

**Case Study**

# Strategy of Parking Planning to Improve Accessibility in Paya Ilang Central Aceh, Indonesia

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## Highlights:

- Conduct surveys to understand visitation patterns and parking demand
- Implement an effective traffic management system to reduce congestion around the shopping center
- Create a pedestrian-friendly environment to encourage better accessibility
- Implement a monitoring system to evaluate the effectiveness of the parking planning strategies implemented

**Abstract:** High activity at a market can cause the increased number of vehicles entering and leaving at a certain time, because the market itself does not have a special parking area, so many vehicles have difficulty finding a parking space. Judging from the characteristics of the parking lot, a good parking lot in the research area is located in the Paya Ilang Takegon Morning Market area on Jalan Blangkolak II, Bebesen District, Central Aceh. This study aims to analyze the selection of optimal parking space design on a 30 m x 50 m lot, focusing on two types of parking patterns: Type I and Type II. Type I, which consists of 30°, 45°, 60°, and 90° parking angles, is generally used in narrow lots and is more suitable for on-street parking. In contrast, Type II is designed for larger lots and is often applied in office and commercial centers. Through the calculation of parking space requirements for 4-wheelers and 2-wheelers, this study found that the Type II parking pattern is more suitable for the analyzed site. With a higher parking capacity, especially at 90° angles, Type II not only meets parking demand but also improves accessibility and user comfort. The results show that efficient parking space design can reduce congestion and improve user experience, as well as contribute to environmental sustainability. Therefore, strategic and data-driven parking space planning is essential to create better and more sustainable urban infrastructure in the future. This research is expected to serve as a reference for urban planners and developers in designing effective and environmentally friendly parking solutions.

**Keywords:** Characteristics, design, land area, parking, vehicles

## 1. Introduction

Parking is one of the integral components or aspects of transportation needs, because transportation will continue to grow from time to time [1]. In order to make the vehicle transportation system more efficient, places that are considered to generate travel movements must provide adequate parking facilities. Parking is an important part of traffic management in urban areas, parking policy must be carried out consistently, so that all aspects of the policy are directed towards the same goal. Parking is an important part of traffic management in urban areas, and parking policy should be consistent, so that all aspects of the policy are directed towards the same goal [2]. On-street parking is parking by using the roadway that is actually intended for the movement of traffic flow [3]. On-street parking on the one hand benefits motorists because they can park their vehicles close to their destination. However, on the other hand, on-street parking reduces road capacity, causing the speed of vehicles passing through the road to increase.

In general, there are three factors that cause congestion problems, namely increasing vehicle ownership (demand), limited resources to carry out road construction and other transportation facilities (supply) [4], and not optimal operation of existing transportation facilities (operating system). This study is motivated by the parking of vehicles on the road in the Paya Ilang Market area in Central Aceh. Paya Ilang market is one of the traditional market centers with a crowd where there is a shopping place that provides a variety of clothing, food, and shelter needs at more affordable prices and besides this location is easily accessible from various directions, especially its location close to the main road, namely Jalan Paya Ilang - Paya Tumpi. With the high number of market

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visitors, of course, the market parking space becomes narrow, especially the parking space close to the shoulder of the road. This can be one of the causes of disruption to the smooth flow of traffic on the road around Paya Ilang Market, which is quite busy on a daily basis crossed by various types of vehicles.

Relocation and revitalization in the Paya Ilang Morning Market area is needed to add attractiveness to increase tourist visits to the area. As we know the Paya Ilang Morning Market area is the city center as well as a city icon that is very crowded with visitors. The Takengon area is the city center because it provides a variety of facilities from cultural recreation, shopping and educational recreation in one place. So, the Takengon area is very crowded with domestic and foreign tourists. In addition, students and students also often make Takengon a place to unwind on weekends. So economic opportunities are very promising in this Takengon area.

An area should be able to accommodate the volume of parked vehicles and a good parking area arrangement so that vehicle users can park safely and comfortably. Until now, it is not yet known how the characteristics of parking and how much parking space is needed in the market at this time. In order to overcome these problems, sufficient parking is needed. The need for parking lots and infrastructure that will be needed must be balanced and adapted to the characteristics of parking while providing proper parking planning. Based on these conditions, there are several problem formulations: (1) What are the characteristics and needs of parking users in the Paya Market area; (2) How is the planning of parking characteristics that can improve user comfort and safety in the Paya Ilang Market area?

## 2. Literature Review

### 2.1. Parking Facilities

Parking facilities are locations designated as temporary stops for vehicles to carry out activities for a period of time [5]. Parking facilities aim to provide a place to rest vehicles and support the smooth flow of traffic [6]. Parking facilities are distinguished as follows [7].

- On-Street Parking Curb Parking, consists of the following restricted Curb Parking; and Unrestricted Curb Parking,
- Off-Street Parking Facilities, consists of the following Surface Lots; and Garages.

### 2.2. Factors Affecting Parking Demand

In planning the provision of parking spaces, the main problem is the amount of demand determined by the number of vehicles parked [8]. The amount is never the same from time to time, in one place to another. This depends on the location of the parking lot, capacity and location facilities, activity activities and so on. Thus each type of activity facility has a different parking demand. Factors that influence parking demand include the following [9]:

- The size of the shopping center is the main determinant of parking demand [10]. The area of a shopping center is not equal to the total area of the buildings within it, including those parts used for public purposes and not leased to tenants.
- The mode of transportation used by visitors to the shopping center such as public transportation, private cars, motorcycles (MC) has an important influence on the need for parking space provision. The higher the percentage of private car use, the greater the parking space required [11].

### 2.3. Parking Characteristics

Parking Characteristics Parking characteristics are a reference that can affect the use of parking spaces (*parking utilization*), and there are things that affect the utilization of parking spaces [12]. Based on parking characteristics, it will be possible to know the parking conditions that occur in the study area. Parking volume is the number of vehicles included in the parking load, which is the number of vehicles per certain period of time [13], usually per day. To determine parking volume can utilize the equation

$$\text{Volume} = \text{Number of Vehicles entering} + \text{Vehicles existing before the survey} \quad (1)$$

Parking Accumulation, also known as parking buildup, describes the total number of vehicles in a parking lot at any given time. This information is very useful for planning parking space requirements and managing parking control in an area. where the integration of parking accumulation over a given period shows the parking load in vehicle hours per given time period [14]. As follows:

$$\text{Accumulation} = Q_{\text{in}} - Q_{\text{out}} + Q_s \quad (2)$$

where:  $Q_{\text{in}}$ : Vehicles entering the parking lot;  $Q_{\text{out}}$ : Vehicles exiting the parking lot;  $Q_s$ : Vehicles that were already in the parking lot before the observation.

The importance of Parking Accumulation is divided into 2 things namely (a) Parking Space Planning in determining the capacity of parking spaces required to meet user demand. It also helps in identifying the peak usage time of the parking area and (b) Parking Control by understanding the accumulation pattern, managers can implement more effective control strategies, such as rate adjustments or parking time restrictions.

Parking capacity is the ability of a parking area to accommodate vehicles at a certain time, or the number of vehicles that can be served by a parking lot during the service time [15]. As follow:

$$K_p = \frac{S}{D} \quad (3)$$

Where:  $K_p$ : Parking capacity (vehicle/hour);  $S$ : Number of parking plots (plots);  $D$ : Average duration of parking (hour/vehicle)

Parking index is the ratio between parking accumulation and parking capacity. The parking index value can show how much parking capacity is occupied [16]. As follows:

$$\text{Index Parking} = \frac{\text{Parking accumulation}}{\text{Parking capacity (Kp)}} \quad (4)$$

As a guideline [17], the IP value is:

- IP value > 100% means that the parking facility is problematic, where the parking demand exceeds the normal capacity.
- IP value < 100% means that the parking facility is not problematic, where the parking demand does not exceed the normal capacity. IP value = 100% means that parking demand is balanced with normal capacity.

Parking duration is the average time taken by each vehicle to stop at a parking facility. It is one of the important parameters in parking management that helps in understanding parking space usage patterns and planning parking infrastructure requirements [18]. As follows:

$$\text{Parking duration} = \frac{(N_x) \times (X) \times (I)}{N_t} \quad (5)$$

Where:  $N_x$ : Number of vehicles parked during the survey time interval (vehicles);  $X$ : Sum of the intervals;  $I$ : survey time interval (hours);  $N_t$ : Total number of vehicles during the survey time interval (vehicles).

### 2.3.1 Parking Space (SRP)

Parking space (SRP) is a measure of the effective area in which to vehicle (passenger car, bus/truck, or MC), including free space and door opening [19]. Additional space is required for vehicles to transfer, which depends on the angle of parking lot [20].

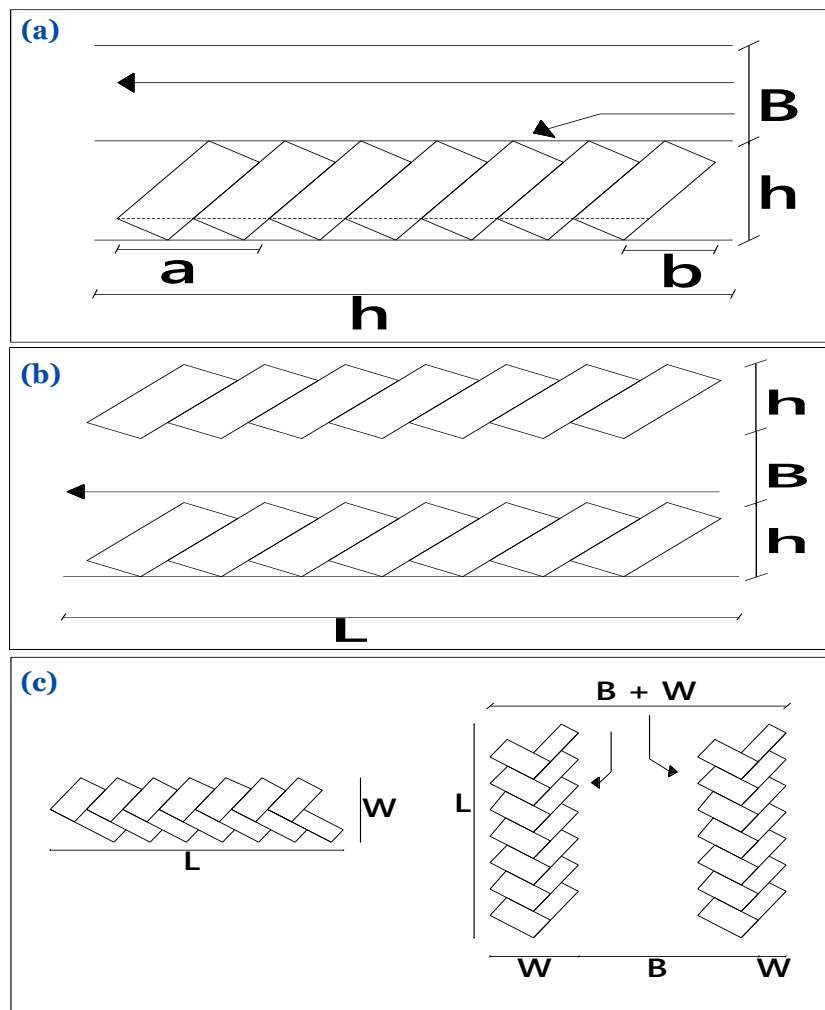
### 2.3.2 Parking Patterns

The parking pattern system is inseparable from the role of the parking facility itself. location that is determined as a vehicle stop that is not temporary to carry out activities at a period of time and aims to provide a place to rest. activities for a period of time and aims to provide a resting place for vehicles and support the smooth flow of traffic [21]. Type I parking pattern consists with type of parking pattern is often planned on a narrow area of land. This type of parking pattern is usually found on the shoulder of the road that has been used as an official parking lot. This type of parking pattern has a great advantage for the driver to maneuver while parking because the car can easily take the parking angle and go straight into the parking space. As for type II parking patterns, they are planned on a large area of land. This type of parking pattern is usually found in official office and shopping centers, aiming to give the driver visibility to pedestrians and other vehicles passing by. Meanwhile, type III parking patterns are often planned on large areas of land. This type of parking pattern is usually found in official parking lots managed by the private sector or the

government. Type III pattern has a great advantage for the driver to maneuver while parking because the car easily takes the parking angle and goes directly into the parking lot. The illustration of these parking patterns are presented in Figures 1, where the detail requirements are summarized in Table 1.

**Table 1.** Parking Requirement Based on Its Types

Angle of Parking	Parking Space
Type I	
30°	$(4,6.N + 0.880 l)x(B+h)$
45°	$(3,2527.N+1,9092)x(B+h)$
60°	$(2,6558.N+1,8360)x(B+h)$
90°	$(2,3.N)x(B+h)$
Type II	
30°	$(5.N + 0,5801 )x(B+h)$
45°	$(3,5355.N+1,7678 )x(B+h)$
60°	$(2,8867.N+1,7783)x(B+h)$
90°	$(2,5.N)x(B+h)$
Type III	
30°	$(2.3.N + 3.8801)x(B+2h)$
45°	$(1.6263.N + 1,9092)x(B+2h)$
60°	$(1.3279.N+1,8360)x(B+2h)$
90°	$(1.15.N)x(B+2h)$



**Figure 1.** Type I (a), Type II (b), and Type III (c) Parking Patterns

## 2.4. Impact of Parking on Functional Road

On-street parking has an impact on the functional aspects of the road. The main impact of on-street parking is the reduction of road capacity due to the utilization of part of the roadway for parking. The effective width of the roadway is reduced (effective width of disruption) due to the use of on-street parking with a variety of parking angles. The layout should be such that the vehicle can move in one motion, without the steering wheel running out of rotation.

## 3. Materials and Methods

This research was conducted at Paya Ilang Morning Market, Jalan Blangkolak II, Bebesen District, Central Aceh Regency. The images of the research site, observed from the satellite and ground-level views, are presented in Figures 2.



**Figure 2.** Observation of the Research Site from The Satellite View (a) and Ground-Level View (b). The Research Site Is Indicated by The Red Arrow in The Satellite Image.

### 3.1. Survey of Parking Space

An observation survey is a survey by observing or monitoring and recording existing vehicles. There are several ways to survey, among others:

- To measure vehicle accumulation in the study area, especially during peak accumulation, in order to determine the percentage of available parking spaces that are being used at the time. Available parking spaces that are being used at that time.
- To determine vehicle accumulation during peak hours when traffic flows are also highest.
- To measure the total capacity of parking spaces per hour, required in 1 (one day).

### 3.2. Preparation of Parking

Identification of the current parking system was performed by direct observation. The collected characteristics of the parking system are as follows:

- The parking lot at Paya Ilang Market does not yet have a parking lot with a centralized parking system, the parking lot is still utilizing the existing road shoulder. existing road shoulder.
- Irregularity in parking MC results in a lot of unused parking spaces. unused parking space.
- The lack of information about empty parking lots is only limited to the sight of drivers, so when conditions are full, many drivers park their vehicles out of place.

Paya Ilang Market has a parking lot facility in front, but the parking facility cannot accommodate the parking volume, because from the dimensions of the existing parking facility it can be used as a car SRP and used to park cars.

### 3.3. Data Collection

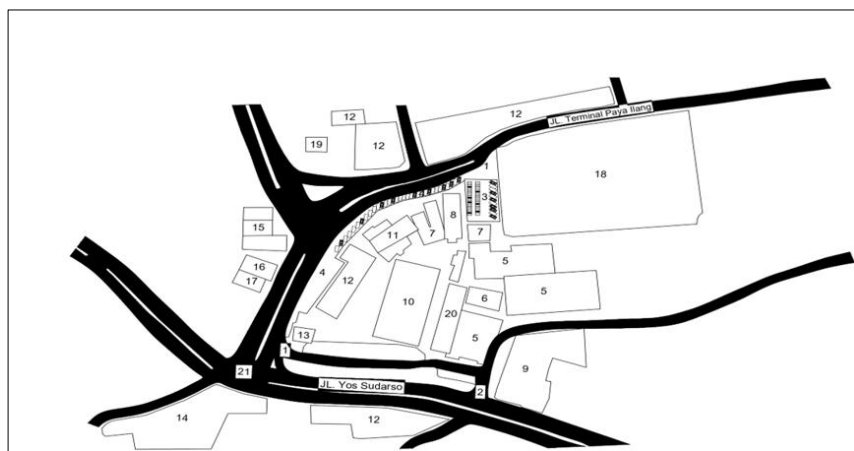
Data sources for parking demand planning in the paya ilang market area are obtained using data sources obtained by the author from primary data in this planning, among others: (1).This inventory survey is intended to obtain data on the capacity of available parking spaces by measuring the area of parking spaces provided: (2) Vehicle entry and exit surveys, Vehicle entry and exit surveys are surveys conducted by ensuring that the survey area is restricted and the entrance and exit of vehicles. selection of certain days (Saturday, Sunday, and Wednesday) with July 2022.

Without a clear explanation, there is a risk that the survey results do not reflect the actual parking usage pattern. For example, if Saturdays and Sundays are days with higher visitation than weekdays, then the survey results may show a greater parking demand than actually occurs on weekdays. Conversely, if Wednesday was chosen because it is a quieter day, then the data obtained may not be representative of busy days. Therefore, it is important to clarify the criteria for selecting the survey day and consider the field conditions, in which the survey was conducted in the morning to afternoon to capture the peak density of vehicles entering the parking lot (07:00 - 13:00). (3).

This method was carried out in accordance with the guidelines for planning and operating parking equipment from the directorate of traffic and urban transport and the Directorate General of Land Transportation. In the parking planning strategy to improve accessibility in Paya Ilang, hypotheses may include the assumption that increasing parking capacity will reduce congestion. Relevant statistics may include analysis of parking utilization data and measurement of changes in vehicle volume. Use statistical tests by applying regression models to understand the relationship between parking capacity and other variables such as congestion.

#### 4. Results and Discussion

The site layout illustrating the distribution of parking areas within the study area is presented in Figure 3, whereas the configuration of the parking facility is depicted in Figure 4. The volume of vehicles in a parking area is determined by counting the total number of vehicles that utilize the parking facility over a one-day period. This process involves recording every vehicle that enters and leaves the parking lot, whether for a short or long period of time. By calculating the volume of vehicles in a day, managers can get a clear picture of the level of usage of the parking area, which in turn can help in planning and managing parking facilities more effectively. The accumulation of light vehicles (LV) on Wednesday and Saturday is 28 vehicles at 07.30-07.45 WIB. While Sunday parking accumulation is 15 vehicles at 12.30-12.45 WIB. In the accumulation of MC on Saturdays as many as 62 vehicles, namely at 07.30 - 07.45 WIB and Sundays obtained 63 vehicles at 09.00-09.15 WIB, except on Wednesdays, namely 25 vehicles at 08.15-08.30 WIB.



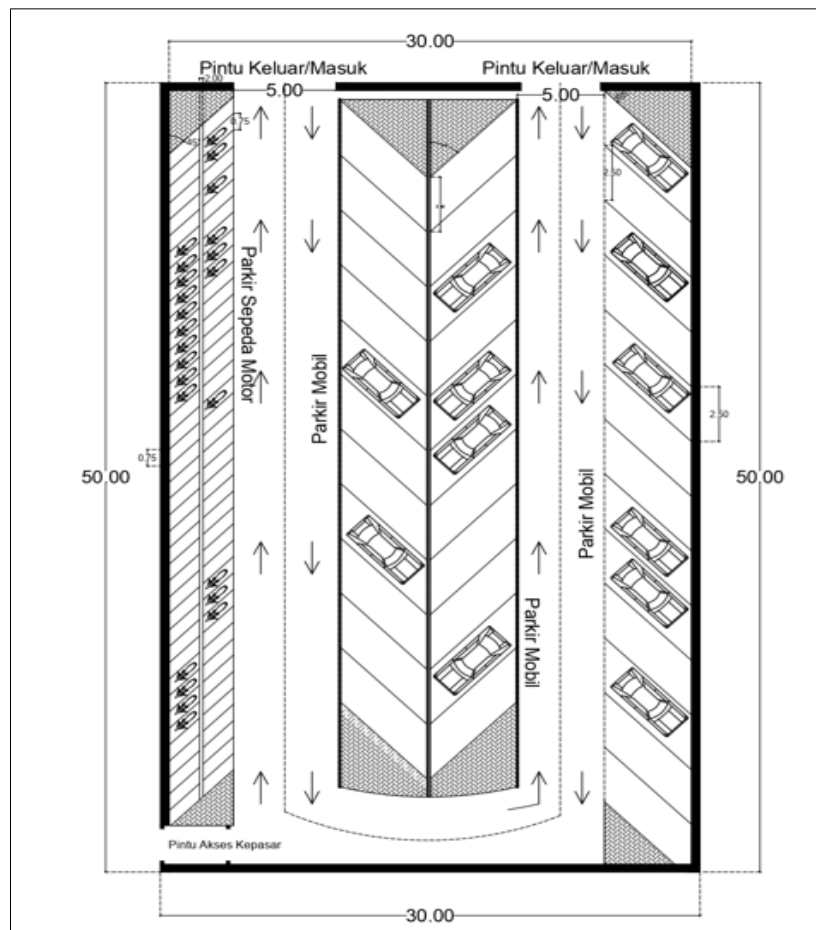
**Figure 3.** Site layout illustrating the location and spatial arrangement of parking areas within the study area.

Results of LV parking duration estimated in Saturday, Sunday, and Wednesday are presented in Table 2. On Saturday, there were 122 vehicles parked with an average duration of 36 minutes, while on Sunday, the number of parked vehicles decreased to 93 with a shorter average duration of 25 minutes. On Wednesday, the number of vehicles increased again to 137 with the same parking duration as on Saturday, which was 36 minutes. The duration of MC parking for a few specific days, namely Saturday, Sunday, and Wednesday. On Saturday, there were 328 two-wheelers parked with an average duration of 38 minutes, indicating a fairly high level of usage.

However, on Sunday, the number of vehicles increased to 401, although the average duration of parking decreased to 25 minutes, which may reflect the use of parking for shorter purposes, such as visits to tourist attractions or social activities. Meanwhile, on Wednesday, the number of parked vehicles decreased to 158, but the average duration of parking increased to 46 minutes, suggesting that vehicles parked on that day tended to be used for longer purposes.

**Table 2.** Number of vehicles, parking duration, parking capacity in observed in three different days

Period	Saturday	Sunday	Wednesday
Number of parked vehicles			
Total of MC	328	401	158
Total LV	122	93	137
Parking duration			
Duration (MC)	328 (0:38:00)	401 (0:25:00)	93 (0:25:00)
Duration (LV)	122 (0:36:00)	158 (0:46:00)	137 (0:36:00)
Parking capacity (LV)			
Parking space (S)	39	39	39
Duration (D)	0:36:00	0:25:00	0:36:00
Capacity (LV)	108	156	108
Parking capacity (MC)			
Parking space (S)	159	159	159
Duration (D)	0:38:00	0:25:00	0:46:00
Capacity (MC)	418	636	345



**Figure 4.** Design Layout of The Parking Area Showing The Configuration of Parking Spaces, Circulation Lanes, and Entrance–Exit Access Used for The Parking Analysis

Parking space capacity can be defined as the maximum number of vehicles that can be parked in a parking area at a certain time and condition. In the present study, the capacity of existing static parking spaces for MC and LV can be calculated using the direct approach method.

Information on parking capacity and duration of use of parking slots for vehicles on Saturday and Wednesday is presented in Table 2. There are 39 parking slots available, with an average duration of slot usage of 36 minutes (0.36:00). The parking capacity on this day is 108 vehicles per hour, indicating that the parking area can accommodate 108 vehicles in one hour if all slots are occupied. On Sunday. The number of parking slots remains the same at 39, but the average duration of slot usage decreases to 25 minutes (0.25:00). The shorter parking duration, the parking capacity on Sunday increased to 156 vehicles per hour. This shows that although vehicles are parked for a shorter time, more vehicles can enter and exit the parking area in an hour.

Based on the number of slots and duration of parking, on Saturday with an average parking duration of 0.38 hours, the parking capacity is 418 vehicles per hour. This shows that although the parking duration is not very long, many vehicles can enter and exit within a one-hour period. Although, on Sunday parking duration (0.25 hours), the parking capacity increases significantly to 636 vehicles per hour. This may be due to the high turnover of vehicles, where more vehicles come and go in a shorter period of time. With a longer parking duration (0.46 hours), the parking capacity decreases to 345 vehicles per hour. This indicates that although there are fewer vehicles parked, they tend to stay longer in the parking area. The total unit of the SRP is summarized in Table 3.

Selection of parking space design on the layout, landform, and also considering the economic benefits, the type of parking if based on the placement of parking facilities can be divided into on street parking) and off-street parking with a land area of 30 m x 50 m. Based on the land area of 30 m x 50 m, this land can be utilized as off-street parking.

**Table 3.** Total Unit of Parking Spaces According to Its Type

Parking Angles	SRP (LV)	SRP (MC)
Type I		
30°	420 SRP/hour	487 SRP/hour
45°	453 SRP/hour	346 SRP/hour
60°	372 SRP/hour	358 SRP/hour
90°	310 SRP/hour	192 SRP/hour
Type II		
30°	98 SRP/hour	114 SRP/hour
45°	105 SRP/hour	152 SRP/hour
60°	250 SRP/hour	224 SRP/hour
90°	731 SRP/hour	307SRP/hour

LV: light vehicle; MC: motorcycle; SRP: parking space

Based on the present analysis, the more appropriate parking pattern for a 30 m x 50 m lot is the Type II Parking Pattern. Type II parking pattern is more suitable for larger lots and is often used in office and trade centers.

- 4 Wheelers (LV) : If maximizing the number of 4 wheelers, a 90° parking angle will provide the highest capacity (731 SRP/hour), although it requires more space for maneuvering.
- 2 Wheelers (MC) : If considering 2 wheelers, a 90° angle also provides good capacity (307 SRP/hour).

With a lot size of 30 m x 50 m, the Type II parking pattern is a better choice, especially if the lot is used for an office or trading center. Be sure to consider the specific needs and characteristics of the site when planning the parking space design.

## 5. Conclusion

It is important to emphasize that effective parking planning plays a crucial role in improving accessibility, optimizing land use, and supporting sustainable urban development, particularly in high-activity commercial areas. This study evaluated parking space design alternatives on a 30 m x 50 m site by analyzing different parking configurations to identify the most efficient and functional layout. The findings provide practical insights for planners and decision-makers in designing parking facilities that enhance operational efficiency while maintaining user comfort.

- 1) The results indicate that the Type II parking pattern is the most suitable configuration for the analyzed site due to its higher parking capacity and greater spatial flexibility compared with alternative parking layouts.
- 2) The analysis demonstrates that parking arrangements incorporating 90° angles maximize space utilization and significantly increase the number of vehicles that can be accommodated without compromising circulation efficiency.

- 3) The selected parking design improves accessibility, traffic circulation, and overall user comfort, particularly in commercial areas with high parking demand.
- 4) Efficient parking layouts can contribute to reducing congestion levels and minimizing the time required for drivers to locate available parking spaces.
- 5) Data-driven parking planning strategies are essential for optimizing land utilization, enhancing transportation efficiency, and supporting environmentally sustainable urban infrastructure development.

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### Author Contributions:

Cut Nawalul Azka contributed in conceptualization, methodology, software, formal analysis, investigation, resources, data curation, writing—original draft, writing—review and editing, supervision, and funding acquisition. Aldina Fatimah contributed in investigation, visualization, and writing—review and editing. Nia Juliantika contributed in investigation and writing—review and editing. Richard Mareno contributed in validation and writing—review and editing. Roni Agusmaniza contributed in software, visualization, and project administration. All authors have read and agreed to the published version of the manuscript.

### Declaration of Competing Interest:

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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