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The Effect of on-Street Parking on Traffic Performance in Commercial Areas of Small Cities in Indonesia (Case Study: St. Merdeka Utara Cirebon)

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ABSTRACT

Street Parking is one of the factors that causes a decrease in traffic performance, especially in commercial areas of small cities, so it is necessary to organize it so traffic performance can remain by the planning. The purpose of this study was to find out what the impact of on-street parking traffic is on-road performance and to provide recommendations in the form of parking location arrangements. The calculation method used to analyze road performance is the Indonesian Road Capacity Guidelines (PKJI 2023) while parking utilizing the technique of the Director General of Land Transportation (1996). The results of the study showed that the presence of on-street parking at the study location resulted in road performance becoming Level Of Service (LOS) D and off-street parking resulted in road performance becoming Level Of Service (LOS) C. If on-street parking and off-street parking are not moved, the Level Of Service (LOS) value will be E and F. And this study is to provide recommendations for moving parking locations around traditional markets. In conclusion, parking rearrangements and relocation of parking locations can improve road performance and reduce congestion, with implications for more efficient transportation planning in small towns, especially around commercial areas and traditional markets.

Introduction

Traffic problems due to on-street parking are a global issue that has a significant impact on transportation efficiency and urban mobility, especially in commercial areas (Geremew, 2024). This phenomenon occurs in various developing countries, including Indonesia, where the rapid growth of motor vehicles is not balanced by the availability of adequate parking spaces. In small towns, especially in traditional market areas, vehicles parked on the shoulder of the road can cause serious congestion, degrade traffic performance, and increase the risk of accidents (Tisnaningtyas, 2015).

Factors that affect the high number of parking on the road include the lack of adequate off-street parking facilities, undisciplined behavior of road users, and government policies that are not effective in managing the parking system (Hlaine, 2024;

Tiwari et al., 2023). In addition, economic growth that increases people's mobility also contributes to the increase in the number of vehicles on the highway. With the increasing traffic flow in commercial areas, the need for better parking management is becoming more urgent.

The road section located in the commercial area with shops along the road causes a lot of movement and market activity, shopping, and at the time of loading and unloading. Some roads are now used for parking because there is not enough parking space (Street Parking) which affects the performance of urban roads.

The presence of vehicles that use the road as a parking lot can cause vehicle movement to be hampered because it can cause congestion (Biswas et al., 2017; Rifai et al., 2020). At a certain point, Jalan Merdeka Utara experiences a very high level of traffic density. The purpose of this study is to determine the impact of on-street parking on Jalan Merdeka Utara and then provide suggestions for parking lot management so as not to cause losses on Jalan Merdeka Utara.

Many studies have been conducted on parking on the shoulder or the road body, many of which have examined the aspect of parking space arrangement and how this affects the function of the road. The research conducted (Masrul & Utami, 2021) about the analysis of road performance related to parking activities on the road. Ultimately the findings of this analysis will be compared to how well a particular road section functions when there is no parking activity. Kasim et al., (2023) analyzed road sections affected by on-street parking on the degree of saturation with the results of the analysis that on-street parking activities showed an increase in the degree of saturation on road sections with a scenario where there were no on-street parking activities. Pota et al., (2023) analyzing road sections affected by on-street parking activities to try to control on-street parking.

This is based on research on on-street parking and off-street parking showing that on-street parking can affect the performance of road sections, so suggestions for parking arrangements in the Market are made in the form of preparing special parking locations for parking and limiting loading and unloading activities during peak hours. Ristiyanto & Abadi, (2023) analyzing the performance of roads affected by parking on the side of the road in traditional markets the findings of this analysis will be compared with how well certain road sections function without parking operations on the highway.

Zulvia et al., (2023) conducted an analysis of parking characteristics and the impact of on-street parking on traffic performance with the results of stable flow characteristics, slightly limited speed with alternatives to improve parking order, and supervision in managing parking. Mubarak et al., (2021) conducting an evaluation of the performance of road sections affected by parking on the shoulder of the road due to shops that do not provide parking spaces and are affected by side obstacles such as street vendors, vehicle parking plus the number of pedestrians and motorized vehicles entering or exiting the side of the road and slow-moving vehicles on the roadside of the Bangkinang City Plaza Market in Sisingamangaraja, an alternative recommendation was produced by eliminating data on side obstacles for parking, vehicles stopping and vehicles entering and exiting, reducing the influence of side obstacles.

Rezanti Bitami (2022) conducted an analysis of the Kiaracondong section, which is the economic center of the city of Bandung, affected by shops that do not have special parking areas, so many vehicles park on the roadside. This increases traffic, causing long queues for two-wheeled and four-wheeled vehicles. The factors that influence the performance of the road section are on-street parking, so recommendations are made to provide adequate parking space for vehicles and traders, so as not to interfere with the performance of the road section. (Kamil et al. 2023) analyzed road sections caused by parking on the road, where the results of the analysis showed very high side obstacles, the alternative offered was to control parking by restricting parking, especially on the roadside. (Paisal et al., 2022) analyzing the performance of roads due to the impact of on-street parking, the results of the analysis showed that the decline in road performance was very influential due to on-street parking. Simanjuntak et al., (2023) analyzing parking needs with the results of the analysis planning parking space for the Horas Jaya traditional market. Nidal et al., (2024) analyzing the integrated parking arrangement for commercial areas where the analysis results propose an integrated parking location at Balong market with a recommendation for a 4-story building. Farhan, Hariani, and Lumtunnanie (2023) analyzed the effect of on-street parking on traffic performance on side streets with the results of the road performance level of service C recommending reducing side obstacles, arranging parking vehicles, scheduling loading and unloading, and moving parking spaces (off-street parking).

Jalan et al., (2023) Evaluating on-street parking against the performance of Agus Salim Street, Malang City, the results of the analysis show that the need for parking spaces exceeds the existing provision with the alternative of providing regulations for each vehicle to park for a maximum of 60 minutes, implementing progressive parking, implementing rules prohibiting loading and unloading during peak hours, and planning land use.

Oktaviani and Ismalina (2022) analyzed the feasibility of on-street parking in front of the Gramedia store, the results of the analysis showed that on-street parking in front of the Gramedia store was not feasible to implement, the parking index exceeded 100% with an alternative solution of eliminating on-street parking in front of the Gramedia store because it could still accommodate vehicle parking provided by the Gramedia store. Bayu Aji et al. (2023) analyzed parking characteristics against the need for parking space at the Central Hamadi market in Jayapura city with the results of the analysis of sufficient parking space for cars while insufficient for motorbikes, the alternative solution was to move the motorbike parking space into the market/building area so that it was sufficient for the motorbike parking area.

This research specifically focuses on the analysis of traffic performance on the Jalan Merdeka Utara section, Cirebon, which is a commercial area with a high level of activity. The main variables in this study are road performance in on-street and off-street parking conditions and their impact on the degree of saturation. This study also examines how alternative parking management can be applied to improve traffic efficiency at the research site.

The novelty of this study lies in the comprehensive analysis of solutions that can be applied to optimize road performance through the latest empirical data-based traffic engineering scenarios. Not only focusing on problem identification, this study also provides recommendations based on the analysis of road and parking capacity calculations combined with traffic growth projections for the next five to ten years. The urgency of this research lies in the urgent need to improve the quality of traffic in dense commercial areas to continue to support local economic growth. By understanding the impact of on-street parking on traffic performance, more effective policies can be implemented to optimize the use of road space and improve the comfort of road users.

The purpose of this study is to analyze the impact of on-street parking on traffic performance in the commercial area of Jalan Merdeka Utara, Cirebon, identify the main factors that affect road capacity due to on-street parking and prepare recommendations for solutions in the form of parking management that can improve traffic efficiency and reduce congestion. The results of this study are expected to provide benefits for various parties, including local governments in the formulation of tourism policies, business actors in improving the accessibility of commercial areas, and the general public in obtaining a better driving experience in urban areas.

Method

This study uses a quantitative method with a descriptive type of research to analyze the influence of parking on the road body on traffic performance. This study aims to identify the level of road performance affected by parking along the road in commercial areas. The data sources used in this study consist of primary and secondary data. Primary data is collected through live surveys in the field, which include observations of traffic volume, road geometry, and parking conditions. Meanwhile, secondary data was obtained from literature studies and relevant documents such as the Indonesian Road Capacity Guide (PKJI 2023) and population data from related agencies.

The data analysis techniques used in this study are analysis of road capacity and degree of saturation, as well as level of service (LOS) analysis to evaluate road performance with parking on the road body. For data collection, the techniques used include manual observation of traffic volume, vehicle counting, and measurement of road geometry and side obstacles. Data collection was carried out at various peak times to obtain a representative picture of the impact of parking on traffic performance in both segments studied.

The research location is in the commercial area of a small town which is divided into 2 segments or two research points, segment one is in the traditional market, and research segment two is in the town square of the commercial area of the small town.

Research Flow

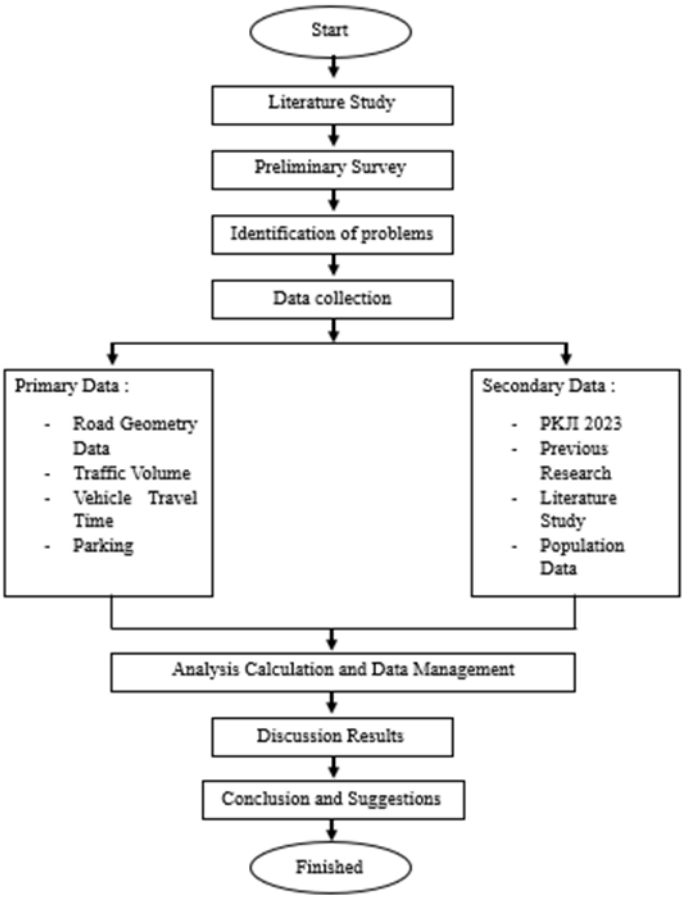

Figure 2. Research Flow Diagram

Data collection

The data needed for this study are primary and secondary. Primary data is obtained through direct surveys in the field, while secondary data is obtained by requesting information from related agencies.

Primary data

a. Road Geometric Survey
b. Traffic Volume Survey
c. Side Obstacles
d. Traveling time
e. Parking Survey

Secondary Data

a. Literature studies are obtained from previous research related to the research to be conducted.
b. Population Data of Cirebon City
c. Indonesian Road Capacity Guidelines (PKJI 2023).

Survey Implementation

The survey was conducted for four days a week: Monday, Thursday, Saturday, and Sunday for 12 hours starting at 06.00 – 18.00 WIB. The observation method was carried out through manual observation or Traffic Counting. The following tools were used:

a. Length measuring tool (roll meter)
b. Survey Form
c. Stopwatch

Results and Discussion

Road Section Geometric Data

Table 1of Research Environment

No.	Description	Information
1	City	Cirebon
2	City Size	Medium
3	Road Environment Type	Commercial
4	Road Type	2/2 TT
5	Analysis Period	Peak Hours
6	Side Obstacles	Height

Source: Research Analysis Data

Identification aims to find out general data from the research environment being analyzed. Road geometric data is data about the geometric conditions of the road segments around the road being studied which also represent the characteristics of the road segments around the road being studied. Geometric conditions consist of situation plans (land use, road markings, and intersections), and road cross-sections (road width and shoulder width). Based on the results of measurements and direct visual observations in the field of segment 1 on-street parking conditions, it was obtained that the road type is 2/2 Undivided, with a lane width of 6 meters with a shoulder of 1.5 meters as seen in Figure 3 below.

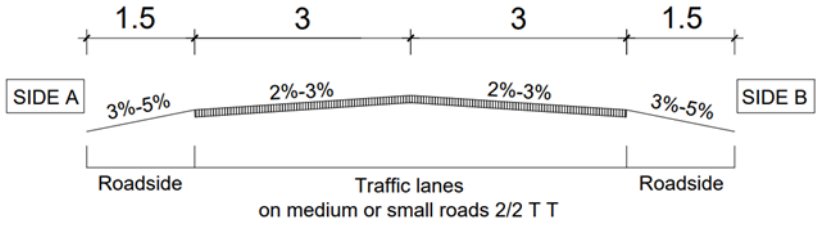

Figure 3. Cross-Section of Segment 1

Based on the results of measurements and visual observations on segment 2 located in Ciledug Square directly in the field, the on-street parking conditions obtained were that the road type was 2/2 Undivided, with a lane width of 7 meters with a shoulder of 1 meter as seen in Figure 4 below.

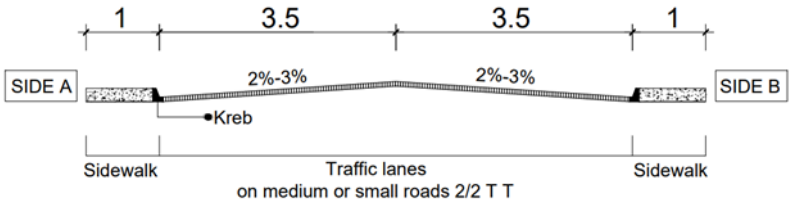

Figure 4. Cross-section of Segment 2

Vehicle Traffic Volume Analysis

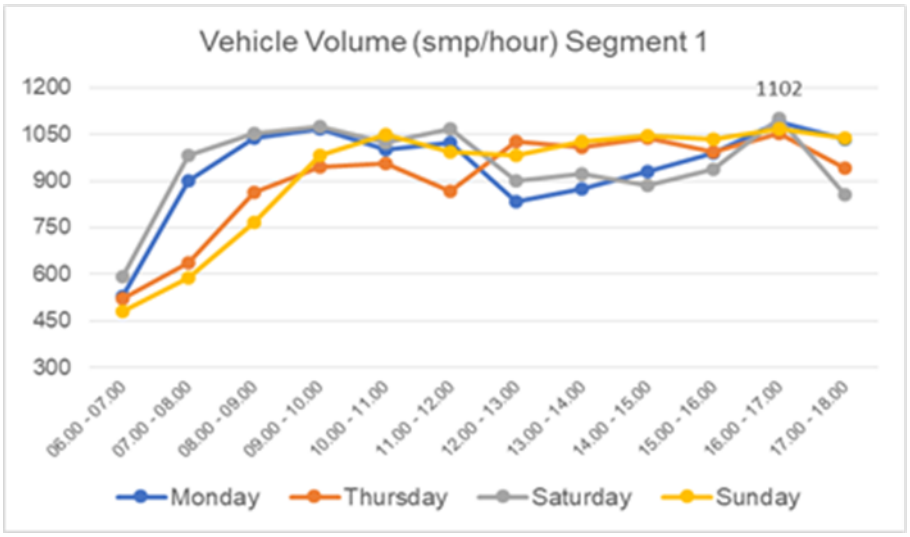

Figure 11 Vehicle Volume

Based on the results of the Segment 1 survey, the peak vehicle volume is at 16.00 - 17.00 WIB in the analysis of vehicle traffic volume used in the form of smp/hour. The highest peak hour volume on Saturday was 1102 SMP/hour.

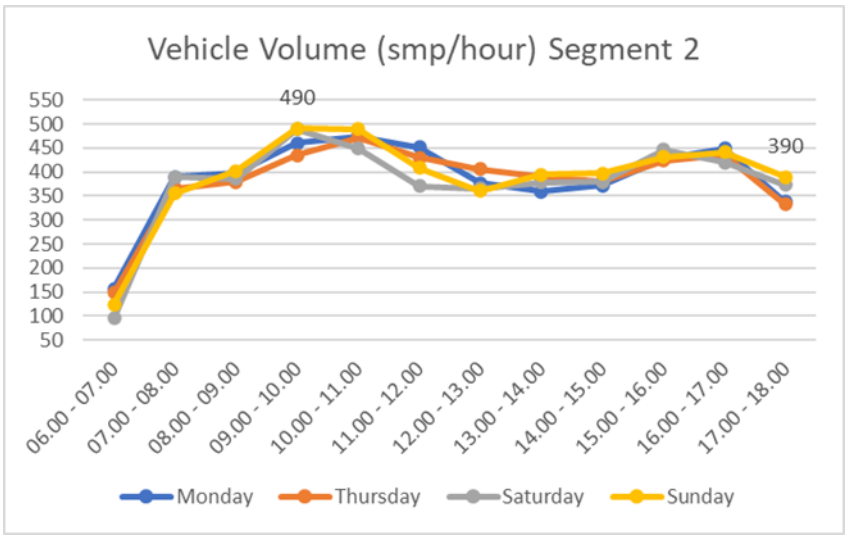

Figure 22 Vehicle Volume

In segment 2, the highest vehicle volume occurred at 09.00 – 10.00 WIB on Sunday at 490 pcu/hour. Analysis of vehicle volume in passenger car units (pcu) is calibrated with passenger car equivalency.

Side Obstacles

Table 2Peak Hour Side Obstacles

Road Section		Segment 1	Segment 2
Day		Saturday	Sunday
Time		10.00 – 11.00	15.00 – 16.00
Pedestrian	0.5	241	149
Vehicle Parking Stop	1.0	48	3
Vehicle In + Out	0.7	389	77
Slow Vehicle	0.4	208	101
Total		524	172
Side Obstacle Class		Height (T)	Low (R)

Source: Research Analysis Data

Data on side obstacles that occurred on the two observed road segments, in segment 1 the side obstacles that occurred were classified as high with a total of 524, while for segment 2 they were in the low category with a total of 172, as can be seen in table 2 above.

Free Flow Velocity and Speed Analysis

Table **3of** Speed Analysis

Speed Analysis		
Location	Free Flow Velocity Analysis	Average Speed
SEGMENT 1	29 km/h	25 km/h
SEGMENT 2	37 km/h	33 km/h

Source: Research Analysis Data

In the free flow speed analysis data for Segment 1, it obtained 29 km/hour while Segment 2 obtained 37 km/hour, that segment 1 is lower than Segment 2 can be compared with the average speed of Segment 1 obtained 25 km/hour lower than segment 2 obtained 33 km/hour. So it can be concluded that the traffic speed in segment 1 is slightly slower than segment 2.

Capacity Analysis

Table 41 and Segment 2

On Street Parking	**Segment 1**	**Segment 2**
Side Barriers (FCHS)	TALL	LOW
Capacity (C)	1327	2043
Off-Street Parking	**Segment 1**	**Segment 2**
Side Barriers (FCHS)	LOW	VERY LOW
Capacity (C)	2221	2425

Source: Research Analysis Data

Analysis of the capacity of the Merdeka Utara road segment 1 contains parking spaces with high side barriers resulting in a capacity of 1327 while without parking spaces with low side barriers resulting in a capacity of 2221. In segment 2 there are parking spaces with low side barriers resulting in a capacity of 2043 while without parking spaces with very low side barriers there is a capacity of 2425 from a basic capacity of 2800.

Road Section Performance Analysis

Table 5. Degree of Saturation of Segment 1

Traffic Volume (smp/hour)	On Street Parking Capacity	Off-street Parking Capacity	Q/C On Street Parking	Q/C Off Street Parking	On-street Parking Loss	Off-Street Parking Lot
590.9	1327	2221	0.45	0.27	C	B
982.6	1327	2221	0.74	0.44	C	B
1054.1	1327	2221	0.79	0.47	D	C
1075.95	1327	2221	0.81	0.48	D	C
1021.8	1327	2221	0.77	0.46	D	C
1069.55	1327	2221	0.81	0.48	C	C
901.4	1327	2221	0.68	0.41	C	B
923.05	1327	2221	0.70	0.42	C	B
884.1	1327	2221	0.67	0.40	C	B
937.7	1327	2221	0.71	0.42	C	B
1101.5	1327	2221	0.83	0.50	D	C
854.95	1327	2221	0.64	0.38	C	B

Source: Research Analysis Data

Based on the results of the analysis of the degree of saturation of segment 1 during on-street parking, the DS was obtained at 0.83 with LOS level D, and the results of Off Street Parking DS of 0.50 were obtained at LOS level C on Saturdays at 16.00 - 17.00 peak time as seen in table 5.

Table 5Degree of Saturation of Segment 2

Volume Traffic (smp/hour)	On Street Parking Capacity	Off-street Parking Capacity	Q/C On Street Parking	Q/C Off Street Parking	On-street Parking Loss	Off-Street Parking Lot
124.95	2043	2425	0.06	0.05	A	A

355.8	2043	2425	0.17	0.15	A	A
401.7	2043	2425	0.20	0.17	B	A
490.45	2043	2425	0.24	0.20	B	B
489.15	2043	2425	0.24	0.20	B	B
409.2	2043	2425	0.20	0.17	B	A
360.8	2043	2425	0.18	0.15	A	A
394.35	2043	2425	0.19	0.16	A	A
397.85	2043	2425	0.19	0.16	A	A
431.65	2043	2425	0.21	0.18	A	A
441.1	2043	2425	0.22	0.18	A	A
389.85	2043	2425	0.19	0.16	A	A

Source: Research Analysis Data

Meanwhile, segment two on-street parking obtained a DS of 0.24 at LOS B level, and off-street parking obtained a DS of 0.20 with LOS B level on Sundays at 09.00 – 10.00 peak time.

Travel Speed (V_T)

Fiure 3 Travel Speed

Travel speed (V_T) is the actual speed of traffic flow whose magnitude is determined based on D J and vB. The travel speed graph in segment 1 uses peak time on Saturday at 16.00 - 17.00 WIB. On Street Parking travel speed is 22 km / h with a travel time of 1.37 minutes / 82.2 seconds; for Off Street Parking travel speed, it is 24 km / h with a travel time of 1.25 minutes / 75 seconds. While the segment two travel speed graph uses Peak Hour on Sunday at 09.00 – 10.00 WIB, For On-Street Parking travel speed is 27 km/hour with a travel time of 0.45 minutes/27 seconds, and for Off Street Parking travel speed is 28 km/hour with a travel time of 0.43 minutes/25.8 seconds.

Traffic Performance Projection for the Next 5 and 10 Years in On-Street Parking and Off-Street Parking Conditions

Table 6Projected Vehicle Volume

On Street Parking	**Segment 1**	**Segment 2**
Year	2024	2024
Vehicle Volume (P0)	1101.5	490.45
Pn (2029-2039)	Q Projection Results	Q Projection Results
5	1345.4	599,037
10	1643.2	731,665
C	1327	2043
DS 5	1.00	0.29
DS 10	1.23	0.36
Off-Street Parking	Segment 1	Segment 2
Year	2024	2024

Vehicle Volume (P0)	1101.5	490.45
Pn (2029-2039)	Q Projection Results	Q Projection Results
5	1345.4	599,037
10	1643.2	731,665
C	2221	2425
DS 5	0.60	0.25
DS 10	0.74	0.30

Source: Research Analysis Data

Traffic volume projections use the exponential method with a traffic growth rate of 4% per year. For segment 1, the vehicle projection 2029 is 1345.4 vehicles, and the projection for 2039 is 1643.2 vehicles. For segment 2, the projection in 2029 is 599,037 vehicles, and the projection in 2039 is 731,665 vehicles, as seen in Table 9.

Parking Accumulation

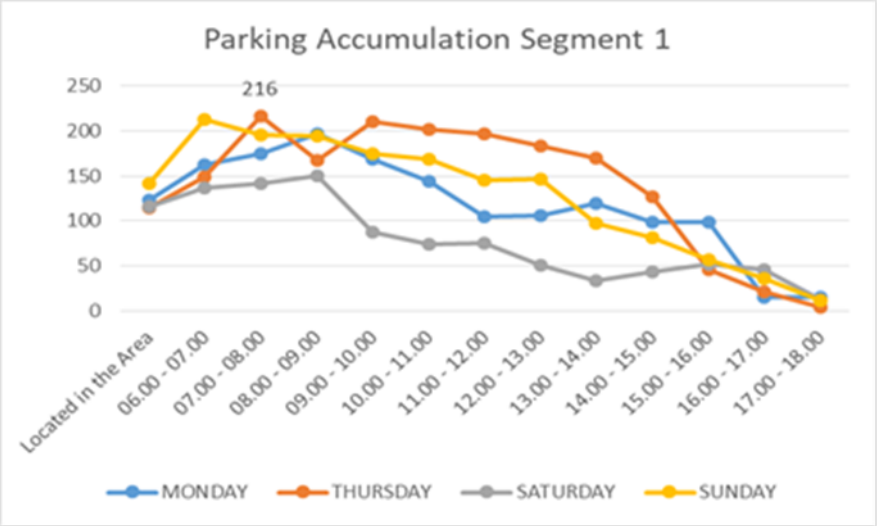

Figure 4. Segment 1 Parking Accumulation

In parking analysis using the direct approach method, segment 1 shows parking accumulation of 216 vehicles during peak hours on Thursday, starting at 07.00 to 08.00 WIB. The number of cars is 5, and the number of motorcycles is 211, as can be seen in the graph.

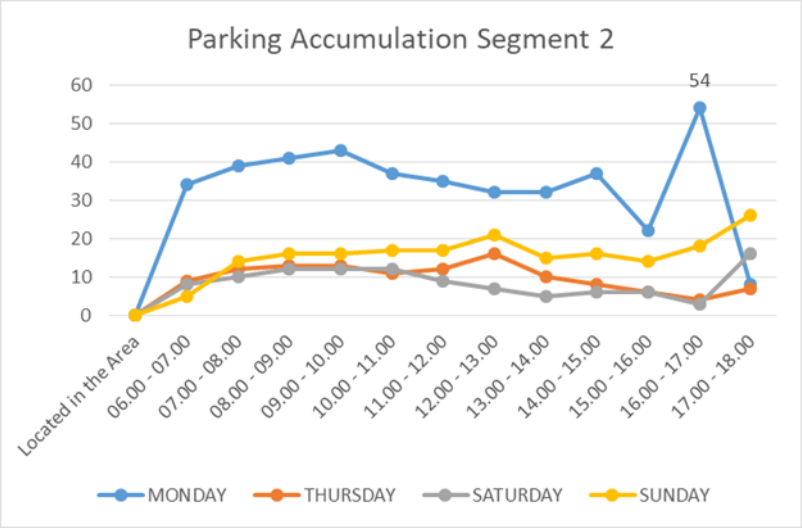

Figure 5. Segment 2 Parking Accumulation

Meanwhile, segment 2 has parking accumulation with peak hours on Monday from 16.00 to 17.00 WIB, amounting to 54 vehicles, with the number of cars zero and the number of motorbikes 54 vehicles, as seen in the graph.

Parking Volume

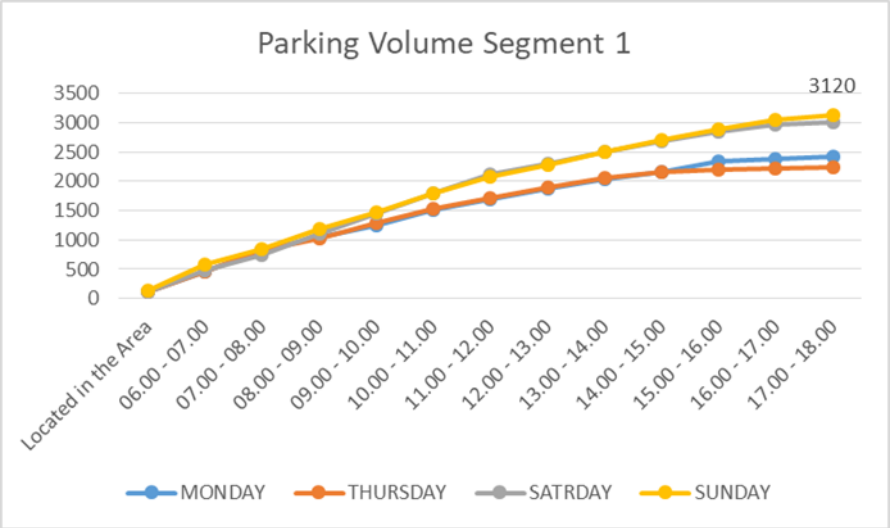

Figure 6. Segment 1 Parking Volume

The parking volume in segment 1 shows that the highest parking volume on Sunday was 3120 vehicles, with 94 cars and 3026 motorbikes.

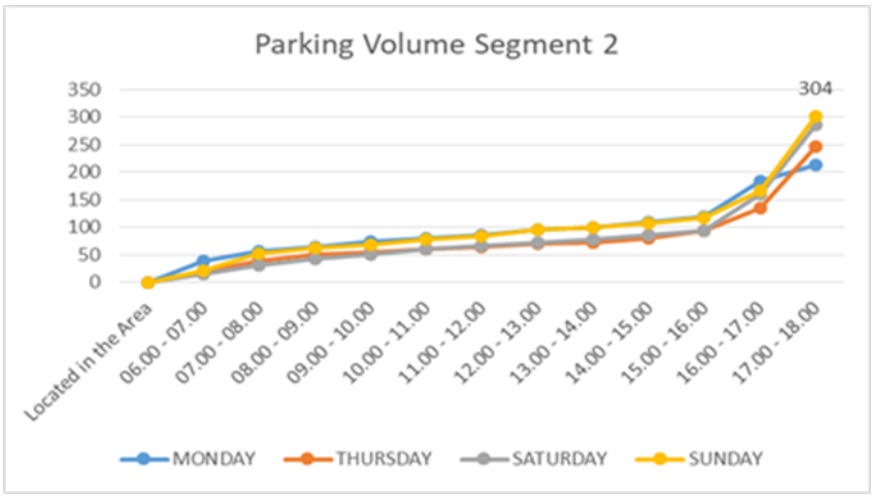

Figure 7. Segment 2 Parking Volume

Meanwhile, in Segment 2, the highest parking volume on Sunday was 304 vehicles with 24 cars and 278 motorbikes. This can be seen in the graph.

Parking Index

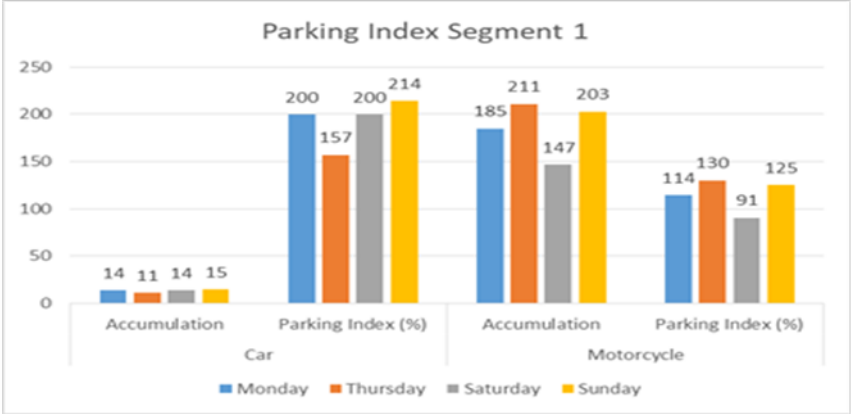

Figure 8. Segment 1 Parking Index

Based on the highest segment one parking index graph for cars on Sundays at 214% and for motorbikes on Thursdays at 130%, IP > 100% means parking facilities are problematic because parking needs exceed standard capacity. Therefore, adding a parking area or creating new parking lots is necessary.

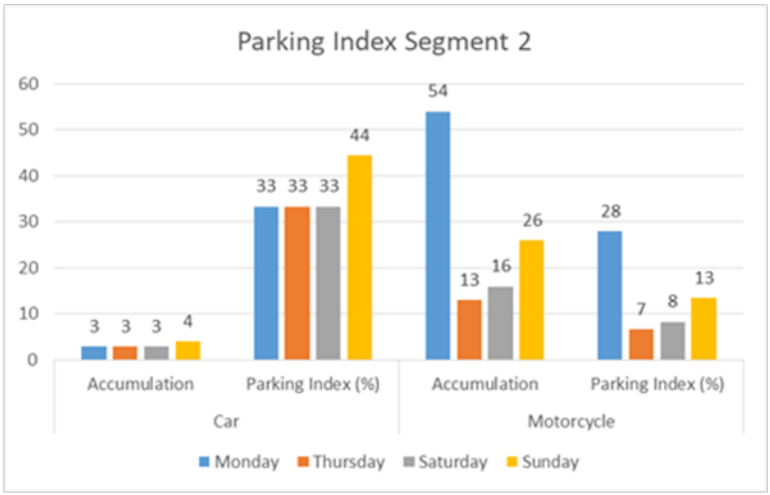

Figure 9. Parking Index Segment 2

Based on the segment two parking index graph, the highest average for cars on Sundays is 44%, and for motorbikes on Mondays is 28%. IP <100% means parking facilities are not problematic and parking needs are balanced with standard capacity.

Parking Space Requirements

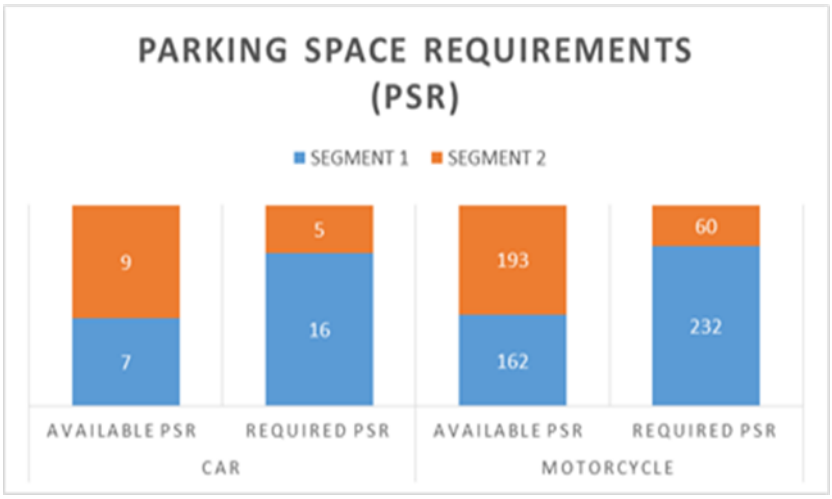

Figure 10. Parking Space Requirements

The results of the analysis of parking space needs at peak hours accumulated for 12 hours with the existing condition of parking facilities in segment 1 are not sufficient. However, the analysis results in segment two show that the need for parking space (KRP) is adequate.

Recommendations and Problem Solutions

There are several recommendations and solutions to problems related to traffic performance due to the impact of the on-road parking system, as follows:

Side Drag Reduction

Many pedestrians and vehicles enter, exit, and park haphazardly. Street vendors also sell on the side of the road, so side obstacles must be rearranged or reduced.

Parking Space Relocation

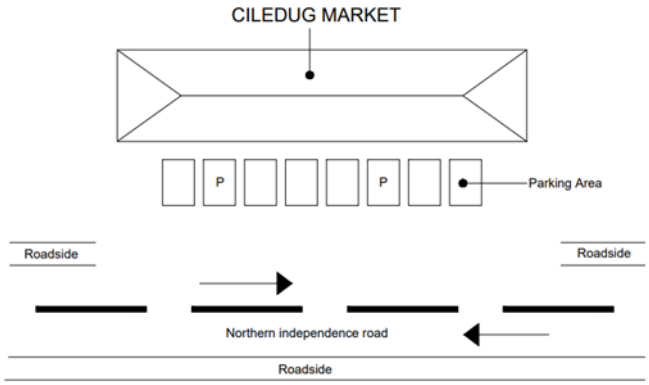

Figure 5. Car Parking Layout Segment 1

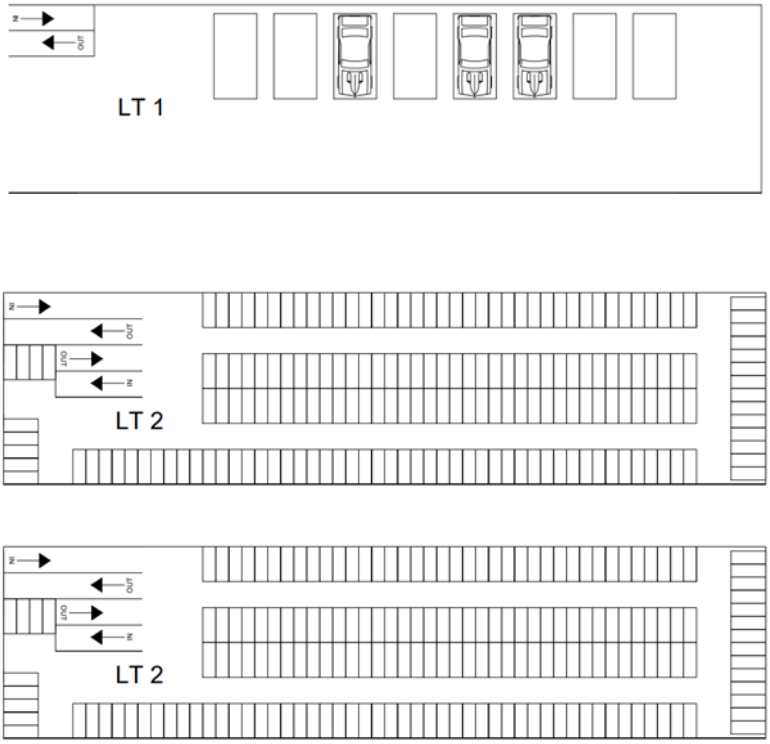

Figure 6. Parking Building Layout Segment 1

Based on the findings of segment one analysis, the highest saturation level was obtained on Jalan Merdeka Utara when on-street parking was obtained D J 0.83 (D) and off-street parking was obtained D J 0.50 (C) with the results that the degree of saturation was relatively high. In addition, the projection of road volume for the next five and ten years on Jalan Merdeonea Utara according to the analysis results, the degree of saturation increased, the degree of saturation on-street parking for the next 5 years was 0.93 (E) for the next 10 years was 1.13 (F). The alternative solution suggested by this study is to add a parking building with an area of 300 m2 near the Ciledug market, which is □60 meters from the Ciledug market. A comfortable walking distance in Indonesia is □400 meters,

so the comfort factor for shopping greatly influences the length of the trip. The market parking area is prioritized for loading and unloading activities with a parking angle of 90 degrees, while it is diverted to the parking building for consumer vehicles. It is expected that the transfer of parking spaces can optimize traffic performance.

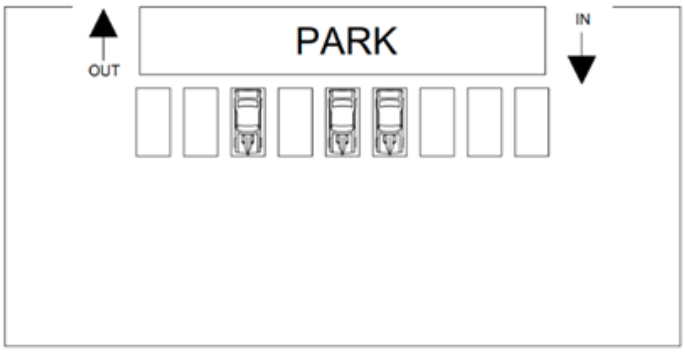

Figure 7. Car Parking Layout Segment 2

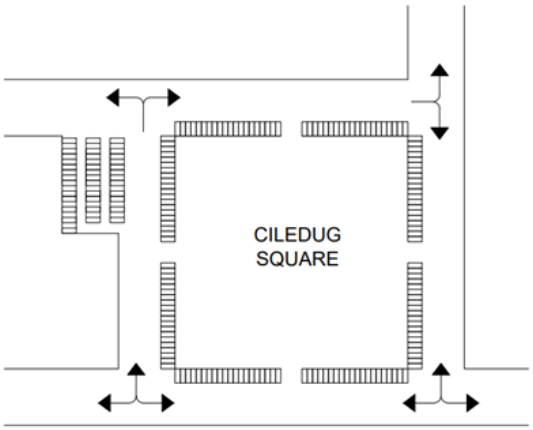

Figure 1Motorcycle Parking Layout Segment 2

Meanwhile, the analysis results in segment 2 showed the highest saturation when on-street parking on Jalan Merdeka Utara was obtained D J 0.24 (B) and off-street parking was obtained D J 0.20 (B) with the results that the degree of saturation was categorized as low. In addition, the degree of saturation of Jalan Merdeka Utara increased in the volume projection for the next five and ten years, according to the results of the study, the degree of saturation of on-street parking for the next 5 years was 0.29 (B) for the next 10 years 0.36 (B). The alternative solution suggested by this study is that vehicles parked in the town square are arranged so as not to interfere with vehicle circulation. Therefore, it is necessary to arrange vehicle circulation by making signs for parking space instructions and placing clear vehicle entrances and exits to facilitate supervision and evaluation of parking areas in the Ciledug town square area. (Pota et al., 2023).

Loading and Unloading Scheduling

With shops on Jalan Merdeka Utara, many expeditions load and unload on the side of the road. This causes traffic congestion and affects the road's performance. Thus, scheduling time for loading and unloading goods is needed.

Conclusion

Based on the results of data analysis and discussion, it is concluded that: The results of the analysis and calculation of traffic volume on the Mmake it one paragrapherdeka Utara road segment one show that the peak vehicle volume occurs at 16.00 - 17.00 WIB and on segment two the peak hour vehicle volume is at 09.00 - 10.00 WIB with the highest total vehicle volume in segment one on Saturday 1101.5 pcu/12 hours and the highest total vehicle volume in segment two on Sunday 490.45 pcu/12 hours. Based on the results of the analysis and calculation of the performance of the Merdeka Utara road section on segment one during On Street Parking, the capacity was 1327 with a saturation degree of 0.83 Level Of Service D. During Off Street Parking it became 2221 with a saturation degree of 0.50 Level Of Service C. While for segment two during On Street Parking, the capacity was 2043 with a saturation degree of 0.24 and during Off Street Parking it became 2425 with a saturation degree of 0.20 Level Of Service B. The traffic volume projection analysis results for the next 5 and 10 years with a vehicle growth rate of 4% per year. For Segment 1, it was obtained in 2029 of 1345.4 vehicles. In 2039 of 1643.2 vehicles, performance in Segment 1 for On-Street Parking for the next 5 and 10 years at Level Of Service E and F. While for segment 2, it was obtained in 2029 of 599,037 vehicles and 2039 of 731,665 cars, performance in segment 2 for On-Street Parking for the next 5 and 10 years at Level of Service B. The analysis and calculation results of the Parking Space Requirements (KRP) in Segment 1 do not meet the parking space requirements (SRP). In segment 1, the parking space requirements (KRP) for cars are 16 KRP and for motorbikes 232 KRP, while the existing car capacity is 7 SRP and for motorbikes 162 SRP. The calculation results of segment 2 show that the parking space requirements (KRP) for cars and motorbikes are sufficient.

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