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Research article

Evaluation of Road Performance under the Influence of Volunteer Traffic Regulators (Supeltas): A Case Study in Pekanbaru

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Abstract: Traffic congestion remains a major challenge in Indonesian cities, where limited enforcement capacity has led to the emergence of Volunteer Traffic Regulators (*Supeltas*) as community-based traffic managers. This study evaluates the impact of Supeltas on traffic performance at a U-turn on Jl. Soekarno Hatta, Pekanbaru City. A mixed-method approach combining qualitative observation and quantitative road performance analysis was employed, following the Indonesian Road Capacity Guidelines (PKJI) and U-turn Planning Guidelines (PPPB). Traffic data were collected over two weeks under conditions with and without Supeltas. The results show that Supeltas increase vehicle volume at the U-turn (from 2,131 to 2,168 pcu/hour) but also reduce average speed (from 42 km/h to 37 km/h) and raise the degree of saturation from 0.36 to 0.49, shifting the Level of Service from B to C. These findings indicate that while Supeltas help manage driver behavior and encourage U-turn utilization, their presence also contributes to higher congestion levels due to inconsistent manual signaling. Improved Supeltas training and dedicated U-turn lanes are recommended to enhance operational efficiency and safety.

Keywords: supeltas, traffic congestion, U-turn, traffic performance, volunteer traffic regulators, Pekanbaru

1. Introduction

Urban traffic congestion has become a pressing issue worldwide, particularly in rapidly growing cities of developing countries. Increased motorization, limited infrastructure expansion, and inadequate enforcement contribute to chronic delays, higher fuel consumption, and environmental impacts. In Southeast Asia, these challenges are further complicated by mixed traffic conditions and informal transport practices [1]. Addressing congestion requires innovative solutions beyond conventional government-led measures.

In Indonesia, traffic congestion is especially severe in mid-sized and large cities, where the number of motor vehicles grows by approximately 5–6% annually, while road infrastructure expands by less than 1% per year [2]. Pekanbaru, the capital of Riau Province, exemplifies this imbalance. As a major commercial hub, the city experiences heavy traffic volumes on arterial corridors such as Jl. Soekarno Hatta. Critical bottlenecks occur at U-turns, where conflicts between through-traffic and turning vehicles reduce overall road performance, a problem well-documented in regional studies [3], [4].

To address shortages in official traffic police, communities have introduced Volunteer Traffic Regulators (Supeltas). These informal actors guide vehicles at intersections and U-turns. Their presence may improve compliance and perceived safety, yet their lack of standardized training raises concerns about efficiency and consistency [5], [6]. Despite being widespread across Indonesian cities, few empirical studies evaluate the measurable impact of Supeltas on road performance using standard traffic engineering indicators.

This study seeks to analyze the influence of Supeltas on vehicle volume, speed, congestion, and delay at a U-turn in Pekanbaru City. By combining qualitative observations with quantitative indicators (capacity, degree of saturation, travel speed, and level of service), the research aims to determine whether Supeltas contribute positively or negatively to traffic conditions. Findings are expected to provide evidence-based recommendations for traffic management policies and for improving the integration of community-based traffic regulation into formal systems.

2. Literature Review

Congestion in urban networks often arises from poorly designed intersections and U-turns. Studies in Bandar Lampung and Manado show that U-turn spacing and road geometry significantly affect road performance [7], [8]. International research confirms this, highlighting turning maneuvers as major contributors to delays [9], [10].

In Southeast Asia, U-turn bottlenecks are particularly problematic in mixed traffic conditions. A study in Phnom Penh quantified delays at uncontrolled U-turns [3], while another study simulated median U-turn designs to enhance road service levels [11]. Similar analyses of U-turn capacity at midblock medians and under modified geometric conditions emphasize that turning movements can drastically reduce capacity [4], [12]. A recent systematic review further underlines U-turns as high-risk maneuvers, with implications for both safety and congestion [13].

Research on Supeltas is limited but growing. Author in [6] found mixed outcomes in Makassar, where Supeltas sometimes improved flow but also introduced irregular delays due to inconsistent signaling. In Yogyakarta, a study demonstrated that volunteer regulators significantly influenced waiting times at unsignalized intersections, though efficiency varied with traffic volume [14]. Author in [5] reported that Supeltas in Kartasura enhanced safety perception among drivers, suggesting their value extends beyond capacity measures. However, reliance on informal actors raises governance questions. Without standardized training, Supeltas' interventions may conflict with official regulations. Comparative studies across Southeast Asia indicate that informal traffic management mechanisms, while filling gaps in enforcement, must be integrated into broader policy frameworks to be effective [1].

Driver behavior in heterogeneous traffic systems also influences the impact of U-turns and Supeltas. Recent models demonstrate how gap acceptance and driver interactions under mixed traffic conditions shape congestion outcomes [15]. Such findings suggest that the effectiveness of Supeltas cannot be understood in isolation but must be contextualized within broader behavioral dynamics.

Taken together, the literature highlights two key gaps. First, while U-turns and informal traffic management are widely recognized as critical to congestion, systematic evaluations of Supeltas using traffic engineering methods remain rare. Second, existing studies often focus on qualitative perceptions rather than quantitative performance metrics. This study contributes by providing a case analysis from Pekanbaru City, assessing Supeltas' impact on both flow and delay.

3. Methods

This study adopted a mixed-method approach, combining qualitative descriptive observations with quantitative traffic performance analysis. The qualitative component was used to describe the role and behavior of Supeltas in guiding traffic, while the quantitative component assessed measurable impacts on traffic flow, speed, and congestion.

3.1. Study Location and Period

The case study was conducted at the U-turn on Jl. Soekarno Hatta, Pekanbaru City, in front of Jasmine Residence, a corridor characterized by mixed residential and commercial activity. Observations were carried out over two consecutive weeks in August 2024. Supeltas were present on August 12, 13, 17, and 18, while observations without Supeltas were made on August 19, 20, 24, and 25.

3.2. Data Collection

Traffic data were collected through direct field observations. For each observation day, measurements were taken during three peak periods (morning, midday, and evening) to capture daily variation. The following variables were recorded:

- Traffic Volume: classified as light vehicles (LV), heavy vehicles (HV), and motorcycles (MC), converted into passenger car units (PCU) using standard equivalency factors.
- Vehicle Speed: measured over a 50-meter section using a stopwatch. To reduce error, two observers independently recorded times, and the average was used.
- Delay Time: defined as additional travel time at the U-turn compared to free-flow conditions. U-turning vehicles were monitored to record duration.

3.3. Road Performance Analysis

Traffic performance indicators were calculated according to the Indonesian Road Capacity Guidelines (Pedoman Kapasitas Jalan Indonesia; PKJI) and U-turn Planning Guidelines (Pedoman Perencanaan Putaran Balik; PPPB) [16], [17]. Key metrics used in this study are road capacity, degree of saturation, travel time speed, level of service, and traffic volume.

3.3.1. Capacity

Road capacity refers to the maximum number of vehicles passing through a road per hour under specific conditions. The traffic flow is divided by direction, and the capacity is calculated for each lane. The formula used to determine capacity is as follows:

$$C = C_o \times F_{CLJ} \times F_{CPA} \times F_{CHS} \times F_{CUK} \quad (1)$$

where *C* represents the road capacity for the analyzed direction or lane (passenger-car units per hour; pcu/h), C_0 denotes basic capacity (pcu/h) under reference conditions according to PKJI, F_{CLJ} denotes the lane/width adjustment factor, F_{CPA} represents the directional separation factor, F_{CHS} is the side-friction/shoulder adjustment factor, and F_{CUK} denotes the city-size or urban area adjustment factor.

3.3.2. Degree of Saturation

The degree of saturation (DS) represents the ratio of traffic flow to capacity as seen in Equation (2). It is a crucial parameter in evaluating the performance of a road segment. The DS value helps to identify whether a segment is facing capacity issues.

$$DS = \frac{Q}{C} \tag{2}$$

where *DS* denotes the degree of saturation, and *Q* is the observed traffic flow in pcu/h.

3.3.3. Travel Time Speed

Travel time speed is defined as the average speed of light vehicles (LV) along a road segment and is a key indicator of road performance. It is calculated using equation (3).

$$V = \frac{L}{TT} \tag{3}$$

where *V* represents the average travel speed on the segment, *L* is the segment length used for measurement, and *TT* denotes the travel time for that segment.

3.3.4. Level of Service

The Level of Service (LOS) describes the performance of a road by evaluating congestion levels. It is determined by comparing traffic volume with road capacity (V/C).

3.3.5. Traffic Volume

Traffic volume measures the number of vehicles passing through a specific point on a road segment within a defined period (e.g., days, hours, or minutes). Vehicles are classified into three types: light vehicles (LV), heavy vehicles (HV), and motorcycles (MC). Using passenger car equivalent (PCE) values, the total traffic flow in vehicles per hour is calculated using equation (4).

$$Q = pce_{LV} \times LV + pce_{HV} \times HV + pce_{MC} \times MC \tag{3}$$

where *LV*, *HV*, and *MC* denote the counted numbers of light vehicles, heavy vehicles, and motorcycles, respectively, while pce_{LV}, pce_{HV}, and pce_{MC} represent the passenger-car equivalent factors for each class of vehicle.

3.4. Data Analysis

Comparisons were made between conditions with and without Supeltas. Results were summarized in tables and graphs for interpretation. Observations relied on manual measurements, which may introduce timing errors. Weather conditions and driver behavior variations across days may also influence results. Nevertheless, triangulating data across multiple days and time periods strengthens validity.

4. Results and Discussion

4.1. Street Geometry

The geometric characteristics of Jl. Soekarno Hatta is presented in Table 1. The site consists of a four-lane divided urban arterial (4/2T) with a 3 m median and a 12 m-wide opening at the U-turn in front of Jasmine Residence. The roadway width varies slightly between directions (7 m and 9 m), and the shoulders range from 2 – 3 m.

Table 1. Geometric data of Soekarno Hatta road.

	Road Type	Road Width (m)	Median Width (m)	Median Opening Width (m)	Shoulder Width (m)
Direction 1	4/2T	7	3	12	3
Direction 2	4/2T	9	3	12	2

These features indicate that the section operates near the lower limit of PKJI 2023 standards for an urban arterial, particularly with respect to median opening width and shoulder width, which influence the maneuverability of U-turning vehicles. Similar geometric constraints were found to reduce efficiency and increase delay in comparable studies in Makassar and Phnom Penh [3], [6].

4.2. Traffic Volume and Speed Characteristics

The presence of Supeltas correlated with an increase in total traffic volume at the U-turn from 1,070 pcu/h (without Supeltas) to 1292 pcu/h (with Supeltas), representing approximately 21% increase in throughput. This suggests that Supeltas encourages more drivers to execute U-turns, likely because of improved perceived safety and clearer manual guidance. Figure 1 shows the traffic volume on the U-turn.

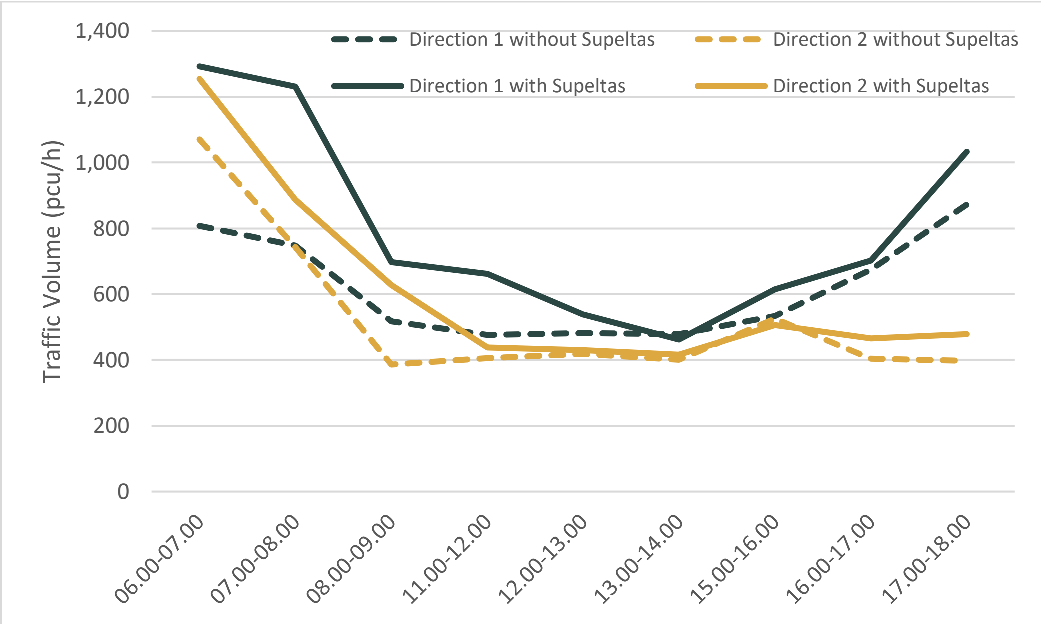

Figure 1. Hourly traffic volume at the U-turn on Soekarno Hatta road for both directions under conditions with and without Supeltas.

However, this operational benefit coincides with a reduction in average travel speed, from 42 km/h to 37 km/h. The speed reduction reflects a behavioral adaptation as drivers approach the manually controlled section, consistent with findings in [14] that volunteer traffic regulators often cause short-term speed reductions due to human signaling variability. The trade-off observed here—increased volume but reduced speed—illustrates a typical congestion–flow paradox also noted in U-turn design studies [4], [12]. It indicates that Supeltas facilitate flow continuity but introduce local friction due to non-standardized signaling.

4.3. Degree of Saturation and Level of Service

As shown in Table 2, the degree of saturation (DS) increased from 0.36 (B) without Supeltas to 0.49 (C) with Supeltas at the U-turn. Directional flows also experienced similar increases (from 0.43 to 0.56 and 0.58 to 0.59). While both conditions remain within LOS B–C, the change signals higher utilization of capacity. The 1.27-second increase in average delay is relatively minor, suggesting that although congestion rose, the operational degradation was limited.

Table 2. Degree of saturation and level of service on Soekarno Hatta road.

Location	Supeltas	Traffic Flow (pcu/h)	Road Capacity (pcu/h)	Degree of Saturation	Level of Service
Direction 1	With Supeltas	1,893	3,400	0.56	C
	Without Supeltas	1,468	3,400	0.43	B
Direction 2	With Supeltas	2,173	3,672	0.59	C
	Without Supeltas	2,131	3,672	0.58	C
U-Turn	With Supeltas	2,546	5,209	0.49	C
	Without Supeltas	1,878	5,209	0.36	B

These results align with [7], who observed that manual or informal interventions at U-turns tend to optimize local throughput while slightly decreasing average speeds. The data also corroborate PKJI 2023 thresholds, where LOS C represents "stable but dense flow"—an appropriate characterization of conditions observed during Supeltas operation. The comparative performance of U-turn operations with and without Supeltas is shown in Figure 2.

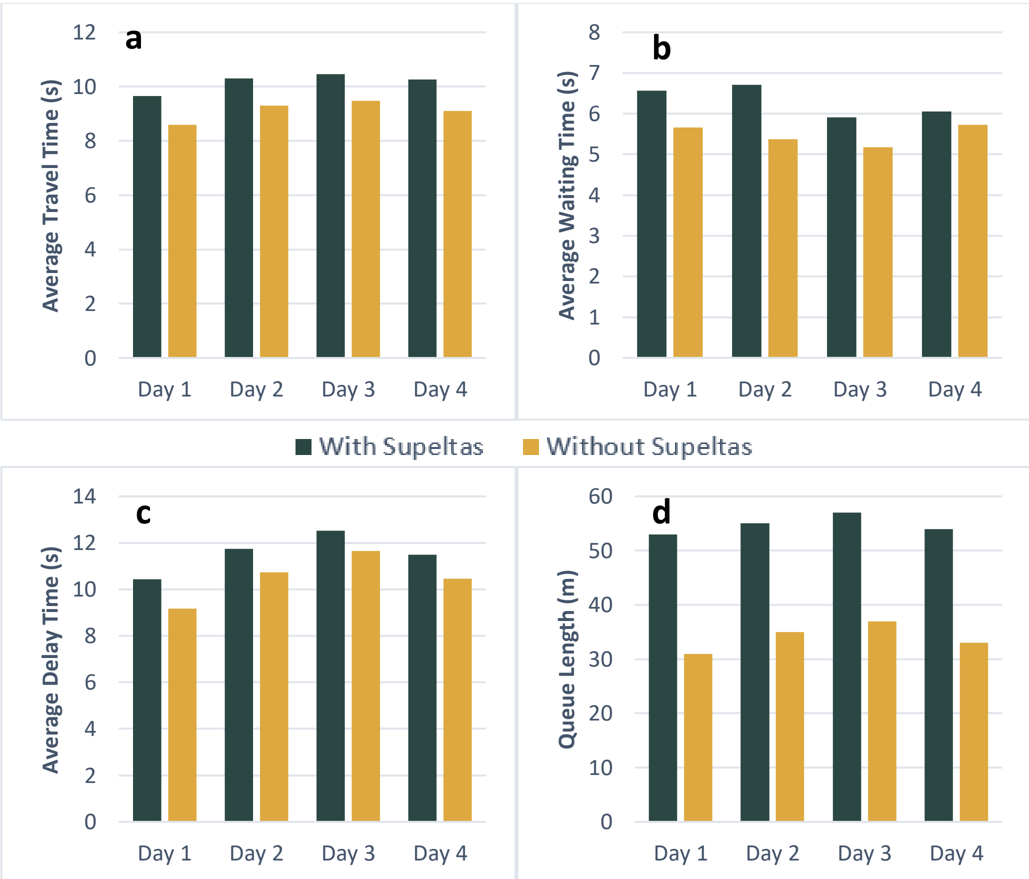

Figure 2. Comparative performance metrics of U-turn operations with and without Supeltas over four observation days: **(a)** average travel time, **(b)** average waiting time, **(c)** average delay time, and **(d)** queue length.

4.4. Impact of Supeltas and Recommendations

The findings demonstrate that Supeltas increase flow volume and intersection utilization but slightly reduce operational efficiency due to inconsistent signaling. The effect magnitude (≈0.13 increase in V/C) is operationally meaningful yet within acceptable service limits.

From a policy standpoint, Supeltas contribute positively when deployed in moderate-volume corridors but could exacerbate congestion if traffic approaches capacity (DS > 0.8). To enhance effectiveness:

1. Training and Certification: Establish short training modules through the traffic police to standardize gestures and timing, as suggested by the authors in [5].
2. Infrastructure Adjustment: Implement a dedicated U-turn lane following PPPB 2005 geometric recommendations, reducing conflict between through and turning vehicles.
3. Technology Integration: Future studies could assess combining Supeltas with adaptive or flashing signal devices to improve consistency and reduce human error.

These recommendations are in line with broader Southeast Asian practices where community-based regulation supplements formal control systems [1].

4. Conclusions

This study evaluated the influence of Volunteer Traffic Regulators (Supeltas) on the performance of a U-turn section along Jl. Soekarno Hatta in Pekanbaru City. The analysis revealed that the presence of Supeltas increased vehicle volume from 2,131 to 2,168 pcu/hour, indicating that more vehicles utilized the U-turn under their supervision. However, this higher flow was accompanied by a reduction in average travel speed from 42 km/h to 37 km/h and an increase in the degree of saturation from 0.36 to 0.49. These changes reflect a shift from LOS B to LOS C, suggesting a denser and more congested traffic condition when Supeltas were present. The findings confirm that while Supeltas facilitate the movement of vehicles through manual direction, their interventions also introduce additional friction to traffic flow, primarily due to inconsistent signaling and limited coordination with formal traffic systems. Consequently, Supeltas' activities, typically involving one to two personnel per U-turn, contribute to slower vehicle speeds and localized congestion along the Soekarno Hatta corridor. Despite this, their role remains significant in managing vehicle behavior, particularly where formal traffic control is lacking.

To mitigate these adverse effects, it is essential to improve the operational framework of Supeltas. Structured training, standardized hand signals, and closer coordination with local traffic authorities could enhance their efficiency. Moreover, infrastructure interventions—such as dedicated U-turn lanes in accordance with PPPB 2005 standards—would help reduce conflicts between through-traffic and turning vehicles. Integrating these community-based regulators into a more formalized system could balance their beneficial guidance role with improved overall traffic performance. In summary, the study concludes that Supeltas' presence, while increasing vehicle participation and local control, tends to raise the degree of saturation and congestion at U-turn points. With targeted improvements in training and infrastructure, their contribution could be optimized to support safer and smoother urban traffic operations in Pekanbaru and similar urban settings.

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Conflicts of Interest: "The authors declare no conflicts of interest.

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