observations and surveys were conducted through direct examination of the study object to collect the required data and information. Data collection using observational instruments was performed during the road damage inventory and documentation stage.

IRI (International Roughness Index) data was obtained by conducting IRI surveys using the Roadroid application [15, 16]. The IRI survey was carried out to estimate road roughness levels along the Perintis Kemerdekaan Road section[16, 17].

3. Results and Discussion

3. 1. Result

The field survey identified 18 types of road damage along the Perintis Kemerdekaan Road section. These damage types include longitudinal cracks, transverse cracks, raveling, patching, corrugation, slippage cracks, polished aggregate, depression, bumps and sags, alligator cracks, swelling, potholes, edge cracks, rutting, joint reflection cracks, block cracks, loss of coarse aggregate, and stripping. Other studies have also identified

similar patterns of pavement distress[1, 18, 19]. The percentage distribution of damage density is presented in Table 2 for the Makassar-bound direction.

TABLE 2. The percentage distribution of damage types in the Makassar-bound direction

Damage Type	Quantity		Density (%)
Longitudinal Cracks	1,050.00	m	74.09
Corrugation	132.00	m^2	9.31
Patching	72.99	m^2	5.15
Raveling	51.37	m^2	3.63
Polished Aggregate	36.00	m^2	2.54
Alligator Cracks	20.60	m^2	1.45
Transverse Cracks	15.00	m	1.06
Swelling	9.10	m^2	0.64
Bumps and Sags	8.46	m^2	0.60
Edge Cracks	8.37	m^2	0.59
Loss of Coarse Aggregate	7.48	m^2	0.53
Rutting	4.86	m^2	0.34
Stripping	0.65	m^2	0.05
Grooving	0.20	m^2	0.01
Potholes	0.14	m^2	0.01

The pavement distress distribution based on International Roughness Index (IRI) values for the Maros-bound section of Perintis Kemerdekaan Road differs from that of the Makassar-bound section. Additional distress types were identified during the survey. Complete data are presented in Table 3.

TABLE 3. The percentage distribution of damage types in the Maros-bound direction

Distress Type	Quantity		Density (%)
Longitudinal Cracks	1,333.15	m	26.23
Transverse Cracks	1,103.00	m	21.70
Raveling	1,083.00	m^2	21.31
Patching	1,013.50	m^2	19.94
Corrugation	258.70	m^2	5.09
Slippage Cracks	107.38	m^2	2.11
Polished Aggregate	63.00	m^2	1.24
Depression	44.50	m^2	0.88
Bumps and Sags	34.63	m^2	0.68
Alligator Cracks	23.00	m^2	0.45
Swelling	13.00	m^2	0.26
Potholes	4.09	m^2	0.08
Edge Cracks	0.54	m^2	0.01
Rutting	0.47	m^2	0.01
Joint Reflection Cracks	0.34	m^2	0.01
Block Cracks	0.26	m^2	0.01

The most dominant types of damage on Perintis Kemerdekaan Road for both directions were longitudinal cracks, transverse cracks, corrugation, raveling, and patching. The highest density percentage was longitudinal cracks, accounting for 74.09% in the Makassar-bound direction and 26.23% in the Maros-bound direction.

The road roughness condition survey, or International Roughness Index (IRI), was conducted using the Roadroid application along Perintis Kemerdekaan Road in both Maros-bound and Makassar-bound directions. Each direction underwent two tests (left and right lanes). The Roadroid application recorded IRI values at 50-meter intervals, showing variations in eIRI values every 50 meters of road length[16, 20].

The IRI survey results indicated that the overall condition of the Makassar-bound section of Perintis Kemerdekaan Road remains classified as good, with an average total IRI value of 3.34 [16, 21]. However,

several sample units (133, 134, 152, 154, 156, 157, 160, 162, and 198) were categorized as having minor damage. Similarly, the Maros-bound section was generally classified as good with an average total IRI value of 3.28, though some sample units (272, 273, 279, 286, 288, 291, 292, 293, 299, 302, and 309) showed minor damage.

3. 2. Discussion

Based on the analysis of condition values using the IRI method for each direction of the Perintis Kemerdekaan Road section, the recommended road maintenance is as follows: routine maintenance for samples classified as good, very good, and excellent condition; periodic maintenance for samples in fair condition; and road improvement/reconstruction for samples classified as poor, very poor, failed, or with minor to severe damage. Figure 2 summarizes the pavement condition based on the International Roughness Index (IRI) values for Perintis Kemerdekaan Road in the direction of Makassar.

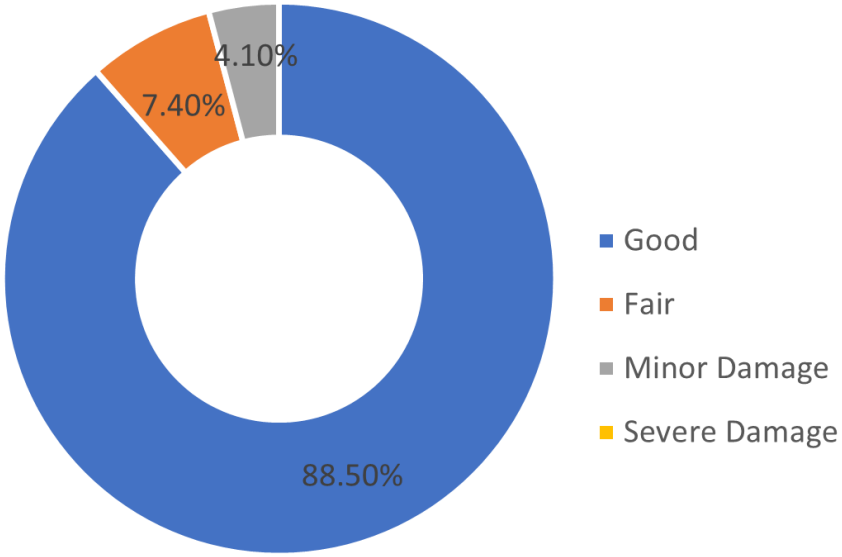


FIGURE 2. Recapitulation of pavement condition parameters for Perintis Kemerdekaan road segment: Makassar-bound direction

Meanwhile, the summary of pavement conditions based on IRI values for Perintis Kemerdekaan Road toward Maros is presented in Figure 3.

Based on data from the National Road Implementation Center (BBPJN) of South Sulawesi, the Perintis Kemerdekaan Road section last underwent comprehensive major rehabilitation in 2006 with a 10-year design life, indicating that the pavement had reached the end of its service life at the time of this study. The survey results recommend routine maintenance using micro surfacing for sections in good, very good, and excellent condition; micro surfacing with crack sealing and patching for fair condition sections; and prioritized overlay repairs for sections in poor, very poor, or failed condition, including those with minor to severe damage.

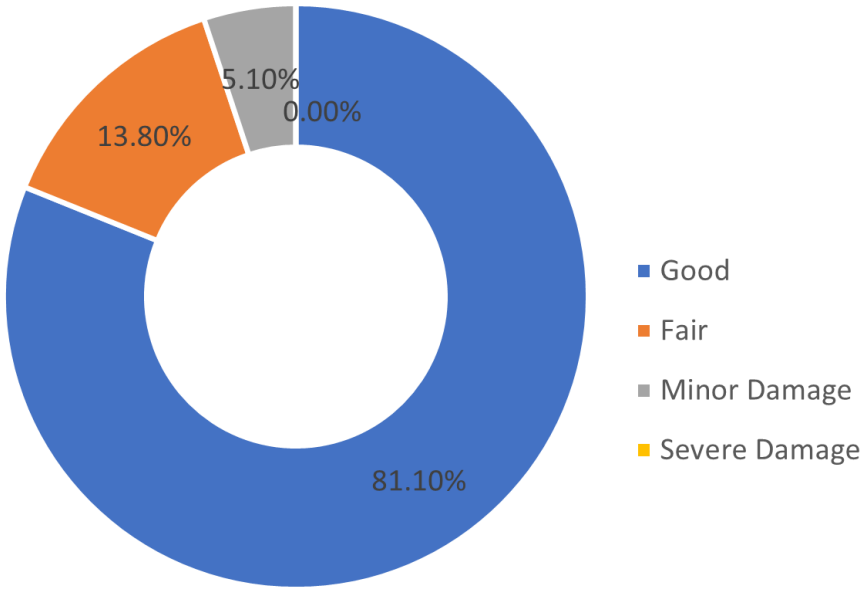


FIGURE 3. Recapitulation of pavement condition parameters for Perintis Kemerdekaan road segment: Maros-bound direction

4. Conclusion

The research on the damage conditions of Perintis Kemerdekaan Road has led to several key findings and conclusions. The pavement section, spanning from STA 0+000 to STA 10+850, exhibits a diverse array of distress types. These damages encompass longitudinal cracks, transverse cracks, raveling, patching, corrugation, slippage cracks, polished aggregate, depression, bumps and sags, alligator cracks, swelling, potholes, edge cracks, rutting, joint reflection cracks, block cracks, loss of coarse aggregate, and stripping. Notably, the most prevalent forms of deterioration documented are longitudinal and transverse cracks. Despite this variety of damage, the pavement's overall functional condition, assessed using the International Roughness Index (IRI) via the Roadroid application, was classified as good. The average IRI values were calculated at 3.34 for the Makassar-bound traffic direction and 3.28 for the Maros-bound direction, both falling within the "good condition" range. Based on this assessment, the recommended maintenance strategy involves the application of a routine microsurfacing treatment. Crucially, to ensure the accuracy and reliability of future IRI data collection using the Roadroid application, given its inherent sensitivity, it is strongly advised that a stable vehicle be employed for all measurement runs.

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Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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