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REVIEW OF FINANCIAL PENALTIES IMPLEMENTATION ON NON-COMPLIANCE WITH ROAD PERFORMANCE INDICATORS

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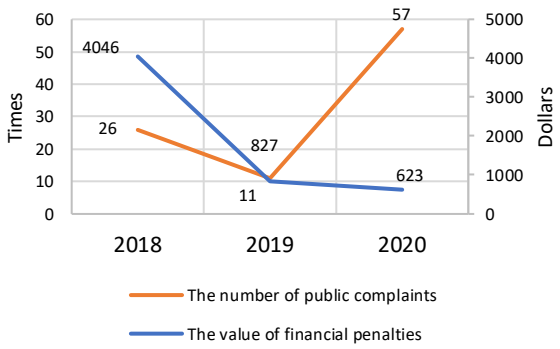
Graphical abstract



Abstract

Indonesia's national road preservation system, mainly routine road maintenance, was initially carried out independently by the project manager as a road section manager. This maintenance has been transformed into a "long segment" scheme since 2016. The contractor is subject to financial penalties in the form of withholding payments for each failure to meet the road performance indicators within the specified repair response times. The government, specifically the project manager, has not adequately applied the current financial penalties for late fulfillment of road performance indicators in Indonesia. The implementation of financial penalties that is not adequate is inversely proportional to the number of public complaints related to road performance, which represents the impact of road performance that does not meet the criteria. This study recommends developing a comprehensive policy for penalties related to the late fulfillment of road performance indicators. The policy should consider multiple indicators and components and adjust the coefficient of each component based on the severity of the condition. In addition, this study advises revising the formulation of financial penalties using relevant data, such as average daily traffic volume or public complaints.

Keywords: Construction project management, long segment scheme, road performance indicators, road preservation, financial penalties.

1.0 INTRODUCTION

In Indonesia, the national road preservation system, mainly routine road maintenance, which was previously carried out independently by each project manager as a road section manager, has been transformed into a "long segment" scheme since 2016. Through the Directorate of Road Preservation, the Indonesian Directorate General of Highways implements a long-segment policy for national road preservation that combines routine road and condition maintenance, preventive and holding work, with widening, rehabilitation, and reconstruction of several road sections into a single contract.

The long segment preserves a road within a single continuous segment length to achieve uniform road conditions, i.e., steady and standard roads along the segment. Based on the length of the road, the scope of road maintenance work is the most dominant treatment, so the forms of routine maintenance work are also the major work of the contract. As a result, each long segment project will be handled in various ways: road widening by adding lanes; road rehabilitation; routine road preservation; treatment of drainage, sidewalks, and road complementary structure; bridge duplication; bridge replacement; bridge preservation; and routine bridge preservation.

The implementation of the government's long segment preservation policy, led by the Ministry of Public Works and Public Housing, aims to promote the implementation of sustainable work preservation. To improve the effectiveness of road maintenance management, contractors must be able to invest in road preservation equipment and develop human resources (skilled

and professional personnel) and technology. The long segment scheme imposes a responsibility on contractors to maintain safe and functional roads. The long segment policy is expected to shift the contractor paradigm from sole executors of construction activities to road segment managers, placing contractors in greater accountability for road maintenance activities.

Figure 1 shows the annual data on surface conditions of Indonesia's national roads, which are classified into the good category. The data collected prior to 2016 was the outcome of policy implementation prior to the long segment, whereas the data collected after 2016 was obtained after the long segment was implemented. The state of a road segment can be determined based on the IRI value. IRI is the magnitude of the road surface's unevenness, derived from the cumulative length of the surface's ups and downs per unit length. IRI is the ratio of the cumulative length of damaged/potholed roads (in m units) to the total length of roads (in km units). Therefore, the road surface condition increases as the IRI value (in m/km) increases.

Figure 1 demonstrates that, despite the implementation of the long segment scheme (since 2016 until now), the condition of the national road surface categorized as good has decreased yearly. It is expected that the implementation of the long segment policy will improve road conditions, especially the condition of the road surface. This indicates that the use of the long segment must be reviewed, as indicated by the analysis results presented in this study.

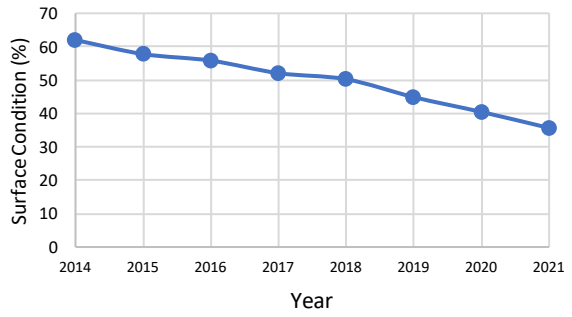


Figure 1 Surface condition of the national road of Indonesia with good category (2014-2021) [1]

The quality of road maintenance work performed over a long segment is one of the critical indicators of success in extending road pavement design life. Therefore, Division 10 of the Indonesian Directorate General of Highways states that contractors must comply with road service levels determined by road performance indicators [2]. The road service level is applied to all work products within the handling scope, including road pavement, road shoulders, drainage, road equipment, complementary structures, and weed control.

For each failure to meet the required road service level, the contractors must complete the necessary actions to correct the cause of the failure to meet the road performance indicators based on the specified repair response time. If, within the repair response time limit, the contractors have not been able to correct the cause of the failure to fulfill the road performance indicators. The contractor is subject to financial penalties for withholding payments due to late fulfillment at the road service level.

A road performance indicator is very influential in road maintenance handling policies. This study aims to evaluate the impact of Indonesian government policies in applying road performance indicators on road maintenance work handled by contractors. The results are expected to provide policymakers insight into formulating decisions on applying further penalties formula. In addition, researchers and academics that study government policies related to road preservation may develop and incorporate references to the findings of this study.

2.0 LITERATURE REVIEW AND METHOD

2.1 Road Preservation

Road preservation is a proactive effort to keep existing roads in good condition. According to Galehouse et al. [3], road preservation encompasses all activities necessary to provide and maintain road services, including corrective maintenance, preventive maintenance, and minor rehabilitation, but not new road construction, reconstruction, or significant rehabilitation with cost-effective treatment to slow down the deterioration (without significantly increasing the structural capacity). According to Geiger [4] the road preservation program consists of preventive maintenance, minor/nonstructural rehabilitation, and other routine maintenance. A road preservation program with adequate funding will provide benefits, including improving pavement performance, ensuring the efficiency of several road handling budget allocations, extending the service life of road pavements, reducing travel delays, increasing passenger and goods mobility, and increasing safety. Wang [5] stated that preservation is a series of cost-effective activities during the early stages of pavement service life. Repairing the damage promptly can restore the pavement's optimum condition. The Indonesian government, specifically the Ministry of Public Works and Housing, implemented a long segment preservation work policy to ensure the long-term sustainability of preservation work. In Indonesia, the implementation of road preservation under the long segment concept is very recent. The capability of service providers plays a crucial role in the implementation of long segment system road maintenance activities. Service providers must be able to shift from the traditional role of construction executors to that of road segment managers. So that the effectiveness and efficiency of the implementation of long segment-based national road preservation can be measured and a more accurate and precise handling program can be implemented, an analysis is required to identify the problems and challenges that exist in the handling of road preservation with the still-relatively-new long segment system.

2.2 Road Performance Indicators in Indonesia and Other Countries

Several countries have implemented road performance indicators and response times that vary depending on the type of road damage and other components. For the type of pothole damage, there are variations in diameter and depth performance indicators as well as response time for handling, with New Zealand being the most responsive country for handling (response time of 48 hours). Table 1 summarizes many research articles on road performance indicators and response times for road service level fulfillment.

According to Table 1, there are several variations among components in terms of road performance indicators and

response times among countries. Road performance indicators in Indonesia do not include non-compliant patching, cleanliness on pavement and right-of-way (advertisements/banners, dirt/garbage, sand/soil, debris/other barriers, puddle), raveling, loose pavement edges, bleeding, lighting, and horizontal road marking. Furthermore, other countries have varied standards for the same component, particularly the dimension. This implies that road performance indicators and their criteria and response times for components in Indonesia must be evaluated.

Road performance indicators include any activities conducted to repair damage or maintain the condition of road sections to achieve the required road performance, such as road pavement, road shoulders, drainage systems, complementing structures, road equipment, and weed control [2]. The contractors must be responsible for the road performance maintenance works and immediately repair any damage that occurs according to the road performance indicators required during the contract period, as summarized in Table 1. According to the Indonesian Directorate General of Highways, the penalty for delaying each non-compliance with the road service level required in Table 1 must have taken the necessary measures to correct the cause of failure to comply with the road performance indicator based on the specified repair response time [2]. Suppose the contractors have not been able to resolve the cause of the non-compliance with the road performance indicators within the repair response time specified in Table 1. In that case, the contractors will be penalized by withholding payments for late fulfillment in the road service.

In 1996, the Ministry of Public Works of Uruguay implemented a performance-based maintenance contract for the country's national road network. As a result, Uruguay altered its road contracting process, and Montevideo City began its first performance-based contract for nearly 140 km. Montevideo established performance standards, response times, and penalties for non-compliance with service levels for roadway pavements, shoulders, and drainage systems. However, because the road condition at the start of the contract was significantly less than the performance standard specified in the contract, the contractors were given between 3-12 months to repair the assets to the required standards [6]. Other Latin American countries, including Brazil, Chile, Colombia, Ecuador, Guatemala, Mexico, and Peru, have also begun implementing or planning a performance-based approach [7].

According to Zietlow [6], most subcontractors engaged in performance-based contracting in Bolivia, Colombia, Ecuador, Honduras, and Nicaragua. The contract details maintenance work such as patching potholes, cracked seals, cleaning drainage pipes, and mowing weeds, as well as performance indicators for each activity. For instance, in the case of patching potholes, the subcontractor must notify the road manager of the pothole's presence and fill it with materials supplied by the road manager.

Table 1 Comparison of road service level fulfillment in many countries

Components	Indonesia [2]	Argentina [8]	World Bank-financed projects [9]	New Zealand [6]	European Bank [10]	British Columbia, Canada [11]
Pavement						
Potholes	Ø > 10 cm, depth > 4 cm = 7 days	Any pothole = 1 day	Ø > 300 mm, max 5 potholes Ø > 100 mm in any 1000 m) = 28 days	Highways > 10,000 vpd, Ø > 70 mm, max 3 potholes on any 10 km = 48 hours; All highways, Ø > 150 mm = 48 hours	Any pothole = 7 days	Any pothole = 3 days
Crack	Width > 3 mm, area > 5% per 100 m length = 14 days	Type 4 = 1 week	Any crack = 28 days		Width > 3 mm, length > 10 m = 7 days	
Deflection/ depression	Depth > 3 cm, area > 5% per 100 m length = 7 days			Depth > 30 mm = 6 months		
Patching			Non-compliant patches = 28 days		Non-compliant patches = 7 days	
Pavement Roughness	IRI > 4 mm = 28 days	IRI max = 3 (AC) IRI max = 3.5 (ST RC) = 1 week				
Rutting	Depth > 7 cm = 7 days	Depth > 1 cm = 1 week	Depth > 4 cm = 56 days	Depth > 30 mm = 6 months	Depth > 20 mm, length > 10 m = 20 days	
Raveling		Any raveling = 1 week	Any raveling = 28 days		None = 28 days	
Shoulder						
Loose pavement edges		Depth > 3 cm = 1 week	Any loose pavement edges = 28 days	Length > 2 m (within any km), width > 0.5 m) = 1 month	None = 20 days	
Pothole/ Defect	Ø > 20 cm, depth > 10 cm = 7 days	Any pothole = 1 week	Any pothole/defect = 28 days			Any pothole = 10 days
Elevation/ Altitude	Height difference with road pavement > 5 cm = 14 days		Height difference with road pavement > 5 cm by road = 56 days			

Components	Indonesia [2]	Argentina [8]	World Bank-financed projects [9]	New Zealand [6]	European Bank [10]	British Columbia, Canada [11]
Deflection/ depression	Depth > 10 cm, area > 3% per 100 m length = 7 days	Any deflection/depression = 1 week				
Clearance						
Cleanliness	Soil, debris, and other materials = 7 days	Any cleanliness condition = 1 day	Danger = 4 hours, no danger = 7 days			Obstructions = 3 days
Obstructions	Obstructions > 10% = 7 days	Any obstructions = 1 day		Obstructions > 10% = 1 week		Any obstructions = 3 days
Weeds/wild plants	Free from weeds height > 10 cm = 7 days	Height < 15 cm over 15 m = 1 week				
Complementary Buildings						
Vertical and Horizontal Signage	Not correctly installed, structurally weak, and bent = 21 days	Unwell maintained and invisible = 1 day				
Guardrail	Not durable, not properly installed, damage = 21 days	Poor condition = 1 week				

According to Regassa [7], Ontario City, Canada, used 95% lump sum performance-based contracts with terms ranging from 7-9 years. The contract covers all routine maintenance, such as pothole repair, vegetation management, bridge maintenance and cleaning, electrical work, and road marking. Performance criteria based on results and time are included in maintenance performance standards. Some studies suggested five components for defining a performance monitoring framework in Performance Based Maintenance Contracts, including the level of service effectiveness, response timeliness, safety procedures, service quality, and cost efficiency [12], [13], [14], [15]. To minimize uncertainty and risk disagreements, performance measurement must be clearly defined and objectively measurable [6], [16]. In addition, financial penalties may be applied if criteria are not met. Furthermore, the contract period's duration gradually grows, as does the maintenance activities [11].

Based on the response time comparison in Table 1, it is necessary to evaluate the addition of regulations for response time for undetermined road components in Indonesia, such as patching, raveling, and loose pavement edges. In addition, components in complementary buildings, such as vertical and horizontal signage and guardrails, must be re-evaluated for the response time that applies because there is a significant difference in response time compared to other countries' policies.

2.3 Road Service Level Fulfillment Response Time

The contractors must consider the traffic volume, pavement strength, road shoulders, drainage conditions, road signs, and the stability of retaining walls or other complementary structures during the contract period. The contractors must maintain and repair the damages caused by the road operation until the road performance indicators and the specified repair response time are met. The response time of the road performance indicators according to the Indonesian Directorate General of Highways [2], e.g., pothole with Ø > 10 cm and depth > 4 cm must be repaired within 7 days; crack with width > 3 mm, area > 5% per 100 m length must be repaired within 14 days; and other parameters as summarized in Table 1. Suppose maintenance or repair of work from damage can affect the performance of the work. In that case, it must be reworked or tested for the work's quality following the requirements' provisions. For example, the patching result will be bumpy if a pothole repair is not done correctly. This results in a new damage known as uneven patching that needs to be reworked.

2.4 Methodology

We compare the road performance, response times, and nominal financial penalties of several countries with those of Indonesia to determine the difference. The purpose of this study is to make recommendations on Indonesian policies that have been implemented thus far based on comparisons with policies from other countries. With these recommendations, road maintenance is anticipated to be more effective and efficient, as the policy of imposing financial penalties for non-compliance with road performance indicators has not been adequately implemented in most subregions within the research area.

This study uses qualitative research methods, which include literature studies and field research. This research's results and discussion include a review of qualitative research methods, literature studies, field studies, and a mix of the two. This study involves acquiring primary data through surveys and secondary data sources. The survey was done on 25 Commitment Making Officers across six work units by collecting information on implementing performance indicator penalties for late fulfillment in road service levels during 2017-2020. Furthermore, secondary data were collected on public complaints to the Central Java-Special Region of Yogyakarta National Road Implementation Organization [17]. In addition, statistics on traffic accidents in Central Java and Special Region of Yogyakarta were retrieved from secondary data collected by Statistics Indonesia [18], [19].

3.0 RESULTS AND DISCUSSION

3.1 Implementation of Financial Penalties on Non-Compliance with Road Performance Indicators

The long segment scheme for road preservation in Indonesia is still relatively new. As a result, contractors' capability is essential in implementing road maintenance activities in the long segment system. The contractors must transform from construction workers to road segment managers to implement a long segment scheme successfully. Thus, analysis of the problems and challenges inherent in handling road preservation using the long segment system is necessary to quantify the effectiveness of long segment-based road preservation and implement a more precise and accurate handling program.

The implementation depends on the project manager's concern about enforcing these penalties. For example, the implementation of financial penalties for failure to meet road performance indicators in the period 2017 to 2020 shows that there was no financial penalty implemented in 2017, and there are two project managers implemented it in 2018, 4 in 2019, and 2 in 2020 out of 22 project managers in the Central Java-Special Region of Yogyakarta National Road Implementation Organization.

Project managers implementing financial penalties for failure in fulfilling road performance indicators entirely in the Central Java Region III NRIWU (National Road Implementing Working Unit) and the other NRIWUs have not implemented financial penalties. In this case, this could be due to the accomplishment of road performance indicators on all road segments or the project manager's reluctance to implement financial penalties.

The project managers did not apply financial penalties due to non-compliance with road performance indicators in Indonesia adequately. This is because the financial penalties are too low, and the procedures are too complicated. The project managers in each NRIWU who implemented financial penalties for late fulfillment in road performance indicators during the 2017-2020 period only from Central Java Region III. Meanwhile, other regions, such as NRIWU from Central Java Region I, II, and Central Java Co-Administration Region, as well as NRIWU from two regions of Special Region of Yogyakarta, did not implement the financial penalties policy.

3.2 Comparison of Financial Penalties for Late Fulfillment in Road Maintenance Services

Silva and Liautaud [8] stated that performance indicators are maintained to a minimum and are easy to measure and evaluate. For example, rehabilitation works must achieve or beyond the minimum thickness of the overlay. During the contract duration, they must comply with the maximum roughness, rut depth, cracking, or raveling level. Regular monthly visual inspections of routine maintenance focus on a few essential items to ensure compliance with requirements: no visible potholes or unsealed cracks, no intense rutting, and decent condition maintained on shoulders, drainage, guardrails, vertical and horizontal signage, and the roadside environment. Penalties for non-compliance are set and implemented for each item in terms of preventing the contractor from failing to meet the road service level, e.g., if a pothole is not patched within the specified response time, the contractors will be penalized around 1,000 USD per day until it is repaired (see Table 2). The total financial penalty fee is charged from the monthly payments.

According to Asian Development Bank [20], non-compliance with performance levels reduces payment. Previously, the term "penalties" was used, but it may be unenforceable in the standard law system. This resulted in the implementation of term payment reductions. Failure to meet each performance level results in a specified payment reduction, e.g., if a report is not completed on time, the average roughness of a road segment exceeds the specified level, or a pothole exceeds the maximum diameter. Payment reductions are a monetary amount or a percentage of the monthly lump sum per kilometer. Payment reductions are commonly made when the project manager identifies non-compliance. Additional payments are implemented if the damage is not immediately repaired within a specific time limit. Reductions in payments may increase if response times are repeatedly not met. An example of the application of reduced payments is presented in Table 3.

Table 2 Penalties for failed fulfillment in meeting road performance criteria in Argentina [8]

Parameter	Road Performance Criteria	In USD
Rehabilitation		
Pavement Roughness	IRI max = 3 (Asphalt Concrete/AC); IRI max = 3.5 (Surface Treatment/ST or Reinforced Concrete/RC)	600/week/km
Pavement Rut Depth	1 cm maximum	1,200/week/km
Pavement Edge Drop	0 cm	1,200/week/sector
Pothole diameter > 2.5 cm	100% patched	1,200/pothole/day
Cracking	100% sealed and < 15% type 2 or 4	600/week/km
Concrete pavement joint cracks	100% sealed	600/week/km
Raveling	0% and < 2% if the surface treatment	600/week/km
Routine Maintenance		
Edge Drop	Maximum 3 cm	1,200/week/sector
Cracking	100% sealed up to type 4	600/week/km
Pothole	100% patched	1,200/pothole/km
Raveling	100% patched	600/week/km
Paved shoulders	Pothole/raveling = 0; Edge drop = 0; Rutting < 12 mm; Crack sealed up to type 4.	1,200/week/km
Unpaved shoulders	No erosion, no rut, good transversal slope; edge drop < 2 cm; width ≥ 3 m.	1,200/week/km
Bush/weeds/plant clearing	Bush height < 15 cm over 15 m.	150/ha/week

Parameter	Road Performance Criteria	In USD
Culvert/drains/bridge cleaning	Clean/unobstructed	600/day/km
Cleaning of right-of-way	No debris; maintain green areas	600/day/km
Vertical signs	Well-maintained, visible day and night	150/day/sign
Lighting	Well maintained	150/day/light
Horizontal Marking	Well-maintained, visible day and night	300/day/line/km
Guardrails	In good condition	1,200/week/location

Table 3 Penalties for failed fulfillment in meeting road performance criteria in CAREC countries* [20]

Criteria	Performance level	Payment reduction on first inspection (% of monthly lump sum/km)	Payment reduction on follow-up inspections (% of monthly lump sum/km)
Potholes on carriageways	Pothole must not be wider than 10 cm from any direction	5% for every 1 km of road that contains the potholes	15% for every 1 km section until the potholes are patched
Rutting	Rut depth should not be > 20 mm for a length of 3 m in any 100 m section	10% on every 100 m that does not meet the criteria	20% on every 100 m section until the rutting is repaired
Vertical signage	One or more traffic signs are missing, damaged, illegible, misplaced, or malfunctioning	5%	10% until the sign is repaired or replaced
Vegetation	The maximum height measured anywhere in a 100 m segment is above the threshold value	5% for every 100 m section	10% for every 100 m section until the vegetation is trimmed to the allowable height

*CAREC countries: Afghanistan, Azerbaijan, China, Georgia, Kazakhstan, Kyrgyz Republic, Mongolia, Pakistan, Tajikistan, Turkmenistan, and Uzbekistan.

Meanwhile, the implementation of financial penalties for late fulfillment in road service levels in Indonesia is as follows: if the length of the road in the scope of routine maintenance is 68.27 km and the value of the scope of routine maintenance is 1,141,971.60 USD, then the value of the financial penalties for three days of late patching (a total of 2 potholes at locations within one segment or 100 m), can be calculated according to Eq. (1) as follows:

$$D = 0.01 \times H \times \frac{Pjc}{Pjl} \times Nlp \quad (1)$$

where:

D = Amount of withholding payment
H = Number of days of late fulfillment in the repair of road service level
P_{jc} = Length of the defective road (does not meet performance indicators) in the specified road segment (segment length of at least 100 m)
P_{jl} = Length of road in the contract based on the scope of work
N_{lp} = Value of scope of work in contract

$$D = 0.01 \times 3 \times \frac{100}{68{,}270} \times 1{,}141{,}971.60\ USD = 50.182\ USD$$

where H = 3 days; P_{jc} = 100 m; P_{jl} = 68,270 m; N_{lp} = 1,141,971.60 USD. Exchange rate of 10,000 IDR = 0.700 USD [21].

Comparison of the application of financial penalties for two potholes in one segment (100 m) with a late of 3 days for various countries can be seen in Table 4. According to Table 4, the value of financial penalties applied in Indonesia is the lowest compared to other countries. According to Eq. (1), the coefficient for all components of the road performance indicator is the same (0.01), even though the impact of each damage to the road performance indicator is varied. Additionally, the value of the scope of work in a contract (N_{lp}) is inappropriate.

According to Asian Development Bank [20], the value of financial penalties should be high enough to give the contractor sufficient incentive to comply. If the financial penalties are too low, contractors tend to be less compliant; if they are too high, contractors may apply a risk premium on their tender price. Therefore, it is necessary to determine appropriate financial penalties for road performance indicators in Indonesia for each instance of non-compliance.

Table 4 Comparison of the implementation of financial penalties for late fulfillment in road service levels

Criteria	Indonesia [2]	Argentina [8]	CAREC countries [20]
2 potholes, 1 segment (100 m), 3 days late	50.182 USD	1,200 USD x 3 days x 2 potholes = 7,200 USD	Subtraction 5% per km = 5% x (1 km/68,27 km) x 1,141,971.60 USD = 836.36 USD

3.3 Public Complaints to Road Performance

The inadequate implementation of financial penalties is inversely proportional to the number of public complaints related to road performance, as shown in Figure 2. As stated in the previous subsection, the data presented here is only from Central Java Region III NRIWU. This is because only the project managers from this region implemented financial penalties for late fulfillment of road performance indicators during 2017-2020. Public complaints were submitted through various media, including social media of Central Java-Special Region of Yogyakarta National Road Implementation Organization (*Instagram*, *Facebook*, and *Twitter*), letters, e-mail, *www.lapor.go.id*, Directorate General of Highways Command Center, and other media (*Whatsapp*, *LaporGub*, and others).

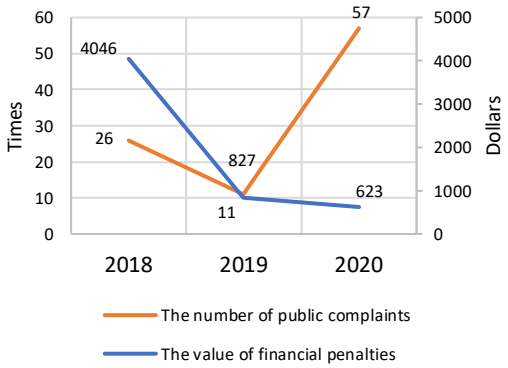


Figure 2 Relationship between public complaints and financial penalties for late fulfillment of road performance indicators in Central Java Region III NRIWU [17]

The analysis indicates a strong negative correlation between penalties collected and the number of complaints (-0.9083). This means that as penalties collected increased, the complaints decreased and vice versa. However, the data from 2019 does not support this conclusion. While there appears to be an inverse relationship between the two variables in 2018 and 2020, this is not the case for 2019.

The slope of the regression line is -0.032, indicating that as penalties collected increase by one unit, the expected decrease in the number of complaints is 0.032 units. However, the small number of data points and an outlier in the 2019 data may affect the accuracy of this estimate. The R-squared value for the data is 0.4796, which suggests a moderate positive linear relationship between the number of complaints and penalties collected. This value implies that the variation in penalties collected can explain 47.96% of the variation in the number of complaints.

The high frequency of complaints indicates that the road performance in the long segment scheme is inadequate, so an analysis of proper response time is needed to lower public complaints. In addition, the appropriate formulation of financial penalties is required so that the contractors do not disregard routine maintenance work.

Krug et al. [22] and Deme [23] stated that road traffic accidents are generally caused by three main things: humans, the environment, and vehicles. The surface of the road pavement is one of the environmental conditions contributing to road traffic accidents. Traffic accident data in the Central Java Province and Special Region of Yogyakarta can be seen in Table 5. Burningham and Stankevich [24] stated that timely road maintenance is essential because if the road is in poor condition, every dollar not spent on road maintenance costs the following:

a. 4-5 USD in additional vehicle operating costs, lost travel time, and more severe accidents for road users;
b. 6-18 USD for road reconstruction and rehabilitation costs to road operators.

Table 5 Traffic accident data in Central Java Province and Special Region of Yogyakarta (2021)

Province	Number of Accident	Victim			Material Loss (USD)
		Death	Severe Wound	Minor Wound	
Central Java	22,521	3,750	77	25,847	1,178,550.45
Special Region of Yogyakarta	5,350	452	6	6,390	167,558.09

Source: [18], [19] (Exchange rate of 10,000 IDR = 0.700 USD [21])

According to Parsa [25] and Chan et al. [26], an increase in traffic volume or Average Annual Daily Traffic (AADT) with a higher IRI value leads to an increase in accident frequency. Several variables of pavement surface conditions cause road traffic accidents. However, the most common causes of road traffic accidents are pavement friction (skid resistance), roughness (ride quality), and rutting [27]. Therefore, accident costs or material losses caused by the condition of this road pavement should be considered in determining the formula/model for financial penalties for late fulfillment in road service levels. In addition, this study suggests new policy development considering traffic volume (vehicles/day), public complaints, and accident costs or material losses caused by accidents to be included in formulating financial penalties.

3.4 Recommendations for New Policy Development

The current implementation of financial penalties for late fulfillment in meeting road performance indicators shows some drawbacks. One is imprecise road performance indicators, including pavement, shoulders, drainage, road equipment, complementary structures, and clearance.

The coefficient (0.01) should be evaluated and revised based on each component of road performance indicators. It is essential to develop a new mathematical model. This model should provide a comprehensive framework for understanding the correlation between different variables intuitively and straightforwardly, based on the concept that mathematical formulas represent a physical representation of mathematical concepts.

To ensure the validity and reliability of the model, tests should be conducted on several road sections in Central Java and Yogyakarta Special Region. The insights gained from these tests can help identify the nature and extent of errors that may arise when using the formula. Based on the results of the tests, a new formula can be derived for calculating penalties for late fulfillment of road service levels. This will provide a more accurate and effective means of incentivizing contractors to meet their contractual obligations.

4.0 CONCLUSION

The government, particularly the project manager, has not adequately applied the current financial penalties for late fulfillment of road performance indicators in Indonesia. The value of penalties applied in Indonesia is deficient compared to those applied in several other countries (< 6%). The application of financial penalties for late fulfillment in road service levels

implemented in Indonesia, according to Eq. (1), is only based on the number of days of late fulfillment in repairing road service levels, the length of roads that do not meet the performance indicators, and the value of the scope of work in the contract. The implementation of financial penalties in Indonesia has weaknesses in its implementation in terms of various indicators:

a. imprecise road performance indicators (road pavement, road shoulders, drainage, road equipment, complementary structures, and clearance) as well as their criteria;
b. inappropriate response times;
c. the value of financial penalties is too low so that the fulfillment of road performance indicators tends to be ignored, both by the government and contractors;
d. the coefficient for each component of the road performance indicator is the same (0.01); although the impact of each damage to a road performance indicator is undoubtedly varied;
e. the value of the scope of work in a contract (N_{lp}) is considered not appropriate;
f. non-compliant patching, cleanliness on pavement and right-of-way (advertisements, dirt/garbage, sand/soil, debris/other barriers, and puddle), raveling, loose pavement edges, bleeding, lighting, and horizontal road marking have not been taken into account in road performance indicators;
g. the length of the road that does not meet the road performance indicators per 100 m requires evaluation;
h. several variables were not considered in determining the formula, such as traffic volume (vehicles/day) and public complaints;
i. the government, particularly the project manager, has not entirely implemented the policy of financial penalties for late fulfillment of road performance indicators;
j. the policy has not considered accident costs or material losses caused by the condition of road pavement in the formula for financial penalties for late fulfillment in road service levels.

The review of financial penalties' implementation on non-compliance with road performance indicators in Indonesia indicates inadequate implementation. A new policy formulation related to road performance indicators and the components involved in determining the penalties for late fulfillment in road performance indicators is required. Field data show that the payment of financial penalties remains low while the number of public complaints is rising. In addition, the value of the accidental losses exceeds the financial penalties incurred by the project manager responsible for road preservation.

Separate research, such as with Structural Equation Modeling (SEM), is necessary to formulate methods for determining financial penalties. The use of SEM to test and assess multivariate causal linkages is becoming more prevalent in scientific research. In addition, formula development must be based on field testing to determine the efficacy of its use before existing formulas can be revised.

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