



Unsignalized Intersection Performance Analysis (Case Study: Three-Gate Intersection 3 Project Area in RDMP RU V Balikpapan)

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ABSTRACT

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The project area in RDMP RU V Balikpapan includes a T-junction at Gate 3, which is an un-signalized intersection frequently experiencing traffic congestion due to project worker activities and area traffic. This congestion reduces vehicle speeds and impacts road performance, especially at the un-signalized intersection on Yos Sudarso Street, Gate 3. This study aims to identify congestion causes and assess the level of service (LOS) at this T-junction within the RDMP RU V Balikpapan area. Data analysis and intersection performance calculations follow the Indonesian Road Capacity Guidelines (PKJI 2014). Observational surveys were conducted over three days: Saturday (October 26, 2024), Monday (October 28, 2024), and Tuesday (October 29, 2024), with data collected every 15 minutes over 12 hours. Results show the highest peak flow occurred on Monday, October 28, 2024, during the evening peak hour (17:30–17:45), with a traffic volume of 1,354.9 passenger car units (PCU) per hour. The capacity (c) of the un-signalized T-junction at Gate 3 is 2,637.5 PCU per hour, with a Degree of Saturation (DS) of 0.5. This corresponds to LOS category C, indicating stable but not free-flowing traffic. The intersection delay (DT) averages 5.8 seconds per vehicle. Queue probability is low, with an upper bound at 0.247% and a lower bound at 0.0065%, indicating manageable congestion levels at this intersection.

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INTRODUCTION

The implementation of the Refinery Development & Master Plan (RDMP) RU-V Balikpapan requires strong synergy among interdependent activities within a predetermined timeframe. In this context, the allocation of resources such as labor, materials, equipment, and financing must be managed to support the sequence of construction activities (scheduling) without causing conflicts between tasks. According to Hasselsteen (2024), effective resource management in modern construction sites requires continuous monitoring and adjustment of labor and material allocation to maintain efficiency. Similarly, Aguda (2025) emphasizes that proper scheduling and optimization of resources in sustainable projects are essential to minimize delays and cost overruns. In complex projects such as the RDMP, the use of resource leveling techniques is highly important to avoid resource overload during certain periods, as efficiency in utilization can mitigate project failure risks (Damcı et al., 2022). Moreover, modern technologies such as IoT have been shown to enhance accuracy in resource allocation through real-time monitoring, significantly improving construction resource management efficiency (Althoey et al., 2024). At the

strategic planning level, Fransco and Siallagan (2024) applied the Kepner-Tregoe and Analytical Hierarchy Process (AHP) approaches to determine corrective action priorities and mitigation strategies, ensuring project consistency with RDMP objectives.

The project area within the RDMP RU V Balikpapan includes an intersection, namely a three-way intersection at Gate 3. This unsignalized intersection frequently experiences congestion due to the activities of project workers and traffic in the area (Krisnadhi & Pratama, 2020). In addition to the increased number of vehicles caused by project-related vehicles such as six- and ten-wheeled dump trucks, crane trucks, open-backed project vehicles, and passenger cars passing through, another cause of congestion is side obstacles (Utomo et al., 2019; Fitri & Hidayat, 2021). The resulting congestion decreases vehicle speeds and adversely impacts road service performance (Pradana & Santosa, 2022), particularly at the unsignalized intersection of Jalan Yos Sudarso, Simpang Tiga Pintu 3. Previous studies indicate that unsignalized intersections with high side friction generate significant delays and lower capacity (Rahman et al., 2018; Dewanti et al., 2021). Moreover, the interaction between heavy construction vehicles and urban traffic has been shown to exacerbate congestion and safety risks in project areas (Sutanto et al., 2020).

Side barriers can be defined as the interaction between traffic flow and roadside activities related to land use along the road (Baldauf, 2017; Mehrara Molan & Ksaibati, 2021; Srivastava & Kumar, 2023). Side barriers include pedestrians, public transportation, stopped vehicles, vehicles parked on the roadway, slow-moving vehicles, and vehicles entering or exiting the roadside. These side barriers affect road service performance, including reducing the speed of vehicles passing through the roadway (Zou & Tarko, 2016).

Furthermore, there are several additional causes of congestion, including construction vehicles and side barriers such as vehicles parked on the shoulder at 45-degree and 180-degree angles, slow-moving vehicles crossing the roadside or traveling along the road, and vendor activity on the roadway, all of which reduce the level of road service.

Previous studies have examined factors affecting the performance of unsignalized intersections. For example, Pande et al. (2020) demonstrated that interactions between construction vehicles and general traffic can reduce vehicle speeds and lower the level of service (LOS) at unsignalized intersections; however, their study was limited to small-scale construction vehicles and did not consider the impact of side barriers such as vendor activity or parked vehicles on the roadside. Similarly, Rahman et al. (2021) emphasized the importance of analyzing side barriers on road performance in industrial areas, yet their research focused primarily on arterial roads and did not examine three-way intersections within large-scale construction project areas with heavy vehicles such as dump trucks and cranes.

Based on the description above, the researcher is interested in conducting a research study analyzing the performance of the unsignalized three-way intersection at Gate 3 in the project area of the RDMP RU V Balikpapan.

The purpose of this research study is to identify the factors causing congestion and to assess the level of service at the three-way intersection at Gate 3 in the project area of the RDMP RU V Balikpapan. The results of this research are expected to provide practical recommendations for traffic management and infrastructure planning, aiming to identify congestion factors and improve the level of service at the Gate 3 intersection, as well as to

provide useful insights for project managers and authorities to enhance traffic efficiency and vehicle safety within the project area.

METHOD

The research in this study was carried out through several stages. Initially, a traffic survey form was prepared to ensure that all relevant data could be systematically recorded. The researchers then familiarized themselves with the survey location and conducted preliminary fieldwork to understand traffic conditions and potential obstacles. Data collection was performed in 15-minute intervals over a 12-hour period, divided into morning (6:00 AM to 10:00 AM), afternoon (11:00 AM to 2:00 PM), and evening (2:00 PM to 6:00 PM), and was conducted across three separate days: Saturday, October 26, 2024; Monday, October 28, 2024; and Tuesday, October 29, 2024. The number of surveyors required was determined to ensure accurate and comprehensive data collection. Following data acquisition, analysis was conducted using methods aligned with the objectives of this study. All calculations and the determination of alternative planning requirements were performed based on the Indonesian Road Capacity Guidelines (PKJI 2014) issued by the Directorate General of Highways.

RESULTS AND DISCUSSION

This research was conducted at the unsignalized intersection at Gate 3 in the project area of the Balikpapan RU V RDMP, located at Jl. Yos Sudarso, Mekar Sari, Balikpapan Tengah District, Balikpapan City, East Kalimantan. The field survey results revealed geometric conditions for the western, northern, and southern sections of the road, each with a road width of 10 m, an approach width of 10 m, road markings, a shoulder width of 2 m, and no median.

Table 1. Population of Balikpapan City in 2023

Subdistrict	Population in 2023 (People)
Balikpapan Selatan	102.959
Balikpapan Kota	97.821
Balikpapan Timur	188.605
Balikpapan Utara	105.749
Balikpapan Tengah	158.320
Balikpapan Barat	85.078
Jumlah Penduduk Kota Balikpapan	738.532

Source: Balikpapan City Central Statistics Agency, 2024

Data Processing Analysis

1. Saturday (October 26, 2024)
 - a. Morning peak hour 9:00-9:15 with a traffic volume of 1,017.2 pcu/hour
 - b. Afternoon peak hour 1:00-1:15 with a traffic volume of 1,172.6 pcu/hour
 - c. Afternoon peak hour 5:30-5:45 with a traffic volume of 1,199.1 pcu/hour
2. Monday (October 28, 2024)
 - a. Morning peak hour 7:15-7:30 with a traffic volume of 1,146.9 pcu/hour
 - b. Afternoon peak hour 1:00-1:15 with a traffic volume of 1,306.6 pcu/hour

- c. Evening peak hour is 5:30-5:45 PM with a traffic volume of 1,354.9 pcu/hour
3. Tuesday (October 29, 2024)

- a. Morning peak hour is 7:45-8:00 AM with a traffic volume of 942.2 pcu/hour
- b. Afternoon peak hour is 1:00-1:15 PM with a traffic volume of 993.2 pcu/hour
- c. Evening peak hour is 5:30-5:45 PM with a traffic volume of 1,203.1 pcu/hour

Based on the analysis of peak hour traffic data, the highest peak hour traffic volume was on Monday (October 28, 2024) during the afternoon peak hour of 5:00-5:45 PM with a traffic volume of 1,354.9 pcu/hour.

Capacity analysis of unsignalized intersections

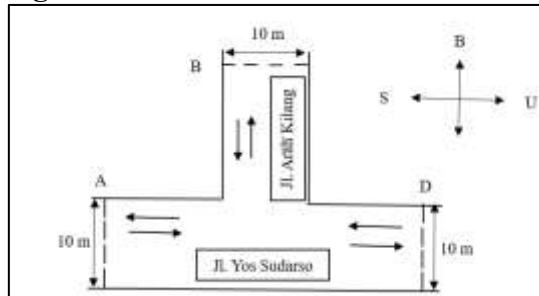


Figure 1. Number of lanes and width of approach road.

Table 2. Approach direction factors.

Basic capacity (smp/hour)	C _o	2700
Average approach width	FW	1,2
Main road median width	FM	1
City Size	FCS	0,94
Side Obstacles	FRSU	0,93
Turn left	FLT	1,2
Turn right	FRT	0,8
FMI/FMA ratio	FMI	0,97
Capacity (smp/hour)	C	2637,5

Source: Calculation Results, 2024

Table 3. Approach Delay

Traffic flow (smp/hour)	Q	1354,9
Degree of saturation	DS	0,5
Intersection traffic delays	DT	5,8
Main road traffic delays	DT _{MA}	4,4
Minor road traffic delays	DT _{MI}	9,9
Geometric delay of intersection	DG	5
Intersection delay	D	10,8
QP% Queue Chance upper limit	BA	0,247
QP% Queue Chance lower bound	BB	0,0065

Source: Calculation Results, 2024

Congestion Factors

Based on observations at the research site, several factors contribute to congestion at the unsignalized intersection at Gate 3 in the project area of the RDMP RU V Balikpapan. According to the Highway Capacity Manual (HCM, 2010), congestion at unsignalized intersections is often caused by interruptions in traffic flow, which can arise from conflicts between entering, exiting, and through vehicles, as well as by roadside activities. In this study, the first identified factor is the misuse of the road surface for commercial activities, such as roadside vendors. These activities reduce the effective width of the roadway, forcing vehicles to slow down or maneuver around obstacles, which is consistent with the findings of Rahman et al. (2019), who demonstrated that informal roadside activities can reduce the capacity of urban intersections by up to 30%.

Second, the misuse of the road surface for vehicle parking exacerbates congestion. Parked vehicles block traffic lanes and create bottlenecks, particularly affecting larger vehicles such as trucks that require wider turning radii. Similar results were reported by Suryanto & Prasetyo (2021) in a study of industrial area intersections, where illegal roadside parking increased travel time and decreased intersection efficiency.

Third, the boarding and alighting of project workers from public transportation create intermittent interruptions, which interfere with traffic continuity. HCM (2010) identifies such stochastic interruptions as a common cause of capacity reduction at unsignalized intersections.

Fourth, the entry and exit of large vehicles, including dump trucks, trailers, and cranes, introduce speed variability and occupy more road space, producing temporary bottlenecks. This aligns with Fitriani et al. (2020), who found that industrial transport vehicles significantly impact traffic flow, particularly in areas with mixed vehicle types.

Finally, uncoordinated crossing movements between project vehicles and main road traffic lead to additional delays, highlighting the need for systematic traffic management. This factor is consistent with the theory of traffic conflict analysis, which posits that intersections experience reduced service levels when vehicle paths intersect without control mechanisms (Papacostas & Prevedouros, 2001).

Addressing the Causes of Congestion

To mitigate congestion, several strategies can be implemented. First, enforcement against illegal roadside parking by security personnel can increase effective lane width, allowing smoother vehicle movement. This approach is supported by Rahman et al. (2019), who recommended strict regulation of roadside activities to improve intersection capacity.

Second, management of roadside vendors through area sterilization or relocation prevents obstruction of the roadway. This method not only improves traffic flow but also enhances pedestrian and vehicular safety. Research by Suryanto & Prasetyo (2021) suggests that regulated vendor zones near industrial sites reduce congestion by minimizing conflict points.

Third, the use of flagmen to regulate the entry and exit of large project vehicles ensures that these vehicles merge with the main traffic flow in a coordinated manner. This strategy is supported by Papacostas & Prevedouros (2001), who argue that human traffic control at critical points can reduce delays and improve intersection service levels, particularly when vehicle sizes and speeds vary widely.

This research fills a gap in the previous studies by directly observing a project-related unsignalized intersection in an industrial construction zone in Indonesia, which has not been extensively analyzed. While Rahman et al. (2019) and Suryanto & Prasetyo (2021) focused on urban intersections, this study contributes by evaluating mixed traffic conditions,

including heavy construction vehicles, public transportation, and roadside activities, providing practical recommendations for traffic management in large-scale project areas.

CONCLUSION

Based on the data analysis and survey results, the highest peak flow at the unsignalized intersection Gate 3 in the RDMP RU V Balikpapan project area occurred on Monday, October 28, 2024, during the 17:30–17:45 peak hour, with a traffic volume of 1,354.9 smp/hour. The intersection's capacity is 2,637.5 smp/hour, and the Degree of Saturation (DS) value of 0.5 corresponds to Level of Service C, indicating stable traffic flow but with some control over vehicle speed and movement, limiting driver speed choices. The average intersection delay is 5.8 seconds per smp, with queue probabilities ranging from 0.0065% to 0.247%, suggesting manageable congestion. Future research could explore the impact of dynamic traffic management strategies or the effect of side barriers and heavy vehicle interactions on the intersection's performance to further improve traffic flow and safety.

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