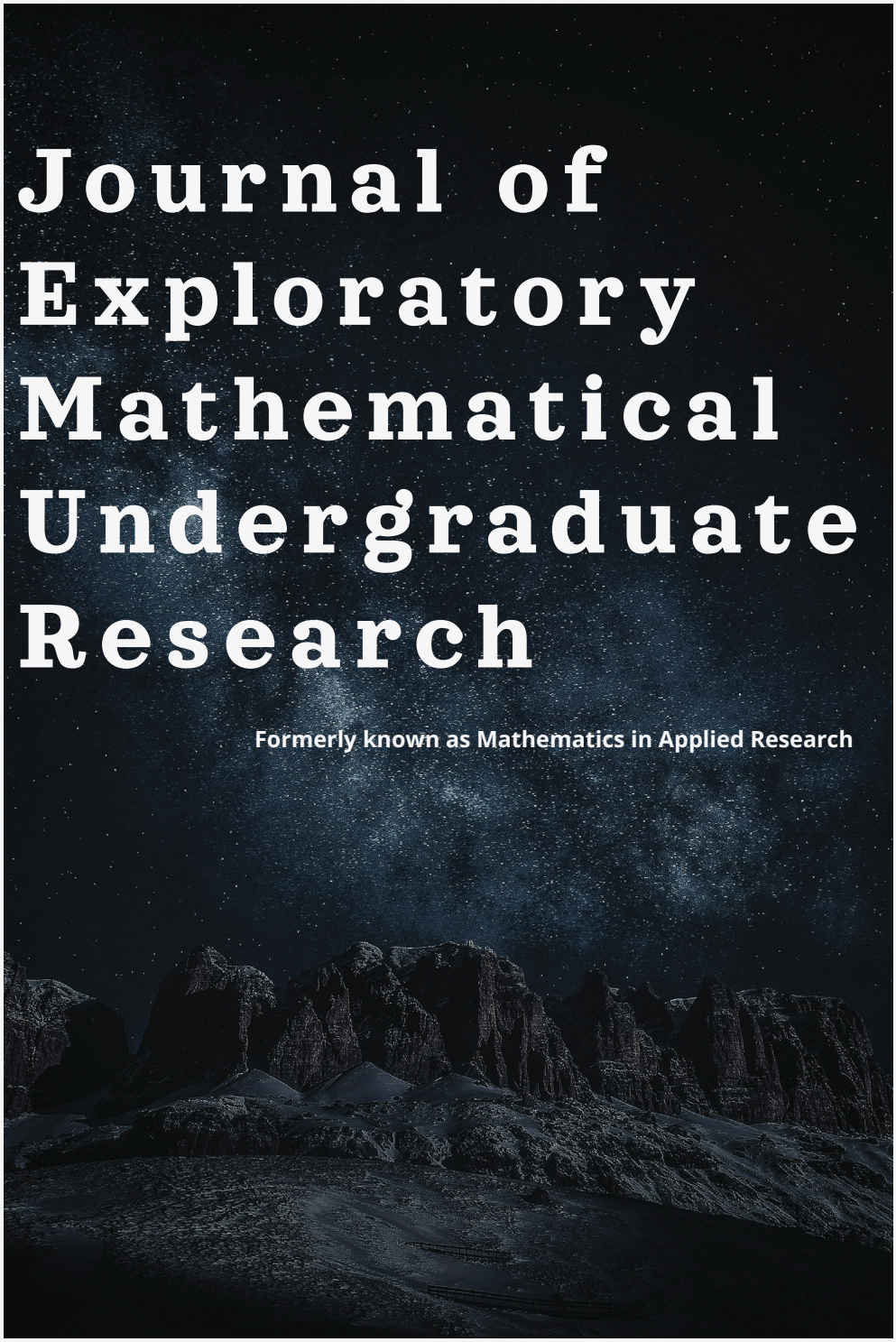
UITMCNS
SEREMBAN

J E M U R

JOURNAL OF EXPLORATORY MATHEMATICAL UNDERGRADUATE RESEARCH

RECENT **MATHEMATICAL PROJECTS** AT UITM, *SEREMBAN CAMPUS*

Vol. 001 | PREPARED BY: KPPIM, UiTM N. SEMBILAN. | DATE: 15 MAY 2024



JOURNAL OF
EXPLORATORY MATHEMATICAL
UNDERGRADUATE RESEARCH

BULETIN RASMI KOLEJ PENGAJIAN PENGKOMPUTERAN, INFORMATIK DAN MATEMATIK, UITM CAWANGAN NEGERI SEMBILAN KAMPUS SEREMBAN
EDISI MEI 2024

PENAFIAN:

Sebarang maklumat yang terkandung dalam majalah ini merupakan pengetahuan dan pendapat peribadi penulis artikel. Pembaca dinasihatkan untuk mendapatkan pandangan profesional sebelum mengikuti mana-mana maklumat dalam majalah ini. Pihak universiti, penerbit, dan sidang redaksi tidak akan bertanggungjawab dan menanggung sebarang risiko atas kerugian secara langsung atau tidak langsung atas maklumat yang dipaparkan.

UITMCNS
SEREMBAN

Diterbitkan oleh:
Universiti Teknologi MARA (UiTM)
Cawangan Negeri Sembilan Kampus Seremban,
Persiaran Seremban Tiga/1, Seremban 3,
70300 Seremban, Negeri Sembilan,
MALAYSIA.

Tel: +606 634 2000, Faks: +606 633 5813

eISSN: 3030-5411
Perpustakaan Negara Malaysia
Majalah ini diterbitkan dua kali setahun

OPTIMAL PARKING DESIGN BY PARALLELOGRAM CONCEPT IN BINGLE PARKING LOT AT MCDONALD'S SEREMBAN 2

Najir Tokachil[1,] *, Nur Farahana Ahmad Ettihad[2], Rabiatul Fatanah M. Noor Hashim [3] and Nursyafifazzry Md Hazi [4]

[1,2,3,4]College of Computing, informatics, and Mathematics,
Universiti Teknologi MARA Cawangan Negeri Sembilan, Kampus Seremban, Negeri Sembilan.
*najir2992@uitm.edu.my

Abstract

Nowadays, the lack of sufficient parking spaces can cause congestion, especially in an urban area because the number of cars has rapidly increased. Therefore, this study was done on how to overcome this problem by optimising the number of parking lots. Using the parallelogram concept that Bingle proposed, the parking lot of McDonald's Seremban 2 was selected as a scope for our study. There were three factors involved in this concept which were the length, width, and angle of the parking lot. The angle of the parking lot was assigned as a main factor that influences the number of parking lots which are 30°,45°, 60° and 90°. As a result, the most appropriate angles for the parking lot in McDonald's Seremban 2 are 60° and 90°, which can contribute to a greater number of parking lots compared to other parking degrees. The AutoCAD software was used to illustrate the parking lot of McDonald's Seremban 2 based on the angles obtained from this result. In the future, other factors such as length, width, or access lane of any width of a parking lot need to be emphasized to obtain an accurate result.

Keywords: Parallelogram concept, Bingle parking lot

1. Introduction

Parking is essential for efficient use of roads and facilities, with on-street parking being the most common form. However, finding parking spots can be challenging, especially in urban areas like Georgetown and Johor Bahru (Trisha, 2022). This is like the statement by Alkheder, Al Rajab, and Alzoubi (2016), the true challenge is when a road user wants to find parking on a site where there are no open parking slots in a city.

Numerous urban centers grapple with insufficient parking space, marked by a disparity between supply and demand, which serves as the primary cause of parking challenges in metropolises (Ibrahim, 2017). It is important to maximize off-street parking in metropolitan locations with limited spots by optimizing design and arrangement.

According to Biswas (2017), on-street parking is widely adopted due to its efficient land use and convenience for motorists, enabling them to park closer to their destinations. Parking lots have access lane widths, lengths, and angles to accommodate different car sizes. Meanwhile, Bingle et al. (1987) stated that access lane width improves visibility, makes it easier for drivers to enter and exit, and reduces incidents. The length of parking spaces determines the total space available, with larger vehicles needing longer spaces and smaller cars needing fewer. The choice of parking angle depends on factors like available space, traffic, and convenience. Bingle's mathematical model minimizes restricted parking without sacrificing driver convenience. The parallelogram concept maximizes parking spaces within a given area.

The width of the aisle is crucial, as it affects the ease of parking. McDonald's Seremban 2 met all requirements for this project. This study aims to improve space utilization, traffic flow, safety, and overall parking experience by employing various parking angle values, such as 90°, 60°, 45°, and 30°.

2. Methodology

This section presents the methodology applied in this study involving data collection and formulation of the models. The collected data was used to analyze the parking type, optimize the number of parking lots and also validate the mathematical model.

The data included the total area of the McDonald's Seremban 2 building, A_T, access lane of any width, R, length, L, width, W, angle of the parking space, θ and the number of parking, N_P, was collected to ensure that it is relevant and necessary for implementing a mathematical model.

2.1. Mathematical model for the parking lot at McDonald's Seremban 2

To optimize the number of parking spaces, a mathematical model was utilized. The model considers three distinct types of parking, each with a different area that can be occupied by a car. By calculating the total area that can be occupied by a car for each type $(A_1 + A_2 + A_3)$, the number of parking spaces can be determined. This number was obtained by dividing the total area of McDonald's Seremban 2 by the total area that can be occupied by a car for the given types. The notation used in this study computational analysis is:

2.2. Number of parking spaces

The total area that can be occupied by a car in three different types can be used in calculating the number of parking spaces. The number of parking spaces can also be formulated as follows:

$$N_P = \frac{A_T}{A_1 + A_2 + A_3} \tag{1}$$

The formula of each A can be defined as follows:

$$A_1(\theta) = W_1[L_1 + R_1 \cos ec(\theta) + (2W_1 - R_1)\cot(\theta)] \tag{2}$$

$$A_2(\theta) = W_2[L_2 + R_2 \cos ec(\theta) + (2W_2 - R_2)\cot(\theta)] \tag{3}$$

$$A_3(\theta) = W_3[L_3 + R_3 \cos ec(\theta) + (2W_3 - R_3)\cot(\theta)] \tag{4}$$

Where

N_p = Number of Parking Lot

A_T = Total Area of McDonald's Seremban 2

$A_1 =$ Area Occupied by a Car Type 1 Parking

$A_2 =$ Area Occupied by a Car Type 2 Parking

$A_3 =$ Area Occupied by a Car Type 3 Parking

3. Data collection

The type of parking angles used in McDonald's Seremban 2 were 60° diagonal parking, 90° parallel parking, and 90° perpendicular parking. The different angles used in McDonald's Seremban 2 have a difference of width, length, and access lane of any width.

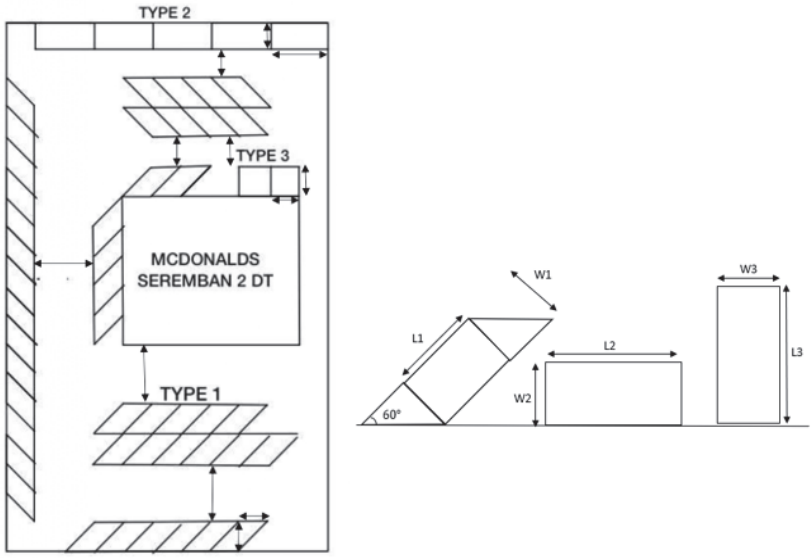


Figure 1: The Plan of McDonald's Seremban 2

McDonald's Seremban 2 has three types of parking and were labelled as Type 1, Type 2 and Type 3. In this study, Type 1 is for diagonal parking which is the length, width and access lane of any width for this type of parking as L_1, W_1, R_1. While, Type 2 is for parallel parking, and the length, width, and access lane of any width for this type of parking are L_1, W_1, R_1 and last Type which is Type 3 is for perpendicular parking where the length is equal to L_3, width is equal to W_3, and access lane for any width is equal to R_3.

The design shows that the Type 1 parking is more than Type 2 and Type 3 parking, is because Type 1 or diagonal parking is most suitable for short-term parking because of easy entrance and exit from the parking space, where this type of parking is prepared for the customer of McDonald's Seremban 2. While Type 2 or parallel parking is the smallest number of parking spaces, they are used at McDonald's Seremban 2 because this type of parking is not suitable for off-street parking, and it reduces the number of parking spaces. Then, Type 3 or perpendicular parking is suitable for long-term parking, where this type of parking is provided with 2 parking spaces only and it is for OKU people.

The increase in population density influences the number of vehicles and might be one of the problems of parking (Çakici and Şensoy, 2023). Therefore, this study prefers McDonald's Seremban 2 as one of the developing areas.

The data such as the total area of the McDonald's building, A_T, access lane of any width, R, length, L, width, W, angle, θ, of the parking space and the number of parking, N_p was collected from the Management Department of McDonald's Seremban 2. The collected data must be related to the information needed to implement the mathematical model. The detailed data are shown in Table 1.

Table 1: Data Collection of McDonald's Seremban 2 Parking Space

INFORMATION				**VALUE**
Total area of McDonald $(ft^2), A_T$				48347.06
Total area of McDonald's building (ft^2)				10152
Total area for parking lot space (ft^2) (50 spaces – standard car) (2 spaces – parking lot for disabled people)				38195.06
Length of parking space $(ft^2), L$		Parallel		16.67
		$\theta = 60^\circ$		16.67
		$\theta = 90^\circ$		16.67
Width of parking space $(ft^2), W$		Parallel		8.33
		$\theta = 60^\circ$		8.33
		$\theta = 90^\circ$		8.33
An access lane of any width $(ft^2), R$		Parallel		14.67
	$\theta = 60^\circ$	R_1	14.33	18.00
		R_2	15.08	
		R_3	21.07	
		R_4	21.41	
		$\theta = 90^\circ$		23.41

4. Result and Discussion

In the first situation, there are four cases, in which the angle of all parking lots was changed based on angles 90°,60°,45°, and 30°. All the cases are described in Table 2. Meanwhile, Figure 2 shows the relationship between the number of parking lots and the type of changes based on information in Table 2. There are four types of changes made to the angle of the parking space. It shows that the fourth change produces the optimal number of parking spaces, which is 54. The angle used in this type of change is 90° for all types of parking. Meanwhile, the number of parking lots will decrease when the parking angle for all types of parking is changed to 30°.

Table 2: Angle for each Type 1, 2 and 3 based on case.

Case	Angle, θ		
	Type 1	Type 2	Type 3
1	30°	30°	30°
2	45°	45°	45°
3	60°	60°	60°
4	90°	90°	90°

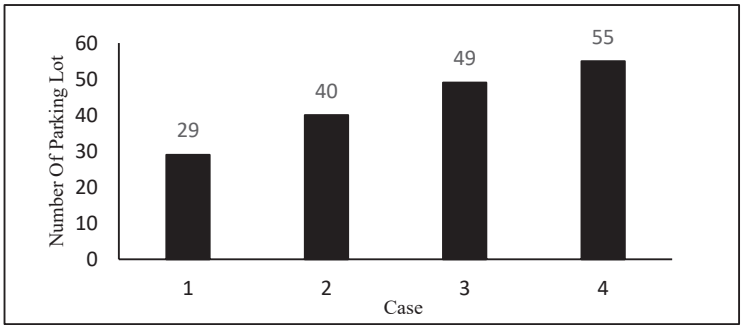


Figure 2: The Relationship Between the Number of Parking Lots and Cases 1,2,3 and 4

To obtain the best result which produces more parking lots. The angle of each type is changed in several cases. This can be illustrated in Table 3. Meanwhile Figure 3 shows the relationship between the number of parking lots and the type of changes made in the angle of parking spaces based on information in Table 3. It shows that case 3 produces the optimal number of parking lots, which is 54. Meanwhile, the minimum number of parking lots is 35 for case 4.

Table 3: The Number of Parking Lots for Situation 2

Case	Type 1		Type 2		Type 3		Total Area Occupied (*ft*)
	Angle,θ	Area (*ft*)	Angle,θ	Area (*ft*)	Angle,θ	Area (*ft*)	
1	90°	288.78	90°	261.06	30°	570.34	1120.19
2	90°	288.78	90°	261.06	45°	415.93	965.77
3	90°	288.78	90°	261.06	60°	353.05	902.90
4	30°	558.26	90°	261.06	30°	570.34	1389.67
5	45°	397.26	90°	261.06	30°	570.34	1228.66
6	60°	327.02	90°	261.06	30°	570.34	1158.43
7	30°	558.26	90°	261.06	45°	415.93	1235.26
8	45°	397.26	90°	261.06	45°	415.93	1074.25
9	60°	327.02	90°	261.06	45°	415.93	1004.02
10	30°	558.26	90°	261.06	60°	353.05	1172.38
11	45°	397.26	90°	261.06	60°	353.05	1011.37
12	60°	327.02	90°	261.06	60°	353.05	941.14
13	30°	558.26	90°	261.06	90°	333.87	1153.19
14	45°	397.26	90°	261.06	90°	333.87	992.18
15	60°	327.02	90°	261.06	90°	333.87	921.95

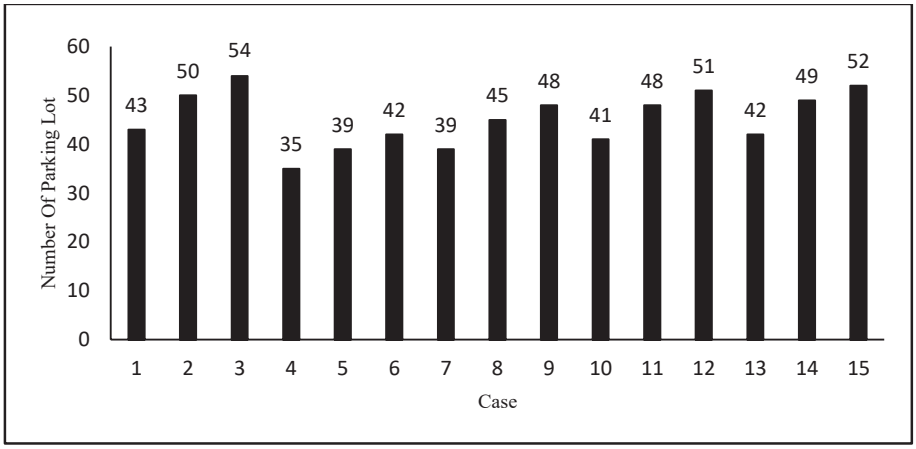


Figure 3: The Relationship Between the Number of Parking Lots and All Cases 1 to 15

The mathematical model used in this study was validated by comparing predicted and actual data for the number of parking spaces. The results showed high accuracy, indicating that the Bingle article's model is suitable for this study. Additionally, the data obtained from the management of McDonald's Seremban 2 DT was found to be relevant as it yielded more parking spaces (54 cars) in line with the study objectives.

5. Conclusion

In conclusion, this study provides valuable insight for optimizing parking lot design by investigating the relationship between the number of parking spaces and changes in parking lot angle. This study focuses on optimizing the parking lot design of McDonald's Seremban 2 to accommodate the increasing number of vehicles and parking issues. This study uses the parallelogram concept and considers factors such as parking angle, total area, vehicle footprint, access lane length, and width to find the optimal parking space maximization number. It is intended to determine the parking angle. Excel and AutoCAD software were used for data analysis and parking lot design. This result highlights the importance of balancing capacity, visibility, and security. This research provides practical solutions for improving parking space utilization and reducing urban congestion. This study supported the AASHTO (2010), which parking angles should range from 0 degrees (parallel parking) to 90° (perpendicular parking), with 60° to 75° angles being the most common for angled parking.

References

AASHTO. (2010). A policy on geometric design of highways and streets (6th ed.). Washington, DC: American Association of State Highway and Transportation Officials.

Alkheder, S. A., Al Rajab, M. M., & Alzoubi, K. (2016). Parking problems in Abu Dhabi, UAE toward an intelligent parking management system “ADIP: Abu Dhabi Intelligent Parking.” *Alexandria Engineering Journal*, *55*(3), 2679–2687. https://doi.org/10.1016/j.aej.2016.06.012

Biswas, S., Chandra, S., & Ghosh, I. (2017). Effects of on-street parking in urban context: A critical review. *Transportation in Developing Economies*, *3*(1), 1–14. https://doi.org/10.1007/s40890-017-0040

Çakici, Z., & Şensoy, A. T. (2023). Determining The Optimum Parking Angles for Various Rectangular-Shaped Parking Areas: A Particle Swarm Optimization-Based Model. *Konya Journal of Engineering Sciences*, *11*(4). https://doi.org/10.36306/konjes.1293799

Ibrahim, H. E., (2017). Car Parking Problem in Urban Areas, Causes and Solutions. 1st International Conference on Towards a Better Quality of Life, 2017, page 1-13.

Trisha, N. (2022, September 15). *Motorists struggle to find parking in busy George Town*. The Star. https://www.thestar.com.my/metro/metro-news/2022/09/14/parking-woe-return