Evaluation of the Parking Space Capacity of Four-Wheeled Vehicle at the State Polytechnic of Sriwijaya

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Abstract. In order to determine whether dedicated parking places for four-wheeled vehicles are necessary on the State Polytechnic of Sriwijaya campus, this study is a follow-up on the parking situation on campus. This is very necessary to find out the need for parking lots as a reference for the design of effective parking facilities. The data collection method is carried out by means of direct surveys in the field. The data taken is primary data consisting of vehicle volume and duration. Secondary data, meanwhile, comes from the quantity of academic communities and the location of parking spots. It was concluded from processing data that the number of four-wheeled vehicle volumes exceeded the existing parking facilities with the average number of changes was 2 to 3 changes per PSU. The most parking duration for four-wheeled vehicles is 0-1 hour, and 5-6 hours with an average parking index of 132,36%. This can be interpreted as the existing four-wheeled parking capacity does not meet the need for parking spaces (exceeding the maximum parking index value of 100%) for the academic community and guests. There is a need to add a parking lot covering an area of 1086,58 m2 (87 PSU).

Keywords: Parking features, parking metrics, parking space units.

1 Introduction

State Polytechnic of Sriwijaya Campus on Srijaya Negara Street, Palembang City, established in 1982, the first time only had 2 (two) majors, namely the Department of Civil Engineering and the Department of Machinery. Along with the demands of the world of education, the Sriwijaya State Polytechnic Campus continues to develop and open the latest study programs. In 2024, Sriwijaya State Polytechnic will have 9 Departments consisting of 36 (thirty-six) study programs. With the increase in the number of departments and study programs, of course, the number of students, lecturers, education staff and staff have also increased. This, of course, affects campus facilities, one of which is the parking lot.

Parking is a short-term location where vehicles are left. The amount of parking space needed is determined by the number of vehicles or users. At the Sriwijaya Polytechnic campus, the parking spaces provided used to be very numerous. This is due to the availability of empty space that has not been used so that the land can be used as a parking

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lot. However, this did not last long because there had been an increase in campus space facilities [1].

The improvement of facilities such as the addition of lecture buildings and offices affects the land function that was previously a parking area converted into a building. This switch is in stark contrast to the need for parking space facilities on the campus. In the current condition, the special area for four-wheeled park is very small and in the end the parking area for four-wheeled vehicles is placed on the road along the Polsri campus road due to the need for inadequate parking space. This is exacerbated if lecture activities increase, many four-wheeled vehicle users do not get parking spaces which in the end park is not in place. Therefore, in order to arrange parking at the State Polytechnic of Sriwi-jaya campus, it is important to determine the demand for dedicated parking places for four-wheeled cars.

2 Theoritical Foundation

2.1 Literature Review

The research was carried out by a transportation team that had conducted previous research related to parking. Sari, N.M and colleagues (2015) conducted a study on the calculation of parking spaces at the Faculty of Engineering State University of Padang (UNP). The results of the study obtained a parking index of 112%, which means that the parking space does not meet and a parking space of 395 m^2 is needed for motorcycles and 544.2 for cars. Furthermore, in 2017, the development of the calculation of Parking Space Units (PSU) was also carried out extensively on the State University of Padang (UNP) campus consisting of 7 (seven) faculties. The results of the study stated that the available parking spaces did not meet the [2].

Susetyo D.A., Buchari, E. (2016) carrying out research at Bina Ilmi Integrated Islamic School in Tanjung Rawa, Palembang, on parking simulation modeling and parking needs analysis. According to the study's findings, parking simulation modeling was required because access to the school parking lot did not match the space's capacity [3].

Bermawi, Y., Sari, N.M., Susetyo, D.A., (2024) The State Polytechnic of Sriwijaya campus's parking area was deemed extremely inadequate and needed more parking spaces as well as a long-term parking design, according to a study done on special two-wheeled parking. Research on the demand for advanced parking spaces, specifically for four-wheeled vehicles, is required in order to implement the parking design at the State Polytechnic of Sriwijaya campus [1].

2.2 Parking

Parking is the act of a car remaining stationery for an extended period [4]. Parking is a designated area where cars can stop for safety. [5].

2.3 Parking Types

Parking Types. This type can be summed up as a variety of vehicles that stop for varying lengths of time, depending on the driver's demands.

2.3.1 Placement

Parking According to its Placement. There are two categories for parking placement, which are explained as follows [4]:

1. On-street parking. This type uses the road shoulder for parking cars. It's easy to park, but it reduces road space, making the road narrower and traffic flow slower. This kind of parking should be minimized to keep roads wider and traffic moving smoothly. [6]**.**
2. Off-street parking. This refers to parking facilities located on land designated for this purpose, where tickets are collected at specific times. The area has designated entry and exit points and tracks the number of vehicles parked at any given time.

2.3.2 Status

Parking According to its Status. Parking is classified into five categories based on its status, which can be stated as follows [7]:

1. Public parking. The local government oversees the parking lot;
2. Dedicated parking. A third party manages this parking area;
3. Emergency parking. This public parking is on land owned by either the local government or private sectors for temporary use;
4. Park parking. This parking lot is overseen by the local government;
5. Parking structure. A parking facility that can either be privately owned or developed by the local government.

2.3.3 Purpose

Parking According to its Purpose. Each vehicle user has their own destination. According to the purpose of parking is divided into [4]:

1. Passenger parking. Passenger parking is parking whose purpose is to get on and off passengers;
2. Luggage parking. Freight parking is a parking lot whose purpose is to raise and lower goods.

2.3.4 Facilites Parking

Parking facilities must be available to regulate the smooth flow of traffic. If it is not available, the effective width of the road will be reduced due to the use of the road body as a parking space. This results in a lack of road capacity which causes congestion and traffic flow to be unsmooth, in addition to affecting the speed of vehicles that are not in accordance with the planned speed [8].

2.3.5 Vehicle Type

Parking According to its Vehicle Type. Parking can be separated into different categories based on the kind of vehicle that occupies space [4]:

1. Parking for two-wheeled non-motorized vehicles (bicycles);
2. Parking for motorcycles;
3. Parking for vehicles with three or more wheels, such as cars, taxis, pickups, and others.

2.3.6 Types of Ownership and Operation

Parking According to its Types of Ownership and Operasions. The different types of parking operations and ownership can be divided into [4]:

1. The owned and operated park is privately owned;
2. Parking belongs to the local government and is managed by the private sector;
3. The car park is owned and operated by the government.

2.4 Parking Patterns

The determination of the placement of parking patterns is based on conditions and needs. Parking area needs to distinguish between level and material as a sign or affirmation [8].

Parallel Parking Patterns. An arrangement of consecutive parking on the side of the road is called a parallel parking pattern. [4]. In general, residential areas and the city center are where parallel parking facilities are used. (see Fig. 1).

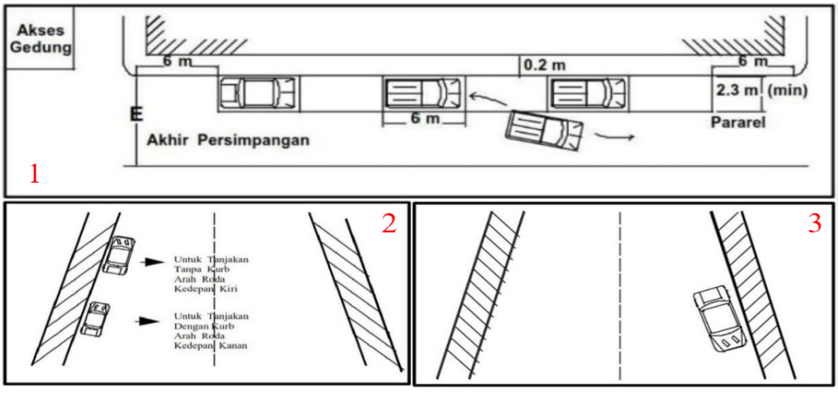


Fig. 1. Parking patterns of Flat (1), uphill (2), and downhill (3)

Angled Parking Patterns. In addition to having greater capacity than the parallel parking pattern, the angled parking pattern facilitates vehicle users' maneuverability in and out of parking spaces [4] (see Fig. 2).

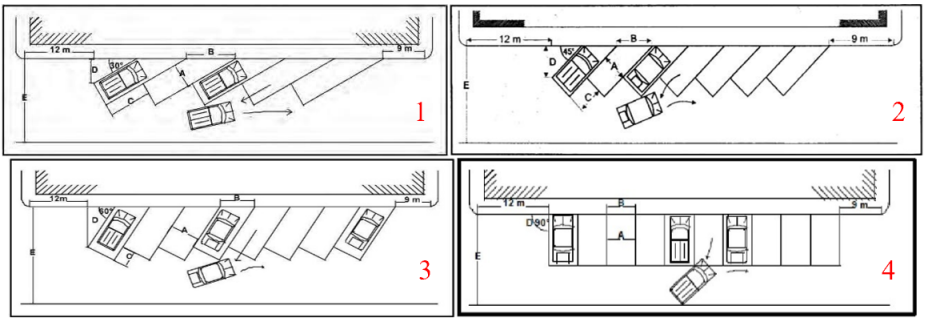


Fig. 2. Angled parking pattern with 30° angle (1), 45° angle (2), 60° angle (3), and 90° angle (4)

Information:

A = Width of the parking space (in meters) D = Effective parking space (m)
B = Width of feet of parking space (m) M = Maneuver room (m)
C = Difference in parking space length (m) E = D + M

The inclined parking pattern can facilitate the process of entering and exiting vehicles when parking [9].

Single-sided parking pattern. This pattern is used when the available land is limited, so only the side can be used as a parking lot.

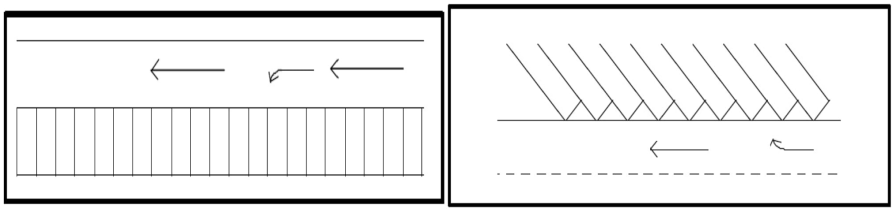
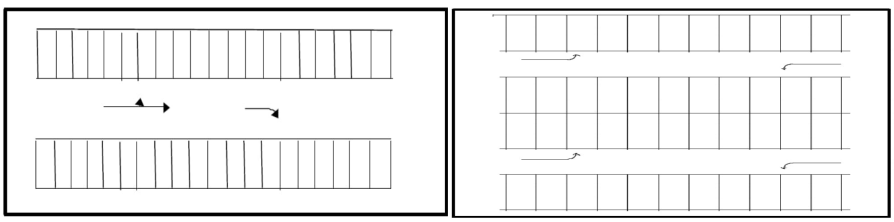


Fig. 3. Single-sided parking pattern shape (perpendicular (90°, 45°, 60°)) [7]

Double-sided Parking Pattern and Island Parking Pattern. In contrast to the one-sided parking pattern, this parking pattern is used when the availability of parking lots is very wide so that it can be more freely implemented in parking design and placement.



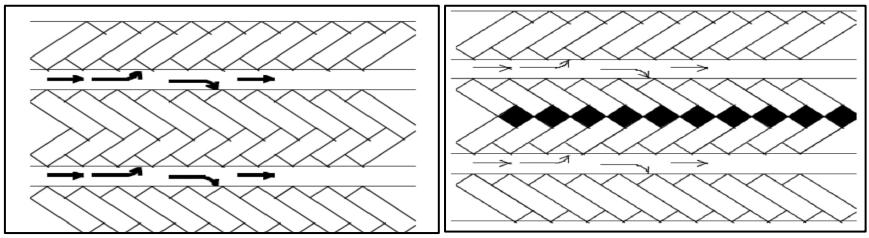


Fig. 4. Example of Double-sided and island parking pattern shape [7]

2.5 Parking Space Units

Determination of Parking Space Unit. Parking space width measurements are typically modified based on the kind of vehicle parked there. The calculation of parking space units (PSU) can be seen in Table 1.

Table 1. Parking space unit (PSU) norms are determined by the kind of road

Road Type	Min Speed (km/h)	Road Body Width (m)	Vehicle Parking Location	Vehicle Stop Location	Wide Pavement
Primary Artery	60	8,00	Not allowed	Not allowed	2 x 7 m 2 x 3 m
Secondary Artery	30	8,00	Limited	Limited	2 x 7 m 2 x 3 m
Primary Collector	40	7,00	Limited	Limited	2 x 6,5 m 2 x 2,5 m
Secondary Collector	20	7,00	Limited	Limited	2 x 6,5 m 2 x 2,5 m
Primary Collector	40	7,00	Limited	Limited	2 x 6,5 m 2 x 2,5 m
Secondary Collector	20	7,00	Limited	Limited	2 x 6,5 m 2 x 2,5 m
Primary Location	20	6,00			2 x 3 m
Secondary Location	10	5,00			2 x 2,5 m

Source: Peraturan Direktorat Jenderal Perhubungan Darat, 1996 [4]

Parking space unit (PSU) measuring standards are determined by the kind of vehicle. can be seen in Table 2.

Table 2. Parking space unit (PSU) standards are determined according to the kind of car

No.	Vehicle Type	PSU (m^2)
1.	a. Passenger Cars (Group I)	2,30 x 5,00
	b. Passenger Cars (Group II)	2,50 x 5,00
	c. Passenger Cars (Group III)	3,00 x 5,00
2.	Bus / Truck	3,40 x 12,50
3.	Motorcycle	0,70 x 2,00

Source: Peraturan Direktorat Jenderal Perhubungan Darat, 1996 [4]

Parking Space Unit for Cars. The size of the vehicle parking space unit is as follows. (see Fig. 3).

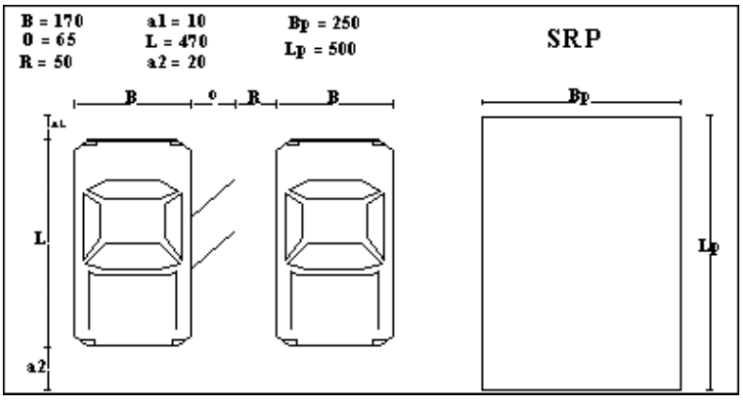


Fig. 5. Parking space units for cars (cm)

Information:

B = Width of total vehicle (cm)
O = Width of door opening (cm)
L = Total length of vehicle (cm)
a1 = Longitudinal direction clearance
a2 = Longitudinal direction clearance
R = Lateral clearance (cm)

Table 3. Passenger Car Parking Space Unit Size (PSU)

Group	B (cm)	O (cm)	R (cm)	L (cm)	a1 (cm)	a2 (cm)	Lp (cm)	Bp (cm)
I	170	55	5	470	10	20	500	230
II	170	75	5	470	10	20	500	250
III	170	80	50	470	10	20	500	300

Source: Peraturan Direktorat Jenderal Perhubungan Darat, 1996 [4]

2.6 Characteristics of Parking

Parking characteristics refer to a basic assessment of parking services and issues in the study area. The analysis results show that the following explanations can help describe the parking conditions in the area. [10]:

1. Parking volume. Is the quantity of cars that make up the parking load (cars per period, usually one day). The total number of vehicles using the parking lot in a given day is used to determine the parking volume;
2. Accumulated parking. Is the quantity of cars parked there at a specific moment;

3. Parking duration. is the amount of time that cars spend in parking spots. The calculation of duration is executed by monitoring the vehicle's entry and exit times from the parking area;
4. Parking turnover. is the quantity of cars using parking spaces at a specific moment.;
5. Parking index. Are the available parking spaces in the parking area equal to the percentage of parking vehicles occupying the parking area? By comparing accumulation and parking capacity, the parking index value is determined;
6. Parking space requirements. is the quantity of automobiles that the parking area can hold [11].

3 Methodology

This research is in the form of qualitative descriptive where the main data is obtained directly in the field (field survey), namely at the State Polytechnic of Sriwijaya campus, Jl. Srijaya Negara, Palembang City. Meanwhile, supporting data is needed to ensure the number of users of the parking area (lecturers, students, and education staff) and the available parking space capacity. The flow chart can be used to provide more information about this research stage. (see Fig. 4).

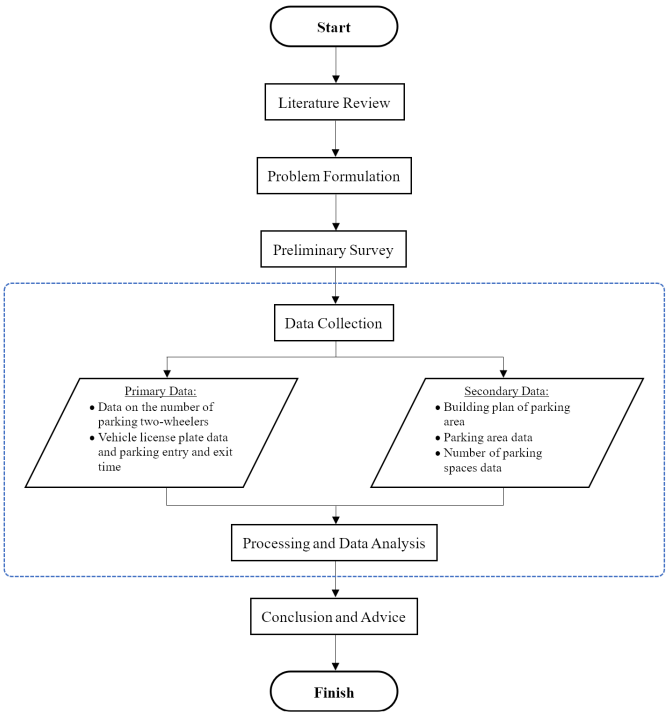


Fig. 6. Research data flow chart

3.1 Primary Data Collection

Four-wheeled cars that park on the campus, either in designated spots or on the road body, represent the primary source of data for this study. (see Fig. 5).

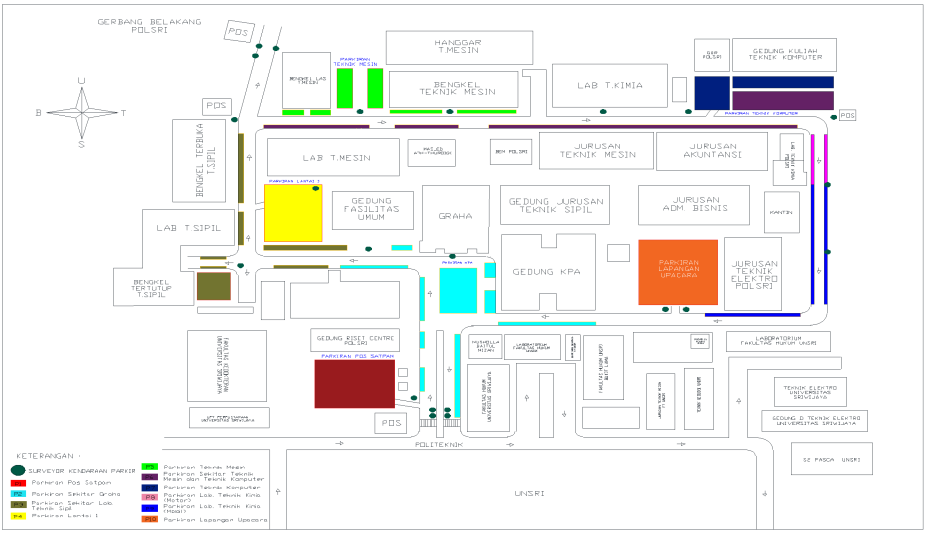


Fig. 7. Parking layout of the main campus of the State Polytechnic of Sriwijaya

The study's primary data was gathered by recording vehicle license plates as they entered and exited. The data collection took place over five weekdays, from Monday to Friday, with a 12-hour observation period each day, running from 06:00 to 18:00 local time.

3.2 Secondary Data Collection

The information serves as an indicator for analyzing the necessity of a parking assessment at the State Polytechnic of Sriwijaya's main campus. In addition, parking dimensions for different vehicle types are assessed using data on the number of parking space units. The parking area and the number of parking spaces are secondary data, which can be found in Table 4.

Table 4. Secondary data on the number of parking space units and the parking capacity area

Vehicle Type	Parking Location	Static Capacity (PSU)	Static Capacity (m^2)
Cars	Administration center parking lot (P2)	51	637,5
	Civil engineering lab parking (P3)	34	425
	Mechanical engineering and Computer engineering parking area (P6)	33	412,5
	Chemical engineering lab parking (P9)	25	312,5

Source: General Administration Section of the State Polytechnic of Sriwijaya, 2024

3.3 Data Analysis Methods

To validate the phases of parking space characteristics, data analysis involves processing source data and assessing secondary data as an indicator.

a. Formulas for calculating parking volume is by calculating the number of vehicles entering and exiting. The parking characteristics equation is as follows:

$$Parking\ Volume = Ei + X \tag{1}$$

$$Parking\ Accumulation = Ei - Ex + X \tag{2}$$

b. Parking Accumulation is calculated by subtracting the number of vehicles entering (*Ei*) and the number of vehicles exiting (*Ex*) plus the number of pre-existing vehicles (*X*)

c. Parking Duration is calculated by subtracting the exit hour (ex time) from the entry time (en time)

$$Parking\ Duration = Ex\ time - En\ time \tag{3}$$

d. Turnover is calculated by dividing the volume of parked vehicles by the number of available parking spaces. Vehicle calculation unit/day

$$Parking\ Turnover\ Numbers = \frac{Parking\ Volume}{Parking\ Space\ Capacity} \tag{4}$$

e. Parking Index (PI). The result of the PI calculation is the answer to the availability of parking space. If the value of the PI value > from 100%, the available parking space can be concluded to be insufficient, and there is a need for additional parking space. Likewise, if the < is from 100% or PI = 100%, then the parking space is still categorized as sufficient. The way PI is determined can be seen in the following formula:

$$Parking\ Index = \frac{Parking\ Accumulation}{Number\ of\ Parking\ Space\ Capacity} \times 100\% \tag{5}$$

f. The Calculation of Parking Area Needs aims to find out how much parking area is needed, with the following formula:

$$Parking\ Area = PI \times Highest\ PA \times PSU\ size \tag{6}$$

Information:
PI = Parking index
Highest PA = Maximum parking accumulation
PSU size = Parking space unit size based on vehicle type

4 Results and Discussion

4.1 Processing and Data Analysis

Vehicle volume results in Tables 5 and 6; The data in Table 7 (accumulation), Table 8 (parking duration), Table 9 (turnover), Table 10 (parking index), and Table 11 (space requirements) are the results of analyzing parking characteristics.

Table 5. Maximum volume data (veh/h) by vehicle type of cars

Vehicle Type	Parking Location	Maximum Volume (veh/h)				
		Monday	Tuesday	Wednesday	Thursday	Friday
Cars	Administration center parking lot (P2)	24	30	25	31	30
	Civil engineering lab parking (P3)	11	20	15	18	11
	Mechanical engineering and Computer engineering parking area (P6)	6	4	4	8	7
	Chemical engineering lab parking (P9)	9	7	4	7	6

Source: Primary Data, 2024

Table 6. Total volume data (veh/day) by vehicle type of cars

Vehicle Type	Parking Location	Total Volume (veh/day)				
		Monday	Tuesday	Wednesday	Thursday	Friday
Cars	Administration center parking lot (P2)	142	133	108	130	135
	Civil engineering lab parking (P3)	99	90	77	74	97
	Mechanical engineering and Computer engineering parking area (P6)	38	44	43	41	4
	Chemical engineering lab parking (P9)	53	52	40	42	48

Source: Primary Data, 2024

Table 7. Highest parking accumulation data (veh/h) by vehicle type of cars

Vehicle Type	Parking Location	Maximum Accumulation (veh/h)				
		Monday	Tuesday	Wednesday	Thursday	Friday
Cars	Administration center parking lot (P2)	61	48	34	33	51
	Civil engineering lab parking (P3)	35	61	39	38	34
	Mechanical engineering and Computer engineering parking area (P6)	15	8	23	22	26
	Chemical engineering lab parking (P9)	24	22	15	26	24

Source: Primary Data, 2024

Table 8. Highest parking duration data (veh/day) by vehicle type of cars

Vehicle Type	Parking Location	Maximum Parking Duration (veh/day)				
		Monday	Tuesday	Wednesday	Thursday	Friday
Cars	Administration center parking lot (P2)	44	41	50	32	50
	Civil engineering lab parking (P3)	34	34	30	28	35
	Mechanical engineering and Computer engineering parking area (P6)	9	8	8	7	8
	Chemical engineering lab parking (P9)	8	10	8	7	8

Source: Primary Data, 2024

Table 9. Parking turnover rate data (veh/PSU/h) by vehicle type of cars

Vehicle Type	Parking Location	Parking Turnover Rate (veh/PSU/h)				
		Monday	Tuesday	Wednesday	Thursday	Friday
Cars	Administration center parking lot (P2)	2,78	2,61	2,12	2,55	2,65
	Civil engineering lab parking (P3)	2,91	2,65	2,26	2,85	2,18
	Mechanical engineering and Computer engineering parking area (P6)	1,15	1,33	1,30	1,24	1,27
	Chemical engineering lab parking (P9)	2,12	2,08	1,6	1,68	1,92

Source: Primary Data, 2024

Table 10. Parking index data (%) by vehicle type of cars

Vehicle Type	Parking Location	Parking Index (%)				
		Monday	Tuesday	Wednesday	Thursday	Friday
Cars	Administration center parking lot (P2)	119,61	94,12	66,67	56,86	107,84
	Civil engineering lab parking (P3)	102,94	179,41	114,71	123,53	100
	Mechanical engineering and Computer engineering parking area (P6)	45,45	24,24	69,70	66,67	78,79
	Chemical engineering lab parking (P9)	96,00	88,00	60,00	104,00	96,00

Source: Primary Data, 2024

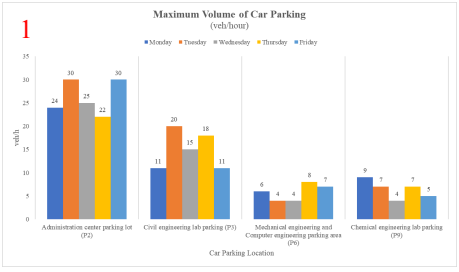
Table 11. Parking space requirements data (m^2) by vehicle type of cars

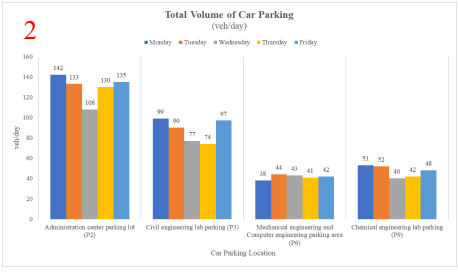
Vehicle Type	Parking Location	Parking Space Requirements (m^2)
Cars	Administration center parking lot (P2)	912,01
	Civil engineering lab parking (P3)	1368,01
	Mechanical engineering and Computer engineering parking area (P6)	256,06
	Chemical engineering lab parking (P9)	338

Source: Primary Data, 2024

4.2 Parking Characteristics Analysis Graph

Parking characteristics data analysis results, including vehicle number, greatest accumulation, parking duration, parking turnover rate, and parking index (see Fig. 6), as well as primary and secondary data on parking space requirements (see Fig. 7), form the basis of the following graph.





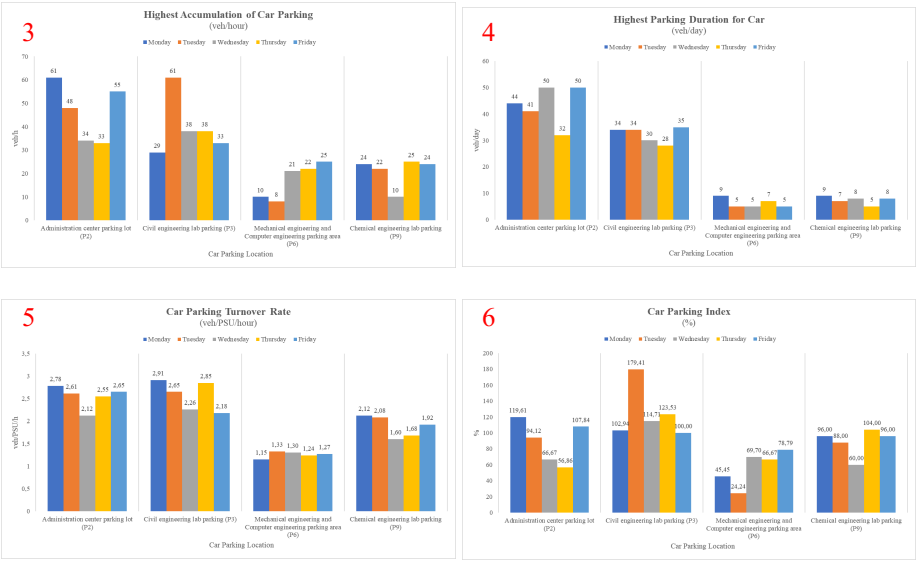


Fig. 8. Parking characteristics, including maximum vehicle volume per hour (1), total vehicle volume per day (2), highest accumulation (3), parking duration (4), parking turnover rate (5), and parking index (6), are used to compare each parking area in a data analysis graph.

The comparison results between the primary and secondary data, after processing, are shown in the following chart.

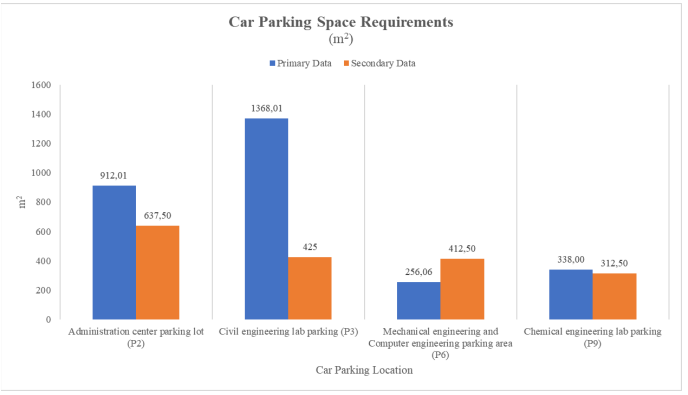


Fig. 9. Data from the outcomes of primary data processing and secondary data are required for a comparison graph of parking space evaluation.

From the picture above, the existing capacity does not meet the needs of parking space.

4.3 Evaluation of the Comparison Between Primary and Secondary Data Results

The findings of the data analysis comparing primary and secondary data processing can be seen in Table 11.

Table 12. Recalculating the assessment of parking characteristics using primary data

Primary Data							
Parking Location	Volume	Volume	Highest Accumulation	Highest Duration	Turnover Rate	Parking Index	Parking Space Requirements
	(veh/hour)	(veh/day)	(veh/hour)	(hour)	(veh/PSU/hour)	(%)	(m^2)
(1)	(2)	(3)	(4)	(5)	(6) = 3-9	(7) = 4-9 x 100%	(8) = 7 x 4 x PSU
(P2)	31 (07.00-08.00) (Thursday)	142 (Monday)	61 (14.00-15.00) (Monday)	0 – 1 (60 veh) (Monday)	2,12 - 2,65	119,61	912,01
(P3)	24 (13.00-14.00) (Thuesday)	99 (Tuesday)	61 (14.00-15.00) (Tuesday)	0 – 1 (380 veh) (Tuesday)	2,18 - 2,91	179,41	1368,01
(P6)	9 (06.00-07.00) (Tuesday)	44 (Tuesday)	26 (09.00-10.00) (Friday)	0 – 1 (88 veh) (Monday)	1,15 - 1,33	78,79	256,06
(P9)	9 (12.00-13.00) (Monday)	48 (Friday)	26 (12.00-13.00) (Thursday)	5 – 6 (117 veh) (Tuesday)	1,6 – 2,12	104	338
Total	73	4791	174			481,81	2874,08

Source: Primary Data, 2024

Table 13. Results of data analysis and comparative evaluation of parking characteristics based on primary and secondary data processing

Primary Data	Secondary Data		Evaluation Results
Parking Location	Static Capacity	Static Capacity	Parking Space Requirements
	(PSU)	(m^2)	(m^2)
(1)	(9)	(10)	(11) = 8 – 10
Administration center parking lot (P2)	51	637,5	274,51 (22 PSU)
Civil engineering lab parking (P3)	34	425	943 (51 PSU)
Mechanical engineering and Computer engineering parking area (P6)	33	412,5	156,5 (13 PSU)
Chemical engineering lab parking (P9)	25	312,5	25,5 (2 PSU)
Total	143	1787,5	1087,08 (87 PSU)

Source: Primary Data and Secondary Data, 2024

According to the results, the State Polytechnic of Sriwijaya campus's four-wheel drive parking capacity is insufficient. In order to meet campus parking requirements and enforce parking laws, it is required to expand the number of parking spaces. Only 1787,5 m^2 of land is available, compared to 2875 m^2 of land required. As a result, up to 87 PSU, or 1086.58 m^2, parking space for four-wheeled cars must be added. There are two to three parking turnovers per PSU, with an average duration of 0-1 hour.

5 Conclusions

The comparison of primary and secondary data, as determined by the evaluation's findings, reveals that:

1. The number of parking volumes of four-wheeled vehicles exceeds the available parking capacity, so many vehicles are parked out of place. The maximum volume of four-wheeled vehicles entering the parking space per day reaches 142 vehicles/parking turnover with the number of changes 2 to 3 times;
2. The available land area does not meet the required parking space capacity, so it is necessary to add a special four-wheeled parking lot covering an area of 1086,58 m^2 (87 PSU);
3. From the calculation of the four-wheeled parking space requirements, there needs to be a follow-up design regarding the placement of parking spaces needed to optimize parking facilities.

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