Paid Parking Performance Evaluation at Depok Baru Station

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ABSTRACT

Depok Baru Station is a train operating facility that stops regularly to pick up and drop off passengers, Depok Baru Station is in the operational area of DAOP 1 Jakarta. Depok Baru Station has so many passengers that one of the motorized vehicle parking facilities cannot accommodate vehicles parked in the area at Depok Baru Station. Therefore, it is necessary to study parking analysis at Depok Baru Station to provide benefits for motorbike users who do not get parking space, this is to create comfort and security for passengers who park their motorbikes in the Depok Baru Station area. So that it can provide an alternative parking control at Depok Baru Station so that no more motorized vehicles are found that are not parked neatly. This study aims to obtain the existing capacity of parking locations at Depok Baru Station and to obtain parking characteristics (accumulation, duration of each vehicle, parking space turnover rate and parking index) of motorized vehicles in the Depok Baru Station area. This study uses quantitative methods, data collection is carried out by means of observation as primary data, including data on the number of incoming vehicles, data on the number of outgoing vehicles, data representing peak hours, peak days, normal hours, normal days, number of Parking Space Units (SRP). The results of this study are that the existing parking lot obtained secondary data using the survey method to produce existing data on an area of 840m^2 motorcycle parking area with a capacity of 300 SRP (parking space units) and a slope angle of 90° at Depok Baru Station. the largest accumulation stasis was 358 vehicles with an average parking duration of 12.20hours on Tuesday, June 13, 2023. During the eight days of the survey, the maximum parking volume was 480 vehicles with a maximum accumulated vehicle parking of 424 vehicles which occurred on Monday June 12, 2023, the highest turn over for motorcycle parking at Depok Baru Station reached 161.00%, therefore the performance of motorcycle parking is quite high. The capacity of motorcycle parking spaces at Depok Baru Station cannot accommodate the available parking space requirements. This can be reviewed by looking at the parking index which exceeds 100%.

Keywords: paid parking evaluation; Parking Space Unit (SRP) capacity; parking duration; accumulation; parking analysis, Depok Baru Station.

INTRODUTION

PT. Kereta Api Indonesia (PT. KAI) is a State-Owned Enterprise (BUMN) which provides train transportation services. Service is the key to success in various businesses or service activities. Public services are becoming an increasingly strategic policy issue because improvements to public services in Indonesia tend to take place. In essence, every human being really needs service, in the extreme it can even be said that service cannot be separated from human life. Depok Baru Station is a station located in the Depok area, Pancoran Mas sub-district, Depok City, West Java.

Depok Baru Station is a train operating facility that stops according to schedule to pick up and drop off passengers. Depok Baru Station is in the DAOP 1 Jakarta operational area. Depok Baru Station has so many passengers that one of the motor vehicle parking facilities is unable to accommodate

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vehicles parked in the area at Depok Baru Station. Some KRL (Electric Rail Train) passengers park their vehicles outside the parking area at Depok Baru Station, for example parking their vehicles in parking lots managed by private parties. Therefore, it is necessary to study parking analysis at Depok Baru Station in order to provide benefits for motorbike users who do not have a parking space, this is to create comfort and safety for passengers who park their motorbikes in the Depok Baru Station area.

Parking is an essential aspect of the transportation ecosystem, playing a crucial role in urban planning, traffic management, and economic activity. From a traffic perspective, parking refers to the process of temporarily leaving a vehicle in a designated space, typically off the main traffic lanes, to ensure the smooth flow of vehicles and reduce congestion. Parking facilities are the physical locations designed to accommodate vehicles for various durations, ranging from short-term parking near commercial establishments to long-term parking in residential and industrial areas (Syaiful S et.al, 2024; Panjaitan H et.al, 2024; Gusty S et.al, 2024; Akbardin J et.al, 2024).

The concept of parking is intrinsically linked to traffic dynamics. Inadequate or poorly managed parking can lead to traffic congestion, increased travel times, and environmental pollution. Vehicles searching for parking spaces contribute significantly to traffic volumes, particularly in dense urban centers. The availability and convenience of parking directly influence driving behavior and route choices. When parking is scarce or expensive, drivers may opt for alternative modes of transportation, such as public transit, cycling, or walking. Conversely, abundant and affordable parking can encourage car use, potentially exacerbating congestion and urban sprawl. Parking facilities can be broadly categorized into on-street and off-street parking. On-street parking refers to spaces located along the sides of roads and streets Syaiful S, Anggi M, 2024; Nopriyanto W et.al, 2024; Syaiful S et.al, 2024; Syaiful S, Yulianto M, 2017). These spaces are often subject to regulations that limit the duration of parking, require payment, or restrict parking during certain hours. On-street parking is typically more convenient for short-term use but can reduce the overall capacity of roadways, leading to traffic bottlenecks. Off-street parking includes facilities such as parking lots, garages, and multi-level parking structures. These facilities are designed to handle a larger volume of vehicles and are usually located near commercial centers, transit hubs, or residential complexes. Off-street parking alleviates the burden on roadways, contributing to smoother traffic flow (Syaiful S, Suherman S, 2024; Syaiful S et.al, 2023; Syaiful S et.al, 2023; Pratama FA et.al, 2023; Ode AL Tafakud La et.al, 2023).

Effective parking management is a cornerstone of modern urban planning. Cities implement various strategies to balance the supply and demand for parking spaces. One common approach is dynamic pricing, where the cost of parking fluctuates based on demand and time of day. This method encourages turnover, ensuring that spaces are available for those who need them most. Zoning regulations also play a critical role by mandating the inclusion of parking facilities in new developments Syaiful S, Rulhendri R, 2014; Sulastri D et.al, 2020; Sah MB, 2021). However, excessive parking requirements can lead to inefficient land use and discourage higher-density development. The integration of technology has transformed the landscape of parking and traffic management. Smart parking systems leverage sensors, cameras, and mobile applications to provide real-time information on available parking spaces. This technology reduces the time drivers spend searching for parking, thereby decreasing traffic congestion and lowering emissions. Additionally, automated parking facilities maximize space utilization by employing robotic systems to park and retrieve vehicles. These advancements contribute to more efficient and user-friendly parking experiences (Rakhmatulloh AR et.al, 2021; Sihombing SB et.al, 2021; Syaiful S et.al, 2022; Handajani M et.al, 2021).

The environmental impact of parking facilities is an increasingly important consideration. Large parking lots and garages can contribute to the urban heat island effect, where built environments absorb and retain heat, raising local temperatures. Furthermore, impervious surfaces associated with parking facilities can lead to stormwater runoff, which may carry pollutants into nearby water bodies. To mitigate these effects, urban planners incorporate green infrastructure elements such as permeable pavements, green roofs, and tree-lined parking areas Rachim Y et.al, 2021; Dewi DIK et.al, 2022; Syaiful S et.al, 2022; Khodam F et.al, 2022). These measures not only reduce

environmental impact but also enhance the aesthetic appeal of parking facilities. From a traffic engineering perspective, the design and layout of parking facilities significantly influence traffic flow and safety. Well-designed parking lots and garages feature clear signage, adequate lighting, and efficient entry and exit points to minimize conflicts between vehicles and pedestrians. The incorporation of designated spaces for bicycles, electric vehicles, and car-sharing services reflects the evolving nature of urban mobility. Additionally, drop-off and pick-up zones for ride-hailing services are increasingly integrated into parking facility designs to accommodate changing transportation patterns (Nur A et.al, 2022; Wiwoho MS, Zakki FA, 2023; Malaiholo D et.al, 2023; Rosdiana UM, Setiawan B, 2023).

The demand for parking varies depending on the context and purpose of the area. In commercial districts, high turnover rates necessitate short-term parking solutions, while residential areas require long-term parking for residents and visitors. Event venues and shopping centers often experience peak demand during specific hours, prompting the need for flexible parking solutions that can adapt to fluctuating usage patterns. Mixed-use developments, which combine residential, commercial, and recreational spaces, present unique challenges and opportunities for parking management. Shared parking strategies, where different users utilize the same parking spaces at different times, optimize space usage and reduce the overall need for parking infrastructure (Permana SG, Dwiatmoko H, 2023; Anshary S et.al, 2023).

Public transportation plays a pivotal role in reducing parking demand and alleviating traffic congestion. Park-and-ride facilities, located near transit stations, encourage commuters to leave their vehicles and complete their journeys using public transit. This approach reduces the number of vehicles entering urban cores, easing traffic pressure and lowering greenhouse gas emissions. The integration of parking facilities with public transportation networks enhances accessibility and promotes sustainable mobility practices. The economic implications of parking are multifaceted. Parking fees generate revenue for municipalities, which can be reinvested into infrastructure improvements and public services. Conversely, the cost of constructing and maintaining parking facilities can be substantial, often influencing the overall cost of development projects. In some cases, the financial burden of providing parking is passed on to consumers through higher prices for goods, services, or housing. Balancing the economic benefits and costs of parking is a critical consideration for policymakers and urban planners (Syaiful S et.al, 2023; Martana SH, Swasto DF, 2024).

RESEARCH METHODS

Parking Definition

The condition of the vehicle stops or does not move for a while and is left behind by the driver (Ministry of Transportation Research and Development Center, 2005; Law No. 22 of 2009 concerning Road Traffic and Transportation).

Parking Space Unit

The length and width of the parking space are usually adjusted to the size of the parked vehicle. While the size of the vehicle varies, the Parking Space Unit (SRP) is determined.

Place and time of research

The research was conducted at Depok Baru Station, Depok, Pancoran Mas sub-district, Depok City. The research was conducted in May-June 2023. This research was carried out for four weeks, in one week the research was conducted in four days, namely Monday, Tuesday, Wednesday and Thursday at 06.00–18.00 WIB.

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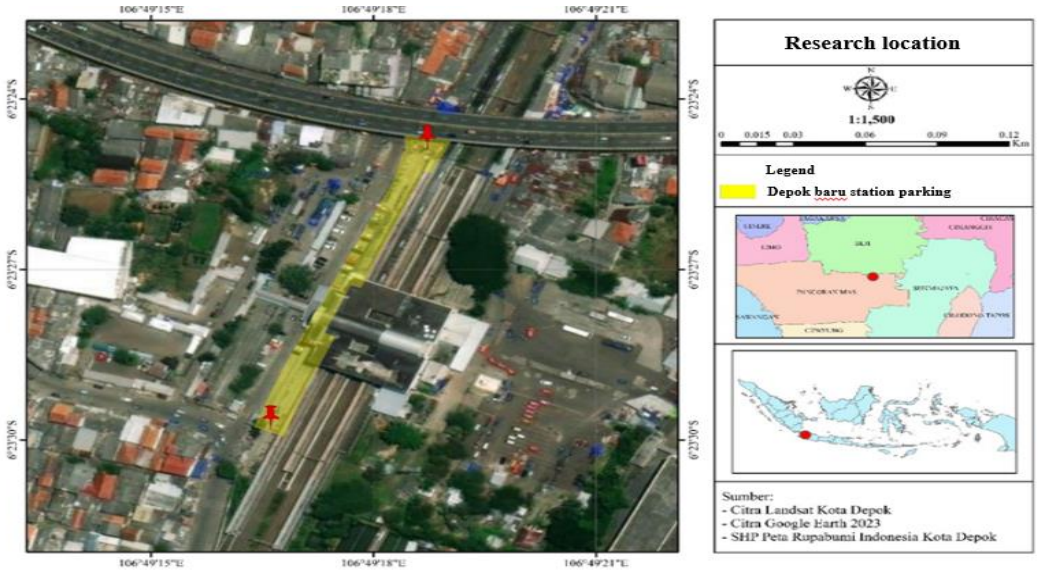

Figure 1. Map of research locations (Source: Arcgis).

Data processing

The data used for analysis uses quantitative methods in the form of primary data by research needs. Data was obtained by conducting a direct review at the research location. From the results of the survey carried out, obtaining data directly in the research area can be done as follows:.

a. Data on the number of incoming and outgoing vehicles.
b. The size of the motorbike parking space at Depok Baru Station.
c. Data represents peak hours, peak days, normal hours, and normal days.
d. The SRP amount is based on the parking slots at Depok Baru Station.

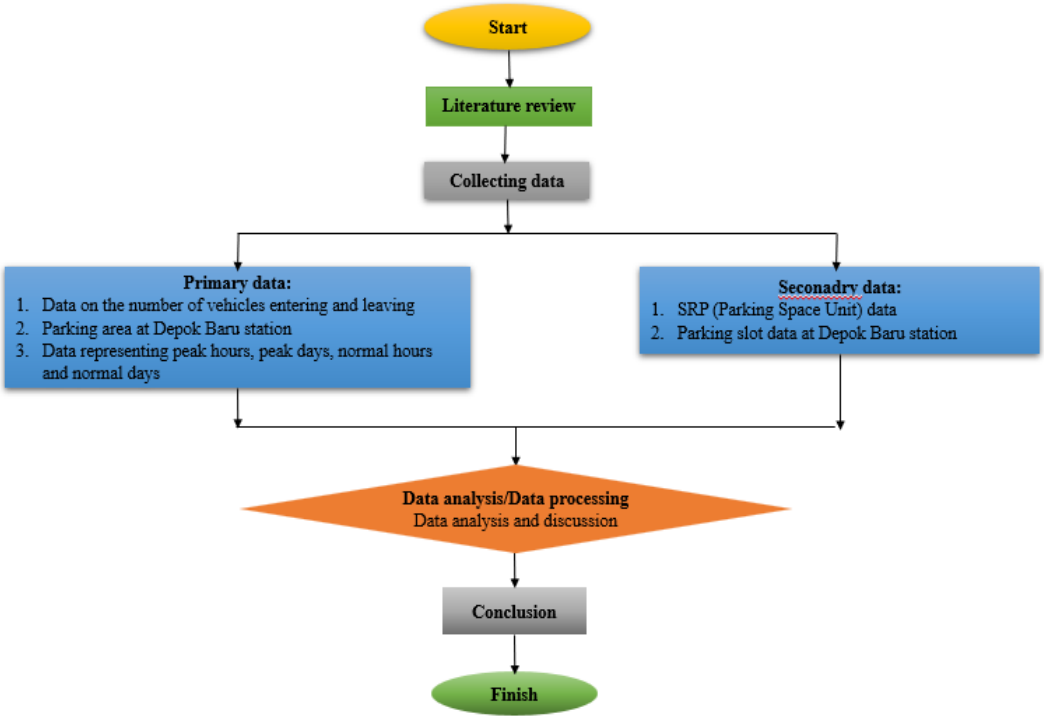

Figure 2. Research flow chart

RESULTS AND DISCUSSION

Existing form of parking at Depok Baru Station

From the results of the review that has been carried out at Depok Baru Station, the parking requirements at Depok Baru Station cannot meet the capacity standards for the parking space units available at the research location. The total parking area available for motorbikes is 300 SRP, so many motorbike users prefer to park haphazardly and irregularly in this area.

Figure 3. The existing condition of parking at Depok Baru Station

Research data

Data collection activities carried out at Depok Baru Station started on June 12, 2023 to July 22, 2023, while vehicle volume data collection was carried out for eight days, namely Monday June 12, 2023 to Thursday, June 22, 2023.

Research variable

To accommodate the need for parking space, several variables can influence the need for parking space, including:

Number of vehicles

Based on research results and calculations of vehicle accumulation, it was found that the highest average number of motorbikes parked occurred on Tuesdays at 07:40–08:00, amounting to 34 vehicles.

Parking area

The parking area at Depok Baru Station is 840m^2.

Vehicle planning when entering and leaving

Parking volume

Parking volume is the number of vehicles parked at the study location during a certain period, in this case, the calculation is grouped at every 20 minutes. By knowing the volume of parked vehicles from a parking facility, you can determine the size of the parking space needed to accommodate the volume of parked vehicles that occur. The larger the vehicle volume, the greater the need for parking space. Next, analysis of the survey data was carried out to obtain the parking volume at the study location for 13 hours in Table 1and Figure 4 below.

Table 1. Bicycle parking volume

Number of Vehicles Entering Per Day

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No	Day/date	Times	Value of vehicle
1.	Monday, June 12, 2023	06:00 - 19:00	483
2.	Tuesday, June 13, 2023	06:00 - 19:00	431
3.	Wednesday, June 14, 2023	06:00 - 19:00	458
4.	Thursday, June 15, 2023	06:00 - 19:00	442
5.	Monday, June 19, 2023	06:00 - 19:00	443
6.	Tuesday, June 20, 2023	06:00 - 19:00	459
7.	Wednesday June 21, 2023	06:00 - 19:00	426
8.	Thursday, June 22, 2023	06:00 - 19:00	470

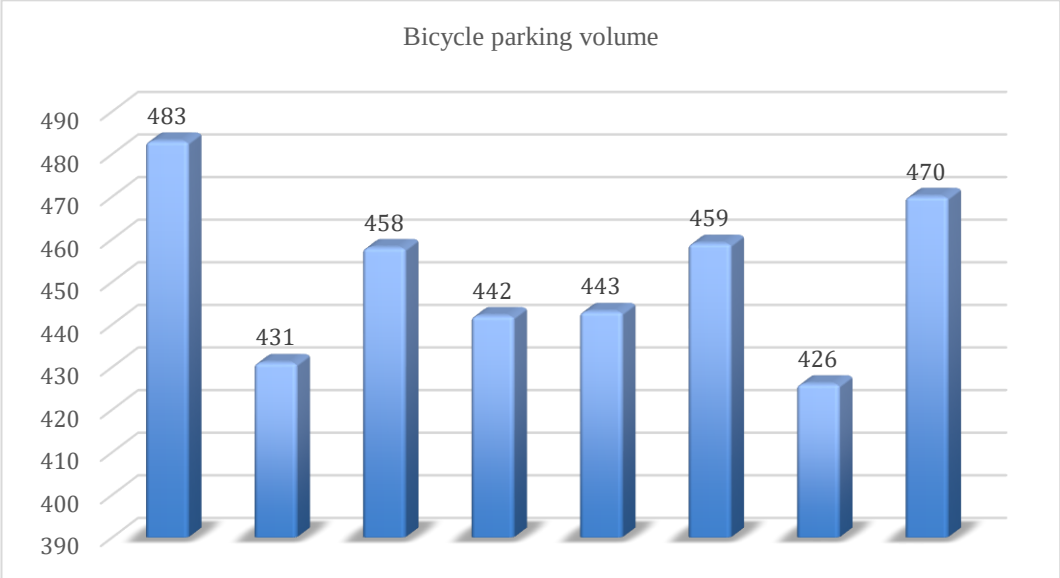

Figure 4. Bicycle parking volume

Peak vehicle entry time

Peak vehicle entry hours are the largest time period when motorists enter the parking area. In this case, peak vehicle entry hours are grouped based on the largest number in the period per day as presented in Table 2 and Figure 5 below:

Table 2. Peak vehicle entry hours

No	Day/date	Times	Total Motorcycles
1	Monday, June 12, 2023	08:00 - 08:20	33
2	Tuesday, June 13, 2023	07:40 - 08:00	34
3	Wednesday, June 14, 2023	07:40 - 08:00	30
4	Thursday, June 15, 2023	08:20 - 08:40	27
5	Monday, June 19, 2023	08:00 - 08:20	29
6	Tuesday, June 20, 2023	07:40 - 08:00	27
7	Wednesday June 21, 2023	08:40 - 09:00	32
8	Thursday, June 22, 2023	07:40 - 08:00	28

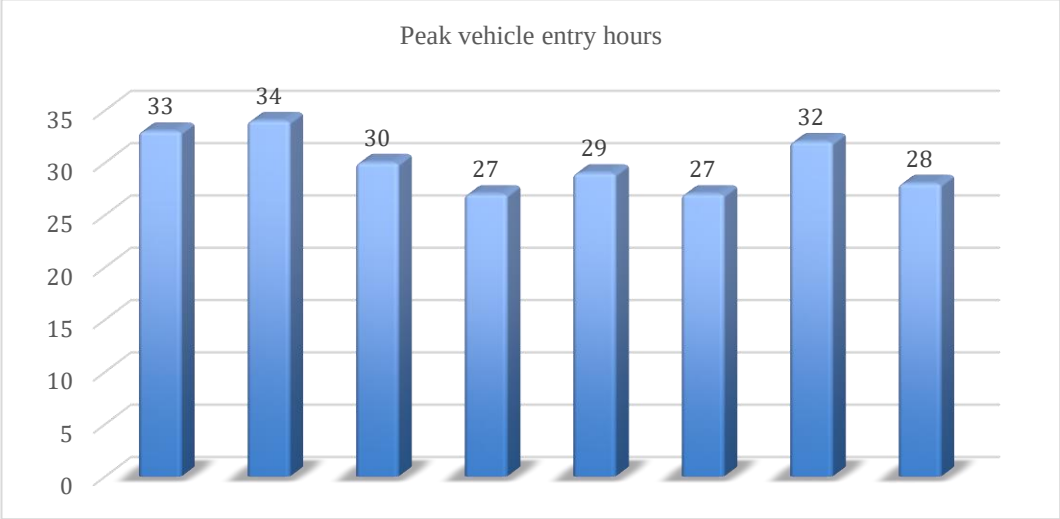

Figure 5. Peak vehicle entry hours

Based on Table 2 and Figure 5 above, it can be seen that the highest peak vehicle entry period occurred on Tuesday 13 June 2023 with a total of 34 vehicles.

Peak time is out

Peak vehicle exit hours are the largest period of time when drivers leave the parking area. In this case, peak vehicle exit hours are grouped based on the largest number in the period per day as presented in Table 3 and Figure 6 below:

Table 3. Peak vehicle exit hours

Number of Vehicles out of Peak Hour			
No	**Day/date**	**Times**	**Total Motorcycles**
1.	Monday, June 12, 2023	15:20 - 15:40	42
2.	Tuesday, June 13, 2023	17:20 - 17:40	41
3.	Wednesday, June 14, 2023	16:40 - 17:00	36
4.	Thursday, June 15, 2023	15:40 - 16:00	36
5.	Monday, June 19, 2023	15:00 - 15:20	39
6.	Tuesday, June 20, 2023	14:20 - 14:40	33
7.	Wednesday June 21, 2023	14:00 - 14:20	31
8.	Thursday, June 22, 2023	17:20 - 17:40	58

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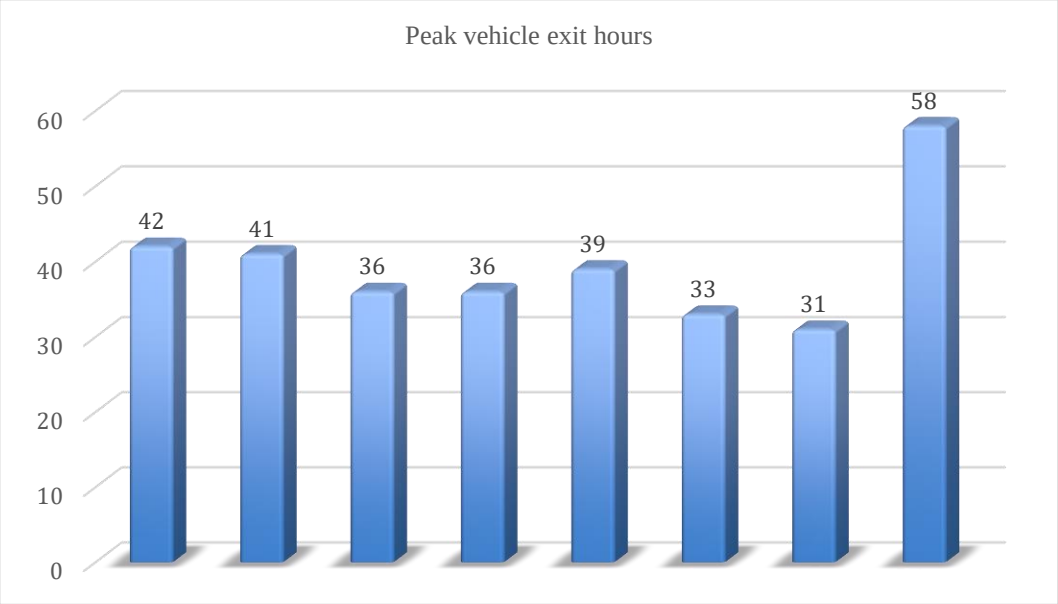

Figure 7. Peak vehicle exit hours

Based on Table 4 and Figure 7 above, it can be seen that the peak hour period for the highest number of vehicles occurred on Tuesday 13 June 2023 with a total of 34 vehicles.

Parking accumulation

Parking accumulation is the number of vehicles parked in a place at a certain time and can be divided according to the type and purpose of travel. Peak parking times and the number of parked vehicles can be obtained from the parking accumulation results. Data obtained over eight days recorded the number of vehicles entering and leaving and then grouped them into 20 minute time intervals, to obtain the percentage distribution of vehicles entering and exiting and parking accumulation figures. Based on Table 5, the accumulated parking and total entry and exit of motorbike riders at Depok Baru Station can be seen by the number of motorbikes available for each interval per 20 minute survey. The following is the maximum accumulation of parking which is presented in Table 5 and Figure 8 below.

Table 5. Maximum accumulation

No	Day/date	Peak Hour (WIB)	Maximum Accumulation (vehicles)
1.	Monday, June 12, 2023	12:40 - 13:00	424
2.	Tuesday, June 13, 2023	11:40 - 12:00	334
3.	Wednesday, June 14, 2023	13:00 - 13:20	400
4.	Thursday, June 15, 2023	12:40 - 13:00	344
5.	Monday, June 19, 2023	12:40 - 13:00	289
6.	Tuesday, June 20, 2023	13:00 - 13:20	363
7.	Wednesday June 21, 2023	13:00 - 13:20	356
8.	Thursday, June 22, 2023	13:40 - 14:00	398

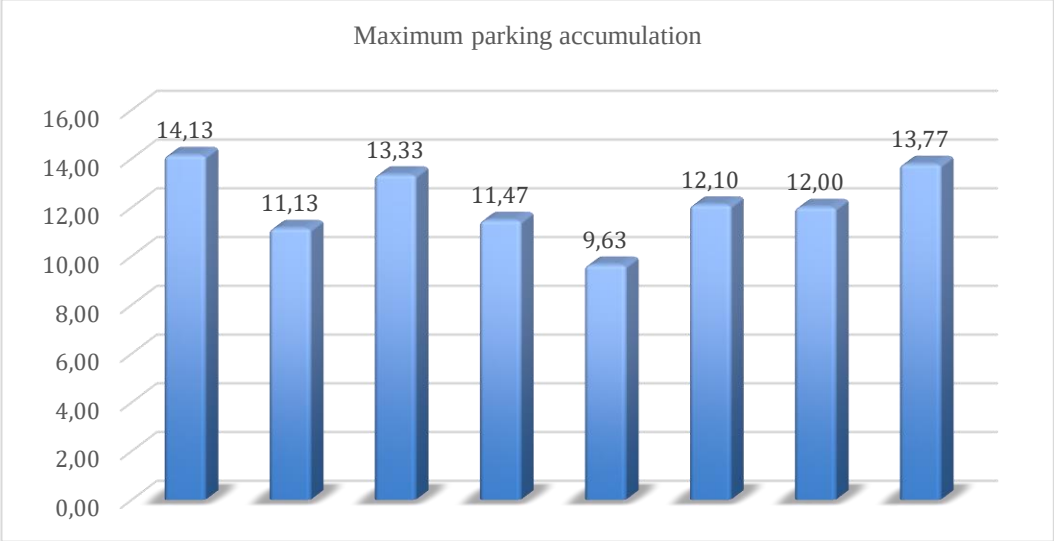

Figure 8. Maximum parking accumulation

The total number of motorbikes entering and leaving on Monday 12 June 2023 can be seen in Table 5 and Figure 8, parking accumulation, the total number of motorbike vehicle exits can be seen in Table 4 and Figure 7 peak vehicle exit hours, as for the number of bicycle vehicle entries motorbikes can be seen in Table 3 and Figure 6 peak vehicle entry hours. The maximum number of motorbikes entering the parking area was 33 motorbikes (6.832%) during the hours of 07:00-08:20. The maximum total of motorbikes leaving the parking lot was 42 vehicles (8.696%) which occurred at 15:20-15:40. Maximum parking accumulation of 424 vehicles is from 12:40-13:00.

Parking duration

Parking duration is the time span for a vehicle to park in a place (in hours). Based on the research results above, it was found that the average parking duration was 20 minutes, as presented in Table 6 and Figure 9 as follows:

Table 6. Parking duration

No	Day/date	Observation Time (WIB)	Maximum Duration (Hours)	Minimum Duration (Hours)	Average Duration (Hours)
1	Monday, June 12, 2023	06:00 - 19:00	11:37	01:20	06:36
2	Tuesday, June 13, 2023	06:00 - 19:00	12:20	00:40	06:25
3	Wednesday, June 14, 2023	06:00 - 19:00	11:56	01:01	06:27
4	Thursday, June 15, 2023	06:00 - 19:00	10:51	00:49	05:57
5	Monday, June 19, 2023	06:00 - 19:00	11:13	06:28	06:28
6	Tuesday, June 20, 2023	06:00 - 19:00	11:47	00:56	06:13
7	Wednesday June 21, 2023	06:00 - 19:00	11:50	01:35	06:27
8	Thursday, June 22, 2023	06:00 - 19:00	11:06	00:32	06:40
		Max		12:20	
		Average		06:24	
		Min		00:32	

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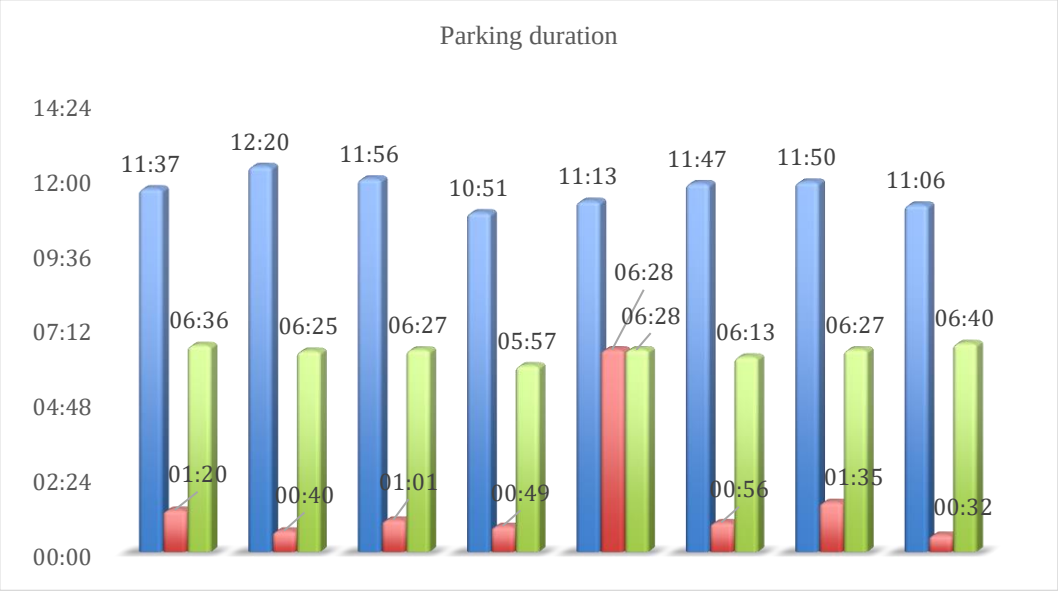

Figure 9. Parking duration

Based on Table 6 and Figure 9 above, it can be seen that the maximum duration will take place on Tuesday 13 June 2023 at 12:20 hours. For the maximum average period it will take place on Wednesday 22 June 2023 at 06:40 hours, and for the minimum period it will take place on Tuesday 13 June 2023 at 00:40 hours.

Turn over parking lot

Parking turnover is the level of use of parking spaces and is obtained by dividing the parking volume by the number of parking spaces for a certain period, as in equation 2.4. By knowing the parking turnover value, you can determine the level of parking space usage as presented in Table 7 and Figure 10 below:

Table 7. Parking turnover turnover

No	Day/date	Parking Capacity (SRP)	Parking Volume (Vehicles)	Parking Turn Over
1	Monday, June 12, 2023	300	483	161,00
2	Tuesday, June 13, 2023	300	431	143,67
3	Wednesday, June 14, 2023	300	458	152,67
4	Thursday, June 15, 2023	300	442	147,33
5	Monday, June 19, 2023	300	443	147,67
6	Tuesday, June 20, 2023	300	459	153,00
7	Wednesday June 21, 2023	300	426	142,00
8	Thursday, June 22, 2023	300	470	156,67
			Max	161,00
			Average	150,50
			Min	142,00

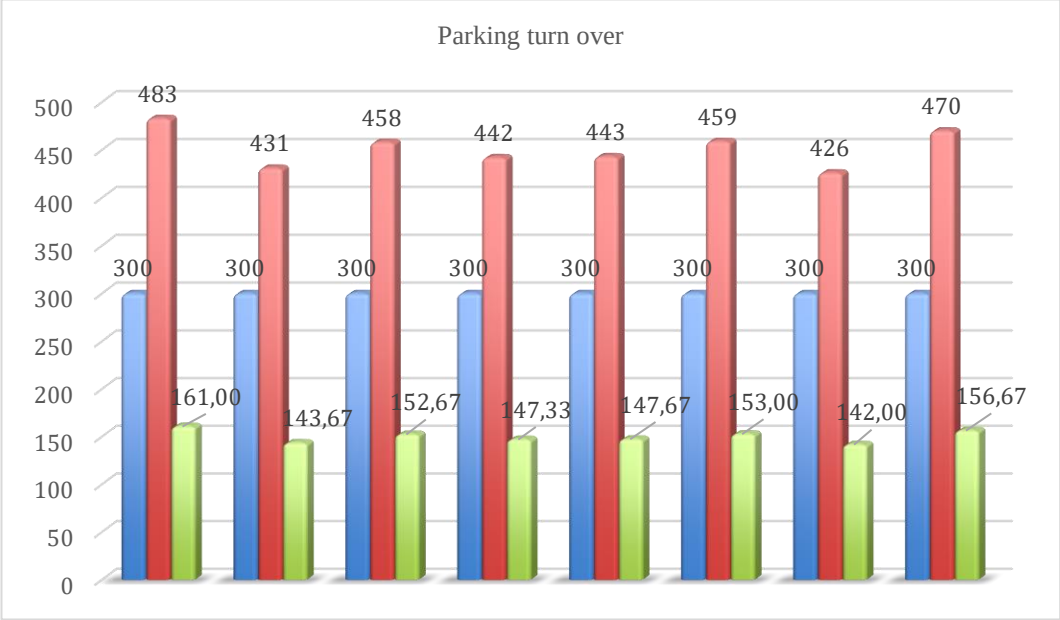

Figure 10. Parking turn over

Based on Table 7 and Figure 10, the motorbike parking turnover rate with the highest value is 161.00%, the average value is 150.50%, and the minimum value is 142.00%. This shows that the parking performance of motorbikes is quite optimal, exceeding 100%.

Parking index

Parking performance can also be reviewed through parking index numbers. The motorbike parking index value at Depok Baru Station is based on the maximum parking accumulation. The parking index after going through the calculation stage is presented in Table 8 and Figure 11 as follows:

Table 8. Parking index

No	Day/date	Parking Capacity (SRP)	Parking Accumulation (Maximum)	Parking Index (%)
1	Monday, June 12, 2023	300	424	141,33
2	Tuesday, June 13, 2023	300	334	111,33
3	Wednesday, June 14, 2023	300	400	133,33
4	Thursday, June 15, 2023	300	344	114,67
5	Monday, June 19, 2023	300	289	96,33
6	Tuesday, June 20, 2023	300	363	121,00
7	Wednesday June 21, 2023	300	360	120,00
8	Thursday, June 22, 2023	300	413	137,67
			Max	141,33
			Average	121,96
			Min	96,33

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Figure 11. Parking index

Based on Table 8 and Figure 11 above, the motorbike parking index that occurs at the maximum value is 195.00%, the average value is 156.39%, and the minimum value is 98.89% (based on maximum accumulation). The parking index value obtained states that the demand for parking spaces is greater than parking capacity because it has an index value of more than 100%.

Analysis of parking space requirements

Parking space requirements

Based on the results of calculations using equation 2, it is concluded that the need for parking space at Depok Baru Station is as presented in Table 9 and Figure 12 as follows:

Table 9. Parking space requirements

No	Day/date	Survey Duration (Hours)	Parking Volume (Vehicles)	Average Duration (Hours)	Parking Space Needs
1	Monday, June 12, 2023	13	483	06:36	357,78
2	Tuesday, June 13, 2023	13	431	06:25	307,29
3	Wednesday, June 14, 2023	13	458	06:27	328,23
4	Thursday, June 15, 2023	13	442	05:57	292,21
5	Monday, June 19, 2023	13	443	06:28	318,30
6	Tuesday, June 20, 2023	13	459	06:13	317,05
7	Wednesday June 21, 2023	13	426	06:27	305,30
8	Thursday, June 22, 2023	13	470	06:40	348,15
				Max	357,78
				Average	321,79
				Min	292,21

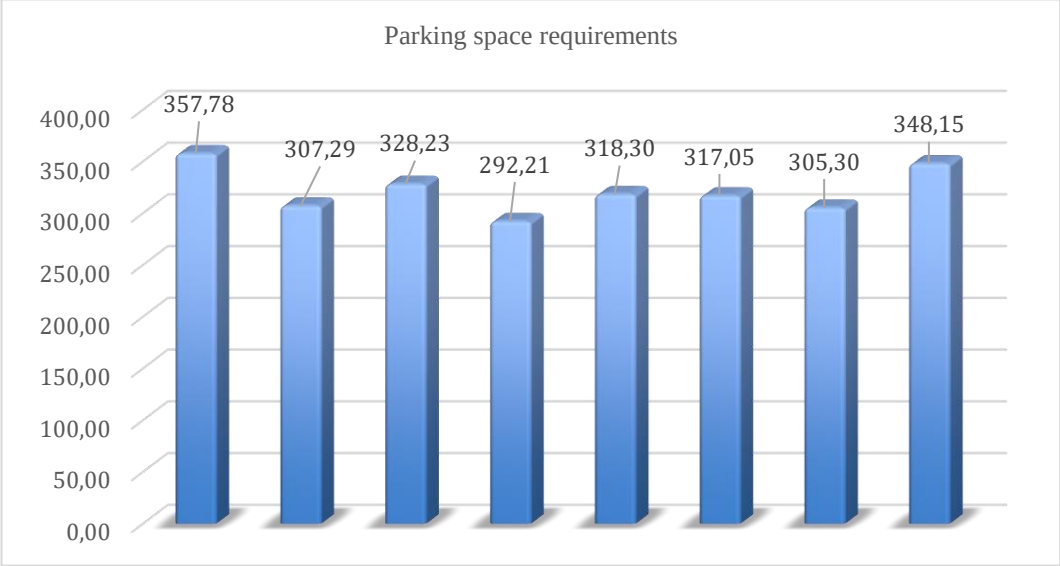

Figure 12. Parking space requirements

Based on Table 9 and Figure 12, it shows that the largest parking space requirement for motorbikes at Depok Baru Station takes place on Monday, June 12 2023, amounting to 358 SRP.

Standard parking space capacity requirements

Based on the data analysis that has been carried out, the existing parking capacity and parking space requirements can be found by analyzing the total number of parked vehicles against the available parking space capacity. If the parking space requirement is greater than the existing parking capacity then the total parking space is not sufficient to accommodate the total. vehicle. If the parking space requirement is smaller than the existing parking capacity, then the total available parking space is still able to accommodate vehicles that will park in that area. The largest parking space requirement based on the equation 2 approach is determined as the value of the parking space requirement that must be met by the Depok Baru Station. If the parking space requirement is determined based on the results of research in the field, then the value of the parking space requirement taken is at the time of maximum accumulation. The following is a comparison of parking space requirements versus parking space capacity which is presented in Table 10 and Figure 13 below.

Table 10. Parking space capacity requirements

No	Day/date	Parking Space Needs	Parking Space Capacity	Parking Space Capacity Difference (+/-)
1	Monday, June 12, 2023	357,78	300	-58
2	Tuesday, June 13, 2023	307,29	300	-7
3	Wednesday, June 14, 2023	328,23	300	-28
4	Thursday, June 15, 2023	292,21	300	8
5	Monday, June 19, 2023	318,30	300	-18
6	Tuesday, June 20, 2023	317,05	300	-17
7	Wednesday June 21, 2023	305,30	300	-5
8	Thursday, June 22, 2023	348,15	300	-48
			Max	8
			Average	-22
			Min	-58

Description: (+) = Parking space capacity is still sufficient
(-) = Parking space capacity is not sufficient

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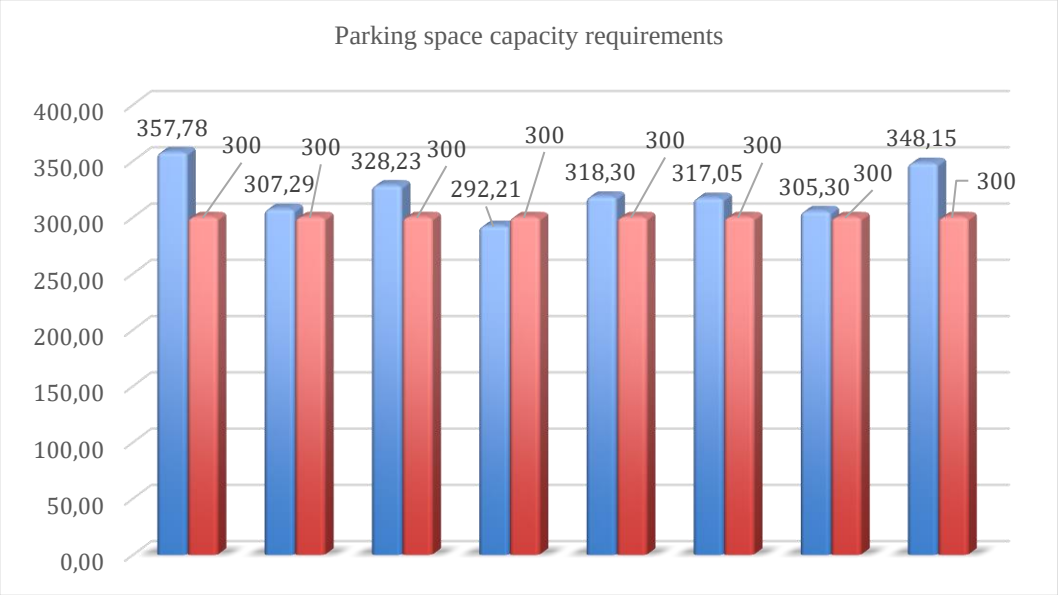

Figure 13. Parking space capacity requirements

Based on Table 10 and Figure 13, the parking space capacity requirement is shown on Monday, June 12 2023. The parking space requirement is 358 SRP, while the parking capacity available at the research location is 300 SRP, so the difference between parking space requirements and parking capacity is -58 SRP

CONCLUSION

Based on the results of the survey and analysis of the data obtained, namely the conditions at the research location, primary data was obtained using the survey method. Data was obtained by conducting a direct survey in the field and obtained results of an area of 840m2 of motorbike parking area with a capacity of 300 (parking space units) SRP and a slope angle of 90° at Depok Baru Station. In this analytical research, the highest accumulated capacity results were 358 vehicles with an average parking duration of 12.20 hours on Tuesday 13 June 2023. During the eight days of the survey it was discovered that the maximum parking volume was 480 vehicles with a maximum accumulated vehicle parking of 424 vehicles occurred on Monday 12 June 2023, the highest motorbike parking turn over at Depok Baru Station reached 161.00%, this shows that the performance of motorbike parking is very large. The capacity of motorbike parking spaces at Depok Baru Station cannot meet existing parking needs. This can be seen in the parking index which exceeds 100%.

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