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Analysis of Parking Characteristics in Rest Area Km 726 B in Planning Parking Space Needs at Rest Area Facilities STA 19+600 Manjungan Klaten Village Solo-Yogyakarta-Nyia Kulon Progo Toll Road Section I Package 1.1 Solo Klaten (STA 0+000 – 22+300)

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ABSTRACT
The problem of traffic jams continues to increase, the government is designing an alternative road connecting Surakarta to Yogyakarta. The increasing volume of vehicles on the Solo - Yogyakarta toll road makes accidents prone due to driver negligence. To reduce the risk of accidents and relieve fatigue after traveling, one of the policies taken is to build rest areas and facilities. The method used in the research is a direct survey to obtain primary data in the form of incoming and outgoing vehicle data, the number of existing parked vehicles, facilities in rest areas and secondary data in the form of daily traffic on the Solo - Yogyakarta toll road obtained from PT. JMM. Based on the condition of the existing rest area, it is necessary to analyze the parking facilities to get an idea of parking capacity and parking space requirements. The guideline used in the research is "Guidelines for Planning and Operation of Parking Facilities for the Directorate of City Transport Traffic System Development 1998", as well as references related to parking analysis. The conclusion of the analysis results is that the parking space needed for the Solo-Yogyakarta toll road in the 2024 planning year is 271 SRP, the volume of incoming vehicles is 2751, the accumulation is 206 vehicles, the parking index is 75.99%, the turnover is 10.15, and in 2033 there are parking spaces. What is needed is a capacity of 541 SRP, a volume of incoming vehicles of 5495, an accumulation of 411 vehicles, a parking index of 76.07%, and a turnover of 10.16.

Keywords: Rest Area Facilities, Solo-Yogyakarta Toll Road, Parking Space Requirements

INTRODUCTION
The Solo-Yogyakarta-NYIA Kulon Progo Section I Package 1.1 Solo – Klaten Toll Road Development Plan (STA 0+000 - 22+300), is a continuation of the Solo-Ngawi Toll Road which is part of the Trans Java Toll Road series and part of a program delayed due to the 1997 monetary crisis. The increasing volume of vehicles crossing the Solo - Yogyakarta toll road causes accidents due to negligence of road users. One of the negligence of road users is fatigue while driving (Pramesti & Widajati, 2021). In the laws and regulations regarding traffic and road transportation, there are terms and conditions that state that every driving a vehicle for 4 hours must rest for at least half an hour, to release fatigue, take a nap or drink coffee, eat, or go to the toilet. Aware of this, research will be carried out on the Rest and Service Area (Rest Area) STA 19+600 Manjungan Klaten Village on the Construction of the Solo - Yogyakarta - NYIA Kulon Progo Toll Road Section 1.1 (STA 0+000 - 22+300).(Rahayu Y. S., 2022)(Salim, 2020)(Destiasri, 2011)

Theoretical Foundation

Highway
Toll roads have a relatively high risk of accidents compared to other types of roads (Zaini

& Maulana, 2024). Safety is a major factor of road design. Road infrastructure as one of the causes of traffic accidents must be designed and built by accommodating all aspects of safety for its users with consideration to minimize the risk of traffic accidents.(Rifai, Hadiwardoyo, Correia, & Pereira, 2016)(Mandal, Pawade, Sandel, & Infrastructure, 2019)(Pembuain, Priyanto, & Suparma, 2019)

Rest Area

Rest Area is a rest area equipped with various public facilities for toll road users, so that both drivers, passengers, and vehicles can rest temporarily. (PERMEN-PUPR, 2028)Rest Area is a facility that provides opportunities for drivers, crew, passengers, and vehicles to stop and rest. As for the vehicle, the Rest Area can refuel, check the vehicle, wash the vehicle and rest the engine.(Purnamasari, 2012)

Parking Characteristics

According to the Technical Guidelines for the Implementation of Parking Facilities of the Directorate General of Land Transportation (1998: 1), parking is a temporary state of immovability of a vehicle, while the definition of stopping is a state of temporary immovability of a vehicle with the driver not leaving his vehicle. Parking characteristics are parameters that affect the utilization of parking lots. Through parking characteristics, parking conditions can be known that occur at the study location.(Raihana & Widyaningsih, 2021)

Parking Index

The parking index is a comparison between parking accumulation and parking capacity (Herdiansyah et al., 2017). Using the parking index it can be known whether or not the parking demand is comparable to the available capacity (Dogaroglu et al., 2021). The formula used to calculate the parking index value is:

$$IP = \frac{\text{Akumulasi Parkir}}{\text{Kapasitas Parkir}} \times 100\% \quad \text{..... (1)}$$

Where applicable conditions: IP < 1, meaning that parking capacity is not problematic.
IP = 1, meaning parking needs are balanced, normal capacity.
IP > 1, meaning that parking needs exceed normal capacity.

Parking Duration

Parking duration can be seen based on the average parking time of a vehicle somewhere in a unit of time. For each vehicle the formula is calculated:

Duration= TIN – TOUT..... (2)

The average longest duration of time for parked vehicles of all vehicles is calculated by the equation

D= (d1 + d2+ ...+ dn)/n. ..... (3)

Where: D = longest duration
D1, D2, DN = Duration of parking time for each vehicle

Accumulated Parking

Accumulated parking can be used as a measure of parking space needs at the study site. The amount of accumulated parking can be determined by the following formulation (Hobbs, 1995).

AP = KM – KK + P .....(4)

Where: AP = Accumulated Parking MILES = Number of incoming vehicles
KK = Number of vehicles out P = Number of vehicles still in the parking lot

Parking Turn-Over and OccupancyRate

Parking turnover is the rate of use of parking spaces and is obtained by dividing the parking volume by the number of parking spaces for a given period. The equation used to find parking turnover is as follows (Hobbs, 1995):

$$\text{Parking turnover} = \frac{\text{Volume Parkir}}{\text{Kapasitas Parkir}} \quad \text{..... (5)}$$

Parking Volume

Parking volume is vehicles that participate in a parking load (i.e. vehicles with a certain period of time). The formulation used is (Hobbs, 1995):

$V = Ei + x$ ..... (6)

Where: Ei = Number of incoming vehicles

x = Number of existing vehicles

RESEARCH METHODS

The steps taken in analyzing the data obtained are to analyze the use of parking spaces by taking into account the characteristics of parking, namely parking volume, parking accumulation, parking duration, parking usage rate, parking index, traffic volume.After analyzing the data and finding a result, the next step is to draw conclusions from the study.

RESULTS AND DISCUSSION

Growth in the Number of Vehicles

Vehicle growth is planned based on secondary data obtained from PT. JMM is daily traffic data that spans 10 years.

Table 1. Daily Traffic List of Solo Jogja Toll Road Section 1.1 (Data source : PT. JMM)

NO	YEAR	TOTAL AMOUNT	%	NO	YEAR	TOTAL AMOUNT	%
1	2024	7.007		6	2029	11.035	7,23%
2	2025	8.061	15,05%	7	2030	11.779	6,73%
3	2026	8.805	9,22%	8	2031	12.518	6,28%
4	2027	9.548	8,44%	9	2032	13.258	5,91%
5	2028	10.292	7,79%	10	2033	13.998	5,58%
	Average Growth Amount						**8,03%**

General Conditions of Rest Area 726 B

The location of rest area 726 B is very strategic located on the toll road between Surabaya - Mojokerto, commonly referred to as Sumo Toll Road. The clean and comfortable rest area of 726 B helps the driver restore power and relieve drowsiness. Apart from being a place to rest, toll road users can also refuel, go to the toilet, perform prayers, buy necessities during the trip at the supermarket and can take a break at restaurants or food court kiosks available at the location.

Geometry Analysis

Layout Rest Area 726 B

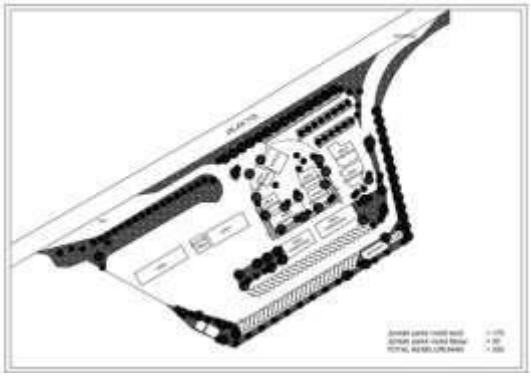

Figure 1. Lay Out Rest Area Km 726 B (Source: survey results)

Parking Dimensions

In Indonesia, the standard that is always used in planning parking dimensions is the Directorate General of Land Transportation Standard in 1998 concerning technical guidelines for the implementation of parking facilities.

Table 2. Comparison of Parking Space Dimensions (Source: Analysis Results)

Vehicle Type	Parking Space Unit		Deviation (m)
	Rest Area Km 726B	Director General of Land Transportation	
Group I	5mx2.3m	5mx2.3m	0
Group II	5mx3m	5mx2.5m	0,5
Group III	5mx3m	5mx3m	0

Rest Area 726 B Inventory

The rest area facility used as a research area is Km 726 B has an area of approximately 5,432 Ha. The vehicle parking area in rest area 726 B has a planned capacity of 225 SRP which is calculated directly on site based on the SRP that is already available in the rest area.

Table 3. List of Public Facilities (Source: survey results)

NO	FACILITIES	NO	FACILITIES	NO	FACILITIES
1	Gas Station	10	Sego Sambel Yu Djum	19	Soto Madura Wawan
2	Mosque	11	Soto Ayam Joyo Trisno	20	Soto Ambengan Mr. Sadi
3	Toilet 1 and Toilet 2	12	Bakmi Jowo	21	Alfa Express
4	ATM	13	Soto Mie Pak Udin	22	Indomart
5	Starbuck Coffee	14	Hepi Dei Coffee	23	Simpang Raya restaurant
6	Kenangan	15	Siomay Prijaji	24	Souvenir Shop

NO	FACILITIES	NO	FACILITIES	NO	FACILITIES
	Coffee				
7	Mc Donalds	16	Bread Boy	25	Patata
8	Rawon Nguling	17	Cak Man City Meatballs	26	Rosin Juice
9	Pecel Yu Gembrot	18	Solaria	27	Solo Meatballs

Parking Characteristics

Results of License Plate Recording Survey, Time of Vehicle Entering and Leaving the Parking Area

The survey time has been set for Saturday, December 9, 2023, according to (Mauren & Lay, 2016) in the journal "Analysis of Traffic Volume Characteristics on the Road" it is explained that the busiest days of the week are Friday and Saturday. The survey was conducted at the parking location in the rest area, namely the entrance and exit of parking in the rest area 726 B Krian starting from 09.00 to 21.00. From the survey results, it was found that the number of vehicles entering was 2283 vehicles and the number of vehicles leaving was 2283 vehicles as shown in table 4.6 below:

Table 4. Survey Results of Number of Vehicles Entering and Exiting (Source: Analysis Results)

No	Hour To-	Hit	Number of Vehicles		No	Hour To-	Hit	Number of Vehicles	
			Enter	Out				Enter	Out
1	0	09.00	112		8	7	15.00-16.00	249	204
2	1	09.00-10.00	99	74	9	8	16.00-17.00	179	232
3	2	10.00-11.00	180	146	10	9	17.00-18.00	141	145
4	3	11.00-12.00	153	236	11	10	18.00-19.00	246	220
5	4	12.00-13.00	234	164	12	11	19.00-20.00	195	212
6	5	13.00-14.00	175	217	13	12	20.00-21.00	175	151
7	6	14.00-15.00	145	143	14	STAY	Above 21.00		139
							SUM	**2283**	**2283**

Parking Duration

In general, the calculation of parking duration as stated in chapter 2.3 time distribution analysis is carried out by calculating the number of vehicles parked per unit of time that is the

same according to the time span.

Table 5. Calculation of Parking Time Distribution in Rest Area KM 726B (source: analysis results)

DURATION DISTRIBUTION							
NO	**LENGTH OF PARKING**	**NUMBER OF VEHICLES**	**%**	**NO**	**LENGTH OF PARKING**	**NUMBER OF VEHICLES**	**%**
1	<1hour	1969	91,84%	8	7-8h	5	0,23%
2	1-2 hours	135	6,30%	9	8-9h	4	0,19%
3	2-3 hours	18	0,84%	10	9-10h	2	0,09%
4	3-4 hours	8	0,37%	11	10-11h	0	0,00%
5	4-5hours	1	0,05%	12	11-12h	0	0,00%
6	5-6 hours	1	0,05%	13	>12 hours	0	0,00%
7	6-7h	1	0,05%				

Parking volume and parking accumulation

Based on the equation formula (6) of chapter 4.2.1.5 the parking volume can be calculated by the following formula:

Vp=Ei + x

VP= 112+99+180+153+234+175+145+249+179+141+246+195+175= 2283

Based on the formula equation (4) parking accumulation can be calculated by the following formula:

AP = KM - KK + P

AP = 99 – 74 + 112= 137 vehicles

So that the volume of parking and accumulation that occurs can be shown in the example of calculating parking accumulation in the table below:

Table 6. Calculation of Volume and Accumulation of parking in Rest Area KM 726 B (Source: Analysis Results)

No	**Hour To-**	**Hit**	**Number of Vehicles**			**Accumulation**
			Enter	**Out**	**Deviation**	
1	Existing vehicles		112			112
2	1	09.00-10.00	99	74	25	137
3	2	10.00-11.00	180	146	34	171
4	3	11.00-12.00	153	236	-83	88
5	4	12.00-13.00	234	164	70	158
6	5	13.00-14.00	175	217	-42	116
7	6	14.00-15.00	145	143	2	118
8	7	15.00-16.00	249	204	45	163
9	8	16.00-17.00	179	232	-53	110

No	Hour To-	Hit	Number of Vehicles			Accumulation
			Enter	Out	Deviation	
10	9	17.00-18.00	141	145	-4	106
11	10	18.00-19.00	246	220	26	132
12	11	19.00-20.00	195	212	-17	115
13	12	20.00-21.00	175	151	24	139
SUM			**2283**	**2283**		

Turn Over Parking

Based on the data obtained during the observation, the parking turn over is as follows:

Turn over parking = $\frac{\text{VOLUME PARKIR}}{\text{KAPASITAS PARKIR}}$

Capacity for parking space on rest area KM 726 B :

Vehicle parking = 225 SRP

Calculation of parking turn over a day in the vehicle parking lot:

$$\frac{2283}{225} = 10{,}15$$

Turn over in the KM 726B rest area parking lot experienced an average turnover of 10.15 times.

Parking Index

From the data obtained from the observations, it can be determined the magnitude of the parking index of car and truck parking lots as follows:

IP x 100%$=\frac{\text{Akumulasi Parkir}}{\text{Kapasitas Parkir}}$

Calculation of car and truck parking index in rest area KM 726 B

Car park

Vehicle parking capacity : 225 SRP

Accumulated vehicle parking : 171 vehicles

$$\text{Indeks Parkir} = \frac{171}{225} \text{ x } 100\% = 76{,}00\%$$

The parking index of the car park in the rest area KM 726 B is 76.00%, so it can be interpreted that the parking lot can still accommodate parked vehicles.

Planning Parking Space Needs for Solo-Yogyakarta Toll Road Rest Area

In planning the need for parking spaces at STA 19+600 rest area facilities, Manjungan Klaten Village, Solo – Yogyakarta-NYIA Kulon Progo Toll Road, Section I Package 1.1 Solo-Klaten (STA 0+000 – 22+300) uses the volume of vehicles that will pass through the toll road section in the 2033 plan year as table 7 with the percentage of growth each year varies. The average growth percentage is 8.03% annually.

Table 7. Results of Daily Traffic Survey of Surabbaya Mojokerto Toll Road (Source: Survey Results)

TIME		Total Vehicles	TIME	Total Vehicles
09.00 – 21.00	09:00-10:00	512	15:00-16:00	462
	10:00-11:00	471	16:00-17:00	518
	11:00-12:00	539	17:00-18:00	425
	12:00-13:00	481	18:00-19:00	541
	13:00-14:00	430	19:00-20:00	523
	14:00-15:00	405	20:00-21:00	509
SUM				**5816**
Number of vehicles entering the rest area				**2283**
Percentage of vehicles entering the rest area				**39,25%**

Table 8. Modelling of incoming Vehicle Volume, Capacity and Accumulation (Source: Analysis Results)

Rest Area	Traffic Volume	Volume of incoming vehicles	Parking Capacity	Accumulation
Rest Area Km 726 B	5816	2283	225	171
Rest Area Plan in 2024	7007	**X1**	**Y1**	**Z1**
Rest Area Plan by 2033	13998	**X2**	**Y2**	**Z2**

To determine the estimated vehicles that will enter the rest area, parking space units (SRP) and accumulation in the planned rest area, it is necessary to calculate using the comparison below:

Calculation X1:

$$\frac{(\text{Vol LHR Eksisting})}{(\text{Volume Kendaraan Masuk})} = \frac{(\text{Volume LHR Rencana})}{(\text{Volume Kendaraan Masuk Rencana})}$$

$$\frac{5816}{7007} = \frac{2283}{\text{Volume Kendaraan Masuk Rencana}}$$

$$\text{Volume Kendaraan Masuk Rencana} = 2283 \text{ x } \frac{7007}{5816} = 2750{,}51 \sim 2751 \text{ vehicle}$$

Calculation Y1:

$$\frac{(\text{Vol Eksisting})}{(\text{Kapasitas})} = \frac{(\text{Volume Rencana})}{(\text{Kapasitas Rencana})}$$

$$\frac{5816}{225} = \frac{7007}{\text{Kapasitas Parkir Rencana}}$$

$$\text{Kapasitas Parkir Rencana} = 7007 \text{ x } \frac{225}{5816} = 271{,}08 \sim 271 \text{ SRP}$$

Z1 Calculation:

$$\frac{\text{(Vol Eksisting)}}{\text{(Akumulasi)}} = \frac{\text{(Volume Rencana)}}{\text{(Akumulasi Rencana)}}$$

$$\frac{5816}{171} = \frac{7007}{\text{Akumulasi Rencana}}$$

$$\text{Akumulasi Rencana} = 7007 \text{ x } \frac{171}{5816} = 206{,}02 \sim 206 \text{ kendaraan}$$

Calculation X2:

$$\frac{\text{(Vol LHR Eksisting)}}{\text{(Volume Kendaraan Masuk)}} = \frac{\text{(Volume LHR Rencana)}}{\text{(Volume Kendaraan Masuk Rencana)}}$$

$$\frac{5816}{13998} = \frac{2283}{\text{Volume Kendaraan Masuk Rencana}}$$

$$\text{Volume Kendaraan Masuk Rencana} = 2171 \text{ x } \frac{13998}{5816} = 5494{,}74 \sim 5495 \text{ vehicle}$$

Calculation Y2:

$$\frac{\text{(Vol Eksisting)}}{\text{(Kapasitas)}} = \frac{\text{(Volume Rencana)}}{\text{(Kapasitas Rencana)}}$$

$$\frac{5816}{225} = \frac{13998}{\text{Kapasitas Parkir Rencana}}$$

$$\text{Kapasitas Parkir Rencana} = 13998 \text{ x } \frac{225}{5816} = 541{,}53 \sim 541 \text{ SRP}$$

Z2 Calculation:

$$\frac{\text{(Vol Eksisting)}}{\text{(Akumulasi)}} = \frac{\text{(Volume Rencana)}}{\text{(Akumulasi Rencana)}}$$

$$\frac{5816}{171} = \frac{13998}{\text{Akumulasi Rencana}}$$

$$\text{Akumulasi Rencana} = 13998 \text{ x } \frac{171}{5816} = 411{,}56 \sim 411 \text{ kendaraan}$$

The composition of the Parking Capacity Plan for Cars and Trucks is calculated based on the percentage of the number of vehicles entering the Rest Area as follows:

Table 9. Calculation of Car and Truck Parking Capacity Composition in 2024 (Source: Analysis Results)

Vehicle Type	Vehicle Volume	%	Volume of Vehicles Entering the Rest Area	Capacity Parking	Accumulation	Check (accumulation <Capacity)
Rest Area Plan			39,25%	271,08	206,0	

Vehicle Type	Vehicle Volume	%	Volume of Vehicles Entering the Rest Area	Capacity Parking	Accumulation	Check (accumulation <Capacity)
					2	
Car	6238	89,02%	2449	241	183	OK
Truck	769	10,98%	302	30	23	OK
Sum	7007	100,00 %	2751	271	206	OK

Turn over parking = $\frac{\text{VOLUME PARKIR}}{\text{KAPASITAS PARKIR}}$

Capacity for parking space in rest area plan, Vehicle parking = 271 SRP
Calculation of parking turn over a day in the vehicle parking lot:

$$\frac{2751}{271} = 10{,}15$$

Calculation of the Parking Index in the rest area of the plan:

IP x 100%$=\frac{\text{Akumulasi Parkir}}{\text{Kapasitas Parkir}}$

Vehicle parking capacity : 271 SRP
Accumulated vehicle parking : 206 vehicles

$$\text{Indeks Parkir} = \frac{206}{271} \text{ x } 100\% = 75{,}99\%$$

Table 10. Calculation of Car and Truck Parking Capacity Composition in 2033 (Source: Analysis Results)

Vehicle Type	Vehicle Volume	%	Volume of Vehicles Entering the Rest Area	Capacity Parking	Accumulation	Check (accumulation <Capacity)
Rest Area Plan			39,25%	541,53	411,56	
Car	12462	89,02%	4892	482	366	OK
Truck	1536	10,98%	603	59	45	OK
Sum	13998	100,00 %	5495	541	411	OK

Turn over parking = $\frac{\text{VOLUME PARKIR}}{\text{KAPASITAS PARKIR}}$

Capacity for parking space in the rest area plan, Vehicle parking = 541 SRP
Calculation of parking turn over a day in the vehicle parking lot:

$$\frac{5495}{541} = 10{,}16$$

Calculation of Car and truck Parking Index in Rest Area plan :

$$\text{IP x } 100\% = \frac{\text{Akumulasi Parkir}}{\text{Kapasitas Parkir}}$$

Vehicle parking capacity : 541 SRP , Accumulated vehicle parking : 411 vehicles

$$\text{Indeks Parkir} = \frac{411}{541} \text{ x } 100\% = 76{,}07\%$$

CONCLUSIONS

From all the results of calculations and a series of observation processes in the field (on Saturday, December 9, 2023, it will be carried out from 09.00-21.00), several things can be concluded as follows: Volume of Vehicles Entering the Rest Area. From the results of observations at the location, it can be known that the volume of incoming vehicles is as follows: Rest Area Km 726 B, Volume of incoming vehicles = 2283 vehicles, Rest Area STA 19+600 Manjungan Klaten Village Solo – Yogyakarta-NYIA Kulon Progo Toll Road Section I Package 1.1 Solo-Klaten (STA 0+000 – 22+300) Year 2024 Volume of incoming vehicles = 2751 vehicles. Characteristics of Rest Area Parking. From the results of observations at the location, it can be seen that the characteristics of the parking lot are Rest Area Km 726 B Capacity = 225 SRP, accumulation = 171 vehicles, parking index = 76.00%, Turn over = 10.15. Rest Area STA 19+600 Manjungan Klaten Village Solo – Yogyakarta-NYIA Kulon Progo Toll Road Section I Package 1.1 Solo-Klaten (STA 0+000 – 22+300) in 2024 capacity = 271 SRP, accumulation = 206 vehicles, parking index = 75.99%, turn over = 10.15. The need for parking spaces at the Solo - Yogyakarta Toll Rest Area within the next 10 years. From the observations at the location, it can be seen that the need for parking spaces Rest Area STA 19+600 Manjungan Klaten Village Solo – Yogyakarta-NYIA Kulon Progo Toll Road Section I Package 1.1 Solo-Klaten (STA 0+000 – 22+300) within the next 10 years is in 2033 the volume of incoming vehicles = 5495 vehicles, capacity = 541 SRP, Accumulation = 411 vehicles, parking index = 76.07%, turn over = 10.16 From the observations of the author wants to give advice, there are two main things, namely: The calculation of the number of parking spaces in 2024 for class II/III/IV/V is 30 SRP, while the provisions for type A rest areas require that for class II/III/IV/V vehicles (trucks with 2 axles or more) is 50 SRP. When the construction is carried out, it is recommended to adjust the number of parking spaces for class II/III/IV/V vehicles with applicable regulations. The capacity for the next 10 years based on the results of this study is predicted to increase by 99% from 271 SRP to 541 SRP, so managers are advised to provide sufficient land area for these needs.

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