

Planning Campus Parking Facilities and Infrastructure: Towards Sustainable Mobility Approaches

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Abstract. The availability and adequacy of parking facilities are essential components of campus infrastructure, influencing the mobility and convenience of students, faculty, and visitors. This article examines the current status of parking facilities at State Polytechnic Manado, identifying challenges and proposing solutions for enhancing parking management. Through surveys and interviews, data on parking demand, utilization patterns, and user preferences are gathered to inform recommendations for improving parking infrastructure. Additionally, the study explores the integration of technology-driven solutions such as smart parking systems and sustainable design principles to optimize space utilization and minimize environmental impact. The findings emphasize the importance of strategic planning and investment in parking facilities to support the diverse needs of campus stakeholders while promoting sustainability and efficient use of resources. Overall, this research contributes to the advancement of parking management practices in educational institutions, with implications for enhancing campus accessibility, safety, and overall user experience.

Keywords: parking facilities, campus infrastructure, environment impact, parking system, sustainability

Introduction

Manado State Polytechnic (MSP) is a vocational education institution located in Manado City, North Sulawesi. MSP was founded in 1984 and has graduated thousands of graduates who are ready to work in the fields of technology and business.

Manado State Polytechnic has several superior departments in the fields of technology and business such as the Department of Electrical Engineering, Department of Mechanical Engineering, Department of Civil Engineering, Department of Accounting, Department of Business Administration, and Department of Tourism.

Lecturers and Education Staff (MSP) have lecturers and education staff who are qualified and experienced in their respective fields. They always try to provide the best education and training to students so they are ready to compete in the world of work.

However, like other educational institutions, (MSP) also has several challenges to face in the future. Some of these challenges include improving the quality of education, improving facilities and infrastructure, as well as increasing collaboration with industry and other institutions.

Currently, the number of registered students is approximately 4000 students with teaching and educational staff numbering around 500 people (Academic Section for Student Affairs, 2023).

With the increasing number of people interested in continuing their education at the Polytechnic, for smooth movement of activities, students, lecturers, and other stakeholders need motorized vehicles. Two-wheeled and four-wheeled motorized vehicles certainly require parking facilities.

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The existing conditions for parking facilities have not been regulated properly and correctly, causing many problems, such as parking vehicles haphazardly, irregularly, and sometimes causing traffic jams.

The parking system on campus is a system designed to organize and manage vehicle parking in the campus area. This system usually includes several aspects such as parking area design, vehicle arrangement, parking management, and security monitoring.

The increasing use of motorized vehicles by lecturers and students as well as other academics, this has resulted in an increasing amount of land needed to park these vehicles (Abas & Takaendengan, 2020).

The following are some basic theories of parking systems on campus:

- **Parking Area Design** The design of parking areas on campus must consider several factors such as the number of vehicles, parking area size, accessibility, and security. Parking areas must be designed to be efficient and able to accommodate a large number of vehicles without disrupting traffic and campus activities. Apart from that, the design of the parking area must also consider security factors such as CCTV placement, sufficient lighting, and vehicle entry and exit arrangements.

- **Vehicle Arrangement** Vehicle arrangement in the parking area must consider space efficiency and driver comfort. Vehicle arrangement must be done regularly and neatly in order to maximize the capacity of the parking area. Apart from that, vehicle management must also pay attention to driver comfort by providing easy and safe access (Azizah & Ahyudanari, 2015).

- **Parking Management** Parking management on campus aims to organize and manage vehicle parking efficiently and optimally. Parking management includes managing parking times, parking fees, and parking payment systems. Apart from that, parking management must also pay attention to motorists' needs by providing clear and accurate information regarding available parking areas.

- **Security Supervision** Security supervision in the parking area is very important to prevent criminal acts such as theft of vehicles or items in vehicles. Security monitoring can be carried out by installing CCTV, placing security officers, and providing information regarding security to drivers.

- **Parking Information System** A parking information system is a system used to provide information regarding available parking locations, parking times and parking fees to vehicle drivers. Parking information systems can be done by installing parking information boards or with mobile applications (Tamin, 2000). In managing the parking system on campus, it is important to consider these factors so that the system can run well and provide comfort and safety for vehicle drivers.

There are several definitions of parking and matters related to the parking system, including, according to the Technical Guidelines for the Implementation of Parking Facilities of the Directorate General of Land Transportation, (1998) which states that parking is a non-temporary state of immobility of a vehicle. Parking according to Budiarto (2007) is a place where vehicles stop for a long period of time, according to the driver's needs. Parking according to the Indonesian dictionary in the journal Annam CK (2011) can be interpreted as a place where vehicles stop for a while. From the several opinions above regarding the meaning of parking and matters relating to the parking system, it can be concluded that parking is a situation where the vehicle stops or does not move for a while and is left behind by the driver.

Parking facilities are locations designated as non-temporary stopping places for vehicles to carry out activities for a certain period of time. Arranging parking, not only technical matters that must be considered but also aesthetic issues must be taken into account. With these activities or facilities, adequate and sufficient vehicle parking facilities are needed because the existence of these activity centers will generate and increase the need for parking activities.

It is realized that the Manado State Polytechnic Campus is also experiencing parking problems, this is caused by poor planning at the beginning of the physical development of the Manado State Polytechnic Campus. So instead parking lots appear as a result of the use of motorized vehicles, both two-wheeled and four-wheeled, which is increasing along with the increase in the number of students.

This research was conducted to provide data regarding the number of motorized vehicle users, both two-wheeled and four-wheeled, and will be adjusted to the area of land that can still be used for parking on the Manado State Polytechnic campus.

Methodology

Method

The methodology used is to calculate the basic space requirements for two-wheeled and four-wheeled motorized vehicles, after that, by elaborating on the data on the number of students, lecturers, and staff who use them, you will get the actual number of parking space requirements.

Data on the area of empty land on the Manado State Polytechnic campus will be collaborated with the actual amount of parking space needed. The placement of parking lots will also take into account various things related to the basic policies issued by the leadership of the Manado State Polytechnic.

This research was conducted at the Manado State Polytechnic campus, data collection on the number of students, lecturers, staff and other users was carried out from August to September 2023.

Parking Characteristic

Parking facilities are locations designated as non-temporary stopping places for vehicles to carry out activities for a certain period of time. Arranging parking, not only technical matters that must be considered but also aesthetic issues must be taken into account. With these activities or facilities, adequate and sufficient vehicle parking facilities are needed because considering the existence of these activity centers will generate and increase the need for parking activities.

A. Parking characteristics

Data will be very necessary for analyzing operational conditions and designing parking lot development. Several terms regarding parking characteristics that must be known so that parking planning and management can be produced properly according to the facilities needed include:

a. Parking Capacity.

Parking capacity is the maximum number of vehicles that can be served by a parking lot during service time. The size of the capacity of a parking lot will greatly determine the volume of vehicles that can be accommodated. This means that the level of capacity greatly influences the dimensions of the parking lot.

b. Parking Duration

Parking duration is the period (length of time) of vehicles that are parked. The length of parking depends on the purpose and objectives being carried out.

c. Parking Accumulation

Parking accumulation is the number of vehicles parked in a place at a certain time. If before the observation is carried out there are already vehicles parked at the survey location, the number of existing vehicles is added up in the accumulated price that has been made. From the results obtained, a graph is created that shows the percentage of vehicles in the parking accumulation curve.

d. Parking Index

The parking index is the percentage of the number of parked vehicles occupying a parking area with the number of parking spaces available in that parking area. This parking index value can show how much parking capacity is filled.

e. Average Parking Accumulation

Average parking accumulation is the total number of vehicles parked in a place at a certain time divided by the number of parking hours.

f. Parking Volume

Parking volume is the total number of vehicles using the facilities calculated in vehicles parked for one day.

g. Parking space unit

A parking space unit is a measure of the effective area for placing a vehicle including free space and traffic flow dimensions

Vehicles tend to get smaller from year to year. Parking is a necessity for vehicle owners where vehicle users want parking that is easy to reach and has guaranteed security.

B. Off-Street Parking Patterns

According to the Technical Guidelines for the Implementation of Parking Facilities (Directorate General of Land Transportation, 1996), off-road parking patterns are divided into: Two-sided vehicle parking patterns. This parking pattern is applied if space is sufficient.

a. Forms a 90° angle; The direction of vehicle traffic can be one-way or two-way

b. Forms angles of 30° , 45° , 60°

C. Parking Space Unit (SRP)

A parking space unit (SRP) is a measure of the effective area for placing a vehicle. A parking space unit is used to measure the need for parking space. However, determining a parking space unit cannot be separated from considerations like other units.

Likewise, determining the parking space unit (SRP) is based on considering the following:

a. Unit of parking space for passenger cars. Figure 1 shows the dimensions of a passenger car.

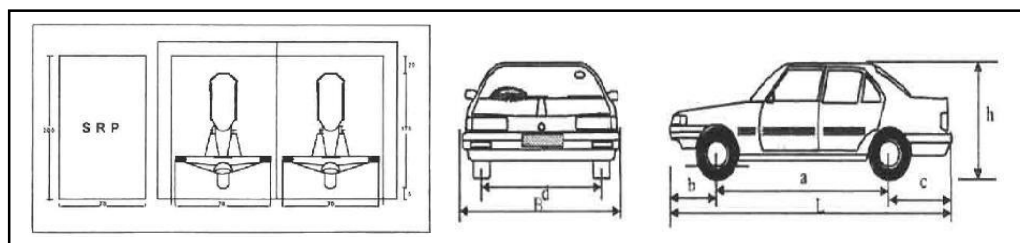


Figure 1. Standard Vehicle Dimensions of Motorcycle and Passenger Cars

(Source: Directorate General of Land Transportation, 1998)

Information:

a = Axle Distance

h = Total Height

b = Front Hanging

B = Total Width

c = Rear Hanging

L = Total Length

d = Trace Width

b. Free vehicle parking space

Free space for parking vehicles is provided in the lateral and longitudinal directions of the vehicle. Lateral clearance is determined when the vehicle door is opened, which is measured from the outer edge of the door to the body of the parked vehicle next to it. This free space is provided so that there is no collision between the vehicle door and the vehicle parked

next to it when passengers get out of the vehicle. To avoid collisions with walls or vehicles passing through the alley. Lateral clearance is taken as 5 cm and the longitudinal clearance is 30 cm.

c. Determination of parking space units (SRP) Based on the table for determining parking space units (SRP) it is divided into three types of vehicles and based on the determination of SRP for passenger cars it is classified into three groups

Data Analysis

Data analysis is a calculation process from primary data or secondary data, usually consisting of several stages carried out sequentially. The data analysis was carried out is calculating parking characteristics using the formula:

1. Accumulation of parked vehicles

$$\text{Parking accumulation} = E_i - E_x \dots\dots\dots (1)$$

Information:

E_i = Entry (vehicles entering the parking location)

E_x = Extry (vehicles leaving the parking location)

If before the observation is carried out there are already vehicles parked at the survey location, then the number of existing vehicles is added up in the accumulated price that has been made, using the formula:

$$\text{Parking accumulation} = E_i - E_x + \dots\dots\dots (2)$$

Information:

X = Number of vehicles available

From the results obtained, a graph is created that shows the percentage of vehicles in the characteristic accumulation curve.

2. Parking duration

$$\text{Parking duration} = E_x \text{ time} - E_n \text{ time} \dots\dots\dots (3)$$

Information:

E_x time = When the vehicle leaves the parking location

E_n time = When the vehicle enters from the parking location

Parking index

$$IP = (\text{accumulated parking}) / (\text{Available parking spaces}) \times 100 \dots\dots\dots (4)$$

3. Turn over parking

Turnover parking = Parking Volume

Parking Space Available

Parking Volume

$$\text{Number of Parking Lots} = ((Q_p \times D)) / T \dots\dots\dots (5)$$

Information:

Q_p : Number of vehicles parked per certain time period

D : Average parking duration (hours/vehicle)

T : Length of observation period (hours)

Results and Discussion

Results

A. Parking

The land area used for parking areas is currently very narrow, so more effective arrangements need to be made. With there being no campus development plans, the land for parking will be narrowed so that arrangements/arrangements need to be made based on needs,

as can be seen in Figure 2. Layout of the Existing Motorcycle Parking Area on the Manado State Polytechnic Campus.

a. Existing Condition of Motorcycle Parking Area on Manado State Polytechnic Campus



Figure 2. Existing Layout of the Motorcycle Parking Area on the Manado State Polytechnic Campus

Figure 2 explains the existing condition of the motorbike parking area with the following area distribution:

- a. Blue Zone (A) is 1,000.74 m²
 - b. Blue Zone (B) is 545.22 m²,
 - c. Blue Zone (C) is 46.56 m²
 - d. Blue Zone (D) is 117.48 m²
- Total area = 1,710 m² x 70% = 1,197 m²

B. Motor Vehicle User Data

From the results of the research that has been carried out, data on motor vehicle users is obtained as follows:

Table 1. Manado State Polytechnic Campus Resident Data 2023

No	Description	Number (people)
1	Student	5.093
2	Lecturers	312
3	Employees	165
Total		5.570

Table 2. Manado State Polytechnic Campus Resident Data 2023

No.	Department	Number of Motors	Number of cars	Information
1	Civil engineering	267	57	
2.	Mechanical Engineering	640	63	
3	Electrical Engineering	277	30	
4	Accounting	276	64	
5	Business Management	28	60	
6	Tourism	193	43	

C. Data Analysis

The analysis that has been carried out in the table above can calculate several parking characteristics including duration, index, and parking requirements as follows:

1) Parking Duration, the lecture system at Manado State Polytechnic has a package system that starts at hourly lectures. 07.45 - 15.25 WITA so that the parking duration is ± 8 hours (480 minutes), from data on four-wheeled vehicles from the survey results, the number of respondents used by students, lecturers, and staff to come to the Manado State Polytechnic campus every day with a total of 346 four-wheeled vehicles.

2) Parking Index = accumulated parking x 100% divided by available parking spaces = $(346 \times 100) / 2,385.18 = 14.51\%$

3) Parking needs = number of parking lots x average duration of parking / length of observation time = $346 \times 8/8 = 346$ vehicles.

Taking into account the Parking Space Unit (SRP) for four-wheeled vehicles = $2.30 \times 5.00 = 11.5$ m², the number of vehicles surveyed = 346 vehicles, and the available land area is 2,385.18 m² on campus, so a large area of land is needed for parking car $346 \times (11.5) = 3,979$ m² is greater than 2,385.18 m² (does not meet).

In the Guidelines and Operation of Parking Facilities issued by the Director General of Land Transportation, the Parking Space Unit for class one passenger cars is 2.30×5.0 m² = 11.5 m². Furthermore, the existing land area planned to be used for Manado State Polytechnic car parking is 2,385.18 m². The results of the vehicle survey (questionnaire) showed that the number of vehicles used to go to campus was 346 cars. With characteristics including a duration of 8 hours, a parking index of 14.51%, the total parking requirement is 346 vehicles, thus, the required parking area is calculated using the equation: Parking area = b SRP x number of vehicles = $2.30 \times 5.0 \times 346 = 3,979$ m². With the available parking area of 2,385.18 m², it does not meet needs. Furthermore, the results of the survey (questionnaire) of two-wheeled vehicles were obtained, the number of vehicles entering the motorbike parking lot was 1,974 motorbikes, with characteristics of an average duration of 8 hours, parking index of 150.24%, parking requirements of 1974 SRP, available land area for motorbike parking 935,137 m² located around the Manado State Polytechnic head office. Thus, the required parking area is calculated using the equation: Parking area = SRP x number of vehicles = $0.75 \times 2.0 \times 1,974 = 2,961.00$ m². With the available parking area of 935,137 m², the existing parking space is The Manado State Polytechnic campus does not meet the needs for parking space, so it is necessary to organize and alternatively provide parking lots and spaces (parking buildings).

Discussion

Parking space is something that, if not planned from the start, will cause problems in the future. In some big cities, parking space is a very crucial need. This is due to the increasingly limited empty land due to development. For this reason, several large cities have adopted policies by increasing parking fees to be very expensive so that users will look for solutions to park their vehicles.

1. Issues with Campus Parking Lots

a. Limited Space

Most campuses, especially those located in urban areas, face the challenge of limited space for parking. This is due to the increasing number of vehicles belonging to students, faculty, and staff, exceeding the capacity of available parking lots.

b. Space Competition

Parking lots often have to compete with other facilities such as academic buildings, sports facilities, and green spaces, making it even more difficult to find adequate parking space.

c. Inefficient Management

Lack of efficient management in utilizing parking space can lead to congestion and confusion among campus users.

2. Case Examples in Indonesia

a. Universitas Indonesia (UI)

UI encounters similar issues with parking space limitations on its campus, especially in busy areas such as faculty zones and student activity centers.

b. Institut Teknologi Bandung (ITB)

ITB also faces similar challenges with limited parking space on its campus, exacerbated by the increasing number of students and vehicles in recent years.

3. Solutions and Strategies

a. Enhanced Public Transportation

Promoting the use of public transportation or vehicle-sharing systems like carpooling can reduce the number of vehicles entering the campus.

b. Development of Multi-level Parking

Introducing multi-level or underground parking systems can maximize the use of limited space on campus.

c. Implementation of Smart Parking Technology

Utilizing technology to manage parking lots more efficiently, such as smart parking applications providing real-time information on parking availability.

The issue of parking space on university campuses is a complex challenge faced by institutions worldwide, including those in Indonesia. Limited space, competition for resources, and inefficient management contribute to congestion and inconvenience for students, faculty, and staff.

Addressing this issue requires a multi-faceted approach, including the promotion of alternative transportation methods, the development of innovative parking solutions, and the adoption of smart technologies for efficient parking management.

By implementing these strategies, universities can alleviate parking-related problems, enhance campus accessibility, and contribute to sustainable transportation practices. However, ongoing research, collaboration, and investment are essential to effectively tackle the evolving needs of campus parking.

Conclusion

The conclusions that can be drawn from this research are:

1. With the number of motorized vehicles, both two-wheeled and four-wheeled, that are used daily by students, lecturers, and employees of the Manado State Polytechnic, the parking space is insufficient to accommodate the number of vehicles.

2. Parking area planning is needed that is holistic and integrated with the general planning and management policies of the Manado State Polytechnic

3. Research, collaboration, and investment are essential to effectively tackle the evolving needs of campus parking.

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