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EVALUATION OF THE IMPLEMENTATION OF STANDAR PELAYANAN MINIMAL (SPM) ON TOLL ROADS IN INDONESIA

Amar Mufhidin[1*], *Anasthasya Syalma*[2], *Fathimah Khoirunnissa*[3], *Janeeta Nur Fadillah*[4]
[1,2,3,4] Building Engineering Education, Faculty of Engineering and Industrial Education, Indonesia University of Education
Jl. Dr Setiabudhi No.229, Bandung City, West Java, 40154, Indonesia
[*1]amar@upi.edu, [2]nasthasyasyal3@upi.edu, [3]kfathimah11@upi.edu, [4]janeetanf30@upi.edu

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Abstract

Toll roads have a strategic role in supporting the mobility and distribution of goods in Indonesia, so the fulfillment of the Standar Pelayanan Minimal (SPM) is important to ensure safety, comfort, and service efficiency. This study evaluates the implementation of SPM in six national toll road corridors based on the Regulation of the Minister of Pekerjaan Umum dan Perumahan Rakyat (PUPR) Number 16/PRT/M/2014. The results of the study show that in general toll road services have met standards, especially in the indicators of average travel speed, transaction speed, and vehicle queue length at toll gates. However, unevenness and roughness of the pavement are still the main obstacles, which is reflected in the Surabaya-Gresik and Ciawi-Sukabumi sections due to unevenness of the pavement, as well as on the Cikampek-Palimanan section and the Ujung Pandang Toll Road Sections 1-3 due to the unavailability of up-to-date periodic monitoring data. The novelty of this study lies in the mapping of cross-corridor SPM fulfillment which shows that the decline in service performance is more influenced by operational factors and vehicle load over dimension over load (ODOL) on the logistics line than the quality of the initial construction. These findings confirm the importance of integrating information technology in predictive maintenance systems and adaptive traffic management to detect pavement degradation early. The limitation of this study lies in the use of secondary data, so that administrative discipline in updating operational data is an important factor for Badan Usaha Jalan Tol (BUJT) in supporting accurate and transparent decision-making.

Keywords: Evaluation, Minimum Service Standards, Toll Roads, Toll Road Service Performance

Introduction

The implementation of Standar Pelayanan Minimal (SPM) on toll roads in Indonesia represents the government's commitment to providing transportation infrastructure services that meet safety, reliability, and sustainability requirements. Within the national transportation system, toll roads play a strategic role in regional connectivity and serve as a primary backbone for mobility and logistics distribution (Makmur & Rajagukguk, 2015). Nevertheless, previous evaluations of toll road service standards have generally emphasized partial compliance assessments, focusing on individual technical indicators or user perception surveys. Such approaches tend to provide fragmented conclusions and do not sufficiently capture the systemic performance of toll roads across multiple corridors. As a result, the existing body of research has not fully addressed how operational conditions and management practices influence sustained compliance with SPM at a network level.

From an engineering perspective, deviations in specific technical indicators have direct implications for overall service performance. Pavement surface unevenness, commonly represented by the International Roughness Index (IRI), is one of the most critical parameters affecting user safety and average travel speed (Arthur, 2015; Adelia & Ayu, 2025). Empirical studies show that IRI values exceeding prescribed standards significantly contribute to the acceleration of functional pavement deterioration and the decline of service reliability (Dina & Amin, 2023). However, many existing studies remain limited to reporting compliance status, without systematically linking technical deficiencies to operational management effectiveness and long-term performance outcomes.

The difference between normative provisions stipulated in SPM regulations and empirical conditions observed in the field constitutes a clear research gap that has not been explicitly articulated in previous studies. Data from 2025 indicate that several strategic toll road sections continue to experience reduced average travel speeds and vehicle queues at toll gates (S. E. Menteri PU, 2025; Hendarto et al., 2021). These conditions are closely associated with increasing traffic volumes and operational constraints. Without adaptive and accurate monitoring mechanisms, such discrepancies may accelerate pavement quality degradation and disrupt the stability of toll road service performance (Rista Septi Nurdiana & Anita Susanti, 2025; Aziz et al., 2025). Therefore, strengthening the integration between routine maintenance programs implemented by Badan Usaha Jalan Tol (BUJT) and an understanding of road user behavioral characteristics becomes a critical factor in maintaining consistent service performance at the macro level (Mudiono & Widyaningsih, 2022; Iskandar, 2018).

From an economic perspective, the level of SPM achievement is closely related to the sustainability of toll road management, particularly in the context of tariff policy. Previous studies indicate that road users exhibit high sensitivity to service quality, where tariff adjustments often lead to negative perceptions if pavement conditions and supporting facilities, such as rest areas and service infrastructure, do not meet expected comfort standards (Purboyo et al., 2024; Arthur, 2015). User satisfaction is not only reflected through quantitative performance indicators but also through the responsiveness and effectiveness of operators in addressing operational disruptions (Noorlaelasari et al., 2023; Kita, 2000). This perspective aligns with international practices emphasizing that infrastructure service quality must be proportional to user costs to ensure economic efficiency and public acceptability (Way et al., 2025). Empirical evidence further confirms that perceived service quality significantly influences user satisfaction, where services that meet or exceed expectations reinforce the perception that toll tariffs are commensurate with the quality provided (Chandra Irawan & Alversia, 2024).

As a strategic effort in answering these challenges, technology-based toll road management is a necessity to bridge the gap between regulatory standards and actual service performance. The adoption of digital governance and intelligent transportation systems enables the availability of real-time operational data, which can be utilized by regulators to enhance the effectiveness of supervision over Badan Usaha Jalan Tol (BUJT) compliance with SPM requirements (Muhammad

Fitri Rahmadana, 2025; Fauzan et al., 2023). Unlike previous evaluations that rely on periodic and manual assessments, this study advances existing research by employing an integrated analytical framework based on aggregated self-assessment data to support continuous evaluation of toll road performance. Through this approach, potential non-compliance with SPM can be identified at an early stage, allowing for timely corrective actions and more adaptive operational management (Laskara, 2021; Tahrir et al., 2023). Ultimately, the synergy between consistent regulations, adaptive operational strategies, and optimal use of technology is expected to support the development of a land transportation system that contributes to inclusive and sustainable national economic growth (Iskandar, 2011; Suwarto et al., 2021).

MINIMUM SERVICE STANDARDS FOR TOLL ROADS

Normatively, the *Standar Pelayanan Minimal* (SPM) or Minimum Service Standards is defined as a provision regarding the type and quality of basic services which are mandatory affairs of the local government and are entitled to obtain at least one citizen (Government of the Republic of Indonesia, 2005). In the context of road transportation, SPM is studied as a minimum quality standard that must be met so that the community obtains the right to accessibility and proper mobility, so that SPM is also a reference for evaluating the implementation of road infrastructure (Iskandar, 2011). In the toll road sector, this provision is then translated into the form of toll road SPM which regulates services to users during the implementation and operation of toll roads, as formulated in the Regulation of the *Pekerjaan Umum dan Perumahan Rakyat* (PUPR) Number 16/PRT/M/2014 concerning Toll Road Minimum Service Standards (Ministry of Public Works, 2014). The regulation stipulates that toll road operators are obliged to meet certain standards so that the security, safety, smoothness, and comfort of toll road users can be guaranteed (Ministry of Public Works, 2014).

In practice, toll road SPM is carried out through a set of parameters that serve as a benchmark for service performance, which at the same time reflects the level of service from the user's point of view. Karsaman explained that the Toll Road Minimum Service Standard is a parameter used as a measure for the provision of services to road users, so that its fulfillment is positioned as a form of service guarantee from operators to users (Karsaman, 2009). These parameters include six main substances, namely road conditions, average traffic speed, accessibility, mobility, safety, and help/rescue units and service assistance.

According to Islam et al. (2014), pavement roughness measurement using a smartphone-based application showed a strong correlation between the International Roughness Index (IRI) value and the quality of the road surface. A high IRI reflects a significant level of unevenness, which has a direct impact on ride comfort and ride efficiency. Smoother surface conditions are able to maintain vehicle stability, thus supporting smooth traffic flow and minimizing negative acceleration that triggers a speed drop. This relationship is strengthened by the findings of (Kumar et al., 2024), who concluded that increased IRI has a strong negative correlation with average travel speed in both free and heavy traffic conditions. Through empirical measurements on various urban roads, every 1 m/km increase in IRI led to a decrease in the average speed of light vehicles by 2.3–3.5 km/h. This shows that the higher the level of unevenness of the road, the lower the average travel speed due to the increase in the vertical dynamic force experienced by the vehicle.

In addition to having an impact on speed, road surface conditions also affect transaction speed and vehicle queue length, especially in areas such as toll gates. Studies by Amarasingha et al. (2025) show that pavement surface distress can reduce road capacity by up to 13.54%. When the road surface leading to the transaction area is damaged, drivers tend to slow down the vehicle to avoid excessive vibration, thereby reducing the transaction throughput speed. As a result, there is an accumulation of vehicles in the transaction lane that extends the vehicle queue length, especially during peak hours.

Overall, the combination of the results of the three studies shows that pavement roughness plays an important role as a key variable that affects the operational efficiency of toll roads. Uneven road surfaces reduce average travel speed, slow down transaction speed, and increase vehicle queue length, resulting in a decrease in capacity and road service levels. Therefore, regular maintenance of the road surface is the main strategy to maintain smooth traffic flow and the efficiency of the transaction system in toll road facilities.

According to Karsaman (2009) In the substance of road conditions, the benchmarks used relate to the roughness, flatness, and absence of potholes on the road surface, which are measured by a certain value limit and regular inspection periods, respectively and the aspect of traffic speed is assessed through the comparison of the average speed of the vehicle to the planned speed, so that if the actual speed drops below a certain percentage, it is an indication of the need for traffic regulation or an increase in the capacity of the toll road. Accessibility is assessed, among others, through the speed of transactions at toll gates and the adequacy of the number of substations, which can also be assessed from the average queue length as a benchmark for the need for additional transaction facilities.

Highlighting that road unevenness is a major problem that often fails to meet standards, especially on toll roads with many heavy vehicles such as Cipali. This is crucial because according to Yandriguna et al. (2025), the physical condition of the road surface is the most sensitive aspect assessed by drivers; If the road is bad, the perception of the service immediately falls.

Another study that examined user satisfaction with the fulfillment of SPM on several toll roads in the Greater Jakarta area showed that the majority of respondents expressed satisfaction with the facilities and services received based on the SPM indicator, with the average satisfaction score approaching the "satisfied" category on the Likert scale (Dina & Amin, 2023). The results of the study also show that the indicators with the highest level of satisfaction include road directions (encroachment and markings), cleanliness, and transaction speed at toll gates, all of which are part of the substance of services in the toll road SPM (Dina & Amin, 2023). Thus, it can be concluded that the quality of SPM fulfillment is not only reflected in technical measurements, but also manifested in the subjective satisfaction of toll road users (Makmur, 2021).

In terms of regulation and supervision, the toll road SPM stipulated in the *Pekerjaan Umum dan Perumahan Rakyat* (PUPR) Number 16/PRT/M/2014 serves as a reference for the BPJT and the technical ministry in conducting periodic monitoring and evaluation of operator performance (Ministry of Public Works, 2014). The monitoring and evaluation process can be carried out through document assessments, surveys, interviews, and field observations to assess whether all SPM indicators have been met (Makmur, 2021). From the perspective of state administrative law, BPJT's discretionary actions in regulating and managing toll roads—including the transfer of part of construction work as well as supervision of compliance with standards—must remain in line with the general principles of good governance (Rusfiantini et al., 2024). The results of the evaluation of the fulfillment of the SPM then become a consideration for the government in formulating policies to improve services, adjust tariffs, and increase the capacity of the toll road network in the future (Rusfiantini et al., 2024).

Overall, toll road SPM can be understood as a set of benchmarks that connect three interests at once, namely the interests of government regulations, the operational performance of toll operators, and user satisfaction as service recipients. When the SPM indicators are met and consistently monitored, SPM not only functions as a minimum requirement, but also as an instrument for improving service quality and accountability for toll road implementation to the public(Makmur, 2021; Karsaman, 2009).

Table 1 summarizes the SPM for toll roads in Indonesia, which are structured into key service dimensions including road condition, average travel speed, and accessibility. Each dimension is operationalized through measurable indicators, clearly defined coverage areas, and quantitative benchmarks, such as pavement roughness limits, minimum operating speeds for urban and interurban toll roads, and maximum transaction times and queue lengths at toll gates. These

indicators provide a practical framework for evaluating toll road performance and ensuring that service delivery remains consistent with regulatory requirements and user expectations.

Table 1. Standar Pelayanan Minimal (SPM) for Toll Roads in Indonesia

NO	SUBSTANCE OF SERVICE	MINIMUM SERVICE STANDARDS		
		INDICATOR	COVERAGE	BENCHMARK
1	Toll Road Conditions	Path pavement:		
		Cruelty	All Toll Road Sections	> 0.33 mm
		Unevenness	All Toll Road Sections	Rigid Pavement or Bending Pavement : IRI 4 years m/km
2	AverageTravel Speed	Average Travel Speed Under Normal Conditions	Inner Urban Toll RoadOuter Toll Roads	≥ 40 km/h ≥ 60 km/h
3	Accessibility	Average Transaction Speed	Open system toll gates	Maximum 6 seconds per vehicle
			System Toll Gate-Substation	Maximum 5 seconds per vehicle
			- Exit substation	Maximum 9 seconds per vehicle
			GTO - Toll Booth Take Card	Maximum 4 seconds per vehicle
			- Transaction Toll Substations	Maximum 5 seconds per vehicle
		Number of Vehicle Queues	Toll Booth	Maximum of 10 vehicles per Substation under normal conditions

Research Methods

This study employs a quantitative descriptive approach to evaluate the level of compliance with the Standar Pelayanan Minimal (SPM) on toll road sections in Indonesia. The data used are secondary data collected from the e-SPM system of the Toll Road *Badan Pengatur Jalan Tol* (BPJT) covering the period of 2025. The Selection of Toll Road Sections was based on the following criteria including road sections that have been in operation from 2025 year ensure data consistency and availability, representation of various regional categories by sampling toll roads across Indonesia to reflect diverse operational conditions availability of complete SPM indicators in the BPJT monitoring system. Consequently, 14 toll road sections were included in this study.

Data collection was carried out through a documentation study of e-SPM reports and data to examine pavement unevenness, surface roughness, average travel speed, transaction speed, and vehicle queue length at toll gates and technical validation, by comparing operator data with independent measurement results from the Tim Evaluasi BUJT under BPJT. Data analysis was carried out descriptively by calculating the percentage of achievement of each indicator and identifying patterns of indicators that were not met repeatedly to provide a comprehensive picture of the level of performance of toll road services in Indonesia.

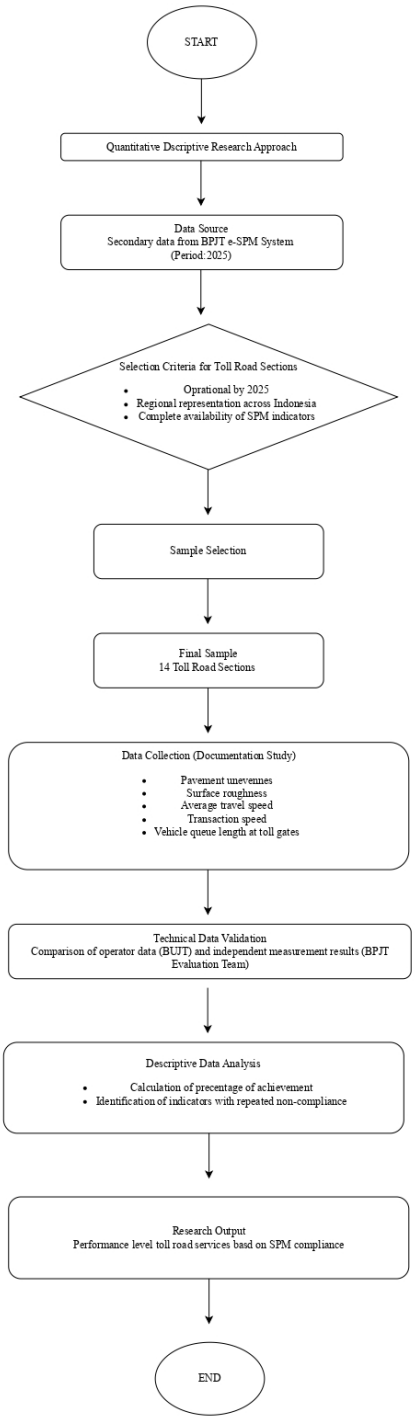

Figure 1. Flowchart of Systematic Quantitative Descriptive by e-SPM Data

Research Results and Discussion

Toll roads have a strategic role in supporting community mobility and smoothing the distribution of goods in Indonesia. Therefore, the consistent implementation of the Standar Pelayanan Minimal (SPM) is very important to ensure safety, comfort, and travel efficiency for road users. Based on the Regulation of the Minister of *Pekerjaan Umum dan Perumahan Rakyat* (PUPR) Number 16 of 2014 concerning Toll Road Minimum Service Standards and the Circular Letter of the Minister of PUPR Number 7 of 2025 concerning the Mechanism of Reporting,

Evaluating, and Checking the Fulfillment of SPM, each Badan Usaha Jalan Tol (BUJT) is required to ensure that all toll road sections it manages meet the service parameters set by the government. Compliance assessments are carried out through indicators such as pavement roughness, pavement unevenness, average travel speed, transaction speed, and vehicle queue length at toll gates, which are presented in detail in Table 2.

Analysis of the data in Table 2 shows that there is a significant variation in performance between toll road corridors in Indonesia. The comparative results show that the Trans-Sumatra corridor has a more stable level of compliance with a status of "MEET" in all sections, in contrast to the main corridor on the island of Java which faces challenges, especially in sections with high logistics activities. These findings are in line with previous research that stated that the high volume of daily traffic on major economic routes is directly proportional to the acceleration of road pavement damage (H. Setiawan et al., 2015). These differences illustrate the different operational characteristics between urban areas such as Greater Jakarta facing high pressure in queue management and accessibility, while non-urban areas focus more on physical maintenance of roads to maintain optimal travel speed.

Meanwhile, the identification of sections with a status of "DO NOT MEET" shows that the main factor for non-meeting of SPM comes from the level of roughness and unevenness of the pavement. Low pavement hardness indicates a reduced ability of the road surface to provide adequate friction force between the vehicle's tires and the pavement layer. This condition has the potential to increase the risk of slipping, especially during sudden braking and on wet road surface conditions, so that it has a direct impact on the safety of road users. The decrease in pavement roughness is generally affected by surface wear due to repetitive traffic, especially heavy vehicles, as well as the degradation of wear layer material that is not compensated for by adequate periodic maintenance. In addition, the high value of the International Roughness Index (IRI) in logistics lines is generally caused by overloading heavy vehicles (Over Dimension Over Load / ODOL) which accelerates structural damage and reduces the quality of road surfaces (Kurniawan et al., 2020). The combination of low level of roughness and high unevenness of the pavement shows that high traffic pressure, especially from heavy vehicles, is the dominant factor in the decline in toll road service standards. These findings confirm the need for fast and appropriate technical measures, both through vehicle load control and improvement of the pavement maintenance system, to ensure the sustainability of the function and performance of the national toll road infrastructure.

Table 2. Results of the evaluation of the *Standar Pelayanan Minimal* (SPM) of Toll Roads in Indonesia

No	Toll Road Sections	SUBSTANCE OF SERVICE					Results and Monitoring
		Toll Road Conditions		Average Travel Speed	Accessibility		
		Cruelty	Unevenness	Average Travel Speed Under Normal Conditions	Average Transaction Speed	Number of Vehicle Queues	
	Trans Sumatra						
1	Palembang - Indralaya	Path A: 0.60 – 0.81 Path B: 0.71 – 0.73	Path A: 2.07 - 3.97 Path B: 1.77 - 3.90	80 Km/hour	1.252 seconds	GT Indralaya: 1 vehicle	MEET

	Sigli - Banda Aceh	Path A: 0.52 – 0.73 Path B: 0.47 – 0.75	Path A: 1.59 - 3.82 Path B: 1.47 - 3.89	97.50 Km/ hour	1 seconds	GT Baitus salam: 2 vehicles	MEET
	Terbanggi Besar - Pematang Panggang - Kayu Agung	Path A: 0.63 – 0.77 Path B: 0.65 – 0.77	Path A: 1,84 - 3.94 Path B: 1.42 - 3.98	60 Km/ hour	1.731 seconds	GT Lambu Kibang: 3 vehicles	MEET
	Trans-Java Toll Road						
2	Cikampek - Palimanan	Path A: 0.43 – 0.87 Path B: 0.40 – 0.82	Path A: 1.35 - 5.43 Path B: 1.30 - 5.37	91.17 Km/ hour	2.15 seconds	GT Cikedung: 1 vehicle	DO NOT MEET
	Jakarta - Cikampek	Path A: 0.56 – 0.89 Path B: 0.55 – 0.89	Path A: 1.23 - 3.85 Path B: 1.28 - 3.89	80 Km/ hour	2.028 seconds	GT Cikampek Utama 6: 7 vehicles	MEET
	Tangerang - Merak	Path A: 0.57 – 0.86 Path B: 0.47 – 0.85	Path A : 1.41 - 3.74 Path B : 1.34 - 3.67	71 Km/ hour	1.7 seconds	GT Cup: 6.44 vehicle	MEET
	JABODETABEK						
3	Cinere - Jagorawi	Path A: 0.52 – 0.74 Path B: 0.46 – 0.70	Path A: 2.60 - 3.91 Path B: 2.70 - 3.77	63.50 Km/ hour	1.277 seconds	GT Limo Utama 1: 5 vehicles	MEET
	Kelapa Gading - Pulo Gebang	Path A: 0.69 – 0.80 Path B: 0.55 – 0.80	Path A: 2.39 - 3.23 Path B: 2.35 - 3.49	60 Km/ hour	1.22 seconds	GT Kelapa Gading: 1.50 vehicles	MEET
	Pondok Aren - Serpong	Path A: 0.63 – 0.68 Path B: 0.60 – 0.63	Path A: 1.24 - 3.90 Path B: 1.50 - 4.00	71,77 Km/ hour	1.30 seconds	GT Pondok Aren 1: 1 vehicle	MEET
	Non Trans Jawa						
4	Surabaya - Gresik	Path A: 0,51 - 0,64 Path B: 0,49 - 0,64	Path A: 2,60 - 5,50 Path B: 2,60 - 6,60	74.50 Km/ hour	2.60 seconds	GT West Ramp: 3.20 vehicles	DO NOT MEET

	Ciawi - Sukabumi	Path A: 0.63 – 0.79 Path B: 0.63 – 0.78	Path A: 2.20 - 4.24 Path B: 2.36 - 4.02	75 Km/ hour	2.492 seconds	GT Parung Kuda : 2 vehicles	DO NOT MEET
	Pandaan - Malang	Path A: 0.65 – 0.82 Path B: 0.66 – 0.82	Path A: 1.73 - 3.97 Path B: 1.75 - 3.97	78 Km/ hour	1.912 seconds	GT Singosari: 3 vehicles	MEET
	Sulawesi						
5	Ujung Pandang Seksi 1 - 3	-	-	80.50 Km/ hour	2.446 seconds	GT Parangloe: 2,90 vehicles	DO NOT MEET
	Kalimatan						
6	Balikpapan - Samarinda	Path A: 0.42 – 0.64 Path B: 0.42 – 0.67	Path A: 2.43 - 5.93 Path B: 2.77 - 5.35	67 Km/ hour	1.96 seconds	GT Palaran 2: 2,50 vehicles	MEET

* The data marked in red shows that the indicator does not meet the *Standar Pelayanan Minimal (SPM).*

The results of the evaluation of six national toll road corridors in Indonesia, namely Trans Sumatra, Trans Java, Jabodetabek, Non-Trans Java, Sulawesi, and Kalimantan, show that in general, the implementation of toll road services has met the SPM as stipulated in the Regulation of the Minister of PUPR Number 16/PRT/M/2014. Of the fourteen sections analyzed, ten sections have met all SPM indicators, while the other four sections have not fully met the set conditions. These inconsistencies are mainly found in the indicators of roughness and unevenness of the pavement. These findings show that the level of compliance with SPM on national toll roads is relatively high, although there are still certain technical aspects that require further attention.

Pavement roughness and unevenness are important indicators that are directly related to the safety and comfort of road users. Low pavement roughness can reduce frictional forces between vehicle tires and road surfaces, increasing braking distance and accident risk, especially on wet road surface conditions. Meanwhile, unevenness of the pavement not only reduces driving comfort, but also has the potential to accelerate pavement structural damage if not handled immediately. Therefore, a more optimal and sustainable road condition monitoring system is needed. In this context, the implementation of digital-based toll road governance is an important strategy to increase the effectiveness of infrastructure management. The data-driven monitoring system allows for more accurate detection of physical damage, increases the transparency of the evaluation process, and strengthens accountability in toll road maintenance activities. With the support of up-to-date and integrated data, potential technical failures on pavement can be anticipated early and prevented more comprehensively and sustainability (Ministry of Public Works, 2014; Makmur, 2021; Hermani et al., 2023; M. A. Setiawan et al., 2024).

The evaluation of the physical condition of the pavement in this study was carried out using two main indicators, namely the roughness and unevenness of the pavement. The results of the evaluation showed that the pavement on most of the toll road sections had met the set standards, which reflected the success of the BUJT in maintaining the safety aspect of users. However,

unevenness of the pavement is still found in some of the main parts of the toll road. These findings are in line with the results of research on the Pekanbaru–Dumai section which states that the physical quality of the road is the most sensitive factor in influencing users' perception of driving comfort (Purboyo et al., 2024). The decline in pavement quality is generally triggered by the volume of heavy vehicles that exceed the planned capacity as well as delays in the implementation of structural maintenance, which ultimately accelerates pavement degradation and lowers the level of toll road services (Refiyanni & Silvia, 2019; Iskandar, 2018; Putra et al., 2023).

In more detail, non-compliance with SPM was found on several toll road sections. The Surabaya-Gresik and Ciawi-Sukabumi toll roads have not met the indicators of unevenness of the pavement. Meanwhile, on the Cikampek-Palimanan Toll Road and Ujung Pandang Toll Road Sections 1-3, due to the fact that periodic monitoring data has not been updated. The delay in updating the data caused the technical condition of the road section to not be verified according to applicable regulations so that it was administratively declared not to meet the SPM. These findings confirm that the achievement of minimum service standards is not only determined by physical conditions in the field, but also highly dependent on administrative discipline and consistency in updating monitoring data. This administrative aspect is an important factor in ensuring the accuracy and validity of evaluation results and supporting decision-making in the management and maintenance of toll roads.

The performance of toll road services is also reflected in the speed of vehicles. The results of the evaluation showed that the average travel speed was within the standard SPM limit, ranging from 60 to 97.5 km/h. The highest speed was recorded on the Sigli–Banda Aceh section, which indicates a good level of mobility, while the lower speed on the section with high traffic volume indicates the need for the implementation of more adaptive traffic management. Research on the Jagorawi section shows that the effectiveness of smooth traffic flow is greatly influenced by the ability to maintain the volume to capacity ratio (V/C ratio) at the optimal level (Fadhil et al., 2024). These findings strengthen the relationship between travel speed and user satisfaction levels, as shown on the Pemalang–Batang toll road, where the smooth flow of traffic is a top priority in user expectations (Prastiyo et al., 2024).

The accessibility aspect of toll roads includes the speed of transactions at toll gates and the length of vehicle queues. In general, the average transaction speed has been in line with the standard thanks to the implementation of an efficient electronic payment system, with the fastest duration of 1 second on the Sigli-Banda Aceh section and the longest duration of 2.6 seconds on the Surabaya-Gresik section. The number of vehicle queues is also still within the SPM threshold, with the shortest queue of 1 vehicle recorded on the Palembang-Indralaya, Cikampek-Palimanan, and Pondok Aren-Serpong sections, while the longest queue of 7 vehicles is on the Jakarta-Cikampek section. While there are variations in transaction times and queue counts across different segments, all performance remains within the standard limits. These findings are in line with research in the Greater Jakarta area which confirms that services at toll gates have a significant effect on the perception and satisfaction of road users (Desy Mei Dina & Amin, 2023). Success in maintaining accessibility standards is inseparable from optimizing toll gate capacity and implementing responsive and efficient transaction technology (Suhalis et al., 2018; M. A. Setiawan et al., 2024). The collaboration between the reliability of electronic payment systems and the effectiveness of operational management is the main factor in maintaining service quality and efficiency of toll road accessibility in a sustainable manner.

Overall, all toll road service indicators have been standardized in accordance with the provisions of SPM and their implementation can be considered to have gone well. However, unevenness of pavement is still a major obstacle that has the potential to reduce user comfort and trigger dissatisfaction, especially in the context of future toll tariff adjustment policies (Purboyo et al., 2024). This condition shows that even though technical standards have been met normatively, users' perception of service quality is greatly influenced by the functional performance of the pavement in the field. Therefore, pavement quality management cannot be done reactively, but

needs to be directed at the development of an accurate and sustainable predictive maintenance system.

In this context, the integration of adaptive traffic management technology with data analysis of road conditions is becoming increasingly relevant. The use of traffic data, vehicle loads, and the results of periodic monitoring of pavement and unevenness allows BUJT to carry out early detection of pavement quality degradation more precisely and based on actual data (Putra et al., 2023; Prastiyo et al., 2024). This approach not only improves the effectiveness of maintenance, but also reduces the potential for service interruptions due to unanticipated structural damage.

Furthermore, improving the quality of toll road services in Indonesia does not only depend on administrative compliance with SPM, but also on the ability to utilize technology in responding to traffic dynamics in real time. A data-driven management system ensures that operational decisions and maintenance actions are based on objective and measurable parameters so that the risk of technical failures can be minimized. Thus, the synergy between the quality of physical infrastructure and the digital-based toll road governance system is a strategic factor in ensuring the safety, comfort, and efficiency of toll road services in a sustainable manner (Ministry of Public Works, 2014; Makmur, 2021; Hermani et al., 2023; Subkhan et al., 2023; Refiyanni & Silvia, 2019).

Conclusion

Based on the results of the evaluation, it can be concluded that the implementation of toll road services in Indonesia in general has met the Standar Pelayanan Minimal (SPM) as stipulated in the Regulation of the Minister of Pekerjaan Umum dan Perumahan Rakyat (PUPR) Number 16/PRT/M/2014, especially in the indicators of average travel speed, transaction speed, and vehicle queue length at toll gates (Ministry of Public Works, 2014; Makmur, 2021; M. A. Setiawan et al., 2024). However, indicators of pavement and unevenness are still the main obstacles in the fulfillment of the SPM, which is reflected in non-compliance on the Surabaya-Gresik and Ciawi-Sukabumi sections due to unevenness of the pavement, as well as on the Cikampek-Palimanan section and the Ujung Pandang Toll Road Sections 1-3 which have not met the provisions due to the fact that periodic monitoring data has not been updated (Purboyo et al., 2024; Putra et al., 2023). The novelty of this study lies in the mapping of the level of SPM fulfillment between toll road corridors which shows that the decline in service performance is more influenced by operational factors and the load of vehicles over dimension over load (ODOL) on logistics routes compared to the quality of the initial construction (H. Setiawan et al., 2015; Kurniawan et al., 2020). The findings emphasize the importance of integrating information technology in predictive maintenance systems and adaptive traffic management to detect road surface degradation earlier so that road user safety and comfort aspects can be ensured in a sustainable manner (Refiyanni & Silvia, 2019; Prastiyo et al., 2024; Subkhan et al., 2023). However, this study still has limitations in the use of secondary data, so administrative discipline in updating operational data is a key factor for Badan Usaha Jalan Tol (BUJT) in supporting accurate, objective, and transparent decision-making (Hermani et al., 2023; M. A. Setiawan et al., 2024).

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