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Evaluation of road pavement resistance to traffic loads case study : (KH Abdul Halim street, Majalengka, Indonesia)

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ABSTRACT

Road pavement is an important part of transportation infrastructure that must be able to bear traffic loads effectively. Evaluation of road pavement resistance to traffic loads is crucial in ensuring road safety and reliability. This research aims to evaluate the performance of road pavement in withstanding loads from passing vehicles, with a focus on analysis of wear, deformation and structural resistance. The method used in the questionnaire may include questions regarding the driver's suggestions and hopes for improving road conditions. Data collected from this questionnaire is integrated with statistical analysis to identify factors that influence road pavement strength. research results on Jalan KH Abdul Halim Majalengka. This indicator has an average Importance of 4.48% and satisfaction of 2.23%. The implication of this research is to increase the safety of road users and extend the service life of road infrastructure.

1. Introduction

The problem of road pavement resistance to traffic loads is an increasingly urgent global issue. With population growth and rapid urbanization, traffic volumes are increasing drastically, putting enormous pressure on road infrastructure. In various countries, both developed and developing, various countries in the world are carrying out sustainable highway construction to support various needs. The countries with the best road quality in the world are the United Arab Emirates, Finland, Switzerland, the Netherlands and Singapore [1], Road damage due to excessive loads is a major concern for the government and society. shows that high traffic loads are the main cause of road pavement damage in large cities around the world. This demands research and development of more durable pavement technologies and more effective maintenance strategies [2].

Road users in Asian countries, especially in Indonesia, may have encountered the separation of one road lane into two special lanes, namely the front road and the fast lane. [3], The problem of road pavement durability is one of the important issues in infrastructure development. With a large area and scattered population distribution, the road network is the main backbone for inter-regional connectivity [4]. The high level of road damage due to heavy traffic loads, especially on main roads and logistics routes, often hampers transportation efficiency. to repair roads damaged by heavy traffic loads, shows the need for more effective solutions to overcome this problem. [5]

At the regional level, especially in West Java, high traffic loads also pose challenges to the sustainability of the road network. Very severe traffic congestion can cause additional carbon emissions and reduce the efficiency of transport networks; it can also cause major economic losses [6], As one of the provinces with the largest population and an important center of economic activity, West Java faces complex traffic problems [7]. Road damage often occurs on strategic sections connecting big cities and industrial areas. roads in West Java are showing signs of premature wear and tear due to high traffic loads, highlighting the need for better planning and maintenance. [8]

Jalan KH Abdul Halim is one of the urban roads located in the center of Majalengka city, this road is several activity centers in the city of Majalengka [9]. This road functions as the main route connecting Majalengka city center with the surrounding area as well as access to West Java International Airport (BIJB) Kertajati [10]. High traffic volumes, including heavy vehicles, cause this road to frequently experience damage. This damage not only disrupts traffic flow but can also endanger the safety of road users. noted that 60% of the total length of Jalan KH Abdul Halim showed surface damage in the last three years, highlighting the importance of evaluating and improving the durability of road pavement on this section. [11]

This research aims to evaluate the durability of road pavement against the traffic load of the KH Abdul Halim-Majalengka road. Through this evaluation, it is hoped that accurate data and information regarding the condition of the road can be obtained, which can be used as a basis for planning road repairs and maintenance. This evaluation also aims to identify factors causing damage and provide technical recommendations to improve the quality and longevity of the road. [12]

2. Literature Review

2.1 Traffic Volume

Traffic volume refers to the number of vehicles passing through a road in a certain time period. This is an important variable because the higher the traffic volume, the greater the pressure received by the road pavement. Studies show that increasing traffic volume is directly related to accelerated damage to road pavement [13]. Traffic safety is a crucial issue that affects people's health and welfare. In Indonesia, the rate of traffic accidents is still high and often have fatal consequences. Factors such as poor road conditions, lack of safety infrastructure, and driver behavior that does not comply with traffic rules contribute to the high number of accidents. Efforts to improve traffic safety require a holistic approach that includes infrastructure improvements, safety education, and stricter law enforcement [14].

Roads are a means of land transportation which is very important for social relations and the economy of goods and services, and with the population increasing every year, the number of vehicles passing on the existing roads increases. [15]. Safe and well-maintained road infrastructure is an important component in improving traffic safety. This includes clear road markings, adequate lighting, and the presence of safety facilities such as road dividers and zebra crossings. Additionally, technology such as traffic monitoring cameras and accident detection systems can help in real-time traffic monitoring and management. The government also needs to invest in building safe toll roads and bridges to reduce the risk of road accidents.

Public education and awareness regarding traffic safety also needs to be improved. Effective traffic safety campaigns can change driver behavior, such as the use of seat belts, helmets, and compliance with speed limits. Educational programs in schools and communities can provide an understanding of the importance of road safety. In addition, strict enforcement of traffic violations, such as drunk driving or the use of mobile phones while driving, is essential to prevent accidents and ensure safer roads for all road users [16].

2.2 Vehicle Composition

Vehicle composition involves the types of vehicles passing, such as passenger cars, light trucks and heavy trucks. Heavy trucks have a greater influence on road pavement damage than passenger cars due to higher axle loads. Research indicates that an unbalanced distribution of vehicle types can accelerate structural damage to pavement [17]. The composition of vehicles on the road has a significant impact on various aspects of transportation, including congestion, air pollution and traffic safety. In Indonesia, the composition of vehicles is dominated by motorbikes and private cars, with a smaller proportion of public transportation vehicles such as buses and trucks. This imbalance often contributes to high traffic density, especially in urban areas. A large number of motorbikes, for example, makes traffic more difficult to regulate and increases the risk of accidents due to unpredictable maneuvers.

Apart from that, the composition of vehicles which is dominated by private vehicles also has a negative impact on the environment. Cars and motorbikes, especially those that use fossil fuels, are the main source of greenhouse gas emissions and other air pollutants. [18]. Increasing the number of electric and hybrid vehicles can help reduce this environmental impact, but adoption is still limited in Indonesia. On the other hand, heavy vehicles such as trucks also contribute to air pollution and road damage, and require special planning for routes and operating times to reduce their negative impacts.

To overcome the issues that arise from the composition of these vehicles, comprehensive policies and strategies are needed. The development of efficient and integrated public transportation can reduce dependence on private vehicles. Incentives for the use of environmentally friendly vehicles, such as electric vehicles, can also help change the composition of vehicles to be more sustainable. In addition, stricter regulations regarding heavy vehicle operations and improving road infrastructure can reduce the negative impact of the current vehicle mix. Collaborative efforts between government, industry and society are essential to creating a safer, more efficient and environmentally friendly transportation system [19].

2.3 Vehicle Axle Load

Vehicle axle load is the weight of the vehicle axle which has a direct effect on the pressure received by the road pavement. Heavier loads produce greater pressure, which can cause deformation and damage to the roadway. Studies using Weigh-In-Motion (WIM) data show that vehicles with heavy axles significantly increase the risk of pavement cracking and deformation [20]. Vehicle axle load is a critical factor that influences road conditions, traffic safety and transportation efficiency. In Indonesia, many roads experience damage faster than expected due to vehicle axle loads that exceed the specified limits. Heavy vehicles such as trucks often carry loads that exceed their maximum capacity, which causes damage to the road surface, decreased road quality, and increased road maintenance costs. This road damage not only disrupts traffic flow but also increases the risk of accidents [21].

Apart from damage to infrastructure, excessive axle loads also have an impact on traffic safety [22]. Vehicles carrying excessive loads have poorer braking capabilities and lower stability, increasing the risk of accidents. This condition is exacerbated by the lack of law enforcement regarding load violations. Close supervision and consistent enforcement are essential to ensure that vehicles do not carry loads that exceed their permitted capacity.

To overcome this problem, a comprehensive approach is needed. First, stricter enforcement of axle load violations should be implemented, including weighing vehicles at various monitoring points. Second, educating drivers and transportation companies about the importance of complying with load limits can help reduce violations. Third, improving the quality and design of roads that are more resistant to heavy

loads also needs to be done to reduce road damage. Implementing technology such as a real-time axle load monitoring system can also help in monitoring and managing vehicle loads on the road [23].

2.4 Traffic Frequency

Traffic frequency refers to how often vehicles pass, both daily and seasonally. High frequencies increase load accumulation on the pavement, which can accelerate the process of material fatigue and decrease road performance. Research using survival analysis methods shows that increasing traffic frequency significantly reduces the life span of road pavements [24] Traffic frequency, which refers to the number of vehicles passing a certain point in a certain time period, is an important indicator in traffic management and infrastructure planning. In Indonesia, high traffic frequency, especially in big cities, results in various problems such as congestion, air pollution and increased travel time. High traffic frequency also affects the comfort and safety of road users, as well as adding pressure to existing road infrastructure.

Traffic jams caused by high traffic frequency are a problem that often occurs in urban areas. Due to the growing vehicle population in this country, big cities in Indonesia experience traffic jams. Traffic jams can result in driver delays, inconvenience, economic loss, and air pollution [25]. Roads that are unable to accommodate the ever-increasing volume of vehicles are the main cause of congestion, which in turn slows down mobility and reduces productivity. In addition, congestion contributes to air pollution because vehicles stopping and moving slowly produce higher emissions. This air pollution has a negative impact on public health, especially in areas with heavy traffic.

To overcome the issues associated with high traffic frequency, various strategies can be implemented. Increasing road capacity and building new infrastructure such as toll roads and flyovers can help reduce congestion. The development of efficient and integrated public transportation, such as bus rapid transit (BRT) and trains, can also reduce the number of private vehicles on the road. In addition, the application of smart technology such as sensor-based traffic management systems and navigation applications can help optimize traffic flow and reduce congestion. Policies that encourage the use of environmentally friendly vehicles and carpooling can also contribute to reducing traffic frequency and improving the quality of life in cities [26].

3. Method

This research used a questionnaire method involving 50 respondents to analyze the community's assessment of the quality of road pavement on Jalan KH Abdul Halim, Majalengka, West Java, Indonesia, focusing on road evaluation and functional improvements. It is hoped that the research results will provide an in-depth understanding of regional challenges and the potential for road infrastructure and driver safety solutions. The questionnaire is considered an effective tool for collecting data on Impact Analysis and Driver Response on Jalan KH Abdul Halim, Majalengka, West Java, Indonesia. First, questionnaires can be designed to identify drivers' perceptions of vehicle road conditions, such as how often they see potholes and bumpy roads. Second, through questionnaires, we can evaluate how road conditions influence driver behavior, such as how often they avoid potholes or feel uncomfortable when driving. This data provides deep insight into how drivers respond to identified problems.

Figure 1 Research Location
Source: Google Earth

In addition, the questionnaire may include questions regarding the driver's suggestions and hopes for improving road conditions. Do they expect quicker fixes or have real ideas for implementing solutions? It is important to design questions clearly and structured to interpret the results accurately. Using rating scales or open-ended questions can add depth to the data collected. Questionnaires can be distributed through various online and conventional channels to ensure representative participation. Lastly, statistical analysis can be applied to questionnaire data identifying emerging trends and patterns from driver responses, thereby providing a strong basis for making more effective policy recommendations.

4. Result and Discussion

4.1 Respondent Information

The data collection process in survey research is very important. So far, researchers or surveyors have collected data manually by printing questionnaires and distributing them by visiting respondents one by one. Data was collected from 50 respondents based on age, gender and vehicle used when crossing Ligung Road, Majalengka. From the survey results, the majority of genders who choose Jalan Ligung Majalengka are men, and many use cars.

Variabel	Category	Frequency	Persent
Jenis Kelamin	Male	32	64%
	Female	18	36%
Usia	≤20	5	10%
	21 - 30	25	50%
	31 - 40	8	16%
	41 - 50	10	20%
	51 - 60	2	4%
Vehicles Used	Car	28	56%
	Motorcycle	12	24%
	Truck	10	20%

Figure 2 Respondent Information

4.2 Level of functional quality of road pavement

The increasing number of vehicles on the road has accelerated the push to increase efforts to implement monitoring systems that maintain the condition of road pavement. The increasing number of vehicles on the road also causes more damage and distress to the road pavement [27]. The level of quality of road pavement is the main assessment in completing 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 KH Abdul Halim Majalengka. This indicator has an average Importance of 4.48% and satisfaction of 2.23%.

NO	Indicator	Rata - rata Kepentingan	Rata - rata Kepuasan	Selisih
A1	Ketebalan Perkerasan	4,48	1,78	-2,7
A2	Kekakuan Perkerasan (Modulus Resiliensi)	4,44	2,07	-2,37
A3	Daya Dukung Tanah Dasar (CBR - California Bearing Ratio)	4,52	2,07	-2,45
A4	Kualitas Perkerasan (Kekuatan Geser)	4,41	2,26	-2,15
A5	Kondisi Permukaan Perkerasan (Retakan)	4,52	2,19	-2,33
A6	Deformasi Permanen	4,41	2,33	-2,08
A7	Daya Tahan Terhadap Air (Drainase)	4,59	2,26	-2,33
A8	Kinerja Struktural	4,33	2,38	-1,95
A9	Pemulihan Elastisitas	4,67	2,22	-2,45
A10	Pengukuran Pola Lalu Lintas dan Beban Aksial	4,41	2,75	-1,66

Source: The following is indicator data from Jalan KH Abdul Halim, Majalengka.

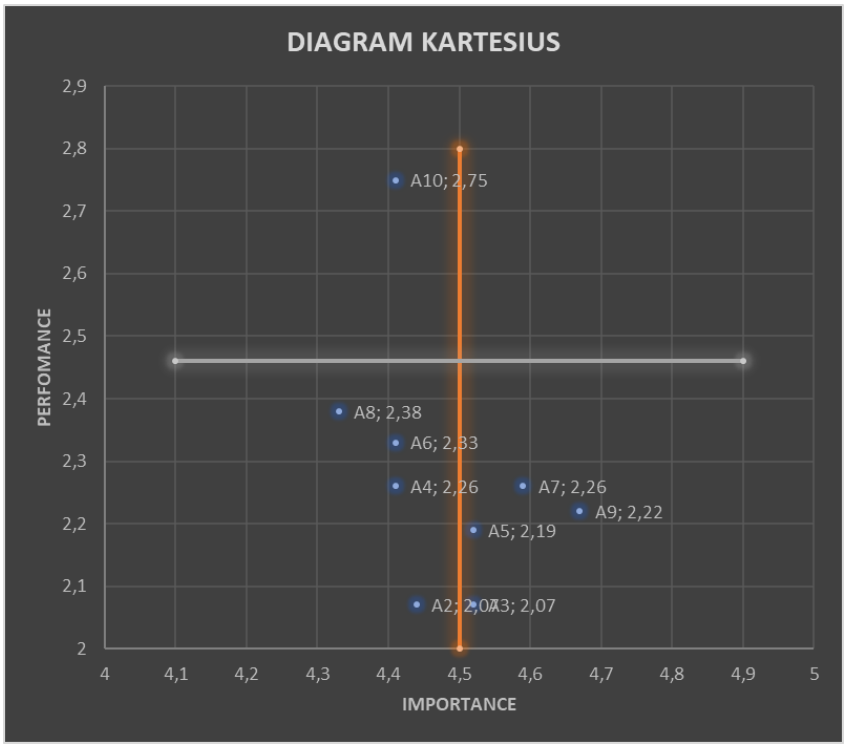

Figure 3 The Importance and Performance Functional quality level of road pavement.

5. Conclusion

Evaluation of the structural and functional aspects of road pavement is an important element in the global management of transportation infrastructure. Rough road surfaces resulting from flooding present significant infrastructure resilience challenges, requiring robust damage models to predict and mitigate flood impacts. By adopting best practices from research in various countries, road management and maintenance within the area can be optimized, ensuring that road infrastructure remains in optimal condition to support the mobility of community economic activities and provide comfort and safety for road users. The ability of road pavement to handle or drain water efficiently is critical to ensuring the sustainability and safety of road infrastructure. Good drainage can reduce the risk of water pooling which can damage road pavement and improve safety for road users. Evaluate pavement conditions to assess suitability and detect early. Road quality reduction can be done by checking the condition of the road surface. This research used a questionnaire method involving 50 respondents to analyze community assessments, obtained an interest score of 4.48% and a satisfaction score of 2.23% regarding the quality of road pavement on Jalan KH Abdul Halim, Majalengka, especially regarding road evaluation and functional improvements . This case study focuses on Majalengka.

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