LEADER
Civil Engineering and Architecture Journal

Civil Engineering and Architecture Journal Vol.2 No.4 (2024) 3026-622X
DOI 10.37253/leader.v2i4.10144

Structural and Functional Evaluation of Road Pavement on Jalan Raya Ligung, Majalengka

Yoga Setyawan[1], Mulia Pamadi[2]
[1]Civil Engineering, Faculty of Engineering, Universitas Majalengka
[2]Civil Engineering, Faculty of Engineering and Planning, Universitas Internsional Batam
Email corresponding: mulia.pamadi@uib.ac.id

ARTICLE INFO

Keywords:

Functional roadpavement,
Traffic load,
Existing Condition and
Maintenance History.

ABSTRACT

Assessing road pavement's structural and functional characteristics is essential for managing global transportation infrastructure. This study evaluates the pavement on Jalan Raya Ligung, Majalengka, using advanced technologies such as sensors and predictive data analytics for real-time monitoring. Implementing predictive models and sensors allows for early road damage detection, facilitating efficient and timely repairs. The study also emphasizes the significance of effective drainage systems to address unstable weather conditions caused by climate change, ensuring the durability and safety of road infrastructure.Heavy traffic loads greatly influence the durability and reliability of road pavements. Commercial trucks and other heavy vehicles accelerate pavement wear. Therefore, selecting appropriate materials and structural designs is crucial. Evaluating the current condition of roads and their maintenance history provides insights into the types of interventions performed, their frequency, and associated costs. The trend towards data-driven preventive maintenance helps identify potential issues early on.The research methodology involved surveying 24 respondents to assess the road pavement quality in Jalan Raya Ligung, Majalengka. The survey revealed that most road users are male motorcycle riders. The evaluation covered surface smoothness, layer thickness, structural strength, and drainage capability. The findings showed an average importance score of 2.93% and a satisfaction score of 2.06%. The study concludes that proper surface layer design is vital for better ride quality and safety. Effective maintenance management is necessary to ensure that road infrastructure remains optimal, supporting mobility and local economic activities.This research offers a comprehensive understanding of the challenges and potential solutions related to road infrastructure and driver safety in the region, providing a solid foundation for more effective policy recommendations in road management and maintenance.

1. Introduction

Evaluation of road pavement's structural and functional aspects is a crucial element in global transportation infrastructure management. As the main structure in the road industry, especially highways, progress in asphalt pavement design cannot be separated from pavement structure calculations [1]. Advanced technologies such as modern sensors and predictive data analytics enable real-time road condition monitoring, which is essential for detecting and addressing damages before they escalate into serious issues. The roughness of pavements affected by flooding poses significant challenges to infrastructure resilience, necessitating robust damage models to predict and mitigate these effects [2]. By adopting best practices from research across various countries, road management, and maintenance in these regions can be optimized, ensuring that road infrastructure remains in optimal

condition to support mobility and local economic activities and provide comfort and safety for road users.

Predictive models for pavement deterioration, utilizing weighted geographic regression, can significantly enhance maintenance planning and resource allocation [3]. Countries like Japan and South Korea have long utilized sensor technology and data analytics in highway management, enabling real-time road condition monitoring and timely repairs. In Southeast Asia, countries like Malaysia and Thailand are beginning to adopt similar approaches to enhance their transportation infrastructure quality. The successful evaluation methods applied on Ligung Highway, Majalengka, could serve as an example and inspiration for other Asian countries, demonstrating how advanced technology and best practices can be applied to enhance the durability and functionality of road networks across the region. These steps will improve regional connectivity and strengthen inter-country cooperation in infrastructure technology.

Roads are vital infrastructure in Indonesia and crucial in land transportation [4]. Evaluating road pavement structural and functional aspects is increasingly important as efforts to improve national transportation infrastructure progress. The government has taken severe steps by integrating modern technology into road monitoring and maintenance. Sensors and data analysis have been employed to detect road damages early and plan more effective repairs. On Ligung Highway, Majalengka, this approach has helped maintain road quality and improve user safety. These efforts reflect Indonesia's commitment to continuously enhance its highway infrastructure sustainably, supporting economic growth, and improving societal well-being by providing safer and more comfortable transportation.

Exceeding planned capacity on roads can degrade pavement quality and lead to faster deterioration [5]. Facilities and infrastructure in developing countries still need to be improved in quantity and quality [6]. Therefore, the importance of evaluating road pavement structural and functional aspects is increasing to ensure optimal connectivity and support local economic activities. On Ligung Highway, Majalengka, local governments have started implementing more advanced monitoring technologies to detect road damages early. With this approach, repairs can be conducted more efficiently and promptly, reducing negative impacts on road users. These efforts also focus on training the local workforce to adopt new technologies, enabling them to participate actively in road maintenance and repair processes. These steps reflect the region's commitment to improve road infrastructure quality continually, which is expected to enhance community mobility, logistic efficiency, and economic growth in the area.

Technical capabilities: Routine maintenance, periodic maintenance, rehabilitation, or reconstruction [7].The primary objective of monitoring on Ligung Highway, Majalengka. It is to detect road damages early, enabling more efficient and timely repairs and reducing negative impacts on road users [8]. These efforts also aim to train the local workforce to adopt new technologies, enabling them to participate in road infrastructure maintenance and repair actively. These initiatives reflect the region's commitment to continuously enhancing road

quality, which is expected to improve community mobility and logistic efficiency and support local economic growth.

2. Literature Review

2.1 Functional Pavement

Road pavement is a layer between the vehicle traffic load and the ground base, designed with a constructive structure to support the load by the subgrade. Therefore, the pavement must be managed properly and appropriately, including quality control of human resources, application of technology (tools, materials, working methods), efficient funding, and research for better maintenance modeling [9]. The structural function of roads will decrease with age, and early damage that often occurs on highways can cause a decline in quality in a relatively short time. The road pavement surface gives drivers an essential level of smoothness [10].

These subtleties affect not only the comfort and safety of road users but also the overall performance of the road. Evaluation of surface smoothness can be done by various methods, including using a profilometer to measure surface unevenness. Significant unevenness can reduce driving comfort and increase the risk of accidents, especially when road conditions are wet or slippery. Therefore, maintaining surface smoothness in optimal conditions increases road user comfort and reduces road maintenance costs in the long term by reducing tire wear and fuel consumption.In recent years, the impact of climate change has increasingly been felt, driven by human activities that amplify the frequency of climate change phenomena. One consequence of climate change is increasing weather irregularities [11]. Many roads are flooded due to rain, a common sight in various regions. This water pooling can cause damage to road pavement, particularly to the worn layer of road pavement (AC-WC). The ability of road pavement to handle water or drain efficiently is crucial to ensuring the sustainability and safety of road infrastructure. Good drainage reduces the risk of water pooling, which can damage pavement and improve safety for road users.

Appropriate repair methods are [12]. Evaluating pavement conditions to assess the level of suitability and detect early deterioration in road quality can be achieved by assessing the condition of the road surface. The service life of road pavement is greatly influenced by the efficiency of the drainage system in dealing with unstable weather due to climate change. With optimal drainage, road pavement can better handle standing water, which can damage the pavement wear layer (AC-WC). Effective management in this regard can not only extend the pavement's service life but also reduce long-term road maintenance costs and improve the overall sustainability of road infrastructure.

2.2 Trafic Load

Traffic load is a crucial factor that influences the sustainability and reliability of road pavement. Empirical studies show that heavy traffic loads can cause damage to pavement, especially on surface layers that are directly exposed to pressure and friction from vehicles. The type and distribution of passing vehicles, such as heavy trucks and commercial vehicles, significantly affect the pavement's wear rate and structural strength. Therefore, careful planning is essential when selecting pavement materials and structural design to ensure the

pavement can withstand ever-increasing traffic loads. The rise in vehicle volume is a primary cause of road damage, with the increasing number of vehicles accelerating pavement deterioration in a relatively short time [13].

Road damage not only hampers economic and social activities but also poses a risk of accidents for road users [14].Traffic prediction plays a vital role in intelligent transportation systems to better understand the impact of traffic loads. Various measurement and analysis methods have been developed [15].They range from traditional manual calculations to advanced technologies like road sensors and automated traffic monitoring systems. These methods provide essential data on traffic patterns, load distribution, and vehicle speed, which are crucial for designing effective road pavement. With technological advances, real-time monitoring can help adjust traffic management strategies and enhance maintenance planning efficiency.

Regular evaluation and implementation of maintenance and rehabilitation (M&R) strategies are required to maintain infrastructure performance at a satisfactory level. Developing and refining performance prediction models is vital for forecasting pavement conditions, particularly to address longitudinal stress cracking, a significant issue in road pavements [16]. Numerous probabilistic models have been developed within various road pavement management systems [17]. Therefore, effective road pavement maintenance necessitates management strategies to mitigate the impact of substantial traffic loads. Preventive approaches such as regular maintenance and timely repairs based on traffic data analysis can extend the service life of pavements. Techniques like overlays or structural rehabilitation can help address damage caused by heavy traffic loads. Moreover, integrating technology into traffic management and infrastructure planning can improve operational efficiency and overall road safety.

2.3 Existing Condition and Maintenance History

Problems that often arise regarding road infrastructure in densely populated areas with limited land require serious attention to meet community needs [18].Maintenance management, particularly regarding condition assessment based on objective data and data-driven methods (DDM), still has room for improvement. Therefore, this review provides a brief overview of road pavement maintenance and the ongoing research on data-based condition assessment and DDM for road maintenance [19]. Road capacity is used to determine the ability of road segments to accommodate traffic flows or volumes [20].Existing road infrastructure often faces challenges from various physical conditions that affect user safety and comfort, such as surface smoothness, layer thickness, structural strength, and drainage capabilities. Recent studies show a decline in the quality of road infrastructure in many countries due to intensive use and lack of timely maintenance. A comprehensive evaluation of existing conditions is essential to determine priorities and the type of maintenance needed to extend the service life of the road and ensure user safety.

Roads are expected to provide the community with comfortable, safe, and efficient transportation services [21].Road maintenance history includes all activities carried out on

road infrastructure over time, from minor repairs and coating replacement to significant projects like structural rehabilitation or road redevelopment. Maintenance history data provides valuable insights into the type of work performed, frequency of interventions, and costs incurred. Effective management of maintenance history can reduce overall costs and extend the life of road infrastructure by prioritizing the proper maintenance at the right time. Since road construction and maintenance projects require significant capital investments, effective transportation planning must focus on maintaining existing roads. Proper and regular maintenance can automatically extend the service life of roads [22].

Managing historical road infrastructure maintenance faces numerous challenges, including complex coordination between various stakeholders, limited resources, and pressure to meet increasingly high safety standards. Effective planning is essential to maintain the condition of road pavement. Issues such as grooves often arise when the pavement experiences permanent deformation due to repeated traffic loads, resulting in a bumpy or uneven road surface that can reduce driver comfort and increase the risk of accidents [23].Today, there is a trend towards earlier, data-driven preventative maintenance techniques to identify potential problems before they become serious. Comprehensive case studies show that strategies such as continuously monitoring road conditions using sensors or monitoring technology can enable faster and more efficient responses to changing road conditions.

3. Method

Structured questionnaires and semi-structured interviews are often used in mixed methods research to produce confirmatory results despite differences in methods of data collection, evaluation, and interpretation [24]. This research used a questionnaire method involving 24 respondents to analyze the community's assessment of road pavement quality in Jalan Raya Ligung, Majalengka, focusing on road evaluation and functional improvements. The case study explicitly targets Majalengka, ensuring a localized and detailed analysis. All scales used in the research have adequate psychometric characteristics and are theoretically meaningful in their relationship with the criterion variables examined [25]. The research results are expected to provide a deep understanding of the region's challenges and potential road infrastructure and driver safety solutions. Questionnaires are considered an effective tool for collecting Impact Analysis and Driver Response data on Ligung Road, Majalengka. First, questionnaires can be designed to identify drivers' perceptions of road conditions, such as how much they notice potholes and inadequate lighting. Second, through questionnaires, we can evaluate how road conditions affect driver behavior, such as how often they avoid potholes or feel uncomfortable while driving. This data offers deep insights into how drivers respond to identified issues.

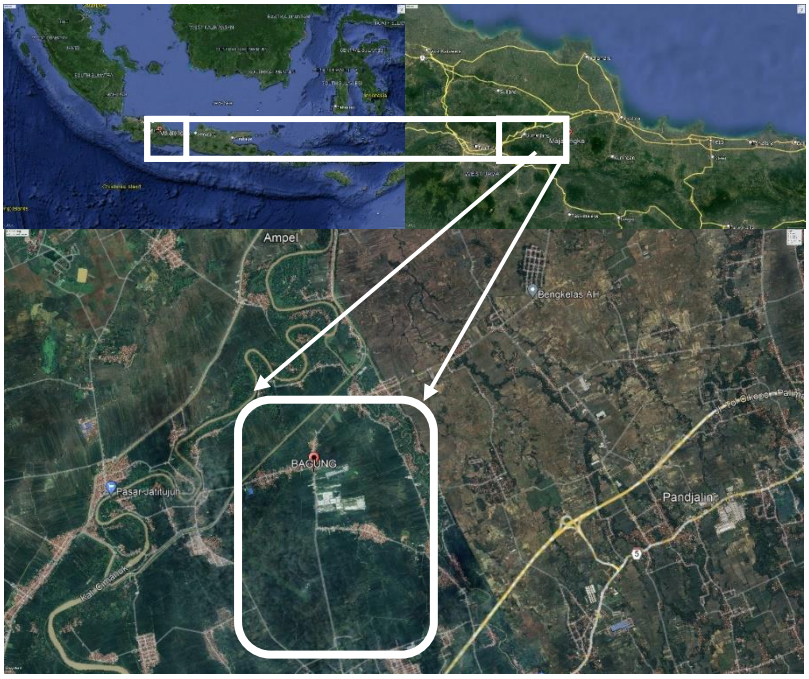

Figure 1 Research Location
Source: Google Earth

Additionally, questionnaires can include questions regarding drivers' suggestions and expectations for improving road conditions. Do they expect quicker repairs or have concrete ideas for practical solutions? It is important to design questions clearly and in a structured manner to interpret the results accurately. Using rating scales or open-ended questions can add depth to the collected data. Questionnaires can be distributed through various online and conventional channels to ensure representative participation. Finally, statistical analysis can be applied to the questionnaire data to identify trends and patterns that emerge from driver responses, providing a solid foundation for more effective policy recommendations.

4. Result and Discussion

4.1 Respondent Information

The data collection process in survey research is critical. So far, researchers or surveyors have collected data manually by printing questionnaires and distributing them by visiting respondents one by one [26]. Data was collected from 24 respondents based on age, gender, and the vehicle used when crossing the Ligung road, Majalengka. From the survey results, the majority of genders who choose Jalan Ligung Majalengka are men, and many use motorcycles.

Variable	Category	Frequency	Percent
Gender	Male	19	79.2%
	Female	5	20.8%
Age	≤20	13	54.2%
	21 - 30	7	29.2%
	31 - 40	4	16.7%
	41 - 50	0	0
Vehicles Used	Car	2	20%
	Motorcycle	22	80%

Figure2Respondent's Information.

4.2 Functional quality level of road pavement

Management processes involve planning, implementation, and control. This process also ensures that the pavement's function remains reliable [27]. Correct road surface layer design can produce hardness with better characteristics in terms of ride quality and safety [28]. The quality level of road pavement is the primary assessment in terminating transportation infrastructure. This evaluation includes various aspects such as surface smoothness, layer thickness, structural strength, and drainage capability.Based on the results of research on Jalan Ligung, Majalengka. This indicator has an average Importance of 2.93% and satisfactionof 2.06%. The following is indicator data from Jalan Ligung, Majalengka.

NO	Indicator	average importance	Average Satisfaction	difference
1	Road Surface Conditions	1.79	1.67	-0.12
2	Structure and Durability	4.04	1.71	-2.33
3	Maintenance and Repair	3.83	2.13	-1.7
4	User Security and Convenience	2.46	2.5	0.04
5	Technology and Monitoring	2	2.08	0.08
6	Impact on Local Economy and Environment	3.83	1.79	-2.04
7	Transportation Efficiency	2.21	1.96	-0.25
8	Infrastructure Sustainability	2.79	2.21	-0.58
9	Real-Time Monitoring	3.96	2.17	-1.79
10	Efforts are made to maintain the sustainability of road infrastructure in the face of environmental factors such as flooding and erosion.	2.38	2.42	0.04

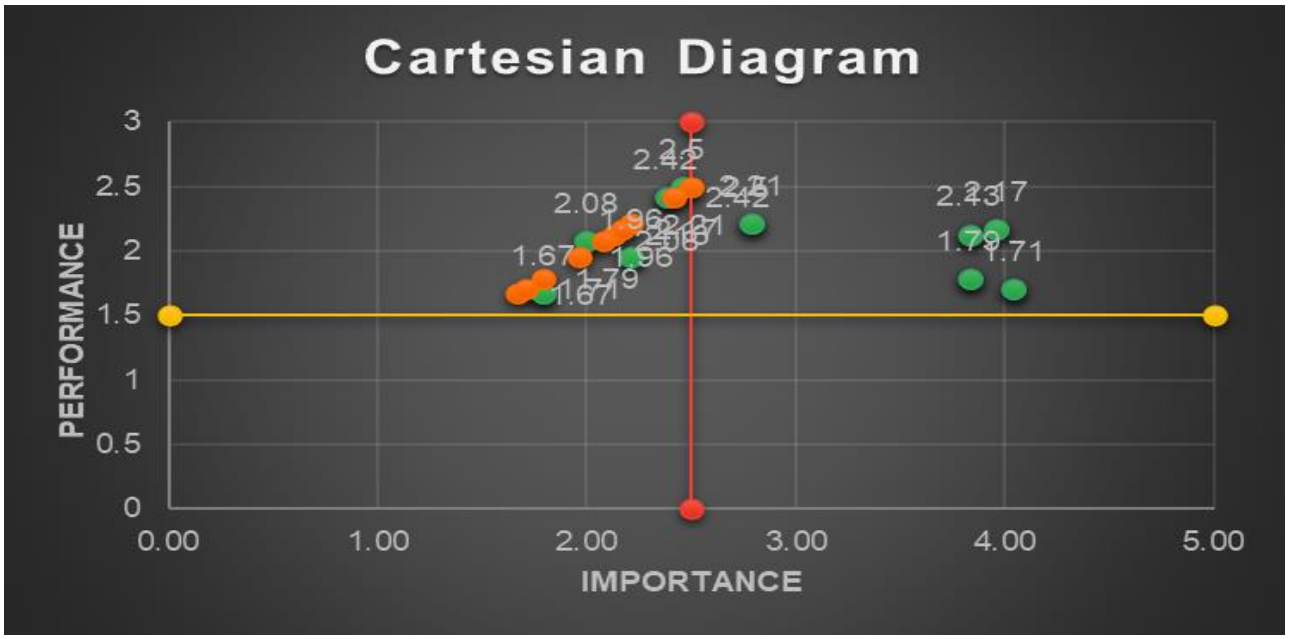

Figure 3 The Importance and Performance Functional quality level of road pavement.

5. Conclusion

Evaluation of road pavement's structural and functional aspects is a crucial element in managing global transportation infrastructure. Rough road surfaces caused by flooding present significant challenges to infrastructure resilience, requiring robust damage models to predict and mitigate flood impacts. By adopting best practices from research in various countries, road management, and maintenance in this region can be optimized, ensuring that road infrastructure remains in optimal condition to support mobility community economic activities and provide comfort and safety for road users.The ability of road pavement to handle or drain water efficiently is essential to ensure the sustainability and safety of road infrastructure. Good drainage can reduce the risk of water pooling, which can damage pavement and improve safety for road users. Evaluating pavement conditions to assess suitability and detect early deterioration in road quality can be done by examining the road surface condition.This research used a questionnaire method involving 24 respondents to analyze the community's assessment, obtaining an importance score of 2.93% and a satisfaction score of 2.06% regarding the quality of road pavement on Jalan Raya Ligung, Majalengka, particularly concerning road evaluation and functional improvements. This case study focuses on Majalengka.

References

[1] F. M. T. Z. J. G. Y. &. C. L. Tang, "Integrating three-dimensional road design and pavement structure analysis based on BIM.," *Automation in construction,,* vol. 113, p. 103152, 2022.

[2] C. G. C. S. M. T. A. Y. R. A. Sultana M., "Rutting and roughness of flood-affected pavements: Literature review and deterioration models.," *Journal of Infrastructure Systems,* vol. 24, no. 2, p. 04018006, 2018.

[3] S. M. C. H. Romano M., "Enhancing Road Infrastructure Management through Advanced

Technologies and Predictive Modeling: Addressing Flood-Induced Sidewalk Roughness Challenges.," *Transportation Research Record.,* vol. 40, no. 2672, pp. 166-175, 2018.

[4] K. &. C. N. Eliansyah, "ANALISIS KERUSAKAN PERKERASAN JALAN MENGGUNAKAN METODE PAVEMENT CONDITION INDEX (PCI) DI KECAMATAN CIAMPEA.," *JMTS:Jurnal Mitra Teknik Sipil,* vol. 7, no. 2, pp. 415-426, 2024.

[5] S. &. K. D. Arif, "STUDI KAJIAN PENINGKATAN RUAS JALAN BANGIL –KEMIRISEWU, KABUPATEN PASURUAN MENGGUNAKAN METODE MANUAL DESAIN PERKERASAN JALAN.," *Kohesi: Jurnal Sains dan Teknologi.,* vol. 1, no. 2, pp. 90-100, 2023.

[6] K. S. YUNITA, "ANALISIS KINERJA RUAS JALAN DAN SIMPANG TAK BERSINYAL (Studi Kasus Simpang Tiga Lengan Jalan Raya Jatikramat–Jalan dr. Ratna Jatiasih Kota Bekasi).," *(Doctoral dissertation, Universitas Mercu Buana Bekasi).,* 2019.

[7] H. Z. H. T. &. R. A. I. Dardak, "A conceptual pavement optimization considering costs and M&R interventions (Learn from Long Segment Maintenance Contract).," *Jour of Adv Research in Dynamical & Control Systemss,* 2022.

[8] D. J. &. R. N. E. Jaya, "Pengembangan Modul Pendidikan dan Pelatihan Materi Perencanaan Perkerasan Jalan pada Perusahaan Jasa Konstruksi.," *Edcomtech: Jurnal Kajian Teknologi Pendidikan.,* vol. 6, no. 1, pp. 162-172., 2021.

[9] H. Z. H. T. &. R. A. I. Dardak, "A conceptual pavement optimization considering costs and M&R interventions (Learn from Long Segment Maintenance Contract).," *Jour of Adv Research in Dynamical & Control Systems.,* vol. 21, no. 2, 2020.

[10] D. S. A. A. &. N. M. D. Nugroho, "Perencanaan Perkerasan Lentur Jalan Raya Dengan Metode Analisis Komponen Bina Marga 1987 (Studi Kasus Ruas Jl. Raya Banjarsari-Cerme Kabupaten Gresik).," *Wahana Teknik,* vol. 9, no. 1, pp. 1-10, 2020.

[11] M. &. K. D. O. S. Abi Rafdi, "Peran Infrastruktur Jalan Dan Drainase Dalam Upaya Adaptasi Dan Mitigasi Bencana Banjir Terkait Konsep Climate Resilient Infrastructure Studi Kasus: Kecamatan Baleendah.," *Jurnal Darma Agung,* vol. 31, no. 2, 2023.

[12] R. Rahadian, "Evaluasi Kondisi Perkerasan Lentur dan Prediksi Umur Layanan Ruas Jalan Wonosari-Mulo KM 4-5.," 2018.

[13] J. A. &. R. I. F. Nabillah, "PENGARUH BEBAN LALU LINTAS TERHADAP KERUSAKAN PERKERASAN JALAN (STUDI KASUS SEGMEN JALAN BANJARBARU – BATI-BATI.," *Jurnal Kacapuri: Jurnal Keilmuan Teknik Sipil.,* vol. 2, pp. 1-10, 2020.

[14] A. P. SANDI, "ANALISA KONDISI KERUSAKAN JALAN PADA LAPISAN PERMUKAAN DENGAN METODE PAVEMENT CONDITION INDEX (STUDI KASUS: JALAN GANCENG, PONDOK RANGGON, CIPAYUNG, JAKARTA TIMUR)," *(Doctoral dissertation, Universitas Mercu Buana).,* 2019.

[15] X. W. G. W. J. S. Y. Q. H. &. Y. B. Yin, "Deep learning on traffic prediction: Methods, analysis, and future directions.," *IEEE Transactions on Intelligent Transportation Systems.,* vol. 23, no. 6, pp. 4927-4943, 2021.

[16] a. alnaqbi, W. Zeiada, G. G. Al-khaateb and M. Abuzwidah, "Machine Learning Modeling of Wheel and Non-Wheel Path Longitudinal Cracking. 2024 Buildings," *Buildings.,* vol. 14, no. 3, p. 709, 2024.

[17] A. I. Rifai, "Manajemen Perkerasan: Implementasi Data Mining & Artificial Intelligence.," 2021.

[18] A. HIDAYAT and S. G. PUTRA, " KAJIAN KONDISI INFRASTRUKTUR JALAN LINGKUNGAN.," *Jurnal Teknik Sipil UNPAL ,* vol. 8, no. 2, pp. 2089-2950, 2018.

[19] K. K. M. C. J. &. H. L. Mbiyana, " Literature Review on Gravel Road Maintenance: Current

State and Directions for Future Research.," *Transportation Research Record. 506-522. 2677,* vol. 2677, no. 5, pp. 506-522, 2023.

[20] I. R. A. I. I. M. &. P. J. Andika, "A Traffic Management System for Minimization of Intersection Traffic Congestion: Case Bengkong Junction, Batam.," *IJEBD International Journal Of Entrepreneurship And Business Development,,* vol. 5, no. 05, pp. 945-956., 2022.

[21] W. R. A. I. &. I. M. Wincent, "The Road Performance Analysis in Jalan Ahmad Yani Batam Using IHCM 1997.," *Indonesian Journal of Multidisciplinary Science,,* vol. 1, no. 1, pp. 103-116., 2022.

[22] A. &. S. S. Nautiyal, "Methods and factors of prioritizing roads for maintenance: a review for sustainable flexible pavement maintenance program.," *Innovative infrastructure solutions. ,* vol. 7, no. 190, p. 3, 2022.

[23] H. K. K. H. S. A. B. B. S. D. &. P. D. Buwono, "Pemodelan Empiris Pemeliharaan Pada Perkerasan Chip Seal Dan Laston.," *Kontruksia.,* vol. 15, no. 1, pp. 179-191, 2023.

[24] L. R. Harris and G. T. Brown, " Mixing interview and questionnaire methods: Practical issues in harmonizing data.," *Practical Assessment, Research, and Evaluation.,* vol. 15, p. 1, 2019.

[25] I. Buric, I. Macuka and A. Sliskovic, " A mixed-method approach to the assessment of teachers' emotions: development and validation of the Teacher Emotion Questionnaire.," *validation of the Teacher Emotion Questionnaire. ,* vol. 38, no. 3, pp. 325-349, 2018.

[26] V. Herlina, "Panduan praktis mengolah data kuesioner menggunakan SPSS. Elex Media Komputindo.," *Elex Media Komputindo.,* 2019.

[27] N. R. A. I. &. T. M. Zulfa, "Road geometric design used AutoCAD® Civil 3D: a case study jalan campaka-wanaraja garut, Indonesia.," *Citizen: Jurnal Ilmiah Multidisiplin Indonesia,,* vol. 2, pp. 843-850, 2022.

[28] V. F. H. M. E. G.-H. A. M. C. A. T. F. R.-T. A. M. &. P. S. E. Vázquez, "Tire/road noise, texture, and vertical accelerations: Surface assessment of an urban road.," *Applied Acoustics.,* vol. 160, 2020.