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Road Surface Assessment of The Kemlagi–Berat Kulon Road Section In Mojokerto District Using The IRI Method

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KEYWORDS
IRI, Road Surface Assessment, Deterioration

ABSTRACT
The Kemlagi–Beratkulon road surface assessment in Mojokerto District covers a section of 3.637 km and features a combination of rigid pavement, flexible pavement, and asphalt. This road plays a critical role as a connecting link between Mojokerto District and Gresik District, supporting transportation and regional connectivity. The primary objective of this study is to evaluate the road surface condition, measure the extent of surface damage, and classify the condition using the International Roughness Index (IRI) method. Data collection was conducted through field surveys with the aid of the Roadroid application, providing real-time measurements of road roughness. The findings reveal that the highest e-IRI value recorded was 1.75 at STA 1+900 to STA 2+000, indicating a road condition classified as "GOOD" based on IRI standards. The study highlights the efficiency of the IRI method in assessing road conditions, ensuring accurate identification of surface damage levels ranging from good to severely damaged. Furthermore, the use of the Roadroid application proves effective in facilitating rapid and precise road surface evaluations. To enhance future assessments, this research suggests integrating alternative android-based applications for comparative analyses and conducting surveys during low-traffic periods to minimize data inaccuracies. These findings contribute to the broader understanding of road infrastructure management, emphasizing the importance of regular assessments to optimize maintenance efforts, extend road lifespan, and allocate resources effectively.

INTRODUCTION

Roads and pavement surfaces are critical infrastructure elements that ensure smooth mobility and economic activity. A well-maintained road surface helps maintain safe and comfortable driving, reduces the risk of accidents, and extends the life of the road. However, road conditions deteriorate over time due to traffic loads, environmental factors, and the age of pavement materials, leading to defects such as cracks, potholes, and deformations (Ramachandraiah et al., 2023). Therefore, periodic road surface condition assessments are necessary to identify early deterioration and plan appropriate maintenance.

The use of sensor-based technology and image analysis enables faster and more accurate detection of defects, especially on large-scale road networks. These technologies reduce the time and cost required compared to manual methods (Annisa et al., 2023). In addition, with the application of machine learning algorithms and artificial intelligence, identification of defects such as alligator cracking and longitudinal cracking can be done automatically and systematically (Qureshi et al., 2022).

In road infrastructure management, data-driven maintenance is essential for efficient and targeted maintenance planning. The results of these road surface assessments are used to determine repair priorities and budget allocations, ensuring each critical road receives the necessary maintenance on time and reducing the risk of further deterioration (Nisumanti & Prawinata, 2020).

With regular road surface condition assessments, infrastructure management can perform road maintenance more proactively and efficiently. Technologies such as image processing and artificial intelligence are increasingly being applied to automatically detect road defects, such as cracks and potholes, thereby reducing reliance on time-consuming and costly manual methods (Ramachandraiah et al., 2023). The data collected through these methods not only help in the repair of roads but are also used to develop long-term maintenance plans, optimize budget allocation, and extend the life of roads (Gutama et al., 2023).

In addition, the integration of digital technology in road maintenance enables more real-time monitoring and responsiveness to defects. With sensor-based data and machine learning algorithms, stakeholders can prioritize repairs and reduce the risk of further road deterioration. In the future, the utilization of IoT and machine learning is expected to further strengthen the road management system, allowing the government to make faster and more accurate decisions (Yastawan et al., 2021).

Road surface condition assessment is one of the stages of the program to evaluate road surface conditions by assessing the condition of the road surface layer (Pangesti et al., 2021). Therefore, this research was conducted to identify the condition of the road surface damage of the Kemlagi - Beratkulon Road Section in Mojokerto Regency using the International Roughness Index (IRI) method obtained through field surveys assisted by the roadroid application (Maulana & Chayati, 2023).

Both IRI methods are considered capable of providing real conditions as a way to obtain an analysis of the road surface that can be said to be in good, moderate, lightly damaged, and severely damaged conditions with different treatments. With the assessment of road stability, it is hoped that the Kemlagi - Beratkulon road in Mojokerto Regency will remain in good condition and terawatt, so that the benefits of the road can be fulfilled and the handling costs can be known (Wahyuni et al., 2022).

Literature Review

Previous Research

This research was obtained from a literature review of previous research related to analysis, evaluation and planning such as published scientific papers, journals, proceedings, theses and dissertations. Based on the researcher's exploration, the following basic theoretical studies were found (NOVRIADI, 2023).

Zulfan et al. (2018), in a study entitled "Road Condition Assessment on Road Section KM.77 (PIDIE Boundary) - Sigli City Limits", revealed that the road conditions on the section were mostly in the steady category with a value above 60%. A maintenance budget of Rp113,645,850,000 is required for all road elements. Further analysis shows a deviation of 4.77% for road stability, while the maintenance budget requirement shows a negative deviation of -Rp98,825,850,000.00.

Setiawan et al. (2024), through a study entitled "Utilization of the Roadroid Smartphone Application to Measure Road Surface Stability Based on the International Roughness Index", showed that the Roadroid application can provide accurate IRI (International Roughness Index) measurement results. These results indicate that this application is effective for use in assessing road stability, with measurement results that are not significantly affected by the type of survey vehicle.

Yahya et al. (2022), in the research "Analysis of Road Damage Using the Pavement Condition Index (PCI) and Surface Distress Index (SDI) Methods", concluded that the average

PCI value of 56.89 indicates the condition of the road surface in the fair category. Based on the PCI method, the distribution of damage levels includes good (12.7%), *satisfactory* (10.7%), *fair* (33.3%), *poor* (20.7%), very poor (15.3%), serious (6%), and failed (1.3%). Meanwhile, the SDI method shows road conditions categorized as good (61%), moderate (16%), lightly damaged (0%), and severely damaged (23%).

Gusnilawat et al. (2021), in a study entitled "Analysis of Road Damage Factor Assessment with Comparison of Bina Marga Method, PCI (Pavement Condition Index) Method, and SDI (Surface Distress Index) Method", found that damage to Patuk-Dlingo Road based on the Bina Marga method has a UP value of 7.92 which is classified as a routine maintenance program. Based on the PCI method, the average damage value of 39.7% is included in the poor category, while the SDI method shows an average value of 11.8 which is also classified as routine maintenance. All three methods provide an overview of the level of road damage that can be used as a database for planning and implementing road rehabilitation and maintenance.

These studies highlight the importance of using various methods to evaluate road conditions and develop effective maintenance strategies, taking into account the characteristics of the road and the analytical results of each method.

Basic Road Theory

Regulation of the Minister of Public Works of the Republic of Indonesia No. 13/PRT/M/2011 concerning Roads defines roads as land transportation infrastructure which includes all parts of the road, including complementary buildings and equipment intended for traffic, which are on the surface of the land, above the surface of the land, below the surface of the land and / or water, and above the surface of the water, except railways, lorry roads, and cable roads. Based on the two definitions above, it can be concluded that roads are land infrastructure that has certain parts and functions as traffic.

Road Classification

Classification according to road function consists of 3 groups, namely (Oetomo et al., 2017):

1. Arterial roads are roads that serve major transportation with characteristics of long-distance travel, high average speed, and the number of driveways is limited efficiently.
2. Collector roads are roads that serve collector / divider transportation with characteristics of medium distance travel, medium average speed and limited number of entrances.
3. Local roads are roads that serve local transportation with characteristics of short distance travel, low average speed, and an unrestricted number of driveways.

Type of Road Condition

Roads are given a condition rating with the following descriptions (Sibuea et al., 2022):

1. Good Condition Road

   A road in good condition is a road with a completely flat pavement surface, no waves and no surface damage.
2. Road with moderate condition

   A road in moderate condition is a road with moderate pavement surface flatness, waves but no surface damage.
3. Roads with minor damage

   Mildly damaged roads are roads where the pavement surface has started to bump, surface damage and patching has begun (less than 20% of the road area under review).
4. Roads with heavy damage

   A severely damaged road is a road with a pavement surface that has a lot of damage such as wavy, cracked - crocodile cracks and chipped quite large (20-69% of the road area under review) accompanied by damage to the foundation layer with foundation layer damage such as collapse, sungkur, and so on.

International Roughness Index

Farida I. and Hamid M.Z (2022) reviewed the level of effectiveness in calculating the roughness value of rigid pavement sections with the Roadroid application effectively, because it was obtained with a more accurate value in determining the roughness value of IRI, the resulting IRI value from the Roadroid application has a good level of effectiveness of data accuracy.

The IRI value defines the road flatness condition consisting of 4 general categories where: - IRI value ≤ 4 with good category, - value 4 < IRI ≤ 8 medium category, - value 8 < IRI ≤ 12 lightly damaged category, and - IRI value > 12 severely damaged category. The visual determination of road conditions is determined by the IRI value between 24 - 17 including very badly damaged where the road conditions cannot be passed (Directorate General of Highways, 2012): - values between 17 - 12 severely damaged conditions, - values between 12 - 9 damaged conditions, - values between 9 - 7 moderately damaged conditions, - values between 7 - 5 fair pavement conditions, - values between 5 - 3 good conditions, - values between 3 - 2 very good conditions, and - values between 2 - 0 very flat and regular pavement surface conditions.

Important settings on the Roadroid settings menu must be done correctly / as needed for User Email (Equipment ID) has been filled with the correct email. Email is used for application activation, vehicle type is selected according to the type of vehicle to be used for the survey, auto photo capture segment length is filled in according to the needs of the photo distance to be taken (for example: every 100 m, 200 m, or 500 m), low speed lat/lng threshold or minimum speed limit of the vehicle during the survey, and other settings are standard from the Roadroid application.

Research using the IRI method when the survey vehicle is running, always maintain a minimum speed limit to maintain the stability of the road condition survey result value, until the end point of the road section.

Road Stability Level

The level of road stability is determined by two criteria, namely construction-steady roads and non-construction-steady roads. In detail the level of road stability is described below as follows:

1. Steady construction roads are roads with construction conditions within the steady corridor, which only require maintenance activities to handle. Steady construction roads are defined according to the minimum service standards as roads in moderate condition, where the IRI is < 6 m/km.
2. Unsteady roads are roads with conditions outside the steady corridor for which the minimum treatment is periodic maintenance and the maximum road upgrade with the aim of adding value to the construction structure.

RESEARCH METHOD

Research Flow of Thought

The research flow of thought is used to determine the stages of research and workflow or process, which displays the steps in the research process, so that it can be understood in each process. The stages of this research conceptual framework are as follows:

1. Search for references on factors affecting road valuation.
2. Identify data on factors affecting road assessment.
3. Determination of data affecting road assessment.
4. Data analysis and processing with the IRI d method
5. Result Conclusion.

Subjects and Objects of Research

The subject of this study is a district road with a length of 3.637 km that connects 2 sub-districts, namely Kemlagi and Dawarblandong sub-districts, and is the responsibility of the Mojokerto District Public Works and Spatial Planning Office.

The research objects studied include: Kemlagi - Beratkulon road section conditions in Mojokerto Regency, road damage factors and International Roughness Index (IRI) data.

Research Location

The research location is located on the Kemlagi - Beratkulon road section of Mojokerto Regency along 3.637 km. With a research time of approximately three weeks to one month.

Use of the Roadroid App

Research by Farida, I and Hamid, Z. H (2022) found that road roughness using the Roadroid application is more accurate in determining the IRI value, so it can be used as a tool to assess the condition of the road roughness surface.

The Roadroid android application is used to obtain IRI values, on road surface roughness. Then the photo and video data can be stored on the cellphone file media, used to view road data in the data manager, after which the IRI value data is entered into excel form and then uploaded to the GIS, and calibrated the data according to the wishes.

The cellphone used has the Roadroid application, placed on the dashboard and placed with a holder as a support. Then the suspense for this application is selected range suspense that is hard-medium, then select the menu for the location of the initial phone settings (fitting adjustment), then select the check mark try to be placed with a y value close to zero.

Figure 1. Roadroid Pro3 App

Select the three-line menu and fill in the road data including length, road width, and road class to define the road work under study. The start button is pressed at the starting point of the road to be measured, the car runs at speeds ranging from 20 km/h - 40 km/h, then the stop button is pressed when it reaches the end point of the road section being studied. Transfer the survey results using notebook paper or make notes on a laptop.

Data Collection Methods

The data collection procedure in this study was carried out by looking for primary and secondary sources.

1. Primary Data, Road data is obtained by conducting surveys using the roadroid pro3 android application as a measuring tool for the IRI method. The equipment used are cars, smartphones, paper, stationery, survey forms, cameras, and measuring instruments.
2. Secondary Data, Secondary data is data obtained indirectly. This data is obtained from DPUPR Mojokerto Regency. Secondary data such as road section data and road inventory.

Data Analysis Technique

The IRI method is a method used to determine the level of unevenness of the road surface, the IRI value is obtained by conducting a survey using the Roadroid application. The IRI survey was conducted to find the estimated road flatness value (International Roughness Index/IRI) on the Kemlagi - Beratkulon road section every 100 meters.

The IRI data that has been obtained is evaluated using the standards issued by the Minister of Public Works Regulation (2011) According to Saleh, et al in Simamora, et al (2018) IRI < 4.0 m / km the road is still in the routine maintenance stage, IRI = 4.0-8 m / km needs periodic maintenance, namely by overlaying, IRI = 8-12 m / km, needs to be considered for improvement, and IRI> 12 m / km needs reconstruction.

RESULTS AND DISCUSSION

Road Asphalt Condition

Road assessment can be determined by conducting a field survey, in this study the functional performance of the road is obtained from direct observation of road damage. Then calculated using the International Roughness Index (IRI) method. This IRI value is used to obtain a roughness index on the road. So that it is known that the condition of the road can be good, lightly damaged, severely damaged.

1. Potholes

   Pothole damage can be caused by excessive traffic loads and poor drainage systems.
2. Patching

   Patching damage due to the patching process performed to repair damage to the surface layer is not done properly, which causes surface unevenness.
3. Polished Aggregate

   The condition of the aggregate grains located in the asphalt layer becomes smooth and loses roughness, causing the road to become slippery. This damage usually occurs because the road is often passed by vehicles that cause friction between the aggregate and the wheels of the vehicle so that over time the aggregate on the pavement surface becomes smooth.
4. Rutting

   Rutting damage is a state of decline in longitudinal collar pavement in wheel tracks caused by repeated vehicle loads on the road track. rutting can occur due to compaction in the surface layer.
5. Bleeding

   Bleeding damage occurs when the temperature increases which causes the asphalt to become soft. This damage is characterized by a difference in color on the pavement surface. Bleeding is caused by high asphalt content in the asphalt mixture.
6. Alligator Crack

   Alligator crack damage is caused by repeated traffic loads, weakened base layers and pavement thickness that is too thin.
7. Shoving

   Soving damage occurs due to plastic deformation which usually occurs where vehicles frequently stop on steep slopes, or sharp bends. This damage can also be caused by poor stability of the asphalt mixture and bonding between pavement layers.
8. Swell

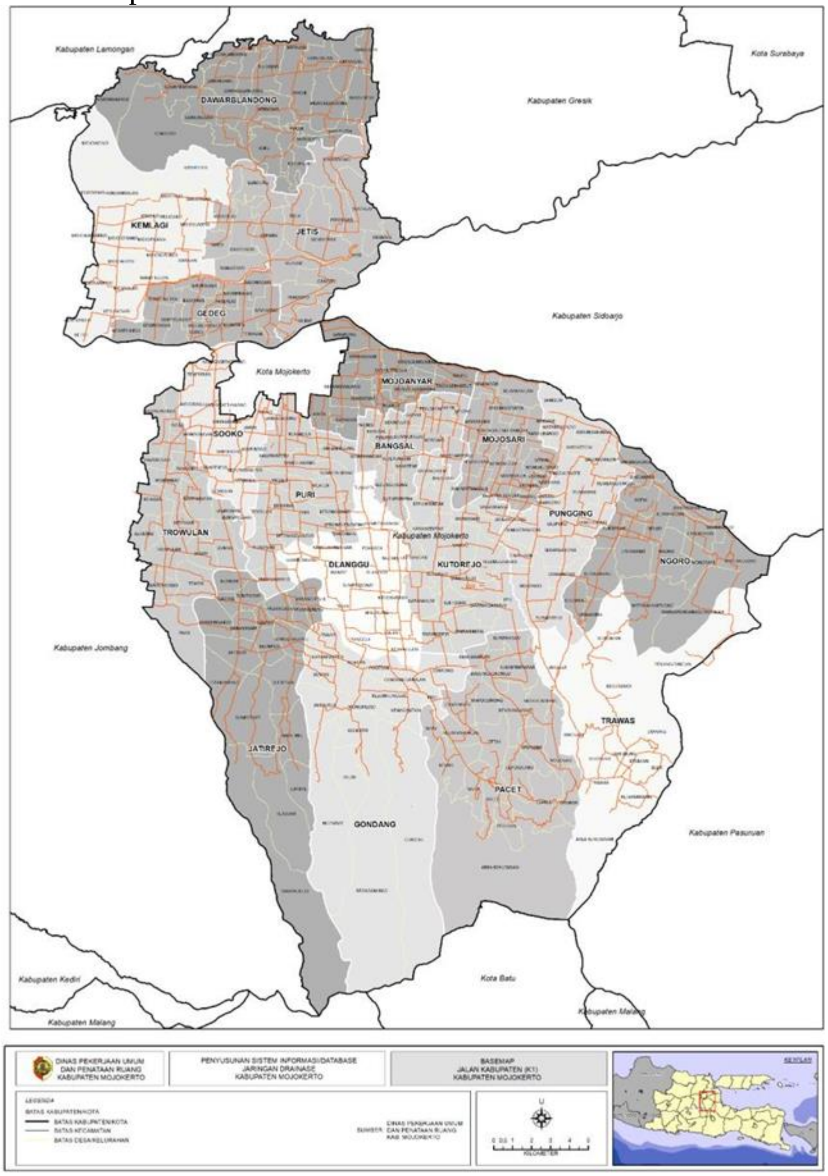
   Swell damage is localized upward movement of the pavement. This damage is caused by the expansion of the layer material under the pavement or subgrade due to the increase in moisture content.
9. Bumps and Sags

   Bumps are upward movements while sags are downward movements that are localized to the asphalt surface. Bumps and sags are caused by upward movement due to freezing or by the influence of vehicle loads followed by the development of cracks.

Road Functional Condition Calculation Data

The data needed in the calculation of road conditions include maps of the Kemlagi - Beratkulon road section, data on the type and dimensions of road damage, documentation of each segment reviewed.

1. Road Section Map



Road Map (K1) of Mojokerto District

2. Road Section Data

   The Kemlagi - Beratkulon road section has the following section identification:
   Data Section No. K1 067
   Base of Section Name: Kemlagi
   End of Section Name : Beratkulon
   Initial Recognition Point : Provincial Road
   Final Recognition Point : Mojokerto District Boundary Section Length (KM) : 3.367 Km
   ADM Status Code : Kemlagi - Beratkulon
   Initial KM : -
   Final KM : 3,367
   Width (M) : 3/5 m

Surface Type : Concrete and Asphalt
Asphalt Length : 30 m
Concrete Length : 3.337 Km
Condition : B/R
Last Planning Year 2018
Month/Year Per. Data 2018

Calculation of International Roughness Index (IRI) Value

The IRI value data used in this study were obtained from field surveys, using the Roadroid Pro3 android application tool, surveys using OPPO A58 4G cellphones, and using 1350 cc Ertiga Disel cars. The following data is obtained every 100 m.

Figure 2. Roadroid Pro 3 Application Settings

The classification of road conditions based on IRI can be described as follows:

Table 1. IRI Value Criteria

ENVY VALUE CRITERIA	
IRI VALUE	**CONDITIONS**
<4	OK
4 - 8	MEDIUM
8 - 12	LIGHTLY DAMAGED
>12	HEAVY DAMAGE

An IRI value of less than 4 means that the road condition is "GOOD", an IRI value of 4-8 means that the road condition is "MEDIUM", an IRI value of 8-12 means that the road condition is "MildLY DAMAGED", and an IRI value of more than 12 means that the road condition is "HEAVILY DAMAGED".

Table 2. e-IRI Value Table

No.	STA Initial	STA End	e-IRI	Description e-IRI
1	0+,000	0+,100	1,48	Good
2	0+,100	0+,200	1,31	Good
3	0+,200	0+,300	1,48	Good
4	0+,300	0+,400	1,41	Good
5	0+,400	0+,500	1,72	Good
6	0+,500	0+,600	1,7	Good
7	0+,600	0+,700	1,39	Good
8	0+,700	0+,800	1,37	Good

9	0+,800	0+,900	1,37	Good
10	0+,900	1+,000	1,13	Good
11	1+,000	1+,100	1,85	Good
12	1+,100	1+,200	1,57	Good
13	1+,200	1+,300	1,33	Good
14	1+,300	1+,400	1,26	Good
15	1+,400	1+,500	1,37	Good
16	1+,500	1+,600	1,2	Good
17	1+,600	1+,700	1,67	Good
18	1+,700	1+,800	1,49	Good
19	1+,800	1+,900	1,67	Good
20	1+,900	2+,000	1,75	Good
21	2+,000	2+,100	1,68	Good
22	2+,100	2+,200	1,13	Good
23	2+,200	2+,300	1,56	Good
24	2+,300	2+,400	1,67	Good
25	2+,400	2+,500	1,74	Good
26	2+,500	2+,600	1,71	Good
27	2+,600	2+,700	1,47	Good
28	2+,700	2+,800	1,64	Good
29	2+,800	2+,900	1,16	Good
30	2+,900	3+,000	0,75	Good
31	3+,000	3+,100	1,03	Good
32	3+,100	3+,200	0,5	Good
33	3+,200	3+,300	0,93	Good
34	3+,300	3+,400	0,93	Good
35	3+,400	3+,500	1,47	Good
36	3+,500	3+,600	1,16	Good

Road research using the Roadroid application, the IRI value is e-IRI, when there is a hole, the IRI value will change to high, for each 100 meter length, a change in the IRI value is obtained, then averaged and most conditions are good. The road condition of the Kemlagi - Beratkulon section is in good to moderate condition, it is necessary to take precautions before the road damage gets bigger.

Discussion

The results of the Kemlagi–Beratkulon Road Section surface assessment using the International Roughness Index (IRI) method provide significant insights into the current condition and maintenance needs of this critical road network. The majority of the road sections evaluated were classified as "Good" with e-IRI values consistently below 4. This indicates that the overall surface condition is satisfactory and requires only routine maintenance to sustain its quality and functionality. However, the findings also highlight certain critical areas that require immediate attention to prevent further deterioration.

The recorded highest e-IRI value of 1.75 at STA 1+900 to STA 2+000, while still categorized as "Good," signals a potential area for preventive maintenance. Early intervention in such sections could mitigate risks of progressive damage, such as potholes, rutting, or cracks, especially in high-traffic zones. The uniformity of e-IRI values across the surveyed segments demonstrates the reliability of the Roadroid application in capturing accurate and consistent data on road surface roughness.

From a methodological perspective, the study underscores the advantages of mobile-based technologies like the Roadroid app in simplifying data collection for road assessments.

These technologies reduce survey costs, time, and reliance on manual methods, offering a scalable solution for large-scale road networks. However, the study also identifies potential limitations, such as the influence of high traffic during surveys, which may result in data variability. Future assessments could benefit from conducting surveys during periods of minimal traffic to enhance data accuracy.

The findings contribute to the broader discourse on sustainable road infrastructure management, emphasizing the need for regular assessments and proactive maintenance strategies. By integrating digital tools and the IRI method, road management authorities can prioritize maintenance tasks, optimize resource allocation, and improve overall road safety and usability. Further research could explore the integration of machine learning algorithms and IoT technologies to automate the detection of road defects, ensuring even greater precision and efficiency in road condition monitoring.

CONCLUSION

The conclusion of the study summarizes the main findings derived from the analyzed data, aiming to clearly and systematically convey the research results that address the previously formulated research questions or hypotheses. Based on the performance analysis conducted, it can be concluded that the highest e-IRI value is 1.75 at STA 1+900 - 2+000, which corresponds to an IRI value in "GOOD" condition, as it is less than 4.

REFERENCES

Annisa, A. N., Adiman, E. Y., & Fahsa, M. N. N. (2023). Analisis Kondisi Perkerasan Jalan Menggunakan Metode SDI dan IRI (Studi Kasus: Ruas Jalan Bangau Sakti Kota Pekanbaru). *Jurnal Teknik Sipil dan Arsitektur*, *28*(1), 13–22.

Farida, I., & Hamid, M. Z. (2022). Efektivitas Aplikasi Smartphone Roadbump Prodan Roadroid dengan Nilai Kekasaran Jalan pada Perkerasan Kaku. *Teras Jurnal*, *12*(2).

Gusnilawati, A., Chrisnawati, Y., & Maryunani, W. P. (2021). Analisis penilaian faktor kerusakan jalan dengan perbandingan metode bina marga, metode pci (pavement condition index), dan metode sdi (surface distress index)(Studi Kasus Ruas Jalan Patuk-Dlingo, Kec. Dlingo, Kab. Bantul). *Jurnal Rekayasa Infrastruktur Sipil*, *2*(1), 15.

Gutama, D. S. L. W., Sutrisno, W., Mustofa, R., Apriadin, A., & Tommy, N. W. (2023). Analisis Kerusakan Jalan Menggunakan Metode Iri Dan Rci (Studi Kasus Ruas Jalan Klangon-Tempel). *Bangun Rekaprima*, *9*(2), 257–266.

Labaso, E. R., Ishak, M. S., & Kasan, M. (2022). Evaluasi Kerusakan Jalan Menggunakan Metode Pavement Condition Index (PCI) dan Surface Distress Iindex (SDI) Studi Kasus Jalan Pue Bongo–Kota Palu. *REKONSTRUKSI TADULAKO: Civil Engineering Journal on Research and Development*, 67–74.

Maulana, M., & Chayati, N. (2023). Analisis Kerusakan Permukaan Jalan Berdasarkan Penilaian Dengan Metode SDI Dan IRI. *Journal of Applied Civil Engineering and Infrastructure Technology*, *4*(2), 34–41.

Nisumanti, S., & Prawinata, D. P. (2020). Penilaian Kondisi Jalan Menggunakan Metode International Roughness Index (IRI) Dan Surface Distress Index (SDI) Pada Ruas Jalan Akses Terminal Alang-Alang Lebar (Studi Kasus: Sp. Soekarno Hatta â€“Bts. Kota Palembang Km 13). *Jurnal Tekno Global*, *9*(2).

NOVRIADI, R. (2023). *Analisa Penilaian Kondisi Jalan Menggunakan Metode Internasional Roughness Indeks (Iri) Diruas Jalan Lingkar Barat V*. Universitas BATANGHARI Jambi.

Pangesti, R. D., Mahbub, J., & Rahmawati, R. (2021). Penilaian Kondisi Jalan Menggunakan Asphalt Paser (Pavement Surface Evaluation and Rating) Dan Iri (International Roughness Index) Roadroid. *Bangun Rekaprima*, *7*(1), 36–44.

Qureshi, W. S., Hassan, S. I., McKeever, S., Power, D., Mulry, B., Feighan, K., & O’Sullivan, D. (2022). An exploration of recent intelligent image analysis techniques for visual pavement surface condition assessment. *Sensors*, *22*(22), 9019.

Ramachandraiah, S. T., Kumar, P., Pasupunuri, S. K., & Shinganmakki, J. R. (2023). Evaluation of pavement surface distress using image processing and artificial neural network. *Journal of Testing and Evaluation*, *51*(4), 2041–2056.

Setiawan, K., Primarti, R. S., Sitam, S., Suridwan, W., Usri, K., & Latief, F. D. E. (2024). Microstructural Evaluation of Dental Implant Success Using Micro-CT: A Comprehensive Review. *Applied Sciences*, *14*(23), 11016.

Wahyuni, A., Said, L. B., & Syarkawi, M. T. (2022). Analisis Tingkat Kerusakan Permukaan Jalan dengan Metode International Roughness Index (IRI) dan Pavement Condition Index (PCI) Menggunakan Alat Mata Garuda: Studi Kasus Jalan Nasional Gatot Subroto Watampone. *Jurnal Konstruksi: Teknik, Infrastruktur dan Sains*, *1*(4), 1–13.

Yastawan, I. N., Wedagama, D. M. P., & Ariawan, I. M. A. (2021). Penilaian Kondisi Jalan Menggunakan Metode SDI (Surface Distress Index) Dan Inventarisasi Dalam GIS (Geographic Information System) Di Kabupaten Klungkung. *Jurnal Spektran*, *9*(2), 181.

Zulfan, et. a. (2018). *Road Condition Assessment On Road Section Km. 77 (Pidie Boundary) - Sigli City Limits. Mt. Syiah Kuala University: Banda Aceh.*