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OPTIMIZING VEHICLE PARKING CAPACITY IN NARROW SPACE: AN ANALYSIS OF THE BINGLE CONCEPT

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Abstract

One of the essential urban issues that cities face worldwide is parking. The number of vehicles is increasing mainly due to the trend of people immigrating to the cities. However, this problem is mainly caused by the limited parking space area. Thus, to figure out this issue, the parking lot of the FSKM, Universiti Teknologi MARA(UiTM) Seremban 3, was selected to be part of this study. The Bingle Concept was implemented to optimize the number of parking lots. Regarding the Bingle Concept, the angle, length, width, and access lane of any parking width were considered as the variables of the concept. The maximum number of parking lots was obtained by testing the different access lanes of any parking width, R and different angles, such $30°$, $45°$, and $60°$. The result showed that the most suitable selection providing the maximum number of parking spaces was the $60°$ of angle and 22.66 feet of R. In the future, researchers might study additional parking width and length to obtain more parking space, thus determining the trade-offs in space utilization, accessibility, and safety.

Keywords: Parking, Optimizing, Bingle Concept

Introduction

Parking is an activity where motor vehicles are stopped temporarily in a specific location. According to Zafirah et al. (2023), a parking lot, often known as a car park, is where individuals can park their vehicles. Parking systems and arrangements can vary from on-street parking, parking in public areas, and parking in multi-story parking buildings. A narrow and limited space is often the result of irregular urban growth, hilly terrain, and dense populations. Ogata and Oya (2023) stated that the narrow area limits the space available for the parking lot. This results in a narrow parking area for one car because of the increasing number of parking lots.

Parking can be challenging when parking is limited while the number of vehicles continues to increase. Therefore, one of the effects of this parking problem is road congestion. Qi et al. (2023) stated in their article that the average time spent by drivers in Kuala Lumpur is 25 minutes looking for a free parking lot. Vehicles frequently use the same path, searching for an open parking space when parking is scarce and full, resulting in traffic jams on the surrounding roads and the parking area itself. The increasing demand for parking spaces, particularly in urban areas, has created significant challenges in optimizing the use of narrow parking spaces.

Bingle et al. (1987) stated that access lane width enhances visibility, makes it easier for drivers to enter and exit, and reduces incidents. The parking angle selection depends on space availability, traffic conditions, and convenience. The Bingle concept might reduce the parking constraints while allowing maximum driver convenience. Besides that, it can optimize multiple parking spaces on a specific site. The FSKM UiTM Seremban 3 met all requirements regarding this project that are to be selected as the main scope of this project. To improve space efficiency, traffic diversion, safety, and parking experience, the project incorporates different angles and widths of access lanes for parking.

Methodology

This section indicates the method implemented in this project, including data collection and model formulation. The collected data was analysed to assess the parking type, optimize the number of parking lots, and validate the mathematical model.

Data including the total area FSKM UiTM Seremban 3, A_T, length, L, width, W, access lane's width, R, angle, θ, of the parking lots, and the number of parking lots was gathered. The collected data must be appropriate for the details necessary to implement the mathematical structure.

The Mathematical Model for Parking Lot at FSKM UiTM Seremban 3

A mathematical model was applied to optimise the number of parking spaces. This model considers two distinct parking types: standard car parking, known as Type 1, and disabled parking (OKU), known as Type 2. The total area of each parking type was set as A_1 and A_2 .Meanwhile, the total area of FSKM UiTM Seremban 3 was A_T .

Number of Parking Spaces

The total area is occupied by two different parking types which are A_1 and A_2 can be used to obtain the number of parking lots. The length, width, angle and access lane of any width were the significant factors that influenced the total area for both parking types. Equation 1 is the formula to calculate the number of parking lots available.

$$N_P = \frac{A_T}{A_1 + A_2}, \tag{1}$$

The total area of parking Type 1 and Type 2 can be defined as follows:

$$A_1(\theta) = W_1\left[L_1 + R_1 \operatorname{cosec}(\theta_1) + (2W_1 - R_1)\cot(\theta_1)\right], \tag{2}$$

$$A_2(\theta) = W_2\left[L_2 + R_2 \operatorname{cosec}(\theta_2) + (2W_2 - R_2)\cot(\theta_2)\right], \tag{3}$$

Where,

N_P = Number of Parking Lot

A_T = Total Area of FSKM UiTM Seremban 3

A_1 = Total Area for Parking Type 1

A_2 = Total Area for Parking Type 2

L_1 = Length for Parking Type 1
L_2 = Length for Parking Type 2
W_1 = Width for Parking Type 1
W_2 = Width for Parking Type 2
θ_1 = Angle for Parking Type 1
θ_2 = Angle for Parking Type 2
R_1 = Access lane for Parking Type 1
R_2 = Access lane for Parking Type 2

Data Collection

The plan of FSKM UiTM Seremban 3 can be illustrated in Figure 1. There is only a single type of angle parking accessible at FSKM UiTM Seremban 3, which is $90°$ Parallel parking. Different parking kinds will have varied measurements even if all parking lots have the same angle.

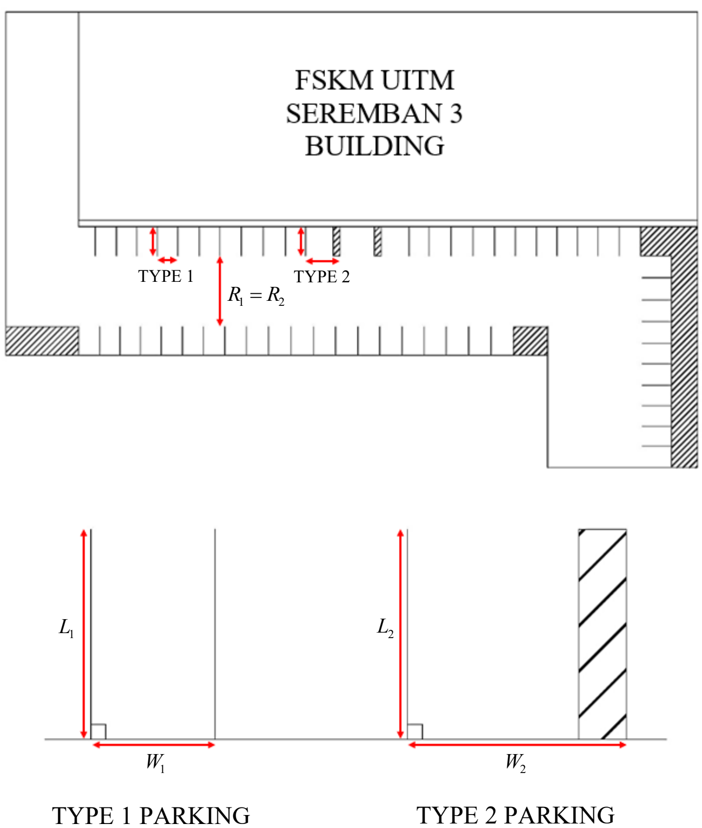

Figure 1: The Plan of FSKM UiTM Seremban 3

By referring to Figure 1, there are two types of parking lots. Type 1 is the standard type of car park, better known as the standard car parking type. For Type 1 parking, the measurements for length, width and access lane for any width are labelled as L_1, W_1 and R_1. As for Type 2 parking, this parking is disabled parking. For this type of parking, the measurements for length, width and access lane for any width are labelled as L_2 , W_2 and R_2.

From the parking layout in Figure 1, Type 1 appears to be more plentiful than Type 2 parking. This is because the demand for parking lots for regular accessible vehicles is usually greater than that for parking lots for people with disabilities. Furthermore, parking Type 2 is wider than parking Type 1 to allow wheelchair access and other mobility devices. Naturally, Type 2 occupies more space than standard parking, so the number of car parks that can be created will drop.

Data including the total area of FSKM UiTM Seremban 3, A_T , length, *L*, width, *W*, access lane's width, *R*, angle, θ of the parking lot, and the number of parking was gathered from the Facility Center of UiTM Seremban 3. The collected data must be appropriate for the details necessary to implement the mathematical structure. Table 1 below displays the gathered data.

Table 1: Data Collection of FSKM UiTM Seremban 3 Parking Lots

Information	**Type of Parking**	**Value (ft)**
Total area of FSKM UiTM Seremban 3, A_T		41020.02
The total area of FSKM UiTM Seremban 3's building		25510.30
Total area of parking lot space (54 spaces – standard car) (2 spaces – OKU)		15924.25
Length of parking lots, *L*	Standard car	15.91
	OKU	15.91
Width of parking lots, *W*	Standard car	7.56
	OKU	11.14
An access lane of any width, *R*	Standard car	23.16
	OKU	23.16

Results and Discussions

This project has identified the number of parking lots based on different angles and access lanes of any width. This is because this project wants to determine which angle and value of *R* can produce more parking lots than the existing car park at FSKM UiTM Seremban 3. Tables 2 and 3 show all the angles and new *R*-values that can be used to determine the current number of parking lots. The new R-values were reduced by 0.5 feet from the original, which is 23.16. The angles 30°, 45° and 60° of parking lots are the standard angles in most urban areas and parking guidelines provided by Dewan Bandaraya Kuala Lumpur.

Table 2: The Number of Parking Lots for Each New *R*-value by Each Angle for Case 1 to 3

Case	New ***R*-values** for Both Types of parking (ft)	**Angle, θ for Both Types of parking**	**Area for Type 1 parking (ft)**	**Area for Type 2 parking (ft)**	**Total Area Occupied (ft)**	**Total Number of Parking**
1	22.66	30°	364.17	674.77	1038.94	39
	22.66	45°	305.55	530.00	835.54	49
	22.66	60°	285.18	466.28	751.46	55
2	22.16	30°	363.15	673.28	1036.43	40
	22.16	45°	303.98	527.69	831.67	49
	22.16	60°	283.00	463.06	746.06	55
3	21.66	30°	362.14	671.79	1033.93	40
	21.66	45°	302.41	520.77	823.18	50
	21.66	60°	280.82	453.41	734.23	56

Table 3: The Number of Parking Lots for Each New *R*-value by Each Angle for Case 4 to 6

Case	New ***R*-values** for Both Types of parking (ft)	**Angle, θ for Both Types of parking**	**Area for Type 1 parking (ft)**	**Area for Type 2 parking (ft)**	**Total Area Occupied (ft)**	**Total Number of Parking**
4	21.16	30°	361.13	670.29	1031.42	40
	21.16	45°	300.85	523.08	823.92	50
	21.16	60°	278.63	456.63	735.26	56
5	20.66	30°	360.12	668.80	1028.92	40
	20.66	45°	299.28	520.77	820.05	50
	20.66	60°	276.45	453.41	729.86	56
6	20.16	30°	359.10	667.31	1026.41	40
	20.16	45°	297.72	518.46	816.18	50
	20.16	60°	274.27	450.20	724.47	57

Based on Table 6, when the R -value is reduced to 20.16 feet, and the angle changes to $60°$, it has the largest number of parking spaces, which is 57. This number of parking spaces has also exceeded the existing number of parking spaces at FSKM UiTM Seremban 3, which has 56 parking lots.

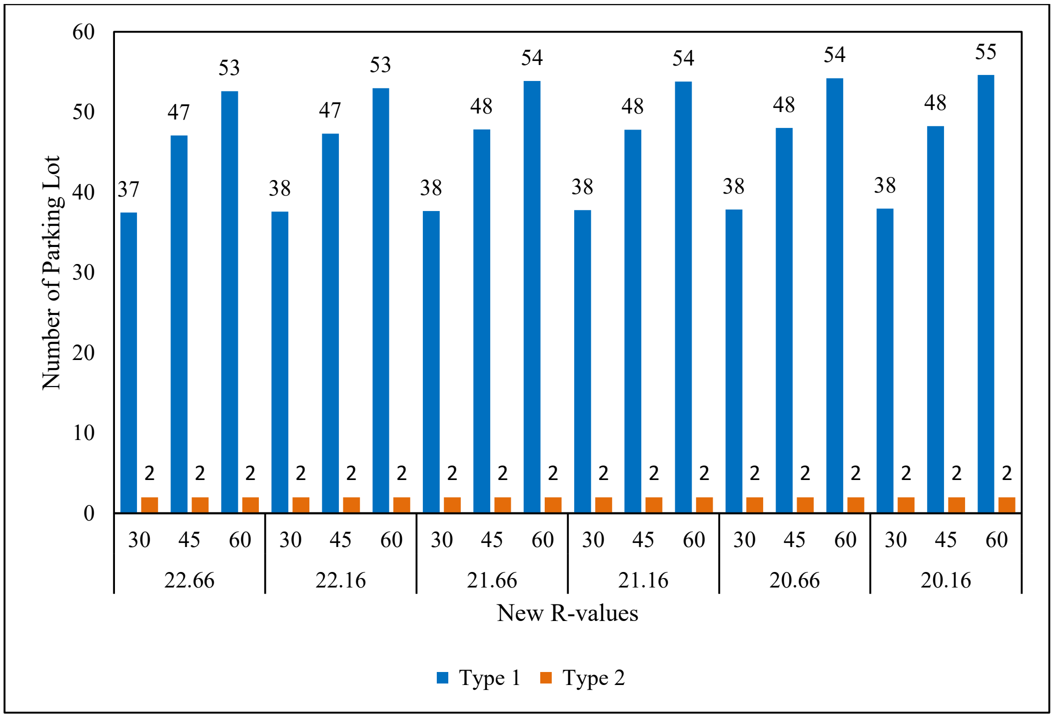

Figure 2: Number of Parking Lots for Each New *R*-value by Each Angle

The graph in Figure 2 illustrates the correlation between the number of parking lots and the new *R*-values by each angle. Six different new R-values have been calculated for each angle. It shows that the change of *R* to 20.16 and the angle to $60°$ The parking produces the optimal number of parking lots, which is 55 for Type 1 parking and 2 for Type 2 parking.

Therefore, the objective of this project, which is to optimize the number of parking spaces, has been achieved. The best angle for parking lot design is $60°$ while the best access lane of any width, R is 20.16 ft. Thus, it is proven in this project that the angle, θ and access lanes of any width, R play a vital role because changing these two factors can increase the number of parking lots in a place. The results demonstrated high accuracy, indicating that the model from the Bingle article is appropriate for this project.

Conclusion

In conclusion, by examining the relationship between variations in parking lot angle, access lane of any width and the number of parking lots, this project offers insightful information for improving parking lot design. This study aims to optimise FSKM UiTM Seremban 3's parking lot design to handle the growing number of cars and narrow space problems. To determine the optimal parking lot maximisation number, this project applies the Bingle concept and considers variables like parking angle, access lane's width, length, width and total area. Excel was used to analyse the data. The result underlines how crucial it is to balance security, visibility, and capacity. This project offers practical methods to increase parking utilisation and reduce city congestion.

Future research may apply this mathematical model based on the established parking guidelines, as Dewan Bandaraya Kuala Lumpur (DBKL) has provided specific guidelines for parking spot design, such as length, width, and access lane width. Furthermore, future research can aim to implement this mathematical model over a more extended area. The optimal optimization in a parking lot depends on choosing the right angle. It's also influencing the width of the access lane. The length and width of the parking lot can be modified to create more parking spaces that fit the area.

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